KEEPING SANTA FE COUNTY WETLANDS VIABLE AND FUNCTIONING

A WETLANDS ACTION PLAN FOR SANTA FE COUNTY

December 31, 2012

Prepared by:

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Justification and Credits

This Wetlands Action Plan was prepared in partnership with the New Mexico Environment Department's Surface Water Quality Bureau Wetlands Program with additional support from Santa Fe County. The Wetlands Action Plan was written to satisfy the grant objectives of a U.S. EPA CWA Section 104(b)(3) Wetlands Grant (Assistance Agreement No. CD-966558-01-0-C (FY2007)), entitled: "Comprehensive Wetland Restoration and Protection in Santa Fe County".

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Conservation Planning for Landscapes in Transition

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In the end, we will only conserve what we love
We will only love what we understand
We will only understand what we are taught
Baba Dioum, Senegalese Poet

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This Wetlands Action Plan is the product of many years of collaboration between all partners of the project Comprehensive Wetland Restoration and Protection in Santa Fe County and the many lessons learned from this project since 2007. The author is particularly grateful for the steadfast support and guidance from the State's Surface Water Quality Bureau Wetlands Program Coordinator, Maryann McGraw. Special words of thanks are also due to project team members and regional wetland and stream restoration professionals John Busemeyer, Alan Hamilton, Chris Philips, Craig Sponholtz, Steve Vrooman, and Bill Zeedyk, and hydrologists and/or geologists Claudia Borchert, Peggy Johnson, Amy Lewis, and Karen Torres, who directly and indirectly have all contributed many insights to the development of this plan. The author is also very grateful for the mapping support offered by Santa Fe County's GIS specialist Tim Cannon, and for the inspiring leadership in natural resource governance in Santa Fe County by County Commissioner Kathleen Holian.

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Figures and Tables

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Acronyms

ACE	Army Corps of Engineers (United States Department of Defense)
ACEC	Area of Critical Environmental Concern
af	Acre feet (equals 43,681 cubic feet)
afy	Acre feet per year
BDD	Buckman Direct Diversion
BISON-M	Biota Information System of New Mexico
BLM	Bureau of Land Management (United States Department of the Interior)
BOR	Bureau of Reclamation (United States Department of the Interior)
CFS / cfs	Cubic feet per second
CWA	Clean Water Act
DOT	New Mexico Department of Transportation
ECIA	Eldorado Community Improvement Association
EMNRD	New Mexico Energy, Minerals, and Natural Resources Department
EPA	Environmental Protection Agency (United States Department of the Interior)
ET	Evapotranspiration
EWI	Earth Works Institute
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FWS	Fish & Wildlife Service (United States Department of the Interior)
FWS	Fresh Water Surface (evaporation)
GBP	Galisteo Basin Preserve
GIS	Geographic Information System(s)
GCM	General Circulation Models
GO	General Obligation (Bonds)
GWCI	Galisteo Watershed Conservation Initiative
HOA	Home Owners Association
HGM	Hydrogeomorphic
HUC	Hydrologic Unit Code
Hwy	Highway
IPCC	Intergovernmental Panel on Climate Change
maf	One million acre feet (1,000,000 af)
MS4	Municipal Separate Storm Sewer Systems
NAWCA	North American Wetlands Conservation Act
NGO	Non-Governmental Organization
NMAC	New Mexico Administrative Code
NMBGMR	New Mexico Bureau of Geology and Mineral Resources (New Mexico Institute of Mining and Technology, Socorro, NM)
NMED	New Mexico Environment Department
NM RAM	New Mexico Rapid Assessment Method (of wetlands)
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service (United States Department of Agriculture)
ONRW	Outstanding Natural Resource Water(s)

PES	Payment for Ecosystem Services
PET	Potential Evapotranspiration
PQAPP	Project-(specific) Quality Assurance Project Plan
QAPP	Quality Assurance Project Plan
RMP	Resource Management Plan (of BLM)
SDA	Sustainable Development Area (Santa Fe County)
SF	Santa Fe
SFC	Santa Fe County
SGCN	Species of Greatest Conservation Need
SGMP	Sustainable Growth Management Plan (Santa Fe County)
SLDC	Sustainable Land Development Code (Santa Fe County)
SLO	State Land Office (State of New Mexico)
SWReGAP	Southwest Regional Gap Analysis Project
SWQB	Surface Water Quality Bureau (New Mexico Environment Department)
SWANCC	Solid Waste Agency of Northern Cook County (ruling of Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers, 531 U.S. 159 (2001))
TBD	To be determined
TNC	The Nature Conservancy
UNM	University of New Mexico
USDA	United States Department of Agriculture
USDHS	United States Department of Homeland Security
USDI	United States Department of the Interior
USFS	United States Forest Service
USGS	United States Geological Survey
WAP	Wetland Action Plan
WAP-SFC	Wetland Action Plan for Santa Fe County
WQCC	Water Quality Control Commission (of the State of New Mexico)
WRAS	Watershed Restoration Action Strategy
WWTP	Wastewater Treatment Plant

Executive Summary

Limited Information - This Wetlands Action Plan for Santa Fe County (WAP-SFC) is a comprehensive examination of available information about the wetlands and riparian resources of Santa Fe County. The information in this WAP-SFC is based on a number of ecological and hydrological studies, wetland restoration and protection project reports, and mapping efforts, including an earlier WAP for the Galisteo Watershed (SWQB 2010a). Due to significant information gaps, however, this WAP-SFC offers at times a piecemeal and dated picture of the County's wetland conditions.

The available literature indicates that in the last few hundred years many wetlands with permanently wet conditions in Santa Fe County have been lost. Ongoing urban development, coupled with the impacts of climate change and cumulative historical land use impacts, continue to present many stressors to wetland ecosystems. Additionally, the present enabling environment for wetland restoration and protection--consisting of local regulations for wetland protection, local institutional capacity, available funding sources, public involvement, and water quality standards for wetlands--appears to be inadequate and offers great challenges to countering the stressors and threats to wetlands in the future.

Purpose - The purpose of the WAP-SFC is to provide guidance to public and private landowners and land managers, decision makers, and resource management professionals about future action initiatives for the protection and restoration of wetlands in Santa Fe County. The information, analysis, and ideas offered in this WAP-SFC aim to stimulate dialogue, coordination, and collaboration. To that end, the WAP-SFC concludes with goals, strategies, and recommendations for future wetland protection and restoration initiatives with an emphasis on the protection and restoration of wetland functions that provide water quality benefits and ecological integrity.

Needs - The future functioning conditions of wetlands and riparian areas in Santa Fe County are dependent on (1) better and more publicly accessible information for planning and decision making on wetland management, (2) improvements of local regulations and their implementation and enforcement, (3) continued and increased restoration and protection initiatives, (4) improved institutional and public support, buy-in, and collective stewardship behavior, and (5) development of water quality standards for optimal natural functioning conditions of wetlands in Santa Fe County.

Proposed Interventions - This WAP-SFC proposes that proper planning for the future conditions of wetlands in Santa Fe County begins with the need to know what wetlands we have and where they are. Therefore, it is critical to collect more data through assessments, e.g., through the NM Rapid Assessment Method for wetlands (NM RAM), and through ongoing monitoring of wetlands and of their stressors and threats. Assessments must be accompanied with wetland mapping and public sharing of documented information about wetlands. Assessments will need to reveal the functioning conditions of wetlands, the stressors and threats that impede wetland functioning, and the ecosystem services and values of wetlands specific to Santa Fe County. Such relevant information will direct what wetland restoration and protection strategies need to be employed as well as where, in what order, and how these strategies need to be implemented.

Simultaneously, regulations must be sharpened, especially Santa Fe County's Sustainable Land Development Code and terrain management guidelines, in order to direct positive land and resource use and stewardship action in the community and to eliminate harmful human-caused stressors. Current regulatory conditions offer many opportunities for Santa Fe County to be a pilot area and leader in developing regulations that counter the projected negative effects of urban development and climate change on wetlands in the future. Additionally, County and State agencies must seek to support all public resource management institutions involved in wetland management to implement and enforce existing and new regulations.

There is growing expertise and practice of wetland restoration and protection in Santa Fe County which should be maintained and further developed. However, the enabling environment for wetland restoration and protection is weak in that it lacks one coordinating entity that manages water, wetland and riparian resources. A primary target for capacity development, therefore, must be to establish a water management authority--ideally one grounded in the State's local government statues--that oversees and coordinates all aspects related to surface water and groundwater management for the restoration and protection of wetlands. Alternatively, a non-profit watershed group with a regional focus could perhaps serve similar functions. Additionally, it is of great importance for growing local wetland management capacity to continue identifying new funding sources and pursuing innovative and collaborative funding models that are linked to the values of the ecosystem services that are being protected. It will also be important to broker more voluntary land protection agreements, i.e., conservation easements, especially for establishing wetland buffer areas, grow multi-party collaboration on projects, and build local institutional capacity among private and public partners. Finally, development of one or more designated staff positions within Santa Fe County's natural resource and planning divisions for wetland and habitat restoration and protection would significantly support the achievement of many proposed interventions of this WAP-SFC.

Public education is essential to achieve these improvements for wetlands over time. Public involvement will help shape the most desirable public planning and decision making body for regional water resource management, generate funding for wetlands, create buy-in for public investments, and educate people about the natural benefits provided by wetlands. As a result, people will be more likely to offer stewardship services and change land use behavior that causes stresses on wetlands. Public and landowner education toward restoration and protection of wetlands may in fact reduce the need to develop certain regulations, which, in turn, may reinforce voluntary stewardship action on the part of landowners to avoid regulatory pressure.

In order to set targets and monitor progress toward desired conditions, it will be important to establish water quality standards for wetlands. While standards development is currently a statewide need, Santa Fe County could serve as a pilot area to develop riverine wetland standards for intermittent lower elevation streams, such as in the Galisteo Basin, in conjunction with the proposed water quality classification in this watershed. Additionally, SWQB could pilot slope wetland standards development in the County following the results of a hydrogeological study in the La Cienega Area. Finally, SWQB's pursuit of the protection of ONRW streams in the County also offers good opportunities for further standards development.

Urgency - This WAP-SFC is timely because it coincides with County planning processes and the development of a new land use code, the Santa Fe County Sustainable Land Development Code. There are many other supporting initiatives under way in the City of Santa Fe and in State and Federal agencies and their partnerships. The WAP is also timely, because the need for wetland restoration and protection planning is great in the face of impacts from development and climate trends. Wetlands are of great importance in Santa Fe County, because wetlands play a critical role in wildlife habitat and linkages between different ecoregions that converge in the County. Additionally, a small but vibrant traditional agricultural community is supported by the County's springs and streams. Wetlands also play a role in flood attenuation, water infiltration, and the buffering of sediment and other water quality impairments.

The combined picture of the literature cited in this WAP-SFC suggests that in the next 10-20 years, urban development in Santa Fe County will take place in areas immediately around the City of Santa Fe, which include important streams and wetlands. Ongoing groundwater diversion (i.e., extraction), potential encroachment of residential and infrastructure construction onto wetlands, and subsequent pollution and urban runoff threaten the wetlands that are in the path of the projected development. Simultaneously, projected climate change impacts, such as increasing losses of available surface- and groundwater due to evapotranspiration and reduced infiltration, are likely to lead to reduced aquifer discharge, ecosystem shifts, wild fire, and ongoing proliferation of invasive plant species. The increase of these wetland stressors will likely precipitate the loss of wetland functions and associated ecosystem services and values.

What is at Stake - Ecosystem functionality of wetlands is the basis for the natural benefits of these ecosystems to the community. The values people attribute to these ecosystem services are, in turn, the driving force behind the justification of funding and motivation to restore and protect wetlands. The main ecosystem functions at stake are biodiversity, habitat and shelter for many species of wildlife, the landscape-wide connectivity between riparian ecosystems, and the water quality of streams and wetlands. It is estimated that annually these values would represent millions of dollars in engineered solutions in the County to compensate for any additional losses of wetland functions.

Goals - This WAP-SFC specifically proposes that attention be given to the establishment of a regional water management authority, the development of County regulations, and the implementation of projects for the establishment of buffer zones for wetlands, storm water infiltration, stream and floodplain restoration (e.g., through beaver reintroduction). These measures should ideally be accompanied by the reduction of the County population's dependency on groundwater and by local regulations and actions to protect habitat and connectivity between wetland ecosystems. The WAP-SFC summarizes proposed actions in eight goals:

Goal 1: Complete the information base-line about wetlands for Santa Fe County.

Goal 2: Establish a monitoring program for data upkeep on status and trends of existing wetlands in Santa Fe County and share and disseminate findings.

Goal 3: Identify Santa Fe County as the pilot area to adopt statewide procedures and strengthen processes that protect wetlands through regulatory measures.

Goal 4: Support federal, state, tribal, and local government agencies in the enforcement of regulations and in offering comments during public review processes of proposed actions that potentially impact wetlands in Santa Fe County.

Goal 5: Achieve restoration and protection of high priority wetlands by 2020.

Goal 6: Further develop and support the institutional capacity for wetland restoration and protection in Santa Fe County.

Goal 7: Educate the public and develop public support, buy-in, and a donor base for wetland restoration, and develop wetland stewardship through an Adopt-a-Wetland program.

Goal 8: Develop water quality standards for wetlands with those in Santa Fe County as a case study for meeting this goal across the State of New Mexico.

Pragmatic Prioritization - The WAP-SFC proposes a pragmatic prioritization approach of wetland restoration and protection actions based on the extent to which stressors impact wetlands and on the feasibility at a given time of specific actions at specific locations or for specific institutions. The WAP-SFC offers a simple check list of prioritization criteria to guide the prioritization approach of on-the-ground initiatives. The WAP-SFC also includes a (not prioritized) list of suggested wetlands restoration and protection projects.

The WAP-SFC focuses principally on the period of 2013-2020. Since the WAP-SFC anticipates urban development and climate effects and responses that stretch several decades from the present time, some proposed actions will extend beyond 2020. The WAP-SFC is a living document and should be updated when the need arises.

1. Introduction

This Wetlands Action Plan for Santa Fe County (WAP-SFC or WAP) has been developed as part of the project "Comprehensive Wetland Restoration and Protection in Santa Fe County", conducted by the New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB) under a Wetland Program Development Grant from the U.S. Environmental Protection Agency (EPA) - Region 6.

To date, wetlands in Santa Fe County have been poorly studied. This WAP-SFC follows one that was written for the Galisteo Watershed (in central-south Santa Fe County) in 2010 (SWQB 2010a). This WAP-SFC is timely and probably long overdue in responding to concerns from local natural resource professionals and residents that wetland and riparian resources have dwindled over the last century or more as a result of population growth, urban development, water diversion, and shifts in landscape ecology and climate. In order to provide a framework for planning, to identify data gaps, and to lay a basis for public education and future stewardship actions, it is essential to begin documenting the status of wetlands and riparian areas in Santa Fe County.

Several County, State, and Federal initiatives are underway that offer timely support to the restoration and protection of wetlands in Santa Fe County. These initiatives may benefit from comprehensive plan support through a WAP for Santa Fe County, and the WAP may also direct and inform any future programs leveraged by these ongoing initiatives. Taken together these initiatives may assist Santa Fe County, the City of Santa Fe, state and federal agencies, NGOs, local contractors, and the public to take action and collaborate on the protection and restoration of wetlands in Santa Fe County.

In 2010, Santa Fe County completed a Water Conservation Plan and a Sustainable Growth Management Plan (SGMP). Based on the SGMP, currently (2012) Santa Fe County is in the process of completing its Sustainable Land Development Code (SLDC). In combination with this WAP-SFC, the County is in a unique position to set the stage for developing staff capacity and regulations which may assist in future wetland protection and restoration.

Additionally, the SWQB Wetlands Program is implementing a comprehensive strategy for the assessment and future monitoring of wetland resources in New Mexico, which will provide information about the location, type, condition, and status of wetland resources. Future SWQB plans are to complete wetland mapping and wetland classification and assessments of wetland conditions in Santa Fe County.

Meanwhile, the City of Santa Fe is making progress with infrastructure and research to help conserve groundwater resources, which may protect discharge to groundwater supported wetlands and springs. A new BLM Resource Management Plan and a recent award of a North American Wetlands Conservation Act (NAWCA) grant to the New Mexico Wildlife Federation and a coalition of partners for waterfowl and wetland protection along the Rio Grande may also offer increased wetland protection opportunities in Santa Fe County.

1.1. Santa Fe County Geography

Santa Fe County is located at 35°37'N 106°5'W, in north-central New Mexico at the southwestern tip of the Sangre de Cristo Mountains, which constitutes the southernmost range of the Rocky Mountains (see Figure 1.1). Neighboring counties include Bernalillo, Sandoval, Los Alamos, Rio Arriba, Torrance, and San Miguel County. The major road systems within Santa Fe County are I-25 (predominantly east-west), US 285/64 (north-south), and I-40 at the southern tip of the county (running east-west). The City of Santa Fe, the capitol of New Mexico, is the largest municipality in the county. The Rio Grande is the geographic boundary to the northwest corner of the county. The Sangre de Cristo Mountains and Glorieta and Rowe Mesa form the eastern boundary (Santa Fe County 2010a).

Santa Fe County has a total area of 1,911 square miles (http://quickfacts.census.gov/....html), or 1,223,040 acres. Approximately 1,909 square miles of it (99.92%) consists of land and 2 square miles of it (0.08%) consists of water. Santa Fe County is the 3rd most populous county in New Mexico, after Bernalillo and Doña Ana. The county includes the City of Santa Fe, portions of the City of Española and the Town of Edgewood. According to U.S. Census data for 2010, the population was 144,170 (http://quickfacts.census.gov/qfd/states/35/35049.html), down from 147,741 in 2008 (U.S. Census 2008 in Santa Fe County 2010a).

Based on projections by the Bureau of Business and Economic Research from the period before the economic downturn that started in 2008, the 2010 Santa Fe County Sustainable Growth Management Plan (SGMP) projected the county population to grow to 176,514 by 2020 and to 200,876 by 2030 (Santa Fe County 2010b). The SGMP projected the most significant growth to occur in the planning area El Centro in and around Santa Fe and especially in the unincorporated parts of Santa Fe County. According to historical population trends the population density increased from less than 7 persons per square mile in 1900 to 77 persons per square mile in 2008 (Santa Fe County 2010a). The highest population density is in the City of Santa Fe.

The topography in the County ranges from the alpine mountain peak of Santa Fe Baldy at 12,622 feet (http://en.wikipedia.org/wiki/Santa_Fe_County,_New_Mexico) to the river bottoms of Galisteo Creek at I-25 and of the Rio Grande at the boundary with Sandoval County, just east of Bandelier National Monument, both at approximately 5,300 feet (BLM 1994). Located in the northeastern part of the County, the Sangre de Cristo Mountain range creates a predominant aspect of western, southwestern, and south-facing slopes, which drain to the Rio Grande. The Rio Grande runs in southwesterly direction across the far northwestern part of Santa Fe County.

The slopes of the Sangre de Cristo Mountains are subdivided in a series of watersheds, which from north to south include the Santa Cruz/Cundiyo, Nambe/Pojoaque/Tesuque, Santa Fe River, Galisteo Creek, and the northwestern corner of the Pecos watersheds. South of the Galisteo Creek Watershed in Santa Fe County is the closed basin of the Estancia watershed. On the far northwestern side of the County are west-facing slopes of the Caja del Rio area that drain to the Rio Grande. Across the Rio Grande are the southeast-facing slopes of the Jemez Mountains, which are dissected in several narrow canyon-shaped watersheds and which originate in Los Alamos County and Sandoval County to the west (see Figure 1.2).

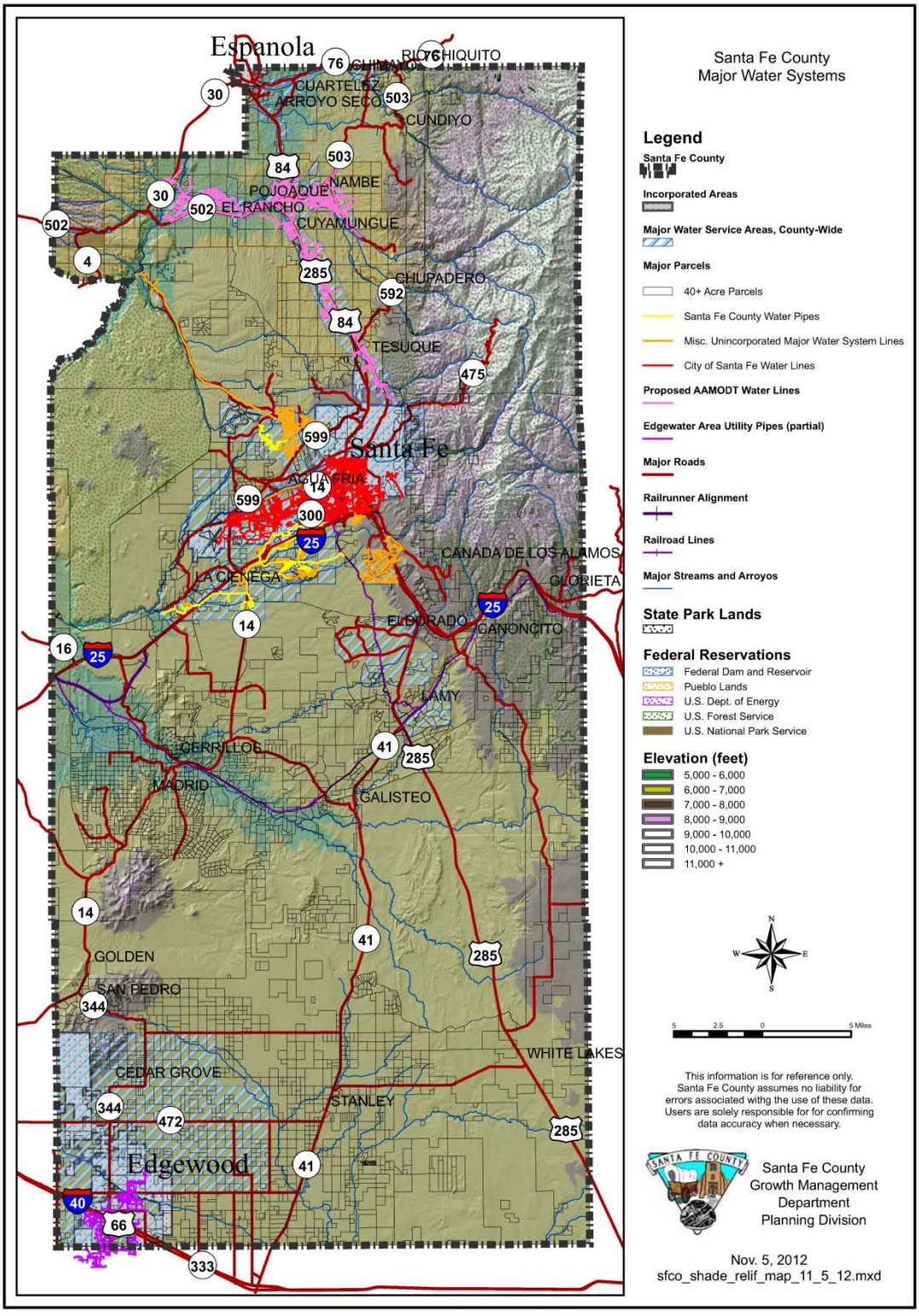


Figure 1.1. Location map of Santa Fe County with ownership and infrastructure details.

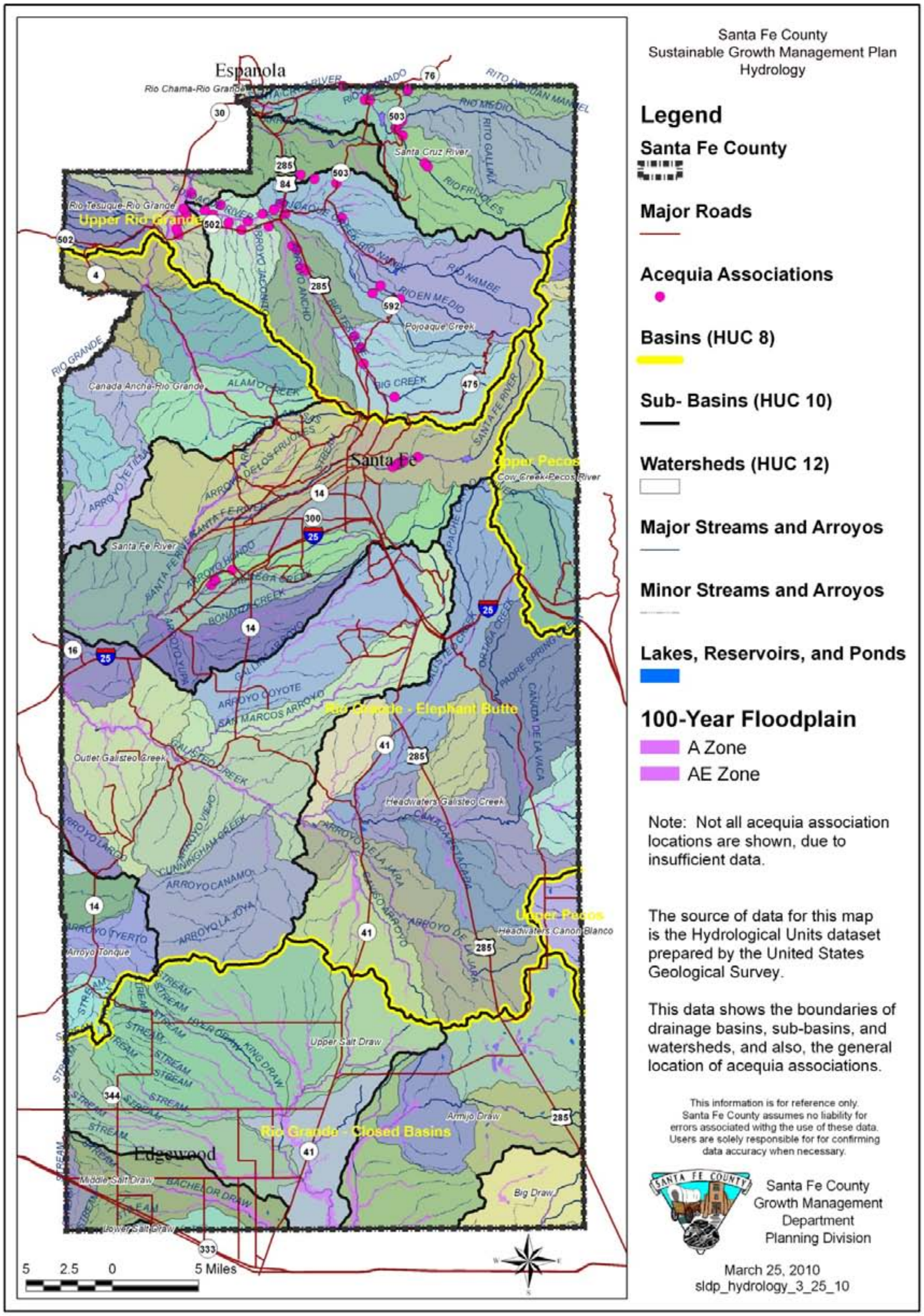


Figure 1.2. Map of basins, watersheds, flood zones, and water bodies in Santa Fe County.

An overview of landscape characteristics of Santa Fe County, including details on a-biotic, biotic, and wetland resources, and details on land use history, is included in Appendix A.

1.2. Purpose and Need

1.2.1. Purpose

This WAP-SFC has been developed to provide guidance to future action initiatives for the protection and restoration of wetlands in Santa Fe County. To this end, the WAP-SFC aims to compile and record the available relevant information, analysis, and ideas, to stimulate dialogue, coordination, and collaboration, and provide recommendations for future wetland protection and restoration initiatives. This WAP-SFC emphasizes the protection and restoration of wetland functions that provide water quality benefits and ecological integrity.

The WAP-SFC intends to inform and mobilize land and water management staff and decision makers of local and tribal government entities, State and Federal agencies, and Non-Governmental Organizations (NGOs), as well as community partnerships and multi-party conservation initiatives that are involved in the preservation, conservation and restoration of wetlands in Santa Fe County. The plan may serve as a model for other watersheds and communities.

In response to the 2010 Santa Fe County Sustainable Growth Management Plan (SGMP) (Santa Fe County 2010b), the WAP-SFC emphasizes and builds on the following selection of principles identified in the first chapter of the SGMP:

- Use studies, reports and assessments to provide a solid basis for development review decisions.
- Utilize and enhance GIS data for environmental suitability to include, wildlife habitat, and archaeology reviews to enhance County decision making.
- Protect important open spaces and range areas that include archaeological and cultural resources by limiting growth and development in environmentally sensitive areas.
- Conserve and protect our water sources by reducing reliance on groundwater consumption.
- Avoid and mitigate pollution from storm water run-off, industrial contaminants and malfunctioning septic systems.
- Prevent further fragmentation of natural areas, eco-systems and eco-regions.
- Identify and protect important wildlife habitats, wildlife corridors and migratory routes, natural resources and ecosystems.
- Enhance gateways and corridors.
- Protect natural and environmental resources and encourage restoration activities.
- Support programs that restore waterways and riparian areas.
- Prepare for potential climate and environmental changes.
- Prepare for economic and environmental impacts of climate change.
- Develop regional partnerships and resources.

1.2.2. Need

The need for this document originates from observations by various resources cited below that wetland acreage and wetland functions in Santa Fe County have been in decline for many years, and that their preservation is important for the long-term wellbeing of the communities in Santa Fe County due to the natural benefits that wetlands offer.

A 1997 USGS summary description of wetlands in New Mexico (Jones 1997) references research of around 1990 by the U.S. Fish & Wildlife Service (Dahl 1990) which estimated that between 1780 and 1980 wetland acreage in New Mexico had decreased by 33% from about 720,000 acres to about 482,000 acres, which constitutes 0.6% of the land area in the State. It is likely that since 1980 the hydrological and ecological conditions of riparian areas, springs and wetlands across the State, and likewise in Santa Fe County, have further degraded despite increases in national protective statutes and regulations and local improvements in land use practices and wetland stewardship.

Many factors are at play in the historical decrease of acreage and functioning conditions of wetlands and riparian areas in Santa Fe County. As one of the first impacts, beaver trapping in the 1700s led by 1830 to the extermination of beaver in the Southern Sangre de Cristo Mountains (DeBuys 1985). As a result, many headwater streams lost their beaver-supported wetlands. Rapid degradation of mountain streams led to the undermining of wet meadows and wetlands in the mountains. Downstream, beavers also disappeared and stream and wetland conditions degraded. In the early 20th century, reservoir construction and agricultural water diversion further impacted stream flow regimes, which led to the loss of native vegetation along streams and the proliferation of non-native vegetation (Howe and Knopf 1991). In the rural parts of the County, wetlands also dwindled due to wetland conversion to cropland, dewatering, diversion of water for irrigation, and poorly managed livestock grazing practices. Additionally, in the urban areas of Santa Fe and Española, urbanization and infrastructure development led to the encroachment of residential and commercial construction and dewatering for municipal and industrial water supply, along with channelization of water courses and possibly contamination from inadequately treated sewage and industrial waste water. Finally, sediment and other pollutants and direct encroachment caused by resource extraction, such as timber harvesting operations, sand and gravel quarrying, and hard rock mining–leading to acidic and alkaline runoff–have seriously affected wetlands across Santa Fe County and across New Mexico (Windell et al. 1986, Jones 1997).

Field observations during the project "Comprehensive Wetland Restoration and Protection in Santa Fe County" have shown that wetlands in Santa Fe County continue to be threatened by degrading forces varying from the impacts of development, impoundment, groundwater extraction, hydro-modification of the Santa Fe River and its tributaries, and ecological degradation from cumulative, historical causes. Past land use and ongoing urban development continue to contribute to increasing variability with accelerated storm water runoff and increasing peak flows as well as increasing intervals of no flow in many streams in Santa Fe County (Grant and Shoaff 2007, Cadmus 2011). As an example of peak flow increases in Santa Fe County drainages, Appendix B shows a table of peak flow data for 1951, 2007, and undated

future conditions in the Santa Fe River downstream from Msgr. Patrick Smith Park, as calculated by The Cadmus Group, Inc. for the U.S. Army Corps of Engineers (Cadmus 2011).

The project's field observations also revealed that many lower order stream tributaries in Santa Fe County start as headcuts and have carved deep gullies that dewater the landscape (Vrooman 2006). Riparian floodplain zones have been invaded with exotic plants, such as Russian olive, saltcedar, and Siberian elm (Milford et al. 2009). In places such as the Tesuque River valley, the Santa Fe Watershed, and the Galisteo Basin, originally moist flood plains, productive alluvial fans, springs, wetlands, and wet meadows have dried up and made place for degraded, dry sediment flats, and in some places for (ex)urban development.

In sum, planning for the restoration and protection of wetlands and riparian areas, river corridors, springs and seeps in Santa Fe County is critical (1) to reverse gradual degradation and loss of wetland ecosystems and their important landscape functions; (2) to address the impacts of gradual fragmentation of landscapes resulting from (ex)urban development, oil, gas and mineral extraction, and construction of transportation lines; and (3) to guide future development activities that minimize encroachments, impacts and losses of water resources and wildlife habitat throughout the County.

1.3. Wetlands Action Plan Partners and Planning Process

This WAP-SFC was developed as part of the unique and innovative, multi-jurisdictional project "Comprehensive Wetland Restoration and Protection in Santa Fe County", conducted by the SWQB under a Wetland Program Development Grant with the U.S. EPA - Region 6. Conceived during the completion of a pilot wetland assessment and planning project in the Galisteo Basin–the largest watershed in Santa Fe County–the project was initiated in 2007, and is scheduled for completion in early 2013. Besides the State of New Mexico, principal project partners included:

- Santa Fe County (various departments and divisions - local government partner)
- Earth Works Institute (a local non-profit environmental stewardship organization; main project contactor until December 31, 2011)
- Ecotone (a local small business; substitute main contractor after the dissolution of Earth Works Institute, since January 2012)

Cooperating entities included:

- City of Santa Fe (Sangre de Cristo Water Division)
- New Mexico Office of the State Engineer
- New Mexico Bureau of Geology and Mineral Resources
- New Mexico Energy, Mineral & Natural Resources Department (Parks Division)
- New Mexico Department of Transportation
- U.S. Fish & Wildlife Service

Additional civic and community partners, cooperators, and contractors included:

- La Cienega Valley Association
- Galisteo Watershed Partnership
- San Marcos Association
- Cerrillos Water Association
- Landowners and residents of Cañada de los Alamos, Arroyo Hondo, La Cienega, La Cieneguilla, San Marcos District, and Cerrillos
- Santo Domingo Tribal Utilities Department/Ecology Division
- University of New Mexico – Community & Regional Planning Program
- Keystone Restoration Ecology
- Rangeland Hands, Inc.
- Riverbend Engineering
- River Source
- WildEarth Guardians

The WAP-SFC has been compiled and authored by Jan-Willem Jansens (project initiator, former Executive Director of Earth Works Institute, and ecological planning consultant, DBA Ecotone), and has been modeled after the 2010 WAP for the Galisteo Watershed (SWQB 2010a). Data and observations for the WAP-SFC were collected largely from project activities between 2007 and 2012. Nothing in this WAP-SFC has received the explicit endorsement or support from the project partners listed above, and the author assumes responsibility of all content of this WAP-SFC.

The WAP-SFC includes descriptive landscape background information in Appendix A, and overview information for three major planning components:

- A (Wetland) Resource Analysis (Section 2)
- Current Status of Wetland and Riparian Resource Management (Section 3)
- Wetland Action Planning (Section 4)

These three planning components help wetland/watershed planning and restoration professionals adequately address wetland management issues. Not all information is presently available and this WAP-SFC aims to fill some of the information gaps. The development and refinement of the WAP-SFC will be an ongoing process. This WAP-SFC is a living document and should be updated when the need arises.

Where possible and appropriate, the WAP-SFC references the 2002 Watershed Restoration Action Strategy (WRAS) for the Santa Fe Watershed and the 2005 WRAS for the Galisteo Watershed. When appropriate the WAP-SFC could serve as a reference document or as an appendix in any future updated versions of these two WRAS documents (presently often referred to as Watershed-based Plans).

2. Resource Analysis

2.1. Definitions

The State of New Mexico defines **"Wetlands"** as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support–and that under normal circumstances do support–a prevalence of vegetation typically adapted for life in saturated soil conditions (NMAC 20.6.4) (SWQB 2012b). In more general terms, a wetland is the interface, or transitional zone, between dry, upland ecosystems and aquatic ecosystems, such as rivers or lakes. Wetlands are also found in isolated locations, away from other bodies of surface water (SWQB 2012b). For assessment and management purposes, the NMED Surface Water Quality Bureau Wetlands Program uses the following expanded definition:

Wetlands – Wetlands are aquatic systems with physical, chemical and biological attributes that are transitional between terrestrial (or upland) and deeper water aquatic systems. In wetland ecosystems, the water table is usually at or near the surface, or the land is covered by shallow water. Wetlands have one or more of the following attributes: (1) at least periodically, the land supports hydrophytes (plants dependent on saturated soils or a water medium); (2) the substrate is predominantly hydric soil or contains hydric soil indicators and/or redoxymorphic features that indicate saturation periodically; and (3) the substrate is non-soil such as bedrock or boulders, and is saturated with water or covered by shallow water at some time during the growing season. Because of the climatic variability of New Mexico which sometimes includes long periods of drought that dry up even the most persistent water sources, wetlands are not expected to be saturated each year. The upland limit of a wetland is where soil and vegetation is not influenced by shallow water or a water table near the surface, displays predominantly mesophytic or xerophytic plant cover that cannot tolerate saturated soil conditions, soil that is non-hydric and land that is not saturated some time during the growing season. The lower boundary between wetlands and deeper water habitat associated with riverine and lacustrine systems lies at 2 meters (6.6 feet) below low water, or the maximum depth at which emergent plants normally grow (SWQB 2010a, SWQB 2012b).

Riparian Areas – Riparian areas are intrinsically connected to and interdependent on the water sources and hydrologic regimes that also support wetlands. Riparian areas include entire floodplains able to support vegetation dependent on runoff and overbank flow, scour, sedimentation, infiltration and shallow groundwater. They include areas considered as somewhat drier portions of a wetland ecosystem and are characterized by phreatophytic and mesophytic vegetation and habitats also associated with flowing or stationary bodies of water. They are dependent on existence of perennial, intermittent or ephemeral surface water and/or hyporheic zones. Riparian areas occupy the same areas of the landscape as wetlands, may contribute to the same functions within the landscape, and are interdependent, and, therefore, are considered together as part of a wetlands ecosystem and constituting a wetlands assessment (SWQB 2010a, SWQB 2012b).

Buffers – Buffers are non-disturbance or minimally disturbed areas surrounding a wetland and/or riparian area where natural vegetation is maintained to protect wetlands and riparian areas from the impacts of stormwater floods, a variety of pollutants, and solid waste from adjacent

terrain (Kusler et al. 2003). Buffers provide the functions and services associated with contiguous natural habitat adjacent to wetlands and riparian areas. Land cover elements which are considered acceptable buffer include natural uplands (forests, grasslands, shrublands), grassy swales, nature or wildland parks, unmaintained old fields, and rangeland in good condition. These buffer elements are expected not to disrupt ecosystem connectivity, provide habitat connectivity, and provide protective services such as preventing erosion, reducing pollutant contamination and preventing encroachment of undesirable landscape elements and activities that affect wetland resources. Wetland assessments include assessment of the condition and extent of buffer areas (SWQB 2012b).

For purposes of long-term protection of wetlands, wetland assessments and Wetlands Action Plans must identify wetland buffer zones. Local government interests in wetland buffer lands often include concern for management of stormwater, avoidance of hazards from flooding, protection of water supplies, and protection of property from future hazards that may be associated with climate change (Environmental Law Institute 2008).

Wetlands form part of the natural system of land and water that helps to make human communities livable. In combination with riparian areas and buffer zones, wetland ecosystems have beneficial functions such as flood control, water storage, ground water recharge, and water purification. They also offer habitat for wildlife and recreational opportunities for humans. Attention to these functions (or "ecosystem services") is essential to governance of the community's land use, public health, safety, and welfare (Environmental Law Institute 2008).

2.2. Santa Fe County Wetlands

Wetlands in Santa Fe County have been poorly studied and documented. Some studies offer local or partial assessments, such as those for the Galisteo Watershed (Vrooman 2006, Milford 2009) and for parts of the Santa Fe Watershed (McGraw and Jansens 2012, Santa Fe Watershed Association 2012). Table 2.1 offers an overview of known wetlands in Santa Fe County for each watershed area. Note that Table 2.1 is only a partial list which could serve as a start for further identification of wetlands throughout Santa Fe County in the future. Figure 1.2 provides a map of Santa Fe County with water features. More information about Santa Fe County's landscape characteristics in included in Appendix A.

Based on estimates by Mitsch and Gosselink (2000b), we may expect watersheds to include wetlands across 3%-7% of their area. In dryland regions such as Santa Fe County, the proportion of wetland area is probably at the lower end of, or below, this range. Wetlands in Santa Fe County are scattered and most wetlands seem to be in functional decline. Later in this chapter, an examination of wetland functions, values, and relative vulnerability will help us identify priorities for wetland protection and restoration, which form the basis of the action plan component in Chapter 4 of this WAP.

Table 2.1. Listing of known springs, wetlands, and wetland areas for each watershed in Santa Fe County with details on wetland ownership, wetland area, wetland type (after Brinson 1993), and geo-coordinates (for select underlined wetland sites only).

WATERSHED AREA	KNOWN WETLANDS	WETLAND OWNERSHIP AND STATUS	APPROX. WETLAND AREA	TYPE OF WET-LAND	WETLAND GEO-COORDINATES & ELEVATION
Rio Cundiyo-Rio Santa Cruz watershed	El Potrero wetland, isolated headwaters wetlands, and springs of Rio Frijoles	SF County Open Space USFS	1-2 acres N/A	Riverine + Slope Slope	35°59'24.31"N, 105°55'47.33"W, 6140 ft
Pojoaque-Tesuque-Nambe watershed	Big Tesuque Creek – spring and wetland Springs and wetland areas along Rio Tesuque (downstream past Pueblo)	FWS/Forest Trust preserve Tesuque Pueblo	<1 acre TBD	Slope Slope + Riverine	35°44'21.39"N, 105°54'01.60"W, 7190 ft 35°48'54.30"N, 105°58'46.99W, 6301 ft
Rio Grande: Black Mesa to Buckman	Rio Grande TBD	San Ildefonso Pueblo, BLM, USFS	TBD	Slope	35°50'53.14"N, 106°09'21.82"W, 5486 ft
Canada Ancha watershed	Spring at Caja del Rio Canyon	USFS/BLM	TBD	Slope	35°48'24.03"N, 106°08'47.15"W, 5795 ft
Rio Grande tributaries of Caja del Rio	Springs	USFS	TBD	Slope	35°48'31.33"N, 106°10'48.60"W, 5435 ft
Santa Fe River watershed	Santa Fe River Twomile reservoir wetlands at TNC site SF River wetlands below WWTP Arroyo Hondo wetland at dam Cienega Creek, Alamo Creek, Guicu Creek, Bonanza Creek	TNC SF County SF County Private	1-2 acres TBD 4-5 acres TBD	Riverine Riverine Riverine + Slope Riverine + Slope	35°41'18.46"N, 105°53'33.32"W, 7354 ft 35°37'23.39"N, 106°06'10.91"W, 6228 ft 35°37'11.45"N, 105°55'23.63"W, 7120 ft 35°34'32.17"N, 106°05'55.32"W, 6087 ft
Galisteo Creek watershed	Wetlands in Valencia Deer Creek Apache Canyon Apache Ridge wetlands Cañoncito wetlands	USFS, Private USFS, Private Private ECIA ECIA	<1 acre <1 acre >10 acres <1 acre 1-2 acres	Slope Slope Slope + Riverine Slope Slope + Riverine	35°34'09.28"N, 105°47'59.30"W, 7169 ft 35°33'18.57"N, 105°49'43.41"W, 6988 ft 35°31'50.65"N, 105°50'41.84"W, 6829 ft

WATERSHED AREA	KNOWN WETLANDS	WETLAND OWNERSHIP AND STATUS	APPROX. WETLAND AREA	TYPE OF WET-LAND	WETLAND GEO-COORDINATES & ELEVATION
Galisteo Creek watershed (cont.)	Galisteo Creek	Private	>50 acres	Riverine	
	San Cristobal playa	Private	1-2 acres	Depressio-nal	35°22'37.55"N, 105°56'15.54"W, 6028 ft
	Galisteo Springs and other GBP wetlands	Private, SLO	1-2 acres	Slope + Riverine	35°27'45.88"N, 105°57'36.12"W, 6344 ft
	Glorieta Mesa springs & wetlands: Padre Springs, Arr. Salado	Private	1-2 acres	Slope + Riverine	35°31'53.02"N, 105°43'35.00"W, 7652 ft
	San Cristobal Arroyo	Private	<1 acre	Riverine	
	Arroyo de la Jara	Private	1-2 acres	Riverine	
	Finger Lakes	Private	<1 acre	Slope	
	Coyote Springs	Private	<1 acre	Slope	
	Cañada de los Alamos	Private	<10 acres	Slope + Riverine	
	San Marcos Arroyo, Gallina Arroyo and Hwy 14 springs	Private, State of NM Private	<10 acres 1-2 acres	Slope + Riverine Slope	35°27'33.84"N, 106°04'17.04"W, 6006 ft
	Cerrillos Hills springs	SF County	<1 acre	Slope	35°27'03.51"N,
	Galisteo Reservoir	US ACE	TBD	Slope	106°07'27.73"W,
	Mailbox Rd Arroyo	Private	<1 acre	Slope	5905 ft
Upper Pecos River watershed	Doctor Creek, Indian Creek, Macho Canyon, Dalton Canyon, Alamitos Canyon, La Cueva Canyon, Hagen Creek, Glorieta Creek	All USFS USFS and private	TBD	Slope	35°46'57.04"N, 105°45'00.71"W, 10793 ft 35°37'03.32"N, 105°44'13.41"W, 7605 ft
Arroyo Tonque watershed (San Pedro Creek)	Arroyo Tonque, Cañon del Agua, Arr. Cuchillo, Tuerto, Valverde	All private (and some BLM)	TBD	Slope	35°16'50.93"N, 106°12'55.63"W, 6471 ft
Estancia Basin	Big Lake (playa)	Private	TBD	Depressio-nal	35°10'42.52"N,
	White Lakes (playas)	Private	TBD		105°47'56.94"W, 6811 ft

2.3. Classification of Local Wetland Types

Wetlands can exhibit great variability in terms of their structural characteristics and processes (Mitsch and Gosselink 2007). The objective of classification is to identify groups of wetland types that are relatively homogeneous in structure, process, and function (Smith et al. 1995).

The SWQB Wetlands Program uses Brinson's Hydrogeomorphic (HGM) wetland classification (Brinson 1993) for the Wetlands Action Plan process. The HGM classification is based on three

fundamental factors that influence how wetlands function: geomorphic setting, water source, and hydrodynamics. At the highest level of hydrogeomorphic classification, wetlands are grouped into hydrogeomorphic wetland classes. Six hydrogeomorphic classes (depressional, lacustrine fringe, slope, riverine, mineral flat, and organic flat) occur in New Mexico (SWQB 2010a). Based on current inventory knowledge, at least four classes are represented in Santa Fe County.

- **Depressional wetlands** occur in topographic depressions that allow accumulation of surface water (e.g., the San Cristobal Playa, Big Lake, and the White Lakes). On a topographic map these wetlands would occur within a closed elevation contour. Dominant sources of water are precipitation, groundwater discharge, and inflow from adjacent uplands (see Figure 2.1).

Figure 2.1. A Depressional Wetland: San Cristobal Playa (a.k.a. Galisteo Rodeo Playa) south of the Village of Galisteo (Photograph by Maryann McGraw, 2010).

- **Lacustrine fringe wetlands** are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. Significant natural lakes in Santa Fe County include high mountain lakes such as Lake Katherine, Nambe Lake, and Santa Fe Lake. Several man-made reservoirs, such as Nambe Reservoir, Twomile Reservoir, and Galisteo Reservoir support lacustrine fringe wetlands (see Figure 2.2).

Figure 2.2. A Lacustrine Fringe Wetland: Nambe Lake, below Lake Peak in the Sangre de Cristo Mountains.

- **Slope wetlands** normally are found where there is discharge of groundwater to the land surface. They normally occur on sloping land; elevation gradients may range from steep hillsides to slight slopes. Hydrodynamics are dominated by down-slope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Headwater wetlands and cienegas are examples of slope wetlands. Flowing seeps and springs that support wetland vegetation are also included in this broad class of wetlands. In Santa Fe County, such wetlands are found in the Sangre de Cristo Mountain headwaters of many streams, on Glorieta Mesa, in La Cienega, and as springs in many hills and low mountains, such as the Cerrillos Hills (see Figure 2.3).

- **Riverine wetlands** occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. Perennial flow is not required. There are numerous examples of riverine wetlands along the Rio Grande, Santa Fe River, Galisteo Creek, and Tesuque Creek (see Figure 2.4).

Figure 2.3. A Slope Wetland: The Bonanza Creek wetlands are part of a large system of slope wetlands in the La Cienega Area caused by groundwater discharge in springs and seeps (Photograph by Maryann McGraw, 2012).

Figure 2.4. A Riverine Wetland: The Galisteo Creek south of the Village of Galisteo.

Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large floodplain terraces where the main source of water is precipitation. Organic soil flats differ from mineral soil flats, in part, because their elevation and topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation. Neither mineral soil flats nor organic soil flats have been recognized in Santa Fe County.

In addition, there are examples throughout Santa Fe County of human-made wetlands (Figures 2.5 and 2.6). In some areas, these artificial wetlands replace, impair or compromise the natural hydrologic regime and associated water and wetland resources. Although these wetlands are the result of anthropogenic activities, such as water pumping, impoundment and diversions, they still provide some valuable ecological services in an overall arid environment. Examples include wetlands developed or expanded at golf courses and those developed or expanded as a result of dams, levees, sumps and irrigation ditches (acequias), cattle tanks, and mill sites (e.g. Santa Cruz Lake, Nambe Reservoir, Twomile Reservoir, Arroyo Hondo Reservoir, Finger Lakes, and Galisteo Dam/Reservoir) (SWQB 2010a).

Figure 2.5. An Artificial Wetland (Left): The Galisteo Dam Reservoir includes several wetland patches.
Figure 2.6. An Artificial Wetland (Right): The Arroyo Hondo Reservoir supports a wetland area with significant biodiversity.

2.4. Wetland Functions

As described in the WAP for the Galisteo Watershed (SWBQ 2010a), "scientific investigations have shown that wetlands unquestionably perform important environmental functions (Mitsch and Gosselink 2007) and that different types of wetlands perform different functions or the same functions to various degrees (Johnson 2005). Wetland functions are defined as a process or processes that take place in a wetland (Novitski et al. 1993). Wetland ecosystem functions are processes that are necessary for the self-maintenance of a (wetland) ecosystem. In a wetland, these functions maintain and sustain the wetland and are essential to the existence of the wetland. Examples of wetland ecosystem functions are primary production, nutrient cycling, and decomposition (Kleindl 2005)."

Wetland (ecosystem) functions also influence adjacent ecosystems. For example, riverine wetlands can modify flooding along a river's course, or nitrogen, sulfur, methane, and carbon cycles in wetlands can affect air quality. Wetlands can also exhibit variability because of climatic conditions, species composition, soil type, biogeochemistry, and other factors. However, regardless of how they are defined, wetlands within a class (or type) share most common functions.

In 2006, the "Planning for Wetlands in the Galisteo Watershed" Steering Committee conducted a review of wetland functions common to classes of wetlands in the Galisteo Watershed. Of the many functions that wetlands provide, the wetland functions determined by the committee to be the most important in the Galisteo Watershed (SWQB 2010a) can readily be assumed to apply also across entire Santa Fe County. They are the following**:**

Hydrologic Functions:

1. Maintenance of Runoff Volume
2. Energy Dissipation
3. Groundwater Recharge

Water Quality and Biogeochemistry Functions:

4. Sediment Retention
5. Phosphorus Retention
6. Nitrogen Removal
7. Heavy Metals and Hydrocarbon Removal
8. Carbon Cycling and Sequestration

Biological Functions:

9. Vascular Plant Production
10. Macro-invertebrate and Fish Production
11. Wildlife Habitat
12. Waterfowl Habitat
13. Biodiversity

2.5. Wetland Values and Ecosystem Services

2.5.1. Linking Wetland Functions to Ecosystem Services

Wetlands and wetland functions are of value to people and society. Each wetland function and/or the aggregate of functions can constitute specific values for humans, because wetland ecosystem functions deliver a wide range of valuable ecosystem services that contribute to human well-being. Linking ecosystem condition and function to services and human well-being, predicting the effects of changes in ecosystem services on human well-being, and improving the identification, quantification, and communication related to functions and ecosystem services was the goal of the Steering Committee review for the Galisteo WAP. The SWQB strives to identify similar linkages in relation to wetlands in Santa Fe County in coming years. This WAP-SFC assists in offering a first step toward this goal.

It was beyond the scope of the project "Comprehensive Wetland Restoration and Protection in Santa Fe County" to conduct an assessment of wetland ecosystem conditions or a detailed assessment of ecosystem functions for each wetland area identified in Santa Fe County. However, SWQB anticipates conducting an assessment of wetland ecosystem conditions in Santa Fe County in the future.

The project team observed and in some cases documented wetland conditions and functions for a select number of wetlands that were chosen for pilot restoration and protection projects. These projects included wetland sites at:

- Cañada de los Alamos (private property along Madre de Dios) (Acreage: approx. 6 acres; Geo-coordinates: 35º34'45.37" N and -105º51'27.18" W)
- Arroyo Hondo (Santa Fe County Open Space above dam along Arroyo Hondo Road) (Acreage: approx. 5 acres; Geo-coordinates: 35º37'11.45" N and -105º55'23.63" W)
- Arroyo los Carrizales (Santa Fe County Open Space along Los Pinos Road and Paseo Real in La Cienega) (Acreage: approx. 1 acre; Geo-coordinates: 35º34'34.51" N and -106º06'53.60" W)
- San Marcos Arroyo (private property immediately west of State Highway 14) (Acreage: approx. 4 acres; Geo-coordinates: 35º27'33.84" N and -106º04'17.04" W)
- Escalante Arroyo (Santa Fe County Open Space in Cerrillos Hills State Park) (Acreage: <1 acre; Geo-coordinates: 35º27'03.51" N and -106º07'27.73" W)

Field assessments at each of the five listed wetlands generated a deeper insight in the ecological functions these wetlands provide and how these functions offer natural benefits to people. These benefits of nature, or ecosystem services, are listed in Table 2.2 for each of the studied wetlands along with three different categories of wetland functions.

Table 2.2. Wetland Functions and Ecosystem Services Observed or Suspected for Selected Wetlands.

Wetland Site (and Type)	Hydrologic Wetland Functions	Water Quality & Bio-Chemistry Functions	Biological Functions	Ecosystem Services Performed and Impact on Human Wellbeing
Cañada de los Alamos (slope and riverine)	Runoff volume and energy buffered; Ground water recharged	Sediment retention; Carbon cycling & sequestration	Vascular plant production; Wildlife habitat; Biodiversity	Groundwater for down-stream well owners; Erosion control; (Micro)Climate control; Human enjoyment
Arroyo Hondo (riverine)	Runoff volume and energy buffered; Ground water recharged	Sediment retention; Carbon cycling & sequestration	Vascular plant production; Wildlife habitat; Biodiversity	Groundwater for down-stream well owners; Erosion control; (Micro)Climate control; Human enjoyment; Public education
Arroyo los Carrizales (slope and riverine)	Runoff volume and energy buffered; Ground water recharged	Some sediment retention; Carbon cycling & sequestration	Vascular plant production; Wildlife habitat; Biodiversity	(Ground)water for down-stream well and acequia owners; Erosion control; (Micro)Climate control; Human enjoyment

Wetland Site (and Type)	Hydrologic Wetland Functions	Water Quality & Bio-Chemistry Functions	Biological Functions	Ecosystem Services Performed and Impact on Human Wellbeing
San Marcos Arroyo (slope and riverine)	Runoff volume and energy buffered; ground water recharged	Sediment retention; Carbon cycling & sequestration	Vascular plant production; Wildlife habitat; Biodiversity	Groundwater for down-stream well owners; Erosion control; (Micro)Climate control; Human enjoyment; Public education
Escalante Arroyo (slope)	Runoff volume and energy buffered	Some sediment retention; Carbon cycling & sequestration	Vascular plant production; Wildlife habitat; Biodiversity	Erosion control; (Micro)Climate control; Human enjoyment; Public education

2.5.2. Wetland Ecosystem Services and Values

Mitsch and Gosselink (2000b) argue that wetlands "have value because many of their functions have proved to be useful to humans." In earlier publications Mitsch and Gosselink (1993 and 2000a) wrote that "the reasons that wetlands are often legally protected have to do with their value to society, not with the abstruse ecological processes that occur in wetlands… Perceived values arise out of the functional ecological processes… but are also determined by human perceptions, the location of a particular wetland, the human population pressures on it, and the extent of the resource."

However, placing a monetary value on wetlands as a function of the services they provide is a challenging and controversial task, and economists have often been criticized for trying to put a "price tag" on nature (http://www.ecosystemvaluation.org/essentials.htm). Many of these goods and services are traditionally viewed as free benefits to society, or "public goods" - wildlife habitat and diversity, watershed services, carbon storage, and scenic landscapes, for example. Lacking a formal market, these natural assets are traditionally absent from society's balance sheet; their critical contributions are often overlooked in public, corporate, and individual decision-making. As a result, both in Santa Fe County and in the United States, resource challenges associated with globalization and urbanization and the impacts of climate change, pollution, over-exploitation, and land use on ecosystem loss and/or on the degradation of wetland functions and their values, are poorly translated into monetary losses (http://www.fs.fed.us/ecosystemservices/). To date, no valuation of wetland functions has been conducted in Santa Fe County, and the author of this WAP did not find any explicit data on wetland values in relation to ecosystem markets for Santa Fe County.

Yet, at a County level and State level it is of importance to consider how government spending decisions and allocating resources for protecting and managing wetlands could potentially be justified to the community and stakeholders that benefit from these resources and that "pay" for the protection and management of these resources through taxation. These types of decisions are based, either explicitly or implicitly, on society's values, as Mitsch and Gosselink (2000b) have argued. Therefore, economic valuation can be useful by providing a way to justify and set priorities for programs, policies, or actions that protect or restore wetlands, their functions and ecosystem services. Such values can in some cases be expressed in a dollar amount, while in

many cases they do not constitute marketable or monetary values, but rather personal, social, and spiritual ones.

In specific markets and market circumstances, wetland functions and their values can be expressed as marketable ecosystem services. "Ecosystem services" are natural assets that offer a full suite of goods and services that are vital to human health and livelihood. The "2005 Millennium Ecosystem Assessment" (http://www.maweb.org/en/index.aspx, Watson et al. 2005) a four-year United Nations assessment of the condition and trends of the world's ecosystems, categorizes ecosystem services as:

- **Provisioning Services** *or the provision of food, fresh water, fuel, fiber, and other goods;*
- **Regulating Services** *such as climate, water, and disease regulation as well as pollination;*
- **Supporting Services** *such as soil formation and nutrient cycling; and*
- **Cultural Services** *such as educational, aesthetic, and cultural heritage values as well as recreation and tourism.*

Wetlands in Santa Fe County provide ecosystem services from each of these four categories. Table 2.3 summarizes the most important ecosystem services prevalent in Santa Fe County wetlands. While each wetland may offer a suite of ecosystem services at the same time, differences exist between each wetland.

Table 2.3. Wetland values likely to be experienced in Santa Fe County.

Value Category	Wetland Values (Ecosystem Services)	Wetland Locations
Provisioning Services	Water for irrigation; Water for livestock; Groundwater infiltration for wells	El Potrero; Pojoaque/Tesuque rivers; Canada Ancha; La Cienega/Cieneguilla; Arroyo Hondo; Cañada de los Alamos; Galisteo Creek; Arroyo Tonque; Estancia Basin lakes
Regulating Services	Wildlife corridor; Water purification; Flood control; Erosion control; Micro-climate regulation	Pojoaque/Tesuque rivers; Rio Grande; Santa Fe River at WWTP; Arroyo Hondo; La Cienega/ Cieneguilla; Cañada de los Alamos; Galisteo Creek; San Marcos Arroyo; Upper Pecos headwaters
Supporting Services	Nutrient cycling	Rio Grande; Santa Fe River below WWTP; Galisteo Creek
Cultural Services	County Open Space/public parks; Tribal heritage land; Recreation/tourism; Education; Research; Cultural and historical values; Scenic enjoyment; Property values	El Potrero; Pojoaque/Tesuque rivers; Twomile reservoir; Santa Fe River; Arroyo Hondo; Cerrillos Hills; La Cienega/ Cieneguilla; Cañada de los Alamos; Galisteo Creek (headwaters); San Marcos Arroyo; Padre Springs; Galisteo Springs and Arroyo de los Angeles; Upper Pecos headwaters
No Information		Isolated tributaries to Rio Grande; Rio Cundiyo; Rio Santa Cruz

How people value these ecosystem services depends on people's awareness and use of these ecosystem services and on the functionality of each wetland in performing these ecosystem services. The population in Santa Fe County appears to be aware of only certain wetland functions as expressed in their use of the wetland areas and water resources and as expressed in behavior, stewardship, and protective measures. Clearly, the presence of cattle tanks near springs and the (often primitive) protection of the spring head areas (e.g., with sumps), the association of acequias with springs, and the development and protection of public open space areas around wetlands for recreational, educational, and scientific activities in connection with historical and cultural preservation and scenic or night-sky appreciation activities express peoples values of the wetlands that provide these services. In some cases, government agencies and landowners have also made use of flood control functions of wetlands, of wildlife habitat and pathway conservation functions, or of groundwater infiltration and storage capacities of wetlands. Comments in recent public meetings about infrastructure projects, such as the highway bridges in Galisteo, have also shown that communities and individuals are concerned about impacts on wetlands for reasons of property values and spiritual and other personal or community values.

However, the lack of protective County regulations for wetlands and ongoing human-caused wetland degradation seem to indicate that many people in Santa Fe County are poorly aware of most regulating and supporting services of wetlands. This is not surprising, because the wetland functions that drive these ecosystem services, such as flood or erosion control and carbon or phosphorus cycling, operate on the scale of ecosystems and the entire biosphere. Mitsch and Gosselink (2000b) observe that most of these services of wetlands accrue to the public at large. Thus wetland protection for these ecosystem services and values is, they argue, properly, the domain of a representative government working in concert with private landowners. In Santa Fe County, such values may include the potential for communal and individual cost savings and other benefits related to ecological and damage regulating functions, such as stream flow maintenance, erosion control, flood control, groundwater recharge, sediment retention, water purification, carbon sequestration, local climate management, and values associated with biodiversity (genetic diversity), biological population maintenance (ecological stepping stones) for ecological resilience, and buffering of catastrophic events.

Furthermore, wetlands could be viewed as "canaries in a coalmine" regarding the general health of ecosystems and atmospheric conditions, e.g., in relation to climate change impacts. Through wetland assessments, such as the recently developed New Mexico Rapid Assessment Method (NM RAM) for Montane Wetlands (Muldavin et al. 2011a and 2011b), wetland stressors are identified which cumulatively and regionally could serve as a warning system about ecosystem health at a larger scale. A Stressors List developed for Santa Fe County based on Muldavin et al. (2011a) is included in Appendix C. In this way, wetlands could offer valuable information services as part of the category of cultural services of wetlands under the definitions of the 2005 Millennium Ecosystem Assessment.

Wetlands may also represent ecosystem services that are considered of negative value. For example, during public meetings and in personal conversations, County residents have often expressed their apprehension of undesirable aspects of wetlands. In the course of several wetland restoration projects, the author of this WAP has experienced that county residents have raised concerns about the nuisance that wetlands cause as breeding grounds for mosquitoes and other

insects, as habitat for undesirable wildlife, or as proliferation areas of undesirable plants (these include non-native invasive plants as well as native wetland plants that are considered undesirable by certain people). Certain groups of residents have also expressed concern that wetlands and their restoration and protection leads to water losses due to evapotranspiration for beneficial uses on adjacent farm lands. Other concerns include that in dry years wetlands contribute to local wildfire risk, especially if woody wetland vegetation has dried out and died, and that wetlands are a barrier to accessing certain pieces of land that could be used more profitably if access were not hampered by the physical limitations and regulatory protections associated with the wetlands.

Therefore, valuing wetlands is a complicated matter because wetland values are variable and transient. The functional marginal value of wetlands--expressed as a product of population times functional value per capita (Mitsch and Gosselink 2000b)--typically increases with population growth when wetlands are becoming rare (due to wetland destruction caused by population pressure). At some point of population density, however, wetland functions become degraded with pollution, lost corridors, etc., and marginal functional value drops precipitously for additional population increase. Therefore, Mitsch and Gosselink (2000b) conclude that, all things being equal, a wetland in a region with moderate but not excessive urban development will have the greatest value because an adequate human population is present to benefit from those values, but the population is not so large as to overwhelm the wetland functions.

In Santa Fe County, the current population density combined with urban development projections and climate projections seem to suggest that we have reached a tipping point in the Santa Fe Watershed and the populated headwaters areas of the Galisteo Basin, and perhaps also in the Pojoaque and Tesuque watersheds and the Estancia Basin. With increased population growth and the resulting urban development, agricultural impacts, and water diversion, wetland functionality in these watersheds will probably decrease, and the functional marginal value of wetlands will precipitously decline, if Mitsch and Gosselink's (2000b) projections apply in these cases.

In their book "Rivers for Life," Sandra Postel and Brian Richter (2003) emphasize the central ecological role of water bodies such as flood plains and wetlands. They cite Vermont researcher Robert Costanza's 1997 estimate (Costanza et al. 1997) that the global, annual ecological value of freshwater swamps and river floodplains at a world market value was about $8,000 per acre (or $20,000 per ha, in 1997 figures). Mitsch and Gosselink (2000b) quote Costanza's 1997 estimate of the global, annual ecological value of wetlands of $14,785/ha, which is $6,720/acre. In present values for 2012 (based on a 43% inflation, according to www.usinflationcalculator.com), these amounts translate into an annual value of $11,440 per acre for freshwater swamps and river floodplains and $9,610 per acre for wetlands. Taken at an average value of $10,000/acre/year, this would mean that every 1,000 acres of wetlands and streams in Santa Fe County represent an annual value of at least $10 million to society for the ecosystem functions these wetlands provide.

There are several other ways to calculate the value of wetlands. Costanza's 1997 figures represent global averages expressed on the basis of annual values of all ecosystem services taken together for freshwater swamps, river floodplains, and wetlands. Alternative calculations may

consider the development or replacement costs of wetland after their destruction, for example due to an urban development or infrastructure construction project. Such costs are typically related to wetland mitigation programs financed by Wetland Mitigation Banking or In-Lieu Fee Services Programs administered by the U.S. Army Corps of Engineers (see Appendix D). A third method for estimating the value of wetlands involves the calculation of an average of restoration costs of degraded wetlands in a certain area. A fourth way of calculating wetland values is to estimate regional values based on national averages of publicly traded wetland ecosystem service offsets in international wetland banking schemes. A fifth way is to evaluate the average value of conservation easements for wetlands and buffer areas, combined with the value of water rights traded in a certain area. Sixth, one can consider the substitution costs of engineered solutions for all ecosystem services wetlands provide. Such calculations, however, have to be calibrated for a specific service area. It would extend beyond the scope of this WAP to conduct these calculation exercises for Santa Fe County.

2.6. Threats to Wetlands in Santa Fe County

Riparian areas, wetlands, and wetland conditions in Santa Fe County are currently threatened by the impacts of:

1. Encroachment, pollution, isolation, and hydrological changes due to urban, industrial, and/or infrastructure development, resource extraction industries, and/or specific land use in and around wetland areas (such as agriculture, recreational uses, waste management), and associated surface water diversion and groundwater extraction
2. Reduced surface water inflow and/or groundwater recharge
3. Increased exposure to high temperatures leading to increased evapotranspiration losses
4. Removal or destruction of vegetation due to grazing, fire, off-road-vehicle use, vandalism, or deliberate vegetation management
5. Encroachment by and proliferation of invasive plants
6. Catastrophic ecological events, such as wildfire, mass wasting, destructive flooding, gully erosion, etc.

These threats can be associated with two large categories of trends:

(A) Urban and land use processes (mostly related to threats 1, 2, 4, 5, and 6); and
(B) Ecological and climate change processes (mostly related to threats 2, 3, 4, 5, and 6).

2.6.1. Urban and Land Use Vulnerability Assessment

In this WAP, we follow a vulnerability assessment approach which includes a review of resource sensitivity, exposure, and adaptability to impacts that could force change or deterioration of the resource (Glick et al. 2011). In addition to an assessment of wetland vulnerability, we will describe adaptation, mitigation, and protection strategies for wetlands, which support final recommendations as part of this plan.

Wetland Sensitivity to Urban Development

Wetlands and riparian areas are very sensitive to direct encroachment by urban development and other land use processes. In many cases, urban development in a wetland or riparian area alters the ecological conditions of the area to the extent that it is irreparably destroyed. Federal regulations under Sections 401 and 404 of the Clean Water Act offer some protection of wetlands through permitting procedures that regulate pollutant discharge and dredge and fill in wetlands. However, agricultural activities are exempt, and many activities that affect small acreages or that involve particular kinds of construction or development activities are authorized under generic "general permits" or "nationwide permits" with minimal scrutiny and standard conditions. Wetlands that are isolated or that lack sufficient connection to navigable waters and tributaries may be totally unregulated (Environmental Law Institute 2008).

Encroachment up to the edges of a wetland or riparian area may not destroy the wetland or riparian ecology per se, but often has significant deleterious effects on wetland functions due to urban runoff volumes, energy, and pollution, and due to potential fragmentation and isolation of wetland/riparian habitat from other ecosystems and water sources that are supportive of species survival in the wetland. Wetlands are so sensitive because they require a presence of water, water-logged soils, and/or water-dependent plant species. Wetland functions in support of wildlife are sensitive because the large majority of all dryland animal species depend for one or more phases of their life cycles on wetland or riparian areas. Moreover, connectivity of wetland and riparian habitat is essential for recharge of water sources of wetlands and for plant and animal species movement patterns and regeneration, which support overall biodiversity and resilience of the wetland ecosystem. If urban development causes fragmentation of wetland and riparian ecosystems, these ecological support functions of wetlands tend to degrade.

Wetland Exposure to Urban Development

The 2010 Santa Fe County Sustainable Growth Management Plan identifies that population growth in recent decades has led to increasing competition for diminishing natural resources, and that unsustainable development patterns negatively impact the environment (Santa Fe County 2010b). While the 2010 Sustainable Growth Management Plan projects significant growth for the period through 2030 (up to 200,876 people; an increase of 49,000 from 2010 projections) (Santa Fe County 2010b), in reality urban development in Santa Fe County has slowed down considerably between 2000 and 2010, especially outside the City of Santa Fe. The urban area of Santa Fe, however, continued its steady growth (Ditzler 2011).

After the completion and adoption of the new Santa Fe County Sustainable Land Development Code, expected for 2013, more urban development can be expected through infill in the City of Santa Fe as well as in annexation areas at the City fringes, and particularly in areas that the 2010 Sustainable Growth Management Plan identifies as "Most Suitable" and which are largely included in Sustainable Development Area 1 (SDA-1) (see Figure 2.7). SDA-1 is the County's target growth area "where development is likely and reasonable to occur within the next ten years" (2010-2020) (Santa Fe County 2010b). SDA-1 encompasses an area north of La Cieneguilla and west of the Aldea subdivision, the build-out of the Rancho Viejo subdivision (or Community College District), the adjoining area along State Highway 14 north of Alamo Creek and Bonanza Creek, and a small strip along Highway 41, north of Moriarty (Santa Fe County 2010b). Projected development along the Santa Fe River north of La Cieneguilla and upstream of

the Alamo Creek and Bonanza Creek may affect sensitive wetland areas downstream along these stream systems and in La Cienega.

In the period between 2020 and 2030, the 2010 Santa Fe County Sustainable Growth Management Plan identifies a much wider zone around Santa Fe and Edgewood as an area where "new development is likely and reasonable to occur within the next 10 to 20 years." Analysis of the SDA-2 zone on the Sustainable Development Areas map (Santa Fe County 2010b) reveals that development in SDA-2 areas may affect wetlands along the Tesuque Creek and Pojoaque River, in the fringes of the Santa Fe National Forest near Chupadero and Rio en Medio, along the Santa Cruz River, the Cañada de los Alamos, Galisteo Creek between I-25 and Lamy, Cañoncito Arroyo in the Eldorado Community Preserve, Arroyo Hondo, Gallina Arroyo, Coyote Springs, San Marcos Arroyo, and the La Cienega area (see Figure 2.7).

Additionally, other forms of development, such as mineral extraction (aggregate quarrying) along the Santa Fe River, possible mining on La Bajada Mesa, and road building such as a proposed road from Highway 14 across the headwaters of the Bonanza Creek and Gallina Arroyo to the intersection of Highway 285 and I-25 north of Eldorado (Santa Fe County 2010b), may impact wetlands located downstream from these development areas as well as related headwater ecosystems upstream, especially if the development interrupts the connective linkages between these ecosystems.

Urban development generates a permanent exposure of wetlands to deleterious effects of urban stormwater volumes, their energy, and pollutants, unless urban stormwater is properly managed and the wetlands are flanked with adequate buffer zones (Environmental Law Institute 2008). Additionally, urban development also increases the exposure of wetlands to the indirect effects of development and land use, such as wild fire, off-road-vehicle use, vandalism, deliberate vegetation removal, encroachment and proliferation of invasive or noxious plants, destructive flooding, and gully erosion.

Exposure of wetlands to urban runoff and indirect development impacts on wetlands can be lessened if urban design and planning has anticipated such impacts with proper planning and mitigation measures, if developers and the community practice good stewardship, and if enforcement of protective regulations is adequate. Santa Fe County's 2010 Sustainable Growth Management Plan proposes to develop a series of policies regarding coordination of monitoring activities, preservation of on-site natural features, the capturing of storm water, and the minimization of flooding that will help protect wetland functions in the face of development (Santa Fe County 2010b). The Public Review Draft of the September 2012 Santa Fe County Sustainable Land Development Code includes several proposed regulations that may codify some of the SGMP policies (Santa Fe County 2012).

Urban development often also leads to groundwater extraction from municipal and domestic wells. One may also be concerned about the interruption of groundwater flows in shallow aquifers as a result of sub-surface impacts of construction activities. Exposure to disruption or reduction of groundwater flows is a potential death sentence to wetlands and riparian areas. Slope wetlands (springs, seeps, and other groundwater dependent wetlands) in particular are sensitive to reduced groundwater recharge and obstructions in surface water inflow. Reduced or

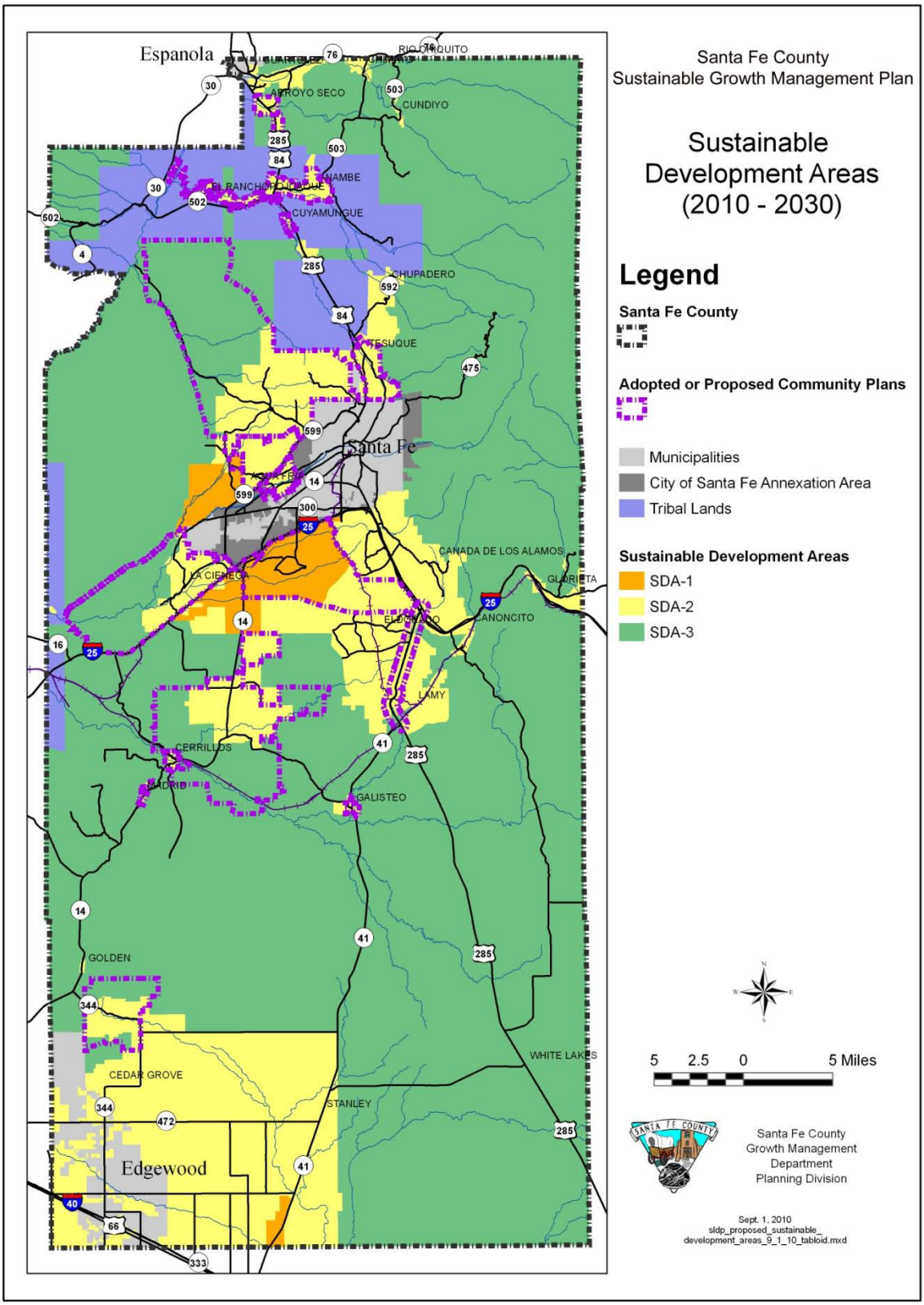


Figure 2.7. Santa Fe County Sustainable Development Areas Map (Santa Fe County 2010b).

interrupted groundwater recharge often cannot be mitigated by any land management, stewardship solutions or buffer zones. Within a short period of time, slope wetland conditions would perish under an enduring shortage of groundwater.

A study of groundwater flows to wetlands in the La Cienega area revealed a 40-year decline of water levels in groundwater measuring wells in the area (McGraw and Jansens 2012). It is likely that the ongoing groundwater level declines will negatively influence the ecological functions of springs and wetlands in the La Cienega area and, likewise, in other parts of Santa Fe County.

City of Santa Fe estimates show that at least about 5,700 to 7,700 afy of groundwater may be extracted annually if no additional groundwater is needed to compensate for reduced water delivery from the Santa Fe River and/or the BDD project (Table 2.4) (City of Santa Fe 2011b).

Table 2.4. Anticipated long term groundwater diversion volumes (City of Santa Fe 2011b).

- Municipal Buckman:	2,000 afy (conjunctively; i.e., if necessary)
- Small Systems:	1,000 afy
- Domestic Wells:	2,000 afy
- Municipal Santa Fe Basin:	2,700 afy
- Periodic Groundwater and/or BDD Compensation for SF River shortages:	3,500 afy

According to a 2011 analysis by the City of Santa Fe (City of Santa Fe 2011b), the Jemez y Sangre Regional Water Plan's 2007 Update projected a demand to meet human needs for the Santa Fe sub-basin of approximately 27,000 acre-feet in 2060. Available supplies in 2011 were approximately 19,000 acre-feet, leaving a gap of 8,000 acre-feet or 30% of projected year-2060 demand. By 2045, the City of Santa Fe's 2008 Long Range Water Supply Plan shows a difference between available supplies and anticipated demand to cover human needs of 2,700 acre-feet of the total projected need of 18,100 acre-feet (15%). Water shortages may begin to appear as early as by the 2020s if any dry years occur in the next decade. Santa Fe County's 40-year Water Supply Plan shows adequate surface water supplies for its planning horizon and has identified the need for groundwater "backup" supplies, which the County will rely upon during drought periods with low flows in the Rio Grande or when the BDD surface water facility is offline (City of Santa Fe 2011b).

The projected demand for surface water and/or groundwater resulting from projected urban development will create a direct conflict with water needed to sustain wetlands, the Santa Fe River ecosystem, local agriculture, recreation, and other watershed needs. Conversely, the federal mandate to care for nationally listed endangered species in the Rio Grande, such as the Rio Grande silvery minnow and the southwestern willow flycatcher, for example by allocating water from the San Juan-Chama Project which is under federal control, may compound water shortage risks to all Rio Grande surface water users, and may further increase water supply stresses on wetlands outside the Rio Grande corridor, because providing adequate water and habitat in the Rio Grande corridor may reduce available surface water supply for all other uses in the basin (City of Santa Fe 2011b).

As climate change increases the chances of reduced river water in the Rio Grande and Santa Fe River and increased forest fire and pollution levels in rivers, it also increases the chance of the need to use groundwater resources beyond the estimated minimum annual levels (Julie Ann Grimm, Santa Fe New Mexican, July 4, 2012). For example, in 2011, Santa Fe County residents experienced how polluted runoff from the Las Conchas wildfire shut down the BDD, while through July 2012 surface water in the upper Santa Fe River watershed was inadequate to meet the City's drinking water demand. In turn, groundwater diversion (i.e., extraction) would increase the chance of reduced discharge in slope wetlands and springs, resulting in reduced water delivery to wetlands dependent on these discharge zones.

Adaptation Strategies

Wetland vulnerability to urban development and land use is dependent on the adaptive capacity of wetlands to the urban development and land use impacts. While wetlands are resilient ecosystems, the nature, severity and duration of the exposure to impacts, the sensitivity of individual wetland components, and the cumulative effects of repetitive impacts may negatively influence the adaptive capacity of wetlands to urban development impacts. Critical is that urban development and land use do not compromise the constant water recharge capacity of wetlands, the uninhibited connectivity to other riparian and wetland systems, and the size of the wetland and riparian ecosystems.

The natural adaptive capacity of wetland ecosystems can be enhanced with the establishment of planned and/or engineered adaptation strategies. Such strategies may include the reintroduction of beaver and the development of buffer zones around the wetlands, including peak flood absorption zones that reduce the volume, energy, and pollution from sudden urban storm water floods into wetlands (Environmental Law Institute 2008). Other strategies include urban storm water management and induced water infiltration systems in urban and natural uplands. While certain entities, such as the BLM and the City of Santa Fe have guidelines in place that encourage such strategies (BLM 2012, City of Santa Fe 2011a: http://clerkshq.com/default.ashx?clientsite=Santafe-nm), Santa Fe County's SGMP and SLDC do not (yet) include many concrete strategies or regulations to protect wetlands against the impacts of ongoing urban development and land use practices (Santa Fe County 2010b, Santa Fe County 2012). The current absence of such regulatory protections is a weakness to the human-supported adaptation capacity of wetlands in Santa Fe County.

Uncertainty of Wetland Vulnerability to Urban Development

Urban development projections in Santa Fe County have become rather uncertain as a result of the recent economic recession of 2008-2011. Since 2008, population growth and the building industry stagnated. Santa Fe County's protracted process for producing a Sustainable Land Development Code that is in concert with the 2010 Sustainable Growth Management Plan may have also played a role in a slowed urban development process. Together these trends have created some uncertainty in the urban development and land use projections for the area.

The complexity of urban development impacts on wetland conditions and the many variables in the planning processes, mitigation options, and wetland sensitivity, leave a large degree of uncertainty in adaptive responses of wetlands to urban development impacts. Coupled with the projected impacts caused by a changing climate and changing regional ecosystems, the

uncertainty of the adaptive responses of wetlands to urban development is further increased. The uncertainties in urban development trends, climate trends, and wetland adaptation capacity increase the importance of monitoring urban development in Santa Fe County, including monitoring of groundwater extraction associated with development, as well as monitoring of cumulative impacts on wetlands of development and climate change.

2.6.2. Ecological and Climate Change Vulnerability Assessment

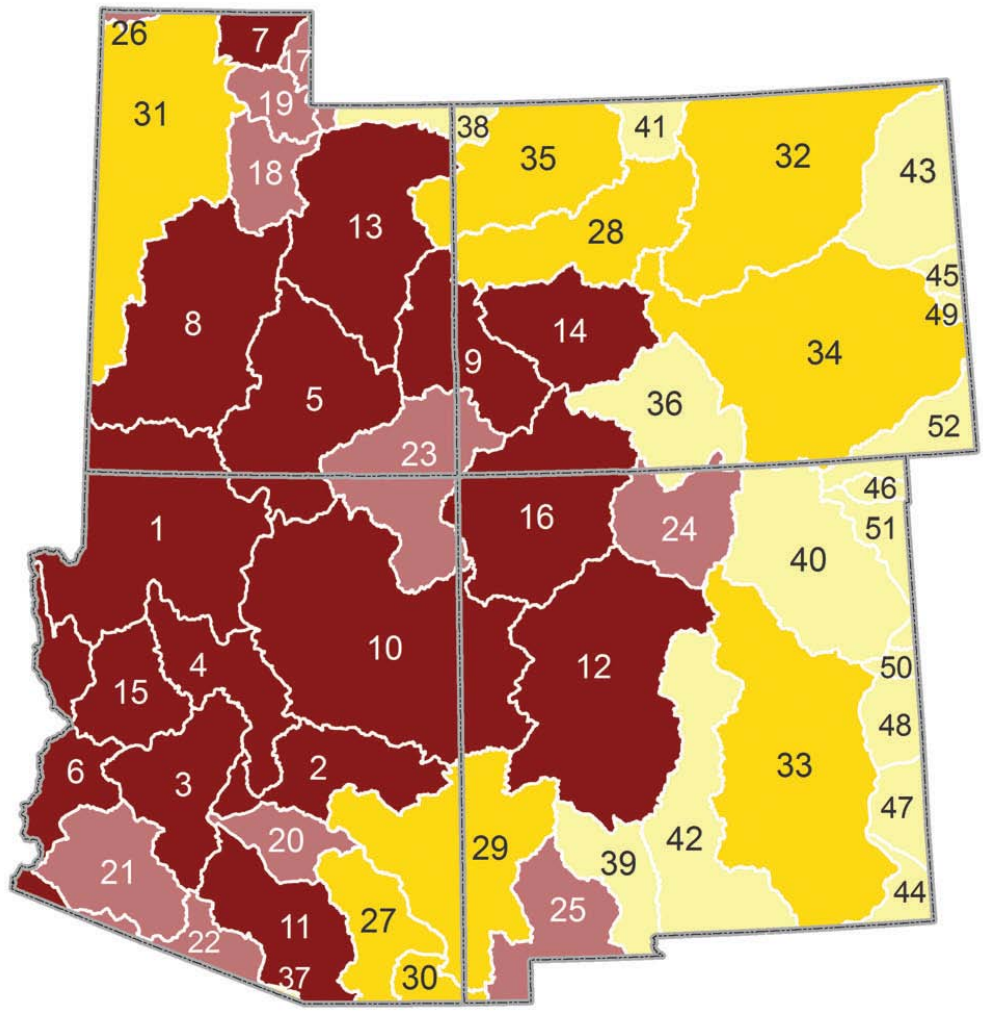
The following ecological and climate change vulnerability assessment describes resource sensitivity, exposure, and adaptability to ecological and climate impacts that could force change or deterioration of wetlands resources based on the approach described by Glick et al. (2011). Vulnerability to climate change is defined by the Intergovernmental Panel on Climate Change (IPCC) as "the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change" (Pg. 783 of IPCC, chapter 19, Schneider et al., 2007, Lewis et al. 2012 Draft). The purpose of defining wetland vulnerabilities to climate change is to assess how to make wetlands less vulnerable and, thus, more resilient and adaptive to systemic change.

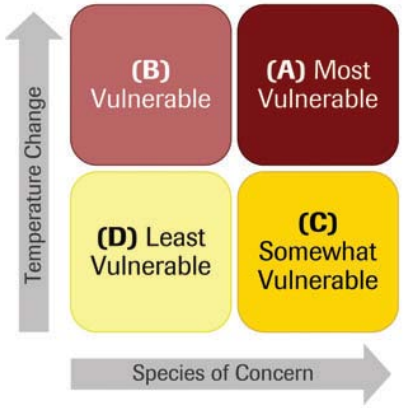
Wetland Sensitivity to Climate Change

If outside forces gradually or suddenly eliminate all three basic characteristics of a wetland area (a prevalence of hydric saturation conditions, hydrophytes, and/or un-drained hydric soils), such a wetland ecosystem ceases to exist. As a result, by their very definition wetlands are inherently susceptible–or sensitive–to losing the characteristics of being saturated with water or covered by shallow water at some time during the growing season of each year. Additionally, regardless of the hydric saturation conditions, wetlands are also sensitive to permanently losing hydrophytes and to disturbance of the un-drained hydric soils.

Climate change studies project that temperature would increase, and that related increases in evapotranspiration, wildfire, early stream flow volume and duration, and declines in plant and animal species are the key factors in landscape vulnerability to climate change in the Southwestern United States (Robles and Enquist 2010, DeBuys 2011, Gangopadhyay and Pruitt 2011, Gutzler 2012, Lewis et al. 2012 Draft). Wetland ecosystems are particularly sensitive to these ecological trends resulting from a changing climate in the Southwest.

In 2010, The Nature Conservancy published a climate vulnerability assessment of landscapes across the Four Corners States with map details for each 6-HUC code watershed in this area (Robles and Enquist 2010), which poignantly clarifies the climate change vulnerability of wetlands in Santa Fe County (see Figure 2.8). The study identified four vulnerability categories for landscapes in the study area based on temperature changes during the 55-year period of 1951-2006, a review of wildfire incidences in the region, a review of documentation about early stream flow and snowpack reductions, and an assessment of changes or decline in plant and animal species.





"Watersheds are grouped by relative vulnerability to climate change. Groups are based on the relative amount of temperature change and freshwater species of concern within each watershed. High values are above the 50th percentile. Low values are below the 50th percentile" (Robles and Enquist 2010).

Figure 2.8. Map of vulnerability assessment results for different watersheds in the Southwest (from Robles and Enquist 2010). Santa Fe County comprises the northeastern part of the Rio Grande–Elephant Butte watershed (12), the most southern tip of the Upper Rio Grande watershed (24), the far northern tip of the Upper Pecos watershed (33), and the northern tip of the Rio Grande-Closed Basin watershed (42). Most of Santa Fe County is located in the Rio Grande–Elephant Butte watershed (12), which is classified as "Most Vulnerable" to climate change.

The study reported that for the 55-year review period there is documented early stream flow in the Rio Grande and reduced snow pack in the Upper Pecos watershed. The documented changes were accompanied with a temperature increase of 1.6°F and an impact on 20 freshwater species in the Rio Grande Basin and an increase of 0.9°F and an impact on 6 freshwater species in the Estancia Basin (Robles and Enquist 2010).

Starting in the mid 1980s, large wildfires have become more prevalent across the region; especially in Montane forest lands (Robles and Enquist 2010). In that period, Santa Fe County was impacted by the Dome fire (1996), Oso Complex fire (1998), Cerro Grande fire (2000), the Las Conchas fire (2011), all in the Jemez Mountains, and the Pacheco fire (2011) in the Nambe watershed of the Sangre de Cristo Mountains.

The study identified that the part of Santa Fe County encompassing the Española Basin (Rio Grande-Elephant Butte watershed (#12)) falls in the category of "most vulnerable" to climate change due to the impacts of temperature increases and species decline. The Montane forest area and the Upper Pecos watershed area (#33) are categorized as "somewhat vulnerable" and the Shortgrass prairie in the Estancia Basin (Rio Grande Closed Basins (#42)) is categorized as "least vulnerable" (Robles and Enquist 2010) (see Figure 2.8). Table 2.5 offers a comparative overview of the projected sensitivity of landscapes in Santa Fe County to documented changes in the ecology and climate between 1951 and 2006.

Table 2.5. Documented ecological and climate changes as indications for landscape vulnerability to anticipated change for five landscape types in Santa Fe County (Source: Robles and Enquist 2010).

Landscape Type	Location in Santa Fe County	Temperature Change in °F	Number of Species of Conservation Concern	Documented Impacts
Subalpine Conifer Forest	High elevations in Sangre de Cristo Mountains	1.6	301	Timing Plants Animals
Two-needle Piñon/Juniper Woodland	Non-urban woodland areas of Española Basin	1.6	525	Plants
Intermountain Grassland	Grasslands between Pojoaque and Santa Cruz; central & northern Galisteo Basin; La Bajada Mesa	1.6	332	
Montane Forest	Mid- and lower elevations in Sangre de Cristo, Jemez, and Ortiz Mountains	1.4	428	Wildfire Timing Plants Animals
Shortgrass Prairie	Grasslands in eastern Galisteo Basin and Estancia Basin	0.8	81	Timing

Landscape types (or habitats) are listed in descending order of their relative vulnerability to climate change, along with information about their location, area, temperature change (°F 1951-2006), the number of species of conservation concern, and documented ecological impacts.

Temperature change and species are evaluated across the range of habitats in the Four Corners States. Observed ecological impacts associated with climate change include:

"Animals" = animal species population shift, change or decline
"Plants" = plant species population shift, change or decline
"Timing" = change in the timing of species events
"Wildfire" = uncharacteristic fire events

Wetland Exposure to Climate Change

Global climate models project a transition to a much more arid climate in the Southwest by the mid-21st Century, primarily due to increasing rates of evaporation and increasing water use by plants, which will result from the projected higher temperatures (Lewis et al. 2012 Draft, DeBuys 2011). Evaporation and plant water use are directly related to surface temperature, as warmer air holds more moisture. Climate models for the Southwest project that long-range precipitation volumes would not change much from current volumes, but the intensity and variability of precipitation is projected to increase. While evaporation and plant water use would increase due to higher temperatures, average surface runoff and groundwater recharge would decrease. It can be expected that irrigation water demand and riparian water consumption will increase, which will most likely result in non-irrigated vegetation becoming increasingly water stressed (Lewis et al. 2012 Draft).

Higher temperatures would also impact winter snowpack depth and duration and snowmelt timing and volume. Climate models project decreases in snowpack throughout the western mountains because, as temperatures increase, more winter precipitation is expected to fall as rain rather than snow. In sum, according to a number of studies for the Southwest (Gutzler and Robbins 2010, Gutzler 2012, DeBuys 2011), and for the Rio Grande Basin and the Santa Fe Watershed, as described by Lewis et al. (2012 Draft), the projected impacts of climate change on wetlands include:

- **Increased temperatures**, leading to increased evapotranspiration;
- **Diminished snowpack**, and earlier spring melt of existing snowpack; drier spring seasons, with earlier peak snowmelt runoff and lower peak flows;
- **More extreme precipitation events** that increase peak storm flows, with an accompanying potential for more sediment transport and erosion and declining aquifer recharge (in between periods of prolonged drought);
- **Reduced stream flow** due to greater evaporation losses, greater water use by plants (transpiration), and less runoff;
- **More severe and more frequent droughts**; and
- **Loss of ponderosa and mixed-conifer forest ecosystems**.

Increased Temperatures and Evapotranspiration

Climate change is already occurring in the Santa Fe Basin, as evidenced by measured temperature increases (Lewis et al. 2012 Draft). Average temperatures in the watershed have risen more than 2^{o}F since 1900. Continuing CO_2 emissions around the world will trap additional heat near the Earth's surface, so that temperatures will continue to rise for the foreseeable future in the Santa Fe watershed and elsewhere. Global climate models (called

General Circulation Models, or GCMs) project that air temperatures in the Santa Fe Basin could increase an additional 5.5° to 7.2°F by 2100 (Gutzler 2012, Lewis et al. 2012 Draft).

Climate projections for the first half of the 21st Century anticipate that average summer and winter temperatures could increase by as much as 3.5° to 4°F to about 70°F during the summer and 59°F during the winter. This change will significantly increase evaporation and evapotranspiration, leading to increasing drought conditions on the ground.

Reduced Snowpack

Depending on different models, snowpack is projected to decline by 20% to 75% by mid Century due to the temperature changes. What snow does fall would melt earlier, due to higher spring temperatures, rain falling on snow, or intense spring windstorms blowing dust onto the snow, making it absorb more sunlight and melt faster. By 2050, spring runoff could be 15 to 35 days earlier than it was under pre-development conditions. Driven by warmer temperatures, the reduced snow pack and earlier peak runoff is expected to generate lower peak flows in the Rio Grande and the Santa Fe River (Hurd and Coonrod 2008; Lewis et al. 2012 Draft). The earlier runoff may fill McClure and Nichols reservoirs over a relatively brief period and then overflow the reservoirs and continue downstream. Therefore, even if the total runoff were comparable to average historic supply, much of this water may become unavailable, and therefore may cause the Santa Fe water supply to be short more often (Lewis et al. 2012 Draft). Even if water needs don't increase, residents would increasingly depend on groundwater resources. Extraction of groundwater for drinking water purposes is likely to negatively affect wetland conditions, as explained above.

Precipitation

Precipitation projections indicate very small differences with the long-range historical precipitation for the area relative to the observed inter-annual decadal variability. However, climate models project increasing variability in precipitation events as the climate warms, leading to fewer but more intense precipitation events and greater, more sudden runoff events, while drought periods may be longer and more severe (Gutzler 2012).

Reduced Stream Flow

The U.S. Bureau of Reclamation made stream flow and runoff projections for the 21st Century based on reference data from the 1990s for several western watersheds, including the Rio Grande above Elephant Butte Dam (Gangopadhyay and Pruitt 2011). Modeling conducted for this study projects a decline in annual streamflow in the Rio Grande from 3 million acre feet (maf) in the 1990s to approximately 2.5 maf by 2050.

More Severe and Frequent Droughts

One of the observations resulting from climate modeling is that the variability of weather will increase, leading to more frequent and more severe droughts, along with an increased frequency of severe storms and concentrated runoff events (Gutzler 2012).

Loss of Ponderosa Pine and Mixed Conifer Forests

In recent publications a research team of Northern Arizona University around Dr. Park Williams postulated that by about 2050 forest drought stress index values for even the

wettest, coolest years are expected to equal or exceed the worst drought years that the Southwestern U.S. has experienced in the past 1000 years (Williams et al. 2010; Lewis et al. 2012 Draft). The researchers expect that as a result of increasing drought stress index values, ponderosa pine and mixed conifer forests would suffer greatly from increased incidences of stand replacing wildfires and beetle outbreaks. As forest fires become even more frequent and possibly larger, the forest fires would in turn affect the stability of the entire landscape. The more intense rainstorms that are expected are likely to increase erosion, and cause the accumulation of ash and sediment in rivers and wetlands downstream (Lewis et al. 2012 Draft). In areas of sudden and rapid loss of ponderosa pine and mixed conifer forest lands infiltration of precipitation is expected to be reduced. Where these ecosystems are essential for gradual mountain front recharge of local aquifers, reduced infiltration and water holding capacity in the mountains might lead to a decrease of aquifer recharge.

The projected climate trends constitute a greater exposure of wetlands in Santa Fe County to evaporative water losses from open waters and transpiration losses through wetland plants. Variability of water inflow from precipitation, runoff, or overbank floods into wetlands would increase, leading to longer periods of minimal water inflow and to occasional flood events with higher energy and volumes of water. As a result, in certain areas, wetlands may thrive, while in other areas wetland vegetation may shift from obligatory wetland species to facultative species and even a mixture of upland species that are tolerant to occasional flooding. The risk of wildfire in dry woody biomass along wetlands can be expected to increase in drying wetlands with many woody plants.

The vulnerability of groundwater supply to climate change is less well understood than surface water vulnerabilities because the mechanisms and timing of groundwater recharge are more difficult to quantify. Climate change projections suggest future precipitation would be delivered in fewer, more intense events, giving the above-ground flow less time to infiltrate into the aquifer. Potential reductions in groundwater recharge coupled with an increase of people's dependency on groundwater resources due to a reduction in runoff volumes in rivers, lakes, and reservoirs, may thus lead to increased water shortages in wetlands.

Climate change impacts on wetlands would affect nearly all wetlands in Santa Fe County (see Table 2.5). The Montane Forest wetlands in the Sangre de Cristo Mountains would be affected by reduced snow fall, more rapid snowmelt, and the potentially devastating effects of catastrophic wildfire. Riverine wetlands along the Tesuque Creek, Santa Fe River, Arroyo Hondo, and Galisteo Creek would be affected by greater periods of low-flow or no flow and by more frequent overbank flood events. In some cases, this may be beneficial to wetland dynamics, while in other cases excessive peak flows may undermine and destroy wetland ecosystems that lack sufficient buffers for flood attenuation. Yet, more frequent severe drought periods would be particularly damaging to many riverine wetlands. Depressional wetlands may also be impacted by sedimentation from eroding uplands and increased evaporation losses. Slope wetlands, such as the springs in the La Cienega area and many springs in low mountains and hills across the County, would most likely be impacted by reduced groundwater recharge, which, along with continued pumping of the aquifer, could reduce the flow into many of the area's wetlands (Lewis et al. 2012 Draft).

In turn, projected climate change effects would impact biodiversity and many wildlife and plant species associated with or dependent on wetlands. Riparian areas and wetlands are vital to many species, especially many federally listed endangered species, and many species of greatest conservation need (SGCN) according to the State's Comprehensive Wildlife Conservation Strategy (State of New Mexico 2006). As free roaming opportunities for animals are increasingly curtailed by fragmentation of riparian areas and wetlands due to (ex)urban and infrastructure development, local effects of a changing climate are likely to lead to greater competition for access to water, food, and shelter among individual animals. As temperatures rise, the number of hours in a day when an animal may be active will likely be reduced, thereby reducing their ability to forage and hunt (Lewis et al. 2012 Draft). If habitat area diminishes due to vegetation loss and ecosystem degradation as a result of warmer temperatures and human activities, migration pathways (i.e. the connections between habitats) become smaller, placing an additional burden on animals already stressed by development and highways.

Uncertainty of Wetland Vulnerability to Ecological and Climate Change Impacts

Wetland vulnerability due to climate change is primarily temperature driven, and climate change impacts on wetlands are expected to occur even if there are no significant changes in annual precipitation. While the anticipated impacts should be considered certain, they are based on modeling, which provides us with projections rather than predictions. We are unable to specifically predict the location, magnitude, pace or timing of climate impacts on wetlands. Other uncertainties are related to future greenhouse-gas emissions, human behavior, population projections, energy sources, economic forecasts, and technological changes.

Adaptive Capacity

The capacity of wetlands to adapt to climate change is limited under climate change projections that involve increasing losses of effective water availability due to evaporation, reduced groundwater supplies, more irregular surface water in-flows, and longer periods of drought between flow events. Some riverine wetlands may be able to adapt to and even thrive as a result of increasing ecological dynamics caused by flooding and sediment deposition. However, bank erosion, channel degradation, and sediment deposition will in many cases lead to the drying or alteration of the soil profiles in wetlands and riparian areas and the decline of hydrophytes.

Increasing transpiration rates would over time put greater stress on wetland plants when transpiration exceeds water availability. In certain wetlands, however, the vegetation may adapt to climate change by shifting from plants with a so-called C3 biochemistry pathway of photosynthesis to plants with the C4 pathway (Mitsch and Gosselink 2007). In C4 plants the first products of incorporation of CO_2 are 4-carbon compounds, oxaloacetate and malate, while the first compound for CO_2 incorporation in C3 plants is a 3-carbon compound, phosphoglycerate. Plants that fix carbon by the C4 pathway can use CO_2 more effectively than other plants. The rate of photosynthesis in C4 plants can be 3 or 4 times higher than in C3 plants. C4 plants also have a significantly reduced transpiration ratio (i.e., the ratio between grams of water transpired in comparison with the plant's dry weight). Optimum day temperatures for net CO_2 fixation of C4 plants are 30° to 47°C (86°-113°F) versus 15° to 25°C (59°-77°F) for C3 plants. The maximum growth rate and dry matter production for C4 plants can be more than 50% the rates for C3 plants. C4 plants are typically also more adapted to saline environments (Mitsch and Gosselink 2007), which is also advantageous in drying southwestern wetland soil conditions. A

shift to C4 plants would constitute the influx of heat and salt tolerant plants from other ecoregions into northern New Mexico wetlands.

2.6.3. Wetland Stressors

SWQB uses a "Stressors Checklist" developed for the assessment of wetland conditions as part of the New Mexico Rapid Assessment Method (NM RAM Field Guide Version 1.1.) in Montane Riverine Wetlands (Muldavin et al. 2011a). For the purpose of this WAP and future wetland assessment in Santa Fe County, the author of this WAP slightly modified the NM RAM Stressors Checklist in order to make it applicable to lower elevation wetlands in Santa Fe County (see Appendix C). Stressors are grouped in four categories and relate to the threats listed in Section 2.5.1 in the following ways:

1. Landscape Context Stressors (threat category 1)
2. Vegetation (Biotic Condition) Stressors (threat categories 4 and 5)
3. Physical Structure (Soil/Substrate) Stressors (threat categories 1, 3 and 6)
4. Hydrologic Condition Stressors (threat categories 1 and 2)

Table 2.6 provides an overview of specific wetland stressors for the six categories of threats for selected wetlands in Santa Fe County.

Key to Codes for Stressors Listed in Table 2.6:
A box colored red [ ] means that a particular threat or stressor for that wetland area could be expected but cannot be verified at this time.
A box colored blue [ ] means that no threats or stressors of a kind are present or likely for a wetland area due to current management, ownership, or ecological conditions.

Landscape Context Stressors:
AR = Active Recreation
IA = Intensive/row-crop Agriculture, including Orchards, Nurseries, etc.
ID = Industrial and Infrastructure Development
RA = Ranching (low intensity or moderate)
UD = Urban/residential Development

Vegetation (Biotic Condition) Stressors:
x = stressors present or highly likely

Physical Structure (Soil/Substrate) Stressors:
C = Various Climate stressors
ET = Evapotranspiration (presence of open water and/or dense wetland vegetation)
CE = Catastrophic/Excessive Erosion
CF = Catastrophic/Excessive Flooding
MW = Mass Wasting
WF = Wild Fire

Hydrologic Condition Stressors:
x = stressors present or highly likely

Table 2.6. Estimated present and future threats and stressors to wetlands in Santa Fe County.

Watersheds and Wetland Areas	Categories of Threats to Wetlands						Time Scale of Threats	
	1: Encroach-ment, pollution, isolation, hydro-modification	2: Reduced surface inflow & groundwater recharge	3: Increased temperature exposure and ET losses	4: Removal of vegetation	5: Invasive plant encroachment	6: Catastrophic ecological events	2012-2020	2020-2030
Rio Cundiyo-Santa Cruz								
headwater springs	AR					WF risk	x	x
El Potrero wetlands			ET		x		x	x
Pojoaque-Tesuque-Nambe								
Big Tesuque Creek	RA, UD		C	x	x	WF risk	x	x
Rio Tesuque wetlands	AR		C	x	x		x	x
Rio Grande tributaries								
Black Mesa-Buckman	AR		C		x	MW risk	x	x
Caja del Rio springs	AR		C		x	MW risk	x	x
Canada Ancha								
Caja del Rio Canyon		x	C	x	x	CF, CE risks	x	x
Santa Fe River								
Twomile reservoir		x	ET			MW risk	x	x
SF River below WWTP			C	x	x		x	x
Cieneguilla	IA, RA, UD		C	x	x		x	x
Arroyo Hondo	AR	x	C			WF risk	x	x
Cienega Creek Area	RA, UD	x	ET	x	x		x	x
Bonanza Creek	ID, RA, UD	x	C		x		x	x
Galisteo Creek								
Valencia wetlands	ID, RA, UD	x				CF, MW risk	x	x
Deer Creek	AR	x			x	WF, MW risk	x	x
Apache Canyon		x	ET					x
Apache Ridge	AR		ET	x	x		x	x
Cañoncito wetlands		x	ET		x	CF, CE risks	x	x
Galisteo mainstem			C		x	CF, CE, WF risks	x	x

Watersheds and Wetland Areas	Categories of Threats to Wetlands						Time Scale of Threats	
	1: Encroach-ment, pollution, isolation, hydro-modification	2: Reduced surface inflow & groundwater recharge	3: Increased temperature exposure and ET losses	4: Removal of vegetation	5: Invasive plant encroachment	6: Catastrophic ecological events	2012-2020	2020-2030
San Cristobal playa	RA	x	C				x	x
Galisteo Springs		x	C		x	CF, CE risks	x	x
Other GBP wetlands		x	C		x	CF, CE risks		x
Arroyo Salado	IA, RA, UD	x	C		x			x
Padre Springs			C			CF, CE, WF risks		x
San Cristobal Arroyo	RA	x	C		x	CF, WF risks		x
Arroyo la Jara	RA	x	C		x			x
Finger Lakes			ET		x	WF risk	x	x
Coyote Springs		x	C		x			x
Cañada de los Alamos	AR, UD	x	C	x	x	CF, CE, WF risks	x	x
San Marcos Arroyo			ET		x	WF risk		x
Hwy 14 springs		x	C		x			x
Cerrillos Hills springs	AR	x	C		x			x
Galisteo reservoir	RA		C		x			x
Mailbox Rd Arroyo	UD	x	C		x			x
Upper Pecos headwaters								
various headwaters		x				WF risks	x	x
Glorieta Creek	UD	x		x	x	WF risks	x	x
Arroyo Tonque								
various springs	RA	x	C	x	x			x
Estancia Basin								
Big Lake Playa	RA	x	C				x	x
White Lakes	RA	x	C				x	x

3. Current Status of Wetland and Riparian Resource Management

3.1. Recent Accomplishments in Wetland Protection and Restoration Capacity

Active wetland and riparian resource management in Santa Fe County began around 1988 in response to the Statewide Comprehensive Outdoor Recreation Plan and the 1986 Federal Emergency Wetland Resources Act. The Act stimulated management of wetlands in New Mexico in an important way with an assessment of State wetlands by the Energy, Minerals, and Natural Resources Department's State Parks and Recreation Division (New Mexico EMNRD 1988, Jones 1997). The 1986 Emergency Wetland Resources Act offered funding incentives and required states to address wetland protection in their Statewide Comprehensive Outdoor Recreation Plans to qualify for funding. The National Park Service provided guidance to states in developing the wetland component of their plans (Jones 1997). Since then, Santa Fe County has been involved in wetland protection with research, data collection, inventory, and delineation of wetlands in the County (Jones 1997).

In the last 25 years, the institutional capacity for wetland restoration and protection in Santa Fe County has grown to include a broad spectrum of local NGOs, ecological consultants and engineers, and local offices of federal, state, and local governments. The available institutional capacity also includes many NGOs, consultants, universities, and government agencies in other parts of the State and beyond that have experience with wetlands in Santa Fe County.

After 1990, individual landowners and NGOs have completed several scattered wetland restoration and protection projects (see Table 3.1). The recent wetland restoration and protection initiatives have helped build a basis of institutional experience and expertise among NGOs and local consulting businesses and contractors, as well as among staff of Santa Fe County and at the SWQB and federal agencies. Annually, the State Wetlands Program Coordinator at SWQB organizes several "Wetland Roundtables" for information exchange and local institutional capacity building among government agencies and among NGOs.

After the 1990s, the varied expertise and funding for watershed and wetland restoration and research in the area has been broadened to include other environmental concerns, such as renewable energy and energy conservation, local food security, wildlife habitat and corridors, and regional environmental policy initiatives with an emphasis on climate change adaptation strategies. Government institutions and NGO's also reached out to include the expertise of local conservation and land trust organizations for wetland protection with voluntary private land protection programs (a.k.a. conservation easements).

Table 3.1. A partial list of completed restoration and protection projects at wetland sites in Santa Fe County between 1990 and 2012.

Wetland Site	Owned by	Restoration work by	Protected by
El Potrero wetland	Santa Fe County	Santa Fe County	Santa Fe County Open Space
Cienega Creek wetlands	Blue Heron Ranch	Contractors	Landowner/Conservation Easement
Guicu Creek wetlands	Las Lagunitas HOA	Developer	Las Lagunitas HOA
Twomile Reservoir	The Nature Conservancy (TNC)	TNC	TNC
Santa Fe River below the Waste Water Treatment Plant/WWTP	Santa Fe County/ BLM/State Land Office/ The Santa Fe Girls School	Wild Earth Guardians and The Santa Fe Girls School	Santa Fe County/ BLM/ State Land Office/ The Santa Fe Girls School
Apache Canyon wetlands	Privately owned	Contractors/land owners	Landowners
Galisteo Creek in Village of Galisteo	Privately owned	Landowners and Earth Works Institute	Landowners
Shooting Gallery Arroyo	Santa Fe County	Earth Works Institute, State Parks	County Open Space/NM State Parks
Mineral Springs	Santa Fe County	Earth Works Institute and the Cerrillos Hills Park Coalition	County Open Space/NM State Parks
Galisteo Springs	Privately owned	Earth Works Institute	Landowner/Conservation Easement
Arroyo de los Angeles wetlands	Privately owned	Earth Works Institute	Landowner
Finger Lakes	Privately owned	Earth Works Institute	Landowner/deed restrictions
Cañoncito Arroyo	Eldorado Community Improvement Association (ECIA)	Earth Works Institute and ECIA	Eldorado Community Preserve (protected status)
San Marcos Arroyo	Privately owned	Wild Earth Guardians, Earth Works Institute	Landowner
Arroyo Hondo Reservoir	Santa Fe County	Santa Fe County	County Open Space
Galisteo Dam/ Reservoir wetlands	U.S. Government	U.S. Army Corps of Engineers	U.S. Army Corps of Engineers

In the last decade, the NGO community and government agencies have successfully brokered a regional culture of collaborative natural resource conservation and restoration, which includes collaboration with youth programs and broad public participation. Most wetland protection and restoration projects in northern New Mexico in recent years were accomplished with County, State or Federal funds through collaborative initiatives spearheaded by NGOs in collaboration with State and Federal agencies and local landowners. Such collaborative programs included the Santa Fe County Open Space & Trails Program, the State of New Mexico's River Ecosystem Restoration Initiative, and, to some extent, the U.S. Forest Service's Collaborative Forest

Restoration Program. The project "Comprehensive Wetland Restoration and Protection in Santa Fe County" that initiated this WAP is a case in point. It brought together the SWQB with Santa Fe County, Earth Works Institute, local landowners and many Federal and State agencies, NGOs, and private partners to pioneer and complete a multi-party and multi-jurisdictional pilot project for wetland restoration and protection in the County. However, the economic crisis of the last few years has led to a reduction of available government resources for environmental restoration and protection. Future government funding programs are uncertain.

Besides the SWQB, government agency capacity for wetland restoration and protection in Santa Fe County includes the NM Department of Transportation (DOT), the Energy Minerals and Natural Resources Department (EMNRD), the Office of the State Engineer and Interstate Stream Commission, the Department of Game and Fish, the New Mexico Bureau of Geology and Mineral Resources, USDA Natural Resources Conservation Service (NRCS) (Santa Fe and Albuquerque), U.S. Fish and Wildlife Service (Albuquerque Field Services Office), the U.S. Geological Survey (USGS) (Albuquerque), BLM (Albuquerque Office and Taos Field Office), the U.S. ACE (Albuquerque District Office), the U.S. Forest Service (Santa Fe and various other locations), and the EPA (Dallas, TX) (Jones 1997).

3.2. Current Status of Wetland Assessments, Mapping, Monitoring, and Regulations

3.2.1. Status of Assessments, Mapping, and Monitoring

SWQB Wetlands Program has only recently begun developing systematic assessment and monitoring protocols for New Mexico's wetlands. In May 2011, SWQB in collaboration with the Natural Heritage New Mexico Division of the Museum of Southwestern Biology at UNM and SWCA Environmental Consultants completed the New Mexico Rapid Assessment Method (NM RAM) for Montane Riverine Wetlands (Manual and Field Guide, Version 1.1.) (Muldavin et al. 2011a, Muldavin et al. 2011b). It is expected that the NM RAM will be applied in an assessment of wetlands in Santa Fe County in the near future.

In 2011-2012 SWQB has undertaken a wetland mapping project for topographic map quadrangles in northern New Mexico, including the Aspen Basin, McClure Reservoir, and Glorieta quadrangles, and quadrangles in Rio Arriba and San Miguel Counties that overlap with Santa Fe County. Recently, other quadrangles have been completed, such as Sierra Mosca, covering the Outstanding National Resource Waters in Santa Fe County. In 2009, UNM completed a wetland mapping project for Santa Fe County in the Galisteo Basin (Milford et al. 2009) (see also Appendix A, Section A.7.2). SWQB is currently working with the U.S. Fish and Wildlife Service on a mapping project of wetlands in the La Cienega area (U.S. Fish and Wildlife Service 2011, McGraw and Jansens 2012) (see Figure 3.1).

Monitoring of wetlands in Santa Fe County is limited to monitoring activities associated with individual wetland or stream restoration projects, and implemented through individual project teams. When funded through the SWQB with EPA funding, monitoring is guided by a Quality Assurance Project Plan (QAPP).

3.2.2. Status of Wetland Management Responsibilities and Regulations

Wetlands are surface waters of the State of New Mexico, and as such are protected under 20.6.2 NMAC (Title 20 Environmental Protection, Chapter 6 Water Quality, Part 2 Ground and Surface Water Protection), and included in 20.6.4 NMAC, New Mexico's Water Quality Standards. Physically and/or legally protected wetlands in Santa Fe County are to be found on Federal lands, especially in U.S. Forest Service Wilderness Areas, such as the Pecos Wilderness, as Outstanding National Resource Waters, in BLM Areas of Critical Environmental Concern (ACEC), in Santa Fe County Open Space areas, and in areas covered by conservation easements or covenants that limit development, such as those governing the Eldorado Community Preserve. The majority of wetland acreage in Santa Fe County is located on private lands (see Table 2.1).

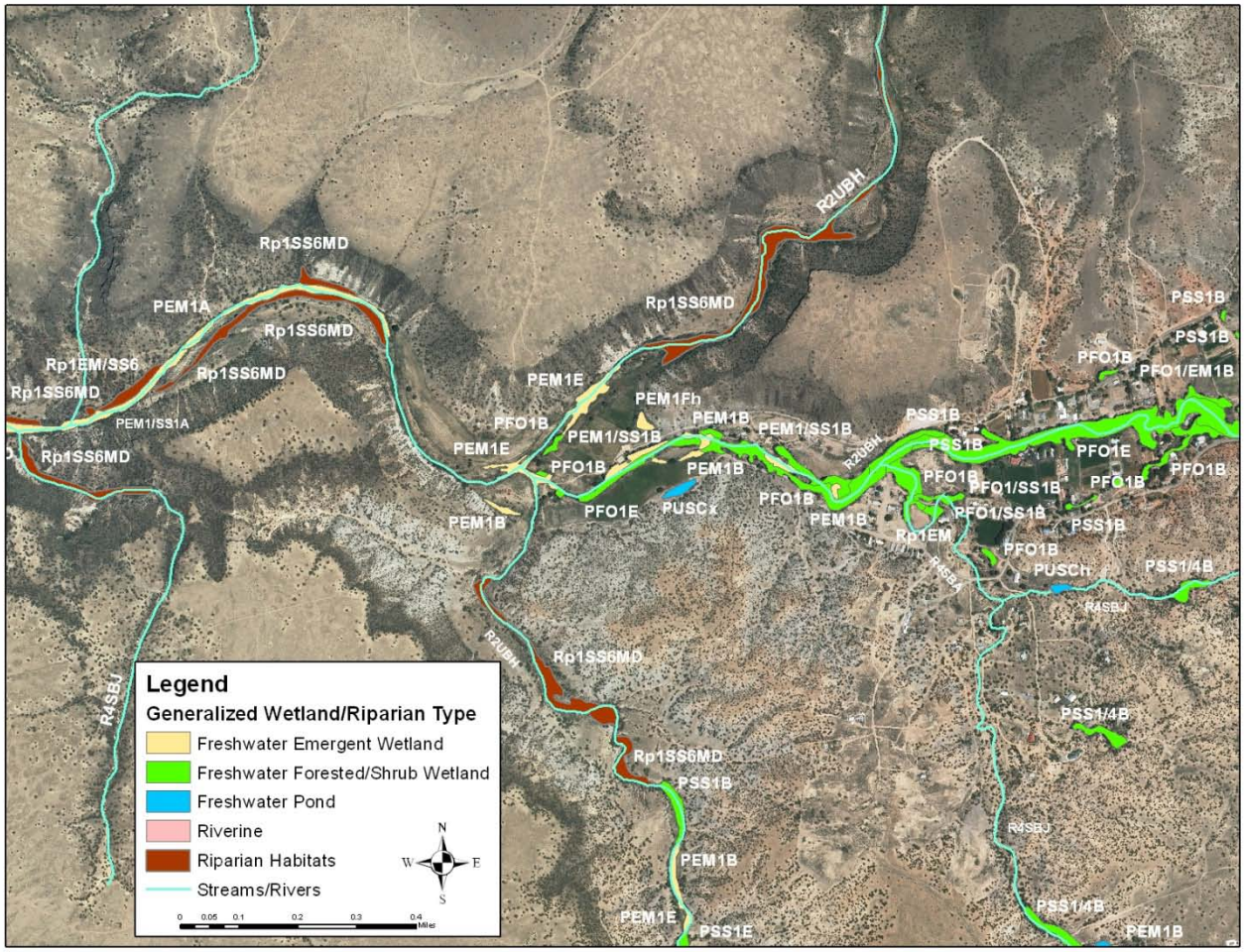


Figure 3.1. Example of a wetland mapping product by the U.S. Fish and Wildlife Service for a hydrogeological case study about wetlands and spring flows in the La Cienega Area (McGraw and Jansens 2012).

Wetlands are also protected under Federal environmental protection regulations and County and City development ordinances. The State of New Mexico has protective authority over wetlands through the State statutes referenced above and provides technical and financial incentives

programs to encourage landowners, NGOs (e.g., watershed groups), and local government agencies to document, restore, protect, and monitor wetlands. Federal wetland protection extends to all natural wetlands in Waters of the United States, as defined by the U.S. Army Corps of Engineers (ACE), that are delineated as jurisdictional or that are potentially jurisdictional (but not yet delineated) (Jones 1997). However, since the SWANCC ruling (Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers, 531 U.S. 159 (2001) [hereinafter SWANCC]), the protection of many isolated wetlands nationwide, and especially also many wetlands and arroyos in Santa Fe County, are subject to case-by-case ACE interpretation of the SWANCC ruling. SWANCC, therefore, is a significant source of regulatory uncertainty in the protection of wetlands in Santa Fe County.

It goes beyond the scope and scale of this WAP-SFC assessment to determine the exact number of jurisdictional wetlands or the acreage of wetlands in Santa Fe County. However, many wetlands in Santa Fe County are smaller than one acre and scattered across the landscape. Due to the largely rural and wilderness character of Santa Fe County, few wetlands have been officially delineated to determine their jurisdictional status. Jurisdictional wetlands in Santa Fe County have probably only been documented as a result of urban development and infrastructure projects and a few ecological restoration projects.

Federal Wetland Management in Santa Fe County

Federal agencies that have some regulatory responsibility or terrain management responsibility for wetlands in Santa Fe County include:

- U.S. Army Corps of Engineers: regulatory oversight of Clean Water Act Section 404 permitting regarding dredge and fill in waters of the United States, including wetland protection and mitigation of destruction brought upon wetlands due to public and private development and infrastructure projects (see below)
- USDI Bureau of Land Management (BLM): terrain management responsibility for wetlands and riparian areas on BLM lands (see below)
- USDI Bureau of Reclamation: terrain management responsibility for certain water bodies and water conservation initiatives, including initiatives under the Landscape Conservation Cooperatives program pertaining to Santa Fe County
- USDHS Federal Emergency Management Administration (FEMA): regulatory oversight of flood plains and disaster management support to insured local government entities (see below)
- USDI Fish and Wildlife Service: terrain management responsibility for wetland and riparian habitat, especially for habitat of threatened and endangered species
- USDA Forest Service: terrain management responsibility for wetlands and riparian areas on national forest lands
- USDA Natural Resources Conservation Service: terrain management responsibility for wetland restoration on private agricultural land

Army Corps of Engineers (ACE) – Section 10 of the 1899 Rivers and Harbors Act gives the ACE authority to regulate certain activities in navigable waters. Section 404 of the 1972 Clean Water Act and its amendments authorizes the ACE to issue permits regulating the discharge of dredge and fill material into wetlands and streams. Permits are subject to review and possible

veto by the U.S. Environmental Protection Agency (EPA), while the U.S. Fish and Wildlife Service has review and advisory roles. Section 401 grants to states and eligible Indian tribes the authority to approve, apply conditions to, or deny section 404 permit applications on the basis of a proposed activity's probable effect on the water quality of a wetland (Jones 1997). Many activities that affect small acreages or that involve particular kinds of construction or development activities are authorized under generic Section 404 "general permits" or "nationwide permits" with minimal scrutiny and standard conditions (Environmental Law Institute 2008).

In Santa Fe County, ACE manages the Galisteo Dam and Reservoir, west of the Village of Cerrillos. This flood and sediment control dam was completed in 1975 to prevent sediment caused by accelerated soil erosion in the Galisteo Basin to pollute waters of the Rio Grande. The dam also helped stem accelerated channel degradation in the Galisteo Creek. The dam was remodeled in 1998. The Galisteo Dam Reservoir includes several small wetlands at its southern fringes. Between 2008 and 2010, ACE removed several hundreds of acres of salt cedar in the Reservoir using goats and protected the wetlands from stray cattle grazing impacts with fencing.

BLM - In May 2012, BLM issued a new Taos Resource Management Plan (RMP) for its management area that covers north-eastern New Mexico including Santa Fe County (BLM 2012). This RMP does not specify any specific goals, targets, policies, or strategies (or "general management guidance" in terms of the RMP) regarding wetland restoration or protection in BLM's multi-county management area. However, the RMP addresses wetland management and protection measures in various sections regarding other resources and land uses. For example, in relation to fish and wildlife management, the RMP lists goals, objectives, and general management guidance for stream management. In relation to the management of vegetation communities, wetlands are addressed in relation to riparian areas with goals, objectives, and general management guidance that specify that BLM aims to maintain healthy watersheds and landscapes and plans to manage wetlands in ways that move toward or maintain Proper Functioning Conditions of wetlands for wildlife species. In relation to water management, the RMP specifies that BLM will maintain highly functioning water conditions regarding physical, chemical and biological parameters. The RMP also states that BLM will "restore, maintain, and preserve natural water fluctuations of flood plains", which typically are essential for healthy wetland functions. BLM plans also to maintain and develop partnerships to develop and implement watershed restoration projects and pursue funding opportunities to complete projects. Specifically, the RMP aims to have BLM reduce channel instability by 50% over the life of the RMP (no time span given). The RMP also includes specific general management guidance that will benefit wetlands regarding the removal of invasive species, livestock management, forest management, and the procedures for environmental assessments and impact statements. For example, the RMP states that BLM will where possible maintain livestock exclosures along streams and riparian and wetland areas. Additionally, BLM plans to maintain and establish "no surface occupancy", i.e., buffer zones, of 200 m (more than 600 feet) of the outer edge of the 100-year flood plain or potential riparian and wetland edges. For specific management areas, the RMP specified that wetlands will remain unavailable for livestock grazing. Wetlands must be considered and described in BLM's environmental assessments and environmental impact statements for projects such as land exchanges and forest management and thinning programs. Furthermore, the RMP states that "Bureau policy is to retain wetlands in Federal ownership

unless Federal, state, public and private institutions and parties have demonstrated the ability to maintain, restore, and protect wetlands and riparian habitats on a continuous basis (BLM Manual 6740)" (BLM 2012).

Bureau of Reclamation (BOR) – BOR operates a Riparian and Wetland research program located at Reclamation's Technical Service Center in Denver, CO, that combines numerous scientific and engineering disciplines to help understand and manage natural riparian and wetland ecosystems. These teams of experts are also involved in the design, construction, and operation of constructed wetland systems to provide for both water treatment and wildlife habitat. This program involves, and is not limited to, activities in (1) understanding and management of large water delivery and related systems for the protection of riparian plant and animal communities; (2) evaluation of environmentally sound techniques for wetland vegetation eradication or restoration; (3) proper design and operation of constructed wetlands for the improvement of water quality to non-point source pollution and wastewater effluent; and (4) proper selection of vegetation, planting schemes, and habitat features that are suitable for important wildlife and waterfowl species. The riparian and wetland research program includes cooperative efforts with other agencies including the U.S. Geological Survey's Fort Collins Science Center, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, State fish and game agencies, water resource agencies, universities, city and local departments, and private contractors. (http://www.usbr.gov/pmts/eco_research/eco3.html).

Federal Emergency Management Agency (FEMA) – Federal regulations overseen by FEMA also require local governments that have established FEMA endorsed flood management plans, such as the City of Santa Fe and Santa Fe County, to follow procedures for construction, including grading and ecosystem restoration activities, in nationally recognized and mapped floodplain areas (FEMA 2011).

Fish and Wildlife Service (FWS) – FWS oversees federal regulations for the protection of federally listed species and their critical habitat. FWS also operates grant programs that offer support to landowners for the restoration and protection of critical habitat, which often constitutes wetlands and riparian areas. FWS supports other federal and state agencies with expertise, mapping, and technical support for species and habitat protection. In Santa Fe County, FWS is specifically involved in the protection of wetland habitat for federally listed threatened or endangered species, such as the Southwest willow flycatcher and yellow-billed cuckoo. FWS has also been supporting a series of wetland and riparian habitat improvement projects in Santa Fe County under its Partners for Wildlife Program.

Forest Service (USFS) – USFS in responsible for the restoration, protection and day-to-day management of wetlands and riparian areas on national forest lands. In Santa Fe County, these include the mountain streams in the Sangre de Cristo Mountains and Jemez Mountains and the streams and wetlands on the Caja del Rio Plateau and Glorieta Mesa on the Santa Fe National Forest. Several of these streams located in USFS Wilderness Areas, such as the Santa Cruz River, have been designated in 2010 as Outstanding National Resources Waters (ONRW). ONRW streams and wetlands represent, for example, waters that are a significant attribute of the State's gold medal trout fishery, are in a designated wilderness area, are part of a designated wild river under the federal Wild and Scenic Rivers Act, or are of otherwise ecological significance.

ONRW streams and wetlands are entitled to the heighted protection under the New Mexico Water Quality Act and the surface water quality standards of the New Mexico Water Quality Control Commission (WQCC), and receive special protection from USFS under this title.

State Wetland Management in Santa Fe County
Several State agencies have some regulatory responsibility or terrain management responsibility for wetlands in Santa Fe County based on the State's role in the CWA Section §404 permit/§401 certification process. State agencies involved in wetland restoration and protection include:

- New Mexico Environment Department, Surface Water Quality Bureau (NMED/SWQB), Wetlands Program: manages the State's Wetlands Program and includes programmatic activities such as water quality data collection and management, water quality standards development, and watershed protection activities (see below)
- New Mexico Energy, Minerals and Natural Resources Department (EMNRD): the EMNRD Oil Conservation Commission oversees regulations that limit the impacts of oil and gas operations on water quality and wetlands in the State
- New Mexico Department of Transportation (NM DOT): responsible for avoidance, minimizing, and mitigation of impacts on wetlands as a result of infrastructure development
- New Mexico Department of Game & Fish: responsible for game and fish species management, including critical habitat and connective linkages, such as wetland and riparian areas

Surface Water Quality Bureau, Wetlands Program – The principal goal which informs the work of the SWQB Wetlands Program and its many public and private partners is a desire to restore and maintain wetlands, allowing them to fully function as natural systems. SWQB Wetlands Program and its partners are considering ways to achieve sustainability through potential funding, programs, and management activities such as wetlands banks and In Lieu Fee programs; through state-sponsored programs, such as the proposed Healthy Rivers Initiative; through partnerships associated with SWQB Wetlands Program's New Mexico Mapping Consortium and NGO and Agency Wetlands Roundtables; by continuing to obtain matching grants through foundations; by organizing and assisting voluntary programs; and by obtaining in-kind resources and assistance through the efforts of watershed groups and their volunteers.

SWQB Wetlands Program's priority technical goals within the next five years are to identify and maintain simple, effective and efficient methods for monitoring wetlands, and to work with Wetlands Program partners towards a complete inventory and baseline assessment of New Mexico's wetland resources. The Wetlands Program emphasizes the role of wetlands in prevention and reduction of water quality impairments and providing habitat and life requirements for wildlife. The state's regulatory program applies to all surface waters of the State including wetlands. Specifically, these regulations are permitting under CWA §402, certification of dredge and fill under CWA §401, establishing water quality standards under CWA §303(c) and reporting under CWA §§303(d) and 305(b). New Mexico's wetlands, including isolated wetlands, are incorporated within the water quality standards definitions and are considered "surface waters of the State" (20.6.4.7 NMAC).

Local Government Wetland Management in Santa Fe County
The City of Santa Fe and Santa Fe County have authority to regulate land uses in order to conserve and protect wetlands in the areas under their respective jurisdictions. Both City and County have staff and technical and mapping capabilities to conduct assessments and planning necessary for implementation of wetland restoration and protection measures.

Local government institutions that have some regulatory responsibility or terrain management responsibility for wetlands in Santa Fe County include:

- Santa Fe County: regulatory oversight based on ordinances and enforcement of County code regarding wetland and riparian area protection in Santa Fe County (see below)
- City of Santa Fe: regulatory oversight based on ordinances and enforcement of City code regarding wetland and riparian area protection in the City of Santa Fe (see below)
- City of Española: regulatory oversight based on ordinances and enforcement of City code regarding wetland and riparian area protection in the City of Española
- Town of Edgewood: regulatory oversight based on ordinances and enforcement of Town code regarding wetland and riparian area protection in the Town of Edgewood
- Santa Fe-Pojoaque Soil and Water Conservation District: management oversight of programs and projects undertaken under its responsibility for soil and water conservation and management in its service area
- Acequia Associations: management oversight of programs and projects undertaken under its responsibility for acequia infrastructure and water delivery in its service area
- Buckman Direct Diversion (BDD): management oversight of programs and projects undertaken under its responsibility for water delivery in its service area

Santa Fe County – Santa Fe County's regulations regarding wetland restoration and protection are described in the original Santa Fe County Land Development Code Ordinance No. 1980-6 (as amended), the Santa Fe County Land Development Code, Ordinance 1996-10, the Flood Prevention and Stormwater Management Ordinance of 2008-10, and a series of additional ordinances. Upon the adoption of a new Santa Fe County Sustainable Land Development Code (SLDC), the Flood Prevention and Stormwater Management Ordinance of 2008-10; the Santa Fe County Land Development Code, Ordinance 1996-10; together with all amendments thereto; and the original Santa Fe County Land Development Code Ordinance No. 1980-6 will be repealed in their entirety (Santa Fe County 2012).

Santa Fe County has several general management goals, policies and guidelines for wetlands restoration and protection. Some tentative policies and strategies are included in the May 2000 Santa Fe County Open Land and Trails Plan, the 2010 Water Conservation Plan, and the 2010 Sustainable Growth Management Plan.

The Santa Fe County Open Land and Trails Plan (Santa Fe County 2000) indicates that wetlands and streams are important natural resources which need to be protected. The plan specifically mentions the Santa Fe River, La Cienega Creek, La Cienega watershed and springs, wetlands in the Rio Tesuque, Rio Nambe, and Pojoaque River corridors, the Santa Cruz river, Rio en Medio and Rio Frijoles, wetlands in the Chimayo area, and the Galisteo Creek, San Marcos Arroyo, San Cristobal Arroyo, Alamo Creek, and Arroyo Calabasas as streams that need protection and more

study. The planning strategies section of the Open Land and Trails Plan defines several protection strategies for sensitive areas, beginning with Preserves (no public use), Conservation Areas (some public use), Regional Parks (public use), Agricultural Lands, Trail Corridors, and Buffer Areas (Santa Fe County 2000).

The Santa Fe County Water Conservation Plan (Santa Fe County 2010a) expresses a general goal of protecting the surface waters and wetlands in Santa Fe County. Additionally, the indirect results of proposed water conservation measures in this plan will help conserve groundwater supply, which will have an important beneficial effect on wetland function and health throughout Santa Fe County.

The 2010 Santa Fe County Sustainable Growth Management Plan (SGMP) expresses in general terms the County's goal to support programs that restore waterways and riparian areas. The Resource Conservation Element (Section 5) states as a planning principle for the County (in "Keys to Sustainability") that "open space, riparian areas, vegetative and wildlife habitat areas and corridors must be protected to support biodiversity. Wildlife habitats provide food, water, space and cover for the protection, hiding and reproduction of individual species" (Santa Fe County 2010b). In the same section, the SGMP observes that "floodplain and stream connectivity are major elements in maintaining healthy riparian habitat and off-channel habitats for the survival of fish species and conveyance of floodwaters. If rivers, floodplains and other systems are not viewed holistically as biological, geomorphological units, this can lead to serious degradation of habitat and increase flood hazards, which, in turn, can contribute to listing of various fish species as threatened or endangered and result in extraordinary public expenditures for flood protection and recovery. Frequently flooded areas, including the 100-year floodplain and the floodway, are mapped on Flood Insurance Rate Maps, or FIRMs. Many areas of the County are inadequately mapped, and improving mapping data is critical to supporting preservation of important environmental areas and preventing natural hazards." The SGMP also observes that "buffer zones should be created along riparian corridors and significant topographical and cultural features that are susceptible to the negative impacts of soil erosion. Development sites must include features to limit stormwater run-off during construction and operation, such as vegetative buffers and limited site disturbance. Improvements to all roads should employ strong erosion control measures during construction and use." Furthermore, the SGMP states that "preservation of connected open space and riparian corridors is a key element of wildlife protection." The SGMP formulated specific policies regarding this point: Policy 20.3 states that Santa Fe County must preserve and protect wildlife habitat, migration corridors, riparian areas and surface water resources that support wildlife health. The SGMP's Water Element (Section 10) includes Policy 42.29: "Protect and preserve riparian areas and recharge zones" (Santa Fe County 2010b).

At the time of completion of this WAP-SFC, the County's Land Use Code is being updated. However, the Public Review Draft of September 2012 of the Santa Fe County SLDC offers only a few limited protections to wetlands and riparian areas. Building forth on the policy intentions of the SGMP, more attention must be given in the code to buffer zones and setbacks in relation to wetlands and riparian areas as well as to water quality issues, biodiversity protection, and measures to encourage infiltration. Also more work needs to be done to provide code language that link groundwater extraction to spring and wetland monitoring and mitigation.

The City of Santa Fe - The City of Santa Fe regulates wetland restoration and protection in Chapter 14 (Land Development) of the City Land Use Code, which was updated in late 2011 and early 2012 (http://clerkshq.com/default.ashx?clientsite=Santafe-nm). Specific code is spread over several articles and sub-sections, such as Article 14-5 Overlay Zoning, 14-7.5 Open Space Standards, 14-8.2 Terrain and Stormwater Management, 14.8.3 Flood Regulations, 14-8.4 Landscape and Site Design, and 14-8.15 Dedication and development of land for parks, open space, trails, and recreation facilities. Together this body of code is meant to offer guidelines that call for respect for, and protection, maintenance, and restoration of groundwater recharge, wildlife habitat, linkages between areas of ecological importance, drainage ways, wetlands, bosques, riparian areas, flood plains, and steep slopes, among other areas of concern. Several sections of the code also mention buffers and setbacks to allow for protective areas between development and flood zones, wetlands, and arroyos. However, no details on specific buffer zone dimensions are provided. Much of the implementation details and applicability of the code is left to the discretion of the City Engineer and City Planning staff. For example, the Code states that the City Engineer may require development setbacks for arroyos, water courses, and streams of less than 100 cfs in at least a 1 percent chance event[1]. The Code also offers guidelines for the application of water conservation measures, such as xeriscaping, drought tolerant landscape design, and water harvesting. Therefore, in principle, the City Code is set up to implement and enforce many necessary wetland restoration and protection measures and to accommodate more stringent wetland restoration and protection measures through staff discretionary action and/or through more detailed regulations, terrain management requirements, and possible future code amendments, if needed, to prevent future deleterious impacts from climate change and urban development on wetlands.

3.3. Information Gaps

Since the inception of a more systematic approach to wetland restoration and protection in New Mexico and in Santa Fe County 25 years ago, much has been accomplished, as described in previous sections. However, much remains to be done. There still are considerable gaps in information for effective wetland restoration, protection and management in Santa Fe County. Some of the most important information gaps include:

Wetland Assessments: Few wetlands have been documented with a formal wetland assessment. SWQB recently completed the NM Rapid Assessment Method (RAM) for montane riverine wetlands (Muldavin et al. 2011a, 2011b), and is planning to document montane wetlands in Santa Fe County using the RAM in the near future. Until that time, the information gap on wetlands in Santa Fe County includes detailed ecological conditions, specific wetland functions, protected status, ownership, restoration work performed, wetland acreage, buffer zone conditions, surrounding land use, planned land use in the area, and the need and feasibility of restoration and protection.

Mapping: This WAP-SFC does not include a map of wetlands in Santa Fe County, because until this time resources have been inadequate to develop a reasonably complete wetland locations

[1] This statement may be an error in the City Code; it probably should read: "…and streams of **more** than 100 cfs in at least a 1 percent chance event."

map. However, wetland mapping is underway for certain areas in Santa Fe County, and when completed these maps will offer a first look at the locations and types of wetlands across parts of the County. The need remains to develop a map of all existing and historical wetland resources in Santa Fe County, if possible with details on exact wetland locations and dimensions, ecological conditions, wetland functions, protected status, ownership, restoration work performed, wetland acreage, buffer zones, surrounding land use, planned land use in the area, and potential need and feasibility of restoration and protection.

General information about specific wetlands is needed regarding their functions, ecosystem services, vulnerability, and priority for protection or restoration. Very little information is available about wetlands in the following areas:

1. Wetlands associated with lakes, bogs, and headwater streams in the Sangre de Cristo Mountains (streams flowing into the Pecos River and streams flowing into the Rio Grande)
2. Rio Cundiyo
3. Rio Santa Cruz
4. Rio Grande tributaries between Black Mesa and Buckman
5. Cañada Ancha
6. Rio Grande riverine wetlands
7. Rio Grande tributaries from Caja del Rio

4. Wetlands Action Planning

4.1. Wetland Restoration and Protection Strategy

4.1.1. Summary of Needs

The future of wetlands in Santa Fe County depends on whether they continue to receive water, support hydrophytes, and/or maintain hydric soils. In other words: whether they stay wet, remain green, and/or have typical wetland soils. There is a concern that for many years proper functioning of most wetlands in Santa Fe County has been severely under siege of the forces of a changing climate and urban development pressures, combined with inappropriate land use and inadequate stewardship practices and the cumulative effect of centuries of land and water use impacts across the County. Without intervention, many wetlands in Santa Fe County may degrade further and some may disappear altogether in the next few decades, and with their demise the community will lose the many natural benefits these ecosystems provide.

Additionally, wetlands and riparian areas in Santa Fe County could be considered "key-stone" ecosystems (in laymen's terms "canaries in the coal mine") that offer signals of dwindling wetland functionality due to declining surface water and groundwater discharge into the wetlands and/or water quality impairments. Decline of water supply and water quality is of general concern to the well being of the community in Santa Fe County, because such declines will have serious implications for available drinking water, public health and sanitation, and area-wide ecosystem stability and productivity.

The following **physical wetland conditions** will direct the future restoration and protection of wetlands in Santa Fe County:

1. Surface and groundwater discharge into wetlands has to be ensured into the future
2. Wetland vegetation has to be protected from environmental stressors and human induced damage and removal; wetland habitats must remain connected by maintaining and protecting ecological linkage systems across the landscape for the flow of water, the movement of wildlife, and the dispersal of native plants
3. Wetland soils have to be protected from pollution, erosion, massive siltation, and drying due to highly fluctuating water tables

These conditions can be achieved with the following **environmental planning principles and strategies**:

A. The enabling (institutional) environment for wetland restoration and protection must be strengthened through research, assessments, mapping, establishment of standards, development of regulations, institutional capacity building, public education, development of financing strategies and funding sources, capacity building for ongoing restoration projects, enforcement, monitoring, and evaluation.
B. Storm water management and infiltration must be improved, especially on flood plains and on alluvial soils, and in (ex/sub)urban, industrial, and rangeland areas and along

infrastructure corridors and resource extraction areas, in order to increase soil stability (erosion control and sediment retention) and vegetation cover

C. Stream channels must be restored to protect riverine wetlands from dewatering and erosion
D. Buffer zones must be developed to protect wetland functions and conditions along all riparian areas and wetlands across the landscape
E. Connective ecological linkage systems across the landscape must be developed and protected in buffer zones and along the stream network
F. Natural fire regimes and wildlife communities must be restored in forests, woodlands, and rangelands
G. Research must be undertaken to increase the general understanding about processes related to aquifer recharge and groundwater discharge in wetlands and to assess the possibilities of discharging treated effluent and gray water into wetlands.

4.1.2. Goals and Objectives

This section outlines a program of goals and objectives (actions) for Santa Fe County wetlands in order to protect and restore physical wetland conditions and in order to develop and apply environmental planning principles and guidelines to meet these physical wetland conditions. Table 4.1 provides an overview of goals and objectives for wetland management in Santa Fe County for the period 2012-2020 (and beyond), to be coordinated by the SWQB Wetlands Program in collaboration with Santa Fe County. The table is organized in four sections according to EPA's four core elements of a wetlands program:

- assessment and monitoring
- regulations
- restoration and protection
- standards

(http://www.epa.gov/owow/wetlands/initiative/cefintro.html). The goals build upon the Five-year goals and objectives of the Wetlands Program Plan for New Mexico (SWQB 2011).

Table 4.1. Goals and Objectives for Wetland (a) Monitoring and Assessment, (b) Regulations, (c) Restoration and Protection, and (d) Standards in Santa Fe County for the next decade and beyond.

Monitoring and Assessment

Goal 1: Complete the information base-line about wetlands for Santa Fe County.			
#	**Objective/Action**	**Time Frame**	**Lead and Partners**
1.1	Complete assessments of wetland ecosystem conditions and ecosystem functions in Santa Fe County.	ongoing	Watershed groups and NGO partners
1.2	Complete wetland mapping in Santa Fe County.	ongoing	SWQB and U.S. FWS, universities, and NGO partners
1.3	Establish a program for periodic updates on growth projections of the County's population, the urban development impact on wetlands, water diversion changes due to development, and the impacts of climate change and other ecological processes on wetlands.	TBD	Santa Fe County and City of Santa Fe, SWQB, universities, and NGO partners
1.4	Establish a web-based database for wetlands in Santa Fe County (e.g., in collaboration with TPL's national GIS database of conservation lands).	TBD	Santa Fe County, universities, and NGO partners

Goal 2: Establish a monitoring program for data upkeep on status and trends of existing wetlands in Santa Fe County and share and disseminate findings.			
#	**Objective/Action**	**Time Frame**	**Lead and Partners**
2.1	Collect base-line data on wetlands; periodically measure (changes in) status and trends of threatened wetland in Santa Fe County.	Ongoing	SWQB and universities and NGO partners
2.2	Translate findings into policy recommendations to protect wetlands from any degrading impacts and update WAP.	Ongoing and TBD for future continuation	Watershed groups, universities and NGO partners
2.3	Collaborate with other federal and state agencies and tribal and local governments to share monitoring data in support of wetland protection.	Ongoing and TBD for future collaboration	Watershed groups and federal, state, tribal , and local governments, universities and NGO partners
2.4	Monitor specific ecological processes, such as reduced surface water and groundwater recharge of aquifers and wetland areas, increased evapotranspiration, ecological changes in headwaters of streams, and other cumulative and landscape-wide impacts on wetlands.	TBD – when funds become available	Santa Fe County and universities and federal, state, and local governments and NGOs
2.5	Monitor natural adaptive responses in wetlands to urban and ecological impacts.	TBD – in ten year intervals	Santa Fe County and universities and federal, state, and local governments and NGOs
2.6	Identify and pursue funding sources and other sources of support for government agencies, NGOs, and contractors to perform more continuous and long-term monitoring.	Ongoing	Watershed groups and Santa Fe County and universities and NGO partners

Regulations

Goal 3: Identify Santa Fe County as the pilot area to adopt statewide procedures and strengthen processes that protect wetlands through regulatory measures.			
#	**Objective/Action**	**Time Frame**	**Lead and Partners**
3.1	Support the development and enforcement of regulatory instruments in Santa Fe County and the City of Santa Fe for storm water retention, increased infiltration, and the establishment of buffer zones around wetlands and riparian areas.	Ongoing with periodic updates; Santa Fe County SLDC to be adopted in 2013	Santa Fe County and City of Santa Fe and SWQB, local NGOs and concerned residents
3.2	Formulate policies and code to restore and protect wetlands, streams and flood plains, reduce land fragmentation, and connect fragmented ecosystems for Santa Fe County and the City of Santa Fe.	Ongoing with periodic updates; Santa Fe County SLDC to be adopted in 2013	Santa Fe County and City of Santa Fe and SWQB, local NGOs and concerned residents
3.3	Explore feasibility, find sites, and identify mitigation options and sponsors for the development of an In Lieu Fee Services Program for the Santa Fe County area.	Ongoing	US Army Corps of Engineers and NGO partners and SWQB

Goal 4: Support federal, state, tribal, and local government agencies in the enforcement of regulations and in offering comments in public review processes of proposed actions that potentially impact wetlands in Santa Fe County.			
#	**Objective/Action**	**Time Frame**	**Lead and Partners**
4.1	Encourage federal, state, tribal, and local land management agencies to enforce their regulations that protect wetlands.	Ongoing	Watershed groups, private entities and local government and NGO partners

Restoration and Protection

Goal 5: Achieve restoration and protection of high priority wetlands by 2020.			
#	**Objective/Action**	**Time Frame**	**Lead and Partners**
5.1	Create a prioritization list for wetlands that need to be restored and/or protected	2013-2014	Watershed groups, NGOs and local government agencies, universities, and contractors
5.2	Establish a County-wide water authority or watershed group that takes on responsibility for wetland protection	2013-2014	Watershed groups, NGOs and local government agencies, contractors
5.3	Identify sources of funding for the restoration and protection of wetlands following the guidelines of the priority scheme for wetland restoration and protection in Santa Fe County.	2012-2020	Watershed groups, NGOs and federal, state, tribal and local government agencies, universities, and contractors
5.4	Establish and update the prioritization list as needed.	Ongoing	Watershed groups, NGOs and appropriate partners
5.5	Collaborate with government agencies and the local land trust movement to establish conservation easements and other land protection measures for the investments made in wetland restoration.	2012-2020	Watershed groups, NGOs and local Land Trusts, U.S. Fish & Wildlife Service and NRCS
5.6	Benefit from large projects such as the NAWCA grant if/when funded and IWJV support to leverage achievement of wetland restoration and protection goals in Santa Fe County and to build local capacity.	2012-2014 and following years	NM Wildlife Federation, NM State Conservation Partnership, NAWCA, IWJV, and SWQB and other government and private partners

Goal 6: Further develop and support the institutional capacity for wetland restoration and protection in Santa Fe County.			
#	**Objective/Action**	**Time Frame**	**Lead and Partners**
6.1	Pursue better coordination and collaboration between local water management agencies, e.g., by pioneering a local water management authority for Santa Fe County.	TBD/Ongoing	NGOs, Santa Fe County, City of Santa Fe and Soil and Water Conservation District, acequias, BDD, and SWQB
6.2	Continue to support and grow the local NGO community's capacity through meetings, project collaboration, and by sharing lessons learned among NGOs and contractors from across the nation.	Ongoing: twice yearly roundtable meetings	SWQB and federal, state, tribal and local government agencies, universities, contractors, and NGOs
6.3	Continue to support and grow the capacity of government agencies and tribes regarding wetland management expertise through meetings and project collaboration.	Ongoing: twice yearly roundtable meetings	Watershed groups, NGOs and federal, state, tribal and local government agencies
6.4	Identify and pursue new funding sources and funds for wetland restoration and protection and seek collaborative partnership funding models.	Ongoing	SWQB, NGOs, and federal, state, tribal and local government agencies, universities, and contractors
6.5	Encourage greater capacity and responsibility in the Santa Fe County government for wetland restoration and protection through designated staffing, development of local funding sources, and active County participation in regional water planning and plan updates.	Ongoing	Santa Fe County and NGOs and City, state, and federal government agencies

Goal 7: Educate the public and develop public support, buy-in, and a donor base for wetland restoration, and develop wetland stewardship through an Adopt-a-Wetland program.			
#	**Objective/Action**	**Time Frame**	**Lead and Partners**
7.1	Continue to develop strategies for working with private landowners and offer incentives and educate them about relevant wetland ecosystem services as benefits of wetland restoration and protection.	Ongoing	NGO partners and SWQB, local and tribal government agencies

Goal 7 (Cont.): Educate the public and develop public support, buy-in, and a donor base for wetland restoration, and develop wetland stewardship through an Adopt-a-Wetland program.			
7.2	Continue to refine information on economic justification and other economic values of wetland restoration and protection, and identify opportunities for payment for ecosystem services programs.	Ongoing	NGO partners and universities, and federal, state, local and tribal government agencies
7.3	Continue to cultivate private charitable donors for wetland restoration and protection.	Ongoing	Watershed groups, NGOs
7.4	Continue to educate the public to offer support for wetland restoration and protection through respectful land and water use and through conservation and stewardship behavior and initiatives.	Ongoing	SWQB and NGO partners and universities, and federal, state, local and tribal government agencies
7.5	Target schools and youth for wetland protection by developing an Adopt-a-Wetland-Program (modeled after the science education program of the Santa Fe Girls School)	2013/2014 and thereafter	SWQB and NGO partners and schools

Standards

Goal 8: Develop water quality standards for wetlands with those in Santa Fe County as a case study for meeting this goal across the State of New Mexico.			
#	**Objective/Action**	**Time Frame**	**Lead and Partners**
8.1	Develop water quality standards for riverine wetlands associated with the proposed water quality standards modification for the Galisteo Basin.	TBD: 2013-2020	SWQB and Santa Fe County and NGO partners
8.2	Develop water quality standards for slope wetlands based on the findings of the geohydrology study for the La Cienega area (McGraw and Jansens 2012).	TBD: 2013-2020	SWQB and Santa Fe County, OSE, NMBGMR, and NGO partners
8.3	Apply anti-degradation policies to protect Outstanding National Resource Waters (ONRW) wetlands, and develop strategies to fully protect and maintain conditions and functions of ONRW wetlands in Santa Fe County.	Ongoing	SWQB and U.S. Forest Service and NGO partners

4.1.3. General Management Guidelines

The following section offers more detail to the environmental planning principles and strategies listed above, which serve as the means ("tools") of achieving the proposed goals and objectives.

A. The enabling environment

An enabling, institutional environment for resource management consists of:

(1) the legal basis and regulatory authority for resource management, including authorities for enforcement and for levying fees, fines, and taxes
(2) standards, procedures, regulations, and governmental management capacity for implementation of wetland restoration and protection measures
(3) financing systems and financing infrastructure for resource management
(4) knowledge systems and non-governmental institutional capacity to support, implement, and maintain resource management programs.

Legal Basis and Regulatory Authority

The legal basis and regulatory authority for wetland restoration and protection in New Mexico and Santa Fe County are scattered over many different agencies and different levels of government. Therefore, wetland management requires careful coordination and cooperation between the many parties involved. However, there are legal and regulatory mechanisms in place that can help streamline resource management processes. For example, municipalities, Santa Fe County, Soil and Water Conservation Districts (SWCD), and Acequia Associations have the status of independent, local governments based on New Mexico statutes. They are authorized to levy fees, fines, and taxes, and they are eligible to apply for specific state and federal funding for governments. They are representation-based, democratic, local institutions, and can act on behalf of local beneficiaries to require various forms of payment from local beneficiaries for ecosystem services offered to beneficiaries provided by the natural resources under their management. The establishment of a local water management authority as an intergovernmental panel from City, County, SWCD, and acequia organizations, potentially with their own elected board, could be pioneered in Santa Fe County to centralize and strengthen the action power for water management and wetland restoration and protection in the future (Objectives 5.2 and 6.1).

Standards, Procedures, Regulations and Government Capacity

As was outlined in Chapter 3, there is an extensive body of standards, procedures, regulations (code), and government capacity in place for wetland restoration and protection among various government agencies with authority in Santa Fe County. Collaboration and information exchange are essential to ensure the effectiveness of this capacity while it is scattered among agencies (Objective 6.1). For example, the City of Santa Fe and Santa Fe County have similar philosophies and principles about terrain management, but there still are many differences in how their individual codes regulate and guide these principles. Ongoing City-County collaboration and information exchange in this field is essential to facilitate wetland restoration and protection work in the City-County transition zone, including the annexation areas and future County Sustainable Development Areas that benefit from City infrastructure and water resources and that impact the same watershed ecosystems.

The effectiveness of the proposed interventions of this WAP-SFC would be greatly enhanced if Santa Fe County had it own designated natural resource staff for planning and management responsibilities regarding wetland and riparian areas and associated habitats. Following an example in Socorro, it is conceivable that in collaboration with New Mexico Game & Fish, the Fish and Wildlife Service, the USDA Natural Resources Conservation Service, and other institutions, funds could be made available for such staffing at the County level while also ensuring staff coordination with State and Federal resource management agencies. Additionally, it would be beneficial to Santa Fe County and its goals toward implementing the Santa Fe County Sustainable Growth Management Plan if County staff could be more involved in supporting regional water planning updates and regional wetland restoration and protection initiatives (Objective 6.5).

There is a potential role for SWQB in offering assistance to the City and County governments as well as to the U.S. Forest Service, BLM, NM DOT, and State Land Office, with information about terrain management guidelines and standards (discussed below), wetland water quality standards (to be developed) (Objectives 8.1-8.3), wetland assessment and mapping (underway), and regarding CWA Section 401 certification (Objective 4.1) and the potential for developing an In Lieu Fee Services Program for Santa Fe County (Objective 3.3; see Appendix D).

Financing Systems and Financing Infrastructure

There are no specific, locally-based financing systems or programs for wetland restoration and protection in Santa Fe County or the City of Santa Fe. However, capital improvement funds in Santa Fe County, such as the County General Obligation (GO) Bonds—periodically approved by County voters—and the special County Capital Outlay Gross Receipts Tax—approved around 2002 for 1/4%—can potentially be used for wetland and riparian area restoration and protection. Additionally, Santa Fe County can obtain funding through a special appropriation by the State Legislature. In recent years, the Capital Outlay Gross Receipts Tax Fund was around $8 million to $10 million annually. However the future of these funds is uncertain (Kathleen Holian, personal communication August 2012). Santa Fe County annually allocated a part of its Capital Outlay Gross Receipts Tax Fund for open space and natural resource conservation efforts, such as the programs overseen by the County Open Space & Trails Division for Santa Fe River restoration and for open space and trails acquisition and maintenance. The County Open Space & Trails funds have been variable based on revenues and annual fund allocations by the County Open Space & Trails Division (Beth Mills, personal communication September 2012) (Objectives 5.3 and 6.4).

In addition, the City of Santa Fe and Santa Fe County occasionally propose capital improvement bonds for specific open space or natural resource conservation issues. While they are highly political, these bond issues are a potential local method for generating funding for wetland restoration and protection. To date no specific wetland restoration and protection bonds have been issued. However, given the dire need and urgency for generating funding for wetlands, this source of funding may need further consideration. Additionally, SWCD and Acequia Associations have the power to collect fees and raise funds for water retention, infiltration improvements, and other water management programs that benefit their agricultural constituencies, and which, indirectly may be of great benefit to wetlands and springs associated with local water sources for agricultural operations (e.g., acequias) (Objectives 5.3 and 6.4).

Until and unless water management in Santa Fe County is addressed at a regional scale (watershed or hydrological unit) through an independent, democratically elected regional water management board, financing for wetlands through fees and taxes levied on all residents may be difficult to realize. However, some experiments are underway to include special resource conservation fees to the water bills of City of Santa Fe's Sangre de Cristo Water Division customers, such as the recent $3 stormwater surcharge and the special water supply fees which cover costs of the BDD as well as management expenses for the Upper Santa Fe Watershed in the Sangre de Cristo Mountains. Additional fees are being researched, such as a fee for a Living River (to finance 1,000 afy of environmental flow in the Santa Fe River) and a fee for the conservation of water for habitat protection of the silvery minnow in the Rio Grande (Objectives 5.2, 6.1, and 6.4).

An alternative, potential future financing system for wetland restoration and protection may be found in developing payment for ecosystem services (PES) schemes (Objectives 6.4 and 7.2). Currently, the most promising PES financing schemes for wetlands are based on wetland mitigation trading or banking (see below), water quality trading (based on NPDES permits; see Appendix A, Section A.5 and Table A.2), and biodiversity trading (based on mitigation of habitat for listed species; see Appendix A, Sections A.7 and A.8). However, various institutional barriers are in the way of making such financing schemes successful in New Mexico at this time. A brief overview of options is included in Appendix D.

Finally, financing infrastructure to provide outlays of capital for water and wetland restoration initiatives through specialized banks and loan funds is entirely absent but sorely needed in Santa Fe County. Many NGOs have experienced ongoing financing challenges for grants that require upfront cash outlays. Further investigations may be useful with the New Mexico Finance Authority and the New Mexico Water Trust Board and other financing infrastructure programs to identify possibilities for the development of special natural resource restoration and protection loan funds and capital management institutions that can facilitate the flow of funds among institutions specialized in wetland restoration and protection (Objective 6.4).

<u>Knowledge Systems and Non-Governmental Institutional Capacity</u>

The SWQB Wetlands Program serves as the central repository of knowledge and communication regarding wetland restoration and protection in New Mexico and Santa Fe County. Through pilot projects, assessments, mapping, and wetland round table meetings with NGOs and government agencies, the SWQB Wetlands Program builds institutional capacity, collaborative opportunities, and staff capacity in Santa Fe County and beyond. In this way, SWQB exchanges and develops a shared knowledge base among the various partners for wetland restoration and protection (Objectives 2.1-2.3 and 6.1-6.5). Likewise, the program coordinates and oversees wetland monitoring and reporting for internal purposes and for purposes of reporting to EPA. Currently, SWQB also participates in public education regarding wetlands in Santa Fe County. Further assistance from NGOs and Santa Fe County in these fields will be necessary in the future to expand the reach of SWQB in the County's communities (Objectives 7.1-7.5).

B. Storm water management and infiltration

Central to the long-term restoration and protection of wetlands and their ecological functions are policies and techniques to increase the infiltration of precipitation across floodplains and alluvial

soils, and across the landscape from the mountains to the Rio Grande Basin. As evaporation will be the greatest factor in projected losses of available fresh water, and increasingly so with a changing climate, a systemic increase of infiltration of precipitation could over time offset anticipated losses.

Urban growth is expected to result in increased rates of rapid runoff unless storm water harvesting, retention, and infiltration techniques are promulgated and realized throughout Santa Fe County. Storm water retention will help increase wetland acreage and vegetation cover on the land and reduce the loss of wetland areas downstream. Upstream storm water retention in forests, woodlands, rangelands, in urban neighborhoods, and in alluvial headwaters (arroyos and streams) is essential to increase infiltration of water in the shallow aquifer and support gradual discharge downstream in arroyos and the Santa Fe River. Additionally, storm water infiltration in arroyos and the Santa Fe River is likely to increase recharge of alluvial aquifers and discharge in downstream spring areas, such as those in La Cienega (McGraw and Jansens 2012).

Water harvesting may also offset the need for the use of drinking water for landscape irrigation, and thus, reduce people's dependency on groundwater reserves. Together with ongoing water conservation strategies that further reduce the regional use of groundwater, a campaign for County-wide storm water capture and infiltration would probably be one of the most promising strategies for the survival of wetlands and riparian area in Santa Fe County (Objectives 3.1 and 3.2).

Based on recent findings documented by McGraw and Jansens (2012), additional research and monitoring projects across Santa Fe County would be useful to identify strategies to prevent the drying of spring-fed wetlands and seeps. Such studies may help decision makers in determining the role of storm water infiltration and associated actions to restore wetland functions across areas that were hydrologically modified by groundwater withdrawal (Objectives 2.4 and 8.2).

C. Stream channels

Wetlands can be protected from the impacts of erosive water forces and mass deposition of sediment by restoring stream channels to arrive at optimal flood water and sediment conveyance and storage. Restored streams and flood plain areas that allow a dynamic stream to access its entire natural flood plain will help attenuate high peak flood volumes and associated scouring energy. Restored flood plains typically lead to increased infiltration capacity, water retention, and alluvial storage (Zeedyk and Clothier 2009). These processes will help offset the expected reductions in infiltration and groundwater recharge and increased water losses due to evapotranspiration under urban development and climate change. Stream channels and floodplain areas can be restored using some of the following practices, as appropriate for site specific conditions:

- Abandoning old entrenched channels and rerouting channels/rechanneling the stream (see Figures 4.1 and 4.2).
- Removing old (natural or man-made) levees and connecting old floodplain areas and oxbows to the channel (see Figure 4.3).
- Opening multiple (old) channels across alluvial fans and broad flood plains to accommodate floods of different magnitudes.

- Replacing the standard one or two culverts under roads with a battery of smaller culverts to accommodate broader flood flows under roads (see Figure 4.4).
- Working with NM DOT and other road management institutions to widen bridge spans and increase the design volumes of bridge structures.
- Building grade controls in incised channels (see below) to lift the water level and induce overbank flows (see Figures 4.5 and 4.6).
- Restoring natural meandering patterns.

Figure 4.1. (Left): Example of an entrenched meander channel that undermined and dewatered a wetland upstream of the Arroyo de los Angeles in the Galisteo Basin (viewing upstream).
Figure 4.2. (Right): View of the same channel after rerouting the channel, building a new bank and terrace on river right (left in the picture) and widening the flood plain.

Figure 4.3. (Left): Natural levees on river right were removed along the Cañoncito Arroyo (Eldorado Community Preserve) to allow flood waters to flow through a wider passage, thus reducing degrading scour in the channel and increased access of flood waters to the flood plain.
Figure 4.4. (Right): The City of Santa Fe installed a battery of culverts in the Arroyo de la Piedra to allow for broader flood passage and reduce channel degradation.


Figure 4.5. (Left): A series of rock cross vanes in Cañoncito Arroyo (Eldorado Community Preserve) wetlands raised the grade of the stream and made point bars, the flood plain and adjacent riverine wetlands accessible to lower level (more frequent) floods.

Figure 4.6. (Right): A series of rock cross vanes and one-rock dams more downstream in Cañoncito Arroyo (Eldorado Community Preserve) wetlands raised the grade of the stream and made the flood plain accessible to lower level floods and enlarged the wetland acreage in the area.

Additionally, small grade control structures can assist in achieving water retention across flood plains. Often a series of structures is needed to maintain the grade over a certain distance (Figure 4.6). Drop structures are typically best located and designed in association with natural grade controls ("nickpoints"), and are needed also to bridge grade differences to downstream areas that are not treated. Current examples of such structures in Santa Fe County can be found in the headwaters of Arroyo Saiz in the Estancia Primera neighborhood, in the headwaters of the Arroyo de los Pinos north of Museum Hill, in the Cañoncito Arroyo along County Road 51 in the Eldorado Community Preserve, and in the San Marcos Arroyo wetlands west of Highway 14, south of Lone Butte (see also Figures 4.7 through 4.10).

Figure 4.7. (Left): One-Rock-Dam and rock rundown in Arroyo Saiz in Santa Fe (looking upstream). Photo by Earth Works Institute 2010.

Figure 4.8. (Right): Cross vane with A-brace in the Arroyo de los Pinos at the Santa Fe Botanical Garden site on Museum Hill (looking upstream).


Figure 4.9. (Left): Large filter dam in the Cañoncito Arroyo in the Eldorado Community Preserve (looking upstream). Photo by Earth Works Institute 2011.
Figure 4.10. (Right): Large cross vane (background) and on-rock-dam (foreground) in the San Marcos Arroyo wetlands (looking upstream). Photo by Earth Works Institute 2011.

Ultimately, the reestablishment of beaver in wetlands will offer natural solutions to grade control and stormwater retention, spreading and infiltration. Examples of the successful effect of beaver on wetland functions can be found at the Twomile Reservoir in the Santa Fe River (see Figure 4.11), off of Upper Canyon Road, and in the Santa Fe River downstream from the Wastewater Treatment Plant (Objective 5.7).

Finally, the removal of water intensive, invasive and exotic hydrophytes and the revegetation of stream areas with suitable native species is an important stream channel restoration technique that may benefit streamside wetlands and downstream wetlands. Stump treatment with herbicide or stump removal is often essential, however, for the long-term success of hydrophyte removal and the effective conservation of water for nearby wetlands.

Regulations for flood plain management may not always be consistent with and supportive of the goals of wetland restoration. FEMA regulations can be restrictive to floodplain modifications, as FEMA regulations restrict flood level increases, which are typically beneficial to the restoration of wetland and riparian functions. Santa Fe County's flood zone regulations, enacted in 2008, are also very restrictive to the effective restoration of wetlands. However, the County's flood zone regulations are being modified under the new SLDC, which is expected to take effect in 2013 or later, and will likely allow more proactive wetland management (Objectives 3.1 and 3.2).

D. Buffer zones

Buffer zones are of great importance to reduce disturbances and pollution from neighboring areas on wetlands and riparian areas. Presently, few wetlands and riparian areas in Santa Fe County are protected by buffer zones. Policies must be developed to provide buffer zone protection along all riparian areas and wetlands across the landscape in Santa Fe County (Objective 3.1). Besides through policy and planning, buffers could also be developed through voluntary land protection agreements (a.k.a. conservation easements) on public and private lands (Objective 5.5).

Figure 4.11. Reestablishing and maintaining beaver colonies in Santa Fe County wetlands (such as in the Twomile Reservoir – this photo) may considerably boost the adaptive capacity of wetlands, offering natural solutions to grade control and stormwater retention, spreading, and infiltration.

Wetland buffers will enable local communities to protect themselves from known hazards associated with climate change, such as extreme runoff and flood events from heavy storms, by altering the infiltration and conveyance capacity of stormwater in and around natural wetland systems. Buffers could also moderate the effects of drought and protect private and public property. Buffers serve as wildlife corridors, helping animals reach other areas, especially in times of ecological change (Environmental Law Institute 2008). Buffers may also help in capturing sediment and ashes after forest fires followed by high runoff events.

The City of Santa Fe and Santa Fe County do not have explicit policies or ordinances regarding buffers. Therefore, this WAP-SFC recommends the City and County to develop wetland and riparian area buffer ordinances. The publication "Planner's Guide to Wetland Buffers for Local Governments" (Environmental Law Center 2008) describes in detail what elements such ordinances may include and offers case studies to help local governments identify details and experiences to craft the best suitable ordinance for their community.

Reasons for developing wetland buffer ordinances besides natural resource protection and ecosystem conservation may include hazard avoidance and public health and safety concerns. Specific purposes relevant to the Santa Fe County community may include water pollution prevention (preservation of water quality), wildlife habitat improvement (protecting and improving biodiversity and preventing undesirable wildlife-human interactions), enhancing opportunities for natural infiltration and groundwater/aquifer recharge, and creating a safe buffer between development and the source of potential flood risks related to rapidly increasing and unforeseen cumulative storm water runoff effects due to climate change and urban development (a contingencies buffer in urban planning). Important for the Santa Fe County community may also be that buffers could contribute to maintaining the scenic beauty of the landscape (Environmental Law Institute 2008), thereby preserving the character of the community, the quality of life for residents and visitors in Santa Fe County, and corresponding property values.

For the City of Santa Fe, a wetland buffer ordinance could conceivably be added as a separate sub-section in Chapter 14 of the recently revised and updated Land Use Code and/or as an expansion of the definitions of protected areas described in 14.5.9 Ecological Resource Protection Overlay District (City of Santa Fe Ord. No. 2006-61 § 2). For Santa Fe County, a wetland buffer ordinance could be included as part of the County's SLDC. We suggest that wetland buffer ordinances specify that the ordinances pertain to all wetlands and riparian areas as defined by the SWQB Wetlands Program. An exclusive focus on only jurisdictional wetlands (as defined by the U.S. Army Corps of Engineers), or wetlands of a minimum size would be ineffective because it would disqualify most of the wetlands in Santa Fe County. The ordinances should describe clearly what activities are allowed and disallowed in the defined buffer areas as well as in the adjacent areas.

Buffer size necessary to provide a particular level of function depends on the functions of the wetland, the wetland's relative sensitivity (as influenced by water retention time and other factors), the characteristics of the buffer, the intensity of adjacent land use, and watershed characteristics (Environmental Law Institute 2008). Buffer distances for water quality improvement should be greater in areas of steep slopes and high intensity land use, or where the chance of serious impacts from urban runoff or forest fire is higher than normal. Buffers of 50 feet and larger tend to show fewer signs of human disturbance. Buffer effectiveness increases with increasing buffer width while relative maintenance cost decrease with increasing buffer width. Buffers for pollution prevention vary for different kinds of pollutants. Buffers for sediment or phosphorus pollution prevention are typically most effective between 30-100 feet or more; for nitrogen pollution buffering, areas of 100-164 feet or more are most effective. Therefore, generally, buffers should be at least 50 feet wide, and buffers of 100-300 feet or more are preferred. For wildlife habitat purposes, buffer width of up to 600 feet may be desirable for mammals. For certain reptiles and amphibians core habitat and buffer areas of up to 950 feet are reported desirable or at least the core habitat size plus a 164–foot buffer zone. Buffer zones for birds are highly variable by bird species and habitat type, but these areas may range from 49 feet and up to 5,000 feet or more for certain birds (Environmental Law Institute 2008).

E. Connective ecological linkage systems

In order to reduce or mitigate fragmentation of habitat and to provide for continuous flood zones, wetlands and riparian areas must ideally be connected across the landscape in connective

ecological linkages. Where possible, such stream and wetland linkage zones must be developed and protected with buffer zones. Ecological connectivity is important to maintain genetic diversity among species, offer species safe passage ways across the landscape, and allow wetlands and riparian areas to expand with increased availability of water in the system. Ecological linkage areas will also contribute to increased flood control and safety, increased visual quality of the landscape, and local outdoor recreation opportunities (Objective 3.2).

F. Natural fire regimes and wildlife communities

Where possible, natural fire regimes must be restored in forests, woodlands, and rangelands to prevent catastrophic wildfire and allow for low to the ground, natural ("cool") fires. Natural fire regimes will encourage optimal ground covering under story vegetation for soil stabilization and ecological resilience. In turn, these ecological conditions will optimize conditions for maximum storm water infiltration across the landscape (Objective 5.5).

Additionally and in concert with natural fire regimes, land management measures that support natural wildlife populations and opportunities for animals to roam freely will generally support wetland and riparian habitat. This would include the restoration of predators in the ecosystem to keep ungulate populations in check. It would also include the restoration of habitat for beaver to restore natural ecosystem dynamics along streams and in wetlands (Objective 5.5).

G. Research

More research is needed to better understand the aquifer recharge process in relation to mountain front infiltration and infiltration in streams, arroyos and alluvial soils in the upper and central parts of Santa Fe County watersheds. Additionally, more research is needed to increase the understanding of the relationships between aquifer recharge due to infiltration in the upper and central parts of the County and aquifer discharge in springs, seeps and wetlands downstream, in the western parts of the County (Objective 2.4).

Concerning wetland mitigation with imported water, research must be undertaken about the use of treated effluent and gray water to recharge valuable wetlands in an artificial way, as is currently happening in wetlands along the Santa Fe River below the Wastewater Treatment Plant. Specifically, research will have to assess the effectiveness and feasibility of these water sources to keep wetlands watered while benefiting from water purification functions of wetlands to improve water quality downstream (Objectives 2.1-2.6).

4.2. Conceptual Action Plan

4.2.1. Prioritization of Wetland Restoration and Protection

Priority Criteria

All wetlands in Santa Fe County are important and deserve to be protected and restored. Yet, from a practical point of view, case by case and from year to year choices will have to be made about which wetland areas will get priority for treatment. Such prioritization choices are most practically achieved by looking at the diversity and intensity of stressors that impair the natural functioning conditions of individual wetlands and the practical feasibility of implementing certain restoration and protection measures. A tentative overview of stressors for selected

wetlands was provided in Table 2.6. The primary feasibility criteria for ranking wetland sites by order of priority for treatment are summarized in Table 4.2. At the end of this chapter, Table 4.3 lists a selection of wetlands and riparian area that should be considered for restoration and protection based on Table 2.6 and other data.

The proposed feasibility ranking process is based on the process developed for the Galisteo WAP (SWQB 2010a) and the Galisteo Watershed Conservation Initiative (Jansens et al. 2011). At this time, insufficient data are available about individual wetlands in Santa Fe County to propose a detailed prioritization ranking and complete a feasibility prioritization process (Objectives 5.1-5.4).

Table 4.2. Primary Feasibility Criteria for Ranking Wetland Sites in Order of Priority for Treatment (to be expressed in high-medium-low).

Criteria	Description
1. Wetland function	Restoration and/or protection will enhance key wetland functions
2. Wetland ecosystem services	Estimated wetland value to society
3. Cumulative, landscape wide value	The impact value of any local wetland restoration and protection work on connective habitats linkages across the landscape
4. Open space protection and buffer zone development	Presence or potential of leveraging open space protection and buffer zone development (e.g. through conservation easements or a local government ordinance) in ways that the project expands existing open space, corridors, and buffer zones
5. Landowner interest and support	The project site is under ownership of landowners or under stewardship or management of land managers who are willing and able to support the implementation and long-term stewardship of the proposed restoration and/or protection project, are willing and able to provide a matching contribution to the project (if necessary) by means of monetary or in-kind support, assistance with monitoring, public education, and demonstration and outreach functions
6. Clear ownership title	The project area has clear ownership title
7. Community preferences/support	The community or neighbors to the wetland/riparian area are supportive of the proposed project
8. Technical feasibility	The site offers technically feasible opportunities for planning, design and implementation of the project (e.g., the site is accessible, and site rehabilitation or protection is technically, financially, and legally feasible within the means of the project)
9. Maintenance and follow-up feasibility	The landowners and the physical site offer the possibility and/or likelihood of practical and affordable maintenance and follow-up
10. Financial self-sufficiency	The restoration and protection of the wetland and/or riparian areas and buffer zones has a great likelihood of contributing to the local economy and/or to the financial well being of the landowner(s) over time in such a way that it is likely that the area will remain or can be kept in good ecological health and under sufficient protection

4.2.2. Public Involvement

A goal of the WAP-SFC is to increase public involvement in wetland restoration and protection in Santa Fe County. Presently, the following initiatives for public involvement are underway:

- Completion and of a Technical Guide for wetland restoration and protection in Santa Fe County
- Completion of a hydrogeological study of wetlands in the La Cienega Area with important information for agricultural producers in the area, and dissemination of research findings through a brochure and community meetings (McGraw and Jansens 2012)
- A public education campaign for the restoration and protection of wildlife habitat and connective linkage areas, TrekWest, which is scheduled to visit Santa Fe County in late June 2013, and which will highlight several wetland areas
- Public outreach regarding a new NAWCA grant and IWJV grant for the Rio Grande corridor in New Mexico, including parts of Santa Fe County (Objective 5.5)

Strategies for public involvement in the coming years will need to bring wetlands closer to the public. Opportunities to achieve this and to overcome barriers related to the abstract, regulatory and bio-technical aspects of wetland restoration and protection may be found in focusing on the natural benefits of wetland ecosystem functions in support of ensuring local water supplies, wildlife habitat, and connective linkages across the landscape. Additionally, opportunities must be pursued to include youth in public involvement for wetland restoration and protection, as exemplified by the successful education program of the Santa Fe Girls School in connection with a wetland site along the Santa Fe River below the Wastewater Treatment Plant. Inspired by the outdoor science education program of the Santa Fe Girls School at wetlands in the Santa Fe River, the SWQB Wetlands Program would like to establish an Adopt-a-Wetland program that targets targeting schools and youth regarding wetland protection and restoration initiatives. In addition, public education opportunities through local NGOs should be sustained and enhanced, especially in order to reach youth. Institutions such as the New Mexico Audubon Society, the Santa Fe Watershed Association, New Mexico Wildlife Federation, River Source, and WildEarth Guardians, play an important role in offering public outreach and education and specific student-oriented programs that can help grow people's affinity for and connection with Santa Fe County wetlands in the future (Objectives 7.1-7.5).

4.2.3. Monitoring

Monitoring wetland restoration and protection work helps identify wetlands degradation and stressors and measures success of implemented wetland restoration and protection projects. Additionally, monitoring data can be analyzed to be used in data to action reports for educational purposes, for adaptive management, and in future wetland restoration and protection actions.

Past and ongoing project monitoring initiatives for wetland restoration and protection in Santa Fe County included those developed for individual pilot projects in the San Marcos Arroyo, the Cerrillos Hills State Park, and the Arroyo Hondo wetlands by contractors and Santa Fe County staff. Monitoring components included an approved Project Quality Assurance Project Plan

(PQAPP), monitoring reports with findings and photo series, and findings and observations by UNM students during the course of the project.

Future monitoring needs are summarized in Table 4.1 (Objectives 1.1-1.4 and 2.1-2.6). The recommended monitoring initiatives revolve around monitoring of wetlands status and trends, especially in threatened wetlands, in order to prioritize protection and restoration measures (Objectives 2.1-2.6). Wetland monitoring should specifically include tracking of wetlands gains, losses and conditions throughout Santa Fe County, as part of a response to the urgent statewide need to track wetlands gains, losses and conditions. SWQB will partly address this need by further implementing the NM RAM program and by working with individual project partners for the restoration and protection of specific wetlands in Santa Fe County.

Tracking wetland gains and losses also affect other initiatives, such as the creation and protection of wildlife linkages across Santa Fe County and beyond and the restoration of bird—especially waterfowl—habitat along the Rio Grande corridor. Santa Fe County and statewide NGOs are pursuing initiatives to preserve wildlife and migration corridors that are of (inter)national and regional significance. The protection of all aquatic systems in the Santa Fe County area is of vital importance to the wildlife linkage preservation initiatives. Additionally, monitoring will be important to support and guide a new long-term initiative of the New Mexico Wildlife Federation together with a broad partnership of public and private institutions for bird habitat protection along Rio Grande with support through the North American Wetlands Conservation Act (NAWCA) and the Intermountain West Joint Venture (IWJV) (Objectives 2-1-2.6 and 5.6).

4.2.4. Wetlands Action Plan Schedule and Timeline

Several tangible activities and initiatives for wetland restoration and protection in Santa Fe County are already underway and will be expanded with other initiatives in 2013 and following years, as outlined in the overview of goals and objectives in Table 4.1. A summary of WAP-SFC-related actions in support of the goals and objectives includes:

2012

- Complete restoration of Arroyo Hondo wetlands and springs and slope wetlands in the Cerrillos Hills State Park (Shooting Gallery Arroyo and Escalante Springs)
- Complete monitoring of San Marcos Arroyo wetlands
- Complete a hydrogeological study of the La Cienega Area wetlands and springs in order to gain a better understanding of groundwater discharge in wetlands in Santa Fe County
- Disseminate the Wetlands Action Plan for Santa Fe County
- Complete a Technical Guide for Wetland Restoration and Protection in Santa Fe County

2013

- Complete restoration of riverine and slope wetlands along the Galisteo Creek in the Village of Galisteo, along Padre Springs on Glorieta Mesa, in the Romero Arroyo near Valencia, and in San Marcos Arroyo, and along the Rio Grande at Buckman
- Begin implementation of NAWCA grant phase 1, apply for funding for phase 2, and prepare proposal components for the implementation phase (phase 3)

- Pursue applications for financial support for ongoing stewardship work and monitoring, e.g., through development of pilot projects for Payment for Ecosystem Services (PES)
- Continue success monitoring of restored sites
- Complete mapping and assessments of wetlands in Santa Fe County
- Facilitate and/or assist with formulation of wetland protection regulations and terrain management guidelines for the Santa Fe County Sustainable Land Development Code

2014 and Beyond

- Complete restoration of more acres of wetlands and riparian areas throughout the Santa Fe County (sites TBD)
- Complete success monitoring of all restored sites
- Pursue applications for financial support for ongoing stewardship work and monitoring: Implementation of pilot projects for Payment for Ecosystem Services (PES)
- Reassess feasibility of an In Lieu Fee Program
- Identify key wetland sites for reference standard, rare and endangered species, waterfowl and other important habitat features
- Conduct a condition assessment of wetland sub-classes in Santa Fe County
- Develop a trends monitoring initiative involving County and private citizens
- Train volunteers to monitor wetland sites
- Develop database and website
- Continue to define and safeguard wetland buffers through conservation easements and by local government ordinances to maintain wetland function and permanence
- Continue to participate in local community planning initiatives that help protect wetland resources
- Continue to work with County and City floodplain managers to coordinate activities that protect and restore floodplains

Table 4.3 lists a selection of wetlands and riparian areas that should be considered for restoration and protection in the period of 2013-2030. The wetlands are listed by watershed area (not by priority), and for each wetland a suggested restoration time frame is offered (2013-2020 or 2020-2030). The list is based on the wetland status assessment summarized in Table 2.6, an assessment of ten major arroyos in the Santa Fe Watershed (Santa Fe Watershed Association 2012), combined with the author's knowledge of certain wetlands, riparian areas and arroyos throughout Santa Fe County.

Table 4.3. List of Wetlands and Riparian Areas to be considered for restoration and protection between 2013 and 2030 as part of this WAP.

Watersheds and Wetland Areas	Suggested Wetland/Riparian Area Assessments, Mapping, Restoration, and Protection				Time Scale of Initiatives	
	1: Assessment needed	2: Mapping needed	3: Restoration needed	4: Protection needed	2013-2020	2020-2030
Rio Cundiyo-Santa Cruz						
headwater springs	X	X	X	some areas	x	x
El Potrero wetlands	X	X	X		x	x
Pojoaque-Tesuque-Nambe						
Big Tesuque Creek	X	X	some areas	some areas	x	x
Rio Tesuque wetlands	X	X	X	X	x	x
Rio Grande tributaries						
Black Mesa-Buckman	some areas	some areas	some areas	some areas	x	x
Caja del Rio springs	X	X	X	X	x	x
Canada Ancha						
Caja del Rio Canyon	X	X	X	X	x	x
Santa Fe River						
Arroyo de los Chamisos	partial	X	select areas	select areas	x	x
Arroyo Rosario	partial	X	X	X	x	x
Arroyo Saiz	partial	X	X	X	x	x
Arroyo Mora	partial	X	lower reach	X	x	x
Arroyo Cabra	partial	X	lower reach	X	x	x
Arroyo en Medio	partial	X	select areas	select areas	x	x
Cañada Ancha	partial	X	X	X	x	x
Arroyo de los Pinos	partial	X	select areas	select areas	x	x
Arroyo de la Piedra (E+W fork)	partial	X	X	X	x	x
SF River below Frenchie's	in progress	in progress	X	X	x	x
SF River below WWTP			some areas	some areas	x	x
Cieneguilla	some areas		X	X	x	x
(Upper) Arroyo Hondo	X	X	X	X	x	x
Cienega Creek Area	some areas		some areas	some areas	x	x
Bonanza Creek	some areas		some areas	some areas	x	x

Watersheds and Wetland Areas	Suggested Wetland/Riparian Area Assessments, Mapping, Restoration, and Protection				Time Scale of Initiatives	
	1: Assessment needed	2: Mapping needed	3: Restoration needed	4: Protection needed	2013-2020	2020-2030
Galisteo Creek						
Valencia wetlands	some areas	some areas	design ready	X	x	x
Deer Creek	X	X	X	X	x	x
Apache Ridge	X	X	some areas	some areas		x
Cañoncito wetlands	some areas	some areas	some areas	some areas		x
Galisteo mainstem	X	X	X	X	x	x
San Cristobal playa	X	X	X	X		
Other GBP wetlands	some areas	some areas	some areas	some areas		x
Arroyo Salado	some areas	some areas	some areas	some areas		x
Padre Springs	some areas	some areas	some areas	some areas		x
San Cristobal Arroyo	X	X	X	X		x
Arroyo la Jara	X	X	X	X		x
Finger Lakes			thinning		x	x
Coyote Springs	X	X	X	X		x
Canada de los Alamos			design ready	X	x	x
Gallina Arroyo	some areas	some areas	some areas	some areas		x
San Marcos Arroyo	some areas	some areas	some areas	some areas		x
Hwy 14 springs	X	X	X	X		x
Cerrillos Hills springs			thinning			x
Mailbox Rd Arroyo	X	X	X	X		x
Upper Pecos headwaters						
various headwaters	in progress	in progress	some areas	some areas		x
Glorieta Creek	in progress	in progress	some areas	some areas		x
Arroyo Tonque						
various springs	X	X	X	X		x
Estancia Basin						
Big Lake Playa	X	X	X	X		x
White Lakes	X	X	X	X		x

References[2]

Arellano, Juan Estevan. 2012. *La Cuenca y La Querencia, The Watershed and the Sense of Place in the Merced and Acequia Landscape,* In: Jack Loeffler and Celestia Loeffler (eds.). 2012. Thinking Like a Watershed, Voices from the West. University of New Mexico Press.

Bauer, P.W., B.S. Kues, N.W. Dunbar, K.E. Karlstrom, and B. Harrison (eds.). 1995. *Geology of the Santa Fe Region*, New Mexico Geological Society, Forty-Sixth Annual Field Conference, September 27-30, 1995.

Benedict, M.A. and E. T. McMahon. 2006. Green Infrastructure: Linking Landscapes and Communities. The Conservation Fund, Island Press, pp 142-146.

BLM. 1994. Surface Management Status. New Mexico – Taos, Los Alamos, Santa Fe, Albuquerque, Villanueva. 1:100,000-scale topographic map. United States Department of the Interior Bureau of Land Management.

BLM. 2012. Taos Resource Management Plan. May 2012. U.S. Department of the Interior. Bureau of Land Management, Taos Field Office, New Mexico. BLM/NM/PL-12-09-1610.

Boykin, Kenneth G. 2010 (Draft). Mapping Conservation Priority Indices at Broad Scales in the American Southwest. New Mexico State University, Las Cruces, NM.

Boykin, Kenneth G., Rachel K. Gray, and Michael T. Calkins. 2009. Santa Fe County Wildlife Habitat GIS Modeling: Workshop and Conservation Priorities. Center for Applied Spatial Ecology, New Mexico State University, Las Cruces, NM.

Brinson, M.M. 1993. A Hydrogeomorphic Classification for Wetlands, prepared for U.S. Department of Army, Corps of Engineers, Technical report; WRP-DE-4, 110 pp.

Cadmus Group, Inc., The. 2011. Evaluation of Hydrologic Alteration and Opportunities for Environmental Flow Management in New Mexico. October 2011. U.S. EPA Contract # EP-C-08-002.

City of Santa Fe. 2011a. Chapter 14 (Land Development) of the City Code. http://clerkshq.com/default.ashx?clientsite=Santafe-nm.

City of Santa Fe. 2011b. WaterSMART Basin Study Proposal: City of Santa Fe and Santa Fe County, New Mexico. Bureau of Reclamation WaterSMART Program Initiative. Santa Fe, New Mexico.

Costanza, et al. 1997. *The Value of the World's Ecosystem Services and Natural Capital,* Nature 387:253-260 (1997).

[2] References are listed for the entire report, including the appendices.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service, Washington, DC. FWS/OBS 79/31, 103 pp.

Dahl, T.E. 1990. Wetlands-Losses in the United States, 1780's-1980's. Washington, D.C., U.S. Fish and Wildlife Service Report to Congress, 13 pp.

DeBuys, W. 1985. Enchantment and Exploitation. The Life and Hard Times of a New Mexico Mountain Range. University of New Mexico Press, Albuquerque, NM.

DeBuys, W. 2011. A Great Aridness. Climate Change and the Future of the American Southwest. Oxford University Press, New York, NY.

Ditzler, Joe. 2011. *City Growth Mostly in Southwest,* Albuquerque Journal/Journal on Sunday. July 24, 2011.

Duke Engineering & Services. 2001. Water supply study, Jemez y Sangre Water Planning Region, New Mexico. Prepared for the Jemez y Sangre Water Planning Council. January 2001.

Earth Works Institute. 2005. Watershed Restoration Action Strategy for the Galisteo Creek Watershed. An Adaptive Management Plan for the Ecological Health of the Galisteo Watershed, In partial Fulfillment of CWA Section 319(h), New Mexico Environment Department, Surface Water Quality Bureau.

Environmental Law Institute. 2008. Planner's Guide to Wetland Buffers for Local Governments. ELI Project Number 0627-01, Washington, D.C.

EPA. 2003. Final Water Quality Trading Policy. U.S. Environmental Protection Agency, Office of Water. Water Trading Policy January 13, 2003. http://water.epa.gov/type/watersheds/trading/finalpolicy2003.cfm

EPA. 2004. Water Quality Trading Assessment Handbook. Can Water Quality Trading Advance Your Watershed Goals? U.S. Environmental Protection Agency. EPA 84-B-04-001, November 2004.

FEMA. 2011. Flood Insurance Study. Santa Fe County, New Mexico, and Incorporated Areas. U.S. Federal Emergency Management Agency. Preliminary February 18, 2011. Flood Insurance Study Number 35049CV001B.

Foreman, David, Kathy Daly, Reed Noss, Matt Clark, Kurt Menke, David R. Parsons, and Robert Howard. 2003. New Mexico Highlands Wildlands Network Vision. Connecting the Sky Islands to the Southern Rockies. Wildlands Project and New Mexico Wilderness Alliance.

Gangopadhyay, Subhrendu, and Tom Pruitt. 2011. West-Wide Climate Risk Assessments: Bias Corrected and Spatially Down-Scaled Surface Water Projections. U.S. Department of the Interior Bureau of Reclamation, Water and Environment Resources Division (86-68200). Technical Memorandum No.86-68210-2011-01. Denver, CO, March 2011.

Glick, P., B.A. Stein, and N.A. Edelson (eds.). 2011. Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment. National Wildlife Federation, Washington, D.C.

Grant, Susan, and Lisa Shoaff. 2007. Santa Fe River, New Mexico, Water Management Plan Study. Hydrologic and Hydraulic Assessment Appendix. U.S. Army Corps of Engineers, Albuquerque District, November 2007.

Griffith, G.E., J.M. Omernik, M.M. McGraw, G.Z. Jacobi, C.M. Canavan, T.S. Schrader, D. Mercer, R. Hill, and B.C. Moran. 2006. Ecoregions of New Mexico (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,400,000).

Grimm, Julie Ann. 2012. *City may need to tap water wells; low levels in reservoirs, Rio Grande could spur pumping*, Santa Fe New Mexican, July 4, 2012.

Gutzler, David S. and Tessia O. Robbins. 2010. *Climate variability and projected change in the western United States: regional downscaling and drought statistics,* Climate Dynamics, 34:10.1007/s00382-010-0838-7.

Gutzler, David S. 2012. *The Earth Is Getting Warmer,* In: Lewis, Amy C., Karen MacClune, and Kari Tyler. 2012 (*Draft/in press*). Preliminary Assessment Report: Climate Change and the Santa Fe Watershed. DRAFT, June 27, 2012. U.S. Bureau of Reclamation WaterSMART Program Initiative. City of Santa Fe, Santa Fe County, Santa Fe, New Mexico.

Howe, W.H., and F.L. Knopf. 1991. *On the imminent decline of Rio Grande cottonwoods in central New Mexico,* The Southwestern Naturalist, v.36, no.2, pp. 218-224.

Hurd, B.H. and J. Coonrod. 2008. Climate Change and Its Implications for New Mexico's Water Resources and Economic Opportunities. New Mexico State University, Agricultural Experiment Station, Technical Report 45, Las Cruces, NM. 28 pp.

Jansens, J.W., W. Dorshow, and R. Peterson. 2011. Galisteo Watershed Conservation Initiative: Quality of Life at a Crossroads. Earth Works Institute and Santa Fe Conservation Trust in Partnership with Earth Analytic, Inc., August 2011.

Jemez y Sangre Water Planning Council. 2003. Jemez y Sangre Regional Water Plan, March 2003.

Jensen, Martin A. 1983. Shelterbelt Effects in Tropical and Temperate Zones. IDRC-MR80e. Manuscript Reports.

Johnson J.B. 2005. Hydrogeomorphic Wetland Profiling: An Approach to Landscape and Cumulative Impact Analysis (US EPA Jan. 2005) (EPA/620/R-05/001).

Johnson, Peggy, Daniel Koning, and Stacy Timmons. 2012. *Geology and Hydrogeology of Wetlands and Springs. New Mexico Bureau of Geology and Mineral Resources,* Section 4, In: McGraw, M.M. and J.W. Jansens (eds.). 2012. Exploring Springs and Wetlands and Their Relationship with Surface Flows, Geology, and Groundwater in the La Cienega Area, Santa Fe County, New Mexico. Wetlands Program Project Report, New Mexico Environment Department, Surface Water Quality Bureau.

Jones. B.D. 1997. *New Mexico Wetland Resources,* In: National Water Summary – Wetland Resources. U.S. Geological Survey, Albuquerque, NM. pp. 285-289.

Kleindl, B. 2005. *HGM for Colorado and Rio Grande Headwater Riverine Wetlands,* Power point presentation for Jicarilla Apache HGM development, December 2005, Durango, NM.

Kusler, Jonathan, et al. 2003. A Guidebook for Local Governments: Wetlands and Watershed Management, Association of State Wetland Managers, Berne, New York.

Lewis, Amy C., Karen MacClune, and Kari Tyler. 2012 (*Draft/in press*). Preliminary Assessment Report: Climate Change and the Santa Fe Watershed. DRAFT, June 27, 2012. U.S. Bureau of Reclamation WaterSMART Program Initiative. City of Santa Fe, Santa Fe County, Santa Fe, New Mexico.

McGraw, M.M. and J.W. Jansens (eds.). 2012. Exploring Springs and Wetlands and Their Relationship with Surface Flows, Geology, and Groundwater in the La Cienega Area, Santa Fe County, New Mexico. Wetlands Program Project Report, New Mexico Environment Department, Surface Water Quality Bureau.

Milford, E., T. Neville, and E. Muldavin. 2009. Galisteo Watershed: Wetlands Map for the Santa Fe Growth Management Strategy, Natural Heritage New Mexico Publ. No. 09-GTR-336. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 12 pp.

Miller, R.C. and J.B. Zedler. 2003. *Responses of Native and Invasive Wetland Plants to Hydroperiod and Water Depth,* Plant Ecology, 167:57-69.

Mitsch, W.J. and J.G. Gosselink. 1993. Wetlands, 2nd ed., John Wiley, New York.

Mitsch, W.J. and J.G. Gosselink. 2000a. Wetlands, 3rd ed., John Wiley, New York.

Mitsch, W.J. and J.G. Gosselink. 2000b. *The value of wetlands: Importance of scale and landscape setting,* Ecological Economics 35(200) 25-33. Special Edition: The Value of Wetlands: Landscape and Institutional Perspectives, Elsevier Science B.V.

Mitsch, W.J. and J. G. Gosselink 2007. Wetlands, 4th ed., John Wiley & Sons, New York.

Muldavin, E.H., B. Bader, E.R. Milford, M. McGraw, D. Lightfoot, B. Nicholson, and G. Larson. 2011a. New Mexico Rapid Assessment Method: Montane Riverine Wetlands. Field Guide Version 1.1. Final report to the New Mexico Environment Department, Surface Waters Quality Bureau, Santa Fe, New Mexico, 39 pp. and appendices.

Muldavin, E.H., B. Bader, E.R. Milford, M. McGraw, D. Lightfoot, B. Nicholson, and G. Larson. 2011b. New Mexico Rapid Assessment Method: Montane Riverine Wetlands. Manual Version 1.1. Final report to the New Mexico Environment Department, Surface Waters Quality Bureau, Santa Fe, New Mexico, 90 pp. and appendices.

National Association of Conservation Districts (NACD). 2009. New Opportunities for Conservation Districts. Markets, Trading and Credits. Supplement to the *Resource, July 2009,* Washington, D.C. www.nacdnet.org.

New Mexico Department of Game and Fish. 2006. Comprehensive Wildlife Conservation Strategy For New Mexico. New Mexico Department of Game and Fish. Santa Fe, New Mexico, 526 pp. and appendices.

New Mexico Energy, Minerals, and Natural Resources Department (EMNRD). 1988. New Mexico wetlands priority conservation plan. Albuquerque, New Mexico. EMNRD State Park and Recreation Division, 78 pp.

Novitzki, R.P., R.D. Smith, and J.D. Fretwell. 1993. *Restoration, Creation, and Recovery of Wetlands, Wetland Functions, Values, and Assessment,* In: National Water Summary on Wetland Resources**,** United States Geological Survey Water Supply Paper 2425.

Phillips, Jeffrey D. and V.J.S. Grauch. 2004. Thickness of the Santa Fe Group sediments in the Española Basin south of Santa Fe, New Mexico, as estimated from aeromagnetic data. USGS. MS 964, Federal Center, Denver, CO 80225, Open-File Report, 2005-1354.

Postel, S. and B. Richter. 2003. Rivers for Life. Managing Water for People and Nature. Island Press.

Prior-Magee, J.S., K.G. Boykin, D.F. Bradford, W.G. Kepner, J.H. Lowry, D.L. Schrupp, K.A. Thomas, and B.C. Thompson (eds.). 2007. Southwest Regional Gap Analysis Project Final Report. U.S. Geological Survey, Gap Analysis Program, Moscow, ID.

Robles, M.D. and C. Enquist. 2010. Managing changing landscapes in the Southwestern United States. The Nature Conservancy, Tucson, Arizona, 26 pp.

Santa Fe County. 2000. Open Lands and Trails Plan. For the Wildlife, Mountains, Trails, and Historic Places Program, Draft 2 – Adopted. Santa Fe, New Mexico.

Santa Fe County. 2010a. Santa Fe County Water Conservation Plan 2010. Santa Fe County Water Conservation Program, Santa Fe, New Mexico.

Santa Fe County. 2010b. Santa Fe County Sustainable Growth Management Plan 2010. Growth Management Department, Santa Fe, New Mexico.

Santa Fe County. 2012. Santa Fe County Sustainable Land Development Code, Public Review Draft, September 2012. Growth Management Department, Santa Fe, New Mexico.

Santa Fe Watershed Association. 2012. Arroyo Assessment Surveys of 10 Major Arroyos in the Santa Fe Watershed. November 16th, 2012. Report to the Public Works Department, City of Santa Fe 2012.

Schneider, S.H., S. Semenov, A. Patwardhan, I. Burton, C.H.D. Magadza, M. Oppenheimer, A.B. Pittock, A. Rahman, J.B. Smith, A. Suarez, and F. Yamin. 2007. *Assessing key vulnerabilities and the risk from climate change. Climate Change 2007: Impact, Adaptation and Vulnerability.* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson, (eds.), Cambridge University Press, Cambridge, U.K. pp. 779-810.

Scott, J.M., F. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'Erchia, T.C. Edwards, Jr., J. Ulliman, and R.G. Wright. 1993. *Gap analysis: a geographical approach to protection of biological diversity,* Wildlife Monographs 123.

Scott, J.M., J.J. Jacobi, and J.E. Estes. 1987. *Species richness: a geographic approach to protecting future biological diversity,* BioScience 37:782-788.

Scott, J.M., T.H. Tear, and F.W. Davis (eds.). 1996. *Gap analysis - a landscape approach to biodiversity planning,* American Society of Photogrammetry and Remote Sensing, Bethesda, MD.

Smith D. R., A. Ammann, C. Bartoldus, and M.M. Brinson. 1995. An approach for Assessing Wetland Functions Using Hydrogeomorphic Classification, Reference Wetlands, and Functional Indices. Technical Report WRP-DE-9, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, NTIS No. ADA307 121.

SWQB. 2010a. Wetlands Action Plan for the Galisteo Watershed. New Mexico Environment Department, Surface Water Quality Bureau, Wetlands Program, Santa Fe, New Mexico.

SWQB. 2010b. 2010-2012 State of New Mexico Clean Water Act 303(d)/305(b) Integrated Report (Appendix A) List of Assessed Surface Waters. New Mexico Environment Department, Surface Water Quality Bureau, Santa Fe, New Mexico.

www.nmenv.state.nm.us/swqb

SWQB. 2011. Wetlands Program Plan for New Mexico. New Mexico Environment Department, Surface Water Quality Bureau, Santa Fe, New Mexico.

SWQB. 2012a (*Draft*). Use Attainability Analysis: Aquatic Life Uses for Perennial Reaches of Streams in the Galisteo Watershed. July 23, 2012. New Mexico Environment Department, Surface Water Quality Bureau, Santa Fe, New Mexico.

SWQB. 2012b (*in press*). State of New Mexico Assessment and Monitoring Strategy for Wetlands, New Mexico Environment Department, Surface Water Quality Bureau Wetlands Program.

The Conservation Fund. 2009. A Training Course for Mitigation Banking & In-Lieu Fee Program Interagency Review Teams. June 15-19, 2009, Shepherdstown, WV, Sponsored by U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, and U.S. Fish & Wildlife Service, In Partnership with the Environmental Law Institute.

U.S. Army Corps of Engineers. 2006. Environmental Assessment for the Galisteo Dam and Reservoir Salt Cedar Eradication Project, Galisteo Creek, Santa Fe County, New Mexico, Albuquerque District, March 7, 2006.

USDA. 2000. U.S. Department of Agriculture. Natural Resources Conservation Service. Climate Narrative for Santa Fe County, New Mexico. National Water and Climate Center, Portland, OR. 1972-2000. www.wcc.nrcs.usda.gov/ftpref/support/climate/soil-nar/nm/Santa_Fe.doc

USDA. 2009. Soil Survey of Santa Fe County Area, New Mexico. U.S. Department of Agriculture, Natural Resources Conservation Service.

USDI. 2011. West-Wide Climate Risk Assessments: Bias-Corrected and Spatially Downscaled Surface Water Projections. U.S. Department of the Interior, Bureau of Reclamation, Technical Memorandum 86-68210-2011-01, March 2011.

U.S. Fish & Wildlife Service. 2009. A System for Mapping Riparian Areas In The Western United States. U.S. Fish and Wildlife Service Division of Habitat and Resource Conservation Branch of Resource and Mapping Support, Arlington, VA 22203, November 2009.

U.S. Fish & Wildlife Service. 2011. Supplemental Map Information, R02Y11P04, La Cienega, NM. National Wetlands Inventory/NSST, Madison, WI, 9 pp.

Vrooman, Steven S. 2006. Assessment and Plan for the Creation, Restoration and Protection of Wetlands in the Galisteo Watershed. Planning for Wetlands in the Galisteo Watershed. Earth Works Institute.

Watson et al. 2005. Ecosystems and Human Well-being: Wetlands and Water Synthesis, Millennium Ecosystem Assessment. World Resources Institute, Washington, D.C.

Willamette Partnership. 2012. In It Together: A How-To Reference for Building Point-Nonpoint Water Quality Trading Programs. Overview (Part 1 and 2 of 3), July 2012. In collaboration with USDA Office of Environmental Markets, Pinchot Institute for Conservation, and World Resources Institute.

Williams, A. Park, C. D. Allen, C. Millar, T. Swetnam, J. Michaelsen, C. J. Still, and S. W. Leavitt. 2010. *Forest responses to increasing aridity and warmth in southwestern North America,* Proceedings of the National Academy of Sciences, USA 107(50): 21289-21294.

Windell, J.T., B.E. Willard, D.J. Cooper, and others. 1986. An ecological characterization of Rocky Mountain montane and subalpine wetlands. U.S. Fish and Wildlife Service Biological Report 86(11), 289 pp.

Zeedyk, William D. and Van Clothier. 2009. Let the Water do the Work. Induced Meandering, and Evolving Method for Restoring Incised Channels. The Quivira Coalition, Santa Fe, New Mexico, 239 pp.

Electronic References

http://clerkshq.com/default.ashx?clientsite=Santafe-nm
http://en.wikipedia.org/wiki/Santa_Fe_County,_New_Mexico
http://quickfacts.census.gov/qfd/states/35/35049.html
http://water.epa.gov/type/watersheds/trading/finalpolicy2003.cfm
http://Weatherspark.com/averages/31551/Santa-Fe-New-Mexico-United-States
http://weather-warehouse.com/WeatherHistory/PastWeatherData_SantaFe2_SantaFe_NM_July.html
http://www.ecosystemvaluation.org/essentials.htm
http://www.epa.gov/owow/wetlands/initiative/cefintro.html
http://www.fs.fed.us/ecosystemservices/
http://www.maweb.org/en/index.aspx
http://www.nmenv.state.nm.us/swqb/Permits/
http://www.nps.gov/partnerships/fundraising_individuals_statistics.htm
http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements
http://www.usbr.gov/pmts/eco_research/eco3.html
http://www.vjel.org/journal/VJEL10019.html
www.bison-m.org/: Biota Information System of New Mexico (BISON-M). New Mexico Department of Game & Fish.
www.nacdnet.org
www.nmenv.state.nm.us/swqb
www.usinflationcalculator.com
www.wcc.nrcs.usda.gov/ftpref/support/climate/soil-nar/nm/Santa_Fe.doc

APPENDIX A: LANDSCAPE CHARACTERISTICS OF SANTA FE COUNTY

A.1. Geology

Santa Fe County is located largely across the Española Basin, a sedimentary basin of the Rio Grande Rift, between the Santa Fe Block of the Sangre de Cristo Mountains to the east and the Jemez Mountains to the west. These geological features of the Española Basin have been shaped by tectonic activity (folding, faulting, and volcanic and seismic activity) that occurred during the Laramide Orogeny (Bauer et al. 1995), between 80 million and 35 million years B.P. (Figure A.1, Johnson et al. 2012, In: McGraw and Jansens 2012). The Santa Fe Block consists of a Precambrian core, the flanks of which are covered with outcroppings of younger material that was tilted during the Laramide Orogeny and of which most of the higher elevation materials have eroded away to form the sediments of the Española Basin. The Jemez Mountains, some of the eastern slopes of which are located in the northwestern parts of Santa Fe County, are of Pleistocene volcanic origin (as recent as approx. 1.4 million years B.P.).

On the western side, Santa Fe County is delineated by the Santo Domingo-La Bajada fault line that defines the eastern boundary of the Santo Domingo Basin of the Rio Grande Rift. On the southwestern side, Santa Fe County includes the Ortiz and San Pedro Mountain complex, which is of intrusive volcanic origin and considered part of the Cerrillos uplift. The southern part of the Española Basin includes the Galisteo Basin, a hydrogeological sub-basin of the Española Basin. The southern part of Santa Fe County includes part of the Estancia Basin, which is a side basin to the Española Basin, and a closed surface water basin. The southeastern part of Santa Fe County consists of the Glorieta Mesa uplift, which is defined on both sides by significant faults and synclines that define the Galisteo Basin to the west and the Pecos valley (largely in San Miguel County) to the east. Santa Fe County includes the far western headwaters of the Pecos Basin associated with the Glorieta Creek which flow east from Glorieta Pass.

Geologic sediments in the Española Basin are collectively referred to as the Santa Fe Group. In central Santa Fe County (north of the Gallina Arroyo), the Santa Fe Group consists of the Tesuque Formation, formed in the Upper Oligocene and Miocene (25 million-13 million years B.P.), the Tuerto Gravels of the Pliocene to lower Pleistocene (13 million-2.5 million years B.P.), and the Ancha Formation of the lower Pliocene to Pleistocene (13 million-2.5 million years B.P.). The Tesuque and Ancha Formations are known as important aquifers in the area (Phillips and Grauch 2004).

In the Galisteo Basin, Oligocene and Lower Miocene volcanic intrusions, such as those of the Ortiz Mountains and Cerrillos Uplift have left clearly visible cones and volcanic dykes throughout the landscape, while intrusive activity has created tilted sandstone layers and rock sills that crisscross the drainage systems (Figure A.2) and that are responsible for creating many of the seeps and springs found throughout the Galisteo watershed.

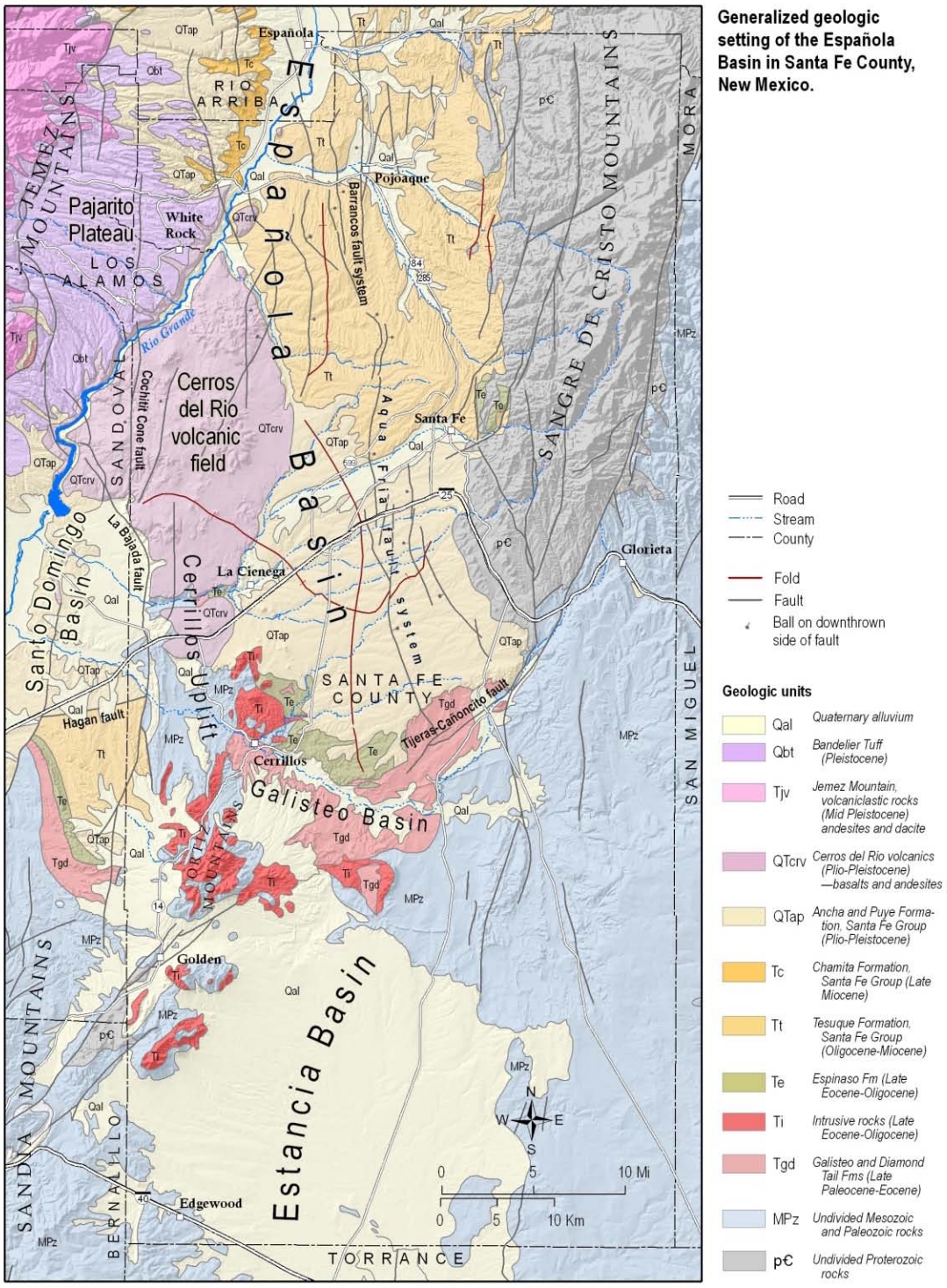


Figure A.1. Geologic Setting Map of Santa Fe County. Courtesy New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, 2012.

Figure A.2. View to the southeast across the hidden wetland of Escalante Springs in the intrusive volcanic hills of Cerrillos Hills State Park.

A.2. Hydrogeology

Research over the last ten years compiled by the New Mexico Bureau of Geology and Mineral Resources has revealed that groundwater flow conditions in Santa Fe County show a segmented pattern in more or less parallel groundwater units (Johnson et al. 2012, In: McGraw and Jansens 2012). As a result of hydrostatic pressure in the Ancha-Tesuque Formation and the surfacing of the Ancha Formation in certain locations to the north and west of Santa Fe, discharge areas exist of aquifer flows that run generally from the mountain front to the northwest, west and southwest across Santa Fe County.

For example, the Tesuque Valley from approximately one mile downstream from the Village of Tesuque to 3 miles downstream from Tesuque Pueblo comprises a significant groundwater discharge zone with depth to groundwater at less than 20 feet. Groundwater flows in another unit trend west-southwest and largely converge in La Cienega. The Santa Fe River from La Cieneguilla down to La Cienega as well as the Arroyo Hondo, Cienega Creek, Guicu Creek, Alamo Creek and Bonanza Creek east of La Cienega comprise a vast groundwater discharge zone consisting of many springs and seeps; hence the name La Cienega (Colonial Spanish for

"marsh" or "bog"). Groundwater in a unit beneath the northern part of the Galisteo Basin flows west-southwest toward the Village of Cerrillos. Groundwater from this unit discharges in a series of arroyos with many small but locally significant spring and wetland areas in the Gallina Arroyo, Coyote Springs, San Marcos Arroyo, and a series of unnamed arroyos that run to the east and west of Highway 14 and downstream to Galisteo Creek (Figures A.3 and A.4).

Figure A.3. (Left): Aerial view in a canyon of the Gallina Arroyo with a hidden wetland.
Figure A.4. (Right): View to the southeast across San Marcos Arroyo wetlands, just west of State Highway 14.

Groundwater flows more to the south in the Galisteo Basin and the Estancia Basin are not well studied. However, it is likely that groundwater flows in the Galisteo Basin generally follow a westerly direction and converge in the streamside wetlands of the Galisteo Creek west of Cerrillos and in wetlands associated with the Galisteo Dam reservoir and the delta of the Galisteo Creek at Santo Domingo Pueblo. Additionally, there are many isolated springs, seeps and riverine wetlands across the Galisteo Basin in association with the complex geological underground of this basin (SWQB 2010a).

A.3. Climate and Climate Change

Hot, dry summers and clear, crisp winters are a consequence of the semiarid continental climate of Santa Fe County (U.S. Army Corps of Engineers 2006). Climate data compiled and analyzed by www.weatherspark.com indicate that the climate in Santa Fe County has four distinct seasons. The cold season (winter) includes 91 days and runs from late November through mid February. A short spring season follows which can include show fall throughout. The warm (summer) season includes 111 days and starts in late May and lasts until mid September. A short fall season runs from mid September until late November. Based on climate data for the period 1972-2000, the NRCS Soil Survey for Santa Fe County shows an average winter temperature of 32.4°F, an average daily minimum of 20.2°F, and a record low of -17°F (on 12/23/1990) (USDA 2000). Because of predominantly clear weather, there is considerable daytime warming during the winter, although the nights are usually cold and the temperature often falls below freezing. Cold weather periods are usually brief and are accompanied by brilliant sunshine and low

humidity. Consequently during the winter, snowfall melts soon after snow events and, except in the high mountains, does not have a chance to accumulate (SWQB 2010a).

The Soil Survey shows an average summer temperature of 68.8 °F, an average daily maximum of 83.9°F, and a maximum high of 99°F (on 6/29/1998). Related to what may be signs of climate change, the summer temperature extreme of 99°F was matched in July 2003 and in June 2012, while the winter minimum extreme was surpassed with a record low of -24°F during the extreme cold in February 2011 (http://weather-warehouse.com/).

The Soil Survey states that the average annual precipitation for Santa Fe County is 14.29 inches, of which 8.52 inches fall between May and September. Summer precipitation is mostly due to thunderstorms and light rainfall. Based on reports from local residents, precipitation extremes occur in local micro-bursts of 3 to 5 inches in a few hours. The measured heaviest 24-hour thunderstorm was 2 inches (8/21/1981) (USDA 2000). The Soil Survey reports that Santa Fe receives an average of 20.7 inches of snowfall a year. More recent snowfall data show record snowfall amounts for January-March 2005 (33.5") and 2010 (45.3") (http://weather-warehouse.com/).

Annual free water surface (FWS) evaporation and annual potential evapotranspiration (PET) exceed precipitation throughout Santa Fe County, except at the highest elevations. Although the annual FWS evaporation and PET may exceed annual precipitation, precipitation for a given storm may exceed the evaporation and PET during the same time period, thus potentially resulting in recharge (Duke 2001). The estimated annual FWS evaporation rate for the County is 45 inches/year. Average annual PET rates for Santa Fe County vary between 16 inches in the high mountain areas, to 18 to 22 inches in the foothills, 22 to 26 inches in most of the lower areas Santa Fe County, and 26 inches and more in the area of the east flanks of Caja del Rio Plateau and La Bajada Mesa, north of I-25 (Duke 2011). Wind speeds in Santa Fe County vary mostly between 0 and 21 mph, with 8 mph being an average low in August (http://weatherspark.com). Empirical wind and evaporation research revealed, however, that wind speeds of 4 to 6 miles/hr readily absorb all the scant moisture released by the earth (Jensen 1983). As a result, warm temperatures, moderate winds, large daily solar radiation, and dry air contribute to maximum evaporation rates and limit infiltration and recharge of stream flow in the summer period between May and September.

Climate change projections for the Rio Grande Basin pertaining to Santa Fe County indicate that average annual temperatures may increase between 0.5°F and 3°F until 2050 (USDI 2011). The greatest change in temperature would be an increase in average winter temperatures, leading to reduced snow pack, reduced number of days with snow on the ground, and earlier and heavier snow melt runoff. As a result, annual runoff for the Rio Grande area is expected to decrease by approximately 10% by 2050, for both December-March runoff as well as for April-July runoff. Due to temperature increases in the summer, the potential evaporation rate would increase, extracting more moisture from the soil and water bodies. The average annual precipitation amount is projected to stay more or less the same (USDI 2011). Overall, weather patterns and weather phenomena are expected to become more erratic, less predictable, and more extreme. A more detailed review of climate change impacts on wetlands is included in Section 2.6.2.

A.4. Surface Hydrology

A.4.1. Watersheds and Water Bodies

Santa Fe County overlaps with ten watershed areas (Santa Fe County 2010a; BLM 1994; Duke 2001; Figure 1.2). Eight watersheds drain to the Rio Grande. Glorieta Creek drains to the Pecos River. The Estancia Basin is a closed basin. Santa Fe County watersheds are listed in Table A.1.

Table A.1. Watershed areas and water bodies in Santa Fe County.

WATERSHED AREA	WATER BODIES	JURISDICTIONS	WATER-SHED AREA WITHIN SF COUNTY	ELEV-ATION	ANNUAL PRECIPITAT-ION AND PET
Rio Cundiyo-Rio Santa Cruz watershed	Rio Santa Cruz*, Rio Cundiyo, Rio Frijoles, Rito Gallina, Rio Medio, Rio Quemado, Santa Cruz Lake	Santa Clara Pueblo, USFS, City of Espanola, Santa Fe County, Private	191 sq miles	6,100 – 8,500 ft	Precip: Approx. 19”; PET: 19.1”
Pojoaque-Tesuque-Nambe watershed	Rio Pojoaque, Rio Tesuque (Big and Little Tesuque* Creek), Rio Nambe, Rio en Medio, Rio Chupadero*, Nambe Lake (2,023 af)	Pojoaque Pueblo, Nambe Pueblo, Tesuque Pueblo, San Ildefonso Pueblo, USFS, Santa Fe County, Private	318 sq miles	5,494 – 12,621 ft	Precip: 14-22” PET: 21.1-21.8”
Rio Grande* and tributaries between Black Mesa and Buckman	Garcia Canyon, Chupadero Canyon, Contrayerba Canyon, Guaje Canyon*, Los Alamos Canyon*; and three small unnamed arroyos on the east bank of the Rio Grande	San Ildefonso Pueblo, Santa Clara Pueblo, BLM, USFS, NPS (Bandelier), Private	Approx. 58 sq miles (or less)	5,400 – 7,000 ft	Precip: Approx. 12” PET: approx. 21”
Cañada Ancha watershed	Cañada Ancha, Calabasa Arroyo, Alamo Creek	USFS, BLM, State Land Office, Private	Approx. 70 sq miles (or less)	5,400 – 6,427 ft	Precip: Approx. 12” PET: 26”
Rio Grande tributaries of Caja del Rio	Cañada de Cochiti, Arroyo Eighteen, Arroyo Montoso, Thirtyone Draw, and several other arroyos	USFS, Cochiti Pueblo	Approx. 56 sq miles (or less)	5,250 – 7,395 ft	Precip: Approx. 12”- PET: 24-26”
Santa Fe River watershed	Santa Fe River*, Arroyo Hondo, Arroyo de los Chamisos, Cienega Creek, Alamo Creek, Arroyo Calabasas, McClure Reservoir, Nichols Reservoir	USFS, BLM, City of Santa Fe, Cochiti Pueblo, Santo Domingo Pueblo, State Land Office, Santa Fe County, Private	279 sq miles	5,220-12,408 ft	Precip: 12.4” PET: 24”

WATERSHED AREA	WATER BODIES	JURISDICTIONS	WATER-SHED AREA WITHIN SF COUNTY	ELEV-ATION	ANNUAL PRECIPITAT-ION AND PET
Galisteo Creek watershed	Galisteo Creek*, San Cristobal Arroyo, San Marcos Arroyo, Arroyo de la Jara, Arroyo Chorro, Galisteo Reservoir, Galisteo Rodeo playa	USFS, BLM, SLO, NPS, Army Corps of Engineers, Santo Domingo Pueblo, Santa Fe County, Private	620 sq miles	5,700-10,000 ft	Precip: 10”-13” PET: 24”
Upper Pecos River watershed	Doctor Creek, Indian Creek, Macho Canyon, Dalton Canyon, Alamitos Canyon, La Cueva Canyon, Hagen Creek, Glorieta Creek*	USFS, NPS, Private	Approx. 67 sq miles (or less)	6,900 – 10,200 ft	Precip: >19” PET: 16-20”
Arroyo Tonque watershed	Arroyo Tonque (San Pedro Creek), Canon del Agua, Arroyo Cuchillo, Arroyo Tuerto, Arroyo Valverde	BLM, Santa Fe County, Private	Approx. 40 sq miles (or less)	6,400 – 8,000 ft	Precip: 10”-15” PET: 20-22”
Estancia Basin	Several short spring-fed drainages; Big Lake, White Lakes	USFS, BLM, SLO, Santa Fe County, Town of Edgewood, Private	Approx. 436 sq miles	6,000 – 7,200 ft	Precip: 13.8” PET: 22-26”

NOTE: Streams marked with * are listed as Category 5 “Impaired Surface Waters” in the 2010-2012 State of New Mexico Clean Water Act 303(d)/305(b) Integrated Report (Appendix A) List of Assessed Surface Waters (SWQB 2010b) (see also Section A.5).

A.4.2. Wetlands

A combination of factors associated with the groundwater hydrology and surface water hydrology in Santa Fe County have contributed to the original existence of many wetlands smaller than one acre throughout the County. Most wetlands are riverine (streamside) wetlands along the major rivers and creeks flowing from the mountains. Additionally, various volcanic intrusive formations and the surfacing of the aquifers of the Ancha and Tesuque formations support the existence of slope wetlands in the form of springs and seeps. Depressional wetlands (playas) occur in the Galisteo watershed and in the northeastern part of the Estancia Basin in Santa Fe County. A wetland resource analysis, including details on wetland classifications, is included in Section 2 of this WAP-SFC.

A.5. Water Quality

The SWQB tracks water quality of streams in Santa Fe County in its 2010-2012 State of New Mexico Clean Water Act 303(d)/305(b) Integrated Report (Appendix A) List of Assessed Surface Waters (SWQB 2010b). For the period 2010-2012, the streams in Santa Fe County which SWQB identified as impaired include:

In HUC 13020101 (Upper Rio Grande):
Guaje Canyon (San Ildefonso boundary to headwaters)
Los Alamos Canyon (NM4 to DP Canyon)
Rio Chupadero (from U.S. Forest Service boundary to headwaters)
Santa Cruz River (from Santa Clara Pueblo boundary to Santa Cruz Dam)

In HUC 13020201 (Rio Grande-Santa Fe)
Galisteo Creek (several perennial reaches)
Rio Grande (Cochiti Reservoir to San Ildefonso boundary)
Santa Fe River (various reaches)

In HUC 13060001 (Pecos Headwaters)
Glorieta Creek (Pecos River to headwaters)

Data on the impact of water quality impairments on wetland functions for wetlands in Santa Fe County is nearly absent. Limited data exist for the Galisteo Creek about the impact of water quality impairments on wetland functions. Technically, Galisteo Creek (perennial reaches above Santo Domingo Boundary) is still included in Water Quality Standards segment 20.6.4.121 NMAC which is classified as a high quality coldwater fishery. It is currently listed for temperature and specific conductance exceedences (SWQB 2010b).

In 2002 it was determined from SWQB fish surveys that the Galisteo Creek Assessment Unit does not contain a coldwater fishery and is misclassified as a High Quality Cold Water Fishery according to fisheries data. Presently, a Use Attainability Analysis (UAA) is under preparation at SWQB instead of a TMDL to determine the appropriate classification for the assessment unit (SWQB 2012a). The Draft UAA proposes to reclassify perennial reaches of the Galisteo Creek as a Cool Water Fishery, while a few perennial headwater reaches will maintain the status of Cold Water Fishery.

The website for National Pollutant Discharge Elimination System (NPDES) permits in Santa Fe County lists ten permits on August 9, 2012 (http://www.nmenv.state.nm.us/swqb/Permits/). The permits and potentially affected wetlands immediately downstream are listed in Table A.2.

Table A.2. List of NPDES permit titles and potentially affected streams and wetlands in Santa Fe County.

NPDES Permit Titles	NPDES No.	Potentially Affected Streams and Wetlands
Buckman Direct Diversion (BDD) Project	NM0030848	Rio Grande below BDD Project
LAC Minerals, Inc./ Cunningham Hill Mine	NM0028711	Cunningham Creek, Dolores Creek, and Galisteo Creek below confluence with Arroyo Chorro
LifeWay Glorieta Conference Center/WWTP	NM0028022	Glorieta Creek below Conference Center WWTP
Oshara Village Water Reclamation Facility	NM0030813	Arroyo Hondo below Oshara Village Water Reclamation Facility, and downstream wetlands in La Cienega
Ranchland Utility Company	NM0030368	Bonanza Creek Ranch, and downstream wetlands in La Cienega
Santa Fe County Judicial Complex	NM0031046	Bonanza Creek, and downstream wetlands in La Cienega
Santa Fe County/Valle Vista WWTP	NM0028614	Cienega Creek, and downstream wetlands in La Cienega
Santa Fe, City of/WWTP	NM0022292	Santa Fe River below WWTP
Pojoaque Terraces Mobile Home Park	NM0028436	Pojoaque River below outfall of Terraces Mobile Home Park
Pojoaque Towa Resort WWTP	NM0030601	Pojoaque River below outfall of Pojoaque Towa Resort WWTP
Santa Fe, City of/MS4 permit	NMR04000	Santa Fe River within and downstream of City of Santa Fe

A.6. Soils

The USDA Natural Resources Conservation Service's 2009 Soil Survey for Santa Fe County determined that there are approximately 172 different kinds of soils in a survey area that comprises a total of 182 individual map units (Santa Fe County 2010a; USDA 2009). However, areas under management of the U.S. Forest Service are not included in the 2009 Soil Survey for Santa Fe County (Aaron Miller, pers. comm. July 2, 2012). The soils vary widely in their texture, color, natural drainage, slope, and other characteristics. The soils in the northern portion of the survey area are at the lowest elevations; gently sloping to rolling with steep breaks occurring in some areas. The soils in the eastern region of the survey area exist at higher elevations and are generally steeply sloping and high in rock fragments (Santa Fe County 2010a; USDA 2009). Upon request of Santa Fe County, soil data for Santa Fe County (other than Forest Service lands) were mapped at a rather detailed scale of 1:12,000 (USDA 2009). NRCS is available to offer staff capacity to assist local and state government agencies to conduct detailed field assessments and delineations for wetlands (A. Miller personal communication, July 2, 2012).

A.7. Ecoregions and Vegetation Communities

A.7.1. Ecoregions

Santa Fe County includes four Level III ecoregions, which encompass twelve Level IV ecoregions (Griffith et al. 2006). An ecoregion is a recurring pattern of ecosystems associated with characteristic combinations of soil and landform that characterize that region. Areas within an ecoregion exhibit spatial coincidence in geographical characteristics associated with differences in the quality, health, and integrity of ecosystems. Geographical characteristics include geology, physiography, vegetation, climate, hydrology, terrestrial and aquatic fauna, soils, and the impacts of human activity (e.g. land use patterns, vegetation changes) (Santa Fe County 2010a). Table A.3 provides an overview of Santa Fe County's ecoregions and Figure A.5 shows a map of ecoregions in Santa Fe County.

A.7.2. Vegetation Communities

Vegetation types in Santa Fe County are controlled by elevation and available water. Vegetation communities that define different landscapes vary from ponderosa pine forests at elevations of 7,500 feet, piñon/juniper woodlands on mesas and hillsides, plains with grassland, and riparian and wetland areas along rivers and streams. Low elevation native vegetation includes alkali sacaton, blue grama, fourwing saltbush, galleta, Gambel oak, Arizona fescue, muttongrass, mountain muhly, and sedge, which cover the broad, lower mountainous to semi-arid landscape across the County (Santa Fe County 2010a).

Detailed wetland assessments in Santa Fe County are still ongoing. The Galisteo Basin is best studied concerning wetlands and wetland vegetation communities. In 2006, Steve Vrooman conducted a study of wetlands in the Galisteo Basin for Earth Works Institute and SWQB (Vrooman 2006). This study identified seven clusters of wetland areas across the Galisteo Basin, and included detailed vegetation assessments, wetland condition assessments, mapping, and suggestions for wetland restoration and protection. The seven wetland clusters included Glorieta Mesa, Cañoncito/Apache Canyon, Galisteo Basin Preserve, Galisteo Main Stem around the Village of Galisteo, San Marcos Arroyo, Cerrillos Hills, and Galisteo Dam area.

In 2009, the University of New Mexico's Natural Heritage New Mexico Program conducted an inventory of wetlands and riparian resources and vegetation communities within the Galisteo Basin (Milford et al. 2009). This study primarily used Geographic Information Systems (GIS) techniques supported by ground-truthing and included all but the far northeast corner of the Galisteo Basin, which was not covered by color-infrared photography. In addition to the location of wetland resources, dominant vegetation was described and high-quality wetland sites were identified. Milford et al. (2009) recognized seven wetland communities based on vegetation including Closed Woodland, Open Woodland, Sparse Woodland with Shrubs, Sparse Woodland with Grasses, Shrubland, Herbaceous Wetland, and Herbaceous. The seven wetland communities are principally distinguished by percent canopy cover of trees relative to total vegetative cover.

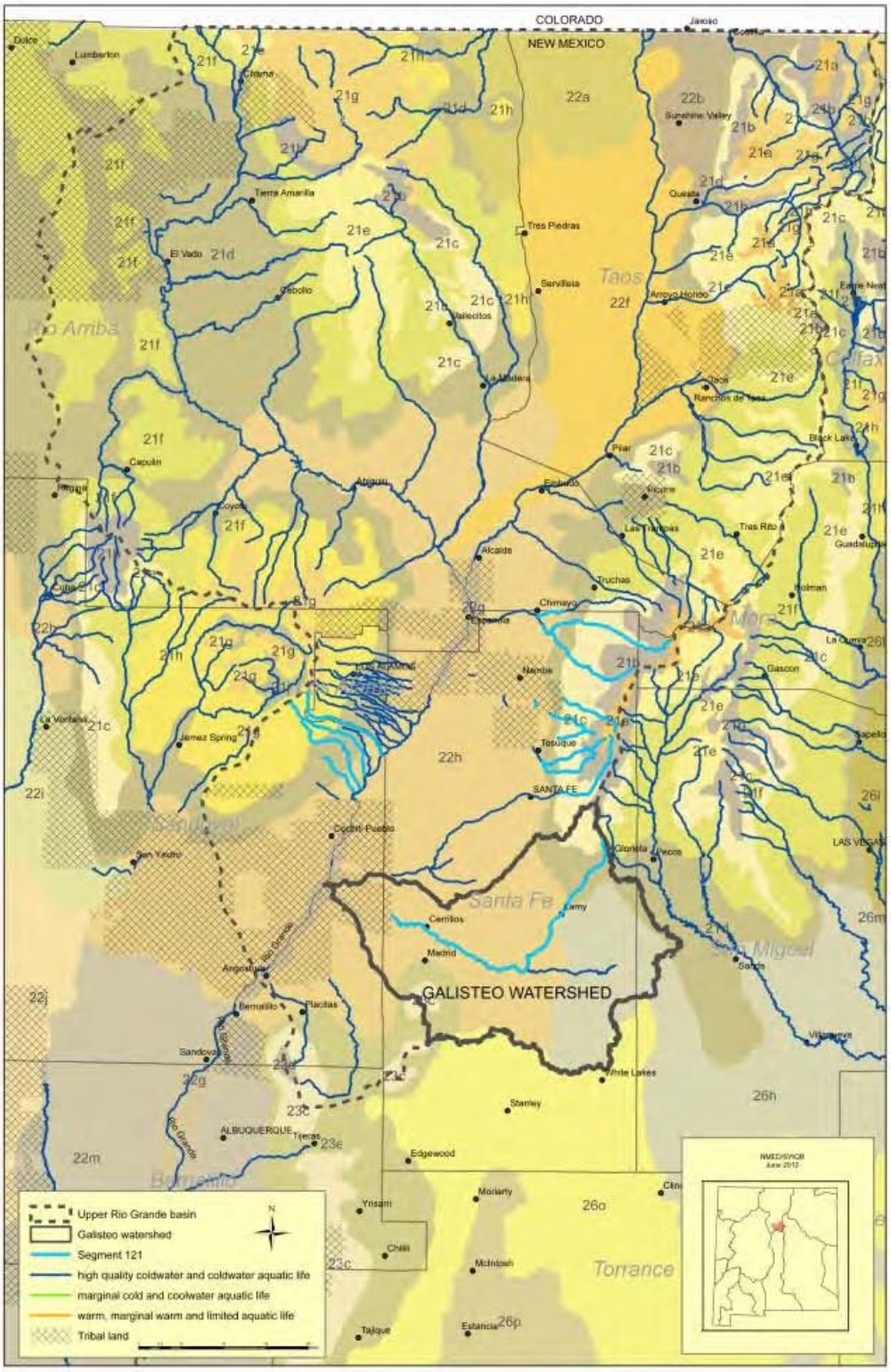


Figure A.5. Ecoregion map of Santa Fe County and surrounding areas with an emphasis on the Galisteo Basin. (Map Courtesy SWQB 2012; Source: SWQB 2012a).

Table A.3. Ecoregions of Santa Fe County with Landscape and Wetland Features (Griffith et al. 2006).

Level III Ecoregions	Level IV Ecoregions	Landscape Features	Wetland Features
Southern Rockies (#21)	Alpine zone (21a)	Mostly glaciated; high, rocky mountain peaks, ridges, and slopes above timberline; alpine meadows, bristlecone pine, Engelmann spruce.	Some wetlands and glacial lakes; high gradient headwater streams with boulder, cobble and bedrock substrates.
	Crystalline Subapline Forests (21b)	High mountains with steep slopes; spruce-fir-aspen forest; alpine meadows; timber, seasonal grazing, and wilderness uses.	High gradient headwater streams with boulder, cobble and bedrock substrates. (Probably few wetlands).
	Crystalline Mid-Elevation Forests (21c)	Low mountain ridges, slopes and outwash fans; ponderosa pine forest type; wildlife habitat, timber, grazing, recreation.	Moderate to high gradient perennial streams with boulder, cobble and bedrock substrates. (Probably few wetlands).
	Foothill Woodlands and Shrublands (21d)	Hills, ridges, and foot-slopes; piñon-juniper woodlands, mixed shrubs, grasses; woodland uses and grazing.	Moderate to high gradient perennial streams with boulder, cobble and bedrock substrates. (Probably few wetlands).
	Sedimentary Subalpine Forests (21e)	High mountains with steep slopes; spruce-fir-aspen forest; timber, recreation, wildlife, grazing, hunting.	High gradient perennial streams with boulder, cobble and bedrock substrates. (Some riverine wetlands).
Arizona/New Mexico Plateau (#22)	Rio Grande Floodplain (22g)	River channel and floodplain; low terraces and levees; cottonwood and willow bosque.	(Some riverine wetlands).
	North Central New Mexico Valleys and Mesas (22h)	Mesas, valleys, piedmont slopes, deep canyons; Espanola and Galisteo Basin area; piñon-juniper woodland and juniper-grass savanna; grazing and urbanization.	Perennial and intermittent streams. (Few wetlands, except those related to discharge zones, springs, and stream sides).
	Albuquerque Basin (22m)	Plains and piedmonts with alluvial fans and some scattered hills (below La Bajada Hill); sand scrub/ desert grass-land; mining/ (ex)-urban.	Mostly intermittent streams. (Few wetlands, except a few riverine wetlands of Galisteo Dam, Galisteo Creek, SF River).
Arizona/New Mexico Mountains (#23)	Conifer Woodlands and Savannas (23e)	High hills, low mountains, numerous canyons; piñon-juniper woodland; grasses; yucca and cacti; grazing, wildlife habitat, recreation.	Moderate to high gradient intermittent streams with bedrock, cobble, gravel, sandy substrates. (Probably few wetlands).

Level III Ecoregions	Level IV Ecoregions	Landscape Features	Wetland Features
	Rocky Mountain Conifer Forests (23f)	Open, low mountains, and high mountains, steep slopes, many canyons; ponderosa pine, piñon, oak, dense understory; recreation, wildlife, grazing, mining.	Moderate to high gradient intermittent streams with bedrock, cobble, and gravel substrates. (Probably few wetlands).
Southwestern Tablelands (#26)	Piñon-Juniper Woodlands and Savannas (26h)	Thin soils of weathered limestone, sandstone, or shale; rock outcrops; wildlife habitat, wood-land, and rangeland.	Spring-fed and ephemeral intermittent streams. (Few wetlands).
	Central New Mexico Plains (26o)	Broad, rolling plains, tablelands, piedmonts; Estancia Basin; short-grass prairie and scattered juniper; farming/ranching.	Ephemeral drainages (Few wetlands).

Figure A.6. (Left): A shrubland wetland in the Santa Fe County Arroyo Hondo Open Space Area.
Figure A.7. (Right): An herbaceous wetland in the Cañoncito Arroyo in the Eldorado Community Preserve.

Shrublands comprise the greatest amount of area delineated (416 ha or approximately 916 acres); while Herbaceous Wetland had the least (12 ha or approximately 27 acres). Much of the Shrubland community is dominated by salt cedar, with lesser amounts of coyote willow and minor amounts of rubber rabbitbrush (*Ericameria nauseosa*). Herbaceous Wetlands often occur near impoundments or, in rare cases, as seeps such as within the Cerrillos Hills State Park outside of the town of Cerrillos (Milford et al. 2009). Exotics dominate the mapped riparian and wetland areas. Exotic-dominated stands comprise approximately 57% of the total vegetative cover with mixed and native at 29% and 13%, respectively. Salt cedar-dominated stands are the most common exotic type, comprising 81% of the total exotic-dominated area, followed by Russian olive-dominated stands at 19%. Less than 1% of the exotic-dominant area is categorized as Herbaceous Exotic. Among native-dominated stands, cottonwood was the most common

dominant, comprising 50% of the total native area. Less commonly dominant were Herbaceous (35%), Coyote Willow (8%), and Herbaceous Wetland (7%) (Milford et al. 2009).

A.8. Wildlife Habitat

As an ecological transition zone, Santa Fe County constitutes a landscape-wide wildlife corridor across the "spine of the continent," as described in the Southern Rockies Wildlands Network Vision to the north with the New Mexico Highlands Vision to the south (Foreman et al. 2003, Benedict and McMahon 2006). Especially the Galisteo Basin with the Galisteo Creek and its tributaries and wetlands serve as an important functional wildlife pathway between the different ecoregions across the County and as part of a large wildlife linkage area between the Southern Rocky Mountains to the north and the New Mexico Mountains to the south, termed the Galisteo Wildway. Additionally, wetlands in the Galisteo Watershed constitute a series of stepping stones for migratory water fowl in an alternative eastern flyway route parallel to the Rio Grande corridor (SWQB 2010a). The New Mexico Game and Fish Department identified the conceptual locations of corridors needed to connect major habitat patches in Santa Fe County in support of the Western Governors' Association's wildlife corridors initiative (Figure A.8). However, suitable habitat and connective corridors for wildlife in Santa Fe County are under stress due to habitat encroachment and land fragmentation as a result of residential and infrastructure development for human habitation (Jansens et al. 2011) (Figures A.9–A.12). Therefore, information and initiatives to support the restoration and protection of wetland and riparian areas as part of wildlife habitat and connective wildlife linkages are becoming increasingly important.

Santa Fe County's unique location at the convergence of multiple ecoregions is expressed in a relatively high level of biodiversity. The County's natural features provide an abundance of native plants and wildlife despite significant urban development and related land fragmentation due to roads, subdivisions, fences, and other anthropogenic barriers (Santa Fe County 2010a).

Landscape scale species richness, based on the number of terrestrial vertebrate species, has been evaluated by New Mexico State University, as a part of the Southwest Regional Gap Analysis Project (SWReGAP) (Prior-Magee et al. 2007). Gap analysis is a method of "identifying gaps in representation of biological diversity in areas managed for long-term maintenance of populations of native species and natural ecosystems" (Scott et al. 1987, 1993, 1996). "Plant communities and terrestrial vertebrate species under-represented in the existing system of areas managed for biological diversity are identified as *gaps* and serve as a focus for conservation evaluation and future habitat management decisions" (Scott et al. 1993, Boykin 2010 Draft). In 2010, a NMSU study refined the SWReGAP analysis for Santa Fe County by assessing and mapping total vertebrate richness and focal species richness in Santa Fe County (Boykin et al. 2009) as well as for Santa Fe County and 8 other surrounding counties in northern New Mexico (Boykin 2010 Draft). Riparian and wetland habitats received the highest ranking in the conservation prioritization model for this study.

In New Mexico, the Biota Information System of New Mexico (BISON-M) was developed for biologists by the New Mexico Department of Game & Fish and the U.S. Fish & Wildlife Information Exchange (www.bison-m.org/) to compile biological information for both vertebrate and invertebrate species which occur in New Mexico. The BISON-M database lists 622 species

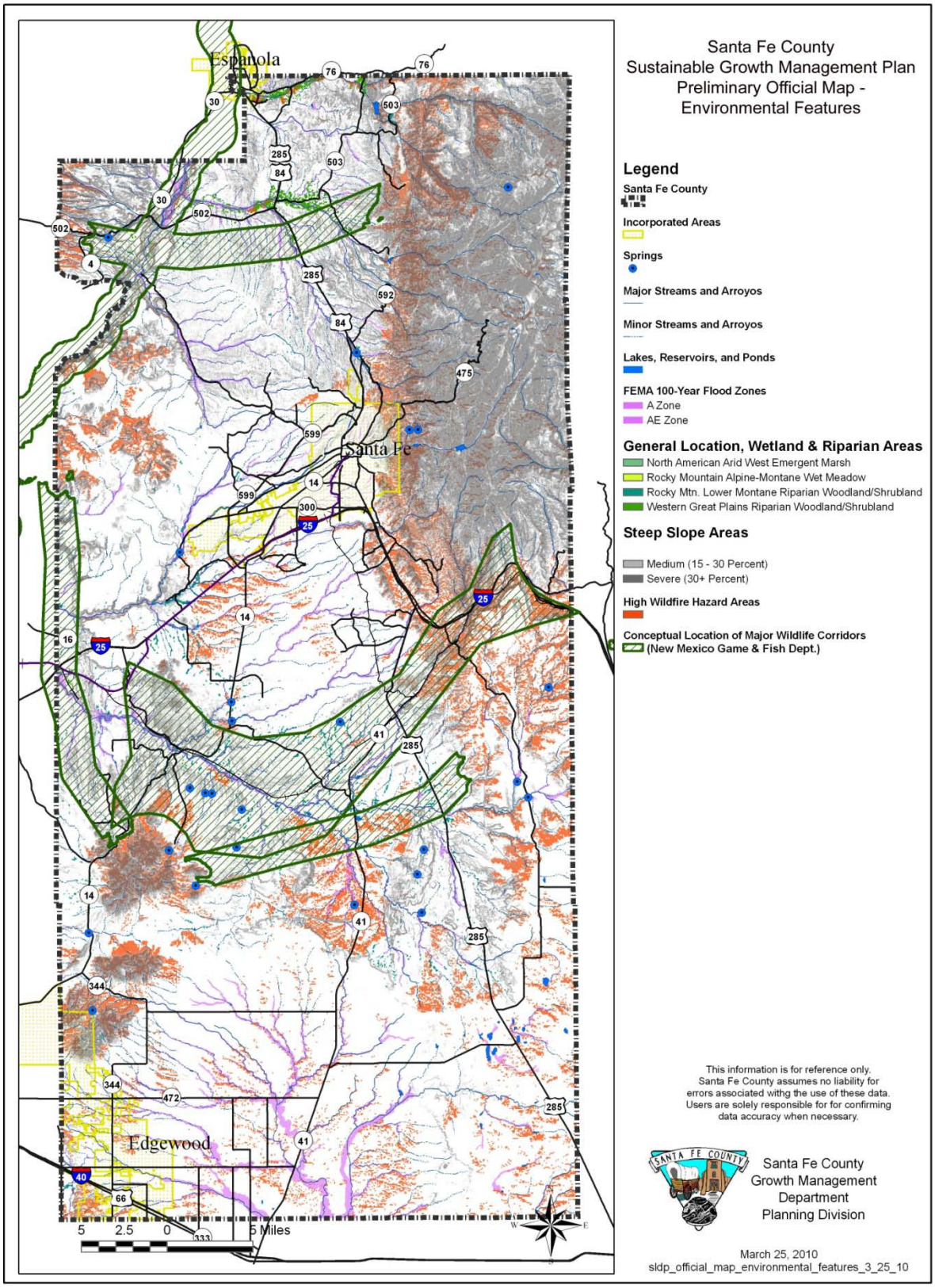


Figure A.8. Santa Fe County Environmental Features Map with some of the most important wetlands, streams, springs, and wildlife corridors in Santa Fe County.


Figure A.9. (Top Left): I-25 and Old Las Vegas Highway cause significant landscape fragmentation and constitute a serious barrier for the continuity of riparian areas and wetland habitat and for wildlife movement between the foothills of the Sangre de Cristo Mountains and the Galisteo Basin to the south.
Figure A.10. (Top Right): Box culverts, such as this one for the Apache Canyon Arroyo are the only connective pathways for wildlife and for floodwaters in riparian ecosystems across the I-25 corridor.


Figure A.11. (Bottom Left): The former Atchison, Topeka, and Santa Fe Railroad bisects the Galisteo Creek floodplain, creating separated riparian areas on both sides of the railroad grade. Only one side remains wet due to the Galisteo Creek; the other side has dried up since rail line construction in 1880.
Figure A.12. (Bottom Right): State Highway 14 cuts across geologic features and streams, wetlands and spring areas east of the Cerrillos Hills in the "Garden of the Gods" area.

in Santa Fe County of amphibians, reptiles, birds and mammals that met one or more of the criteria of being (1) NM Endangered or Threatened and/or (2) NM Species of Greatest Conservation Need (NM SGCN) (Santa Fe County 2010a).

There are a number of federal and state protected species that are known in Santa Fe County. Among them are the grey vireo, bald eagle, whooping crane, Baird's sparrow, Southwestern willow flycatcher, spotted bat, and the meadow jumping mouse. The 1973 Endangered Species Act, through federal action and by encouraging the establishment of state programs for the

conservation of ecosystems, authorizes the determination and listing of species as endangered and threatened (SWQB 2010a). The Act and the state program open the way for species and (wetland) habitat protection, restoration, and mitigation initiatives.

A.9. Occupational History

Santa Fe County has a rich and complexly layered history of human population. Research indicates that people may have lived in the area as early as 14,000 B.P. The first confirmable population living along the Galisteo Creek was the Clovis Culture around 10,500 B.P. Archaeological and historical research data show that during the last 10 millennia the landscape of Santa Fe County has been a land of many wandering people. Highly variable water resources, disease, and conflicts of various kinds may have been major reasons for the historical fluctuations in the area's populations (SWQB 2010a).

In the 1200s and 1300s, the Santa Fe County area experienced a rapid growth of native settlements in the form of multi-story room blocks around a plaza. Most settlements were close to natural water sources, such as springs and permanent streams. Most remarkable of this era was the development of about 18 permanent Puebloan settlements in the Galisteo Basin, each with hundreds of homes, which probably gave shelter to as many as 10,000-20,000 people throughout the watershed. This population dwindled to only a few thousand after the Pueblo revolt in 1680 (Jansens et al. 2011).

Spanish settlement continued throughout the 1700's. These settlements led to the discovery of gold in 1821, in Cerrillos and Madrid. By 1840 an estimated 10% of the State's population resided in the Ortiz Mountains, the country's first Gold Rush site in history. Madrid and Cerrillos boomed, attracting thousands of people from around the world looking to make a fortune in gold. The population grew to around 30,000 during the height of the mining days in the mid and late 1800s, with high population concentrations in the Madrid and Cerrillos area. This population was decimated to nearly 3,000 by the 1930s (Earth Works Institute 2005).

The character of Santa Fe County's diverse settlement patterns is best defined by a variety of criteria such as geographic setting, proximity to sources of fresh water, land use, culture, economy, community services, and proximity to transportation corridors. Dispersed among the County's settlements are large expanses of public lands such as national forest, BLM, and State Trust Lands. Additionally, traditional community centers on large holdings of tribal lands from San Ildefonso, Santa Clara, Pojoaque, Nambe, and Tesuque Pueblos are located within Santa Fe County. Santo Domingo and Cochiti Pueblos also have portions of land at the western border of the County. However, the natural resource base in Santa Fe County is relatively sparse, limiting economic activities, coupled with finite water supplies. Despite these resource limitations, traditional communities were able to flourish thanks to an intricate combination of Native American survival strategies and Spanish settlement and irrigation procedures and techniques (Arellano 2012).

Historical Spanish settlements were largely dependent on irrigation technology based on gravity flow by way of earthen irrigation canals (*acequias*), which closely followed the contours of the sloping land form. Acequias were fed by streams with reliable surface flows, such as the Santa

Fe River, or from springs with reliable groundwater discharge, such as in La Cienega (Santa Fe County 2010a). Acequias in the upper Rio Grande area have supported human subsistence for hundreds of years. The community-based acequias in Santa Fe County are one of the oldest water management institutions in the United States. Acequia irrigation systems date back to Middle-Eastern agricultural techniques brought by the Iberian colonists and to pre-historic Native American irrigation practices (Arellano 2012). The Spanish expanded the acequia system as more colonizing settlements began to occur. Spanish colonization policies required that officials of the crown, and settlers from the central valley of Mexico must locate their communities in the vicinity of water resources essential to permanent occupation (Arellano 2012). Figure A.13 presents a schematic of the topographical relationships of acequias in the surrounding landscape and in relation to wetlands (Santa Fe County 2010a).

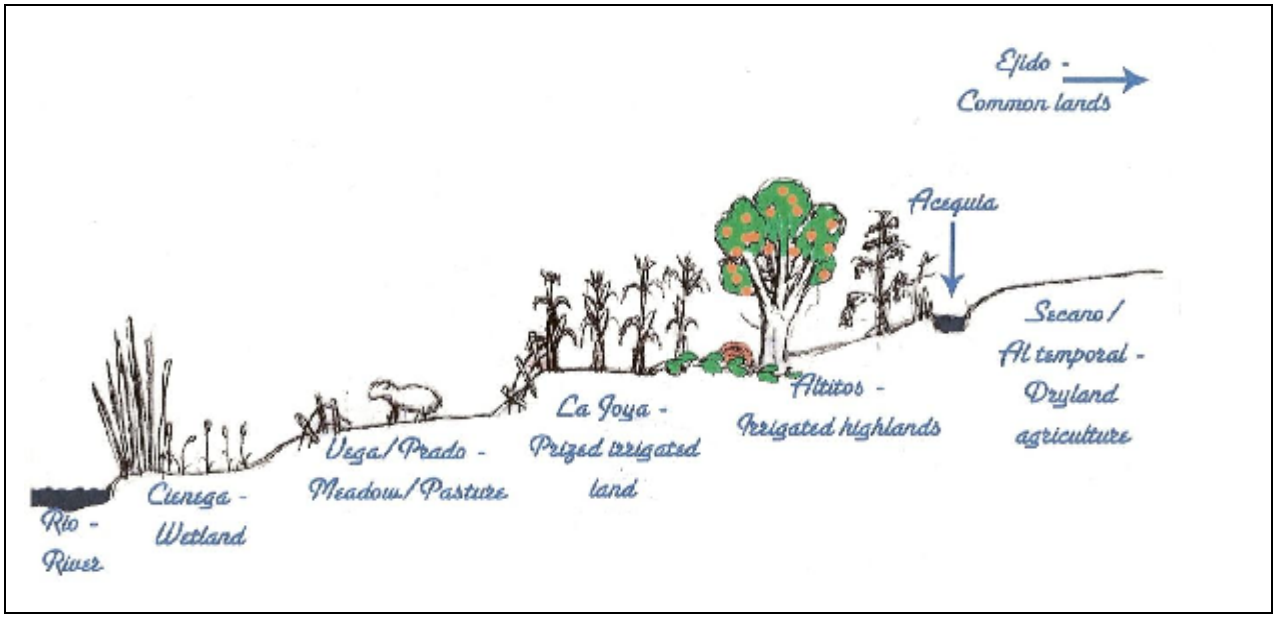


Figure A.13. Cross-section of landscape types traditionally associated with acequia agriculture (Santa Fe County 2010a).

As in the past, acequia communities today are still in charge of day-to-day acequia governance and collectively maintain and repair their irrigation works and diversion structures when necessary (Santa Fe County 2010a). Many acequia communities are very concerned with water source areas, such as springs and wetlands, and have a habit of removing all woody plants from springs, wetlands, and nearby riparian areas to reduce transpiration by plants and optimize water availability for agriculture (Jan-Willem Jansens, personal observation).

Each irrigated acre is estimated to use approximately 2 acre-feet/yr (afy) of water. The primary areas of acequia-irrigated acreage within Santa Fe County are Santa Cruz, Nambe, Cundiyo, Chimayo, Tesuque, Pojoaque Valley, Agua Fria, La Cienega, and La Bajada. The southern areas of the County such as Stanley, Edgewood and Cañoncito mainly use groundwater for irrigation purposes (Santa Fe County 2010a) (see also Figure A.2).

A.10. Land Use, (Ex)Urban Development and Water Diversion

In the 20th Century Santa Fe County experienced significant urban growth. Most of the urbanization is concentrated in the Santa Fe Watershed. Other (sub)urban centers include Española and its outskirts in the Santa Cruz watershed in the northern part of Santa Fe County, the small urbanized part of the Pueblo of Pojoaque in the Pojoaque watershed, the small sub-urban center of Eldorado in the Galisteo watershed, and the Town of Edgewood in the Estancia Basin. Additionally, significant ex-urban development can be found in the Nambe Watershed, in the central Tesuque valley, in the Santa Fe Watershed in the outskirts of Santa Fe, in most of the northern parts of the Galisteo watershed (Cañoncito, Eldorado, Sunlit Hills, Lamy, San Marcos District, Silverado, Goldmine Road, and Mailbox Road), and in smaller villages, such as La Cienega, Galisteo, Stanley, Cerrillos, and Madrid (see also Figure 1.1).

Groundwater wells continue to play an important role as sources of water for residents and businesses in Santa Fe County. As a result, wetlands, streams, and groundwater flows in Santa Fe County are likely to be impacted by groundwater withdrawals from County and City well fields and thousands of domestic wells. Groundwater withdrawals are used for municipal water supply in the City of Santa Fe (Buckman and City of Santa Fe well fields), Los Alamos County (Los Alamos, Guaje, Pajarito Mesa, and Otowi well fields – which may impact downstream riparian areas in Santa Fe County), the City of Española well field, and well fields for smaller communities, such as Eldorado.

Average annual withdrawal between 1990 and 1997 for Española was 1,170 afy and for Los Alamos 4,418 afy. Between 1990 and 1999, the City of Santa Fe measured a withdrawal of 7,177 afy, and in 1999, the community of Eldorado measured a withdrawal of 500 afy (Jemez y Sangre Water Planning Council 2003). Total annual municipal groundwater withdrawal up to 2000, therefore, was around 13,000 afy, with a peak in 1996 of 14,138 afy. In the Buckman Direct Diversion (BDD) Service Area alone, which encompasses the area around the City of Santa Fe – with its outer edges including the communities of Cañada de los Alamos, Lower Cañoncito, the San Marcos District, La Cienega, La Cieneguilla, the developments along Hwy 599, La Tierra, Tesuque, and Cerros Colorados – 9,176 households were served by domestic wells with an estimated water demand of 2,294 afy (i.e., 0.25 af/household) (Karen Torres, personal communication 2012; see also Figure A.14). However, the total amount of ground water diversion (i.e., extraction) by domestic wells in Santa Fe County is largely unknown because in 2010 only approximately 2,000 domestic wells were being monitored, while informal estimates of the number of operating domestic wells varied between 12,000 and 16,000 (Laurie Treviso, personal communication 2010).

In order to address the complex water need and scarcity problems in Santa Fe County in a proactive manner, both the City of Santa Fe and Santa Fe County follow a conjunctive use principle in water supply planning. Both local government entities prioritize the use of surface water, combined with rainwater capture, the BDD project (water from the Rio Grande), and water conservation measures. Groundwater will thus be saved as a backup for years of special or additional need, such as in years of droughts when surface water sources are inadequate (City of Santa Fe 2011b, Santa Fe County 2010a). For example, in 2010 and 2011, the BDD project helped the City of Santa Fe and Santa Fe County to reduce its dependence of groundwater

supplies dramatically. In 2012, however, the City needed to use its wells in the aquifer again to provide sufficient drinking water (Julie Ann Grimm, The New Mexican July 4, 2012).

Figure A.14. Density of domestic wells in the BDD Service Area in central Santa Fe County. The outline of the City of Santa Fe is visible in the open void surrounded by well areas just northeasterly of the center of the map. (Source: Santa Fe County Public Works, 2012).

APPENDIX B: PEAK FLOW MODELS FOR SANTA FE RIVER BELOW MSGR. PATRICK SMITH PARK

The following tables (Tables B.1, B.2, and B.3) show examples of measured and projected peak flow increases in the Santa Fe River for 1951, 2007, and undated future conditions for locations downstream from Msgr. Patrick Smith Park (Cadmus 2011). The tables support the registered and projected trend of increased peak flow volumes (in cfs) at various locations in the Santa Fe River over time for a spectrum of probability intervals of 2-year (50%) to 500-year (0.2%) peak flow probabilities (Cadmus 2011).

Table B.1. Measured peak flow data for locations along the Santa Fe River for 1951.

Location	Area sqmi	1951 Historical Conditions Peak Flow (cfs)						
		2yr	5yr	10yr	25yr	50yr	100yr	500yr
NE side of Msgr Patrick Smith Park	34.3	No data	No data	No data	No data	No data	No data	No data
Palace Ave bridge	34.5	24	29	44	1365	2367	6194	3569
Delgado Street bridge	34.8	41	56	101	1363	2363	6181	3570
Paseo de Peralta bridge	35.2	48	65	112	1397	2401	6238	3691
Santa Fe Trail bridge	35.6	73	139	304	1405	2410	6249	3730
Galisteo Street bridge	35.6	79	146	308	1401	2405	6234	3736
Guadalupe Street bridge	35.7	105	171	346	1403	2406	6231	3755
just below Arroyo Mascaras junction	42.4	264	449	728	1869	3511	6522	9365
Camino Alire bridge	42.9	273	458	744	1932	3613	6600	9593
just below Arroyo Torreon junction	43.3	276	457	745	1962	3685	6595	9869
Cristobal Colon low-water crossing	43.8	289	475	812	2023	3796	6590	10139
near La Joya Road	44.1	No data	No data	No data	No data	No data	No data	No data
NW corner Frenchy's Field Park	46.5	350	630	1115	2426	4983	7484	12323
near Siler Park	47.0	No data	No data	No data	No data	No data	No data	No data
San Ysidro low-water crossing	47.8	345	618	1097	2405	4783	7500	12508
Lopez Lane bridge	48.3	341	608	1083	2387	4583	7453	12386
Cottonwood bridge	49.3	334	595	1061	2368	4575	7450	12387
NM 599 bridge	50.0	331	620	1056	2375	4551	7498	12560
below Wastewater Treatment Plant	54.8	330	579	1032	2367	4524	7653	12998

Table B.2. Measured peak flow data for locations along the Santa Fe River for 2007.

Location	Area sqmi	2007 Existing Conditions Peak Flow (cfs)						
		2yr	5yr	10yr	25yr	50yr	100yr	500yr
NE side of Msgr Patrick Smith Park	34.3	108	154	365	1341	2327	3369	6279
Palace Ave bridge	34.5	120	169	366	1340	2323	3367	6266
Delgado Street bridge	34.8	139	205	367	1339	2321	3366	6252
Paseo de Peralta bridge	35.2	153	222	378	1364	2354	3416	6348
Santa Fe Trail bridge	35.6	229	358	571	1373	2372	3443	6391
Galisteo Street bridge	35.6	234	366	582	1371	2371	3442	6388
Guadalupe Street bridge	35.7	251	392	615	1374	2368	3442	6381
just below Arroyo Mascaras junction	42.4	1042	1437	2049	3408	4845	6443	10492
Camino Alire bridge	42.9	1113	1527	2172	3580	5038	6687	10757
just below Arroyo Torreon junction	43.3	1106	1514	2218	3670	5163	6858	11060
Cristobal Colon low-water crossing	43.8	1260	1716	2461	3947	5463	7196	11526
near La Joya Road	44.1	1282	1747	2516	3995	5514	7249	11662
NW corner Frenchy's Field Park	46.5	1636	2219	3214	5428	7016	8978	14075
near Siler Park	47.0	1627	2210	3175	5218	6974	9033	14150
San Ysidro low-water crossing	47.8	1628	2210	3157	5189	7048	9034	14310
Lopez Lane bridge	48.3	1612	2193	3135	5157	6994	8970	14293
Cottonwood bridge	49.3	1598	2165	3094	5036	6897	8945	14278
NM 599 bridge	50.0	1600	2163	3076	5050	6932	9048	14450
below Wastewater Treatment Plant	54.8	1980	2643	3648	5670	7621	10031	16097

Table B.3. Projected peak flow estimates for locations along the Santa Fe River.

Location	Area sqmi	Future Conditions Peak Flow (cfs)						
		2yr	5yr	10yr	25yr	50yr	100yr	500yr
NE side of Msgr Patrick Smith Park	34.3	135	181	369	1344	2331	3397	6284
Palace Ave bridge	34.5	150	210	370	1344	2328	3400	6273
Delgado Street bridge	34.8	178	258	383	1344	2327	3401	6264
Paseo de Peralta bridge	35.2	193	276	407	1371	2364	3464	6361
Santa Fe Trail bridge	35.6	298	451	672	1384	2388	3506	6409
Galisteo Street bridge	35.6	302	456	687	1383	2386	3504	6410
Guadalupe Street bridge	35.7	318	481	718	1385	2385	3507	6404
just below Arroyo Mascaras junction	42.4	1263	1748	2485	3827	5227	6908	10710
Camino Alire bridge	42.9	1354	1877	2657	4048	5472	7192	11041
just below Arroyo Torreon junction	43.3	1348	1868	2686	4151	5611	7359	11340
Cristobal Colon low-water crossing	43.8	1506	2074	2949	4453	5940	7722	11839
near La Joya Road	44.1	1535	2110	3011	4518	6005	7795	11999
NW corner Frenchy's Field Park	46.5	1952	2630	4307	5993	7569	9590	14548
near Siler Park	47.0	1946	2624	4078	5905	7613	9684	14612
San Ysidro low-water crossing	47.8	1944	2626	3916	5927	7639	9710	14815
Lopez Lane bridge	48.3	1938	2604	3862	5830	7603	9640	14786
Cottonwood bridge	49.3	1911	2580	3756	5666	7488	9590	14800
NM 599 bridge	50.0	1915	2582	3733	5696	7594	9689	15036
below Wastewater Treatment Plant	54.8	2422	3237	4547	6619	8628	11140	17002

APPENDIX C: A WETLAND STRESSORS CHECK LIST FOR WETLANDS IN SANTA FE COUNTY

The following Stressors Check List for Wetlands in Santa Fe County has been modeled after the one developed for the NM RAM for Montane Riverine Wetlands Field Guide, Version 1.1, 2011 (Muldavin et al. 2011a).

WOI CODE_____ AA No. _____ Date: Mo_____ Day_____ Year_____ Surveyor Initials ____

Stressor Checklists

Worksheet 1a. Landscape Context. Check all that apply in the upper, middle and lower AA segments during field reconnaissance. The absence of these indicators indicates that disturbances are naturally occurring (e.g., flood deposition, or low-density wildlife trails).

Landscape Context	Buffer		Assessment Area	
	<10%	>10%	<10%	>10%
Urban residential				
Industrial/commercial (including waste management facilities)				
Military training/air traffic				
Transportation corridor (roads, rail lines, utility corridors)				
Sports fields and urban parklands (golf courses, soccer fields, etc.)				
Intensive row-crop agriculture				
Orchards/Nurseries				
Dryland farming				
Commercial feedlots				
Diaries				
Ranching – moderate (enclosed livestock grazing or horse paddock)				
Ranching – low intensity (livestock rangeland)				
Passive recreation (bird watching, hiking, etc.)				
Active recreation (off-road vehicles, mountain biking, hunting, fishing)				
Physical resource extraction, mining, quarrying (rock, sediment, oil/gas)				
Biological resource extraction (aquaculture, commercial fisheries, horticulture, and medicinal plant collecting, back-yard forestry, agroforestry)				
Multi-year impact logging and thinning operations				
Comments:				

Worksheet 1b. Vegetation (Biotic Condition). Check all that apply during field reconnaissance. The absence of these indicators indicates that disturbances are naturally occurring (e.g., flood deposition, or low-density wildlife trails).

Vegetation (Biotic Condition)	Buffer		Assessment Area	
	<10%	>10%	<10%	>10%
Mowing, grazing, excessive herbivory (with occurrence)				
Excessive human visitation (e.g., trampling, horse-back riding impacts, off-road vehicles, vandalism)				
Predation/habitat destruction by non-native vertebrates, including feral introduced naturalized species (domestic livestock, exotic game animals, and pet predators)				
Tree/Sapling or shrub removal (cutting, chaining, cabling, herbiciding)				
Removal of woody debris				
Treatment of non-native and nuisance plant species				
Presence of exotic plant species				
Pesticide application or vector control				
Biological resource extraction or stocking (various)				
Excessive organic debris (for recently logged sites)				
Lack of vegetation management to conserve natural resources				
Fire and burn impacts to natural vegetation				
Comments:				

Worksheet 1c. Physical Structure. Check all that apply in the upper, middle and lower AA segments during field reconnaissance. The absence of these indicators indicates that disturbances are naturally occurring (e.g., flood deposition, or low-density wildlife trails).				
Physical Structure (Soil/Substrate)	**Buffer**		**Assessment Area**	
	<10%	>10%	<10%	>10%
Filling or dumping of sediment or soils **(N/A for restoration areas)**				
Grading/Compaction **(N/A for restoration areas)**				
Plowing/Disking **(N/A for restoration areas)**				
Resource extraction (sediment, gravel, oil and/or gas)				
Vegetation management as negative impact (terracing, root plowing, pitting, drilling seed, or other practices that disturb soil surface)				
Disruption of leaf litter/humus, or peat/organic layer, or biological soil crust				
Excessive sediment or organic debris (e.g., excessive erosion, gullying, slope failure)				
Pesticides or trace organics				
Trash or refuse				
Climate (heat and evaporation) exposure on soil and water surfaces)				
Flood impacts on soils				
Wildfire impacts on soils				
Comments:				

Worksheet 1d. Hydrologic Condition. Check all that apply in the upper, middle and lower AA segments during field reconnaissance. The absence of these indicators indicates that disturbances are naturally occurring (e.g., flood deposition, or low-density wildlife trails).				
Hydrologic Condition	**Buffer**		**Assessment Area**	
	<10%	>10%	<10%	>10%
Point source discharges (and other non-storm water discharge)				
Non-point source discharges (urban runoff, farm drainage)				
Flow diversions or unnatural inflows (restrictions and augmentations)				
Dams (reservoirs, detention basins, recharge basins)				
Flow obstructions (culverts, paved stream crossings)				
Weir/Drop structures				
Dredged inlet/channel				
Engineered channel (riprap, armored channel bank, bed)				
Dikes/Levees				
Groundwater extraction				
Ditches (borrow, agricultural drainage, mosquito control, etc.)				
Actively managed hydrology (e.g., lake levels controlled)				
Comments:				

Worksheet 1e. Stressor Summary. Sum the number of stressors checked above for the buffer and AA.				
Stressor Summary	**Buffer**		**Assessment Area**	
	<10%	>10%	<10%	>10%
Total # of Landscape Context Stressors				
Total # of Vegetation (Biotic) Stressors				
Total # of Hydrologic Condition Stressors				
Total # of Physical Structure Stressors				
Total # of Stressors				
Comments:				

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APPENDIX D: PAYMENT FOR ECOSYSTEM SERVICES SCHEMES

Wetland Banking and In-Lieu Fee Services Programs

The U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (Corps) maintain primary jurisdiction of wetlands through the Clean Water Act (33 U.S.C. §1251 et seq. (1972)). The agencies maintain a "no net loss" policy regarding wetlands activities. As a result, any activity that results in loss of wetlands requires a permit and also requires compensation through wetland mitigation. Mitigation can be performed by the permittee, or through a third party.

One method of mitigating loss of wetlands is through wetlands mitigation banking. Under wetlands mitigation banking, a permittee needing to compensate for loss of wetlands due to development activities can purchase credits that provide funding to a third party to compensate for the loss of wetlands in another location. Mitigation activities can involve restoration, establishment or preservation of wetlands. In 2008, EPA and the Corps announced a new wetlands compensatory mitigation rule that creates new standards to improve wetland restoration and protection. The new standards clarify the mitigation sequence of "avoid, minimize and compensate." The rule emphasizes site selection; watershed needs assessments; ecological performance standards and monitoring; and aquatic ecosystem science in compensation measures (NACD 2009).

An opportunity for future financing of wetland restoration and protection is the development of an In Lieu Fee Services Program for wetland mitigation in Santa Fe County (SWQB 2011). An assessment of the long-term average number of CWA Section 404 permit applications in Santa Fe County and the associated monetary value for wetland mitigation activities may indicate the scale of a potential market for such a County-wide In Lieu Fee Service Program (ILF). The U.S. Army Corps of Engineers, which administers federally regulated wetland mitigation programs (The Conservation Fund 2009), offers several mitigation strategies, such as ILF and Mitigation Banking. Given the historical development trends in Santa Fe County, the development of an ILF program may be a more feasible option than the development of a Mitigation Banking program. The development of an ILF program requires the initiative of a non-profit entrepreneur who is able and willing to submit a proposal in the form of a prospectus to the U.S. Army Corps of Engineers for consideration of the collaborative development of a local ILF program. Upon approval of the proposal, a program plan and business plan must be developed and approved by an Interagency Review Team. However, given the current uncertainties of urban development and anticipated physical disturbances of wetlands that require subsequent mitigation action, the opportunities for establishing an ILF program in Santa Fe County are equally uncertain.

Water Quality Trading

U.S. EPA defines water quality trading as "…an approach that offers greater efficiency in achieving water quality goals on a watershed basis. It allows one source to meet its regulatory obligations by using pollutant reductions created by another source that has lower pollution control costs" (EPA 2003).

Water quality trading is an innovative, market-based, cost-effective mechanism to help achieve local water quality improvements (EPA 2003). In water quality trading, sources with high costs of reducing pollution (also called abatement) can purchase equal or greater pollution reductions from sources with lower costs. This cost difference provides an incentive for trading to occur. Entities with lower abatement costs are able to economically lower their pollution discharges beyond permitted levels, enabling them to sell their excess reductions (EPA 2003). Entities with higher abatement costs benefit by meeting their abatement goals at a reduced price. Permits under the Clean Water Act drive a lot of the current activity in water quality trading, but it is also possible to have trading driven by local water quality needs (EPA 2003, EPA 2004).

CWA related permits are based on Total Maximum Daily Loads (TMDLs) and enforced through the National Pollution Discharge Elimination System (NPDES). Under a water quality trading system, impaired streams or watersheds are identified and targets are set for the amount of allowable pollution or a TMDL. Landowners can generate credits by implementing best management practices (BMPs) to reduce nonpoint source pollution in the impaired stream. Regulated point source entities needing to reduce pollution levels for such pollutants as phosphorus, nitrogen or sediment can purchase the credits generated by the landowner(s) as an alternative to costly technology upgrades to their facility. Water quality credit trading offers an innovative strategy with great potential to improve water quality and natural systems in both urban and rural settings (NACD 2009).

However, because water quality standards for wetlands have not yet been developed for New Mexico, and there is no State-wide or State-issued trading policy, guidance, or set of rules, water quality trading based on regulatory pollution controls and enforcement mechanisms is not yet practical in New Mexico. The nearest states that do have such systems and that could serve as models for New Mexico are Colorado, Idaho, and Oregon. Other states include several states of the Great Lakes area and on the East Coast from New York to Florida (Willamette Partnership 2012). However, voluntary mechanisms are conceivable if markets could be found.

Biodiversity Trading

Loss of ecosystems and species habitat nationwide has resulted in many species being listed as endangered or at risk of extinction. Emphasis is placed on protecting or restoring habitat for these species through the 1973 Endangered Species Act (ESA) (7 U.S.C. § 136, 16 U.S.C. § 1531 et seq.). A solution that is gaining momentum involves working with landowners to provide wildlife habitat through conservation banking.

The U.S. Fish and Wildlife Service (FWS) issued the first federal guidelines for conservation banks in May 2003 (NACD 2009). The FWS guidelines standardized establishment and operational criteria for mitigation of wildlife habitat. Under these criteria, FWS utilizes conservation banks as a system of tradable credits based on desired species habitat, especially for at-risk and endangered species. Similar to wetlands mitigation banking, conservation banking works when developers or others are required to compensate for activities that adversely impact wildlife habitat. Lands used for ranching, farming, and timber can offset adverse impacts by selling habitat or species credits to those who need to compensate for impacts in return for an easement establishing specific wildlife management goals. Credits can be based on different sizes of land depending on the habitat needs of the species in consideration, but large tracts of

land work best because of their ability to provide a functioning ecosystem and greater biodiversity. Conservation banking can create a win-win-win situation where developers are able to offset the impact of their activities with regulatory certainty, landowners gain income for managing land for the impacted wildlife, and wildlife benefit from protected open space and habitat (NACD 2009).