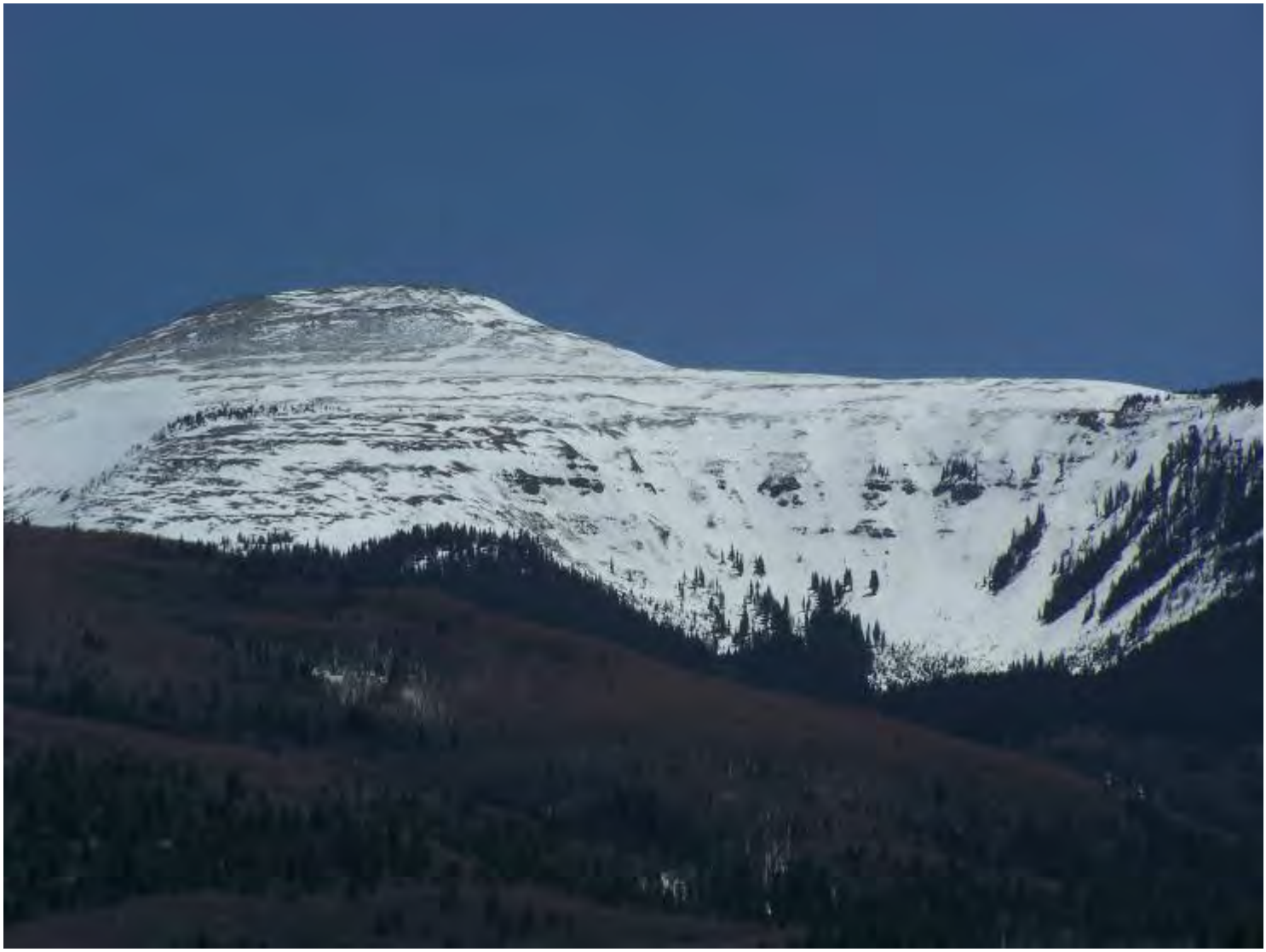
Upper Rio Grande:
La Jicarita through Embudo Valley
Watershed Management Plan
September 1, 2007
Revised for the Rio Santa Barbara in May, 2010



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Introduction

This Watershed Management Plan (WMP) has been developed through the collaborative efforts of various entities, individuals, and land management agencies throughout the watershed. A WMP is a living document that belongs to stakeholders as a community and should be revised and updated regularly to fit the needs and changes of the watershed and communities that lie within. This document is a result of a shared effort to identify local watershed health issues and concerns and formulate possible solutions for long term management options that seek to conserve the natural resources, cultural, social and economic integrity of the region.

The information utilized in this document was gathered through a combination of public outreach, watershed group discussions, individual interviews and surveys, and meetings with land management officials. Throughout the process a multitude of various stake holders have been identified and engaged and have acted as an integral part of the management planning process. This process was begun with the basic assumption that land and water resource management should be defined and practiced by those with the most intimate knowledge on a local level.

One of the highlights to come out of the process is direct communication with public land managers including the US Forest Service, Bureau of Land Management, and the New Mexico State Land office. Through local meetings, educational forums, and on the ground projects stakeholders were able to create dialog expressing the specific needs of the watershed and the communities that it supports.

Water and its relationship to land is so deeply entwined within the culture and the spirit of our communities that when concepts of watershed management are brought up, dialogue emerges about many issues affecting the health and integrity of the watershed communities. This document seeks to address watershed management from a holistic point of reference; acknowledging that ecological, cultural, and societal elements are interdependent. It is important for us to understand that the landscape and the water that flows through it does not recognize political, cultural, or familial boundaries but is a system in and of itself, with stakeholder collaboration being indispensable as part of a healthy system. It is for this reason that a full circle of watershed issues are being addressed in this document.

In addition, this document seeks to understand the current day as a point of reference. Before we can move forward into the future we must examine and attempt to understand the historical activities in the watershed that have contributed to current conditions.

We also acknowledge that we are not isolated. Our community is deeply affected by decisions and actions made at state, federal and global levels. Our communities must accept and deal with the repercussions and direct effects that these decisions bestow upon us, and recognize the power and ability to do so. Therefore it is important to acknowledge and embrace the future with a willingness to adapt and overcome the changes that happen on a daily basis.

It is with this philosophy and intent that this document is presented to the communities that make up the Rio Embudo Watershed. It is our hope that this work serves its purpose with the communities and provides a basis for improvement and management projects, healthy collaboration, and an examination of practices within the region for the future health, integrity, and livelihood of the watershed and the communities it supports.

What is a Watershed?

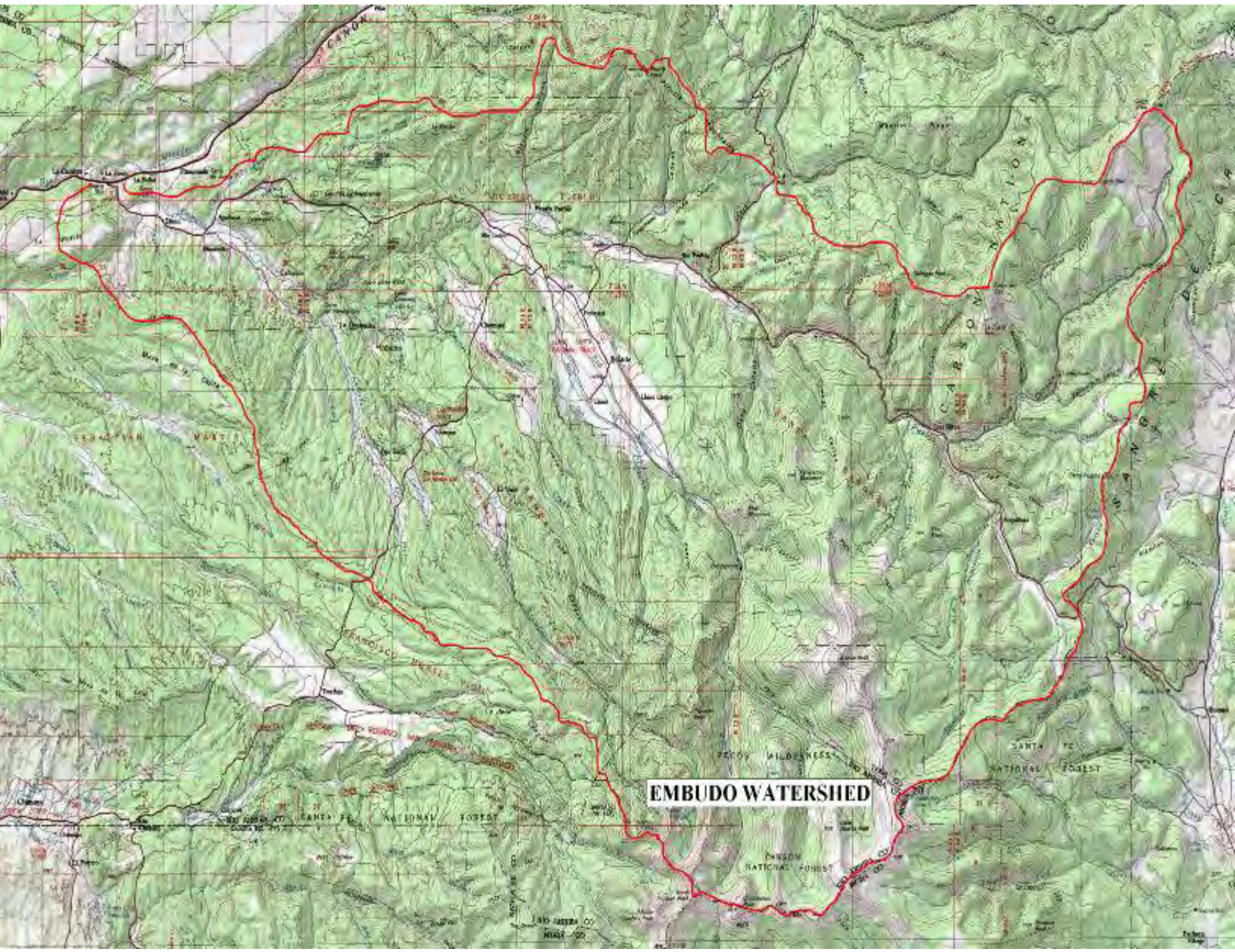
A watershed is an area of land where all the waters drain into a common place. All places are part of some watershed. Sometimes they are very large, others can be small. The size of a particular watershed is determined by what place on a river you are interested in. For this report, we have chosen the spot where the Rio Embudo enters the Rio Grande. The red line on the following map shows the area of the Rio Embudo watershed. All the rain that falls inside this line provides water to the Rio Embudo and all the rain that falls outside this line drains to other streams. Watershed boundaries (also called drainage divides because they divide the waters of different watersheds) are based on the topography of a landscape and are not determined by political boundaries. Drainage divides are often chosen as political boundaries, however, as where Rio Arriba and Mora counties' boundaries are drawn at the crest of the Sangre de Cristo Mountains.

Produced by Lane Council of Governments

Watersheds have thus become a framework by which local communities can evaluate the health of local water bodies and the health of their local ecosystems.

Planning Region for the Watershed Management Plan (WMP)

The Rio Embudo Watershed lies within the Upper Rio Grande II Watershed in north central New Mexico descending from an altitude of 13,100 feet at the northern section of the Truchas Peaks to 6000 feet, where the Rio Embudo empties into the Rio Grande at Embudo.



Map courtesy of NMED DOE Oversight Bureau

The watershed boundary line begins at North Truchas Peak and follows the Rio Arriba/Mora County line east and then northeast as it turns into the Taos/Mora County Line. Continuing northeast, delineated by the Sangre de Cristo Mountain Range, it turns southwest at the Rancho del Rio Grande Land Grant boundary and turns northwest at Gallegos Peak. It continues in a northwesterly direction through the Picuris Mountains and then west until it reaches the Rio Grande at La Junta. The boundary turns southeast over La Mesita and crosses Mesa de la Cajita and continues until it reaches the North Truchas Peak.

It is important to consider that, when planning, the Rio Embudo Watershed, as it is formally known, consists of two distinct yet interrelated areas of community. The top of the watershed begins in La Jicarita which consists of the communities of Placita, Vadito, Llano de la Yegua, Rodarte, Llano de San Juan, Peñasco, Chamisal, Las Trampas Truchas, Rio Lucio, and Picuris Pueblo. The Embudo Valley makes up the downstream section of the watershed as a whole and consists of the communities of Ojo Sarco, Cañoncito, Apodaca, Dixon, and Embudo.

Surface Water

Rio Embudo is a major tributary to the Rio Grande and is formed within the boundaries of Picuris Pueblo where the Rio Santa Barbara, Rio Pueblo, Rio Chiquito, and Trampas Creek converge. The Rio Ojo Sarco and Trampas Creek both join the Rio Embudo outside the Pueblo boundaries. The alpine lakes that feed this stream system are Hidden Lake, Trampas Lake, San Leonardo Lake, Lake Alice, Lake Ruth, and Lake Hazel. Rain and snow that soak into the ground flow underground as groundwater and provide the water that flows in our streams during dry periods.

Rio Santa Barbara originates in the Sangre de Cristo Mountains and flows through the Pecos Wilderness before converging with the Rio Pueblo to form the Rio Embudo within the Picuris Pueblo boundaries.

Rio Pueblo also originates in the Sangre de Cristo Mountains and converges downstream with the Rio Santa Barbara within the Picuris Pueblo boundaries to form the Rio Embudo.

Rio Chiquito originates in the Sangre de Cristo Mountains just outside of the northwestern boundary of the Pecos Wilderness and empties into the Rio Santa Barbara within the Picuris Pueblo boundaries.

Chamisal Creek originates in the Sangre de Cristo Mountains and empties into the Rio Embudo just outside of the Picuris Pueblo's western boundary.

Rio de las Trampas is formed in the Sangre de Cristo Mountains and empties into the Rio Embudo just to the east of Cañoncito.

Cañada de Ojo Sarco originates in the Sangre de Cristo Mountains and flows through the town of Ojo Sarco before it empties into the Rio Embudo in Cañoncito.

The Rio Embudo is formed within the Picuris Pueblo boundaries that politically segregate the watershed area, with the Pueblo being active in watershed management projects that address the health of the watershed as a whole. The Rio Embudo continues to flow until it empties into the Rio Grande just north of Embudo.

Vegetation Zones

The Rio Embudo Watershed is comprised of four vegetation zones that change as the landscape descends in altitude. These zones are:

Alpine Grasslands (above 11,000 feet) - This zone lies in the upper reaches of Jicarilla Peak, the area around Hidden and Trampas Lakes, and the bald area of La Jicarita Peak. Vegetation in this zone is slow growing.

Spruce-Fir Zone (8,500-11,000 feet) - Much of the Pecos Wilderness area lies within this zone including around La Jicarita Peak and up La Junta Canyon. There is no human habitation here and limited to no vehicular access.

Pine Zone (7,500-8,500 feet) - Area covered by this zone encompasses the communities of Ojo Sarco, El Valle, Llano de San Juan, Llano de la Yegua, Rodarte, Peñasco, part of Picuris Pueblo, and Tres Ritos.

Piñon-Juniper-Brush Zone (6,000-7,500 feet)

This zone encompasses the villages of Las Trampas, Vadito, Chamisal, Cañoncito, Apodaca, Dixon, and part of Picuris Pueblo.

Geology

The broad Peñasco and Dixon valleys are cut into tertiary volcanics (basalts and ash) and sediments together known as the Santa Fe group (late Miocene to early Pliocene).

The valleys of the Rio Embudo Watershed are cut into rocks that were deposited between approximately 1.8 billion and 3 million years ago. These valleys were carved by the streams that flow in our watershed and their 'ancestors'. At and near the headwaters, rock units include sedimentary beds (shales, sandstones, and limestones) deposited by east-flowing rivers about 300 million years ago. These are the rocks that have 'seashells' in them. These rocks were deposited in deltas, rivers, and shallow seas (like the Mississippi delta today) and on carbonate shelfs (like the bahama banks today). These sediments lie on above crystalline pre-Cambrian basement rock (schists, quartzites and granites).

At and near the headwaters, primary rock units include unmetamorphosed Pennsylvanian sedimentary beds (shales with some limestones and sandstones) of the Magdalena group (La Posada, Alamitos and Flechado formations). These mid-Pennsylvanian marine units represent deep marine and carbonate shelf rock types. These sediments lie unconformable above crystalline pre-cambrian basement rock (schists, quartzites and granites).

At the southwestern end of the Picuris Range, the Rio Pueblo cuts a very deep, narrow, precipitous canyon through Pre-cambrian granites, quartzites, muscovite schists, and amphibolites.

Near the confluence with the Rio Grande, badlands are the prominent topographic feature. Badlands are characterized by claylike material of low permeability (ashes and sediments of the Santa Fe group), little or no vegetation, rainfall concentrated in widely scattered showers, and downcutting of the drainage system.

Brief History of the Watershed

The ability to settle an area has always been determined by water supply, it being the life blood of the landscape, and settlement in this area occurred mainly along the river channels and streams. For over 6000 years this area has been occupied non continuously; first by the ancestors of Picuris, and then by settlers under the Spanish Crown. The ancestors of the Picuris people developed agricultural techniques, which utilized the rich valleys and abundance of water, to produce crops. Crops were grown in specialized sunken gardens known as waffle gardens. These gardens were designed to capture and concentrate moisture, by use of cobble mulch and check dams. This allowed the soil to become saturated and facilitated the growing process. Rivers and springs were also used traditionally by the peoples of this area.

Settlement by the Spanish began in the 1700's, under land grants issued by the Spanish governors. The first of these grants was known as the La Plaza de Santa Barbara grant, and was issued in 1744. With an average elevation of 7500 feet above sea level, fertile soil and availability of water, this area proved ideal for the settlers, for production of wheat, oats, barley, beans, corn, squash, and potatoes. Sheep, goat and wool production also came along with Spanish settlers. They also planted fruit trees near their homes to establish orchards that produced apples, peaches, apricots, pears, and cherries.

During the first part of the twentieth century railroad ties were becoming increasingly in demand. This facilitated a search for suitable material. In 1907, work began with the purchase of 338 acres by the newly formed Santa Barbara Tie and Pole (SBT&P) company. During the next 32+ years SBT&P acquired more land, and greater than 400,000 ties were being produced annually. To assist in getting the ties to the creosote plant in Albuquerque, splash ponds were built along the waterway, and dynamited, creating walls of water that would carry the ties down to the Rio Grande. To facilitate the operation, a narrow gauge railway was put in along with five miles or more of track, in an area near Hodges. Three steam powered sawmills were also constructed, in order to accompany work done by hand, using broadaxes. During this period many logging roads were built in order to access the timber stands. Many were poorly located and resulted in high erosion potential. The result of the SBT&P operation was intensive logging in what is now the Carson National Forest. This accompanied by heavy grazing pressures were large impacts on the environment. During this period riparian and under story vegetation were hit hardest, and to this day are still in the process of recovery. (Arrellano, Draft Rio Embudo WRAS, 2004)

The Oglebay mica mining site has been a concern in the watershed for nearly 40 years, especially to the Picuris people on whose ancestral lands the site sits. The area, called Mowlownan-á in the Tiwa language is less than 4 miles from the village and encompasses about 200 acres of land. This area has been used for over 1000 years for the gathering of micaceous clay and other tribal uses. Since mining began in the 1960's access to the site by tribal people was lost and the clay gathering sites have been buried under tons of waste rock.

The mine itself was the largest mica mine west of the Mississippi, and last operated by Oglebay Norton Specialty Minerals. The Picuris people never gave up ownership of the land and filed an aboriginal title claim to have the use of the land returned. With the use of the land now returned to the people of Picuris, responsibility for reclamation of the site falls to them.

The complete history of the Embudo Watershed is rich in culture, and complex in nature. With that in mind it is important to understand historical settlement patterns and land ownership, land uses, traditions, and the reasons for the development patterns. An in depth look at the history of the area including land grants, settlement, acequia development and history, Picuris/Mora diversion, and place names was developed by Estevan Arrellano for the purpose of this report and is presented in appendix F for a greater understanding of the life process of the Rio Embudo Watershed.

Land Use

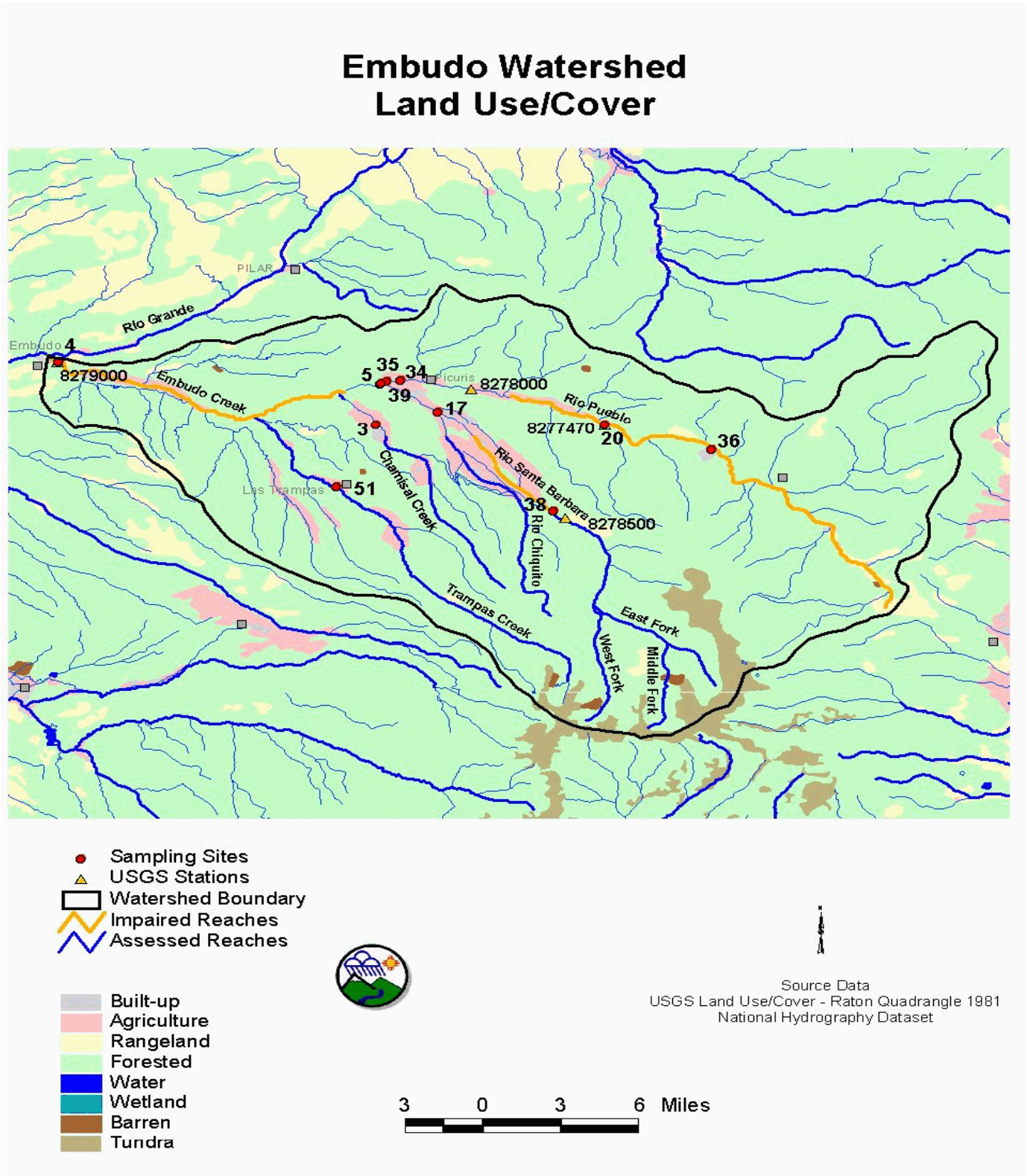
- Forest- 89%
- Agriculture- 4%
- Barren tundra- 2%
- Rangeland- 2%
- Developed land-1%
- Water- < 1%
- Wetlands- < 1%

Statistical information was taken from the Total Maximum Daily Load (TMDL) report for the Upper Rio Grande II.

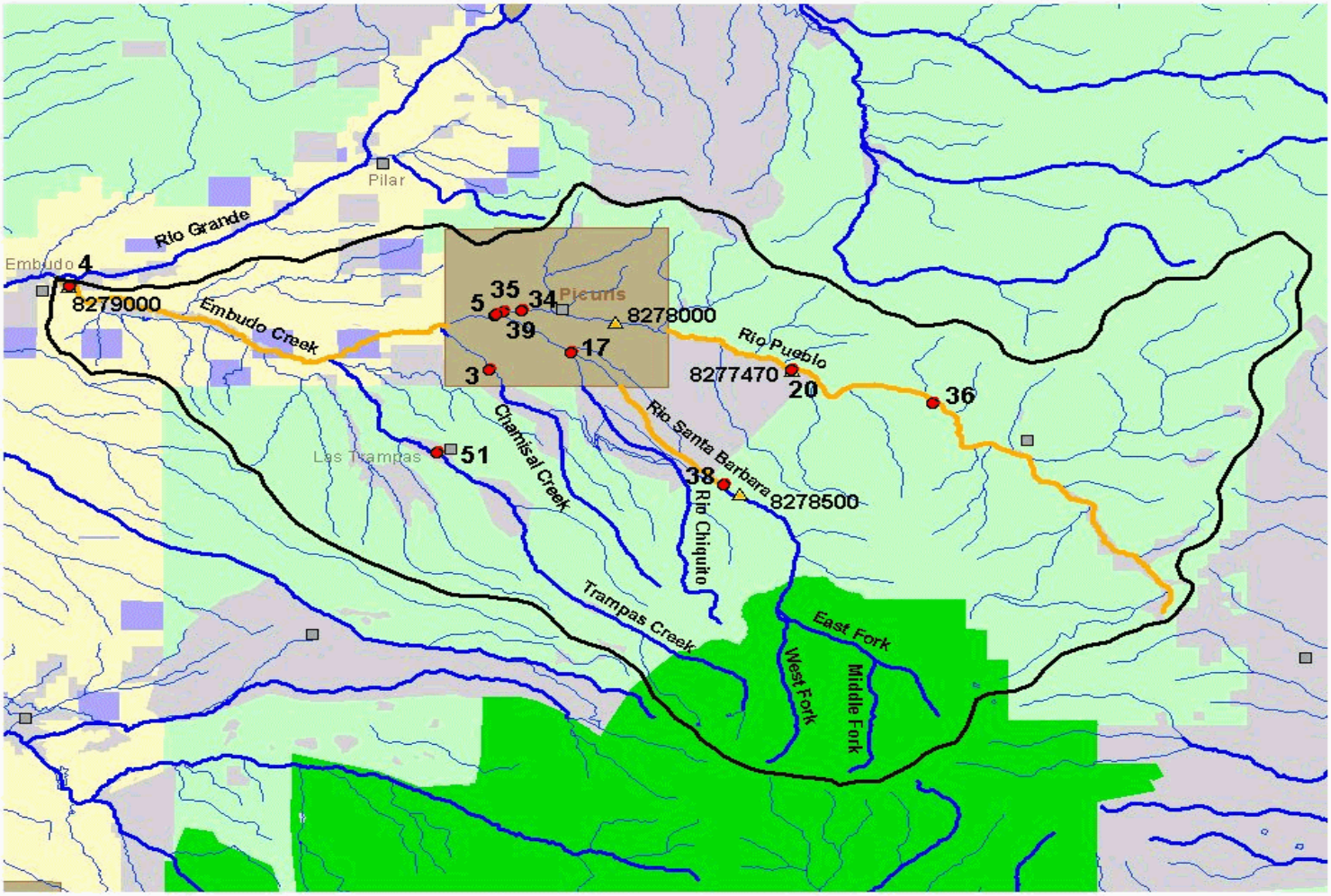
Alpine grasslands and the spruce/fir zones are mainly wilderness areas and has sustained very little human impact. The wilderness area is closed to vehicular traffic but is open to hiking and camping. There are approximately 14 campsites located in the watershed area, which lies in the Carson National Forest. Recreational uses also include Sipapu Ski Resort located on the banks of the Rio Pueblo, cross country skiing, snowmobiling, horseback riding, and packing tours.

Sipapu Ski Resort does engage in snowmaking using a product called SNOMAX. This product is considered inert and is made from corn smut. Sipapu is currently testing a new snowmaking product called DRIFT. This product is also inert but easier to handle, doesn't have a smell, and disperses water more efficiently than SNOMAX. Currently Sipapu sends monthly well water samples to the NMED for coli form testing but does not test surface waters in the Rio Pueblo. The classification for the well water is currently "well water under the influence of groundwater."

Livestock production on private, USFS, and BLM lands is currently an important land use in the watershed, and many people still cultivate small farms and kitchen gardens although agriculture has not been economically viable for some time. Local community members estimate that approximately 80% of inhabited or managed lands in the watershed are used for some type of agriculture. The Embudo Valley hosts fruit orchards that were much more abundant in the past but many have fallen into disrepair and fruit production has diminished. However there are still several successful orchards in operation today.



Embudo Watershed
Land Ownership



- Sampling Sites
- USGS Stations
- Watershed Boundary
- Impaired Reaches
- Assessed Reaches
- Pueblo Lands
- BLM
- State
- Private
- Wilderness
- US Forest Service

Source Data
BLM Land Status 2004
National Hydrography Dataset

3 0 3 6 Miles

Intent of This Document

This document is funded by US EPA Clean Water Act Section 319 and administered by the New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB) for addressing non-point source contaminants in surface water bodies.

Non-point source (NPS) pollution comes from unknown or dispersed sources throughout the landscape and it is a directive of this planning process to determine sources for these pollutants. In the Rio Embudo Watershed the Rio Santa Barbara, and the Rio Embudo have been recognized as exceeding state standards for sedimentation/siltation and turbidity, and are presented on the 303(d) List of Impaired Waters for the State of New Mexico. Although these regulatory mechanisms play a key role in the determination of watershed issues and solution building it has been the expressed desire of the stakeholders involved that this document be presented in a fashion that is non-technical in nature so that any member of the communities (including high school students) can utilize the information for improvement projects and programs. For this reason, a summary is presented here with the regulatory overview and full explanation of terms presented for reference in appendix A.

The New Mexico Environment Department performs surface water quality sampling periodically to determine if the surface waters are meeting water quality standards as prescribed by the New Mexico Water Quality Control Commission (NMWQCC). The standards are determined by designated uses within the stream segment. Some examples of designated uses are irrigation, livestock watering, wildlife habitat, primary contact, marginal coldwater fishery and warm water fishery. If a stream segment does not meet water quality standards for its particular designated use it is placed on the list of imapaired waters for the state and given a priority ranking. In the case of the Rio Embudo Watershed these designated uses that are not being met are:

- Rio Santa Barbara (Picuris Pueblo boundary to USFS boundary)
    - Designated use- High quality coldwater fishery
    - NPS Pollutant- Turbidity
- Rio Embudo (Rio Grande to Cañada de Ojo Sarco)
    - Designated uses- Marginal coldwater fishery and warmwater fishery
    - NPS pollutant- Turbidity and sedimentation/siltation
- Rio Chiquito (Picuris Pueblo boundary to headwaters)
    - NPS pollutant- Turbidity

It is important to note that Picuris Pueblo is a sovereign nation that determines its own water quality standards which are more stringent than NMWCC standards. As such the upper watershed is responsible for delivery at or above that standard.

Seven sampling stations were used for collection in 2001 and are shown on the Land Ownership map on page 12 of this document. These stations were:

- Rio Embudo at USGS gage near Dixon and HWY 68
- Rio Embudo below confluence of Rio Santa Barbara and Rio Pueblo
- Rio Pueblo above Rio Santa Barbara
- Rio Pueblo at Hwy 75

- Rio Pueblo above Sipapu
- Rio Santa Barbara at Hodges
- Rio Santa Barbara at mouth

The Rio Embudo (Cañada de Ojo Sarco to Picuris Pueblo Boundary), Rio Santa Barbara, and the Rio Pueblo were also found to be impaired through benthic macroinvertabrate bioassessments, or bug counts. Macroinvertabrates (bugs) are good indicators as to the health and proper function of an ecosystem but more information is needed in order to determine the actual cause of impairment.

Further explanation of these impairments can be found in Appendix B of this document.

This document is the result of a collaborative process to determine how, as communities, we can create actions that contribute to the well being of our watershed and land base. Individual actions on part of land owners and governments contribute to the health of the landscape and the accompanying water resources. By acknowledging that we are all part of the ecosystem we can use creative and collaborative solutions to protect our resources.

This document serves to provide a frame work by which multiple parties can seek to form collaborative solutions for common problems affecting the larger watershed. This is a voluntary and a living document meaning that it is intended to only present an introduction to the issues. There still remains a need for further partnerships, out reach, planning and action.

Watershed Group Formation and Public Outreach

In the development of the planning process for the Rio Embudo Watershed two watershed groups have been instrumental in the gathering of information and providing a basis for outreach.

Embudo Valley Watershed Group (EVWG) was formed in March of 2005 when a series of group discussions occurred in Dixon, NM that focused on the care and sustenance of the Embudo Valley. During these discussions it became clear that the formation of a watershed group was a desire within the communities that comprise the Embudo Valley. The group began meeting on a monthly basis and examining prevalent issues within the watershed. As specific issues were discussed and examined, the appropriate land management agencies were invited to participate. It was in this manner that dialogue between local landowners and public officials began to grow.

Throughout the process of examining specific issues and concerns several ideas for group purpose were also discussed in reference to the role that the group would play in the watershed communities. These purposes are:

- Play a supporting role for landowners or associations (grazing allotments, acequias, community service associations, or schools) who intend on planning watershed improvement projects or programs.
- Act as a resource for planning and implementing educational events or programs that target overall watershed health.

- Bring stakeholders together to actively restore, maintain, beneficially use and plan for the health of the Rio Embudo Watershed.

La Jicarita Watershed and Wastewater Study Committee is an organization of representatives from public agencies such as Mutual Domestics Water Consumers Associations and Acequias. These representatives join together to provide leadership, to protect and improve water quality, examine watershed and wastewater issues, and to study and provide recommendations for the health of future generations. This committee expressed the desire to act as the watershed group for La Jicarita and take on the greater watershed health planning. This organization is currently moving forward to create two pilot projects for wastewater treatment as well as being active in the watershed management planning process.

In addition to these groups a partnership was formed with the Embudo Valley Environmental Monitoring Group (EVEMG) in the summer of 2005 to initiate a soil and sediment sampling program at stations throughout the watershed. With the support of NMED DOE Oversight Bureau, soil and sediments were sampled at five locations throughout the watershed as well as one plum sample in Llano de la Yegua. A produce sampling program was initiated in the summer of 2006 with lettuce samples being taken at the same five locations throughout the watershed. In the summer of 2007 EVEMG and watershed representative, together with NMED DOE Oversight went out again to the same five locations and performed water sampling using the water that the lettuce was irrigated with, as well as taking more soil samples. This program is being developed with the intent to establish a background of information that will help to determine the overall watershed condition.

In addition the Northern New Mexico Watershed Institute was formed as a non profit under the State of New Mexico in order to:

1. function in a support and resource capacity in watershed related matters for individuals, groups, organizations, and communities within Northern New Mexico watershed areas and
2. Develop and implement programs and projects that address watershed needs not normally feasible or practical by other entities.

This organiation is governed by a board of four and is currently working on development of group structure and seeking operational funds.

Through discussions many subjects were brought to the table that contribute directly and indirectly to the health of the watershed, such as education, immigration, economics, politics, technology, etc. Over time we were able to focus our attention on how all of these different elements affect the health of the landscape. It was the initial focus to determine what features are most valued within the watershed. Those features identified were:

- Water
- Landscapes
- Acequias
- Agriculture
- Ranching
- Food security

- Tradition
- Low density development
- Open space
- Wildlife, birds, fishes
- Recreation
- Spiritual nurturing
- Clean drinking water
- Hunting, fishing, boating

A survey was also conducted in the watershed with several stakeholders; the primary purpose being to gain response to a number of basic watershed-related issues. There are a number of watershed issues/concerns that were voiced by most of the persons who took part in the survey, including:

1. A need for local environmental education in the schools – Kindergarten-12th grade.
2. A great concern about diminishing agricultural activity and eroding cultural values.
3. A deep sense that water belongs to the community and that regulation of it is a community responsibility.
4. A need for some kind of structured community approach to watershed management. People are interested, but many do not know how to begin to deal with the issue.
5. Explicit concern for water conservation (in both private and agricultural use).
6. A widespread concern for septic regulation and waste management.
7. A great concern about drug and alcohol abuse.
8. The vast majority of the youth interviewed have no intention of becoming involved in traditional farming/ranching. They are either interested in moving to an urban area or gaining employment from other than agriculture-related activities.

With all of these concerns that affect the value, function, and health of the watershed communities surfacing over time, it became apparent that in order to comprehensively plan we needed to focus our attention on those issues that address the greater watershed as a whole. The groups began to look at components of the physical landscape and to learn about the functions and conditions of each. Statements of Challenge and Opportunity were developed and are intended to serve as basic building blocks for expansion, additions, and growth of the planning process for the health of the watershed. These statements are presented in the following section.

Most of the information contained in this document was compiled by various members of the watershed groups utilizing available information, past research, and local knowledge. Some of the issues are examined in more depth than others, this being related to factors such as the degree of concern by the communities in the watershed, and available information.

Watershed Issues: Challenges and Recommendations

The groups determined seven distinct issues to be examined in the management plan. All of the stated issues are interrelated yet it is easier to view them individually to examine

them as modules that can fit together to complete a larger picture. The issues addressed in depth in this document are:

- Forest Health
- Arroyos/Drainages
- Wetlands and Riparian Areas
- Illegal Dumping
- Education/Outreach
- Agriculture and Acequias
- Wastewater Management

Forest Health

Forest health has been identified as a watershed concern and current conditions are affecting the health, integrity, and aesthetics of our watershed. Forest conditions have also been determined to be a potential contributor to NPS pollution in the watersheds surface waters.

The health of the forest plays a dominant role in the quality and quantity of the water available. From the spruce, fir, and aspen, at the higher levels, to ponderosa pine at midlevel and piñon/juniper near the river, the entire Rio Embudo watershed is almost fully forested with the exception of the communities, fields, and roads that have been carved into the landscape.

Certain conditions currently exist that compromise the ability of the forest to capture, retain and release the available water, in a manner consistent with human use. These conditions have developed over time through direct human impact, land management policy, natural climatic cycles, and general negligence.

Historically, natural fire processes served to clean the forests of debris and fuel. As a result of the regular occurrence of these fires, they burned at a very low temperature allowing life to continue and regenerate.

Slow change in fire policy which occurred in the early 1900s began the gradual alteration of natural forest conditions. Fire suppression served to clog forests and change the character of the fires that do occur. Forest fires in contemporary times burn at intensely high temperatures, penetrating the soils and reaching microorganisms, leaving no life behind. The healing of the landscape from such a fire could take up to 100 years.

Overgrazing has taken its toll on the landscape. Although conditions have greatly improved in the last 50 years due to restrictions and policies such as rotational grazing practices, there is not enough manpower available for adequate enforcement. Private landowners, in some instances, don't rotate their pastures either. Livestock will always go where the grass is best, usually where vegetation is seeding. The cool season grasses that start seeding in the spring are the hardest hit, and they are the ones that provide seed critical for germination during moisture of the monsoon.

Although much of the landscape has begun to heal from the effects of overgrazing, the south facing slopes that face the harsh summer sun with no mulch or cover for seed have not been able to revegetate. This subjects the landscape to heavy erosion during the rainy season, and sediments are washed down into the surface waters, contributing to the sedimentation problems.

Over the past fifty years many water impoundments have been built in the forests, in most cases for livestock usage. They are on public and private lands and were funded, mostly, by public funds. Though the livestock need is waning, the need for impounded water is perpetual. These water storage areas contribute to the health of the forest in several ways. They were built in natural water flow areas, and they slow down the water from heavy spring runoff and rains. They provide water for wildlife, and a small wetland environment during dry periods.

<u>Objectives</u>

The Rio Embudo, Rio Santa Barbara, and Rio Pueblo are on the river watch list in New Mexico, due to sedimentation and turbidity problems. A healthy forest is the overall objective and by meeting certain forestry objectives, sedimentation will be measurably reduced in the watershed.

- Relieve severe overcrowding through thinning to a goal of 60-80 DBH/acre in order to
    - Reduce hazardous fuels
    - Allow regeneration of vegetation on forest floor

    - Allow healthy trees to help perpetuate a hydrological cycle
- Revegetate eroded areas
- Repair and maintain existing forest access routes
- Repair and maintain existing water storage impoundments
- Rotational grazing practices implemented and enforced

Getting there requires a many faceted approach which includes but is not limited to:

- Fire Management
- Erosion Control
- Thinning projects
- Economic incentives
- Educational opportunities

Challenges

Bringing together key players and need for a plan- A wide variety of state, regional and federal initiatives are addressing specific aspects of the overall ecological condition. Some of these include:

- The National Fire Plan
- Southwest Strategy's Water Task Team
- Drought Task Force, Office of the State Engineer
- Fire Planning Task Force of the State Forestry Division
- Biomass Working Group of the State's Energy, Minerals, and Natural Resources Department
- Watershed Task Force of 2004 HB2

Although these efforts are making progress separately, they are not being coordinated to address the overall condition, and therefore are not achieving the impact of a fully integrated approach. In addition, there is much duplication of effort resulting in inefficient utilization of limited resources. (The New Mexico Forest and Watershed Health Plan-May 2004)

Multi Jurisdictional- The landscape does not recognize political and private boundaries and, as such, many problems cannot be effectively addressed by one landowner or entity. The development of partnerships to address the health of the entire landscape during planning is important. The challenge is to bring the various federal, state, tribal and private stake holders together and use the funds that are available to all of them, in a coordinated manner, for the benefit of forest health and, thereby, the watershed. All of the entities have done some forest restoration. But the total acreage treated is miniscule compared to the acres needing work. The vast majority of the land in this watershed is under Forest Service, Bureau of Land Management, or Picuris Pueblo jurisdiction.

Communication between private stakeholders and governing entities- There is a history of lack of communication and disagreement between private landowners and land management agencies. Federal land management processes are lengthy and expensive and this is frustrating to many people. In many cases traditional land management, and

governmental land management processes and policies are in opposition. Genuine public involvement and activity are needed in USFS and BLM management plans.

Learning other "languages"- Learning specialized terms and organizational approaches (scientific, bureaucratic, grant writing, legislative, technical, legal, etc.) is often a necessary, trying, and exhaustive process.

Climate- The natural climatic cycles in this arid region can limit the growth of vegetation and grasses that slow water runoff, increase soil permeability, and hold soil in place. Lack of vegetative cover can also greatly increase the potential for flash flooding.

Overcrowding- The overcrowding of forested lands with small diameter, unhealthy trees interferes with the natural hydrological cycle. Water is not allowed to reach the forest floor severely limiting the growth of ground cover which helps prevent unnecessary erosion. Trees are not able to receive space or water necessary to maintain healthy size and condition. Fire danger is severely increased.

Roads- Roads are necessary for forest restoration, recreation, fire fighting, and livestock control; however road development and poor maintenance in the upland areas and forested regions can be a potential cause for concern. Road designations and reclamation of unused roads while still allowing for access to firewood and construction wood presents a challenge but is necessary for a collaborative solution. Forest access routes have a variety of erosion problems, some having been well built and some not. The USFS budget for maintaining forest roads is inadequate.

Vehicles- Undesignated use of off road recreational vehicles such as ATVs can be destructive to vast expanses of sensitive landscape. Many undesignated sites run through forested lands and this can cause problems such as changing the landscape, loss of vegetation, and disturbing soils, all of which increases erosion.

Development- Land that is cleared for development reduces vegetation and grasses that slow water runoff and hold soils in place. Development also creates hard and impermeable surfaces such as roofs and paved lots. This speeds up water velocity and decreases potential for infiltration. Development also constrains the use of prescribed burns because of the additional hazard to structures as well as more challenging air quality permitting in proximity to residences.

<u>Recommendations and Best Management Practices (BMPs)</u>

Forest thinning projects- thinning and cleaning the forest will provide a variety of positive results. The major effect will be to reduce the chances for catastrophic crown fire. Fire, even under high wind conditions, is less likely to reach the next tree if they are far apart. With an open canopy more sun will hit the ground. This, in turn, will promote reestablishment of the natural vegetation-grass and shrubs. This, in turn, will promote more wildlife and assist in natural ground fires. This, in turn, will assist the forest to keep its natural tree spacing by burning many of the germinating trees before they achieve the size necessary to choke out the sun.

A pilot thinning project to provide educational opportunities to local schools and as a demonstration site for public education is a recommendation under this WMP.

Utilization of "Forest Restoration Principles"- Development was a collaborative effort and these principles are presented in Appendix E of this document.

Rotational Grazing- this is already a policy of the USFS on allotments on FS lands but proper enforcement has been difficult. Although this is a recommendation in this report, there have been failures to previous efforts. The Quivera Coalition received a grant to support herding practices with the Santa Barbara Grazing Association (SBGA) and the challenges faced were:

- Large allotments
- Cattle not used to herding
- Not enough time spent herding by the herder
- Only one herder

Although encouragement of private landowners to follow rotational grazing practices is recommended, feasibility of this should be researched with the SBGA and Quivera Coalition.

Revegetation of south facing slopes- Mulching and seeding these slopes can provide the necessary vegetative cover to hold the moisture and the soil.

Forest road upgrade and maintenance- The main issue is proper design so the water gets off the roads before it gathers mass and momentum to damage the road. Water bars, culverts and vegetation reseeding will alleviate erosion problems. Most forest roads in the watershed are under USFS or BLM jurisdiction and strong public input into the USFS Travel Management Plan (under development) and the BLM Travel Management Plan (under development) is recommended.

Proper fire management- Fire management over suppression introduced slowly into the ecosystem should act as previous natural fire processes and be considered as a recycling mechanism for debris to be processed into nutrients which will then feed new growth.

Identification, repair, and maintenance of existing water impoundments- All of these water storage areas require maintenance and upgrading to function as they were designed to.

Small business development incentives- Development of small business enterprise to process and market forest products.

<u>Programs and Possible Funding Sources</u>
There are several programs and funding sources that can be drawn on that emphasize collaborative solution building:

USFS

- Collaborative Forest Restoration Projects
- Taking Wing

USDA

- Rural Business Enterprise Grants
- Healthy Forest Reserve Program (HFRP)
- NRCS Grant to Quivera Coalition for the promotion of rotational grazing (herding)

National Forest Foundation

- Matching awards program

National Forest RELEAF Program

NMED

- CWA section 319 funding

Arroyos/Drainages

Arroyo function has been identified as a watershed concern and current conditions are affecting the health, integrity and aesthetics of our watershed. Arroyo conditions have also been identified as a possible source of NPS pollution.

Arroyos are ephemeral surface channels, which mean that they do not flow all year round. They can develop characteristics of perennially flowing streams, such as riparian areas and active floodplain, but are subject to extreme behavior in dry/flood times.

There are many factors that can affect arroyo function. Some of these factors are related to the nature of the area such as climate, vegetation, and soil conditions; and some factors are related to the health of the landscape such as range conditions, roadways, channelization, and development.

Intense rains in the summer of 2006 demonstrated the severity possible of flooding events. Excess water, sediments, and garbage were displaced during this season onto

local roads, and into acequias and the rivers. These events have caused damage to infrastructure and threaten water quality.

The flood damage from arroyos to Acequias in the Embudo Valley was extensive in the Acequia Junta y Cienega, Acequia del Bosque, Acequia de la Plaza, Acequia del Llano, and to a lesser degree in Acequia del Medio.

Objectives

Our land base and accompanying waterways have been identified as valued features within the watershed. The health and proper function of the land base and the waterways is a priority for the watershed community. Several objectives can be reasonably considered:

- Identification of proper drainages
- Repair and maintenance of existing silt ponds
- Projects that address upper watershed health issues such as range and forest management projects
- Sensible development
- Revegetation of barren arroyos
- Instigating water slowing techniques (traditional and contemporary) such as one-rock dams, siltation ponds, and terracing
- Properly replacing and maintaining culverts
- Plan for long term maintenance of drainages

Challenges

Multi Jurisdictional- The landscape does not recognize political and private boundaries and, as such, if one landowner corrects a problem it could cause further destruction or benefit downstream. An arroyo often flows through several jurisdictions making it difficult to view it as part of a system rather than a dislocated problem affecting one property. The development of partnerships to address the health of the entire landscape during planning is important.

Climate- Natural climatic cycles in this arid region can limit the growth of vegetation and grasses that slow water runoff, increase soil permeability, and hold soil in place. Lack of vegetative cover can also greatly increase the potential for flash flooding and turbid runoff.

Range Conditions- Poor range conditions contribute to the potential for destructive flash flood events by reducing vegetation and grasses that slow water runoff. Good management practices on grazing allotments can help to improve the health and vitality of the landscape and should be implemented.

Roads- Road development and poor maintenance in the upland areas can contribute to increased runoff. In addition, culverts that have displaced natural drainage systems speed up and divert run off exacerbating the intensity of the flow. Many roads either cross arroyos, or run in conjunction with arroyos in certain places, this can contribute to an

increase in erosion, cause destabilization of the arroyo bottom, and destroy riparian vegetation that provides waterway stability. Drainage culverts also need to be distinguished from irrigation culverts as road sediments can be loaded onto agricultural land.

Vehicles- Undesignated use of off road recreational vehicles such as ATVs can be destructive to vast expanses of sensitive landscape. Many undesignated sites run through arroyos and this can cause problems such as changing the landscape, loss of vegetation, and disturbing soils, which increases erosion.

Channelization- Because arroyos are subject to intense run off, they are also susceptible to becoming like a water chute instead of a meandering watercourse. This creates a similar effect to the driving of motorized vehicles in the arroyos**.**

Development- Land that is cleared for development reduces vegetation and grasses that slow water runoff and hold soils in place. Development also creates hard and impermeable surfaces such as roofs and paved lots. This speeds up water velocity and decreases potential for infiltration. In addition, soils that are disturbed by development can contribute to the spreading of invasive species. Development can also encroach on the arroyo channels, causing more erosion to occur on the opposite bank.

Soils- Highly erosive soils, such as those found in the Upper Rio Grande Valley, are more susceptible to erosion and therefore will load sediments into arroyos, acequias and streams.

Bringing together key players- Most people have very full lives and find it difficult to devote many hours of volunteer time. Nonetheless this watershed area is inhabited by people from a great diversity of social, cultural, and professional backgrounds who have shown active interest in pursuing collaborative solutions.

Communication between private stakeholders and governing entities- There is a history of poor communication and disagreement between private landowners and land management agencies. Federal land management processes are lengthy and expensive and this is frustrating to many people. In many cases traditional land management, and governmental land management processes and policies are opposing. Genuine public involvement and activity are needed in USFS and BLM management plans.

Coordination- Requires time and effort which when effective; evolves infrastructure, develops overview, defines and communicates realistic goals, evolves a comprehensive plan, which in turn fosters the design, implementation and maintenance of programs and projects**.**

Recognizing and honoring human diversity – Adhering to a common cause permits the wealth of different approaches and ideas to flourish. The issues pertaining to arroyos and discharges are global and have been addressed in many different ways by many different cultures through the ages - therefore it is important not only be to able to advocate a

"tried and true" position but also to be open to examining other traditional, and non-traditional approaches to arroyo and drainage management.

Incorporating traditional and contemporary solutions - In some cases this may involve making an effort to apply science, organizational dynamics or technology, while in other cases it may mean making an effort to apply traditional approaches to the issues.

Learning other "languages"- Learning specialized terms and organizational approaches (scientific, bureaucratic, grant writing, legislative, technical, legal, etc) is often a necessary, trying, and exhaustive process. (a glossary of water science terms is available at http://ga.water.usgs.gov/edu/dictionary.html)

Recommendations and BMPs

Formation of Arroyo Management Task Force- To plan for implementation of recommended actions and act as a support system to individuals and entities who take on recommended actions. Arroyos are probably one of the most complicated issues the community has to deal with because there can be various individuals and agencies that are involved along just one drainage. Suggested participants for taskforce would include, representatives from Rio Arriba and Taos counties, local Acequia Associations impacted by the drainages, Department of Transportation, Bureau of Land Management, Natural Resources Conservation Service (NRCS), and FEMA.

Development of Arroyo/Drainage Management Plan- Long term restoration and management plan to be developed collaboratively with private landowners, Arroyo Management Task Force, Rio Arriba and Taos Counties, BLM, USFS, and supporting entities.

Examination of how infrastructure is affecting the system- when possible roadways should be designed to accommodate the channels, or avoid the channel, i.e. bridges.

Zoning ordinance- Encourage people to build outside of the arroyo and/or the floodplain.

Upgrade development ordinances- To reduce impervious surfaces by implementing water collection systems onsite, i.e. rain catchment systems and mandatory drainage plans for building on slopes.

Land conservation tools- Development and use of land conservation tools such as arroyo designation as open space or public domain/public infrastructure, and landowner conservation agreements.

Upland health projects- Projects focused on the mitigation of unnecessary erosion. Recommended projects are:

- Range improvements
- Forest health projects
- Desagues

Examine use of traditional methods on smaller arroyos that drain into acequias-
Traditional methods of water slowing and retention such as one-rock dams and terracing.

Potential Funding Sources
New Mexico Environment Department

- CWA 319
- River Ecosystem Restoration Initiative

New Mexico Water Trust Board

Capital Infrastructure Improvement Planning

Federal Emergency Management Agency

- Emergency resources including acequia restoration from arroyo flood damage.
- 406 FEMA Funds, Limited Mitigation, generally localized – aimed at preventing damage to a specific site.
- 404 FEMA Funds, Mitigation, limited discretionary funds based on percentage of 406 funding to specific programs. Primarily to be targeted to mitigation point and non-point source watershed issues– allocated to state agencies – which in turn may be delegated to the USACE for Blue Line Stream programs.

US Army Corp of Engineers

- Section 206 Aquatic Stream Restoration
- Section 1135 Project Modifications To Improve The Environment
- Section 14 Emergency Streambank And Shoreline Protection

Natural Resources Conservation Service (NRCS)

- Cost share programs for private landowners to implement conservation projects on range or agricultural lands.
- Technical assistance to private landowners.

Wetlands and Riparian Areas

Wetland and riparian areas have been identified as valued features within the watershed. The health of these areas has a direct impact on water quality, water quantity, and the overall wellbeing of the watershed communities. Degraded wetland and riparian conditions have been identified as a watershed concern that affects the health, integrity and aesthetics of our watershed communities. Loss of wetlands and riparian vegetation has been identified as a possible cause of NPS pollution in the watershed.

Riparian areas occupy less than 1% of the New Mexico landscape but provide the most biodiversity of plant, wildlife, and macroinvertabrate species. Riparian areas serve important functions within the watershed including streambank stabilization, flood control, aquifer recharge, provide wildlife habitat, and filter sediments and other pollutants. They also serve to foster spiritual nurture and recreational opportunities.

Wetlands are areas that support plant life that thrives in saturated soils either ephemerally or perennially. Wetlands serve important functions within the watershed that include wildlife habitat for all or part of the year, water filtration, nutrient processing, water storage, aquifer/groundwater recharge, flood control, streambank stabilization and plant buffers, spiritual nurture, and small scale atmospheric maintenance.

Extensive human interference has altered the conditions of wetland and riparian areas in the watershed. Activities such as river channelization, development in the floodplains, loss of native vegetation and introduction of invasive plant and tree species have changed the functions of these areas

The riparian areas and wetlands surrounding the watercourses have also seen heavy use and abuse by livestock. When other vegetated areas in the watershed are not producing feed, these are. The combined damage of overgrazing and heavy traffic has knocked down many stream banks and changed the vegetative structure to non native species.

Current conditions of many of the watershed's wetland and riparian areas present a fire hazard and do not allow for the natural function of the landscape to operate at full capacity.

Objectives

Our land base and accompanying waterways have been identified as valued features within the watershed. The health and proper function of the land base and the waterways is a priority for the watershed community. Reasonable objectives for the watershed community to take on are:

- Restoration, enhancement, protection, and creation of wetland and riparian zones
- A plan for long term maintenance of these areas
- Educational opportunities for youth

Challenges

Bringing together key players- Most people have very full lives and find it difficult to devote many hours of volunteer time. Coordination of all parties involved is important and requires incentive and motivation.

Multi Jurisdictional- The landscape does not recognize political and private boundaries and, as such, one landowner's property is directly impacted by neighboring properties. The development of partnerships to address the health of the entire landscape during planning is important

River Channel Alteration- Alteration of the original river channel has caused severe degradation of the streambanks, unhealthy distribution of the water's energy flow, and loss of riparian vegetation. Extensive study of the river channel needs to be done in order to determine the possibility of any restoration of the original channel.

Development- Many homes and businesses have been built in the original river channel and accompanying floodplains. This severely limits restoration possibilities.

Invasive Species- The introduction of invasive species, many as a means of erosion control, have severely degraded the function of wetland and riparian areas. Invasive species alter the makeup of the soils, increase the risk of wildfire, choke native species, provide poor habitat, and are difficult to remove or control effectively.

Riparian overgrazing-

Current Efforts

Many efforts already exist to begin wetland and riparian restoration within, and in outlying areas of the watershed, and efforts at forming partnerships, developing educational and monitoring programs, and collaborative planning are underway. The importance of viewing all segmented problems as a whole with each affecting the other is being addressed as the different entities involved come together. Some of these efforts that are currently being undertaken are:

Watershed Group –Watershed groups have identified local wetlands and riparian areas as valued features within the watershed community and are currently identifying restoration and improvement projects that can be done.

Northern New Mexico College (NNMC) - The Upper Rio Grande Watershed Groups have formed a partnership with Northern New Mexico College to include Environmental Science students in restoration projects. In the spring of 2006, students participated for 16 weeks in understanding and identifying the functions and values of local wetlands and participated in the NMED sponsored Wetlands Restoration Project, at Cottonwood Ranch in Alcalde, New Mexico. In the fall of 2007 students will participate in a Wetland and Riparian Restoration Project sponsored by the State Lands Office at Cañada de Ojo Sarco in Cañoncito, New Mexico

New Mexico Environment Department (NMED) - NMED has received funding to create a Wetlands Action Plan with the intent to increase wetland acreage.

State Land Office (SLO) - State Lands Office has currently funded a wetlands and riparian restoration project on leased lands on the Cañada de Ojo Sarco. The work will begin in the autumn of 2007 with watershed groups and NNMC participating.

Various Private Landowners- There have been various restoration projects that have been completed or are ongoing on private lands, funded by the US Partners for Fish and Wildlife.

Bureau of Land Management (BLM) – BLM is currently conducting a riparian restoration project at Orilla Verde Recreation Park. This project ends at the northwestern boundary of this study area, but is important for two reasons: 1) invasive species and their seed source are being eradicated upstream 2) serves as a pilot project to continue the work on BLM lands further down stream. Many of the riparian corridors within the Upper Rio Grande Watershed including Rio Arriba County line south to Velarde and much of the Rio Embudo are under the jurisdiction of the BLM.

Recommendations and BMPs

Inventory of wetlands and potential wetland areas- A comprehensive inventory of wetlands and potential wetlands. This includes maps (soils, topography, and floodplain), water table information, aerial photos, and specific functions and values.

Protect remaining wetland and riparian areas- Several recommendations have been issued:

- Encourage livestock and wildlife to direct grazing elsewhere through exclosure or placing nutrient rich feed elsewhere.
- Use of land conservation tools such as conservation easements, conservation agreements, or purchase/transfer of development rights.

Restore improperly functioning wetland areas- Restoration projects include pond dredging, removal of invasives, and riparian and wetland plantings (including food bearing plants).

Recreate wetland/riparian areas that have been lost- Projects include recreation of pond systems, wetland and riparian plantings, and removal of invasives.

River corridor invasive species identification and removal

Implement and enforce land use ordinances- Such as wetlands ordinance, floodplain ordinance, and stream buffer/acequia ordinance.

Possible Funding Sources:

New Mexico Fish and Wildlife

- Habitat Stamp

Soil and Water Conservation Districts

- Receive state funding to remove invasive species on private lands

NMED

- CWA section 319
- Wetlands Program
- River Ecosystem Restoration Initiative

US Fish and Wildlife Service

- Partners For Fish and Wildlife

USDA

- Farm Service Agency

USDA-NRCS

- Technical Assistance to private landowners
- EQUIP funds for livestock fencing and to protect riparian areas

Illegal Dumping

Illegal dumping in the watershed has been identified as a water quality concern and is affecting the health, integrity and aesthetics of our watershed communities.

The garbage that has been illegally dumped poses a water quality concern by being washed directly into the waterways. Water quality can also be compromised by contaminant seepage into the underground aquifers and streams that connect to local waterways.

Because of the topography of the local environment, many of the dumpsites are in arroyos, which are the natural drainage systems of the area. Arroyo runoff during heavy rains causes trash to wash down onto roads, fields, and eventually into acequias and surface water bodies.

Local illegal dumpsites are a mixed bag; some contain household waste, appliances, building materials, mattresses, tires and dead animals. In some instances, the garbage is from many generations past such as old cars, in others the dumping appears to be more

recent. Many efforts have been made to clean up dumpsites by various land managers but dumping continues to be a prevalent problem.

However, legal dumping at the old Dixon dump is also a huge potential sources of contamination. At most dumps people throw all sorts of stuff they aren't supposed to. Now that that dump is buried we may never know what it contains and it is perfectly situated to leach into the Rio Embudo through groundwater flow.

Objectives

Our land base and accompanying waterways have been identified as valued features within the watershed. The health and proper function of the land base and the waterways is a priority for the watershed community. Reasonable objectives for the community to take on are:

- Initial clean up of public and private lands
- Annual community clean up days of areas targeted by watershed groups
- Plan for long term maintenance of areas

Challenges

Breaking a habit that has been carried on for generations- Historically, community dumps were common in the area. Trash collection services were not provided until more modern times, and only in some areas. Unfortunately, the tradition has continued in some areas of the watershed, as it has been more convenient and less expensive to dump in an inconspicuous area, than travel sometimes very long distances to landfills

Bringing together key players- Coordination of all stakeholders. Most people have very full lives and find it difficult to devote many hours of volunteer time. Coordination of all parties involved is important and requires incentive and motivation.

Convenience- Convenience and transfer stations need to be easily accessible, controlled, and well known. Trash services must be convenient and remain affordable, operating when the community needs access, such as weekend hours.

Enforcement- Public land management budgets for manpower and enforcement are inadequate.

Current Efforts

The Embudo Valley Watershed Group has examined this issue throughout the course of management planning. This group has carried on the past efforts of community members and groups who have attempted to address this issue in the past, and has opened up dialogue between community members, BLM, and North Central Solid Waste Authority (NCSWA) which is contracted to handle the waste management services in Rio Arriba County.

The group collaborated with the New Mexico Rural Water Association Source Water Protection Planning Committee, which is also addressing illegal dumping, to follow up

on past community efforts at planning for the construction of a local convenience station, such as the one recently constructed in Truchas. At this time the community members of the Embudo Valley have made a definite site selection which is located on BLM lands near Apodaca, and are encouraging BLM and NCSWA to begin procedures for land transfer.

Education and Outreach

Education and outreach has been identified as a watershed concern for they are the principal means that we possess to impart knowledge, training, and visions of the watershed to others.

The health of the watershed is increasingly dependent upon the stewardship of human beings. Unquestionably, the future well-being of the watershed will be a function of human ability to understand and to intelligently support and interface with the complex interrelationships that are ever-present and ever-changing in the watershed. Major keys to accomplishing this are:

- Education – the ability to gather and to impart information, foster inquiry and to stimulate productive attitudes and actions with regard to watershed status and watershed management.
- Outreach – education leads to sharing. Sharing is realized by interacting with others. Our tools are communication, organization, information, linking, and most importantly, the spirit of good will**.**

Objectives

Our land base and accompanying waterways have been identified as valued features within the watershed. The health and proper function of the land base and the waterways is a priority for the watershed community. The principal objective of education and outreach in the watershed is to:

- Utilize the guidelines developed by the various stakeholders (regarding such factors as, but not necessarily limited to: forest restoration principles, arroyo, waste, wetland and riparian management) and
- Incorporating these guidelines into a framework that can be accessed and utilized by:
    - schools
    - watershed groups
    - communities
    - general public
    - private and public organizations

Challenges

Educational

Bringing together key players – most people have full lives – however as the saying goes "if you want something done ask a busy person to do it" – coordination of these "busy" players is imperative in order to evolve meaningful educational programs.

Transcending obsolete educational modalities- is a complex issue that is linked to culture and geographical location as well as local social, political, and economic factors - the keys to dealing with this issue, which also present a challenge, are inclusion and gentle inquiry.

Awareness of local educational watershed programs – An inventory of programs that currently exist both in and out of school settings is needed.

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Incorporation of new information technologies – technology has provided us with the means to access information on an unprecedented scale. Information, however, must be integrated with local social, cultural and economic watershed issues, and that takes time, energy, and money.

Differentiating between Watershed support and Watershed exploitation –There is a constant need to recognize factors that are contributive or detrimental to watershed management -the keys to dealing with this issue are scrutiny and inquiry.

Computer literacy – is increasingly an imperative. There is a particular need for adult computer education – this is probably most evident in rural areas throughout the Upper Rio Grande Watershed.

Developing a data base – the computer gives us unprecedented means of accessing and storing practically any kind of information. The challenge is to organize data so that is easily accessible. This takes time, energy, money, and computer hardware and software.

Template Development – There is a need to train stakeholders to develop and to utilize templates that target watershed-related issues. (needs assessments, by-laws, problem solving methodologies, organizational structure, communication dynamics, inventory, climate, etc)

Information translation - Often information needs to be translated into a format that can be understood by the layperson. This takes time, energy, and usually, money.

Organizational, communication and management training – This is often much needed – it is lacking in the schools as well as in general society.

Outreach

Outreach implies that an entity has something to give or to request from another entity or wishes to form an association with others based on common goals. It is the purpose of watershed groups to address issues relevant to watershed management and to record the process in some kind of sharable format (text, pictures, etc). The development of an efficient outreach program has important educational, political, social and economic implications.

Bringing together key players – most people have full lives – however, again, "if you want something done ask a busy person to do it" – coordination of the "busy" players who are devoted to watershed management is imperative in order to create meaningful outreach programs.

Linking with outside individuals and groups – Clearly it is not necessary to "reinvent the wheel" when dealing with every watershed management issue. Linkage is a tool that gives us the opportunity to discover practical approaches that have been experienced and documented by others – throughout the world.

Developing a data base – the computer gives us unprecedented means of accessing, augmenting and storing practically any kind of information. The challenge is to organize data so that is easily accessible. This takes time, energy, money, and computer hardware and software.

<u>Recommendations</u>

Development of the Northern New Mexico Watershed Institute

- Obtain space and resources

- Obtain 501(c)3
- Development of a clearing house to keep track of project, needs, funding and information
- Develop/Maintain Database
- Continue to provide workshops/educational program that can lead to dialogue and positive action on the part of the communities
- Website/Newsletter

Continue engagement of stakeholders by

- Continued evolution of group structure/communication methods
- Utilizing outreach methods such as
    - Existing community newsletters (Dixon Co op, PACA)
    - Information packets to be enclosed in billing statements such as Kit Carson Electric, Amerigas, Adobe Propane
    - School payroll flyers
    - Phone trees and shared e-mail
    - Participation in acequia meetings
    - Local radio stations

Develop a partnership with students of Woodbury University- Students have been spending time in the area working on watershed health based development planning design projects to present to the communities. It was suggested that students continue planning in this area as a program of the university and work to establish a clearinghouse for the plans that are developed under this program.

Develop/ maintain partnerships with local governments/agencies and other groups actively involved in watershed projects.

Continued partnerships with Northern New Mexico College and Environmental Science curriculum/ Environmental Student Organization

Seek to create partnerships with Elementary/High School science programs

Promote grassroots planning and decision making, avoiding a top down approach

Agriculture/Acequias

The agricultural base and accompanying acequias have been identified as a valuable resource that is threatened within the watershed. Irrigated agriculture has been part of the cultural landscape in the Embudo Watershed for hundreds if not thousands of years. Prior to the arrival of Juan de Oñate and the settlers that came with him under the Spanish Crown, the Picuris and Ohkay Owingeh people had used the watershed for hunting, irrigated agriculture, and foraging for edible plants, fruits, and medicinal herbs.

With the development of the land grants, starting with the Embudo land grant in 1725, the Embudo Watershed was introduced to another form of agriculture, a more intensive agriculture based on the acequia system. At present there are over 40 *acequias madres* in the watershed, branching off of the Río Pueblo, Río Santa Barbara, Río Chiquito, Río Trampas, Río Ojo Sarco and Río Embudo.

The acequias are all autonomous, managed by a three-member commission and a mayordomo, who is charge of managing the water on a daily basis. Each acequia elects

its own commission and mayordomo and each serves for two years and can be re-elected for as many terms as the community mandatges. Five years ago a regional acequia association, the Embudo Valley Acequia Association, was formed in the lower Embudo area.

In the past 40 years the acequias throughout the watershed have slowly been abandoned due to out migration. This has created a crisis and friction among the old traditional users and the new comers that has been detrimental to the system and to the agricultural lands. Now most of the villages within the watershed are bedroom communities and most of the native population is employed out of the area.

Objectives

Our land base and accompanying waterways have been identified as valued features within the watershed. The health and proper function of the land base and the waterways is a priority for the watershed community. Reasonable objective for the community to take on are:

- Protection of the agricultural lands and traditions and the accompanying acequias from abandonment or degradation
- Education for the better understanding of traditional land use patterns

Challenges

Degrading Infrastructure Systems – Acequias have historically been maintained as a worker-owned coop, where the owners of the irrigated land, called *suertes*, cleaned the acequias annually during the spring and did any repairs as needed during the irrigation season, from April to October. As people's attention has been diverted to activities outside of the watershed such as outside employment, the acequias have suffered.

Loss of Parciantes – A *parciante* is a landowner who has water rights within a certain acequia. Possibly one of the biggest drawbacks in maintaining the system is *parciante* availability and age. Most of the *parciantes* are already in their 50s, 60s and 70s, and whereas in the past there was the extended family to count on, now the families are smaller, and many younger people have moved away, meaning there are less workers available to do the work, and many of the new property owners have no interest in agriculture.

Invasive Species – Because certain lands are not worked or maintained, the agricultural lands are rapidly disappearing as they are been taken over by invasive species. Those that do farm have a growing problem on their hands, since every time they water their fields, the seeds of these invasive species and noxious weeds spread.

Development – Population growth is another threat to the agricultural land, as both the native people and the new land owners are building new houses or putting new mobile homes on agricultural lands. People are now building on flood plains, in the middle of arroyos, a few feet from the river, without any regard to the landscape.

Taxes, Land Values and Economic Returns– In the past 40 years land values have risen dramatically, mostly due to the building boom and also because of land speculators that have driven the price of land to astronomical prices. Agricultural land in the Española Valley is now selling upwards of $65,000 an acre and around Española for as much as $100,000 per acre. Thus as a piece of land changes hands, the property values go up and so do the taxes, forcing traditional people to sell because they cannot keep up with the tax increases. Current agricultural land prices are prohibitive to anyone who would like to be an agricultural producer.

Water Commoditization /Protecting Historical Water Rights – As the competition for water resources has intensified by new growth and urban demands, water markets have developed. With the price of a water right at an all time high, water is subject to become a commodity that can be sold to the highest bidder, instead of a community resource. Some people view acequias and their associated water rights that are used for agriculture as a low value use for water.

Recommendations and BMPs

Support local agriculture- If the agricultural lands and the acequias are to continue to be used for the production of food, the communities have to be more involved in supporting the acequias and the local growers. Growers also need to make the food they grow more affordable, a difficult undertaking as small farmers are hard pressed to earn a living. Understanding of the environmental cost of cheap food from large supermarket chains is a challenge to most consumers who work hard for what money they have. However consumers could look at the price paid to growers as an investment in the stewardship of the land and water, and a saving over the high gas prices invested in a trip to one of the surrounding cities. Growers and consumers both have to support each other and treat each other as co-growers, for that is the only way to grow the community.

Cooperative CSA- Community Supported Agriculture could be a collaboration of different farms and types of farms to supply a diverse range of products to local citizens.

Dixon Land Link- This is a project that is currently functioning under the umbrella of the Dixon Cooperative Market. The idea is to connect people who need agricultural land with people who have land and water rights that they are not using. The results of this projects will be building education about traditional and ecological farming techniques, pairing people who can work the land and who have none with people who have land and can no longer work it, keeping water rights tied to the land, and helping new landowners/parciantes understand their role as owners of agricultural land and water rights. Long term goal is to get more land into the program that can be put into conservation easements or land trusts.

Parciantes have to become more proactive and participate- by attending annual acequia meetings and also supporting their elected commissioners and mayordomo. They also have to become better educated as to their role within the acequia community and the larger community and to put their water rights to beneficial use so the community won't

lose their water rights. *Parciantes* have to become more conscious of their role as owners of agricultural land and water rights.

Create an acequia needs assessment- for each acequia to determine improvements that may be necessary. Individual plans are helpful when it comes to seeking funding.

Agricultural Protection Ordinance – Rio Arriba County has an agricultural protection ordinance that has had several problems since its development. These problems are currently being worked out by the county and the completed ordinance will be presented in the county wide five year plan. Taos County at this time does not have an agricultural protection ordinance. This should be in place and supported in order to protect agricultural lands and to keep people from building too close to the acequias, the river and in arroyos.

Land conservation tools- such as acquisition, purchase or transfer of development rights, and conservation easements

Create a strong organizational structure for each acequia- including development of by-laws, water banking system, and compliance with the open meetings act to protect water rights. Assistance can be provided by the New Mexico Acequia Association.

<u>Potential Funding Sources</u>

Interstate Stream Commission

- Technical Assistance and low interest loans.

Army Corp of Engineers

- Loans on projects over $250,000.

USDA/ NRCS

- Mostly technical assistance, especially in planning water systems but they also offer help to individual property owners.

Infrastructure Capital Improvement Plan **(ICIP)**

Wastewater Management

Although addressing wastewater issues is not a directive of the CWA section 319 program, it is a prevalent concern of the entire watershed and needs to be addressed in any water related document.

Wastewater management has been identified as a potential surface water quality concern due to the sheer number of unregulated septic systems in use. The watershed is comprised of small, rural villages dotted throughout the landscape and along the waterways with no regional system for treatment. This has been an issue for several years and there are multiple efforts at collaborative solution building by various entities.

Problems associated with septic system contamination include increased nitrates, which can pose health issues for infants (methemoglobinemia a.k.a. blue baby syndrome), and increased nutrient/bacteria levels which may result in algal blooms and lead to anaerobic conditions, within a stream. Contamination may also be linked to reports of malformed trout, in stretches of the Rio Santa Barbara, in particular the area within the community of Peñasco.

Picuris Pueblo has identified this as concern throughout the watershed and has addressed this in their Non Point Source Assessment and Best Management Plan. Currently they are working with Border Water Works, a construction and design firm, on the upgrading and expansion of treatment ponds on Picuris lands. The Pueblo acknowledges that their water supply is affected by the greater watershed health, and for that reason they have also been working with Border Water Works on an overall watershed assessment.

La Jicarita Watershed and Wastewater Study Committee is working with NMED and Rural Community Assistance Corporation (RCAC) on developing a work plan for dealing with septic issues. They have looked at different types of viable technologies for small, rural communities and have begun moving forward to create pilot projects for wastewater treatment.

Sipapu Ski Resort has its own small acreage facility for treatment and testing of wastewater. This facility only uses a fraction of its treatment capacity at this time and staff has offered to present to the local concerned citizens and to explain the technology utilized.

Mutual Domestic Water Consumers Associations in the Embudo Valley have been working on a Memorandum of Understanding with the help of New Mexico Rural Water Association (NMRA) and the RCAC in order to collaboratively deal with several issues including wastewater. This issue is addressed in the Lower Rio Embudo Source Water Protection Plan (Dec, 2006).

It is recommended that support of these efforts is fostered, and collaboration, wherever possible, is encouraged.

Monitoring

Monitoring programs will be developed along with the specific project planning process. It is highly recommended that school programs be utilized in monitoring efforts for educational and perpetuity purposes. Although monitoring will be developed on a project by project basis, several overall monitoring recommendations have been made for the greater watershed. These recommendations are:

- More frequent water quality monitoring, ideally seasonal; to better characterize water quality conditions.
- Additional sampling stations
- Monitoring for contaminants from septic systems
- Additional macroinvertabrate bioassessments and pebble counts on impaired stream reaches

- Continued collaboration and support for the Embudo Valley Environmental Monitoring Group (EVEMG) produce, water, and soil/sediment sampling programs. Collaboration and support for future planned water quality monitoring programs. Under these programs soil, water, and produce is tested for a full suite of heavy metals as well as radionuclides.

The NMED Surface Water Quality Bureau plans to conduct another water quality survey of the watershed's streams in 2009. During the sampling in 2001 several streams were not assessed for secondary contact because of time and equipment constraints. At this time there are no such constraints as the equipment is available. It is recommended under this management plan that these streams be assessed:

- Rio de las Trampas- This stream was only sampled three times and was never sampled for metals or bacteria. Uses not assessed for this stream segment are irrigation, livestock watering, wildlife habitat.
- Rio Chiquito- This stream was only sampled three times and was not sampled for metals or bacteria.
- Chamisal Creek- This stream was only sampled three times and was not sampled for metals and bacteria.

The Rio Santa Barbara Watershed-Based Plan

This is a watershed-based plan to address a water quality problem identified by the State of New Mexico in a portion of the Rio Santa Barbara. The watershed planning elements published by the Environmental Protection Agency in the Federal Register on October 23, 2003[1] are used as a guide for focusing on this purpose. The stream segment of concern is the Rio Santa Barbara downstream of the Carson National Forest, excluding portions on Picuris Pueblo, and is identified by NMED as "Rio Santa Barbara (Picuris Pueblo bnd to USFS bnd)", with assessment unit identification number NM-2120.A_419.

This portion of the Rio Santa Barbara lies wholly within a watershed referred to by USGS as "Outlet Rio Santa Barbara", with hydrologic unit code 130201010905. This sixth-code watershed also contains part of an upstream segment of the Rio Santa Barbara (USFS boundary to confluence of East and West Forks, AU NM-2120.A_420) which is not presently thought to be impaired. Another sixth code watershed upstream, called "Headwaters Rio Santa Barbara" (HUC 130201010904) contains several assessment units within the Pecos Wilderness which were designated by the New Mexico Water Quality Control Commission (WQCC) in 2005 as Outstanding Natural Resource Waters, and are thought to be relatively pristine.

The lower Rio Santa Barbara watershed (130201010905) is identified as a priority for both watershed planning and water quality improvement activities in the New Mexico Nonpoint Source Management Program[2]. The upper watershed (130201010904) is included in this planning effort because sources of pollutants affecting the lower Rio Santa Barbara may exist within the upper watershed.

This section was drafted by staff of the New Mexico Environment Department Surface Water Quality Bureau, and input was solicited from the La Jicarita Watershed and Wastewater Study Committee, the Pueblo of Picuris, Taos County Public Works Department, Taos Soil and Water Conservation District, Santa Barbara Grazing Association, Rio Chiquito Grazing Association, and Carson National Forest (the Supervisor's Office and the Camino Real Ranger District). Review and input were solicited over a period of several months with formal letters requesting review, and parallel emails and phone calls, and similar follow-up correspondence. The La Jicarita Watershed and Wastewater Study Committee, Taos County Public Works Department, Taos Soil and Water Conservation District, Santa Barbara and Rio Chiquito Grazing Associations, and Carson National Forest (the Supervisor's Office and the Camino Real Ranger District) reviewed the document and provided some input. Other key stakeholders may provide input to a later draft as time and priorities permit.

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[1] The *Nonpoint Source Program and Grants Guidelines for States and Territories* are available on line at frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2003_register&docid=fr23oc03-39.pdf.

[2] The New Mexico Nonpoint Source Management Program planning document is available on line at www.nmenv.state.nm.us/SWQB/WPS/Plan/index.html.

All reviewers who provided input felt that the plan has merit and that the quantitative aspects represent an improvement over the earlier effort. Reviewers generally are looking forward to implementation of specific components of interest to them. Carson National Forest staff felt that the load reduction estimates for pollutant sources and management measures would benefit from a more technical analysis with input from more natural resources professionals and a larger group of watershed residents.

Causes of Impairment

One of the designated uses of the Rio Santa Barbara, recognized in New Mexico's water quality standards, is high quality coldwater aquatic life. The State of New Mexico recognized in 2004 that high quality coldwater aquatic life is not fully supported in the Rio Santa Barbara downstream of the Carson National Forest, and turbidity is a cause of that impairment[3].

The WQCC approved a total maximum daily load (TMDL) for turbidity in January 2005, and EPA approved it in June 2005[4]. The TMDL establishes a goal for pollutant load reduction (called the target load reduction in the TMDL) of 1,503 pounds per day of total suspended solids. Because there are no permitted point sources in the Rio Santa Barbara watershed, this load reduction goal can be met only by addressing nonpoint sources of pollution or other pollution occurring in the absence of discharge permits.

Sources of Pollutants

The TMDL does not establish maximum acceptable loads for individual sources or source activities of nonpoint source pollution, and nor does it establish quantitative load reduction goals for them.

The data used for the initial assessment and subsequent TMDL were collected by the NMED Surface Water Quality Bureau (SWQB) from a site on the Rio Santa Barbara on Picuris Pueblo land, near its confluence with the Rio Pueblo (STORET code URG120.022001), in a water quality survey conducted in 2001[5]. This site was sampled eight times during the survey, and the data were considered representative of the subject reach of the Rio Santa Barbara. Two of eight turbidity measurements exceeded the water quality criterion (25 NTU) in place at that time. The two exceedences occurred on consecutive days in August, recently following characteristic summer thundershowers.

Additional relevant data were collected from the Rio Chiquito, a small tributary of the Rio Santa Barbara, which was sampled on three dates in 2001 near its confluence with

[3] Recognition of impairment is documented in the *2004-2006 State of New Mexico Integrated Clean Water Act §303(D)/§305(B) Report*, available on line at www.nmenv.state.nm.us/wqcc/303d-305b/2004/index.html.
[4] The TMDL is available on line at www.nmenv.state.nm.us/SWQB/Projects/RioGrande/Upper/TMDL2/index.html.
[5] A report of the survey is available on line at www.nmenv.state.nm.us/swqb/Surveys/UpperRioGrandePartII-2001.pdf.

the Rio Santa Barbara. Relatively turbid water (in excess of the water quality criterion) was observed in the Rio Chiquito on one date in May (during peak snowmelt), and on August 14 when the Rio Santa Barbara was also quite turbid. During the August sampling, SWQB staff observed turbid water draining from the road into the stream, but the Rio Chiquito was also turbid upstream of that point.

More relevant data were collected during the 2001 survey from the Rio Santa Barbara (USFS boundary to confluence of East and West forks) near Hodges Campground (STORET code URG120.022023). This site is near the lower end of the assessment unit on Carson National Forest land. There were no exceedences of water quality standards among the eight data points available, although the data can be used to estimate background conditions for the Rio Santa Barbara entering the impaired reach. Though low, levels of total suspended solids at the Hodges Campground may conceivably be elevated by a road leading up the canyon from there and by other minor watershed disturbances and land use activities including grazing. Specialist reports prepared by Forest Service staff (and available upon request) on various aspects of management of the upper watershed may assist with further defining pollutant sources in this area.

Two meetings were conducted in Vadito in July 2008 with watershed residents to collect and document information about pollutant sources and the most promising solutions. The membership of the La Jicarita Watershed and Wastewater Study Committee was invited, and each meeting was attended by approximately six watershed residents. The meetings were dedicated exclusively to discussions of the impaired reach of the Rio Santa Barbara. SWQB staff developed a spreadsheet which was projected onto the wall to help facilitate discussions of pollutant sources. The spreadsheet consisted of three tables presented below. One table focused on geographic source areas, one table focused on source activities, and one table identified appropriate practices to reduce pollutant loading. Participants were asked to evaluate different source areas, source activities, or management changes relative to one another in terms of percent, and formulas were used to calculate corresponding load reductions.

Suggested portions of the watershed, source activities, and management practices were entered into the tables prior to the meetings, but participants were able to change these to reflect their understanding of the watershed and of likely pollutant sources. The participants iteratively specified values such that the load reductions were appropriately sized relative to one another, and such that the sum of load reductions would equal the target load reduction in the TMDL, and they compared the results in different tables to ensure that the rationale for entering a specific value in one table was reflected in the other tables. This exercise often resulted in participants changing their minds, and by the end of the second meeting a consensus developed that the tables were populated in a way that reasonably reflects reality.

Table 1: Sources of suspended sediment in the Rio Santa Barbara, by geography

Geographic Area	Percent	Load (lb TSS / day)	Notes
Background at Hodges (upper end of reach)	5	75.15	Hodges TSS concentration was 29% of RSB at mouth TSS concentration (n=5)
Loading between Hodges and Rodarte	15	225.45	
Loading from Rodarte through Peñasco (including Peñasco, but excluding the Rio Chiquito watershed)	45	676.35	
Rio Chiquito watershed (includes a portion of Peñasco)	20	300.6	Chiquito concentration was 253% of RSB at mouth concentration (n=2)
Loading from Peñasco to Rio Lucio	15	225.45	
Totals	**100%**	**1503**	

Table 2: Sources of suspended sediment in the Rio Santa Barbara, by source activity

Source Activity	Percent	Load (lb TSS / day)	Notes
Accelerated runoff from ponderosa and mixed conifer forest	5	75.15	
Accelerated runoff from Piñon/Juniper forest	10	150.3	
Off-road vehicles	8	120.24	
Runoff from unpaved roads including driveways	50	751.5	County maintained and unmaintained roads
Runoff from pastures and hayfields	20	300.6	
Accelerated bank erosion	5	75.15	
Ojitos and esteros	0		organic matter in water, oily film on top. Part of background.
Rio Chiquito gravel pit	2	30.06	
Totals	**100%**	**1503**	

Management Measures

Ponderosa Pine Forest Restoration

As noted in Table 2, a small amount of preventable loading that contributes to the impairment of the lower Rio Santa Barbara is thought to originate from degraded ponderosa pine forest. Most ponderosa pine forest lies within the watershed of the upper Rio Santa Barbara (HUC 130201010904), and most of that is at middle elevations within the Carson National Forest (where the stream meets its water quality standards). Ponderosa pine forest restoration may include thinning, prescribed burning, and use of

prescribed natural fire[6]. The hydrologic basis of forest restoration as a practice to improve water quality hinges on observations that understory vegetation, which prevents soil erosion and promotes infiltration, is often thicker in a more natural (*i.e.*, open) ponderosa pine forest. This activity has more promise as a method to protect water quality (and other watershed resources and values) than to improve water quality. A relatively minor portion of ponderosa pine forest acreage is within the Pecos Wilderness, where active restoration methods such as thinning is limited by Wilderness Act protections. The ability of a forest floor to carry low intensity fire is affected by grazing management, which is a separate category of management measure.

In 2001, the Carson National Forest conducted NEPA analysis for the Santa Barbara Watershed Restoration project, which has since only been partially implemented. The project would thin 500 acres of mixed conifer woodland, burn 5000 acres with prescribed fire, develop a prescribed natural fire plan, restore one wetland, and close and obliterate approximately two miles of spur roads in the watersheds of the Río Santa Barbara, Río Pueblo, and Río Chiquito.

USFS Grazing BMPs

Grazing best management practices on Carson National Forest land are stipulated in Allotment Management Plans and Annual Operating Instructions developed by the Forest Service, in cooperation with permittees, and with public input through the NEPA process. These activities apply to all Carson National Forest lands, which in this watershed lie primarily within the ponderosa pine forest and above, including within the Pecos Wilderness. Most of the relevant acreage is within the Santa Barbara Allotment (which is primarily within the upper Rio Santa Barbara watershed), followed by the Rio Chiquito Allotment, which comprises significant acreage in the upper Rio Chiquito watershed (and 30% of HUC 130201010905). The Carson National Forest has conducted significant analysis of grazing management options in these allotments[7]. Planned grazing BMPs related to water quality include use of herding and salting to achieve better distribution of livestock, proper timing and intensity of grazing (supported by monitoring), compliance with grazing schedules, construction of drift fences, and construction of hiking stiles to prevent gates from being left open, and construction of holding pens and corrals to assist with livestock gathering. Generally, permittees are required to maintain fences and other range improvements specified in Allotment Management Plans, and must share the costs for these practices with the Forest Service or, possibly in cooperation with the Forest or other organizations, seek funding for them.

Piñon/Juniper Forest Restoration

Piñon/juniper forests within the Rio Santa Barbara watershed lie at lower altitudes, and are roughly evenly divided between USFS management and private ownership. Because these forests occur at lower, drier elevations, the intercanopy areas are generally more barren and erosive than the ponderosa pine forest floor, and thus are thought to contribute

[6] For more information, see Allen, *et al*., *Ecological Applications,* 12(5), 2002, pp. 1418–1433. This article is available on line at www.biologicaldiversity.org/publications/papers/Allen-Restoration-2002.pdf.

[7] Several related documents are available on line at www.fs.fed.us/r3/carson/natural_resources/range/camino_real/2009/2009_camino_real.shtml.

more fine sediment to the river and present more opportunities for load reduction than do ponderosa pine forests. Restoration approaches in piñon/juniper forest are similar to those of ponderosa pine, but are more controversial because less is known about the natural fire regime, and because the fire regime is thought to be much more intense (more likely endangering infrastructure)[8]. For these reasons, firewood harvest is considered a practical means of reducing competition of piñon and juniper with intercanopy grasses and forbs. The most practical means of implementing significant firewood harvest in the context of restoration is for the agency (USFS) to pay applicants a small amount to cut all but marked trees within small stewardship plots. In exchange for cutting unmarketable small trees, the applicant may remove whatever product he or she deems useful, such as firewood, fenceposts, latillas, etc. In more remote locations (*e.g.*, away from roads), this approach is not as practical, and thinning of piñon or juniper trees under larger contracts without firewood harvest would be necessary to significantly increase intercanopy herbaceous growth.

Recreation Management

Recreational off-road vehicle (ORV) use in the Santa Barbara watershed occurs primarily on public land, and disproportionately affects water quality compared with roads and hiking trails because ORV users often create user-developed trails running perpendicular to slopes, which channel water and sediment downhill. Most of this use is on Carson National Forest land at middle elevations (*i.e.,* generally not within the Pecos Wilderness). The Carson National Forest is conducting an environmental assessment (EA) to weigh options for a travel management plan for the Camino Real Ranger District. The EA will lead to a decision designating a system of roads open for use by motorized vehicles. Existing routes (roads or trails) not designated as "open" to motorized use will be closed and motorized use will no longer be legal on those routes[9]. Closed routes may continue to receive use, and even once effectively closed they may continue to erode, and so this category of management measure includes structural enforcement of closures and reclamation of closed roads beyond the actions that may be described in the travel management EA. Also within the category of recreation management is trail maintenance and improvement within the upper Rio Santa Barbara watershed. Though minor compared with ORV use, these hiking trails are subject to frequent summer thunderstorms and may produce turbid runoff reaching the Rio Santa Barbara. In 2000 and 2001, the West Fork and Middle Fork trails were maintained and proper drainage was installed. The East Fork trail has not received that treatment yet, and is often dramatically muddier as a result.

Unpaved Roads BMPs

Runoff from unpaved roads, including private driveways, County maintained roads, and unmaintained roads, is thought to contribute about 50 percent of the excessive TSS loading to the Rio Santa Barbara. Ninety percent of that loading, or forty-five percent of the overall target load reduction, may be prevented with implementation of best management practices to improve drainage from these roads, along with selective road

[8] A review of the state of knowledge regarding fire ecology is piñon/juniper woodland is presented by Baker and Shinneman (*Forest Ecology and Management* 189 (2004) 1–21).

[9] Relevant documents are available on line at www.fs.fed.us/r3/carson/recreation/travel_mgmt/index.shtml.

closure and reclamation[10]. The greatest road density is in the Peñasco area. Many of these roads and driveways are near the Rio Santa Barbara and Rio Chiquito, and are the highest priority for drainage improvements.

Riparian Grazing Management

Much of the private land within the Rio Santa Barbara and Rio Chiquito valleys is used as irrigated pasture. Often, a crop of hay will be produced either before or after livestock are let onto the pasture. Most is permanent pasture, seldom requiring tilling. Most private parcels are fenced. Where the river marks a property boundary, one or both adjacent property owners will typically maintain a fence that results in incidental protection of the river, even if only a narrow buffer is thus protected. Where a parcel crosses the river, livestock will generally have access to the river. The result is fenceline contrasts with dramatically different channel morphology from one parcel to another. Typically, where livestock have access to the stream, the channel is wider, shallower, and less protected by woody or other vegetation. Where fences are present, the channel is often much narrower (indicating lower bank erosion rates) and shaded by woody vegetation. This observation led to the conclusion that fencing of riparian areas to either exclude cattle or manage grazing on a controlled basis can reduce the excessive sediment loading by about fifteen percent. Fencing generally needs to be supplemented with gates (allowing livestock to be rotated through pastures), water crossings (where fences cross streams), water gaps (providing access of cattle to the stream for water), and off-channel water sources.

Bank Stabilization BMPs

Portions of the Rio Santa Barbara and Rio Chiquito within their lower valleys (generally on private property) were channelized beginning in the 1970's in an effort to prevent flooding. Straightening the channel led to an increase in channel slope, entrenchment, and erosiveness of flood flows, which together have created new cut banks, some of which in recent years have been treated with wire gabion baskets. Some of the older gabion baskets are beginning to fail. These areas present opportunities to utilize alternative bank stabilization techniques that preserve natural channel function (including maintaining floodplain capacity where possible), such as construction of cross-vanes, j-hooks, and other structures[11].

Mine BMPs

A small gravel pit near the Rio Chiquito lacks significant BMPs to prevent runoff from the mine and associated disturbed areas from reaching the Rio Chiquito. Ordinary stormwater detention practices could protect the Rio Chiquito (and the Rio Santa Barbara downstream) from a small amount of excessive loading of suspended sediment.

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[10] Appropriate BMPs are described in greater detail in *A Good Road Lies Easy on the Land…Water Harvesting from Low-Standard Rural Roads (2006),* by Bill Zeedyk. This manual is available on line at quiviracoalition.org/images/pdfs/1597-A_Good_Road_Lies_Easy_on_the_Land.pdf.

[11] Fluvial geomorphologist Dave Rosgen has provided some guidance for cross-vanes and j-hooks at www.wildlandhydrology.com/assets/cross-vane.pdf. Another relevant handbook called *An Introduction to Induced Meandering: A Method for Restoring Stability to Incised Stream Channels* is available on line at quiviracoalition.org/images/pdfs/1905-Induced_Meandering_Field_Guide.pdf.

Arroyo Treatments

Arroyos leading to the Rio Santa Barbara typically flow through public and private lands in the piñon/juniper woodland on steeper terrain before reaching the valley. The arroyos are generally small, and may have tributary gullies which supply them with turbid runoff from adjacent uplands. The gullies themselves add to the sediment load, and arroyo channels often have unstable banks as a result of carrying so much sediment (which tends to push the channel to one side of the arroyo or the other). Sediment loading from piñon/juniper forest in this area can thus be divided into two categories – that from the uplands and best dealt with using forest restoration (described above), and that from within the channels of arroyos and gullies, which may be addressed more actively with structures of local materials such as post vanes, one-rock dams, baffles, and rock bowls[12].

Other

The meeting participants that contributed much of the above information on pollutant sources and management measures reached a point where consensus could not be attained either because of insufficient detailed information about sources, or differences in opinion regarding appropriate practices. In order to reach a conclusion that would permit progress towards implementation, the participants agreed to leave a portion of the excessive loading unaddressed by proposed management measures.

Table 3: Load reductions expected for specific management measures

Best Management Practices	Percent	Load (lb TSS / day)	Notes
Ponderosa pine forest restoration	1	15.03	Not much happening, relatively expensive, but preventative of major water quality degradation
USFS Grazing BMPs	4	60.12	
Piñon/Juniper forest restoration (thinning, firewood harvest)	5	75.15	
Recreation management (including ORVs)	8	120.24	Forest Service land and only a little private land. ORV access is important for firewood harvest and should be protected. The primary target for management is recreation. East Fork Santa Barbara trail is a small portion of this item.
Unpaved roads BMPs	45	676.35	
Riparian grazing management	15	225.45	
Bank stabilization BMPs	5	75.15	
Mine BMPs e.g. ponding areas	2	30.06	

[12] In addition to the *Induced Meandering* field guide, another useful handbook with more focus on smaller channels such as gullies is *An Introduction to Erosion Control,* available on line at quiviracoalition.org/images/pdfs/1902-Erosion_Control_Field_Guide.pdf.

Best Management Practices	Percent	Load (lb TSS / day)	Notes
Arroyo treatments e.g. one-rock dams, stock tanks	5	75.15	
other	10	150.3	
Totals	**100%**	**1503**	

Education and Information

Consistent with the schedule for implementation outlined below, the education and information program to support achieving and maintaining water quality standards has been placed into three main phases. The first and second phases are the implementation phases in which water quality standards will be achieved. The third phase is a maintenance phase, in which the goal is maintenance of water quality to meet standards.

Phase I: Engaging Early Implementers
The first implementation phase will rely on recruitment of early implementers, which may include stakeholders who assisted with development of this plan and other progressive landowners and agency personnel who already agree with the principles of the plan and may be familiar with many of the management measures to be implemented. Early implementers would be engaged by enlisting them to host or attend specialist workshops on unpaved roads BMPs, riparian grazing management, and erosion prevention.

The initial target audience for roads workshops would be equipment operators and managers for the Taos County Public Works Department. Landowners who are individually responsible for private roads and who have an interest in maintaining or improving their roads in a cost effective manner are also likely to attend these workshops. Initial demonstration work done on County roads during the workshops, if successful, will attract the attention of road users and boost attendance of later workshops by individual landowners.

While riparian grazing management may be primarily a matter of controlling livestock access to the stream, workshops may be useful. Workshops may be used to contrast conditions on nearby properties with and without riparian fencing, to highlight the benefits of increased forage production and reduced bank erosion that accompany managed grazing of riparian areas, to share technical information related to fence stream crossings and water sources for livestock, and to encourage early implementers. The primary target audience for this type of workshop is the individual owners of irrigated pasture within the Rio Santa Barbara and Rio Chiquito valleys.

Erosion prevention workshops proposed under this education program are of two main types. The first focuses on streambank stabilization methods and natural fluvial functioning that can assist landowners with preventing excessive erosion and recognizing

characteristics of streams, such as the periodic tendency to flood, that are better adapted to than fought. In some circumstances, banks may be strategically protected with structures or planted, to accelerate natural channel evolution processes towards a more stable form, and workshops may be used to help participants recognize and promote those processes. The second type of erosion prevention workshop, which may be conducted on private or public land, may be used to teach techniques of upland erosion prevention. None of these workshop subjects are mutually exclusive, but others have found each of these subjects to be appropriate for a two to three day workshop.

An additional category of outreach activities is related to public lands management. Generally, public lands managers are disposed towards management measures outlined in this plan, and possess appropriate skills and knowledge of the affected ecosystems and interrelated resources. Public lands are managed through public processes, however, and in this area particularly, public lands managers strive to serve the needs of watershed residents and sometimes face strong criticism for decisions without strong local support. Concerns such as smoke from prescribed fire, the viability of grazing as a business, and access to firewood all factor into public lands decisions. For these reasons, some extra effort may be required to engage the public in developing alternatives to implement ponderosa pine forest restoration, grazing BMPs on National Forest lands, piñon/juniper forest restoration, recreation management, and arroyo treatments on public lands. This effort may include retaining the services of a facilitator to conduct meetings and analysis in support of the NEPA process.

Phase II: Encouraging Widespread Implementation

In order for the plan to be fully implemented, at least one more round of more conservative implementers will need to be recruited in the second phase of implementation. Two conditions should be present in order to increase participation of this group. The first is that the results achieved by the early implementers should be at least partially successful, and the second is the presence of a local coordinator who can gain the rapport of, and share successes with, the more conservative implementers.

In the best-case scenario, the first few workshops outlined above will generate interest among another round of more skeptical landowners, who will attend additional workshops. There is no significant portion of public land in the Rio Santa Barbara where riparian streambank stabilization or grazing management projects or workshops can produce a lasting demonstration visible to the public. As such, participation in workshops is the main way for landowners to actually see the results of several proposed management measures, and hosting workshops will likely be a key incentive for some landowners to support implementation of management measures.

Another aspect to promoting more widespread implementation is to monitor parameters appropriate to measuring success towards water quality standards attainment, but also towards other objectives that landowners may have, such as reducing bank erosion, increasing forage for livestock, and experiencing drier conditions on roads during snowmelt or periods of frequent rains. A proposed monitoring program is described below. During later workshops, participants should revisit past work, be presented with

summaries of monitoring data indicating whether goals are being met, and progress should be reported in local newsletters to make this information more widely known.

A key aspect to encouraging widespread implementation is coordination. No organization or individual has been identified who possesses the necessary skill set, available time, and motivation to serve in this capacity. While some initial activities related to encouraging early implementation may be coordinated by an outside nonprofit or for-profit organization, a long term commitment will be required to maintain the continuity of the relatively complex implementation and education program outlined in this watershed plan. Success in the earlier phase may attract one or more individuals or organizations to serve in this capacity. While such a coordinator need not be a watershed resident, residence in the watershed would be a valuable attribute along with technical and business skills. This coordinator could also take the role of facilitator for some NEPA planning for work on public lands.

Phase III: Developing Incentives to Maintain Water Quality

As water quality improves in the impaired reach, protection of that improvement will be a challenge. This plan does not attempt to outline all of the relevant factors for this watershed, except to highlight a few possible opportunities that can reduce or overcome ongoing costs of maintaining a restored condition.

The notion that landscape level problems such as turbidity in the Rio Santa Barbara can be addressed with a one-time round of BMP installation ignores the reasons for present conditions. Some combination of ongoing subsidy or economic shifts conducive to water quality maintenance, and new enforcement measures would be required to maintain water quality standards. Further, although no significant threats to water quality exist in the upper Rio Santa Barbara watershed[13], protection of water quality there warrants some attention.

The education efforts in Phase I and II will highlight incentives to maintain water quality where they occur. Only time will tell whether these incentives are sufficient to justify the economic costs of voluntarily preserving water quality, and even if they are economically sufficient their acceptance depends on social factors well beyond the scope of this plan.

Because of the abundant high quality cold trout waters on public lands in the area, where water quality standards are met (such as renowned trout streams within the upper Rio Santa Barbara watershed, and downstream on the Rio Embudo), restoration of the fishery within the lower Rio Santa Barbara does not present a significant economic incentive for

[13] The upper Rio Santa Barbara watershed lies primarily within ecosystems which are naturally affected by stand-replacing fire at very infrequent intervals (perhaps once every two or three hundred years). While a major fire in the upper watershed would undoubtedly be detrimental to the trout fishery, such an affect may not be classified as an impairment relative to the state's water quality criterion for sediment, which reads, "Surface waters of the state shall be free of water contaminants including fine sediment particles (less than two millimeters in diameter), precipitates or organic or inorganic solids *from other than natural causes* that have settled to form layers on or fill the interstices of the natural or dominant substrate in quantities that damage or impair the normal growth, function or reproduction of aquatic life or significantly alter the physical or chemical properties of the bottom" [emphasis added].

landowners to implement components of this plan. Restoration of the fishery and improving other aspects of ecologic health may still present ethical or aesthetic incentives, however. Preliminarily, more significant economic incentives to maintain water quality are as follows:

Ponderosa Pine Forest Restoration
Provided that sufficient fuel is maintained to carry periodic fire, ponderosa pine forest restoration may produce an increase in available forage for livestock. In areas with homes or other infrastructure, insurance actuaries may eventually factor the ecologic state of nearby ponderosa pine forest into calculation of property insurance premiums. Also, once restored, the costs of utilizing prescribed natural fire to maintain ponderosa pine forest in a natural state are much lower than conducting prescribed burns or actively thinning trees to permit the use of fire without causing crown fires.

USFS Grazing BMPs
The management measures described above generally have some promise for producing better weight gains in livestock grazed on USFS lands, partially compensating for the costs of those practices. Increased demand for grass-fed or local beef, or conversely decreased subsidization of corn- or soy-fed beef production systems, may improve the economics of public lands livestock production and thus may make some new costs of production more affordable.

Piñon/Juniper Forest Restoration
A primary means of implementing this management measure is through firewood harvest. Approximately 80% of households in the area depend on firewood for heat, and many area residents are engaged in firewood harvest for their own homes or as a business activity. Existing activity may be focused within this specific watershed to achieve objectives related to water quality.

Recreation Management (Including ORVs)
ORV use may decrease within this watershed in the near term as a result of management changes being contemplated by the Carson National Forest. Thus, an enforcement mechanism may prevent new ORV routes from developing at the rate seen in recent decades. Area residents are likely to need to access areas for firewood harvest, and low-impact ORV use (e.g., selecting routes to minimize impacts, and avoiding use in wet conditions) can be prescribed within firewood harvest permits and stewardship contracts.

Unpaved Roads BMPs
Properly drained roads concentrate runoff less than roads which capture or retain flow on their surfaces. Properly drained roads also require less maintenance to correct erosion problems, they generally produce less wear and tear on vehicles, and they may support faster average speeds. These benefits may largely offset the costs of training, labor, and equipment associated with installing and maintaining proper drainage.

Riparian Grazing Management
Limiting grazing within riparian areas (or pastures in general) to short periods of intense grazing may result in greater total forage production, faster weight gain by livestock, and protection of woody riparian plants sufficient to increase bank stability. Many private parcels within the Rio Santa Barbara and Rio Chiquito valleys are too small for economic livestock production or subdivision into pastures (including riparian pastures). However, some property owners may find that leasing these pastures is easier than using them themselves, and livestock producers with several adjacent or nearby leases may be able to operate a group of properties as managed pastures, with less impact overall to riparian areas. In addition to the economics of raising livestock, hay production, and leasing pastures, increased streambank stability (i.e., reduced erosion) provides an incentive for landowners to pursue improved management options. Increased streambank stability in the vicinity of acequia diversions may also reduce costs of maintaining the diversions.

Bank Stabilization BMPs
In addition to the benefits of reducing or changing grazing pressure described above, more active management measures also generally reduce erosion and may protect irrigation infrastructure.

Mine BMPs
The proposed management measures may already be required by existing regulations. Thus, an existing enforcement mechanism may serve to partially or wholly cause these measures to be implemented.

Arroyo Treatments
On private land, the treatments identified by this plan may help landowners preserve or increase the value of their property by reducing and stabilizing gullies and arroyo cut banks.

Monitoring Progress

The primary purposes of monitoring outlined in this plan are to measure progress of implementation against milestones identified below, to model pollutant load reductions that are expected to accompany implementation, to detect changes in water quality over time, and to determine whether water quality standards are being met in the Rio Santa Barbara.

Implementation Monitoring
Progress towards implementing the identified management measures, in the units specified in Table 4 (below), will be tracked and reported in revisions of this plan and in reports required by organizations funding implementation of this plan. Each individual structure and treated area will be photographed and designated with a tracking number and GPS position to enable follow-up monitoring, to determine whether the measure has been effective at its intended site-specific purpose (*e.g.,* prevent bank erosion) and whether any maintenance or adjustments are necessary. Implementation monitoring will provide photographic data and evidence that structures have accomplished their site-

specific goals, which will be essential information in recruiting more conservative implementers and in qualifying for some sources of funding.

Pollutant Load Reduction Modeling
Pollutant load reductions will be estimated based on implementation progress relative to total need outlined in Table 4 (below), coupled with the load estimates provided in Table 3 (above). For example, if 10 drainage features are installed on unpaved roads, then an estimated daily load reduction (under wet weather conditions) of 13.5 pounds per day of total suspended solids will be realized (10/500 x 676.35 lb TSS/day).

Effectiveness Monitoring
Effectiveness monitoring will be conducted using an approach outlined by Grabow and others[14]. The specific approach will be the upstream/downstream, before/after approach, in which data are collected from two points above and below BMP implementation, both before and after BMP implementation. This approach is cost effective, feasible for non-statisticians, and has the promise of permitting scientifically valid conclusions regarding whether pollutant loading has changed between sampling points. Due to natural variations in water quality that are unrelated to BMP implementation, the method cannot be expected to detect real water quality changes of small magnitude, and so should not be relied upon entirely as an indicator of progress. The Surface Water Quality Bureau's Watershed Protection Section has an effectiveness monitoring program that can either assist with or conduct this monitoring, including development of more detailed study designs.

Assessment of Standards Attainment
Both the Pueblo of Picuris and the State of New Mexico implement monitoring programs under Section 106 of the Clean Water Act, a primary purpose of which is assessment of standards attainment. As such, either entity may continue to recognize impairment, or may recognize that standards are attained, based on available data. Such decisions are reviewed and approved by either the New Mexico Water Quality Control Commission or the Governor of the Pueblo, and by EPA, generally with public input.

The Surface Water Quality Bureau Monitoring and Assessment Section (MAS) is responsible for this program for the State of New Mexico. To provide data to be used for assessment, MAS conducts water quality surveys on a rotating watershed basis, surveying each major watershed approximately one year out of eight. MAS conducted a survey in 2009 that included the Rio Santa Barbara. Data collected during the 2009 survey may be assessed in time to affect the *State of New Mexico Clean Water Act §303(d)/§305(b) Integrated Report* for 2012 – 2014. SWQB is developing a new assessment protocol to allow assessment of data against the narrative turbidity criterion, which was adopted (replacing a numeric criterion) after the turbidity TMDL was developed. Future assessment of the Rio Santa Barbara depends on completion of this protocol.

[14] Grabow, G.L., J. Spooner, L. A. Lombardo, and D. E. Line. 1992. *Detecting water quality changes before and after BMP implementation: use of a spreadsheet for statistical analysis.* NWQEP Notes 92: 1 – 9. This article is available on line at www.bae.ncsu.edu/programs/extension/wqg/issues/92.pdf.

If in the future this plan is essentially implemented, and either the State or the Pueblo finds that the turbidity standard is still not met, then NMED or the Pueblo may develop a new TMDL to reflect current conditions and provide a revised target load reduction.

Technical and Financial Assistance Needed

Table 4 lists the estimated costs for implementing the management measures, education, and monitoring identified above. Each management measure cost is based on an estimate of the cost of materials, equipment, and labor, with an additional ten percent added for design, consultation, meetings, and planning at a level of detail beyond the scope of this watershed plan. The "general coordination" item under education includes the costs incurred by a coordinator, but no costs incurred by landowners, agency staff, or contractors. It is anticipated that projects developed to implement this watershed plan will include design and planning phases to provide more detailed information such as the precise locations and placements of structures.

Table 4: Estimated implementation costs

Management Measure Category	Management Measure Subcategory	Units	Units Needed	Estimated Cost per Unit	Total Cost
Ponderosa pine forest restoration	Thinning	ac	1000	$500.00	$500,000.00
Ponderosa pine forest restoration	Prescribed burning	ac	5000	$50.00	$250,000.00
Ponderosa pine forest restoration	Prescribed natural fire	ac	8000	$2.00	$16,000.00
Subtotal					**$766,000.00**
USFS grazing BMPs	Drift fencing	mi	5	$11,000.00	$55,000.00
USFS grazing BMPs	Herding	season	5	$32,000.00	$160,000.00
USFS grazing BMPs	Range monitoring	pasture	105	$200.00	$21,000.00
USFS grazing BMPs	Hiking stiles	each	3	$1,000.00	$3,000.00
USFS grazing BMPs	Corrals and holding pens	each	3	$5,000.00	$15,000.00
Subtotal					**$254,000.00**
Piñon/juniper forest restoration	Firewood harvest	ac	500	$50.00	$25,000.00
Piñon/juniper forest restoration	Other thinning	ac	1000	$500.00	$500,000.00
Subtotal					**$525,000.00**
Recreation management	Install drainage features on designated ORV routes	each	200	$825.00	$165,000.00

Management Measure Category	Management Measure Subcategory	Units	Units Needed	Estimated Cost per Unit	Total Cost
Recreation management	Close unauthorized ORV routes	each	30	$1,100.00	$33,000.00
Recreation management	Install drainage features to reclaim unauthorized ORV routes	each	50	$825.00	$41,250.00
Recreation management	Install drainage features on East Fork Trail	mi	6	$3,000.00	$18,000.00
Subtotal					**$257,250.00**
Unpaved roads BMPs	Install drainage features on unpaved roads and driveways	each	500	$1,650.00	$825,000.00
Unpaved roads BMPs	Selective road closure	each	20	$1,100.00	$22,000.00
Unpaved roads BMPs	Reclamation of closed roads (installation of drainage features)	each	30	$1,650.00	$49,500.00
Subtotal					**$896,500.00**
Riparian grazing management	Fencing (inc. gates and water crossings)	ft	10000	$1.52	$15,200.00
Riparian grazing management	Water gaps	each	7	$2,000.00	$14,000.00
Riparian grazing management	Off-channel water sources	each	15	$550.00	$8,250.00
Subtotal					**$37,450.00**
Bank stabilization BMPs	Boulder vanes	each	10	$2,640.00	$26,400.00
Bank stabilization BMPs	Post vanes	each	20	$1,760.00	$35,200.00
Bank stabilization BMPs	Log vanes	each	10	$1,320.00	$13,200.00
Bank stabilization BMPs	Baffles	each	5	$2,090.00	$10,450.00
Bank stabilization BMPs	Boulder cross-vanes	each	10	$4,950.00	$49,500.00
Subtotal					**$134,750.00**
Mine BMPs	Ponding areas	cy	10000	$3.00	$30,000.00
Mine BMPs	Disturbed area reclamation	ac	2	$244.13	$488.26
Subtotal					**$30,488.26**
Arroyo treatments	Post vanes	each	20	$1,320.00	$26,400.00
Arroyo treatments	One-rock dams	each	100	$220.00	$22,000.00
Arroyo treatments	Baffles	each	20	$1,650.00	$33,000.00

Management Measure Category	Management Measure Subcategory	Units	Units Needed	Estimated Cost per Unit	Total Cost
Arroyo treatments	Rock bowls	each	20	$550.00	$11,000.00
Subtotal					**$92,400.00**
Education	Roads workshop	each	5	$7,500.00	$37,500.00
Education	Gully treatment workshop	each	5	$5,000.00	$25,000.00
Education	Riparian restoration workshop	each	5	$7,500.00	$37,500.00
Education	Local watershed tours / conferences	each	4	$5,000.00	$20,000.00
Education	Literature printing and distribution	each	2	$11,000.00	$22,000.00
Education	General coordination	year	7	$26,000.00	$182,000.00
Subtotal					**$324,000.00**
Monitoring	Implementation monitoring	year	10	$2,000.00	$20,000.00
Monitoring	Load reduction modeling	year	10	$100.00	$1,000.00
Monitoring	Effectiveness monitoring	year	5	$17,000.00	$85,000.00
Monitoring	Assessment of standards attainment	each	2	$7,500.00	$15,000.00
Subtotal					**$121,000.00**
Grand Total					**$3,438,838.26**

Funding which is already available to support implementation of this plan include United States Forest Service operational funds (which are well suited for NEPA planning and small on-the-ground projects), Taos Soil and Water Conservation District operational funds (supported by a small tax levee), and Taos County Public Works Department (which has available a budget for maintenance of County roads).

Other possible sources for funding implementation of this watershed plan are listed in the 2009 State of New Mexico Nonpoint Source Management Plan, Appendix D[15]. This document also lists several on-line tools for identifying funding opportunities.

One of the more likely initial sources of new funding will be the Clean Water Act Section 319 program. This program and the funding made available through it are primarily intended to directly or indirectly restore water bodies to meet water quality standards and support designated uses. This plan has been tailored to meet the requirements for this program, increasing eligibility for funding. Funding programs commonly require specific planning elements to have been completed prior to application for funding, or express preference for specific planning to have been completed, and thus most other sources of

[15] This document is available on line at ftp://ftp.nmenv.state.nm.us/www/swqb/WPS/NPSPlan/WQCC-Approved2009NPSPlan.pdf.

funds will not be available as soon. Section 319 funds are available on a competitive basis through the New Mexico Environment Department, which conducts a request for proposals on an approximately annual basis. An RFP is planned for early 2010.

Provided that the New Mexico Legislature authorizes the program in 2010 or beyond, the River Ecosystem Restoration Initiative is another program with goals consistent with components of this watershed plan. Another mechanism of funding available through the New Mexico State Legislature is the Water Trust Board process, in which a board with representation by several cabinet-level agencies recommends, on an annual basis, funding of water-related projects identified through an application process coordinated by the New Mexico Finance Authority. Several years ago, the board created a category of project related to watershed management, and has received only a small number of applications each year. The board has received applications for projects which would implement TMDLs, and at least one such project was recommended and funded. This source of funding is only available to local or Tribal governments (including SWCDs).

A source of funding appropriate for implementing agricultural best management practices is the Environmental Quality Incentives Program (EQIP) administered by the USDA Natural Resources Conservation Service. This program is well-suited to individual private property owners who use their land for agriculture, although under some circumstances the program may be used on public land. Because of the reliance of EQIP on individual applications for relatively small projects, projects appropriate for accomplishing the goals of this plan are most likely to result from the aid of a coordinator.

The Habitat Stamp Program administered by the New Mexico Department of Game and Fish may be well-suited to the management measure of establishing off-channel water sources for livestock on National Forest land, if elements are included to provide water for wildlife and prevent accidental drowning by wildlife. NMDGF has supported this type of activity in the past both to benefit upland wildlife populations and to protect riparian areas for riparian-dependent wildlife and fisheries.

Schedule for Implementation

A schedule for implementation is presented in

Table 5 (Phase 1) and Table 6 (Phase 2). These tables include all of the needed items identified in Table 4 (above), except for a portion of the prescribed natural fire, which is primarily a management measure appropriate for maintaining a restored state (*i.e.*, Phase 3).

Table 5: Schedule for implementation (Phase 1)

Management Measure Subcategory	Units	Units Needed	Phase 1 - Early Implementation				
			2011 (year 1)	2012 (year 2)	2013 (year 3)	2014 (year 4)	2015 (year 5)
Ponderosa pine thinning	ac	1000			50	100	150
Ponderosa pine prescribed burning	ac	5000				100	200
Ponderosa pine prescribed natural fire	ac	8000					200
USFS drift fencing	mi	5					1
USFS herding	season	5					
USFS hiking stiles	each	3	3				
USFS Corrals and holding pens	each	3		3			
USFS Range monitoring	pasture	105			7	14	14
P/J firewood harvest	ac	500	50	50	50	50	50
P/J other thinning	ac	1000			100	200	300
Install drainage features on designated ORV routes	each	200	10	20	40	80	50
Close unauthorized ORV routes	each	30	10	20			
Install drainage features to reclaim unauthorized ORV routes	each	50	10	20	20		
Install drainage features on East Fork Trail	mi	6				3	3
Install drainage features on unpaved roads and driveways	each	500	20	40	50	50	100
Selective road closure	each	20		1	2	3	4
Reclamation of closed roads (installation of drainage features)	each	30		2	3	4	5

Management Measure Subcategory	Units	Units Needed	Phase 1 - Early Implementation				
			2011 (year 1)	2012 (year 2)	2013 (year 3)	2014 (year 4)	2015 (year 5)
Private lands fencing (inc. gates and water crossings)	ft	10000	100	400	1500	1500	2000
Water gaps	each	7		1	1	1	2
Off-channel water sources	each	15	1	1	2	2	3
Boulder vanes	each	10		1	2	2	2
Post vanes	each	20		1	2	3	4
Log vanes	each	10		1	1	2	2
Baffles	each	5		1	1	1	1
Boulder cross-vanes	each	10		1	2	2	2
Ponding areas	cy	10000					10000
Disturbed area reclamation	ac	2					2
Post vanes	each	20		2	3	4	5
One-rock dams	each	100		8	15	14	12
Baffles	each	20		2	3	4	4
Rock bowls	each	20		1	2	3	5
Roads workshop	each	5	1		1		1
Gully treatment workshop	each	5		1		1	
Riparian restoration workshop	each	5	1		1		1
Local watershed tours / conferences	each	4				1	
Literature printing and distribution	each	2	1				1
General coordination	year	7				1	1
Implementation monitoring	year	10	1	1	1	1	1
Load reduction modeling	year	10	1	1	1	1	1
Effectiveness monitoring	year	5	1		1		1
Assessment of standards attainment	each	2		1			

Table 6: Schedule for implementation (Phase 2)

Management Measure Subcategory	Units	Units Needed	Phase 2 - Widespread Implementation				
			2016 (year 6)	2017 (year 7)	2018 (year 8)	2019 (year 9)	2020 (year 10)
Ponderosa pine thinning	ac	1000	200	200	200	100	
Ponderosa pine prescribed burning	ac	5000	400	800	1500	1500	500
Ponderosa pine prescribed natural fire	ac	8000					1000
USFS pasture fencing	mi	5	2	2			
USFS herding	season	5	1	1	1	1	1
USFS Range monitoring	pasture	105	14	14	14	14	14
P/J firewood harvest	ac	500	50	50	50	50	50
P/J other thinning	ac	1000	300	100			
Install drainage features on designated ORV routes	each	200					
Close unauthorized ORV routes	each	30					
Install drainage features to reclaim unauthorized ORV routes	each	50					
Install drainage features on East Fork Trail	mi	6					
Install drainage features on unpaved roads and driveways	each	500	50	50	50	50	40
Selective road closure	each	20	2	2	2	2	2
Reclamation of closed roads (installation of drainage features)	each	30	4	4	3	3	2
Private lands fencing (inc. gates and water crossings)	ft	10000	1500	1000	1000	500	500
Water gaps	each	7	1	1			

Management Measure Subcategory	Units	Units Needed	Phase 2 - Widespread Implementation				
			2016 (year 6)	2017 (year 7)	2018 (year 8)	2019 (year 9)	2020 (year 10)
Off-channel water sources	each	15	2	2	2		
Boulder vanes	each	10	2	1			
Post vanes	each	20	4	4	2		
Log vanes	each	10	2	1	1		
Baffles	each	5	1				
Boulder cross-vanes	each	10	2	1			
Ponding areas	cy	10000					
Disturbed area reclamation	ac	2					
Post vanes	each	20	3	3			
One-rock dams	each	100	11	10	10	10	10
Baffles	each	20	2	2	2	1	
Rock bowls	each	20	5	2	2		
Roads workshop	each	5		1		1	
Gully treatment workshop	each	5	1		1		1
Riparian restoration workshop	each	5		1		1	
Local watershed tours / conferences	each	4	1		1		1
Literature printing and distribution	each	2					
General coordination	year	7	1	1	1	1	1
Implementation monitoring	year	10	1	1	1	1	1
Load reduction modeling	year	10	1	1	1	1	1
Effectiveness monitoring	year	5			1		1
Assessment of standards attainment	each	2					1

Milestones

This section outlines the major events that can be used to determine how implementation of this plan compares with the above schedule. One milestone has been identified for each year of the plan's first and second phases.

Table 7: Milestones

Year	Milestone	Significance
2011	Initial implementation	Initial implementation indicates that the plan is being implemented, and can add support for the plan by demonstrating that it has lead to action.
2012	Assessment of standards attainment	Assessment of standards attainment is dependant on development of a new assessment protocol for turbidity, and may confirm the need for this plan early in its implementation.
2013	Commencement of active forest restoration	Active forest restoration, which includes thinning and prescribed burning, may only commence on USFS land with significant support of the Forest administration and technical staff, following establishment of purpose and need, NEPA analysis with public input, sufficient funding appropriate for this activity, and adherence to complicated procurement procedures. On private lands, funding sources such as the Collaborative Forestry Restoration Program are accessible on a competitive basis to those willing to pursue a separate detailed planning process. These hurdles make commencement of active forest restoration a significant milestone for this watershed.
2014	Coordinated restoration begins	Before this milestone, implementation is likely to occur at some level, but with little coordination and possibly with leadership provided by organizations located outside of the watershed, or organizations lacking permanent responsibility within the watershed. Local or regional coordination will increase the rate of implementation to a level that is more likely to achieve the goals of this watershed plan.
2015	Peak implementation	Implementation accomplishments for each year can be compared with the goals for each year identified in **Table 5**, and together provide an indication of whether implementation is proceeding as planned. 2015 is the approximate year in which most activities will be at their peak of implementation.
2016	Significant effectiveness and implementation monitoring reports presented at local watershed conference	2016 is the first year when statistically significant effectiveness monitoring results may exist for presentation at a local watershed conference. Implementation monitoring will provide photographic data and evidence that

Year	Milestone	Significance
		structures have accomplished their site-specific goals. If successful, this information will be essential in recruiting more implementers and in qualifying for some sources of funding. If not successful, this information may lead to revision of the watershed plan.
2017	Effective prescribed natural fire policy in place	Existence of a policy to allow prescribed natural fire in ponderosa pine forest ecosystems will be necessary for this management tool to be used at a level appropriate for maintaining ponderosa pine ecosystems. Development of such a policy depends on public support, policy support by the NMED Air Quality Bureau, and the will of USFS management and technical staff to develop this policy amid competing priorities.
2018	Active bank stabilization work is completed	Completion of a major category of management practice will signify that implementation of the plan is nearing completion, and also signals a period of greater focus on interpreting monitoring results and possible plan revisions.
2019	Thinning is completed	Completion of a major forest thinning initiative on Forest Service land will signify that the Carson National Forest has fulfilled the main expectations for a project developed with significant public input.
2020	Assessment of standards attainment	The Surface Water Quality Bureau, Monitoring and Assessment Section, will conduct a water quality survey to enable assessment of standards attainment within this watershed in approximately 2018. The data collected may be the first such data available to enable assessment, which can be published in 2020. If the plan has been implemented and the Rio Santa Barbara is found to meet its water quality standards for turbidity, then this plan will have accomplished its goals. More information is provided in the following section.

Criteria for Measuring Success

If this plan has been implemented and the Rio Santa Barbara is found to meet its water quality standards for turbidity, then the plan will have accomplished its goals. Assessment of standards attainment is expected to take place in 2012 (before significant implementation) and 2020 (after significant implementation).

A milestone expected in 2016 ("significant effectiveness and implementation monitoring reports presented at local watershed conference") will provide an interim measure of success. Effectiveness monitoring may also provide an indication whether progress has been made if, in 2020, the Rio Santa Barbara still does not meet its water quality criterion for turbidity.

If in 2020 this plan has been substantially implemented, the Rio Santa Barbara does not meet its water quality criterion for turbidity, and effectiveness monitoring data show less improvement in water quality than expected given the level of implementation, or if there is no statistically significant improvement in water quality, then the plan will be revised using guidance, information about management measures, and program approaches which have not yet been developed.

Several other developments may occur which would warrant revision of this plan.

If the waters within the Rio Santa Barbara watershed are found to meet their water quality standards in 2020 (or sooner), this plan will be revised to focus on protecting water quality.

The Pueblo of Picuris may develop a TMDL for turbidity or other parameters during the period outlined in Table 7. In the event that a TMDL is set which is lower (*i.e.,* more protective of water quality) than the current State of New Mexico TSS TMDL, or in the event that a TMDL is adopted by either the State of New Mexico or the Pueblo of Picuris for a parameter other than TSS for any water within the Rio Santa Barbara watershed, this plan will be revised.

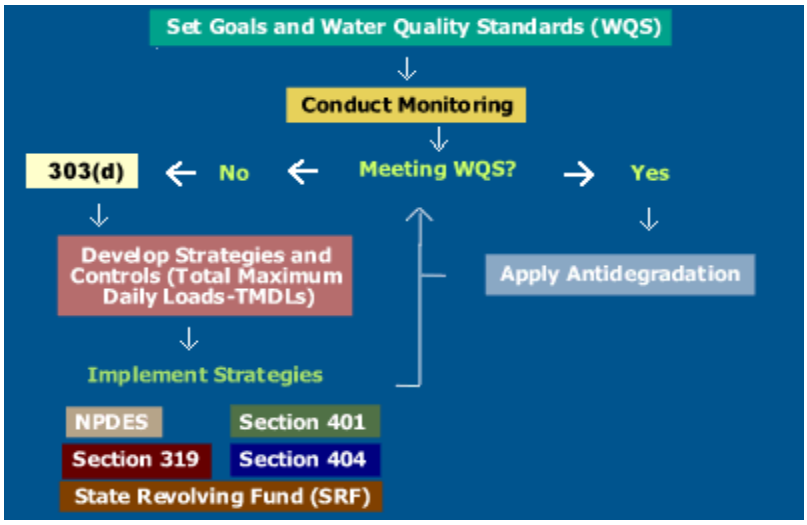
However, until such time as the plan is revised, this plan will still be considered valid for the subject reach of the Rio Santa Barbara (NM assessment unit NM-2120.A_419). This statement applies as long as a recognized turbidity impairment and TSS TMDL are in place. Also, if a lower TSS TMDL is established, implementation of the management measures identified in this document should proceed until such time as the watershed plan can be revised.

APPENDIX A

Regulatory Overview

Clean Water Act Regulation

(adapted from EPA Website)



The Clean Water Act (CWA) is the cornerstone of surface water quality protection in the United States. (The Act does not deal directly with ground water nor with water quantity issues.) The statute employs a variety of regulatory and nonregulatory tools to sharply reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

Brief Overview of Key CWA Elements

First, water quality standards (WQS) consistent with the statutory goals of the CWA must be established. Then waterbodies are monitored to determine whether the WQS are met.

The designated uses (DUs) of a waterbody are those uses that society, through various units of government, determines should be attained in the waterbody. The DUs are the goals set for the waterbody. In some cases, these uses have already been attained, but sometimes conditions in a waterbody do not support all the DUs.

Water quality criteria (WQC) are descriptions of the conditions in a waterbody necessary to support the DUs. These can be expressed as concentrations of pollutants, temperature, pH, turbidity units, toxicity units, or other quantitative measures. WQC can also be narrative statements such as "no toxic chemicals in toxic amounts."

WQC can be divided up for descriptive purposes in many ways. For instance, numeric criteria (weekly average of 5 mg/L dissolved oxygen) can be contrasted with narrative criteria (no putrescent bottom deposits). Criteria can also be categorized according to what portion of the aquatic system they can be applied to: the water itself (water column), the bottom sediments, or the bodies of aquatic organisms (fish tissue). The duration of time to which they apply is another way of dividing WQC, with those dealing with short-term exposures (acute) being distinguished from those addressing long-term exposure (chronic).

If all WQS are met, then antidegradation policies and programs are employed to keep the water quality at acceptable levels. Ambient monitoring is also needed to ensure that this is the case.

EPA publishes recommended water quality criteria corresponding to a number of key designated uses. For aquatic life uses, criteria for both short-term (acute) and long-term (chronic) exposures are provided. Different criteria for freshwater systems and marine (saline) systems are often provided. Most human health criteria, except certain pathogens, address chronic exposures.

States, tribes, and territories are not required to adopt the exact numbers that EPA has published, but once EPA has issued a criterion for a parameter, they must adopt a corresponding criterion. Such criteria must provide the same level of protection as EPA's, and state/tribe must document that this is the case.

Unfortunately, most states do not have the funding required to carry out ambient monitoring on the scale needed to keep close track of the condition of our nation's surface waters. Most of the waters in the United States are not monitored several times a year or even once over a period of several years. A high degree of uncertainty, therefore, is associated with what can be said about the condition of most rivers, lakes, bays, and other surface waters.

In order to be virtually certain that WQS are being met, instruments capable of performing continuous monitoring and analysis would need to be employed. Unfortunately, this is rarely the case, particularly for certain types of pollutants like synthetic organic chemicals. Consequently agencies are usually able to make only statistical inferences -- often at high levels of uncertainty -- as to whether a waterbody is actually meeting WQS."

States, tribes, and territories are required to provide the results of their monitoring efforts in the form of two reports, submitted to EPA and made available to the public. These reports are generally submitted on April 1 of every even-numbered year (i.e., biennially).

The first report is the "305(b) Report," after the requiring section of the CWA. It should include all that which the state, tribe, or territory knows about all its waters -- healthy, threatened, and impaired.

The second is the "303(d) List" and should include only those waters that are either threatened or impaired. (Waters attaining WQS should not be on the list).

Starting in 2002, EPA is asking states, tribes, and territories to submit the information previously contained in separate 305(b) and 303(d) reports in one consolidated format. Under this new approach, all waters would be placed in one of five categories. These categories are defined by the amount of information available regarding a waterbody and the condition of the waterbody

If monitoring and assessment indicate that a waterbody or segment is impaired by one or more pollutants, and it is therefore placed on the 303(d) list, then the relevant entity (state, territory, or authorized tribe) is required to develop a strategy that would lead to attainment of WQS

If the waterbody is not meeting WQS, a strategy for meeting these standards must be developed. The most common type of strategy is the development of a Total Maximum Daily Load (TMDL). TMDLs determine what level of pollutant load would be consistent with meeting WQS. TMDLs also allocate acceptable loads among sources of the relevant pollutants.

TMDLs are required for "pollutants," but not for all forms of "pollution." Pollutants include clean sediments, nutrients (nitrogen and phosphorus), pathogens, acids/bases, heat, metals, cyanide, and synthetic organic chemicals. As noted previously, pollution includes all pollutants but also includes flow alterations and physical habitat modifications.

At least one TMDL must be done for every waterbody or segment impaired by one or more pollutants. TMDLs are done pollutant by pollutant, although if a waterbody or segment were impaired by two or more pollutants, the TMDLs for each pollutant could be done simultaneously.

EPA is encouraging states, tribes, and territories to do TMDLs on a "watershed basis" (e.g., to "bundle" TMDLs together) in order to realize program efficiencies and foster more holistic analysis. Ideally, TMDLs would be incorporated into comprehensive watershed strategies. Such strategies would address protection of high quality waters (antidegradation) as well as restoration of impaired segments (TMDLs). They would also address the full array of activities affecting the waterbody. Finally, such strategies would be the product of collaborative efforts between a wide variety of stakeholders

The first element of a TMDL is "the allowable load," also referred to as the pollutant "cap." It is basically a budget for a particular pollutant in a particular body of water, or an expression of the "carrying capacity." This is the loading rate that would be consistent with meeting the WQC for the pollutant in question. The cap is usually derived through use of mathematical models, probably computer based.

The CWA requires that all TMDLs include a safety factor as an extra measure of environmental protection, taking into account uncertainties associated with estimating the acceptable cap or load. This is referred to as the margin of safety (MOS).

Once the cap has been set (with the MOS factored in), the next step is to allocate that total pollutant load among various sources of the pollutant for which the TMDL has been done. Although ideally, load allocations should be assigned to individual nonpoint sources, this is often not practical or even scientifically feasible; hence, loads can be assigned to categories of nonpoint sources (all soybean fields in the watershed, for example), or to geographic groupings of nonpoint sources (all in a particular subwatershed).

Even though the CWA provides no federal authority for requiring nonpoint sources to reduce their loadings of pollutants to the nation's waters, the Act does require states (and authorized territories and tribes) to develop TMDLs for waters where nonpoint sources are significant sources of pollutants. TMDLs do not create any new federal regulatory authority over any type of sources. Rather, with regard to nonpoint sources, TMDLs are simply a source of information that, for a given waterbody, should answer such questions as the following:

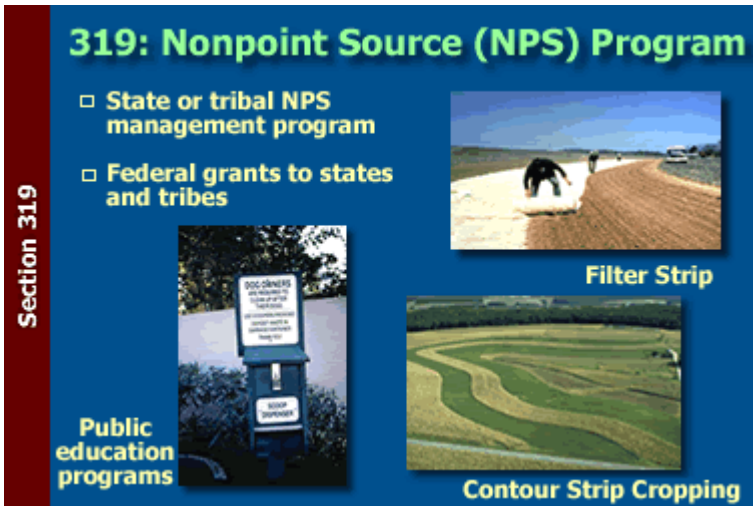
- Are nonpoint sources a significant contributor of pollutants to this impaired waterbody?
- What are the approximate total current loads of impairment - causing pollutants from all nonpoint sources in the watershed?
- What fraction of total loads of the pollutant(s) of concern come from nonpoint sources vs. point sources?
- What are the approximate loadings from the major categories of nonpoint sources in the watershed?
- How much do loads from nonpoint sources need to be reduced in order to achieve the water quality standards for the waterbody?
- What kinds of management measures and practices would need to be applied to various types of nonpoint sources, in order to achieve the needed load reductions?

TMDLs are not "self-implementing." Hence, other authorities and programs must be used to implement the pollutant reductions called for by a TMDL or other strategy to achieve water quality standards. The exact authorities and programs a state, territory, or authorized tribe uses will depend on the type of sources present, as well as on social, political, and economic factors.

A variety of federal, state, local, and tribal authorities and programs can be brought to bear, together with initiatives from the private sector.

Necessary reductions in pollutant loading are achieved by implementing strategies authorized by the CWA, along with any other tools available from federal, state, and local governments and nongovernmental organizations. Key CWA tools include the following:

- **NPDES permit program**
  Covers point sources of pollution discharging into a surface waterbody.
- **Section 319**
  Addresses nonpoint sources of pollution, such as most farming and forestry operations, largely through grants.
- **Section 404**
  Regulates the placement of dredged or fill materials into wetlands and other Waters of the United States.
- **Section 401**
  Requires federal agencies to obtain certification from the state, territory, or Indian tribes before issuing permits that would result in increased pollutant loads to a waterbody. The certification is issued only if such increased loads would not cause or contribute to exceedances of water quality standards.
- **State Revolving Funds** (SRF)
  Provides large amounts of money in the form of loans for municipal point sources, nonpoint sources, and other activities.



Section 319: Nonpoint Source Program

Nonpoint source pollution (NPS) represents the most significant source of pollution overall in the country. According to states' 305(b) and 303(d) reports, more miles of rivers and acres of lakes are impaired by overland runoff from row crop farming, livestock pasturing, and other types of nonpoint sources than by industrial facilities, municipal sewage plants, and point source runoff from municipal storm sewer systems and storm water associated with industrial activity. The most recent set of 303(d) reports indicated that more than 40 percent of all impaired waters were affected solely by nonpoint sources, while only 10 percent of impairments were caused by point source discharges alone.

The CWA does not provide a detailed definition of nonpoint sources. Rather, they are defined by exclusion -- anything not considered a "point source" according to the Act and EPA regulations. All nonpoint sources of pollution are caused by runoff of precipitation (rain and/or snow) over or through the ground. However, as noted previously numerous types of precipitation-induced runoff are treated as point sources rather than as nonpoint sources under the CWA -- including stormwater associated with industrial activity, construction-related runoff, and discharges from municipal separate storm sewer systems.

Atmospheric deposition is also a form of nonpoint source: pollutants discharged into the air and returned directly or indirectly to surface waters in rainfall and snow, as well as so-called dry deposition between precipitation events. (Of course, "smokestack industries" such as fossil-fueled electric generating plants could be considered "point sources of air pollution". But the diffuse deposition of pollutants emitted by such facilities is a form of nonpoint source in the context of water pollution.)

Pollutants commonly associated with NPS include nutrients (phosphorus and nitrogen), pathogens, clean sediments, oil and grease, salt, and pesticides

Congress chose not to address nonpoint sources through a regulatory approach, unlike its actions with "point" sources. Rather, when it added Section 319 to the CWA in 1987, it created a federal grant program that provides money to states, tribes, and territories for the development and implementation of NPS management programs.

Under the Clean Water Act Section 319, states, territories, and delegated tribes are required to develop nonpoint source pollution management programs (if they wish to receive 319 funds).

Once it has approved a state's nonpoint source program, EPA provides grants to these entities to implement NPS management programs under Section 319(h). Section 319 is a significant source of funding for implementing NPS management programs, but there are other federal (e.g., Farm Bill), and state, local, and private programs.

States and tribes must identify waters that are impaired or threatened by nonpoint sources of pollution, develop short and long-term goals for cleaning them up, and identify the best management practices (BMP) that will be used. The state and tribal NPS programs must also have a monitoring and evaluation plan, which is usually tied into the state 305(b) assessment and reporting program.

The BMP section of the plan requires identification of the most common types of stressors, the categories of sources of those stressors, and the types of BMPs that will be both effective and affordable in addressing the identified stressors and sources in general. (Stressors include pollutants, flow alteration, channel modification, invasive species, and others.) BMP efforts include both "statewide" and targeted elements. The former involves efforts to get a baseline level of BMPs implemented in all land uses that can generate nonpoint source pollution -- farms and forestry operations, for example. Targeted BMP

efforts are aimed at having additional amounts and types of BMPs employed in the drainage of impaired or threatened waters.

Nonpoint source management plans also identify strategies for working with other agencies and private entities. For example, the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture is an extremely valuable partner in farm country, since NRCS has access to technical staff and significant cost-share funding under the Conservation Reserve Program and the Environmental Quality Improvement Program and other programs authorized in the 2002 Farm Bill.

Management plans also include the identification of federal lands and activities, which are to be managed in a manner consistent with program objectives of the 319 management plan.

Early in the life of the 319 program, EPA emphasized development of management strategies, combined with deployment of BMPs for education, demonstration, and research purposes. Recently, EPA has increased emphasis on evaluation of program effectiveness, including attempts to document the water quality benefits of BMPs and other program elements. Also, the Agency has notified some states that, starting in FY 03, a sizeable portion of 319 funds should be spent on on-the-ground BMPs only if they are related to a holistic watershed plan or a TMDL specific to the area in which they are located.

APPENDIX B

Non Point Source Pollution, Water Quality Impairments, and Load Reductions

What is Non Point Source Pollution?
Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water. These pollutants include:

- Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas;
- Oil, grease, and toxic chemicals from urban runoff and energy production;
- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks;
- Salt from irrigation practices and acid drainage from abandoned mines;
- Bacteria and nutrients from livestock, pet wastes, and faulty septic systems;

Atmospheric deposition and hydromodification are also sources of nonpoint source pollution.

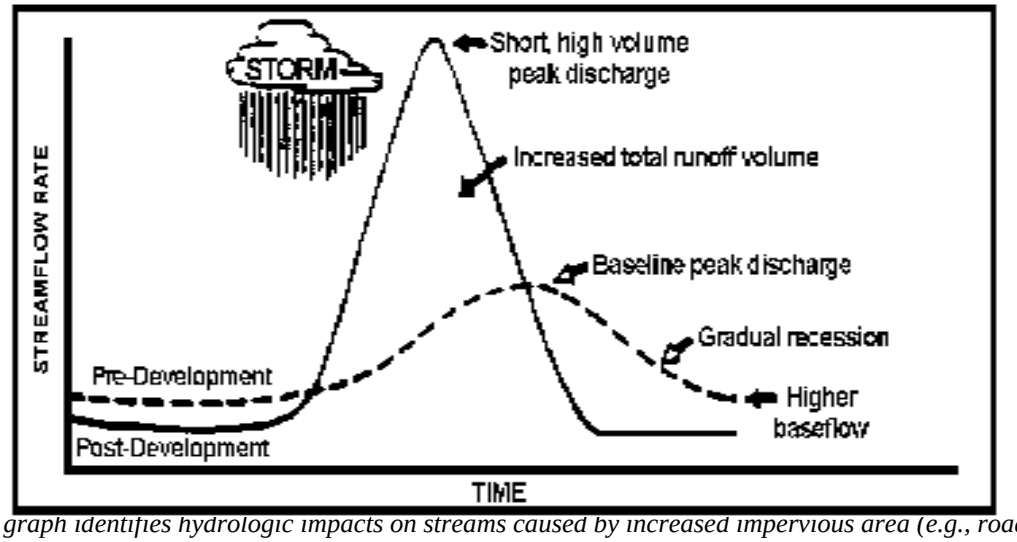
What are the effects of these pollutants on our waters?
States report that nonpoint source pollution is the leading remaining cause of water quality problems. The effects of nonpoint source pollutants on specific waters vary and may not always be fully assessed. However, we know that these pollutants have harmful effects on drinking water supplies, recreation, fisheries, and wildlife.

What causes nonpoint source pollution?
We all play a part. Nonpoint source pollution results from a wide variety of human activities on the land. Each of us can contribute to the problem without even realizing it.

What can we do about nonpoint source pollution?
We can all work together to reduce and prevent nonpoint source pollution. Some activities are federal responsibilities, such as ensuring that federal lands are properly managed to reduce soil erosion. Some are state responsibilities, for example, developing legislation to govern mining and logging, and to protect groundwater. Others are best handled locally, such as by zoning or erosion control ordinances. And each individual can play an important role by practicing conservation and by changing certain everyday habits.

Non Point Source Pollution Impacts and Controls
Urbanization causes changes and impacts to the environment and our communities. Many effects of urbanization are positive, such as new places for people to live and work, increased recreational opportunities, and economic growth. However, some of the impacts might be negative if they are not handled with foresight.

These impacts include increased frequency of flooding and peak flow volumes, increased sediment loadings, loss of aquatic/riparian habitat, changes in stream physical characteristics channel width and depth), decreased base flow, and increased stream temperature.



This graph identifies hydrologic impacts on streams caused by increased impervious area (e.g., roads, driveways, parking lots, and rooftops) in urban developments. EPA, 2007.

Urbanization also leads to loss of pervious areas (porous surfaces) that allow rainwater to soak into the ground. This can increase the amount and velocity of rainwater flowing to streams and rivers. This increased speed and volume of water can have many impacts, including eroded stream banks, increased turbidity and pollution, increased stream water temperature, and increased water flow. All of these can have an adverse effect on the fish and other organisms living in the stream and the receiving waters. When rainwater cannot soak into the ground, the result can be a loss of drinking water because many areas of the country rely on rainwater soaking into the ground to replenish underground drinking water supplies.

"Best management practices," or BMPs, help address these impacts. BMPs are designed to help reduce the amount of pollution in urban runoff. Some help to control the volume and speed of runoff before it enters receiving waters. Many help to increase the amount of rainwater that soaks into the ground to restore groundwater. There are two general types of BMPs: structural and nonstructural. Structural controls involve on the ground projects while non-structural controls would include policy or ordinances that contribute to watershed health.

This document has identified and recommends uses of both structural and non structural BMPs to mitigate non point source pollution into waterbodies as well as to contribute to the overall health of our watershed communities.

Water Quality Impairments in the Rio Embudo Watershed
Samples were collected at seven stations during the spring, summer, and fall of 2001. Water quality impairments were found and TMDLs were developed for:

- Rio Embudo (Rio Grande to Cañada de Ojo Sarco)- turbidity, sedimentation/siltation (stream bottom deposits)
- Rio Santa Barbara (Picuris Pueblo boundary to USFS boundary)- turbidity

Impairment was also found but no TMDL was developed for:

- Rio Chiquito (Picuris Pueblo boundary to headwaters)- turbidity

The Rio Embudo upstream of Cañada Ojo Sarco, the only remaining impairment listing is for "benthic macroinvertebrate bioassessments". As previously mentioned in the document, benthic macroinvertebrates (bugs) are good indicators of a possible impairment. The benthic macroinvertebrate community was found to be only 59% of the reference condition (which was determined at the Rio Santa Barbara at the Santa Barbara Campground), and as a result the state is being encouraged by the Environmental Protection Agency (EPA) to consider that the "marginal coldwater fishery [now called coldwater aquatic life]" use is not fully supported, even though there is no standard to associate with the benthic macroinvertebrate score at this time. It is not known what the pollutant is (or even whether it is a pollutant) that is causing this impairment.

During 2001 spring sampling the Rio Santa Barbara, Rio Embudo, and Rio Pueblo near their confluence all suffered from low flows, due to a combination of drought and diversion. Flow had increased again by the time samples were collected in August but the low flows may have set the insect communities back enough to indicate that some kind of problem had been occurring within the previous few months. Low flow could impair the bug community either from simple lack of habitat (part of the stream bed being dry) or from water quality problems like low dissolved oxygen or high temperature. This type of sampling has been done in other areas, but usually if there was a problem with the bug community, there was also a water quality parameter that could explain it. Further bug counts are necessary to collect more data to determine cause of impairment or if there even is an impairment.

The table below shows a summary of water quality data for stream reaches that show impairment as well as other stream reaches within the watershed that are considered in this document as being an integral part of the watershed as a whole.

Stream	**Bioassessment status**	**Water quality exceedences**	**Notes**
Rio Pueblo (entire stream)	Aquatic life use impaired	None	Impairment may be due to parameters that were not well characterized, possibly related to diversion. Sedimentation and siltation are not a problem overall, but may affect high altitude meadow reaches (which were not surveyed). Impairment less than in Rio Santa Barbara, according to NMED and Picuris Pueblo data.

Rio Santa Barbara on Carson National Forest	Aquatic life use not impaired	None	Thought to have excellent water quality.
Rio Santa Barbara between Picuris Pueblo and Carson National Forest	Aquatic life use impaired	Turbidity	Impairment may also be due to parameters that were not well characterized, possibly related to diversion. Lack of management of riparian grazing may exacerbate water quality problems.
Rio Chiquito	No data	Turbidity	Impairment may also be due to parameters that were not well characterized, possibly related to diversion. Lack of management of riparian grazing may exacerbate water quality problems.
Chamisal Creek	No data	None	Stream poorly characterized. Stream qualitatively appears degraded (incised channel, unstable banks, fine sediment in bed). Some portions may not be perennial. Impairment may be due to parameters that were not well characterized related to diversion or grazing.
Rio de las Trampas	No data	None	Stream poorly characterized. Stream qualitatively appears to be stable (well vegetated banks, cobble and gravel substrate) and supporting fish at Trampas.
Cañada Ojo Sarco	No data	None	SWQB has not sampled this stream at all. Some portions may not be perennial.
Rio Embudo above Cañada Ojo Sarco	Aquatic life use impaired	None	Impairment may be due to parameters that were not well characterized, possibly related to diversion. Sedimentation and siltation are not a problem.
Rio Embudo below Cañada Ojo Sarco	Aquatic life use impaired	Sedimentation and siltation, turbidity	Episodic sediment loading from tributaries and straightened channel probably combine to produce observed problems.

Some comments are in order to explain the above table. First, the table is an attempt to summarize the state of knowledge of the Surface Water Quality Bureau regarding the quality of the streams in the Rio Embudo watershed. The information is consistent with that found in the State's 2004-2006 Integrated §§303(d)/305(b) List of Impaired Waters

and the Record of Decision for the List. It includes additional relevant information such as that bioassessments were not performed for every stream, and some streams have fewer water quality data from which to draw conclusions than others.

The bioassessments that are mentioned in the table refer to analyses of the insect communities living among the cobbles and gravels of the stream beds. These communities are necessary to sustain fish populations, and their condition provides a general indicator of water quality over time. This approach for evaluating water quality requires comparison of studied sites to sites that are known to have good water quality. The reference for the Rio Santa Barbara and Rio Pueblo sites was the Rio Santa Barbara at the Santa Barbara Campground. The reference for the Rio Embudo was the Rio Santa Cruz downstream of the bridge near Cundiyo (Santa Fe County).

Several of the streams are thought to possibly be impacted by diversion for irrigated agriculture. These diversions reduce the flow available to dilute pollutants, and may result in water that is too warm, too low in dissolved oxygen, or of insufficient quantity to support fish or the insect communities on which they depend. In each of these cases, unmanaged riparian grazing may exacerbate any problems that develop. A large portion of the private land fronting these streams is grazed, and differences across fence lines reflect clear differences in grazing management that probably effect water quality. Continuous or frequent grazing on these lands is the cause for some reaches being devoid of woody riparian vegetation (which can shade the water and thus help keep temperatures lower and dissolved oxygen levels higher), and through bank-trampling may have produced channels which are wider and shallower than those on ungrazed lands with more careful grazing management. Wider and shallower channels tend to warm up more in the sun than narrower, deeper channels.

What is turbidity?
The general narrative according to New Mexico Water Quality Standards (20.6.4 NMAC) for turbidity reads:

Turbidity: Turbidity attributable to other than natural causes shall not reduce light transmission to the point that the normal growth, function, or reproduction of aquatic life is impaired or that will cause substantial visible contrast with the natural appearance of the water.

Turbidity is a measurement of suspended sediments in the water body. The sediments will accumulate at the bottom of the watercourse where small aquatic insects and fish species live. In addition, an increase in suspended sediments will inhibit the penetration of light into the stream, reducing photosynthesis. The sediments can also physically damage algae and other plant species in the watercourse.

Suspended sediments within a stream vary with the flow of a river. Since flow in the river varies throughout the year, permissible limits of suspended sediments can also be variable. Turbidity exceedences are generally attributable to actions such as soil erosion,

excess nutrients, and displacement of materials within the watercourse during high flow events such as peak flow.

Estimates have been made in the Total Maximum Daily Load document that calculate the necessary reduction of these pollutants into the watercourse, so that the water quality conditions of this stretch of river can improve and hopefully eventually meet water quality standards.

What is sedimentation/siltation (stream bottom deposits)?
The general narrative according to New Mexico Water Quality Standards (20.6.4 NMAC) for sedimentation/siltation (stream bottom deposits) reads:

Bottom Deposits: Surface waters of the state shall be free of water contaminants from other than natural causes that will settle and damage or impair the normal growth, function, or reproduction of aquatic life or significantly alter the physical or chemical properties of the bottom.

Increased sediment loads can be the most important adverse effect of activities on streams and severely reduces the available habitat for macroinvertebrates, and fish species that utilize the streambed throughout the phases of life. Food sources for aquatic life species can be buried under sediment, either rendering them inaccessible or increasing the length of time it takes to find the food. Sediments also fill crevasses where fish species generally deposit their eggs.

Estimates have been made in the Total Maximum Daily Load document that calculate the necessary reduction of these pollutants into the watercourse, so that the water quality conditions of this stretch of river can improve and hopefully eventually meet water quality standards.

Load Reductions Estimate
Loading is defined as a fluvial process that transports a quantity of material by processes that include dissolved load, floatation, suspended load, and bed load (saltation and traction). Loading is usually expressed in units such as mg/l, ppm, lbs/day, etc. Loading must be reduced in order for the listed streams to be de-listed for turbidity as well as sedimentation and siltation. Watershed restoration projects, as well as education are a means to de-list rivers and reduce the likelihood of additional listings.

Rio Embudo (Rio Grande to Cañada de Ojo Sarco)
The Rio Embudo upstream from the Rio Grande to Cañada de Ojo Sarco is on the draft 2004-2006 303(d) List for turbidity and sedimentation/siltation. The most recent data to support these listings were collected in 2001. For turbidity, two of eight samples exceeded the water quality criterion of 50 NTU (Nephelometric Turbidity Units). The values of these were 240 NTU and 72 NTU. These observations were made on August 14 and 15 after precipitation events. SWQB uses an assessment protocol which attempts to recognize that an impairment listing should not be based on exceedences following rare chance events (such as rainfall). As such, impairment is recognized when 15% or

more of sample data indicate exceedences (for data sets with eight or more observations). Impairment of this section of the Rio Embudo would not have been recognized if turbidity had been reduced by 22 NTU on August 14. Therefore, by implementing recommended BMPs a reduction in turbidity by 22 NTU following rain events is a reasonable initial goal for meeting water quality standards, based on these few available data.

When the TMDL for this stream segment was developed the target load allocation was expressed as TSS (Total Suspended Sediment) in lbs per day. The table below shows a load reduction estimate based on this measurement.

Impairment	Target Load Allocation (lbs/day)	Measured Load	Reduction objective
Turbidity	16.630	66,728	50,098

The single site (at the USGS gage near Dixon) sampled for bed material from this segment of the Rio Embudo had a bed composed 24% of particles 2 mm or smaller ("fines") in 2001.

Impairment	Target load Allocation	Measured Load	Reduction Objective
Sedimentation	20%	24%	4%

SWQB uses an assessment protocol for sedimentation and siltation that results in recognition of no impairment by sedimentation and siltation when fines make up 20% or less of the stream bed. Impairment of this section of the Rio Embudo would not have been recognized if percent fines had been reduced by 4%. Therefore, a reduction in fines by 4% (of all bed material) is a reasonable initial goal for meeting water quality standards, based on these few available data.

Rio Santa Barbara (downstream of Carson National Forest boundary)
The Rio Santa Barbara downstream of the Carson National Forest is on the draft 2004-2006 303(d) List for turbidity. The most recent data to support this listing were collected in 2001. Two of seven samples exceeded the water quality criterion of 25 NTU. The values of these were 36 NTU and 37 NTU. These observations were made on August 14 and 15 after precipitation events. SWQB uses an assessment protocol which attempts to recognize that an impairment listing should not be based on exceedences following rare chance events (such as rainfall). As such, impairment is recognized when two or more samples indicate exceedance (for data sets with seven or fewer observations). Impairment of the Rio Santa Barbara would not have been recognized if turbidity had been reduced by 11 NTU on August 14. Therefore, by implementing recommended BMPs, a reduction

in turbidity by 11 NTU following summer rain events is a reasonable initial goal for meeting water quality standards, based on these few available data.

When the TMDL for this stream segment was developed the target load allocation was expressed as TSS (Total Suspended Sediment) in lbs per day. The table below shows a load reduction estimate based on this measurement

Impairment	Target level	Measured level	Reduction objective
Turbidity	1,753	3,256	1,503

Rio Chiquito

The Rio Chiquito is on the draft 2004-2006 303(d) List for turbidity. The most recent data to support this listing were collected in 2001. For turbidity, two of three samples exceeded the water quality criterion of 25 NTU. The values of these were 43 NTU and 62 NTU. These observations were made on May 22 and August 14, 2001 (during spring runoff and after a summer rain event, respectively). SWQB recognizes impairment when, two or more samples indicate exceedance (for data sets with seven or fewer observations). Impairment of the Rio Chiquito would not have been recognized if turbidity had been reduced by 18 NTU on May 22. Therefore, by implementing recommended BMPs, a reduction in turbidity by 18 NTU during spring runoff is a reasonable initial goal for meeting water quality standards, based on these few available data.

No TMDL was developed for this stream reach so the table below expresses load reduction objectives in NTUs.

Impairment	Target level	Measured level	Reduction Objective
Turbidity	25NTU 25NTU	43NTU 62NTU	18NTU

APPENDIX C

Project Tables

General Objectives and Recommendations

Objectives	Recommendations	Potential Partners
Forest Health	Thinning projects on private and public lands	Watershed Groups, private landowners, American Tree Farmers, USFS
Forest Health	Complete USFS Travel Management Plan	USFS, Watershed Groups, Private Landowners
Forest Health	Revegetation of south facing slopes. Mulching and seeding to provide the necessary vegetative cover to hold the moisture and the dirt.	USFS, private landowners, BLM, watershed groups
Forest Health	Forest road upgrade and maintenance- Water bars, culverts and vegetation reseeding	USFS, BLM, watershed groups
Forest Health	Exercise proper fire management- Fire management over suppression	USFS, watershed groups, BLM
Forest Health	Identification, repair, and maintenance of existing water impoundments	USFS, BLM, private landowners
Forest Health	Small business development incentives to process and market forest products.	USDA, watershed groups, stakeholders, USFS, BLM
Arroyo Management	Form an arroyo management task force	Rio Arriba and Taos Counties, local Acequia Associations, Department of Transportation, Bureau of Land Management, USFS, NRCS and FEMA
Arroyo Management	Investigate previous use of sediment dams	Watershed Groups, BLM, USFS
Arroyo Management	Encourage projects on uplands that mitigate unnecessary erosion- range improvements, restricted ORV use and close or upgrade severely degraded roads	BLM, USFS, Watershed Groups, Permittees, Recreationalists
Arroyo Management	Utilize land development ordinances such as floodplain, reduced impervious surfaces	Rio Arriba and Taos Counties, Watershed Groups, landowners
Arroyo Management	Possibly use land conservation tools to designate an arroyo as an open space or public domain/public infrastructure.	Rio Arriba and Taos Counties, Watershed Groups, Taos Land Trust

Arroyo Management	Land use ordinances such as wetlands ordinance/floodplain ordinance /stream buffer/acequia ordinance	Rio Arriba and Taos Counties, Watershed Groups, private landowners
Arroyo Management	Land conservation tools: Acquisition Purchase or transfer of development rights Conservation easements	Rio Arriba and Taos Counties, Watershed Groups, Taos Land Trust
Restore, protect wetland and riparian resources	River corridor invasive species removal; salt cedar, tamarisk	East Rio Arriba and Taos Soil and Water Conservation Districts, Watershed Groups, private landowners, NMED, NRCS, USFWS, BLM
Restore, protect wetland and riparian resources	Recreate wetland/riparian areas that have been lost ie planting, dredging, river channel assessments	NMED, USFWS, Watershed Groups, private landowners, grazing permittees, BLM
Restore, protect wetland and riparian resources	Riparian fencing as wildlife and grazing exclosures	Private landowners, permittees, watershed groups, USFS, BLM
Protect the remaining agricultural lands and traditions	Support community agriculture	Community, Farmers, Acequias,Watershed Groups
Protect the remaining agricultural lands and traditions	Agricultural lands ordinance	Rio Arriba County, Taos County, Watershed Groups, Acequias, landowners
Protect the remaining agricultural lands and traditions	Land conservation tools: Acquisition Purchase or transfer of development rights Conservation easements	Rio Arriba and Taos Counties, Watershed Group, Taos Land Trust, Acequias
Protect the remaining agricultural lands and traditions	River corridor and acequia invasive species removal; salt cedar, tamarisk	East Rio Arriba and Taos Soil and Water Conservation Districts, Watershed Group, private landowners, Acequias
Protect the remaining agricultural lands and traditions	Create an acequia needs assessment for each acequia to determine improvements needed.	Rio Arriba County, Taos County, Watershed Group, NMAA, Individual acequias
Protect the remaining agricultural lands and traditions	Create strong organizational structure for each acequia including by law development, water banking system and compliance with the open meetings act.	NMAA, Individual acequias, Watershed Groups, Rio Arriba and Taos Counties

Improve range conditions	Complete Travel Management Plans for BLM and USFS	BLM, USFS, Watershed Group, Permittees, Recreationalists
Improve range conditions	Best Management Practices on Rangelands such as sediment dams and contour terracing	BLM, USFS, Watershed Groups, Permittees
Improve range conditions	Range Improvements such as fencing, brush removal, seeding and additional stock tanks	BLM, USFS Watershed Groups, Permittees
Improve range conditions	Identification, improvement, and maintenance of water impoundments	USFS, BLM, Watershed Groups, private landowners, permittees
Clean up/prevent illegal dumping	Create an educational program for the community focused on illegal dumping	Local schools, Watershed Groups, BLM, USFS
Clean up/prevent illegal dumping	Design signs prohibiting illegal dumping and place them in the most prominent areas	Local schools, Watershed Groups, BLM, USFS
Clean up/prevent illegal dumping	Organize an annual community clean up day	Local schools, Watershed Groups, BLM, USFS
Clean up/prevent illegal dumping	Restrict vehicular access to BLM lands to prevent further dumping	Watershed Groups, BLM, USFS
Clean up/prevent illegal dumping	Monitor public lands for illegal dumpers	Watershed Groups, BLM, USFS Permittees, Recreationalists
Clean up/prevent illegal dumping	Adopt a BLM Area Plan	BLM, Watershed Group, Permittees, Recreationalists
Clean up/prevent illegal dumping	Work to improve curbside service as has already been set forth	Watershed Groups, North Central Solid Waste Authority, Taos Waste Management
Clean up/prevent illegal dumping	Encourage recycling/ bring curbside recycling containers to each community	Watershed Groups, North Central Solid Waste Authority, Taos Waste Management
Education/Outreach	Watershed/environmental programs in schools K-12	Watershed Group/Local School Districts
Education/Outreach	Service learning projects at the elementary, high school and college level	Watershed Group/Local School Districts
Education/Outreach	Continue to provide workshops/educational programs that can lead to dialogue and positive action on the part of the communities	Watershed Groups
Education/Outreach	Continue engagement of stakeholders	Watershed Groups
Education/Outreach	Develop useful communication networks that accessible to everyone in the community	Watershed Groups
Education/Outreach	Continued evolution of group structure	Watershed Group

Education/Outreach	Promote grassroots planning and decision making/ avoiding a top down approach	Watershed Groups
Education/Outreach	Develop/ maintain partnerships with local governments/agencies and other groups actively involved in similar projects.	Watershed Groups
Education/Outreach	Development of the Northern New Mexico Watershed Institute/other organization Obtain space and resources Obtain 501c3	Watershed Groups
Education/Outreach	Development of clearing house to keep track of project, needs, funding and information Develop a database	Watershed Groups, Northern New Mexico Watershed Institute
Education/Outreach	Comprehensive inventory	Watershed Group
Education/Outreach	Monitoring program to identify successes	Watershed Group

Identified On the Ground Projects

In order to prioritize specific projects the groups have developed a set of criteria according to what is most beneficial to the communities involved. The set of criteria for prioritizing projects is as follows:

- Is there support for research ie. forest thinning, wastewater facilities, acequias, economic development?
- Does it address concerns of the affected communities?
- Is there community support?
- What is the intensity of need?
- Does it address water quality or quantity?
- Is there potential for collaboration?
- What is the cost of the project?
- What is the potential for collaboration?
- What are the funding needs and possibilities for funding?

The projects tabled below are those that have come forward throughout the management planning process. It is important to remember that this document is a "living document" and is intended to be added to and revised as is necessary.

Watershed Issue	Location and Stream	Project Description	Objectives	Participants	Estimated Cost and Possible Funding
Forest Health	Llano de la Yegua, private lands Rio Santa Barbara	Thinning of trees to goal of 60-80 DBH, Revegetation of slopes	Reduce sediment loads into surface waters, healthy tree growth and size, promote healthy ground cover, stabilize soils, reduce hazardous fire risk, provide educational opportunities	Private landowners, American Tree Farmers, Watershed Groups	$150,000 CWA 319 CFRP
Riparian Health	Rodarte, private lands Rio Santa Barbara	Replacement of old and broken fencing exclosures	Regenerate riparian vegetation, improve channel geometry, reduce turbid runoff, increase wildlife habitat, protect riparian areas	Private landowners, NMED, Watershed Groups	CWA 319 EQUIP CFRP USDA
Arroyo Management Rio Embudo	Dixon Arroyo de la Mina, Arroyo del Pino, Arroyo Lorenzo, Arroyo de la Placita	Assessment of function of these arroyos	Fully determine their potential as sources of NPS pollution	Watershed groups, BLM, private landowners, Rio Arriba County, arroyo management committee	
Arroyo Management	Dixon Arroyo de la	Assessment of damage to	Repair damage to	Watershed groups, Acequias,	

Acequias Rio Embudo	Mina, Arroyo del Pino, Arroyo Lorenzo, Arroyo de la Placita	acequias by extreme flooding through these arroyos.	acequias to previous or better conditions	parciantes, Rio Arriba County	
Arroyo Management Riparian Health Rio Embudo	Dixon, private land, BLM land	Upland health seeding, water slowing techniques in arroyo, arroyo vegetation seeding, removal of Russian Olives in Bosque, riparian planting	Reduce sediment loads into Rio Embudo, decrease potential for flood damage, increase wildlife habitat	Watershed groups, private landowners, BLM	CWA 319 Partners for Fish and Wildlife, East Rio Arriba SWCD
Forest Health Upland Health	Ojo Sarco, west Ridge of Bear Canyon, private land	Installation of ground water tank and trick tank, tree and vegetation plantings, landscape contouring to slow and retain water	Slow water through landscape, reduce erosion, increase wildlife habitat, provide drinking water away from riparian areas, replenish groundwater, regenerate vegetative cover	Watershed groups, private landowners, USFS	$6000 CWA 319 NRCS
Acequias and Agriculture	Dixon	Dixon Land Link Program that pairs farmers with no land to those with land and water rights who cannot farm	Foster healthy agricultural tradition, bring people together with the land and food, Keep water within the community and tied to the land	Dixon Coop, watershed groups, private landowners and parciantes, farmers	

APPENDIX D

Programs and Funding Opportunities

Clean Water Act State Revolving Fund

Grant monies to states to aid in the development of State Revolving Funds. These monies are then made available from States in the form of loans or other types of financial assistance to municipalities, individuals, and others for high-priority water quality activities.

Projects that can be funded through this program:

- Build or improve wastewater treatment plants
- Agricultural, rural, and urban runoff control
- Wetland and estuary improvement projects
- Wet weather flow control such as including stormwater and sewer overflows
- Alternative treatment technologies.

Type of assistance: Low interest loans through States up to four percent below market rates. Some small and economically disadvantaged communities may be eligible for lower rates from some states.

Who is eligible: Municipalities, individuals, communities, citizen groups, and non-profit organizations. Eligibility is decided by the States.

Contact information

U.S. EPA
Office of Wastewater Management
1300 Pennsylvania Avenue,
Washington, DC 20460
Phone: (202) 260-7360 or (202) 260-2268
Fax: (202) 260-1827
E-mail: srfinfo.group@epa.gov
Web Site: http://www.epa.gov/OWM

Five-Star Restoration Program

This program aims to promote community-based wetland and riparian restoration projects.

Projects that can be funded through this program:

- Projects with strong on-the-ground habitat restoration components that
    - provide long term ecological, educational, and/or socio-economic benefits to the people and their communities.

Type of assistance: EPA provides a matching contribution of approximately $10,000 on average. Projects must have partners, ideally at least five, that will provide matching funds, land, technical assistance, labour, or other in-kind services.

Who is eligible: Partners may include

- citizen volunteer organizations
- corporations
- private landowners
- local conservation organizations
- youth groups
- charitable foundations
- federal, state, tribal agencies and local governments.

Contact information

Five-Star Restoration Program,
US EPA, Wetlands Division (4502F),
100 Pennsylvania Ave., N.W.,
Washington, DC 20460
Phone: (202) 260-8076 #55
Fax: (202) 260-2356
E-mail: pai.john@epa.gov
Web Site: http://www.epa.gov/owow/wetlands/restore/5star/

Nonpoint Source Implementation Grants (319 Program)

These monies are provided to help States, Territories, and Tribes develop and implement programs to prevent and control nonpoint source pollution.

Projects that can be funded through this program:

State, Territories, and Tribes receive grant money who will distribute to local groups to support a large variety of activities such as:

- technical assistance, financial assistance,
- technical programs, education, training,
- demonstration projects that implement best management practices
- monitoring specific to nonpoint source implementation.

Type of assistance: Grants are first awarded to state agencies through which local organizations can apply for grants. There is a 40% non-federal match requirement for the

entire project budget. This can be provided through matching funds (non-federal), labour, equipment, technical services, or other in-kind services.

Who is eligible?

- State, local, and tribal governments,
- nonprofit and local organizations

Contact information
U.S. EPA,
Office of Wetlands, Oceans, and Watersheds,
1300 Pennsylvania Avenue,
Washington, DC 20460
Phone: (202) 260-7100
Fax: (202) 260-7024
E-mail: ow-general@epa.gov
Web Site: http://www.epa.gov/owow/NPS

DEPARTMENT OF AGRICULTURE (USDA)

USDA - Forest Service

Taking Wing
The intent of this program is to create and enhance partnerships for the management of wetland ecosystems benefiting waterfowl and wetland wildlife. This should coexist with a variety of recreational opportunities on the National Forest System lands.

Projects that can be funded through this program:

- On-the-ground wetland enhancement and restoration
- Assessment and analysis with a focus towards on-the–ground projects

Type of assistance:
Funds are allocated to Forest Service units through an internal budget process.

Who is eligible:

- Non-federal entities and individuals
- Projects that are on National Forest System lands or provide benefits to those lands.

Contact Information
Cynthia Ragland,
One Waterfowl Way,
Memphis, TN 38120
Phone: (901) 758-3722 #56
Fax: (901) 758-3850
E-mail: cragland@ducks.org

Web Site: http://www.fs.fed.us/outdoors/wildlife

Southwest Sustainable Forest Partnership

SWSFP is developing sustainable community based enterprises capable of addressing the utilization of small diameter trees harvested from forest restoration and fire mitigation projects. Goals of the partnership are:

- Provide technical transfer opportunities that promote the science of healthy forest ecosystems and the acceptable practices for reducing hazardous forest fuels.
- Provide business and marketing expertise opportunities for wood use to build sustainable forest and wood product enterprises.
- Promote sustainable, community-based forest and wood product enterprises.

Projects include but are not limited to:

- Projects that use wood biomass as a renewable natural resource to provide clean, readily available energy suitable for use in heating or power systems for public schools, public facilities or commercial buildings or that
- develop sustainable forest practices, markets, and infrastructure in Arizona and New Mexico.

Who is eligible? State, tribal and local governments, communities, small businesses, and non-profit organizations can apply. In addition applicants must meet the following criteria:

- Projects must take place in or be directly beneficial to tribes and/or communities within Arizona and New Mexico.
- Projects must be eligible for Economic Action Program funding as set out by the USDA Forest Service and illustrate a collaborative approach to implementation among individuals and groups within the project's regional community who are interested in restoring the diversity and productivity of forest ecosystems.

Cost and match requirements

- Indirect costs may not exceed 10% of the total project budget.
- Projects must contain a _non-federal cash and/or in-kind match of at least 20% of the total project cost. (Example - $50,000 (request) x 20% divided by 80% $12,500 match required. Total cost of project = $62,500.)
- Applying organizations or businesses must have the ability to ensure fiscal accountability.
- The contract period lasts for approximately 18 months.

For the Notice and RFP: http://www.emnrd.state.nm.us/forestry/

Contact Information

For more information you can contact one of the following coordinators:*

Kim Kostelnik
Program Manager

New Mexico Forestry Division
P.O. Box 1948
Santa Fe, NM 87504
Email: kim.kostelnik@state.nm.us <mailto:kim.kostelnik@state.nm.us>
(505) 476-3337

Tribal: John Waconda
BIA-Southwest Region
(505) 563-3360
johnwaconda@bia.gov mailto:johnwaconda@bia.gov

Collaborative Forest Restoration Program

The Collaborative Forest Restoration Program (CFRP) is a new approach to building agreement among people and organizations that care about New Mexico's public forestland. The Program provides grants for projects that restore forests on public or tribal land and improve the use of small trees thinned from those lands. Organizations that have often been in conflict are encouraged to collaborate on the design, implementation, and monitoring of projects that value local and traditional knowledge, create healthy and productive forests and watersheds, and build ownership and civic pride. The CFRP provides an alternative to appeals and litigation over the management of our public forestlands. By working together, small business owners, conservation and environmental organizations, community groups, tribes, colleges, universities and other organizations can qualify for CFRP grants for forest restoration projects that reduce the threat of wildfire, improve watershed conditions, and provide jobs and training to local communities.

What is the purpose of CFRP?

- Promote healthy watersheds and reduce the threat of large, high intensity wildfires, insect infestation, and disease
- Improve the functioning of forest ecosystems and enhance plant and wildlife biodiversity by reducing the unnaturally high number and density of small diameter trees on Federal, Tribal, State, County, and Municipal forest lands
- Improve communication and joint problem solving among individuals and groups who are interested in restoring the diversity and productivity of forested watersheds
- Improve the use of, or add value to, small diameter trees
- Encourage sustainable communities and sustainable forests through collaborative partnerships, whose objectives are forest restoration
- Develop, demonstrate, and evaluate ecologically sound forest restoration techniques.

What are the objectives of the grant program?

- Reduce the threat of large, high intensity wildfires and the negative effects of excessive competition between trees by restoring ecosystem functions, structures, and species composition, including the reduction of non-native species populations.

- Re-establish fire regimes approximating those that shaped forest ecosystems prior to fire suppression.
- Replant trees in deforested areas if they exist in the proposed project area.
- Create local employment or training opportunities (including summer youth jobs programs) within the context of accomplishing forest restoration objectives.

Who is eligible?

- State, local and tribal governments
- educational institutions
- landowners
- conservation organizations

Projects that can be funded through this program

Restoration projects must be entirely on, or on any combination of federal, tribal, state, county, or municipal forestlands in New Mexico. The program does not provide grants for the treatment of private land, but CFRP grants can be used for processing facilities on private land that use small trees from thinning projects on public land.

What level of funding is available?

Cost share grants of up to $360,000 are available for projects up to 4 years in length. The federal share is limited to $120,000 per year. A 20% non-federal match is required for all federal funds.

For further information, contact:

Walter Dunn Program Manager
Collaborative Forest Restoration Program
USDA Forest Service Southwestern Region
333 Broadway Blvd. SE Albuquerque, NM 87102
(505) 842-3425
Email: wdunn@fs.fed.us

COLLABORATIVE FOREST RESTORATION PROGRAM
New Mexico Forests Rural Community Assistance Coordinator:

National Forest Coordinator
Carson
Ignacio Peralta
P.O. Box 558 Taos, NM 87571
505-758-6344

USDA - Farm Service Agency

Conservation Reserve Program

The purpose of this program is to establish long-term resource-conserving covers on eligible cropland that will conserve soil, water, and wildlife.

Projects that can be funded through this program:
Landowners plant cover on marginal cropland either by

- receiving rental payments or
- entering into a costshare restoration agreement while maintaining private ownership

Type of assistance: Contracts are typically 10-15 years in length and provide three options for landowners.

- receive annual rental payments of up to $50,000/year
- receive payment of up to 50% of cost to establish cover
- receive payment of up to 25% of cost for wetland hydrology restoration.

Who is eligible:

- Individuals, states, local governments, tribes, or any other entity who has owned private land for at least 1 year that is:
    - cropland planted with a crop in 2 of the last 5 crop years
    - marginal cropland that is enrolled in the Water Bank program or suitable to be used as a riparian buffer.
- The land must be either:
    - highly erodable land,
    - cropped wetland
    - devoted to highly beneficial environmental practices
    - subject to scour erosion
    - located in a CRP priority area
    - cropland associated with or surrounding non-cropped wetlands.

Contact Information
Contact your local or state Farm Service Agency office
(see"http://www.fsa.usda.gov/dapdfo/")
Department of Agriculture,
Farm Service Agency,
Conservation Reserve Program Specialist,
Stop 0513,
Washington, D.C. 20250-0513
Phone: (202) 720-6221
E-mail: info@fsa.usda.gov
Web Site: http://www.fsa.usda.gov/pas/publications/facts/pubfacts.htm

USDA - Natural Resources Conservation Service

Emergency Watershed Protection Program
The purpose of this program is to protect lives and property threatened by natural disasters such as floods, hurricanes, tornados, and wildfires.

Projects that can be funded through this program:

Includes but is not limited to:

- Clearing debris from clogged waterways,
- Restoring vegetation
- Stabilizing river banks
- Restoring wetland flood retainers.

Type of assistance:

- Some funds cover up to 75% of costs to restore the natural function of a watershed.
- Land can be offered for a floodplain easement that would permanently restore the hydrology of the natural floodplain as an alternative to traditional attempts to restore damaged levees, lands, and structures. These funds can cover up to 100% of the agricultural value of the land, costs associated with environmental measures taken, and costs associated with establishing the easement.

A sponsor must assist in applying for funds. Sponsors can be any legal subdivision of state, local, or tribal governments, including soil conservation districts, U.S. Forest Service, and watershed authorities.

Who is eligible: Owners, managers, and users of public, private, or tribal lands if their watershed area has been damaged by a natural disaster.

Contact Information
Contact your local or state National Resources Conservation Service office (see "http://www.ncg.nrcs.usda.gov/perdir.html
Department of Agriculture,
National Resources Conservation Service,
Watersheds and Wetlands Division
P.O. Box 2890
Washington, D.C. 20013
Web Site: http://www.nhq.nrcs.usda.gov/CCS/ewpFs.html

Environmental Quality Incentives Program
The purpose of this program is to install or implement structural, vegetative, and management practices in priority areas.

Projects that can be funded through this program:
Conservation practices such as:

- grassed waterways
- filter strips
- manure management facilities
- capping abandoned wells
- any practices important to improving and maintaining water quality and the general health of natural resources in the area
- land management practices such as nutrient management, manure management, integrated pest management, irrigation water management, and wildlife habitat

management.

Type of assistance:

- Cost sharing may pay up to 75 percent of the costs of certain conservation practices.
- Incentive payments may also be made to encourage a producer to perform land management practices for up to three years.
- Offers 5-10 year contracts.
    - Maximum of $10,000 per person per year and $50,000 for the length of the contract.

Who is eligible: Eligibility is limited to persons who are engaged in livestock or agricultural production.

Contact Information
Contact your local or state National Resources Conservation Service office (see "http://www.ncg.nrcs.usda.gov/perdir.html")
Department of Agriculture,
National Resources Conservation Service
P.O. Box 2890,
Washington, D.C. 20013
Phone: (202) 720-1873 or (202) 720-1845
Web Site: http://www.nhq.nrcs.usda.gov/OPA/FB96OPA/eqipfact.html

Watershed Protection and Flood Prevention
Works through local government sponsors to help participants voluntarily plan and install watershed-based projects on private lands.

Projects that can be funded through this program:
Projects include watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in watersheds of 250,000 or fewer acres.

Type of assistance: Provides technical and financial assistance. Funds can cover:

- 100% of flood prevention construction costs,

50% of costs associated with agricultural water management, recreation, and fish and wildlife habitat

Who is eligible:

- Local or state agencies
- County, municipality, town or township,
- Soil and water conservation districts
- Flood prevention or flood control district
- Tribe or tribal organizations
- Nonprofit agencies with authority to carry out, maintain, and operate watershed improvement works.

Contact Information
Contact your local or state National Resources Conservation Service office (see "http://www.ncg.nrcs.usda.gov/perdir.html")
Department of Agriculture,
National Resources Conservation Service,
Watersheds and Wetlands Division,
P.O. Box 2890,
Washington, D.C. 20013
Phone: (202) 720-3527
Web Site: http://www.nrcs.usda.gov/NRCSProg.html

Wetlands Reserve Program
The purpose of this program is to protect and restore wetlands, riparian areas and buffer zones.

Projects that can be funded through this program:
Voluntary program where landowners may sell a conservation easement or enter into a cost-share restoration agreement, while maintaining private ownership.

Type of assistance: This program provides three options for landowners:

- Permanent easement - USDA purchases easement (payment will be the lesser of: the agricultural value of the land, an established payment cap, or an amount offered by the landowner) and pays 100% of restoration costs
- 30-year easement - USDA pays 75% of what would be paid for permanent easement and 75% of restoration costs
- Restoration cost share agreement - 10-year minimum agreement to restore degraded habitat where USDA pays 75% of restoration costs.

Who is eligible: Individuals, states, local governments, tribes, or any other entity who owns private land. The land must have been owned for at least 1 year and be restorable and suitable for wildlife.

Contact Information
Contact your local or state National Resources Conservation Service office (see "http://www.ncg.nrcs.usda.gov/perdir.html")
Department of Agriculture,
National Resources Conservation Service,
Watersheds and Wetlands Division,
P.O. Box 2890,
Washington, D.C. 20013
Phone: (202) 690-0848
E-mail: RMisso@usda.gov
Web Site: http://www.nhq.nrcs.usda.gov/OPA/FB96OPA/WetRule.html or http://www.nhq.nrcs.usda.gov/OPA/FB96OPA/WRPfact.html (fact sheet)

Healthy Forest Reserve Program **(HFRP)**

The Healthy Forests Reserve Program (HFRP) is a voluntary program established for the purpose of restoring and enhancing forest ecosystems to: 1) promote the recovery of threatened and endangered species, 2) improve biodiversity; and 3) enhance carbon sequestration.

Benefits

Restoring and protecting forests contributes positively to the economy of our nation, provides biodiversity of plant and animal populations, and improves environmental quality. Safe Harbor will be made available to landowners enrolled in the HFRP who agree, for a specified period, to restore or improve their land for threatened or endangered species habitat. In exchange, they avoid future regulatory restrictions on the use of that land protected under the Endangered Species Act.

Enrollment Options

The Program offers three enrollment options:
1) A 10-year cost-share agreement; for which the landowner may receive 50 percent of the cost of the approved conservation practices,
2) A 30-year easement, for which the landowner may receive 75 percent of the market value of the enrolled land plus 75 percent of the cost of the approved conservation practices, or
3) An easement of not more than 99-years, for which landowners may receive 75 percent of the market value of the enrolled land plus the cost of the approved conservation practices.

Who is Eligible?

To be eligible for enrollment, land must be private land which will restore, enhance, or measurably increase the likelihood of recovery of a threatened or endangered species, must improve biological diversity, or increase carbon sequestration.

Wildlife Habitat Incentives Program

The purpose of this program is to develop and improve fish and wildlife habitat on private lands.

Projects that can be funded through this program:

Preparation of a wildlife habitat development plan in consultation with the local conservation district. The plan should describe the landowner's goals for improving wildlife habitat and include a list of practices and a schedule for installing them. Plan should show in detail the steps necessary for maintenance.

Type of assistance:

- Technical assistance and cost-share agreements where NRCS pays up to 75% of cost of installing wildlife practices.
- Typically 5-10 year contracts.

Who is eligible: Those who own or have control of the land which cannot be enrolled in other programs with a wildlife focus, such as the Wetlands Reserve Program, or use the land for mitigation. Other restrictions may apply.

Contact Information
Contact your local or state National Resources Conservation Service office (see "http://www.ncg.nrcs.usda.gov/perdir.html")
Department of Agriculture,
National Resources Conservation Service,
P.O. Box 2890,
Washington, D.C. 20013
Phone: (202) 720-3534
Web Site: http://www.nhq.nrcs.usda.gov/OPA/FB96OPA/WhipFact.html

DEPARTMENT OF INTERIOR (DOI)

DOI - Fish and Wildlife Service

North American Wetlands Conservation Act Grant Program
The purpose of this program is to promote long-term conservation of North American wetland ecosystems and the wildlife that depend on them.

Projects that can be funded through this program:
- On-the-ground wetland and wetland-associated acquisition, creation, enhancement, and/or restoration.

Type of assistance:
- Regular Grant Program (over $50k) and Small Grant Program ($50k or less)
- 1:1 non federal match is required as well as the formation of public-private sector partnerships

Who is eligible: Public-private sector partnerships.

Contact Information
Department of Interior,
U.S. Fish and Wildlife Service,
North American Waterfowl and Wetlands Office
4401 N. Fairfax Drive, Room 110
Arlington, VA 22203
(Attn: specific grant program)
Phone: (703)358-1784
Fax: (703)358-2282
E-mail: R9ARW_NAWWO@MAIL.FWS.GOV
Web Site: http://www.fws.gov/r9nawwo/nawcahp.html

Partners for Fish and Wildlife Program

The purpose of this program is to conserve, protect, and enhance fish and wildlife and their habitats.

Projects that can be funded through this program:

- Restoring wetland hydrology
- Planting native trees and shrubs, and planting native grasslands
- Installing fencing and off-stream livestock watering facilities
- Removal of exotic plants and animals
- Prescribed burning
- Reconstruction of in-stream aquatic habitat.

Type of assistance: Financial and technical assistance available with a minimum 10-year contract.

- The landowner may perform the restoration and be reimbursed directly for some or all expenses
- A service may hire a contractor to complete the work, or may complete the work itself.

A dollar-for-dollar cost share is sought on a project-by-project basis. In some states where the program is very popular, however, a 50:50 cost share is required.

Who is eligible: Although the primary partners are private landowners, anyone interested in restoring and protecting wildlife habitat on private or tribal lands can get involved in the Partners for Fish and Wildlife Program, including other federal, state and local agencies, private organizations, corporations, and educational institutions.

Contact Information
Contact your state office for assistance. National, regional and state contacts are listed at http://www.fws.gov/r9dhcpfw/CONTACTS/altcont.html;
U.S. Fish and Wildlife Service,
Division of Fish and Wildlife Management Assistance and Habitat Restoration,
4401 N. Fairfax Drive, Room 400,
Arlington, VA 22203
Phone: (703) 358-2161
Fax: (703) 358-2232
Web Site: http://www.fws.gov/r9dhcpfw/

NATIONAL FOREST FOUNDATION

Matching Awards Program

The National Forest Foundation (NFF), a private, nonprofit 501(c)(3) organization, chartered by Congress, engages America in community-based and national programs that promote the health and public enjoyment of the 192-million-acre National Forest System, and administers private gifts of funds and land for the benefit of the National Forests. The NFF believes that communities should play a significant role in determining the future of National Forests and Grasslands. By matching federal funds provided through a cooperative agreement with the US Forest Service to non-federal dollars, the NFF

Matching Awards Program (MAP) is able to effectively double the resources available to nonprofit partners to implement projects that directly benefit our National Forests and Grasslands.

Project Emphasis:

- Wildlife Habitat Improvement
- Recreation
- Community-Based Forestry
- Watershed Health and Restoration.

The NFF is mainly interested in collaborative projects that address the rising demand for outdoor recreation in National Forests and Grasslands through projects activities such as:

- Restoration of impacts of excessive or inappropriate use in sensitive areas
- Improvement of recreational resources through trail restoration and maintenance.

The NFF will support watershed restoration and enhancement projects, especially those initiatives that include diverse perspectives and address critical issues such as non-point source pollution and fish habitat enhancement through project activities such as:

- Sediment reduction through slope stabilization and contouring
- Planting of native species in damaged riparian areas
- Removal of invasive exotic species
- Culvert replacement to improve fish passage.
- Community-based Forestry

The NFF believes that communities can work to improve natural resources, while providing local economic and social benefits. The aim of community-based forestry is to empower those who work, live and recreate in the woods to work together and strive towards a common set of goals. The NFF will make strategic investments in community-based forestry projects, particularly those that focus on forest health and restoration. Projects should address the need for greater collaboration in community-based forestry projects. Local constituencies should be included in the decision-making process through ecological restoration activities and action-oriented training, conservation and restoration projects that support economically sustainable natural resource use, and address wildfire risk reduction and response through project activities such as:

- Collaboratively developed and implemented fuel reduction projects;
- Fire recovery efforts, involving re-seeding, erosion control, and/or riparian restoration;
- Citizen-based monitoring and/or fuels reduction efforts, especially in the wildland/urban interface.

Match Requirement- a 1:1 non federal match is required

Who is eligible? Applications will be considered from non-federal partners, community-based organizations, Native American tribes and other nonprofit 501(c)(3) organizations doing on-the-ground conservation work on or around National Forests or Grasslands.

Community Assistance Program

The NFF established the Community Assistance Program (CAP) to promote the creation of locally-based, collaborative natural resource partnerships which seek to build ecological, social and economic sustainability. The program will support newly-forming or re-organizing nonprofit organizations that are in need of start-up funds for capacity building that intend to proactively and inclusively engage the local community in forest management and conservation issues on and around National Forests and Grasslands.

CAP awards provide collaborative groups with start-up grants of $5,000 to $15,000, as well as basic tools and guidance, to enable them to resolve differences and play a more active role in the sustainable management of nearby National Forests, Grasslands and surrounding communities. CAP will support the organizational and technical assistance needs of newly forming or reorganizing, multi-party collaborative groups that act as problem-solvers, bringing diverse members of the community together to address specific issues related to community-based forest stewardship, recreation, watershed restoration, and wildlife habitat, through constructive dialogue and hands-on involvement.

Organizations applying for funding through CAP will be considered based on need, and will not be required to match the NFF funds. CAP funds can be used for a wide range of tools, including: technical assistance, training, consultants, community outreach, obtaining 501(c)(3) status, group facilitation, basic start-up and operating costs, materials and equipment, program development, nonprofit management skill building, and communications. If an organization does not have 501(c)(3) status, they must use a nonprofit fiscal sponsor organization with that designation.

Who is eligible?

Applications will be accepted from organizations that:

- are newly forming or reorganizing collaborative community-based nonprofit entities;
- are in need of capacity building and start-up organizational and technical assistance; and wish to proactively engage in natural resource issues on and around National Forests and Grasslands.
- Applicants must have 501(c)(3) nonprofit status, or utilize a fiscal sponsor organization with that designation.
-

Contact Information

Please contact Adam Liljeblad at (406) 542-2805, ext. 12 with any questions or concerns.

Forestry Division of the Energy, Minerals and Natural Resources

Department (EMNRD)

New Mexico Forest ReLeaf Program

Grant emphasis will be on tree planting conservation projects including:

- street plantings
- windbreaks
- park plantings
- living snow fences
- riparian rehabilitation
- energy conservation
- community green belts
- wetland rehabilitation
- reforestation
- erosion control.

ReLeaf grants can be used for partial funding of larger projects but cannot be used to maintain existing projects. Projects will only be designated for public land and must show substantial public benefit. The Forestry Division reserves the right to require easements or leases to assure public access.

Contact Information

George Duda
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New Mexico Forest ReLeaf Coordinator
1220 S. St. Francis Drive

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APPENDIX E

New Mexico Forest Restoration Principles

Preamble

These principles were collaboratively developed by a team of dedicated professionals representing industry, conservation organizations, land management agencies, and independent scientists. These principles for restoration should be used as guidelines for project development and they represent the "zone of agreement" where controversy, delays, appeals, and litigation are significantly reduced. They may be appropriate for application to specific restoration projects in the southwestern United States. Projects using these principles should be driven primarily by ecological objectives while promoting economic and social benefits.

Participants

The Nature Conservancy in New Mexico
Natural Resources Conservation Service
Bureau of Land Management
Sierra Club, Rio Grande Chapter
Forest Guardians
New Mexico State Forestry Office
U.S. Forest Service
Bureau of Indian Affairs
New Mexico State Land Office
Forest Guild
Center for Biological Diversity
Restoration Solutions
Public Service of New Mexico

Principles

1. **Collaborate**. Landscape scale assessment, and project design, analysis, implementation and monitoring should be carried out collaboratively by actively engaging a balanced and diverse group of stakeholders.
2. **Reduce the threat of unnatural crown fire.** A key restoration priority must be moving stands toward a more natural restored condition and the reduction of the risk of unnatural crown fires both within stands and across landscapes. Specific restoration strategies should vary based upon forest vegetation type, fire regime, local conditions, and local management objectives. Forests and woodlands characterized by infrequent and mixed-severity fire should be managed for stand structure consistent with their historical ranges of variation—including, in some cases, high-density, continuous stands. Discontinuous stand structure may be appropriate in areas such as the wildland urban interface for these forest and woodland types.
3. **Prioritize and strategically target treatment areas**. Key considerations for prioritizing restoration treatment areas are: degree of unnatural crown fire risk, proximity to human developments and important watersheds, protection of old-

growth forests and habitats of federally threatened, endangered, or listed sensitive species, and strategic positioning to break up landscape-scale continuity of hazardous fuels. Treatments should be done at a landscape scale to decrease forest vulnerability to unnatural stand-replacing fire. This priority-setting should take place during fire management planning, land management planning, and community wildfire protection planning.

4. **Develop site-specific reference conditions.** Site-specific historical ecological data can provide information on the natural range of variability for key forest attributes, such as tree age structure and fire regimes that furnish local "reference conditions" for restoration design. A variety of constraints, however, prevent the development of historical information on every hectare of land needing restoration. General goals should be to restore ecological integrity and function.

5. **Use low-impact techniques.** Restoration treatments should strive to use the least disruptive techniques, and balance intensity and extensiveness of treatments. In many areas, conservative initial treatments would be the minimum necessary to adequately reduce the threat of unnatural crown fire. Wildland fire use or management ignited fires may be sufficient to reestablish natural conditions in many locations. In the extensive areas where fire alone cannot safely reduce tree densities and hazardous ladder fuels, mechanical thinning of trees may be needed before the introduction of prescribed fire. Patient, effective treatments will provide more options for the future than aggressive attempts to restore 120 years of change at once. In certain areas, however, such as some urban-wildland interfaces, trade-offs with imminent crown fire risks require considerations of rapid, heavy thinning of mostly small-diameter trees.

6. **Utilize existing forest structure.** Restoration efforts should incorporate and build upon valuable existing forest structures, such as large trees, and groups of trees of any size with interlocking crowns excluding aspen. These features are important for some wildlife species, such as Abert's squirrels and goshawks, and should not be removed completely just to recreate specific historical tree locations. Since evidence of long-term stability of precise tree locations is lacking, especially for piñon and juniper, the selection of "leave" trees and tree clusters in restoration treatments can be based on the contemporary spatial distribution of trees, rather than pre-1900 tree positions. Maximizing use of existing forest structure can restore historical forest structure conditions more quickly. Leaving some relatively dense within-stand patches of trees need not compromise efforts to reduce landscape-scale crown fire risk.

The underlying successional processes of natural tree regeneration and mortality should be incorporated into restoration design. Southwestern conifer regeneration occurs in episodic, often region-wide pulses, linked to wet-warm climate conditions and reduced fire occurrence. Periods with major regeneration pulses in the Southwest occurred in the 1910s–1920 and in 1978–1998. Some of this regeneration would have survived under natural conditions. Restoration efforts should retain a proportion of these cohorts.

7. **Restore ecosystem composition.** Missing or diminished compositional elements, such

as herbaceous understories, or extirpated species also require restoration attention. The forest understory, including shrubs, grasses, forbs, snags, and down logs, is an important ecosystem component that directly affects tree regeneration patterns, fire behavior, watershed functioning, wildlife habitat, and overall patterns of biodiversity. Similarly, soil organisms, such as mycorrhizal fungi, are vital elements that can influence community composition and dynamics. A robust understory provides a restraint on tree regeneration and is essential for carrying surface fires. The establishment and maintenance of more natural patterns of understory vegetation diversity and abundance are integral to ecological restoration.

Restoration planning should include the conservation of habitats for diminished or extirpated wildlife species. Comprehensive forest ecosystem restoration requires balancing fire risk reduction with retention of forest structures necessary for canopy dependent species.

Recovery plans and conservation plans for threatened, endangered, and sensitive species should be incorporated to the fullest extent possible in planning for comprehensive forest restoration.

8. **Protect and maintain watershed and soil integrity.** Low impact logging techniques will minimize sedimentation, disruption of surface runoff, and other detrimental ecosystem effects. Equipment and techniques should be managed according to soil and water conservation "best management practices" applicable to site-specific soil types, physiography and hydrological functions.

   Reconstruction, maintenance, or decommissioning of existing roads to correct for poor hydrologic alignment and drainage condition can greatly reduce soil loss and sedimentation rates. Projects should strive for no net increase in road density.

   Managing forest density and fuels to avoid uncharacteristically intense wildfire events will reduce the likelihood of catastrophic post-fire soil erosion and nutrient depletion from forested landscapes. Soil productivity should be protected and maintained by avoiding soil loss and compaction, and managing for on-site nutrient retention. Avoid repeated whole tree biomass removal from the forest to maximize nutrient retention. Whenever feasible, green foliage should be recycled by scattering on site; followed by prescribed burning to release stored nutrients.

9. **Preserve old or large trees while maintaining structural diversity and resilience.** Large and old trees, especially those established before ecosystem disruption by Euro-American settlement, are important forest components and critical to functionality of ecosystem processes. Their size and structural complexity provide critical wildlife habitat by broadly contributing crown cover, influencing understory vegetation patterns, and providing future snags. Ecological restoration should manage to ensure the continuing presence of large and old trees, both at the stand and landscape levels. This includes preserving the largest and oldest trees from cutting and crown fires, focusing treatments on excess numbers of small young trees.

   Develop "desired" forest condition objectives that favor the presence of both abundant large diameter trees and an appropriate distribution of age classes on the landscape, with a wide distribution of older trees. It is generally advisable to maintain

ponderosa pines larger than 41 cm (16 inches) diameter at breast height (dbh) and other trees with old-growth morphology regardless of size (e.g. yellow-barked ponderosa pine or any species with large drooping limbs, twisted trunks or flattened tops).

Treatments should also focus on achievement of spatial forest diversity by managing for variable densities. Overall, forest densities should be managed to maintain tree vigor and stand resiliency to natural disturbances. Disease conditions are managed to retain some presence of native forest pathogens on the landscape, but constrained so that forest sustainability is not jeopardized. Guidelines must provide opportunities to apply differing site-specific management strategies to work towards attainment of these goals, and recognize that achievement may sometimes require more than one entry.

Stand level even-aged management may be appropriate for some objectives, including disease management, post wildfire tree regeneration, accelerating development of old growth characteristics, or for, forest types for which even-aged stands are characteristic, such as spruce or aspen. Treatments should be identified through collaboration with key stakeholders.

Some ponderosa pine forests contain extremely old trees and dead wood remnants that may be small but are important because they contain unique and rare scientific information in their growth rings. Such trees have become increasingly rare in the late 20th century, and the initial reintroduction of fire often consumes these tree-ring resources. Restoration programs should preserve them where possible.

10. **Manage to restore historic tree species composition.** Forest density levels and the presence of fire in the ecosystem are key regulators of tree species composition. Where fire suppression has allowed fire-sensitive trees like junipers or shade-tolerant white fir or spruce to become abundant in historical ponderosa pine forests, treatments should restore dominance of more fire-resistant ponderosa pines. However, fire intolerant species sometimes make up the only remaining large tree component in a stand. Retention of these large trees is important to canopy dependent wildlife species. In mixed conifer forests, landscapes should be managed for composition and structure that approximates the natural range of variability.
11. **Integrate process and structure.** Ecological sustainability requires the restoration of process as well as structure. Natural disturbance processes, including fire, insect outbreaks, and droughts, are irreplaceable shapers of the forest. In particular, fire regimes and stand structures interact and must be restored in an integrated way; mechanical thinning alone will not reestablish necessary natural disturbance regimes. At the same time, fire alone may be too imprecise or unsafe in many settings, so a combination of treatments may often be the safest and most certain restoration approach.

    The single best indicator of whether a proposed approach should be considered as "ecological restoration" is to evaluate if the treatment would help successfully restore the fire regime that is natural for that forest type. Approaches that do not restore natural fire regimes will not achieve full ecological restoration.
12. **Control and avoid using exotic species.** Seeding of exotic grasses and forbs should be prohibited as ecologically incompatible with good restoration. Once established,

exotic species can be extremely difficult or impossible to remove. Seeding should be conducted with certified or weed free seeds to reduce the risk of contamination by non-native species or varieties.

In general, it is ecologically desirable to allow native herbaceous vegetation to recover incrementally unless there is potential for serious soil erosion or the potential for establishment of non-native invasive plants. If enhancement of herbaceous vegetation is needed, especially for road closures and recovery, using locally sourced native seeds or transplanting individuals from nearby areas into treatments is ecologically desirable.

Restoration treatments should also routinely incorporate early actions to control the establishment and spread of aggressive exotics that can be expected from restoration-related site disturbance.

13. **Foster regional heterogeneity**. Biological communities vary at local, landscape, and regional scales, and so should restoration efforts. Ecological restoration should also incorporate the natural variability of disturbance regimes across heterogeneous landscapes. Heterogeneity should be fostered in planning and implementing ecological restoration and all spatial scales, including within and between stands, and across landscape and regional scales.
14. **Protect sensitive communities**. Certain ecological communities embedded within ponderosa pine or other types of forests and some riparian areas, could be adversely affected by on-site prescribed burning or mechanical thinning. Restoration efforts should protect these and other rare or sensitive habitats, which are often hotspots of biological diversity, particularly those that are declining in abundance and quality in the region.
15. **Plan for restoration using a landscape perspective that recognizes cumulative effects**. Forest restoration projects should be linked to landscape assessments that identify historical range of variation (reference condition), current condition, restoration targets, and cumulative effects of management. Ecosystems are hierarchical; changing conditions at one level arise from processes occurring at lower levels, and are constrained, in turn, by higher levels. The landscape perspective captures these complex relationships by linking resources and processes to the larger forest ecosystem. Forest restoration projects should incorporate plans for long-term maintenance of ecological processes.
16. **Manage grazing.** Grass, forbs, and shrub understories are essential to plant and animal diversity and soil stability. Robust understories are also necessary to restore natural fire regimes and to limit excessive tree seedling establishment. Where possible, defer livestock grazing after treatment until the herbaceous layer has established its current potential structure, composition, and function.
17. **Establish monitoring and research programs and implement adaptive management**. Well-designed monitoring, research, and documentation are essential to

evaluate and adapt ongoing restoration efforts. Monitoring programs must be in place prior to treatment, and must evaluate responses of key ecosystem components and processes at multiple scales. Use research and monitoring results from a variety of sources to adjust and develop future restoration treatments.

When possible, restoration projects should be set up as experiments with replicates and controls to test alternative hypotheses. The locations and prescriptions for all restoration treatments should be archived in a geographic information system, so that land managers and researchers have access to site-specific records of restoration treatments.

18. **Exercise caution and use site-specific knowledge in managing persistent piñon juniper woodlands, piñon-juniper savannas, and areas of potential expansion and contraction.** These systems are diverse and complex. Knowledge of local reference structure, composition, processes and disturbance regimes is lacking or uncertain for many piñon–juniper ecosystem types. Given the diversity, variability, and complexity of pinon-juniper systems, identification of local reference conditions is critical to the development of restoration objectives. Exercise caution and use best available science and site-specific knowledge in planning and implementing ecological restoration projects.

    Active management may be appropriate to mitigate soil erosion, community wildland fire hazard, or degraded hydrologic functioning in cases where historical ecological dynamics are insufficiently understood to justify ecological restoration.

    Piñon-juniper sites may be particularly susceptible to ecological damage–from treatments, for example, soil erosion and invasion by non-native plants.

    Use the Grassland and Woodland Restoration and Management Framework for development and implementation of specific projects (The Framework is currently under development).

APPENDIX F

Embudo de Picurís Watershed

By Juan Estevan Arellano

The Physical Landscape

The Embudo Watershed, and Rio Grande Española Valley

The Embudo Watershed rises from an altitude of 5,800 feet starting at Embudo, where the Acequia Junta y Ciénaga empties onto the Río Grande to a little over 13,100 ft. where it begins at the north end of the Truchas Peak. From Jicarita (Gourd Mountain), looking west, the watershed stretches south to the tip of Truchas Peak and north to the top of la Junta Canyon, then west to where the Rio Embudo waters meet those of the Río Grande, born on the San Juan Mountains in southern Colorado. Below the north side of the Truchas Peak are two lakes that feed the Trampas River, known as *Laguna Escondida* (Hidden Lake) and Trampas Lake. The creeks that converge to form Río Embudo are the Trampas Creek, San Leonardo Creek, Santa Barbara Creek, Río Pueblo, La Junta Creek, Alamitos Creek and Quemado Creek. Besides, there's also San Leonardo Lake, Lake Alice, Lake Ruth and Lake Hazel that feed the stream system. The watershed is in the form of a V, or an *embudo* (funnel); it also resembles a man on a cross, with Jicarita forming the head, with its two outstretched arms, one to la Junta Canyon, the other towards Truchas Peak and the feet where the two waters meet at la Junta, present day Embudo.

The watershed contains three broad vegetation zones, with a fourth in the highest altitudes; in this area primitive conditions are still preserved; there are no roads, no commercial timber cutting is allowed, and no developed campgrounds exist. The area is open to public hunting and fishing; travels on foot or horseback is permitted, but no automobiles. Most of the human occupancy is along the streams, which feed the approximately 40 acequias madres in the piñon-juniper and ponderosa pine zones. There are about 8,500 acres of arable land, with most of the acreage occurring in the Peñasco area as there are only about 700 acres of irrigated land in the Embudo Valley (including Rinconada which gets it water from the Río Grande), watered by ten historic acequias.

Piñon-Juniper-Brush Zone

This area, which is characterized by steep slopes, mesas and deep arroyos, canyons and *cañadas* with level or gently rolling terrain occur along the Río Pueblo, Río Santa Bárbara and Río Embudo, at altitudes between 5,800 ft. to 7,500 ft. Soils here are mostly deep old alluvium with good fertility, though erosion is a major concern over most of this zone, especially in the foothills neighboring the villages of upper Santa Barbara, along the Río Trampas, Chamisal and in the lower Embudo starting in Cañoncito, Montecito, Apodaca, Bosque, Dixon, Embudo and Rinconada, though this village lies along the banks of the Río Grande. Public lands here are in better condition than what they were 25 years ago, especially in the Embudo valley, since there hasn't been any grazing allowed in quite sometime. But though there hasn't been any grazing, of road vehicles have made deep scares in the fragile hills throughout the valley and the arroyos have become and eye sore, not to mention an environmental and health problem. Average rainfall in the

Embudo Valley is 12 inches per year, with the Trampas, Ojo Sarco area receiving 14 inches.

Pine Zone

Area covered by this zone encompasses the communities of Ojo Sarco, El Valle, Llano de San Juan, Llano de la Yegua, Rodarte, Peñasco, all the way to Tres Ritos and the terrain here consists of rolling foothills with several steep slopes. Watershed conditions along the eastern boundary and in the northwestern are generally satisfactory. The remainder of the area has poor plant cover and severe erosion, especially close to the villages. The private lands constitute about 88% of the pine zone in the National Forest. In the Peñasco, Llano area the average precipitation is 16 to 20 inches per years, while the Tres Ritos area gets about 25 inches yearly.

Spruce-Fir Zone

There are no human habitats within this area and the vegetation cover is mostly in good condition and the soils are somewhat stable. Erosion is not much of a problem. This area covers a lot of the Pecos Wilderness area, the area around Jicarita Mountain and up the la Junta canyon and south towards Jicarilla Peak. Average rainfall per year in this zone is around 30 inches.

Alpine Grasslands

In this area is the highest precipitation and water-yield zone of the watershed. Soils are mostly of sedimentary or metamorphic origin and the rate of plant growth is very slow. This area encompasses the upper reaches of the Jicarilla Peak, the area around Hidden Lake, Trampas Lake, which are north of the Truchas Peak and bald area of the Jicarita Mountain. There is also serious erosion on the denuded slopes due to runoff from melting snow and summer rains. This area receives the most rainfall per year, approximately 40 inches.

The Upper Embudo Watershed: Land Use In Each Area, Historic and Present

Picuris, Peñasco, Chamisal, Trampas, Ojo Sarco

The headwaters of the Embudo Valley also form an embudo shaped watershed which forms natural terraces, descending from Santa Barbara to la Junta, extending from the western slopes of the Sangre de Cristo Mountains on the northwest shoulder of la Jicarita and traversing down through the *alamitos*. The boundaries extend to northern *Cañon de la Junta*, above *Tres Ritos*, and the *laguna escondida* that receives the water of the northwest part of Truchas Peak, the eastern boundary of *el Chimayoso* and the Jicarilla Peak to the south of the watershed. The geological embudo is formed between Vallecitos and Cuestecitas, where el Río del Pueblo, cascades past Río Lucio east, to meet el Río Santa Bárbara which is agumented by the Río Chiquito, slivering through the verdant vegas in Peñasco in serpent like motion, to become Río Embudo where the Río de Trampas meets the others.

Up above, on the north brazo of la Jicarita, the alamitos is rejuvinated by countless arroyos with water, versus those further down the valleys which are typically

dry, then the ríito del Cañon de la Junta and the Piedralumbre Creek in Tres Ritos. La Jicarita and Truchas Peaks are part of the southern Rocky Mountains known as la Sangre de Cristo. These waters form the rivulet known as el Río del Pueblo since the river cuts through the middle of Picuris Pueblo. Las Mochas, Placita and Vadito also get their water from this Río. Rodarte, Santa Barbara, Llano Largo, Llano de la Yegua, Peñasco, and Río Lucío all irrigate with water from el Río de Santa Bárbara; so does Chamisal and Ojito. The Río Santa Barbara waters originate on the west side of la Jicarita, a majestic reminder of where our water is stored and where it trickles down, enough only to never die of thirst or hunger.

Further south, the villages of el Valle, Trampas and Vallecitos get their water from the eastside of the Chimayoso Peak, the northside of the Truchas peak, second highest in the state, and Jicarilla Peak to give birth to the Río de Trampas. This creek originates at l*a laguna escondida, la laguna de arriba* and *la laguna de abajo,* where this peaks unload their winter stash, to give birth to the fields down below. Below Río Lucío the Río del Pueblo meets the Río de Santa Barbara and by present day Cuestecitas, all three come together to form el Río Embudo. El rito del Ojo Sarco also contributes some water to the Río Embudo, but it is a very minor tributary as does some "ojos," springs on the *Cañada del Oso.*

John Baxter in *Dividing New Mexico's Water*, wrote that in 1755 the residents of Trampas "made plans to divert [the water from the Rito San Leonardo] for irrigation in the Cañada del Ojo Sarco, a proposal vigorously opposed by residents of Truchas, who claimed an exclusive right." Apparently the Truchas settlers had been promised the water by Gov. Veléz Cachupín since they had been given permission to construct an acequia two years before the grant was made. However, the people from Trampas were determined to expand farming into the Ojo Sarco portion of their grant. In 1836 they started a legal battle; this resulted in the water from the Rito San Leonardo declared free and available for use by members of the Trampas community in Ojo Sarco. There were threats of violence but the Trampero irrigators prevailed.

It must also be noted that some of the water that used to flow west now flows east to the Mora Valley, due to an agreement between Picuris Pueblo and the people of Mora in the mid-1800s. The water that starts above 13,000 ft., by the time it reaches the Río Grande at la Junta the elevation has dropped to 5,800. Today the expansion in the Tres Ritos area (which includes a ski resort) threatens not only the water supply but also the water quality of these ancient communities, though for some the ski area means employment.

The Mora-Picurís Water Challenges

Today the only thing that's left of how the water was taken from the Rio Grande watershed and transferred into the Canadian River watershed is but a footnote, of how farmers on the other side of la Jicarita accomplished such an engineering feat. The first acequia that diverted the water to the other side was dug in 1832, this with the permission of the Picurís Indians who were the first inhabitants of the watershed. But as the population grew, more water was needed, and therefore more acequias had to be dug to take water from the west of the watershed and into the eastside. Not much has been written about this remarkable accomplishment attained by people of the land who at times used an old empty whiskey bottle with water as a level. This from the only

published account by Therese Griffiths and Laura Robertson for *New Mexico* magazine, March 1979, "The Flow of Mountain Water." There is also a more scholarly account by historian, Dr. Anselmo Arellano from Las Vegas, *Acequias de la sierra and early agriculture of Mora Valley*, 1994, which can be found at the Santa Fe Public Library.

In July 1882 Governor Juan Pando of Picurís Pueblo filed a complaint on behalf of his people in the Taos District Court. Named as defendants in the complaint were Migual García and twenty-two other residents from the Agua Negra area. The soldiers from Ft. Union were called in to intervene and several people were supposedly killed. That document can be found at the state archives in Santa Fe. According to Eusebio Arellano, who was 87 years old when he was interviewed for the New Mexico magazine article in 1979, the writers wrote, "Arellano recalled his father's saying that soldiers from Fort Union set up camp at Peñasco and intervened to stop the fighting. 'Some people were killed,' said Arellano. 'They are buried up there on the mountain'." The question left unanswered is who were these people? Were they from Picurís? From Peñasco? Or, from Agua Negra [today Holman]? And did people really die?

From the New Mexico magazine article, "Today only two of the ditches still serve their communities as well as they did on the days of their completion: *Acequia de la Sierra* which supplies Holman (Agua Negra), Cleveland and Mora, and *La Presa Sierra* Ditch, which supplies Chacon, with the reminder flowing on to Holman.

"The *Acequia de la Sierra* is born at Jicarita Peak and the high mountain valleys along the northern edge of the Pecos Wilderness in the Rio Grande watershed. The ditch carries water across the mountain divide to the east, and spills it into the upper creeks of the Mora River. About three miles downhill from the tiny settlement of Medina the acequia separates into three channels – one to Holman, one to Cleveland and another short one angling off to the northeast.

"La Presa Sierra Ditch draws part of the headwaters of the *Rito la Presa*, as well as natural southern drainage, and drops in a spectacular waterfall into Griego Canyon above the town of Chacon."

From a document in the New Mexico State Archives in Santa Fe:
An eyewitness has left us this account:
The Mora people took the water of the middle branch [referring to the distinct branches of headwaters of the Río Pueblo – one of the three main streams that make up the Río Embudo] many years ago and they took the water of the northern branch 15 to 20 years ago. During the last three years the people of the little known town of Agua Negra have been building a ditch to the southern branch and last April 1882 the water was turned into the new acequia. It was constructed by about 14 men who were provisioned by Padre Jean Baptiste Guerin, Parish Priest living at Santa Gertrudes [in Mora].

These were built to move water between the Rio Grande and the Canadian watersheds, thus giving the settlers in Agua Negra (Holman) and Chacon additional water for farming. This was no easy task, often taking several years to accomplish. They were built with the very crude tools and instruments of the time. Three were built with the last being completed in April 1882.

In 1985, Dr. Anselmo Arellano, wrote *Acequia de la Sierra and early agriculture of the Mora Valley*. Arellano says that a, ". . . resident who lived on Picurís Pueblo lands was Antonio Olguín, a soldier who played a major role in the early settlement of the

Mora Valley. The Hispanic population near Picurís continued to expand after 1800; and finally, in 1816, Olguín and a group of families needing agricultural lands and water set aside their perilous fear of Indian attacks and engaged in a new settlement venture. They traversed the Jicarilla Mountain and descended into the fertile Mora Valley on the eastern border of the Rockies. This effort consequently launched the settlement of the north-eastern sector of the Spanish frontier in New Mexico."

But they encountered a problem, the Mora River not carry sufficient water to meet the needs of the growing population. Arellano goes on to say, "Olguín, the early leader of the San Antonio settlement, also rallied the people to confront the emerging problem of an inadequate supply of irrigation water from the Mora River. He approached the Picurís Indians and successfully requested permission to take some pueblo water from the high mountain valleys and the crest of the Jicarilla Mountain. The water was to be diverted from the western watershed whose tributaries followed a natural course into the Río Grande. The plan included an ingenious scheme to cut an irrigation canal into the rock and across the mountain into the Mora Valley. The water taken by Olguín and the settlers flowed into one of three branches of the Río Pueblo that irrigated the farmlands lying within the Picurís Pueblo land grant.

"The *acequia* was connected to the middle branch of the headwaters of the Río Pueblo. Through hard labor and native ingenuity, the people were able to defy the gravitational flow of water in places, elevating it until they created a major diversion into the Mora Valley along the eastern watershed. Although the exact date that the *acequia* was constructed is unknown, testimony provided in 1882 stated that the water from the middle branch of the Río Pueblo was taken "many years ago, . . . by the individual Antonio Olguín. . . [who] was allowed to take this water."[i] In view of this evidence, the *acequia* had to be constructed before 1832, since Olguín did not return to San Antonio with the families who resettled the valley in 1835."

According to Lorraine Aguilar's genealogical research, there was a José Antonio Olguin who was born in 1769 and died on Dec. 4, 1835; he married in 1791 a María Dorotea Garcia de Noriega in San Lorenzo de Picurís.

"The original families who settled the Mora Valley were largely from Las Trampas, Chamisal, and Santa Bárbara [Peñasco]," writes Arellano. He continues, "Sometime prior to 1865, the people from the Chacón area began construction on another mountain *acequia*, taking water from the northern branch of the Río Pueblo for their own use. This ditch which continues in use to the present was referred to as the '*Acequia de El Rito y La Sierra,*' and it first began irrigating the farm plots of Chacón in 1865. Other valley residents today refer to it as the '*Acequia de la Presa y la Sierra*' because it begins its course at a holding dam built by the people at the top of the mountain. The reservoir collects and retains water until it is released to the lower valley in early spring."

In 1879 plans for yet another transmountain *acequia* which would take water from the third and final branch of the Río Pueblo—the southern branch, were made.

The parish priest at Santa Gertrudis, Juan Bautista Guerín, met with the residents of Agua Negra and they agreed on fourteen men to do the work. Writes Arellano, "When they reached the stream, they also built a dam across it to hold the water which would be diverted to the fields at Agua Negra. After three years of arduous, backbreaking toil, the *acequia* was completed; and on April 1882, the water was turned into the new "*Acequia de la Sierra*."

Statehood

Towards the end of the territorial period, in 1907, which is why Gov. Bill Richardson declared 2007 as the Year of Water, New Mexico's water code was revamped. Though the 1907 Territorial Water Code recognizes acequias as a distinct class of water rights protected by the Treaty of Guadalupe Hidalgo and governed according to Spanish and Mexican water law and local custom, it also allowed for the separation of water from the land. Prior to 1907 water could not be sold separately from the land; in essence the new water code made water a commodity. In 1912 when New Mexico joined the Union, the New Mexico State Constitution confirmed all pre-existing water rights.

Santa Barbara Tie & Pole Co.

The Santa Barbara Tie & Pole Co. organized by A. B. McGaffery from Vermont in 1907 to cut timber for the Santa Fe railway. After cutting the timbers in the Santa Barbara grant, he hauled the logs in true New England fashion, floating the cut ties down the Rio Grande. Between 1909 and 1926 Santa Barbara Tie & Pole Co., harvested over 65,000 acres of forest service land. A special train, No. 3, was constructed by Lima in 1909 and it was used in Hodges until the early 1920s. Since McGaffery was an easterner where ties were floated down the rivers, he did the same in the Embudo watershed, floating down ties down the Río Embudo where some were picked up at the present day Embudo Station Restaurant, when it served as a train depot for the Chile Line train that ran from Antonito, Colorado to Española, New Mexico between 1881 and 1942. Other ties were floated all the way to Cochiti. For a while it provided employment for local men from the Embudo and Peñasco area but it also destroyed a lot of the habitat along the banks of the Río Embudo, especially around present day Dixon.

In this area of the upper Río Embudo, historically it grew mostly grains, especially wheat, and hay for pasture for livestock. Up to the depression wheat and corn, *maíz concho* and *maiz de los rincones*, two varieties of local corn that have practically disappeared were grown mostly for human consumption, either as fresh on the cob, or saved for winter use as posole and chicos. Chicos are made from corn that is harvested while tender, known as *xilote*, then cooked overnight in husk and all in adobe ovens known as *hornos*. In the morning when it is pulled out of the oven, the husk is pulled back and a few leaves are left and tied and hung to dry. When the corn is dry, it is then removed from the corn cob, cleaned and it is ready to cook. This area also produced peas that were consumed either green or when mature and dry in soups. *Haba* beans also do well here though today they are hard to find. *Calabazas mexicanas* that were eaten either green while tender and when ripe in pies or alone do well in this type of altitude, since they don' get the bugs that destroy the pumpkins and squash in the lower valley. Potatoes also grow well here, and can be grown as high as Tres Ritos, though there is only one family that grows them today. Potatoes and cabbage were grown as high as Arellano canyon going up to the la Junta canyon. Today most of the land is used for pasture or cut as hay to feed the few cows that remain or sold out of the watershed. Historically most families had a few heads of cows, some sheep and goats; one to three pigs and up to 15, 20 chickens. Today very few people have any domestic animals. In the 50s there was a small diary in Vadito.

The villages in the Upper Embudo start at Tres Ritos on the Río Pueblo, then

Sipapu Ski area, los Mochas, Placita, Vadito and Picuris Pueblo. There are also houses scattered starting at the Mora – Taos County line, known as los Mondragones. On the Santa Bárabara the first houses are up by Hodges, then there's Santa Bárbara today Rodarte. Above, on the north ridge is Llano de la Yegua, and the south Llano de San Juan and down below is Llano Largo. At the center of the valley, the major economic town is Peñasco and then Río Lucio. Going south one comes upon the town of Chamisal; northeast is Ojito and west Vallecitos. On the Trampas, above is El Valle, then Trampas situated on the main road between Truchas and Peñasco. Over the ridge is Diamante, then west is Ojo Sarco and the last hamlet before descending towards Cañoncito is Cuestecitas, named thus by the late Chester Salazar, according to his dad, Silas who still lives there at the age of 100.

The Acequias of the Upper Embudo Watershed

There are close to 40 acequias in the Upper Embudo Watershed comprised of the Río Pueblo, Santa Bárbara, Río Chiquito, Río Trampas and the Ojo Sarco Creek. In the Río Pueblo, the upper most acequia is at *los Alamitos*, close to where the road descends towards Mora and it's in Mora County. Excluding the irrigated lands of Picuris Pueblo, the Río Pueblo water over 700 acres, according to the Office of the State Engineer, in a report from 1987. The nine acequias in the Río del Pueblo irrigate 785 acres they are: the Acequia de los Alamitos, Spring Ditch, Acequia los Mochas, Acequia Vadito North, Acequia Lower Vadito South, Acequia de Placitas del Sur Vadito, Acequia de la otra banda, Acequia de Leña Pesada and Acequia del Pueblo de Picurís.

Acequias on the Río Santa Bárbara irrigate 4,541 acres. There are 13 major acequias, not counting the laterals or secundarias. They are: Acequia del norte de Río Lucio, Acequia del Medio de Río Lucio, Acequia del Sur de Río Lucio, Acequia Madre de Peñasco, Acequia de Abrieu, Acequiecita de Peñasco, Acequia de Pennasco del camino, Acequia Sur de Rodarte, Acequia Madre de Santa Bárbara, Acequia Madre del Llano Largo, Acequia Madre del Llano de San Juan, Acequia del Cañon Chamisal-Ojito, and Acequia del Llano de la Llegua.

The Río de Trampas irrigates 585 acres and it includes the following acequias: Acequia Sur de las Trampas, Acequia Norte de las Trampas, Acequia Abajo de el Valle, Acequia Arriba de el Valle, Acequia del Llano de San Miguel and Acequia de Ojo Sarco which irrigates 200 acres. This acequia gets its water from the Rito de San Leandro which flows into the Trampas, then is diverted and runs for 12 miles before arriving in Ojo Sarco.

The Lower Río Embudo: From Cañoncito to la Nasa

This area is composed of the hamlets within the Embudo land grant, which includes the villages of Cañoncito, Montecito, Apodaca, Bosque, la Plaza (Dixon), la Junta, Ciénaga, Rincón and la Nasa, who irrigate using the water from the Río Embudo. Rinconada, la Bolsa and *la otra banda*, which includes two properties between Rinconada and La Bolsa and another by the desagüe of the Acequia Junta y Ciénaga on the north side of the river, water from the Río Grande. This area historically grew wheat, corn and chile, with fruit grown mostly in the Rinconada area. In fact, Rinconada in the late 1800s was known as *Durazno* (Peach) because of all the wonderful peaches grown in the area. This area also grew all types of garden vegetables and people, like in the upper

watershed, also had a few domestic animals for household consumption. At one time one individual had about 500 cattle, but he grazed in the Tusas area by Tres Piedras. Though people grew mostly for home consumption, people would also peddle their chile and fruit to the Taos, Peñasco, and Mora valleys, as well as far north as Questa, Costilla and the San Luis valley in southern Colorado. There they would sell for cash, or barter *(cambalache)* for pinto beans, bolita beans, *habas*, dried peas, potatoes and meat, mostly sheep. Today there are very few cattle and sheep left. Most people grow only small kitchen gardens for home consumption or for the farmers market in Santa Fe, Taos, Pojoaque, Los Alamos, Española and the four-year old Dixon Market. As the demographics of the area have changed dramatically in the past 35 years, people grow mostly greens today, with very little chile and corn grown and no grains at all. At most only about two percent is planted in small kitchen gardens. More fruit is grown today, as mostly everybody filled their properties with apple trees in the 50s but a very cold winter, which dropped the temperature to 36 below zero on Jan. 7, 1971 killed most of the orchards. As a result most of the orchards were cut down for firewood and the few fruit trees that remain are only for home use or to sell at the farmers markets. There are only three big orchards left, one in Cañoncito with 18 acres, another in Embudo with ten acres and one in Rinconada of about 20 acres. A new fruit crop grown here commercially is the grape. The vineyards in Cañoncito are the farthest north grown grapes in New Mexico at 6,000 ft. and there are two wineries in the area.

The Velarde to Española Corridor

This area is mostly grassland above the acequias that dissect the land starting at the canyon in Velarde to Española on both sides of the Río Grande. The altitude ranges from 5,650 in Española to 5,800 at the mouth of the canyon. The rainfall here is about 10 inches per years. Irrigation water is drawn from the Río Grande via nine ditches, known as the *Nueve Acequias*. Velarde at one time was known as *La Joya*, implying very fertile land, as *joya* is a jewel. Soils here are mostly deep old alluvium with good fertility but due to overgrazing, the lands east of Highway 68 are not in very good condition. Though there is still some grazing in the commons on the old Sebastian Martín land grant, there are also erosion problems due to off road vehicles and four-wheelers. And now due to housing developments west of the road to the acequias, overcrowding is also impacting and compounding the erosion and waste problems.

Historically this area grew a lot of chile and corn as well as fruit, especially in Velarde. San Juan or Ohkay Owingeh which at one time produced a lot of corn and chile, today has most of it's 1,800 acres of irrigated land fallow. Today a lot of the orchards have been cut down, but the Velarde area still produces most of the apples in the valley. There are also a few farmers who plant several acres of chile, but not as much as before. Two wineries are also doing a good business in the valley, one in Velarde and another in Los Luceros. This area seems to be good for grapes, and since grapes use less water than other crops and due to the demand for good wines, this might be a money crop for the future. Now a lot of the agricultural land is being subdivided for housing, mostly for mobile homes, which is affecting the water quality of the area due to all the septic tanks that have to be installed. Especially troubling and of concern are those building close to the river in wetland areas, areas that historically people never constructed houses on. If people were more aware of the historic ordinances such as the Laws of the Indies of

1681, which dictated how most of the settlement were built, the agricultural land won't be in its present deteriorated condition.

The Río Grande Valley: Pueblos Encounter New *Vezinos*

Ohkay Owingeh Christened San Juan Pueblo Rechristened Ohkay Owingeh

The Embudo Watershed, which by extension for the purpose of this document extends all the way to present day Española on the Westside of the Sangre de Cristo Mountains, so named during the 1880s by the railroad industry promoting tourism to the southwest. When the first settlers under the Spanish Crown first arrived the same mountain range was known as the Sierra Madre. But the watershed also spills to the eastern side of the southern Rockies because of deal by the Picuris Indians that allowed the people from the new settlement of Mora in the early 1830s to take water from the Río Grande Watershed and transfer it to the Canadian watershed. The reason for mentioning this pact is because nobody knows how the courts will rule when the Río Embudo, and its tributaries, is adjudicated by the Office of the State Engineer. Or, what stance today's leaders in Picuris and Ohkay Owingeh will take, considering the Aamondt and Abeyta cases, and how the tribes have negotiated to acquire as much water as possible for their future growth.

This watershed is very unique, if for nothing else, that the four major Spanish land grants at one time were controlled by the powerful Martín Serrano clan who came to the area with don Juan de Oñate in 1598. It must be noted that the Martín Serranos were mestizos. During the Pueblo Revolt of 1680 they ended up in El Paso del Norte, present day Ciudad Juarez, but returned with don Diego de Vargas starting in 1692. The most famous of the clan was Sebastián Martín who was awarded what's known as the Sebastián Martín land grant in 1703, which was then reissued in 1712, and extended from present day Alcalde *(la Soledad del Río Arriba)*, east to Ojo Sarco and Trampas. Then in 1725 when the Embudo grant was made, his brother Francisco *"El Ciego"* Martín was one of the who applied and received the 25,000 acre triangular grant, whose southern boundary is the Sebastián Martín grant. In 1751 when the Trampas grant was made, Sebastián allowed the new settlers from the Barrio de Analco in Santa Fe, to carve out part of his grant for the new settlement. Genealogy tells us that there were some Martíns (females), who more than likely were of the same clan. Finally in 1796 when the Santa Bárbara grant was made, it was awarded among others to Valentín Martín, grandson of Francisco Martín. Therefore in a period of one century this family somehow controlled all the land between Ohkay Owingeh and Picurís. Again based on documents uncovered by scholars, the Martín Serranos never denied their "Indian" blood. Still today, the surname Martínez is the predominant one in the watershed and in the Española Valley.

Ohkay Owingeh was christened as San Juan de los Caballeros by don Juan de Oñate when he first came to the Española Valley in 1598. In 2006 the Indian village at the confluence of the Río Chama and the Río Grande reverted to its original name of Ohkay Owingeh (The Village of the Strong People). The village is located in north-central New Mexico in the center of an area known as the Tewa Basin. It is situated on an eroded alluvial remnant about one mile east of the Rio Grande and has been continually occupied since about 1300 A.D. At present the reservation covers about 12,213 acres, including about 1,800 of irrigated farmland. It is situated 28 miles north of Santa Fe and

43 miles south of Taos.

Prehistoric plant remains reveal the Pueblo IV Rio Grande inhabitants grew a short cob of 10-12 row corn, common beans, bottle gourds, two species of squashes and cotton. They also gathered piñon nuts, prickly pear cactus, yucca fruits, juniper berries, pigweed, goosefoot seeds and purslane. Purslane appears to have been a green that is native to both sides of the Atlantic, as it is also consumed in the Mediterranean area.

Located on the Upper Sonoran life zone, to the east are the Sangre de Cristo Mountains, while the Jemez Mountains are situated to the west. Elevation is 5,660 ft. The historic village is built of adobe and forms two plazas. Besides their house in the village, families also maintain a summer home in the agricultural fields. The language spoken is Tewa, and Ohkay Owingeh is considered the mother village; it is a sub-family of Tanoan, a family in the Uto-Aztecan stock.

Representatives of two of the first three major expeditions under the Spanish Crown, Capt. Francisco de Barrionuevo, scouting for Coronado in 1541, and Rodriguez-Chamuscada,1580, reached Ohkay Owingeh. Only Espejo in 1582 did not go there. The first successful colonization in the Rio Grande area was under Juan de Oñate at Yungue Oweenge renamed San Francisco, which a year later was renamed San Gabriel.

Juan de Oñate/Establishment of San Gabriel

With the arrival of Oñate and his colonists, which included 129 families who were either peninsular, criollos or mestizos, there also came 400 Tlaxcalteca families who came under contract with the Spanish Crown. The Tlaxcaltecans, who were never conquered by the Crown were contracted to do the layout of the acequias and develop the agriculture of the area, according to Mexican agriculture historian Dr. Tomás Martinez Saldaña of the Colegio Postgraduado in Texcoco, south of Mexico City. It is an undeniable fact that the arrival of the new settlers from the south brought along ecological implications by changing the ecosystems and also forcing the Tewa to new economic adjustments.

Oñate signed a contract, in fact it can be called the first proposal for economic development in what was to become New Mexico in 1595. The inventory done in Santa Bárbara, Chihuahua (Española's Sister City) in 1596 and 1597 is most informative. Oñate had procured 312 *fanegas* of corn, some 12 *fanegas* of beans, and 500 *fanegas* of wheat seed, though most of these might have been consumed during the expedition's subsequent delay. A *fanega* is a dry measurement equal to 12 gallons. In the past, people planted by *fanegas* instead of acreage. What did survive was the medicine box which contained beans, barley and lentils, most likely in flour form, for plasters. Among the medicinal herbs brought by the settlers were *manzanilla* (chamomile), *eneldo* (dill), *ruda* (rue), *estafiate* (a Mexican herb) and *malvas* (mallow).

Domestic animals, which could provide food and also be used for breeding stock included 846 goats, 198 oxen, 2,517 sheep, 383 rams, 96 colts, 101 mares, and 41 mules and jackasses. The new settlers, in other words, introduced the plants, animals, and tools that would quickly alter the landscape. Thus the ecology as well as the diet of the upper Río Grande was changed forever. The same as the Anglo-Saxon culture views the world through different lenses than the Indo-hispano today, so did the new settlers *(vezinos)* and Tewa see the world through different cultural glasses then.

Whereas the Tewa, who were subsistence farmers and foragers and hunters

instead of herders, had learned to adjust to unexpected weather changes; agriculturalists, though not immune from climatic change, can often regulate the ecosystem by raising crops in favorable locations and alter nature by artificial irrigation and terracing. Their ecological relationships are illustrative of different strategies for survival, that over 400 years have blended into one, though differences still persist even if the blood has mixed over time. Probably nowhere else is this a daily reality than in the foods eaten by both the Indo-hispanos and the Pueblo families.

According to Oñate's historian Villagrá, in his *History of New Mexico*, he wrote the new settlers gave the Pueblos lettuce, cabbage, peas, *garbanzo*, cumin seed, carrots, turnips, garlic, onions, artichokes, radishes and cucumbers. Four hundred plus years later, these same crops are still grown in the area. Oñate and a group of advanced scouts arrived in Ohkay Owingeh, or at the confluence of Río Grande and Chama on July 11, 1598. Even before the others arrived on Aug. 18, and irrigation canal, i.e., an *acequia*, was constructed with the assistance of 1500 Indians. What is not known whether these "Indians" were pueblo; more than likely it included Tlaxcaltecas. Oñate wrote, "On the 11th we began work on the irrigation ditch. . ." This proves that the first thing the settlers did was to construct an *acequia*, for without water they couldn't do anything.

Then "On the 23rd (of August) the building of the church was started, and it was completed on Sept. 7," and the blessing took place on Sept. 8. The *acequia* was imperative for the wheat harvest the following year in order to replenish their depleted stores. They also brought seed for kitchen gardens *(huertas)* and orchards, both unknown to the Tewa. The plants, animals and tools – especially the iron ax – would soon change the landscape. The following year the new neighbors demonstrated a new technology that the Indians would soon adopt: plowed fields, irrigated wheat and kitchen gardens for their vegetables and herbs. Kitchen gardens were a new innovation and their polyculture added variety to the Tewa diet, complementing the wild plants they gathered. Orchards were also established either as hedge-rows or on the irrigated land.

A letter sent from San Gabriel in 1601 and cited by Torquemado, stated: "Irrigation water [from the *acequia*] was used for fields of wheat and barley and maize. . . and all other things that were planted in gardens because in that land are .. . cabbages, onions, lettuces, radishes and other small garden stuff . . . many good melons and *sandias* [watermelons] . . . wheat, *maize*, and Mexican chile all do well."

When Fray Benavidez came through New Mexico in 1625 (he wrote his *Memorias* in 1630) lentils, *habas* (broad beans), lima beans and vetches were all growing and doing well. Plums, peaches and apricots were mentioned specifically; not mentioned were apples. Benavidez also observed, "so fertile is the land that it has been seen to harvest a 120 and a 130 *fanegas* to each *fanega* sown of wheat." When melons and watermelons came to the upper Río Grande is not known for certain. But the large fruit and sweet taste were symbols of a prosperous harvest. One witness at the Valverde inquest stated, "The people devote themselves to agriculture, growing *maize*, beans, calabashes, fine melons and watermelons."

In 1599 Oñate noted, "There are fine grape vines, rivers, and woods, with many oak and some cork trees' there are also fruits, melons, grapes, watermelons, Castilian plums, *capulins*, piñon, acorns, native nuts, *corolejo* which is a delicate fruit, and other wild plants. There are also many fine fish in this Río del Norte and other streams." In 1601 he wrote, "Our wheat has been sown and harvested; it does extremely well in that

land. The Indians devote themselves willingly to its cultivation."

Besides the Mexican and European (many from North Africa and the Middle East) plants, kitchen gardens *(huertas)* were introduced as a new method to grow vegetables. Besides the European cultigens, the new settlers also introduced a number of plants domesticated elsewhere in the Americas. Among them chile, including a new variety of corn such as the large cob, *Cristalina de Chihuahua* corn and the high-rowed Mexican dent from highland Mexico. This corn was more productive and was adopted by the Tewa but according to their color categories. They also brought Hubbard squash, known as *calabaza mexicana,* from South America as revealed by seeds from Picuris. Also introduced was the non-food plant, tobacco or *punche* as it is known in Spanish.

Herd animals became a double-edged sword, on the one hand they became a source of meat, textile material and beasts of burden. On the other hand, they overgrazed the grass, trampled the young trees and compacted the soil. By 1601 the breeding stock grew to 3,000 sheep and cattle. Probably what caused more ecological change was the metal ax, for instead of only gathering dead limbs for fire, huge trees were felled. The same thing happened with introduction of the power saw, which supplanted the ax. On the plus side of what the new settlers brought, there was a several fold increase in domesticated plant species which provided for a more beneficial and secure subsistence base. Draft animals permitted easier access to distant sources for wood, and riding animals opened new hunting grounds. The new plants and animals safeguarded against ecological disaster and it might have provided cultural continuity, in that it might have prevented them from migrating to another location. In a sense it anchored them to a specific site, where they have remained for over 400 years, alongside their neighbors, albeit as they say in Spanish, *"juntos pero no revultos,"* together but not mixed, as each live in their separate communities.

The Camino Real de Tierra Adentro

What came to be known as the *Camino Real de Tierra Adentro* (the Royal Road of the Inner Province), has been used by the people in the Americas since pre-historic times. During the Spanish epoch, the road stretched from Mexico City to Taos, though most historical accounts have it ending in Santa Fe. The only problem is that Santa Fe didn't exist when Oñate made his way up north since he settled in San Gabriel, on Ohkay Owingeh land. Until the Santa Fe Trail came into existence all trade and migration into northern New Mexico was from south to north. The Camino Real followed what is known as the *"camino del medio"* between Ohkay Owingeh and Velarde (then *La Joya*). It then made it's way to the *Plaza del Embudo* (Dixon today) following the southside of the Mesita, down the Arroyo de la Mina, through *la plaza*, then made it's way following the Apodaca Trail where it forked, with one road going to Picuris and the other to Taos.

Los Alamos

Two years after the Chile Line became history, the "Secret City," on top of the Pajarito Mesa was born. More than anything else, since Oñate and his settlers arrived in the Española Valley, Los Alamos had profound effects on the land and water in the valley. Prior to Los Alamos most of the villagers in the Española Valley and the Embudo Watershed survived of the land by maintaining their acequias or working the railroad, as sheep-herders or migrants in Colorado, Utah and Wyoming. With the advent of Los

Alamos, most of the men returned to their villages and became wage earners, though as the lowest paid employees since most were uneducated. As their earning power increased and Los Alamos grew, Española grew and it became the hub for all the surrounding villages. The first food store, Fairview Foods was established in the mid-50s. Of course there existed the "mercantile stores," such as one in then San Juan Pueblo and the Bond and Willard where the ill-fated Plaza de Española is now located. The first fast-food establishment, Lota Burger was setup ten years later. And as Española grew, as a result of the expansion in Los Alamos, less and less people tended their farms and acequias. The people in the valley went in one generation from a pastoral economy to a post-industrial economy, by-passing the industrial epoch almost completely. Their only contact with the industrial epoch was the short lived romance with the Chile Line.

Land Grants in the Embudo Watershed

Sebastián Martín, Embudo, Santa Bárbara and Trampas

There are several *mercedes* or land grants within the Embudo Watershed and the present-day Española Valley. The most important ones for this project are the Sebastián Martín, the Embudo, Santa Bárbara and Trampas and what makes these grants significant is that someway or another the settlers were all related to the Martín Serrano clan. On the south was Ohkay Owingeh and on the north Picurís. Those who settled on these grants are all descendents of Hernán Martín Serrano, a native of Zacatecas, who was 40 years old when he made the trek up the *Camino Real* with don Juan de Oñate in 1598. Of all the settlers that traveled with Oñate, the family that undoubtedly made the biggest impact in the Española Valley was the Martín Serrano, today known as Martínez. When we look at the grants within the prevue of this work, all of the four grants mentioned above were squeezed between the Ohkay Owingeh and Picurís land grants.

The Martín Serranos, it must be mentioned considered themselves *indios*, according to Dr. Bernardo Gallegos who has done extensive research into this family. It is said that once two first Martín Serrano cousins wanted to marry and the church wouldn't allow them. Their response, "We are Indians and don't have to follow church law," and they got married.

After the reconquest by Don Diego De Vargas in 1692, the Martín Serranos returned to their ancestral lands in Santa Cruz de la Cañada and present-day Los Luceros. It's here where Sebastián Martín, the most famous of all the clan, was awarded the Sebastián Martín land grant in 1703, then reissued in 1712, and it went from the boundary with the Ohkay Owingeh grant all the way to La Joya (present-day Velarde) and extended all the way east to Ojo Sarco, including what became the Trampas grant.

Then in 1725 the Embudo grant, whose boundary on the south was the Sebastián Martín grant, was given to Francisco *"el Ciego"* Martín, Sebastián's younger brother. Its boundary to the east was the dry arroyo before one climbs up to present-day Cuestecitas. The north and west boundary was the Río del Norte, today the Río Grande.

In 1751 the Trampas grant was carved out partly from the Sebastián Martín grant. The reason that Sebastián gave up part of his grant to a group from the Barrio de Analco, the Tlaxcalta settlement in Santa Fe, might have been relatives were married to some of the original settlers. Then in 1796 the Santa Bárbara grant was awarded to Valentín Martín, grandson of Francisco. From this brief sketch it can be seen, that by 1800 all of

the lands between Ohkay Owingeh and Picuris were controlled one way or another by descendents of the Martín Serrano clan.

Today the most prominent name in the area is Martínez, and many who are not Martínez have a mother or grandmother who are Martínez. Within the Embudo grant, most if not all, of the acequias were constructed by members of the Martín clan.

Brief History of the Embudo Land Grant

El Puerto del Embudo de nuestro Señor San Antonio was founded in 1725, by a group led by three men from *la Villa de Santa Cruz de la Cañada.* Franciso Martín, known as *"el ciego,"* appears to have been the leader of the three since most of today's native population can be traced to him. He was the bother of Sebastián Martín, who in 1703 had received the grant that bears his name. It is interesting to note that the *las Trampas* Grant was carved out of the norteastern part of the Sebastian Martín grant. The two others that are mentioned on the grant papers are Lázaro Córdoba and Juan Marquez. I am a descendent of Francisco Martín. Part of his house survives in the *plazuela,* where it has been remodeled and is maintained in a very good condition. The settlers were looking for a place with land and water for agriculture, both livestock and growing of food. And these properties had been used for agriculture, cultivated by both the Picurís and San Juan people before the grant was awarded; before Oñate ever made his way here in 1598 these lands were already providing a livelihood. According to local oral history, at one time there were five indian *"pueblitos"* of people living here. One, above *el bosque,* on a *banquito* or natural terrace facing the south; there was supposed to have been another Indian settlement east of la plazuela, northwest of the present day school on the Martinez property. Supposedly there was one up the arroyo that divides Cañoncito and Montecito. There is also archeological evidence backed by oral history that at the mouth of the *Cañada de los Comanches,* where the Embudo empties onto the Río Grande, on the north side of the river, there used to be Indian vecinos. A flood in 1948, according to Teresa Archuleta, made these people flee their house and the sliver of garden land where they planted was destroyed by the flooding river. Lands at el Embudo were supposed to have been, and still are, very fertile, growing all sorts of vegetables, fruits and a rich bounty of fish and eel from the cold waters of *"el Bravo."*

Though the grant was made in July, the *pobladores* didn't actually take possession of the grant until September of 1725. As was the custom, the new pobladores pulled weeds, yelled and shouted and had a merry time to celebrate their taking ownership of a triangular piece of land consisting of approximately 25,000 acres. Today less than 700 acres are in private hands with the Bureau of Land Management and the State Land Office owning most of the grant land.

When a piece of vacant land was settled, first on their agenda was to layout an acequia, an artificial way of moving water, then once constructed, plant, as was custom. And even before building a house, "plant trees," as recommended by Gabriel Alonso de Herrera. For the first few years the *pobladores* lived in *jacales* (a temporary house made of wooden posts stacked together than plastered with mud). Undoubtedly the first acequia in the Embudo Grant was la Acequia de la Plaza, since it irrigates the lands immediately north of the plaza. It has its beginnings where the Arroyo Lorenzo and the Arroyo de la Apodaca empty into the Río Embudo and it has its *desague*, or sleuth, by the Arroyo de la mina. This crescent moon shaped piece of land which makes up the land irrigated by

the Acequia de la Plaza, had to have been the original rancho of the grant. The next, by analyzing the layout of the land and its proximity to the plaza, had to have been the Acequia del Llano, which is the longest and one with the most parciantes.

Hamlets within the Embudo Grant

Present day Embudo, where the *Acequia Junta y Ciénaga* is situated, is located approximately 25 miles southwest from the Town of Taos and 20 miles northeast from Española, on the southeast tip of Río Arriba County. The *"merced del Embudo,"* known today as the Embudo Valley, consists of the communities of *Cañoncito* and *Montecito* on the eastern part of the merced, on the south side of the Río Embudo, four miles east of the *plaza* (present day Dixon); on the northeast side of the river is Apodaca and el Bosque. Southwest from *el Bosque* is the *Plaza del Embudo*. Directly across the *pareja* (above el Bosque), which served as a track for horse races in the past, and along the south side of the Río Grande is present day *Rinconada,* known in the 1880's as *Durazno*. Today some of the best peaches are grown here. West of *Rinconada* is *la Bolsa*. North of la Junta, between the Río Embudo and the Río Grande is el *Rincón*. West of the *plaza* is las *Pasaditas*, where the *presa* of the *Acequia Junta y Ciénaga* is located. Nearby used to be a "*tunelito,"* through where the water traveled on the carved rock, until it was destroyed by a Highway department project in 1948, according to local people. Half a mile west is *la Junta,* which is separated from *la Ciénaga* by the *Arroyo Jacinto*. Two miles west of *la Ciénaga* is *la Nasa,* the western most community in the Embudo Valley. *La Nasa* irrigates with the *sobrante* from the *Acequia Junta y Ciénaga.*

After being in the new población for 19 years, there was a mini-Pueblo uprising in 1744, 64 years after the Pueblo Revolt of 1680, and as always Embudo was at the crossroads, where the Pícuris, Taos, San Juan, San Ildefonso and Santa Clara met to plot the fate of the settlers. But after six years, in 1750 most of the original pobladores came back permanently to stay. There are still families in the valley (mine included), whose roots date back to 1725. Embudo, along with Abiquiu and Ojo Caliente, are considered *pueblos genízaros,* or settlements where non-pueblo Indians (mostly Plains Indians) settled and their principal language was Spanish.

After nearly a century of peace, since Mexican Independence and the *Grito de Dolores* didn't have any effect on the life of the *paisanos,* the American invasion of 1847 changed their lives forever. There was a fierce battle, known as the Battle of Embudo, during the Taos Rebellion where over 50 *paisanos* - *mexicanos e indios* - lost their lives on the *Camino Real de Tierra Adentro* between *La Joya* (today Velarde) and la *Plaza del Embudo,* on what's known as the *Cañada de las entrañas.* The *descansos* are still etched on the basalt rocks; there are over 50 *descansos* engraved on the lava rocks on the southside of *Mesita,* the exact location given on an Army map of the battle, before meeting the *Arroyo de la mina,* which connected the north to the south. The people of Embudo, with their hand-made work tools for tilling the soil, made of oak and piñon, were no match for the cannons carried by the Americans.

But through all the turmoil, the ranchos kept expanding as acequias were dug and new lands were opened up for cultivation. Up until the early part of the 20th century, the majority of the people lived off the land. During the Depression the man of the house started going out to work as a wager laborer, either as a sheepherder, on the ranches as an *obrero* or on the railroad. The coming of the Chile Line, as the narrow gage railroad was

known because of the chile it hauled north to Colorado, was a big event; when it first arrived at what today is the Embudo Station in 1881 it was celebrated with a fiesta, known as Santa Rosa, because it was on that day that the railroad arrived from Colorado on its way to Española, on the westside of the Río Grande, by historic *Santa Cruz de la Cañada,* the *villa* from which most settlers ventured north. In the span of 60 years, which is how long the railroad existed, the people in Embudo went from the agrarian epoch to the industrial age, if only marginally, to the Atomic Age, as Los Alamos opened as the Chile Line disappeared. Now they have catapulted to the computer age, but the roots are still anchored to the land, to the acequias, though the "old" agriculture is giving way to the new slogans of organic farming, sustainable agriculture and permaculture, which is a new way of packaging traditional agriculture.

Acequias within the Embudo Land Grant

The *acequias,* by following this analysis, appear to have watered originally one *granja* or *rancho* made up of several *suertes.* An *acequia* can also be looked at as each been one terrace, though each suerte might further be broken up into more than one terrace. The *rancho,* or *acequia,* was probably owned by one family, at least by an extended family. Up to 1950 usually one family, or extended family, owned most of the land in one *acequia.* An example is the *Acequia Sanchochada* which was owned by family of Juan Isidoro Martinez and Albinita Martinez (who lived to be over 100 years), a full blooded Apache, according to my father, since they were his great-grand parents. Their children were Ricardo, Manuel, Ramon, Rafael, Juanita and María de la Luz, who married José Ignacio Arellano at the age of 13. My grandfather José Agustín Arellano, was there eldest child, born in 1868.

Since the coming of the "hippies" in the early 1970s a lot has changed, especially how the acequias are viewed and maintained. In the Embudo grant there are nine major *acequias* who get their water from the Río Embudo. On the south side of the river, starting east by the box canyon, the first one is the *Acequia de la Sancochada* which waters mostly Cañoncito; the *Acequia del Medio* irrigates parts of Cañoncito and Montecito. The *Acequia del Llano* and *Acequia de la Plaza* water the area starting at the *Arroyo de Lorenzo* to *las pasaditas* where the *Acequia Junta y Ciénaga* begins its journey along the northside of the *Mesita*. This *acequia* waters approximately 80 acres, the *ranchos* of *la junta* and *la ciénaga,* and at one time (until about 1998) with the *sobrante* it irrigated the lands at *la Nasa*.

Then, on the north side of the river is the *Acequia de Leonardo Martinez,* which is the smallest, irrigating about 20 acres, but it includes the biggest apple orchard in the area. The *Acequia de los Duranes, Acequia de la Apodaca* and *Acequia del Bosque* irrigates the piece of land extending from Apodaca, which means cranberry in Basque, to *la plaza,* on the northside of the creek. Then there are three very small *acequias* that irrigate at most ten acres, *Acequia de las Pasaditas, Acequia del Rincón* and *Acequia de Eliseo Martinez,* which hasn't been used in about 25 years. Then drawing water from the Río Grande is the *Acequia de la Rinconada*, which now gets its water through plastic pipes directly from the river instead of the traditional presa, the same as the *Acequia de la Bolsa.* Then on the northside of Río Grande is the *Acequia de los Roybales*, which now irrigates at most 10 acres and at one time harvested about 20 acres of crops.

Though no official records have been uncovered as to which is the oldest acequia within the Embudo Land Grant, migration patterns and genealogy can be used to piece together the history of the acequias. Based on migration patterns, since most of the settlers came from the Santa Cruz de la Cañada and the Sebastián Martín Land Grant near present day Alcalde, more than likely the first acequia might have been the Acequia Junta y Ciénaga. The reason, settlements usually started at the mouth of a river then moved upstream. And more than likely the Junta section since it is the first on the Río Embudo and also because the word Ciénaga was later added on. The first acequia to draw water from the Embudo, was the *Acequia de la Nasa*, a few feet from the confluence with the Río Grande. Recent records uncovered give this acequia a 1783 date; later it got it's water as *"sobrante,"* or excess from the Acequia Junta y Ciénaga due to problems in maintaining its presa. All of the other acequias within the grant have only one name. Or if there was no irrigation going on in the area at the time the grant was made in 1725, then the first acequia was possibly the *la Plaza*, since it irrigates the properties below where the *Plaza del Embudo de Nuestro Señor San Antonio* was built, today present day Dixon.

But since the Picuris protested the granting of the Embudo Grant, because they claimed the land as theirs, and they said the Picuris and Ohkay Owingeh people already used the Embudo lands for cultivation, there might have already been irrigation. And there are also records that indicate the lands in Rinconada were already planted since the1600s, which also gives credence to the fact the Acequia Junta y Ciénaga might have already been established.

As far as the other acequias, based on genealogy and the settlement patterns it appears that the last to built were the Leonardo Martinez, *Sanchochada* (means half done; was it constructed haphazardly originally?), Medio and Duranes. And why is that? Because all those lands were up until about 30 years ago, settled by descendents of Juan Isidro Martinez and Alvina Maes Martinez, who had 12 children. Juan Isidro Martinez was a descendent of Francisco Martín, married to Casilda Contreras.

Leonardo Martinez was the son of Manuel Martinez, son of Juan Isidro and Alvina. Fidel Martinez, who owned big chunks of land in el Medio and Duranes, was the son of Ricardo, another son of Juan Isidro. The Arellanos who also owned a lot of land in Sancochada and el Medio, were also descendents of Juan Isidro since María de la Luz Martinez married José Ignacio Arellano; she was his daughter. And all the Martinez's with land in Sancochada, Medio and Duranes, and the Martinez acequias were all descendents of Juan Isidro, born in 1822, this according to the genealogical research of Lorraine Aguilar from El Valle in the Trampas Land Grant.

Therefore, it appears that Apodaca, Bosque and Llano were established earlier than the above acequias. Also, it must be noted that acequias, by following the migration pattern on the west side of the Sangre de Cristos, were established starting from the bottom of the river and moved up. Whereas, as again based on migration, those of the east side of the Sangre de Cristos, in the Mora Valley, were started from the top of the watershed and moved towards the bottom.

The Chile Line

The Denver and Rio Grande Western Railroad was affectionately called the Chile Line because of all the chile and fruit that it took from the Española Valley to the San Luis Valley and is still remembered by this name. From 1887 until abandonment in

1941, passenger service in Esapañola was generally daily except Sunday. Española was founded in the 1880s as a stop on the Denver and Rio Grande Railroad. The railroad has disappeared, but the city has grown and prospered as the commercial center for the Valley's smaller villages.

Water Rights and the Treaty of Guadalupe Hidalgo

There is probably no more misunderstood and misinterpreted section of the New Mexico State Constitution than *Article II [Rights under Treaty of GuadalupeHidalgo preserved]* when it comes to water rights. Hundreds of thousands, if not millions, of dollars have been spent paying scholars and lawyers to clarify what rights we have under the treaty. Any attempt to understand what those rights are, in reference to the use of water for irrigation, come from the Romans, Visigoths and Arabs.

The first reference, or attempt, at any form of water law is found in the *Fuero Juzgo* of 654 A.D., adopted by the Visigoth, which deal more with penalties for the abuse of water. *"El Fuero Viejo de Castilla,"* refers only to the use of running water for the functioning of grist mills and for fishing purposes. It was not until the 13th century that we encounter a series of laws dealing with water. The use and distribution of water for irrigation purposes was based on the ancient Roman law. This monumental task of codifying all existing ordinances up to 1256 was the work of King Alfonso X, known as *"The Wise."* They became known as *Las Siete Partidas.* The publication of said laws signaled a step in the right direction in the cultural evolution of Europe and Spain. Though they were influenced by the Romans, they didn't acquire any influence until the *Ordenamiento de Alcalá* in the middle of the 14th century. In the *Tercera Partida*, the laws declares "*common things*" "*the flood waters and the use of the rivers*." It also stipulates that "*the headwaters that are found there,*" are common property.

Another very important concept, relative to the "*right of way*" of easements for the acequias is also addressed: "which right-of-way will be twice as wide as the measurement of the bed of the ditch, or four *pasos de Salomón* (according to Spanish historian don José Antonio Crespo Frances y Valero a "*paso de Salomón*" is equivalent to 75 cm. instead of 65 cm for a regular *paso*), measured on each side of the bank of the acequia, of which right-of-way no person can claim, for it is community property." This is very important, for it defines legally for the first time, the rights acequias have through private property. Today many property owners try to block the mayordomo or peones from going through their property during spring cleaning. The banks of the acequias were also used as roadways by the villagers.

In New Spain, including New México, the new legislation pertaining to land and water that starts to emerge follows what is contained in the *Siete Partidas.* These dispositions, ordinances and instructions end up being called the *Recopilación de las leyes de los reinos de las indias* or the "Laws of the Indies," which were compiled in 1681. For example, it stipulates that "the pasture, mountains and water shall all be communal." Others deal with administrative mandates, like the naming of Water Judges (today called *mayordomos*) so that they can distribute the waters used for irrigation by the Indians. Yet others give the viceroys and courts the administration of the waters in terms of "justice and equality" relating to managing the water. This is where the custom of sharing the water in times of shortages comes from.

In paper, at least, the interest and respect the Crown had for the *"Indians"* is evident in several laws. It orders that the laws should respect the water rights the Indians had. And that the waters should be shared equally among the Indians and Spanish settlers. For northern Mexico (which of course included New Mexico) the court in charge of administering the law was in Guadalajara. In the ninth edition of the *Laws of the Indies*, in 1788 King Charles III included language concerning the construction of new acequias where needed for irrigation purposes.
Protecting the communal right over the individual right as established by *Las Siete Partidas* and *Recopilación,* not only in general terms, but in specific cases,we find a Royal Order by Charles IV, dated November 18, 1803 and confirmed four years later: "that the settler of such city is the true and only owner of the waters that run through public pipes, as long as the public needs them." This is also repeated in the *"Plan de Pitic,"* of 1783. To understand the rights claimed under the Treaty of Guadalupe Hidalgo people need to know what those rights are. *Las Siete Partidas, the Laws of the Indies* and the *Plan de Pitic* are three very important documents that people need to understand if they want to know what rights were guaranteed by the Treaty of Guadalupe Hidalgo.

The Anatomy of a Land Grant: The Commons and Acequias

To understand the land patterns in New Mexico one has to understand the history of the *mercedes* or land grants under the Spanish crown and later the Mexican government, starting in 1598 until 1847. Though there's been a lot of "chatter" regarding land grants since Reyes Tijerina's infamous 1967 Tierra Amarilla Courthouse Raid in northern Río Arriba County, very few people understand the land grants and the struggle of its people.

What we have in northern New Mexico, in trying to comprehend "traditional" agriculture, is a lot more complex than what appears on the surface. But traditional agriculture can never be understood without fully comprehending the division of the land based on the *Mercedes* or Land Grants. There were also *Mercedes de agua,* or free distribution of water for irrigation, but these were not as common. We will look at the three main components, or the anatomy that constitute a *merced*. First, the land known as the commons; second, the *acequias* and their rigid design which separates the first from the third like an exacto knife cutting a zigzag line across a paper, which are the *suertes* (because they were allotted to the *vecinos,* or settlers, by lottery or luck) and how they are irrigated, by the use of *acequias*. Each acequia in essence forms a separate terrace. If the *suertes* are the body, the *acequias* are the veins that give life to the high desert landscape and this produces in turn a holistic food. And when you have nourishing food based on grass fed meat from the commons, fruits and vegetables watered with fresh stream water then the life one has is abundant. Dr. Tomás Atencio calls this life, *"una vida buen y sana,"* a good and healthy life, to which I would add, *"y alegre,"* and joyful.

The Commons:

When analyzing the land patterns in New Mexico we always go back to the *"Recopilación de las leyes de los reinos de las indias"* known as the Laws of the Indies of 1681, which are based on the *Ordenanzas* of King Philip II of 1576. But like the onion, when you start searching for its antecedents, or what I call pealing the onion, we

encounter the Arab influence in all aspects of land and water use in New Mexico albeit under the guise of Roman law. The Moors are the prodigal sons.

Under the Laws of the Indies, the land was divided into what we know today simply as commons and the irrigated lands. What divides the one from the other is a rigid zigzag line formed by the *acequia,* the channel that delivers the water and gives life to all the land below it. This rigid design line follows the contours of the land. Above the *acequia* is the dry land, which is more in tune with how the land was managed in Northern Europe prior to the arrival of the Arabs in the Iberian peninsula in 711 and who stayed there until 1492. When the Moors were kicked out of Spain, how they managed the land did not disappear, in fact it resurfaced in the "indies" under the guise of different *ordenanzas,* the laws under which the Spanish land grants were made to settlers.

Many people in the Río Arriba region when referring to the commons think of *ejidos,* which simply supplanted the word *latifundia* here. And though the term land grant has a high recognition level among the general population, especially the Indo-hispanos, very few understand its anatomy. *Latifundias* are big expanses of land, in the thousands of acres, whereas *minifundias* are small land holdings of only a few acres. And *ejido* simply means *"exitus,"* or the place which is at the outskirts of a village, which is neither planted nor worked and is common to all. It's from the latin verb *exeo, exis*, to exit, to leave. There are four main divisions within an *ejido,* or the commons even though they blend and overlap into each other at times, again like a braid:

* Sierras
* Montes
* Dehesas
* Solares

Sierras provided the early settlers - and still today the descendents of these early *pobladores,* like their ancestors before them - a place to harvest firewood, *vigas* and *latillas* for constructing houses and other buildings needed to be built for survival. When the *mercedes* or land grants were awarded, building materials for living quarters were dragged from the *sierra* and *monte* using animal power; today trucks are employed for this type of labor. The settlers also combed the lands for wild fruits, *capulín* (choke cherries), *chatacow* (elderberries), *moras silvestres de matas y de suelo* (wild raspberries, alpine strawberries), piñon, and *beyotas* (acorns). Wild herbs, such as *oshá, oregano de la sierra y del campo, altamisa, poleo, yerbabuena,* were and are also harvested today. Each village has their place where certain essential herbs are grown and harvested; many of these sites are kept secret. Since the coming of the Flower Children or hippies, many of these sites have been raided to the point of near extinction as some started harvesting the herbs to sell commercially.

Like the allocated lands, these communal lands or *ejidos* were broken down into *sierras, montes, dehesas and solares* where the houses were built. But the commons were also crisscrossed by *cañadas* and *veredas.* A *cañada* can be described as a *"camino mesteño,"* wild road, since they were used to move the livestock, mostly sheep and goats, from the winter to summer pastures and vice versa, from the *dehesas* to the *sierras*. A *cañada* is usually defined as a space between two high peaks or *lomas* and *cuchillas (*mountain ridges) that have water holes or *abrevaderos* and vegetation for animals to eat and are at least 90 *varas* (a little less than a yard; around 33 inches) wide, and their main use is to move livestock. Besides *abrevaderos,* or watering holes, *cañadas* also have

spaces where the livestock rest called *descansaderos* or *majaderos*, which referred not only to a resting place but also where manure is deposited. Also part of the commons are the *veredas*, or trails which are more narrow but usually a minimum of 25 *varas* and usually used by horses or to move smaller flocks or herds of livestock. It's from the *cañadas reales* that the term *dehesa* might have originated, according to some scholars, since this caused a conflict between those moving livestock and the inhabitants of the villages through where the animals were moved twice a year. From there the term *defendere*, which means permission, *dehesa* is thought to have come about, since the king had to intercede and grant permission. All of these concepts eventually made their way into the Laws of the Indies and thus to New Mexico.

Sierra, is a mountainous terrain whose features resemble the teeth of a saw, but can also be from the Arab, which refers to a rugged high desert. In Spain the word applies to high, saw tooth mountains and it was appropriately transferred to the Southwestern ranges by the Spanish colonists. It's in the *sierra* where the *cuencas*, watersheds, form and they act as the keepers of the water because the snow melts slowly thus providing not only the irrigation water for the *acequias* but also feed the aquifers that feed the *norias* (another Arabic word, from *na'ura*) or wells that provide the water for domestic uses.

Monte is derived from the latin, *mons, tis tierra alta*, high ground while *montaña* is *tierra alta, áspera y habitata*; that is, highlands, harsh but habitable.

The non-irrigated lands of the *mercedes*, especially those lands known as *secano*, used for dry farming, are usually on the lower reaches of the *dehesas*, known as *"tierras de pasteo,"* or pasture lands. In latin the *dehesa* is called *pascua*, and it is a place where the livestock is grazed. It could very well come from the Roman custom of establishing *latifundias* in marginal lands. But the term does not appear until the year 924 in the dictionary Corominas, though the term is also found in the laws of the Visigoth, known as *pratum defensum*, as noted by the Romans. According to Covarrubias it is an Arab term that means, "a low land, full of weeds where it is hard to walk, from the moisture in the soil and thick with weeds." Covarrubias says the word comes from *dehisetum*, from the verb *dehesa, "que vale espesar y estrechar."* But he says it could also be Jewish, from *"dese, herba,"* for the *deshesa* is nothing more than "a piece of land full of weeds." A *dehesa* is a semi natural ecosystem where there is usually a certain amount of human involvement. In New Mexico this meant that the piñon trees were pruned to the extent of removing what is known as "piñon blanco," the dead piñon branches that have gotten a gray patina and are treasured by the ladies when they relied on fire wood for cooking and heating for it is seasoned wood. Also this type of piñon tree is the one that usually produces the best piñon nuts and because it has been taken care of the nuts are easier to harvest.

A *dehesa* is also a space that conserves a great number of both flora and fauna; it also has great economic and social importance. Regardless of its original meaning, whether it has latin roots, Arabic or Hebrew, it is understood to be an agroforestal system with poor soil and a harsh climate where man has intervened to make it somewhat productive. Some scholars say that a *dehesa* is not very ecological due to the economic pressures of grazing more livestock than what it can sustain. *Dehesas* once formed part of the different land grants, are now managed by the Bureau of Land Management, the State Land Office and the Forest Service. It is usually a type of pasture with scattered trees of evergreen piñon and juniper *(cedro y sabina)* and deciduous oak, and in the past grains

were often grown under the sparse tree covers. The space then between the *dehesa* and the *solar* is what was used for dry farming, known as *secano,* situated above the rigid line made by the *acequia,* which separated the commons from the private lands. A *dehesa* can be better understood as a mosaic because of its different uses; it's also part *monte,* but also used for grazing and when necessary dry farming. The best pinto and bolita beans are grown on *secano*. It's an agroforestry system with the joint production of trees and agricultural crops and/or animals; it's also known as an agrosilvopastoral system.

Besides the *sierras, montes* and *dehesas,* though private and to a certain extent part of *suertes,* and usually above the *acequia,* are the *solares* where the houses were commonly built. A *solar* comes from the word *"suelo,"* to make a floor as in constructing a house on a plot of ground. But a *solar* is not only the site where the house is built, it also is the space between the acequia and the commons where the settlers built their *corrals, gallineros, trochiles* and *leña,* that is, the space where the corrals, chicken coop, pig pens and wood pile was kept. The house, if away from the town plaza, was constructed following an L- shape or U-shape. Also part of the house complex included the *dispensa* or utility room, and *soterrano* or root cellar where people kept their food supplies for winter.

Acequias: The lifeblood of the Villages

To understand the *acequia* it has to be looked at from the perspective of the human body and how the blood flows from the main arteries, to the capillaries to the vessels. For the acequia follows the same principle.

Each *acequia,* to better understand it, is a separate terrace. In the Río Embudo within the Embudo land grant there are nine major *acequias,* or nine major terraces, with the smallest irrigating about 20 acres, and the biggest 150 acres. Where the water is diverted from the river it is known as the *toma,* or "place" where the water is taken from. Being that the settlers were very aware of their environment, the *toma* was chosen for its *venitas de agua,* which means the veins like in the human body, which pumped water from the springs in the river or the *veta,* the main lode. The structure that diverts the water is the *presa* then a *desagüe* (outlet) about 100 feet from the *presa.* A *presa* is a diversion dam, which diverts the water from the river to the *acequia madre.* Usually, there is another *desagüe,* another 100 feet from the first *desagüe.* The reason for the second *desagüe* is, for in case there is a lot of water in the river, like when the arroyos run in the summer or during the spring runoff, the water can be regulated. Some *acequias* have a third *desague* about a quarter mile from the second, again for an emergency, but it is hardly ever used. Usually after an arroyo, if it happens to run into the *acequia,* like they do in many *acequias,* another *desagüe* is needed to clean the *acequia* of silt after a flood.

Here in northern New Mexico the *acequia* is also used to delineate property boundaries, and such *acequias* are known as *linderos* or *cequiecitas menores,* (to differentiate from the *acequia madres* or mother ditch*)* when they flow perpendicular; and as a *cabecilla* when it flows horizontally along the *acequia madre.*

When the water gets to the *suertes,* each *parciante* has to install a *regadera* or *compuerta* (a head gate) to divert the water from the *acequia madre* to the individual property. Once the water enters the *parciante's* property, from there it is spread out via *brazos* which take the water to the different *bancales,* also known as *ancones* (terraces), or *melgas,* then further broken down to irrigate the *eras,* through smaller *cequiecitas*

called *ramos* and finally *hijuelas* or *carreritas.* Eventually all the water comes together at the *desagüe* (outlet) which every property also has in order to move the water to the next *parciante* (water rights owner) or to the river. In the last property there is another *desagüe* to send the water that is not used back to the river.

One of the most misused terms in understanding an *acequia* is *sangria* (bloodletting; drainage), which a lot of people, but mostly those born outside the *acequia* culture, confuse with a small *cequiecita.* A *sangria* is indeed a small ditch, but it is used to drain a *ciénaga,* or marsh land, in order to use that piece of land for cultivation. And like a lot of the concepts pertaining to *acequias*, this one is also derived from the human body. When a person smashes a finger, or has a tumor, that needs to be drained to relieve the pain one *sangrars* (drains) the injury. The same is done with a piece of land that has too much water; it's drained by a *sangría*. Some people call a small lateral ditch that runs horizontally to the *acequia madre,* and is used to water a *melga,* a *sangría*. But that is a more contemporary usage.

The person in charge of the water in the Rio Arriba bioregion is known as the *mayordomo,* and he is either appointed by the three *comisionados,* (commissioners), or elected along with the *comisionados* by the *parciantes.* According to state law the *mayordomo* has to be elected along with the *comisión*. Either way he is under the direction of the *comisión.* In earlier times he was known as the *cequiero* he is the one who divides the water, for he acts as the "barmaid," making sure everyone has water.

The *mayordomo* is always referred to as one who is *"digno de confianza"* (worthy of being trusted), "*el que es fiel*" (he who is faithful), or *"el fiel del agua"* (faithful with the water). In the *hispano-musulman* world, as well as in the Indo-hispano world, the concept of water is that it is a *"don divino"* (divine right), which means it is nobody's property but belongs to all, and that it ought to be divided equally among those who need it.

Water is always divided based on the amount of land in each *acequia,* then based on the number of *peones* each *parciante* has under that particular *acequia,* and based on the amount of water in the river. In talking about *peones,* there are two definitions. One refers to a worker in the acequia, like during the annual spring cleanup or when cutting willows. But the second definition refers to water rights, and a peon is divided into quarters. Example, someone with a quarter peon, means he irrigates less than an acre; one-half peon two acres and so on. That was in the past, today with land being divided as subdivisions the formula doesn't always apply. At times *parciantes* try to apportion more *peones* than what they have by subdividing the land into more pieces of land than water rights. Example, dividing a four acre plot into four one acre plots when they have only half a *peon*; and thus they can only divide the land into two, two acres plots, so that each parcel of land can have at least one-quarter *peon.* Dividing into smaller portions than one-quarter *peon* would turn into a nightmare for the *mayordomo* and *comisión* to manage. The amount of water in a river is measured in *surcos*. And here is where the old concepts of measuring water come into place. One of the most used concepts is *sulco,* or *surco*. In northern New Mexico a *surco de agua* is the amount of water that can flow through the *buje*, or opening in the center of a cartwheel in a *carreta* (cart). That is no longer the case because as land has been divided or sold the same equation has not been followed.

The *repartimiento de agua* is based on the Moorish concept of *equidad*, which comes from the *Qur'an.* This concept, regardless of the amount of water in the river, is based on equality and the number of acres under cultivation. It is based on custom and tradition and is always passed down orally, not in written form. The *Tribunal de Agua in Valencia* has met every Thursday in the steps of the cathedral of that city for over a thousand years and none of their decisions have ever been written down. In Murcia they have a similiar entity called the *Consejo de Hombres Buenos*, the Council of Good Men. In the Río Embudo they follow a similar practice, though it has no formal name, and functions mostly in times of drought during the *repartimiento*. When the *repartimiento* goes into effect, the water in the river is first divided by the number of *acequias* (in the Río Embudo eight *acequias*), then the water in each *acequia* is divided by the number of acres based on the number of *peones*, or shares. Example, in the *Acequia Junta y Ciénaga* there are approximately 80 acres under irrigation with 80 quarter-*peones* (shares) and at present 32 *parciantes* (water rights owners), with some having only one-quarter *peon* (or share) and others up to two *peones* (or 8 shares).

In years of drought, the water, once apportioned by *surcos* in the river, is divided into *filas* (or *hilas, hilos* here in northern New Mexico). A *filo de agua,* or *hilo,* is another concept like *surco*, that is used by the elders, and though it means somewhat different to everyone, somehow people knows what it means. These *filas*, or *hilos* are known as *tandas* or *turnos*, and during the *repartimiento* people call it the *tiempo del papelito,* because they receive a paper note telling them when they can have the water and for how long. The *papelito* is based on the amount of land, which should correspond to the number of *peones*, and supposedly to the number of acres.

A *hilo de agua* usually corresponded to one hour of water use. The problem here is that usually the big *acequias* end up losing irrigation time because the division is not done equally since the *peones* in one *acequia* don't represent the same amount of land (in terms of acreage) in every *acequia.* And when the water is divided by the upper and lower *acequias,* the upper three days and the lower four days, again they are not all equal when it comes to acreage so the smaller *acequias* end up getting more watering time per *peon.*

In times when there is plenty of water, nobody really cares about measuring the water and how much water an *acequia* uses, though with water adjudication now a reality, sooner than later water will be quantified. But in times of drought, like in the 1950s and in 2002, *acequias* have had to fall back on the ancient tradition of adhering to the *repartimiento de agua,* or the sharing of water, based on *"la palabra del hombre"* (the oral word of man) and equality. When the *repartimiento* is in force, the *comisionados* and *mayordomos* figure how many *surcos* are in the river at that time and then divide the number of *surcos* among the different *acequias* based on the number of *peones* (which should correspond to acreage) each *acequia* has. For centuries this system has worked, but during the summer of 2002 some of the newcomers didn't want to follow the custom and tradition, and how long it continues no one knows.

Two other very important concepts, in terms of the philosophy of the sharing of water are *sobrante* (which is the excess water) and *auxilio* (which is sharing, or coming to the rescue of those who don't have enough water). Usually when a new piece of land was exploited, it was watered with the *sobrante* from an already established *acequia*. Again in the Embudo Valley, the farmland in *la Nasa,* water with the s*obrante* from the *Acequia*

Junta y Ciénaga. But the *sobrante* can also be applied to in times of drought, when there might be more than enough water for one or two *acequias* who might have the water for that particular turn, or *turno.* The water that is shared in times of need *(auxilio)* is not a *sobrante,* or excess water, though New Mexico law does not recognize *sobrante* since the water is already over appropriated. If an *acequia* has plenty of water, instead of *desaguando* the water into the river at the end of that *acequia,* the water has to be allowed to run into the other *acequia* so they can use it, but first rights belong to the upper *acequia*. Also, such as in the case of the *Acequia Junta y Ciénaga* and the *Acequia de la Nasa,* both are independent of each other, with separate *comisiones* and *mayordomos. Acequias,* which appear easy to understand, in essence are very complex to comprehend and manage.

Suertes, Long-Lots

The land grants are divided into common lands and private lands. The irrigated parcels known as *suertes* is what originally comprised the private lands and they have their origins in the Middle East. When the Arabs settled in the Iberian peninsula after 711 they brought with them their ideas of how they viewed the land and water, which was different from the Roman ideals that were in place at that time in the peninsula, though the Laws of the Indies were strongly influenced by Roman Law. To the Arabs the irrigated or appropriated lands were known as *"mamluka;"* under The Laws of the Indies, which dictated how the lands had to be apportioned, these appropriated lands became known as *suertes.*

The reason these pieces of land became known as *"suertes,"* was because they were given to the settlers of the land grants based on a lottery, or *"suerte,"* which is luck. The *suertes,* especially under Spanish law (Mexican grants seemed to have operated different, i.e., the Sangre de Cristo land grant in southern Colorado for example), were those lands that fell below the *acequias,* and were therefore the irrigated pieces of land. It was the *acequia,* which divided the private lands from the common lands.

The reason for the *suertes,* or long-lots, was so everyone could have access to the river and to the commons; this type of land distribution made sure everyone had good land for growing crops but also land for the domestic animals such as a milk cow including grazing a few sheep close to home. *Suertes* were then divided into the *altitos,* or highlands where fruit trees were planted; below were the *joyas.* Still today you find people when talking about their individual piece of land where the best land is located as *"la joyita."*

Velarde in the Española Valley was originally known as *La Joya* due to its fertile lands. There is also a *Joya* by Belen. Below the *joya* was the *vega,* which can be used for planting, but in New Mexico is most commonly used for pasture for the domestic animals and below the *vega* was the *ciénaga,* or the marshland. *Ciénagas* can also be used for growing crops if they are drained, or *sangradas*.

This type of land division was not oriented towards growing for a market, but rather to provide for the community, which was usually a very tightly knit society based on familial ties. In a way it was an intentional community, which is now the rave among the rich in the Santa Fe area. But these intentional communities were composed of *"campesinos"* or rural people, farmers whose pieces of land were rather modest of only a few acres. These land holdings were known as *minifundias* compared to the land holdings

of northern Spain known as *latifundias*, which were very extensive and usually used for livestock grazing.

In Spain these *minifundias* when under the care of the Moors could feed a family of four, but when taken over by the Castilians who were unfamiliar with this type of irrigated farming could barely feed one person.

The traditional land divisions served a purpose. *Altitos* were usually where the fruit trees were planted since they were less susceptible to freezes due to the cold settling at the bottom towards the river. Also, each one of these land divisions has a different microclimate and the traditional landowners knew exactly what could or could not be grown. Another important factor was that the irrigated land was never used for housing but now since a lot of the land grants are no longer intact and the Bureau of Land Management and Forest Service now own most of the common lands and the population has grown, the cultivated lands are becoming residential suburban style lots.

Vega, then, refers to a low land that is humid and level, or *llano*, and comes from the word *a vigore*, because it's vigorous and fertile. In Arab it signifies, *"a tierra de labor puesta en llano,"* or a level land that is worked, or planted. In New Mexico it refers more to an irrigated pasture whereas in Andalucía it's where food is grown, such in the Vegas of Granada, Valencia and Murcia. And *ciénaga* comes from the word *cieno*, which is usually a black mud, smelly and soft, which is neither mud nor water and without draining can only be used marginally for grazing.

Ideally most *suertes* would be composed of *altitos, joyas, vegas* and *ciénagas* but not all contain all four types of land, especially now a days, as the land is broken up into smaller and smaller parcels and the concept of the land with its origins in the Middle East is all but forgotten.

Suertes, it must be understood, were arranged in terraces, with the *altito* being the highest terrace, followed by the *joya, vega* and finally the *ciénaga* being the lowest of the terraces, along the river bank. Also, there are different types of terraces or *terrazas*, also known as *bancos* or *bancales*, and *ancones*. There are terraces along the valleys and on slopes, and those by the meandering of a river are known as *ancones*. Terraces are watered by diverting water from the *acequias*, therefore it is the *acequias* because of their rigid design patterns which give birth to the *suertes*.

Historically the *suertes*, as mentioned earlier, went from the *acequia* to the river but there are also places in the Río Arriba bioregion, such in the San Luis Valley of southern Colorado, where the *suertes* extend above the *acequia*. In San Luis these long-lots are known as *extensiones*, or extensions.

But this type of agroecosystem whose roots can be traced to the Fertile Crescent, with modifications made in southern Spain, then in Mexico and finally arriving in New Mexico in 1598 is now on the verge of disappearing. Very few people now know how this type of system operates, and less the history about its origins.

A similiar system of land division also exists in Hawaii, known as Ahupua'a and is more in tune with the *extensiones* of the San Luis Valley, since these strips of land divisions originate in the mountains and go all the way to the sea.

The Joyas

Now lets further dissect the *suerte* by focusing exclusively on the *joyas* from the Tuscan word *gioia,* which means happiness but also something very precious such as a

jewel. Translated to land this meant the most fertile lands where people usually plant their chile and other vegetables for home use or in those days to trade for what they didn't have. This form barter still practiced today is known as *cambalache*, from the word *cambiar*, or to trade.

Traditionally these lands were used for growing food, that is, the *huertas* or large vegetable gardens and *jardines* or small gardens were planted in these strips of irrigated land also known as *tablas*. The term *huerta* comes from the latin and from there the term *hortelano*, he/she who works the land for food. *Jardin*, or flower garden, from *riardin* is more tied to the Arab concept of garden. Others say it's from the German and from there adopted by the French as *jardin*. But in northern New Mexico we added the concept of *milpa*, from Mesoamerica, referring to a cornfield.

Thus the *joya* was where the *huerta de chile* and *milpa de maíz* were planted and also the *melonar*, or where melons and watermelons were planted which had to be sandy soil. The farmer thus knew his land like the palm of his hand, he knew were he could plant what because he understood the microclimate of his place. But to understand the *joya* and how it is understood by those who work it, the *joya* was further broken down into *melgas*, from the word *mielga*, which came from Italy from the region of Media, a corruption of the words *medica herba* which was a common pasture plant for animals. The Arabs called the plant *alfalfasat* or alfalfa. Here this cultivated *mielga* became a piece of land where alfalfa was planted. An emelga is known as the land between two sulcos or surcos, the land between two furrows. In New Mexico this type of land division, or *melga*, has become known as strips of land that have been broken down into manageable parcels of usually fifty feet in length and the width of the *suerte*. A *melga* when it is part of the *joya* can further be broken down into *eras* as a water conservation strategy. There are two types of *eras*, one is for threshing wheat or other grains and that is located in the commons, and the other is in the form of a sunken bed. Among the Zunis these beds are known as waffle gardens.

An *era* usually refers to the place the *hortelano* plants lettuce, radishes, and other vegetables, and it is also known as an Afghan garden, which looks like a comb. Today these type of beds are still found in New Mexico and also in the outskirts of Chihuahua City.

Traditionally, before people started building on agricultural land, people would never build on food producing land, or if there was no other alternative, it would always be on the most marginal space - on a slope - or where the soil was very sandy or gravelly. No one would ever think of building on the *joya* (the jewel), the most fertile land, which was set-aside for the *huerta de chile* and *milpa de maiz*. In the fall the *suerte* became a *rastrojo*, the stubble from the corn stalks, *chile* plants, or whatever else was grown was opened up for the livestock. The livestock not only cleaned the land, but they also fertilized the land with the manure that was left behind. This type of landscape always provided for a variety of soils, from excellent to not very desirable, but also access to the river to get water when the *acequias* were shut off during the winter. In a traditional garden, *huerta* or *milpa* water conservation is very critical. In Mesoamerica, watering was equally important in the way the waffle gardens, or *eras*, and *chinampas* were constructed. *Eras* were the opposite of the raised beds familiar today, in that they were sunken beds to retain the little moisture of the desert environment.

Terracing has always been a very important concept of traditional agriculture, and in the Indo-hispano tradition we are heirs to the terraces of the *Alpujarras* south of Granada, as well as the terraces of Michu Pichu in Peru. Terraces were also abundant around Mexico City during the reign of the Aztecs. Every village in northern New Mexico has terraces and if no longer visible to the untrained eye, once the landscape is peeled back like an onion, their outline appears and they can once again be reconstructed. I have identified four types of terraces based on oral history (this is nowhere found in books): *bancos* on slopes, *bancales* in valleys, *ancones* by the river and small garden terraces that resemble a flat mud roof, *sotellitas* from the word *azotea*. Terraces were constructed to hold the soil back, and also this way the *"flor de la tierra,"* or the most fertile soil, is retained and used for growing food. Also, terraces were a way of bringing the water in a beneficial way from high up above to the bottom, and be able to use the water again and again, without the negative effects of erosion; another conservation strategy.

APPENDIX G

One Man's Granite

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AN INTRODUCTION

TO GEOLOGIC THINKING,

'DEEP TIME', ROCK TYPES, AND

ROCKS OF THE DIXON AREA

Copies of this book as well as "Bones and Stones" can be obtained at Dixon Cooperative Market in Dixon (please support local knowledge)

"God's motto is evolution."
--a crazy girl from Kerala

What Geology (Science) is and is not:

Science--in this case the science of Earth, Geo-ology, or Earth's logic-- is not the establishment of
The Absolute Truth.
Science is a *process* that is constantly evolving a new and *hopefully*, more complete picture of what our **five senses** tell us about the world around us.
Now, only a fool would deny that some other kinds of senses exist.
Sharks, for instance, seem to sense electric fields. Does this mean that sharks live in another reality?

Yes in one way and no in another…

Another example:

How do you feel about your job?
How do you feel about your lover or your children or yourself?
Well, *where* are you having these feelings?
They're not a flavor or a color are they?
Does this mean they don't *exist* or just that they are not amenable to 'scientific' reasoning?

My point is that Geology (Science) can only tell you what

taste,
smell,
touch,
sight,
and hearing
can tell you about
rocks and dirt and Earth's history. (or anything else)
Now , to believe that what the five senses tell you is valid…
To believe that what they (your senses—not that other 'they") tell you is true whether **you** *exist or not* and is true in some sense *for all time* is a faith.
Geology/Science is a sort of
religion of the five senses and
is fundamentally sensual,
carnal in nature,
and rooted in the experience of being human.
.
Since nobody can get around to seeing-tasting-hearing-smelling-touching IT *ALL* we must rely on other people to do some of it for us.
One of the trickiest parts is figuring out who is playing by the rules--even at the stage of just observing (seeing, tasting, etc) things.
Then you get to the truly messy business of
INTERPRETING the facts that observation reveals.
The rock *is*
is a fact.
The rock is granite
Is a fact
(as long as you agree on what the sound 'granite' means.)
The granite
was formed by the cooling of magma (molten rock)
Is *practically* a fact
(based on a lack of any other reasonable hypothesis consistent with other known facts)
The granite was generated by the collision of North America with another continent
Is an interpretation.
Subject to change.
Maybe wrong.
But
Maybe right!

Scientific interpretations
(being ever-changing and *always* based on some bogus facts and *always* based on an incomplete set of facts)
do **not** give simple answers to questions of what to *do*.

Remember this the next time someone tries to tell you how to live based on a study.
Geology can however, open your inner 'EYES' to marvelous happenings in the history of this planet,
and in this way geologic science is as close as you are likely to get to time travel,
friend.

If your body can't go then send your mind…

…but never trust your mind--
much less anyone else's mind--
completely.

What follows is one man's interpretation of the geology of this area as interpreted from a smattering of facts and a shelf full of scientific papers and books.

But first, let's just talk about time and the types of stones for a bit…..

Billions of beautiful years.

Geology inevitably deals with huge spans of time.
I don't believe many people really really understand what a million years is like;
and hundreds-of-thousands sound a lot like thousands-of-millions pretty quickly don't they?

So, being a firm believer in rounding things off and approximating—especially when dealing with spans of time so out of our normal experience…
….being a believer in over- simplifying if it makes a point that is worth making….
I propose the following system:
Let's say that Earth is a nice, round 4.5 billion years old. (and let's ignore the fact that the length of a year has changed through time—no kidding—and that a 'billion' means different things in different parts of the world).

Ok, now let's talk about the age of rocks as a *percentage* of that 4.5 billion years

--This system would make **Earth's** age = **100**%.
(and everything ON Earth will then necessarily be less than 100%)
Something half as old as Earth (2.25 billion years) would be = 50%
Something a tenth the age of Earth (450 *million* years) would be =10%

GET IT?

The age of the **Universe** is then between **200** and **400** %
{Seriously, that's the current range of ages according to the books I have.
Astronomers can only *look* out there—there *is* no feeling, smelling, or hearing in space}

The earliest evidence of Life (single celled) is at ~ **77**%.
(by the way, I really like that "~" symbol. It means "about" or "maybe"—in other words: "at the present time we sort of think that life began about 77% or so.")

Plants 'invaded' the land (with no living opposition) at ~**10**%
(Actually ~9.8%--but always feel free to round things off, I say—there *will not be* any test)

The **dinosaurs** died out and birds and mammals (and frogs, snakes, etc…) really got going around 1.5%
Some little rat-like things were around since about 5 % and birds supposedly *are* dinosaurs.

Humans came on the scene at ~.00056%

Writing was invented at about .00013 %

Yesterday is : .000000000006% ago.(a number with so many zeros after the decimal that you start to get those same problems with meaninglessness, no?)

Throughout what follows below I will put these percentages in parenthesis after ages or spans of time are mentioned.

That's the best I can come up with for simplifying what they call 'DEEP TIME'.

Confidentially, even good, old, shallow time gives me some problems.

There are billions of beautiful stones but…

…THERE ARE ONLY THREE (basic) TYPES OF ROCKS
1) The Broken
2) The Cooked
3) And the Melted

Broken stones move downhill, downstream, and/or downwind. They sometimes later trap lightly cooked slime (that is, oil—actually mostly dead plants and bacteria and *not* dead dinosaurs by the way) that wars are fought over. If the broken stones (sand and gravel and clay) find a basin to land in, they may be preserved as **sedimentary rocks**).
Cooked stones change their form (like cooked dough) and in the process create most of the gems wars are fought over. The cooking happens when rocks are buried far enough (by sediments laid down above—which also give them a good squeeze) that they get hot enough to change form; like a butterfly in a cocoon except *without ever becoming a liquid*. They become **metamorphic rocks,** as a butterfly is a metamorphosed caterpillar.

Melted stone cools if it gets into a cool enough spot (near enough to or on the surface) and in the process concentrates many of the precious metals that wars are fought over. The heat to melt stone comes ultimately from the radioactivity of a small percentage of Earth. If the melt finds a way to the surface it is called lava and if not it is magma. Cooled lava is called volcanic rock (named for Vulcan, the blacksmith of the Gods) and cooled magma is called Plutonic rock (for Pluto, the God of under Earth). Cooled lava and cooled magma are collectively known as **Igneous rock** (from a Latin word for fire).

Dixon has a little of each.

There are billions of years behind us but…

…THERE ARE ONLY FOUR (basic) AGES OF ROCKS.

Now, this gets pretty complicated so stay with me here.
The four ages of rock are:
the first,
the second,
the third,
and the fourth.

Huh?
I thought there was a beezillion names for different time periods ?
Weellllll, ok, there are.
But In the Beginning (of Geology, not time), they didn't know diddly-squat (technically speaking) about fossils or about how much time there *was.* They *could* see that there were four basic ages of rock and they could tell which was oldest and which youngest because the first one to get there is the one on the bottom. Think of when you 'dog-pile' somebody—who gets there first?.
The one on the bottom.

The **Primary (First)** rock is what is under everything else, the 'basement' rock. It is all from the melted or cooked categories.
The **secondary (Second)** rock is made up of pieces of the Primary that have been moved by wind and water, so it's all (mostly) of the broken type. This type forms vast blankets that cover much of the Primary. Much of it is derived from mountain ranges that *have been completely eroded away.*
The **Tertiary (Third)** rock is made up of pieces of the Primary and Secondary that have been moved by wind and water, so it's all (mostly) of the broken type too. The Tertiary rock, however, is (usually) found in proximity to known mountain ranges and you can trace the stones in it back to specific Primary and Secondary rock sources.
The **Quaternary (Fourth)** rock is all (mostly) sedimentary too and is distinguished from the Tertiary in that it is clearly related to the *present landscape* (e.g. It is the deposits left by modern rivers as they carved their valleys.)

Now, what is all of that “all (mostly)” and “is (usually)” stuff?

Well, it’s a little more complicated than that ...
And some of the cooked and melted turn out to be younger, Third rock when age-dating comes along….
And Earth is not a simple place in many respects…
…But, I say these terms are simple, valid, and a good way to make Geology more easily understandable, so let’s use them here.

Literally here, in DIXON.

First rocks in the Dixon area.
The first rock goes from 4.5 billion years to 570 million (0.57 bilion years) --from 100 % to 13%--*it covers **87 %** of all time*.
***Granite* is the name for one rock type formed when molten rock (magma) cools into a solid under the earth.**
So granite is in the ‘melted’ category.
The continents are made of granite.

Actually,
the continents are made of a suite of rocks that are commonly called ‘granite’, but can be further subdivided into granodiorite, diorite, monzonite, quartz monzonite, etc…
These subdivisions are based on each geologist’s estimation of the percentage of three minerals that make up the bulk of all these rocks, and estimates made by eye alone are notoriously variable between individuals.
One man’s granite is another person’s granodiorite. {Again, remember that this is the type of subtle vagueness that underlies all science. This is one of the reasons why your heart is just as valid a source of information as a clinical study-----both have uncertainty. The TRUTH is slippery.}

Actually,
the continents are made mostly of ‘granite’ and cooked (metamorphic) rocks that this ‘granite’ has *intruded into* and then cooled. However, if you melted these metamorphic rocks completely (and most sediments too by the way) and then gave them a million or so years to cool you would have----ta-da!—‘granite’.

The continents are of granitic composition.
(The spell-checker doesn’t like it but you *can* make a rock name into an adjective).

Granite is less dense than the stuff underlying the oceans (Basalt is that stuff’s name—we’ll get to it in the Tertiary) and that is why the continents are above the water and the oceans are not.

LOOKING NORTHEAST FROM THE DIXON CO-OP

Those high hills to the northeast of the Dixon Co-Op—above Apodaca-- are made of Granitic rocks. And the beautiful rocks at the west end of the Embudo Valley—just up from the main highway towards Dixon where you go through a narrow stretch—are examples of the cooked (Metamorphic) rocks that the granites intruded into. These metamorphic rocks are also easily seen in spectacular road-cuts on the way to Penasco. The Metamorphic rocks in this area are at least 1.7 billion years old (38%). This is known by combining two facts:

1) The granites intrude the metamorphic rocks (they squeezed into them when they were still liquid) and

2) The oldest Granites are ~1.65 billion (37%) according to radiometric ages—so the metamorphics are at least a little older

This illustrates a very basic, yet profound insight that geologists had a couple hundred years ago. Namely (drum-roll please), a thing must *exist* before you can *do something* to it. This concept is basic to allll geology and is how geologists figure out relative ages (younger versus older) of rocks without spending a dime on age-dates.

Now, these rocks are clearly hella' old, but are less than half as old as Earth. At the time these rocks were forming the earliest multi-cellular life was getting under way after a long period of single-celled life known as

"The age of slime".

The multi-celled life was, technically, 'slime'

—but was slime more like ourselves than that which came before it.

The metamorphic rocks which now represent the First rock in this area were originally laid down as sediments in a sea. Since all life at the time of which we speak was *in the sea* it is remotely possible that the first (maybe even *the very first*) multi-celled things wiggled and strove and broke wind in these very rocks! One of the types of wind they broke was oxygen and you are breathing that very wind *right now*.

Now, the granites in this area are not all of one age-they did not all intrude and cool at the same time. They span the time period from 1.65 (37%) to about 1.3 (29%) billion years ago and the younger they get the *deeper within the earth they cooled*. (This is known by analysing the specific minerals in each granite.)

The oldest one was intruded at about a half mile below the surface while the youngest cooled at something in the neighborhood of FIVE MILES DOWN. The easiest way to get these rocks further and further down is to bury this patch of Earth with sediments. That means that five miles of sediment was deposited on top of those rocks (check out how far this is with your odometer). It also means that since then *five miles of sediment have been eroded away* from this area to re-expose them.

This gives some hint of just how much time a billion years is and how profound the changes in Earth have been. Many mountain ranges—many entire landscapes-- have come and gone.

You can see one of these granites if you go east from the Dixon CO-OP and then over to Apodaca.

This one is officially called "the Puntiagudo Granite Porphyry"

"Porphyry" means it has some big crystals in it (about half an inch in most places) and "Puntiagudo" is Spanish for "pointy" and is the name of the pointy peak yonder.

This is one of the older granite bodies around here (~37% or 1.65 billion years old) and was intruded into Earth at a depth of ONLY about *two miles*.

Second rocks in the Dixon Area

The secondary 'covers' the period from 570 million years ago to 65 million years ago (from 13 % to 1.4% --*it covers about **12 %** of all time*).
Secondary rocks *cover* **none** of the land around Dixon today.
But that won't keep me from saying a few things anyway.

All the secondary rocks in this region are found to the East of here. They are mostly on the East side of the Sangre de Cristo Mountains because these mountains have been uplifted on the West side and the Secondary rocks have been eroded away in the Dixon area.
These secondary rocks to the East are sediments deposited by ancient oceans—in this case about 300 million years (7%) to about 65 million (1.5%) years old.

Notice how the percentages have gotten a lot smaller since the Primary?
All that missing 'rock record' represents the period of deposition and then erosion mentioned before (the five miles of sediment).
This means that 1.1 Billion years (24%) of Earth's history is just not recorded at all in this area.
This is a fairly typical time span to separate Primary from Secondary rocks and is often referred to as "the Great Unconformity"—any missing part of the rock record being known as an unconformity.

Third rocks in the Dixon Area

The Third covers the period from 65 million years ago to 1.6 million years ago (from 1.4 % to .04% --*it covers about **1 %** of all time*).

TO THE SOUTH OF DIXON

Although the Secondary rocks are missing from the Dixon area they did provide one source for the sand and gravel of Tertiary sediments that make up the wonderful badlands to the south of Dixon (behind the Dixon co-op and that whole side of the Embudo valley).
The source of these sediments is mostly to the East near the Truchas peaks (the spectacular, sharp peaks to the east, you can see them on the drive up from or down to Santa Fe).
Now, the Truchas peaks themselves are composed of First rocks but they are surrounded by thick deposits of Secondary sedimentary rocks. Since you can tell that the Tertiary sediments came from this area by measuring the orientation of channels in these sediments, this means that the Secondary rocks once covered the Truchas Peaks area but have been eroded away.
Now, fossils in the Tertiary rocks south of town are known (by comparison with other areas and the whole 'fossil record') to be ~ 10-13 Million years old (0.2-0.3 %). This tells you *when* the Secondary sediments were stripped off of the Truchas peaks and implies that this is when the peaks rose up rapidly.

This is one of the ways that geologists reconstruct Earth's history (although there is still a lot of arguing to do over the details, the basic story is there for anyone with a little background information to 'see').

About those "fossils found in them":
There are very few known. Four to be exact. The ones already identified are:
A type of CAMEL,
A BONE-CRUSHING DOG (imagine a dog with big, deep, jaws that lived by scavenging),
and A RHINOCEROUS-type thing.
Fossil experts interpret these animals as indicating a savannah-type environment at that time.

NOW, LOOKING WEST FROM DIXON

The first concept is ……
Inverted (or upside-down) topograpy.

This is the case where a place that *was* a river valley once is filled up with something very hard. Sometimes they fill with oodles of big river cobbles, and sometimes they fill up with…
…LAVA.
Some kinds of **magma** (underground melted rock) make **lava** (above-ground melted rock) that explodes********** and some kinds of magma make lava that flows like water.

Downhill to the nearest stream bed that is…

…and then they cool off and harden into a black rock called basalt.

Basalt underlies all of the oceans on Earth and is not uncommon in New Mexico.

Now, the next time rivers erode down into the landscape
the ancient river valley filled with lava will often be harder than the surrounding rock.
The lava ends up capping a **Mesa** .
Or in our case La Mesita (little mesa).
This is the name of the black-capped mesa up above and to the left as you go toward the main highway on your way out of Dixon to Rinconada or Embudo.
That mesa up there was the *lowest spot around* when some erupted out of vents near Taos about three million years ago (about the time our 'family' separated from the orangutangs if you believe in that sort of thing).

There is one spot up on La Mesita where the lava flowed *into* water.
Now, as you follow the gorge to the south or north from Dixon there is black-capped mesa on both sides and it turns out that the cap is made of some of the same lava flows as the cap on La Mesilla.

These lava flows flowed down a river valley that paralleled the modern Rio Grande—
but was not in a gorge.

By the way, Black Mesa near Santa Clara Pueblo is the same type of thing.

As are most of the other places called “Black Mesa” in New Mexico---of which there are many.

The rivers around here started to cut down not too long after the basalts filled what
was the lowest place around
at *that* time.

Fourth rocks in the Dixon Area

The Quaternary covers the period from 1.6 million years ago until today (from .04 % to 0%--it covers *only four hundred<u>ths</u> of one percent of all time*).

You may have noticed that each successive period is *way* shorter than the last. This is because as you get closer to the present finer and finer divisions are possible because more detail is preserved.

I got into (specialized in) the Fourth rocks in school
because I thought it would be simpler--
because its younger and shorter.

HA!
When you study the most recent events in Earth’s history
you can tell what you can’t tell.
(And you can ‘see’ finer divisions of time.)

The Quaternary is a song sung (mostly) by rivers.

The history of a river is determined by:
How much snow fell at different times of the year, how quick the snow fell,
how much rain fell and whether it fell all at once in a deluge or gently in a ‘female’ rain, what type of sediment was in the river and what type of rocks it was made of,
what the vegetation was and how it changed,
what the mountains were ‘doing’ (rising *and* eroding or just eroding away),
if there where any mountains,
how much relief (difference in elevation from high point to low point) there was,
the shape of the hillslopes at the time,
what kind of animals grazed there,
etc
etc
etc
It gets kind of complex when you start to think about it.
However, some things are clear:

For example, Rivers Carve their *own* Valleys.
Leonardo da Vinci noted this in a notebook—but then the idea lay dormant for centuries.
There was never a Rio Embudo as big as the Embudo Valley but *Rivers like it carved the whole landscape around you since the Basalt was erupted onto La Mesilla!*
One river's worth at a time—know what I mean?
Rivers meandered back and forth across the Embudo Valley and storm-by-storm they moved the sediment that once filled the space above you downstream.
Sometimes they left footprints…….sometimes they left little bits of :

Fossilized rivers

NOW,
LOOK TO THE NORTH FROM THE DIXON CO-OP

There is a flat spot below the skyline. This is known as La Pareia or Horserace Mesa.
It is relatively flat because it was cut by the Rio Embudo and river valleys are relatively flat. You can tell it was cut by this river because it is underlain by ten or twenty feet of river cobbles and sand that is the same as the river cobbles and sand going by in the Rio Embudo today. These are some of the abrasive material the river used to carve out this beautiful landscape you are in.
If you look carefully around the Embudo Valley you will see lower and higher levels that are also old paths of the Rio Embudo and have the same type of cobbles on them.

If you look at rivers throughout northern New Mexico you will see similar features.
These features are called river terraces because they sometimes form features that are like the
terraced gardens of Babylon and the terraced hillsides of the Inca.
Collectively these many terraced valleys tell us that the whole of Northern New Mexico is in a *period of incision*.
Northern New Mexico is currently in one of those periods of "down-cutting" of the landscape mentioned above in the discussion of La Mesilla.
And that is why we have such spectacular scenery –at least the part of 'spectacular' that comes from RELIEF.
The rivers of Northern New Mexico have been cutting down into the landscape during at least the last two or three million years or so (.04--.06%), since that is how old the basalt is on La Mesilla that marks the level of the base of the '*fossil* Rio Grande' at that time.
{Incidentally, the 'Rio Grande' of that time was a relatively minor stream.}
Now, recall that Earth has swung back and forth from 'Ice- ages' **{**with ice-caps that extended well down into America and glaciers in the mountains here**}** to 'less-ice-ages' **{**like now, with ice only at the poles and a few very high places**}.**

This has happened at least ten times in the last million years.
How do you think those ice/no ice cycles have affected this river valley here?

Do you think terraces form when there are glaciers or when there are not glaciers? These are the type of question Quaternary geologists ask and it may be that some of them will have reasonable answers before I die.

Two or three additional concepts

Contacts.

One of the main things that geologists do "in the field" (that is, when they are making maps of the rock types in an area) is TRACE CONTACTS.
A geologic contact is the place where two rock types meet.
Contacts are of three (basic) kinds.
ONE: One type of rock is *deposited* by water or wind on top of another **or** flows onto it as lava. These are known as depositional contacts.
TWO: One type of magma (melted rock) *intrudes* into another rock type and cools into solid rock there.
These are called intrusive contacts (sounds sort of criminal doesn't it?).
THREE: One type of rock is faulted against another. When you put a rock under strain (by moving the continents around on the surface of Earth) it breaks somewhere.
The place that it breaks is a fault.
These contacts are called fault contacts.
The shape of the contact as one traces it and the relations of the rocks on either side tell you what kind of contact it is and help to reveal the history of the rocks.

As you travel along the Embudo valley you are following contacts.
You start at the narrow place below La Mesita in Primary rock on both sides.
Above the narrows and as you go through town there is one kind of Tertiary sediments (purplish/reddish) off to the north (left) across the valley
and a different type (orangish/greenish) of Tertiary sediment to the south.
If you turn up 580 at the stop sign and go toward Canoncito there is Primary Granite on the left side of the Embudo Valley and Tertiary sediments (some of the greenish and some of the purplish) on the right close to the road.

At the Embudo Box the River goes back into First rock on both sides again.
If you keep going up county road 69 toward Ojo Sarco you keep following the contact between First rock on the left and Third rock on the Right.
This is a *depositional* contact. (You'll see why in a minute.)
Ojo Sarco Creek and county road 69 more or less follow this contact for a mile or two.
Look to the right going up this road and you will see layers in the sediments. Each layer kind of represents an individual stream at some particular time. Streams meander with time. If the place where they wander is *sinking* then when the stream wanders back to a certain spot that spot will be *lower* and the next layer of sediment will be deposited on top of the first.
Geologists call these layers **beds**.
When these beds *here* were deposited there were small hills of granite to the left and the sediments *buried* those hills.
Now, the other thing about beds of sediment is this:

They are nearly *flat when first laid down.*
Look at those ones to the right and you will notice they are tilting away from you about 10 degrees. This means they have been tilted that much since they were deposited there. This type of tilting, along with the age of the sediments and what they are made of etc…is another of the *fundamental ways* that geologists reconstruct the history of a place.

For instance, the granite on the left does not have layers that were flat to begin with, but since it is older than the sediments it must have been tilted too. Ten degrees does not seem like much , but if you project this tilt to the north (to the left) it is *more than enough* to account for the height of the Picuris Mountains above Picuris Pueblo which rise about four thousand feet above this point.

<u>Corestones and Joints</u>

Look at the granite now to the left. If you look down near the creek you will see sets of nearly parallel, nearly straight cracks running in all directions through this granite. These type of cracks are called *joints.*
Recall that these rocks are a third of the age of Earth, more or less. Many times in this last third of Earth's history our continent has collided with other continents. When this happens, much faulting happens at the point of collision and rocks far into the interior of the continent are *stressed*—in other words, squeezed. When you squeeze a big body of hard rock like this granite, it responds by cracking and the cracks are those joints. The different sets of joints break the granite into big cubes.

Now take another look at the granite on the left.
Notice the beautiful, big, roundish boulders lying all over the surface?
Those big stones are called corestones and here's why:

When you bury a jointed granite in sediment (like I just got done saying happened here) and then water works it's way down through the sediments and into the granite the water seeps down along those joints. The water causes what we call *weathering* of the granite. Basically, the granite crumbles into gravel-sized pieces. The corners and edges of the big cubes formed by the jointing crumble faster than the sides of the cubes.
The corners weather off first.
The *cores* of the cubes are left as big, irregular spheres.
Remember that this is all happening beneath the sediments. When you cut down into the landscape at some later time and remove the sediment those big spheres of granite are left lying around. They tell you both that the granite was buried and that it has been re-exposed fairly recently—since the corestones are still lying there.

A concluding thought:
I recently read
(Bill Bryson "A short history of nearly everything")
that all the bones in all the folks in America today

(something like 60,000,000,000 bones) will likely produce about fifty *fossilized* bones.(The chance of preserving any people that live some environments is almost zero.)
This gives an idea of what we have to work with in the fossil record. And yet…….
We do really know that evolution has occurred.
As beautifully pointed out in Richard Forty's book *Life,*
Darwin's theory of the *mechanism* of evolution may be"Just a Theory", but the fact that the forms of life have changed through time is ***Fact.***
The oldest rocks (the ones on the bottom of the 'dog pile')
have the bones of certain beasts in them,
and the younger rocks have the bones of others.
Science reveals things like this to us.
Science leads us to certain places but then it can't,
by its nature,
lead us further.
It ***can't*** tell us why.

APPENDIX H

Project Participants

This document would not have been possible without the dedication and contributions of these participants.

A very big thank you to all who gave of themselves to create this vision.

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APPENDIX I

Resources

New Mexico Environment Department, Surface Water Quality Bureau, for information on state watershed and wetland programs, TMDL's, 303d lists, water quality standards and monitoring and assessment.
http://www.nmenv.state.nm.us/SWQB/index.html

Environmental Protection Agency, an invaluable website with information on everything water, watersheds, wetlands and ecological restoration. My favorites include:

Clean Water Act Module

http://www.epa.gov/watertrain/cwa/index.htm

Principles for the Ecological Restoration of Aquatic Resources

http://www.epa.gov/owow/wetlands/restore/principles.html

Non Point Source Pollution
http://www.epa.gov/owow/nps/

Ecological Restoration
http://www.epa.gov/owow/nps/Ecology/

Total Maximum Daily Load for the Upper Rio Grande Watershed (Part 2) Cochiti Reservoir to Pilar, NM. Final Approved. June 02, 2005.
http://www.epa.gov/waters/tmdldocs/11424_URG_Pt2TMDLs.pdf

New Mexico Office of the State Engineer, for information on water quantity, water rights, adjudications and water regulation
http://www.ose.state.nm.us/

Natural Resource Conservation Service Programs, for extensive listing of available programs
http://www.nrcs.usda.gov/programs/

Rio Arriba County now has a website said to be update daily, some county ordinances are currently available, including sand and gravel mining ordinance, worth checking out.
http://www.rio-arriba.org

Mitigating the Effects of Gravel Mining upon Rural New Mexico
http://www.raintreecounty.com/Recycle.html

New Mexico Acequia Association, a good website for acequia matters especially by law creation, water banking, assistance with the open meetings act, technical assistance and workshops
http://www.lasacequias.org/

United States Geological Survey, for information on large-scale water measurements such as streams, rivers and some aquifers.
http://www.usgs.gov

CLIMAS, for information on climate assessment in the southwest.
http://www.ispe.arizona.edu/climas/

University of Arizona, for information on tree ring research.
http://www.ltrr.arizona.edu/resources.html

Jemez y Sangre Regional Water Plan, for information on regional water planning.
http://www.dbstephens.com/project_plans/

Embudo, A Pilot Project for the Embudo Watershed of New Mexico, Interagency Council for Area Development and the New Mexico State Planning Office. 1963.