Prepared pursuant to the Clean Water Action Plan and
Unified Assessment of New Mexico Watersheds
(USEPA and USDA, 1998a, 1998b)

Pueblo Canyon
Watershed Restoration Action Strategy (WRAS)

Revision 0A

Issued January 25, 2004

Prepared by the Pajarito Plateau Watershed Partnership (PPWP)

PPWP Mission: "To work together to protect, preserve and restore the quality of water in the Pajarito Plateau Watershed"

http://www.ppwatershed.org/ppwatershed/default.htm

Disclosure: Any opinions expressed regarding goals and objectives of this watershed assessment are those of the principal authors and do not necessarily reflect the policies of their funding organizations.

History of Revisions

Revision	Date Issued	Description of Changes
Rev. 0	January 13, 2004	Initial revision. Version approved for posting on PPWP web site
Rev. 0A	January 25, 2004	Incorporated figures directly into report. Revised Appendix A to remove personal information. Minor editorial changes.

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Acronyms and Abbreviations

BAER	Burned Area Emergency Response
BMP	Best management practice
cfs	Cubic feet per second
DCGL	Derived Concentration Guideline Level
DOE	Department of Energy
EJRC	East Jemez Resource Council
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GIS	Geographic information system
GPS	Global Positioning System
HUC	Hydrologic Unit Code
LAC	Los Alamos County
LANL	Los Alamos National Laboratory
LASO	[DOE / NNSA] Los Alamos Site Office
mg/L	Milligrams per liter
NMDOT	New Mexico Department of Transportation
NMED	New Mexico Environment Department
NNMCAB	Northern New Mexico Citizens Advisory Board
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NSSA	National Security and Safeguards Agency
pCi/L	picocuries (10^{-12} curies) per liter
PPWP	Pajarito Plateau Watershed Partnership
RRES	[LANL] Risk Reduction and Environmental Stewardship
SWQB	[NMED] Surface Water Quality Bureau
TA	Technical Area
TDML	Total Maximum Daily Loads
TSS	Total Suspended Solids
ug/L	Micrograms per liter
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
VTF	Volunteer Task Force
WRAS	Watershed Restoration Action Strategy

Background about this Report

The Pajarito Plateau Watershed Partnership (PPWP) is a regionally-based group of technical professionals and citizens concerned with issues affecting watersheds on the Pajarito Plateau (Table 1). This area includes Los Alamos, San Ildefonso Pueblo, Española, and the surrounding areas. The group discusses issues of water quality, erosion, and water quantity for the purpose of encouraging citizens and landowners to initiate or maintain projects that protect, preserve and restore the quality of water in the Pajarito Plateau Watershed.

In order to provide a systematic approach for assessing the health of individual watersheds on the plateau and for prioritizing the need for action in each watershed, the PPWP drafted a Watershed Restoration Action Strategy (WRAS) for Pajarito Plateau watersheds in 2003. The preparation of this document was in response to the Clean Water Action Plan initiated by the U.S. Environmental Protection Agency and U.S. Department of Agriculture in 1998, which requested the preparation of a WRAS for each priority watershed (USEPA and USDA, 1998a, Chapter III). New Mexico's Unified Watershed Assessment identified the Upper Rio Grande watershed, in which the Pajarito Plateau is situated, as a Category I watershed for water quality problems.

Prioritized tasks and detailed restoration strategies are being developed and documented for individual watersheds of the Pajarito Plateau in separate WRAS such as this one for Pueblo Canyon. These documents are intended to summarize the following elements about each watershed and are to be annually reviewed and updated.

1. Watershed Assessment—This section describes the geographic setting, summarizes factors contributing to water quality impairments in the watershed, and discusses techniques used by the PPWP to conduct watershed assessments.

2. Identification of Issues Affecting Water Quality—This section describes pollutants and probable causes of water quality impairment in the watershed.

3. Overview of Member Programs—This section provides an overview of participating agencies and their activities and authorities, and each member's current and planned activities in the watershed. It also summarizes the challenges and issues that are unique to each PPWP member.

4. Monitoring—This section summarizes the results of past and present water quality monitoring activities in the watershed, and describes PPWP plans for coordinated monitoring efforts.

5. Education, Training Community Outreach, and Stakeholder Involvement—This section describes what the PPWP does to maintain and expand the local talent pool in the watershed management arena, and to share skill sets and lessons learned among the Partnership, and to inform and involve local communities and organizations in PPWP-member activities in the watershed.

6. Implementation Opportunities—This section provides an overview of the range of tools available for protecting, improving, and/or restoring water quality in the watershed, as well as the PPWP decision-making process for implementation of these tools. A list of specific restoration projects are proposed, together with corresponding monitoring, assessment, and

outreach activities, an implementation schedule, management targets, and success measures. Potential funding sources are identified.

PPWP members and other participants in the Pueblo Canyon WRAS development process are listed in Appendix A.

Table 1. Standing Members of the Pajarito Plateau Watershed Partnership (PPWP)

- Los Alamos County Department of Public Works
- Los Alamos County Utilities
- Los Alamos County Engineering and Project Management
- Los Alamos National Laboratory, Risk Reduction and Environmental Stewardship, Water Quality and Hydrology Group
- New Mexico Environment Department Surface Water Quality Board
- New Mexico Environment Department DOE Oversight Bureau
- US Department of Energy / National Security and Safeguards Agency, Los Alamos Site Office
- US Forest Service, Santa Fe National Forest
- National Park Service, Bandelier National Monument
- Pueblo of San Ildefonso
- Volunteer Task Force
- Local citizens

Pueblo Canyon Watershed Restoration Action Strategy (WRAS)

1. Watershed Assessment

1.1 Geographic Description of the Pueblo Watershed

Location. The Pueblo watershed is located in north central New Mexico approximately 30 miles northwest of Santa Fe (Figure 1). The watershed covers eight square miles of the extensive Pajarito Plateau, a five to six-mile wide apron of volcanic rock skirting the eastern slope of the Jemez Mountains (Figure 2). Pueblo Canyon is an ephemeral tributary to Los Alamos Canyon, which drains into the Rio Grande above Cochiti Reservoir. Los Alamos and Pueblo Canyons are within the Upper Rio Grande watershed (U.S. Geological Survey Hydrologic Unit Code [HUC] 13020101).

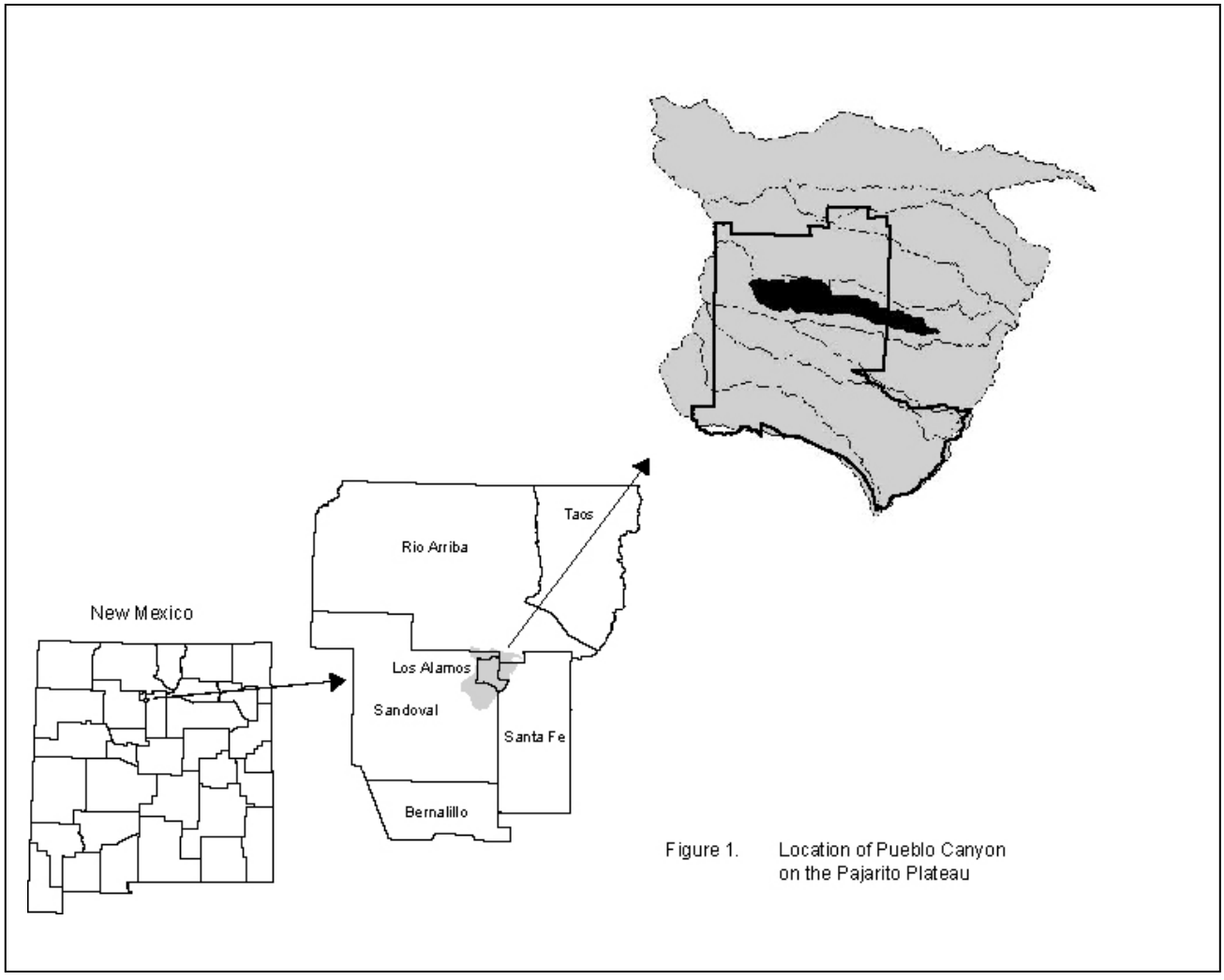

Figure 1. Location of Pueblo Canyon on the Pajarito Plateau

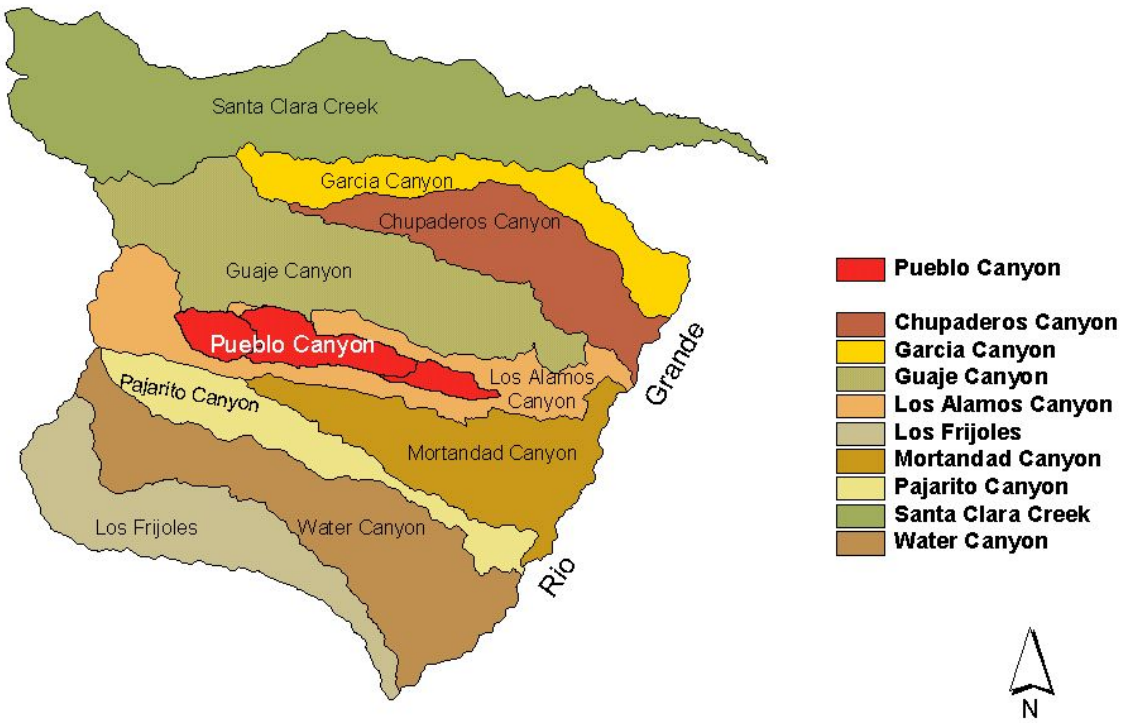

Figure 2. Watersheds of the Pajarito Plateau

Land ownership and use. The Pueblo watershed lies mostly in Los Alamos County, although downstream parcels owned or managed by the Department of Energy (DOE), Los Alamos County, and San Ildefonso Pueblo are in Santa Fe County. The watershed heads on undeveloped land managed by the U.S. Forest Service, which comprises 22% of the total watershed area (Table 2, Figure 3). The middle portion of the watershed extends east through mostly developed residential and commercial properties on the mesa tops, intermixed with County-owned open space and public utility infrastructures. For the most part, the canyon bottom is undeveloped open space under the jurisdiction of federal, county, or pueblo governments. Developed portions of the canyon bottom are culverts at road crossings, a utility access road, and a small state-owned patrol yard. All portions of the watershed that are currently under the jurisdiction of the Department of Energy are slated for transfer to Los Alamos County (in 2007) and to the Pueblo of San Ildefonso (in 2004).

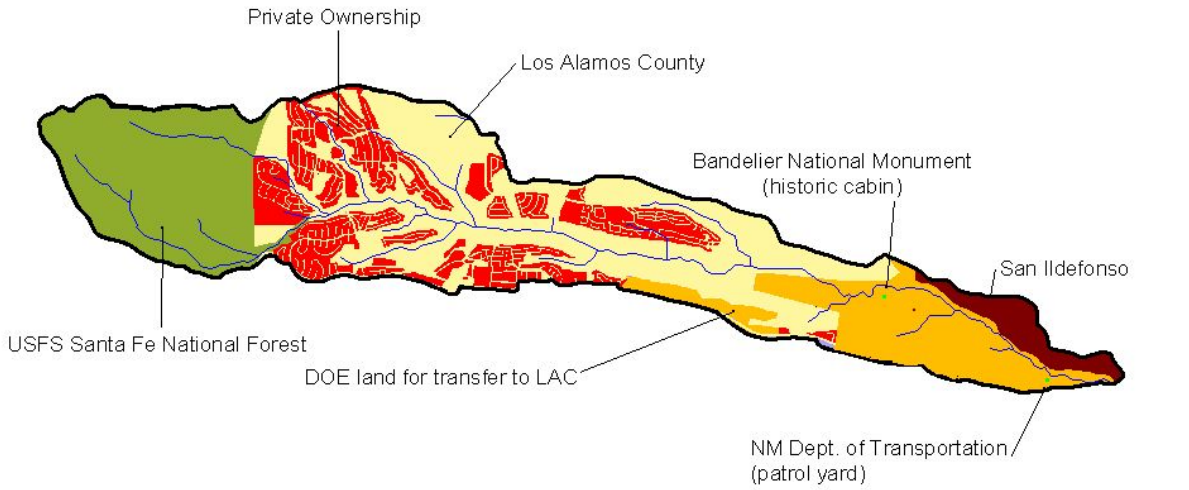

Figure 3. Land Ownership in the Pueblo Watershed

Topography. Pueblo Canyon has a channel length of ten miles before it empties into Los Alamos Canyon just east of the interchange at SR 4 and NM 502 (the "White Rock Y"). Subsidiary watersheds in the middle reach of Pueblo Canyon are Acid Canyon, Graduation Canyon, and Walnut Canyon; these are rimmed by developed parcels but are undeveloped recreational open space in the canyon sides and bottoms. Elevations in the drainage area range from 9000 feet at the top of the Pueblo watershed, to 6300 feet at its confluence with Los Alamos Canyon, to 5500 feet where Los Alamos Canyon enters the Rio Grande at Otowi Crossing. Pueblo Canyon ranges from 500 to 3000 feet in width and from 200 to 500 feet in depth (LANL, 1995, Section 2.1).

Climate. The Pajarito Plateau has a temperate, semiarid mountain climate. Microclimates on the plateau are strongly influenced by elevation and distance from the mountain crest, resulting in large differences in temperature and precipitation. Average annual precipitation increases gradually from 12 inches along the Rio Grande to 24 inches along the crest of the Sierra de los Valles, in which the Pueblo watershed heads. Although the summer monsoon season accounts for only half of the annual precipitation, convective storms that occur in June through September are responsible for most if not all of the significant flooding and erosion events in the watershed (Reneau et al., 2003).

Table 2. Land Uses and Jurisdiction in the Pueblo Watershed

Jurisdiction	Current land use	# of parcels	Acres	Percent of watershed
US Forest Service (USFS), Santa Fe National Forest	Open space	1	1212	22
US Department of Energy (DOE)	Open space[1]	10	192	4
Los Alamos County				
Public open space	Open space	52	1856	34
Public facilities[2]	Developed	26	153	3
Commercial	Developed	17	29	1
Residential	Developed	3035	885	16
Undeveloped tracts	Zoned for development	132	225	4
Pueblo of San Ildefonso	Open space	1	836	16
New Mexico Department of Transportation (NMDOT)	Developed[3]	1	2	<1
National Park Service (NPS), Bandelier National Monument	Open space[4]	1	1	<1
Total		*3274 parcels*	*5388 acres*	*100 %*

Notes:

[1] These DOE parcels are slated for land transfer to the Pueblo of San Ildefonso and to Los Alamos County. Some of the parcels to be transferred to the County may be developed.

[2] The Los Alamos County Bayo Sewage Treatment Plant is located in Santa Fe County.

[3] NMDOT owns a patrol yard at the SR4/NM502 interchange, and the right-of-way along these state roads.

[4] The NPS owns the historic log cabin at Camp Hamilton.

Data source: Los Alamos County, 2000

Vegetation. The climax vegetation type in Pueblo Canyon is spruce-fir at the highest elevation, grading through mixed conifer to a wide band of Ponderosa pine forest for elevations between 7000 and 9000 feet. Below 7000 feet, pinon-juniper grassland is the dominant vegetation. Riparian vegetation traditionally lined most of the canyon bottoms (LANL, 1995, Section 3.8.3.2). However, the areal extent and density of climax species in these zones have been severely modified by a number of natural and man-caused events which have occurred on time scales ranging from years to centuries. These include sheep and cattle grazing, logging, fire suppression techniques, forest fires, residential and commercial development, drought, and insect infestations.

Hydrology. Surface water in Pueblo Canyon occurs primarily as short-lived and intermittent stream flows. An unknown number of perennial springs in the form of low volume seeps are scattered in the upper part of the watershed. Runoff from heavy monsoon season thunderstorms reaches the Rio Grande several times a year. Since the mid-1940s, stream flow in Pueblo Canyon has been dominated by anthropogenic contributions from effluents discharged from former Laboratory facilities at TA-1 and TA-45 and from three different sewage treatment plants (Pueblo, Central, and the current county sewage treatment plant) (LANL, 1995, Section 3.7.3.2). Treated effluent from the Los Alamos County sewage treatment plant, located on the low divide between Bayo Canyon and Pueblo Canyon in the lower sections of those watersheds, is

discharged at a rate sufficient to maintain surface flow for about a mile. Annual discharges are approximately 900,000 m^3.

1.2 Watershed Assessment Process

The Pueblo watershed is given high priority for attention in the PPWP's Watershed Restoration Action Strategy for Pajarito Plateau Watersheds (2003). For the assessment, the Plateau was divided into 29 sub-watersheds to identify and rank areas on the Pajarito Plateau that may be contributing significant quantities of non-point source pollution to the Rio Grande (Buckley, 2003). Based on discussion among PPWP members, the assessment currently focuses on erosion vulnerability. Preliminary criteria selected for ranking the erosion vulnerability of individual watersheds in that assessment were road density, drainage density, steepness, and Cerro Grande Fire burn severity (Buckley, 2003).

- **Road density**. Roads that are improperly designed, located, or maintained can accelerate erosion and contribute significant amounts of sediment to streams. High road density can alter the runoff characteristics of a watershed. Roads modify the natural drainage networks and can change stream flow patterns, sediment transport and storage. When roads are built near streams, the cut and fill associated with the road can affect the stability of slopes adjacent to streams. The PPWP watershed assessment looked at miles of road per square mile of watershed to rank the relative impact of roads in individual watersheds.
- **Drainage density.** The density of a drainage network reflects the geology, soils, vegetation, and climate patterns of a watershed. Drainage density is characterized as miles of stream channel per square mile of watershed.
- **Slope steepness**. Surface erosion is the movement of individual soil particles. Erosion usually has three phases, detachment, transport, and deposition. Slope gradient and slope length influence how easily soil is eroded from a slope. A long steep slope will tend to have greater erosion potential due to the fact that as slope angle and length increase runoff can achieve greater speeds and erode more soil. Erosion is a natural process occurring on landscapes. Man's activities such as road building and timber harvesting tend to increase the natural erosion process.
- **Burn severity.** Burn severity is a measure of the effects of fire on soils and vegetation in the watershed. In areas receiving high burn severity, all forest litter and duff is consumed and the soil structure may be altered to form a hydrophobic or water repellent layer. This hydrophobic layer prevents infiltration and percolation of rainfall and increases surface runoff and erosion. In watersheds where more than 10% of the watershed is classified as high burn severity, the burn area will drive erosion processes in the watershed (G. Kuyumjian, personal commun.).

Sub-watersheds were assigned low, medium, or high scores for each criterion based on their ranking among one another. Breakpoints for the scoring categories are defined in Table 3. The four scores were summed to develop a relative erosion vulnerability rating for each watershed (Buckley, 2003). The overall ratings range from 4 to 11. All watersheds burned by the Cerro Grande Fire received relatively high scores ranging from 8 to 11. Los Alamos Canyon has the highest ranking with a score of 11 as a result of its high burn severity and high road density;

Pueblo Canyon also scored in the highest categories for these two criteria. The upper portion of the Pueblo Canyon watershed was heavily impacted by the fire, with approximately 80% of this area having a high-burn severity (BAER Implementation Plan, 2000). The area just west of and within the townsite had a light to moderate burn severity (approximately 20% of the upper watershed). The fire did not directly impact the middle and lower portions of Pueblo Canyon.

Table 3. Scoring Categories for Erosion Vulnerability

Criterion	Units	Low (Score = 1)	Medium (Score = 2)	High (Score = 3)
Road density	Miles of road per square mile	< 1	1 to 1.8	>1.8
Stream density	Miles of stream per square mile	< 1.4	1.4 to 1.7	>1.7
Steepness	Percent	<15	16 to 39	>40
Cerro Grande Fire burn severity	Percent of watershed classified as high burn severity	<10	Not used	>10

Source: Buckley (2003)

In subsequent discussions, the PPWP agreed to focus its mitigation and restoration efforts on the Pueblo watershed due to the large number of values at risk, including major public and private investments (Figure 4). The canyon hosts the main sewage line for the townsite as well as the county's sewage treatment plant. A natural gas pipeline traverses the upper part of the watershed, transferring natural gas from Farmington across the Jemez Mountains to the Rio Grande valley. Archaeological ruins and artifacts, particularly in the lower watershed area, provide ample evidence of traditional uses by Native Americans extending back centuries and even for millennia (LANL, 1995, Section 2.2). The upper watershed is also laced with a popular network of recreational trails and forest roads that connect to trails in adjoining watersheds.

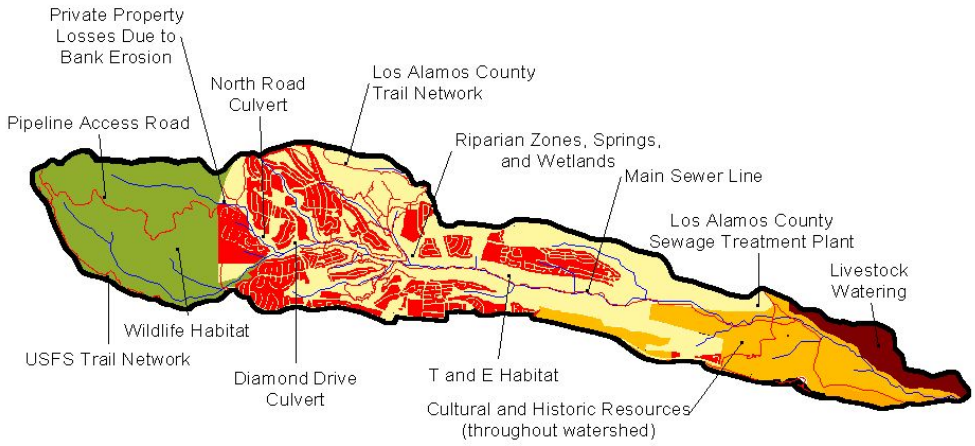

Figure 4. Values at Risk in the Pueblo Watershed

2. Identification of Issues Affecting Water Quality

Attainable or designated uses in the Pueblo watershed include coldwater aquatic life, irrigation, livestock watering, wildlife habitat, and secondary contact recreation (LANL, 1995, Chapters 2 and 3; NMED, 2003). Uses are considered attainable if they can be achieved when effluent limitations are imposed on point source dischargers, and when cost-effective and reasonable best management practices are imposed on nonpoint source dischargers. The capability of the Pueblo watershed to attain or sustain these uses has been impacted by a variety of factors:

- Concentrated population: 43% of the County's residents live in the watershed, which comprises only 6% of the County's total area.
- Concentrated commercial district: About 75% of the Los Alamos downtown commercial district is located in the watershed, with about 95% impervious surfaces.
- Wildfire damage: The upper two square miles of the watershed (20% of the total) was severely burned in the Cerro Grande Fire of 2000, with complete loss of vegetative cover and large-scale loss of soil from post-fire flooding.
- Loss of canopy cover: In the unburned lower two-thirds of the watershed, bark beetles have killed more than 95% of the piñon and more than 50% of the ponderosa pines.
- Loss of ground cover: The regional drought being experienced in the Southwest has diminished the rate of recovery of ground cover within the burned area; protective mulch applied as part of postfire mitigation activities has degraded more quickly than it is being replaced by new vegetation.
- Active land disturbance: Development in the watershed has increased since 2000 and new urbanized areas contribute significant amount of runoff and eroded sediments to the stream channel flows. This watershed is the only one in Los Alamos County in which large-scale new development is occurring.
- Remobilization of contamination: Contaminated sediments in the lower portion of the watershed are vulnerable to remobilization by channel widening.

The New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB) has listed Pueblo Canyon tributary for not meeting water quality standards because the tributary does not support its designated uses of livestock watering and wildlife habitat. The listings are reported in the 2002-2004 State of New Mexico Section 303(d) List for Assessed Surface Waters: Reaches Requiring Total Maximum Daily Loads (TDMLs). [Appendix B in the WRAS for Pajarito Plateau Watersheds (PPWP, 2003) lists water quality standards and guidelines issued by the EPA, the New Mexico Water Quality Control Commission (NMWQCC), and the DOE for inorganic constituents, metals, and radionuclides.]

Probable causes of water-quality impairment in the Pueblo watershed include (NMED, 2003):

- Gross Alpha. Four stormwater samples in 2001 were above the livestock watering criterion of 15 pCi/L total gross alpha activity, with uranium-corrected values of 1197,

78, 867, and 1569 pCi/L.

- Selenium. Three stormwater samples in 2001 were above the wildlife habitat criterion of 7.5 µg/L, with measured values of 27, 15, and 13 µg/L.

Samples collected in 2002 and 2003 continue to show concentrations above these two standards (Tables 4 and 5). Other pollutants that are not currently listed on the State 303(d) list are also of concern in this watershed. These include:

- PCBs. Two samples collected by the NMED/DOE Oversight Bureau in September 2000 were above the wildlife habitat criterion of 0.021 µg/L, with measured values of 0.8 and 0.5 µg/L (NMED, 2003).
- Mercury: Eight stormwater samples in 2002, collected by the NMED/DOE Oversight Bureau, contained mercury levels above the wildlife habitat criterion of 0.77 µg/L, ranging from 1.2 to 8.2 times the criterion (Yanicek, 2003). Three stormwater samples collected by LANL in 2003 contained mercury levels above this criterion, with values of 0.84, 0.95, and 1.3 µg/L (LANL, 2003).

Table 4. Pueblo Canyon Water Samples with Concentrations Greater than the Livestock Watering Standard for Total Gross Alpha[1], 2000 to 2003

Sampling Location[2]	Sampling Date	Sample Matrix	Result[3], pCi/L
Pueblo above SR-502	10/23/2000	Storm runoff	283 ± 118
Pueblo above SR-502	10/27/2000	Storm runoff	22 ± 4
Pueblo above SR-502	7/2/2001	Storm runoff	3070 ± 154
Pueblo above SR-502	7/26/2001	Storm runoff	1240 ± 105
Pueblo above SR-502	8/9/2001	Storm runoff	309 ± 17
Pueblo above SR-502	8/11/2001	Storm runoff	1090 ± 110
Pueblo above Acid	8/13/2001	Storm runoff	211 ± 15
Pueblo above SR-502	8/16/2001	Storm runoff	1800 ± 129
Pueblo above SR-502	10/28/2002	Base flow	27 ± 4
Pueblo above SR-502	8/26/2003	Storm runoff	90 ± 8
Pueblo above SR-502	9/6/2003	Storm runoff	533 ± 42
Pueblo above Acid	9/6/2003	Storm runoff	470 ± 24

Notes:
[1] NMWQCC Livestock Watering Standard for Total Gross Alpha, 15 pCi/L
[2] Sampling locations shown in Figure 5
[3] Results are for unfiltered samples
Data source: LA-13979-ENV (LANL, 2002b) and LANL Water Quality Data Base (LANL, 2003)

Table 5. Pueblo Canyon Water Samples with Concentrations Greater than the Wildlife Habitat Standards for Total Mercury and Selenium, 1996 to 2003

Sampling Location[1]	Sampling Date	Sample Matrix	Constituent[2]	Measured Concentration[3], µg/L
Pueblo above Acid	8/26/2003	Storm runoff	Total Mercury	0.95
Pueblo above Acid	9/6/2003	Storm runoff	Total Mercury	0.84
Pueblo above SR-502	9/6/2003	Storm runoff	Total Mercury	1.30
Pueblo 3	12/10/1996	Base flow	Total Selenium	18.0
Pueblo above SR-502	8/9/2001	Storm runoff	Total Selenium	26.8
Pueblo above SR-502	8/11/2001	Storm runoff	Total Selenium	15.1
Pueblo above SR-502	8/16/2001	Storm runoff	Total Selenium	13.1
Pueblo above Acid	8/30/2003	Storm runoff	Total Selenium	9.54
Acid above Pueblo	9/6/2003	Storm runoff	Total Selenium	6.14

Notes:
[1]Sampling locations shown in Figure 5
[2] NMWQCC Wildlife Habitat Standard for Total Mercury, 0.77 ug/L; Total Selenium, 5 ug/L
[3] Results are for unfiltered samples
Data source: LA-13979-ENV (LANL, 2002b) and LANL Water Quality Data Base (LANL, 2003)

- Sediment. The general standard for sediment (as stream bottom deposits) states "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." (NMAC 20.6.4.12 A.) Physical changes to the channel bottom in Pueblo Canyon along its entire length have been dramatic since the Cerro Grande fire, with six or more feet of downcutting, two feet of sediment accumulation, and a factor of five for channel widening. These changes have had devastating effects on riparian vegetation and bank stability (Ford-Schmid and Englert, 2003; Englert et al., 2003; VTF, 2003).

These water quality problems can be partially attributed to postfire changes in the quantity and quality of stormwater runoff, with associated landscape-scale soil loss, erosion damage, unstable channel banks and downcutting, and contaminants transported with eroded ash and sediments. Although always present, the frequency and intensity of stormwater problems greatly intensified in the aftermath of the Cerro Grande fire in May 2000. In Pueblo Canyon, a record-high runoff of about 90 acre-feet resulted from a 60-minute thunderstorm on July 2, 2000, causing damage on the order of several million dollars, including the loss of 2000 feet of sewer line. The amount of sediment carried by stormwater in burned watersheds is 100 to 1000 times greater than pre-fire levels (LANL, 2002b) (Table 6). Largely because of the sediment load and associated background concentrations, record levels of many metals and several radionuclides have been measured in storm runoff.

Table 6. Total Suspended Solids in Surface Water Samples from Pueblo Canyon, 1995 to 2003

Location Name[1]	Sample Date	Field matrix	Total Suspended Solids, mg/L
Acid Weir	7/28/1995	Base flow	< 1
Pueblo 1	7/28/1995	Base flow	2
Pueblo 3	12/10/1996	Base flow	87
Acid Weir	6/2/1997	Base flow	< 1
Pueblo 1	6/2/1997	Base flow	2
Pueblo at SR-502	6/12/1997	Base flow	1
Pueblo 3	6/12/1997	Base flow	< 1
Pueblo at SR-502	9/3/1998	Base flow	1
Pueblo 1	11/7/1998	Base flow	3
Acid Weir	11/7/1998	Base flow	7.2
Pueblo 3	11/12/1998	Base flow	3144
Pueblo 3	5/20/1999	Base flow	3.4
Pueblo 1	6/23/1999	Base flow	2
Acid Weir	6/23/1999	Base flow	10
Pueblo at SR-502	12/1/1999	Base flow	76
Pueblo 3	7/25/2000	Base flow	4
Pueblo 1 R	7/25/2000	Base flow	64
Acid Weir	7/25/2000	Base flow	82
Pueblo at SR-502	8/14/2000	Base flow	< 1
Pueblo above SR-502	10/23/2000	Storm runoff	8470
Pueblo above SR-502	10/23/2000	Storm runoff	10800
Pueblo above SR-502	10/27/2000	Storm runoff	3910
Pueblo at SR-502	12/6/2000	Base flow	12.6
Pueblo 2	4/3/2001	Snow melt	5.6
Pueblo 3	4/3/2001	Base flow	182
Acid Weir	4/11/2001	Snow melt	< 1.4
Pueblo 1 R	4/11/2001	Snow melt	4.4
Pueblo above SR-502	7/2/2001	Storm runoff	49500
Pueblo above SR-502	7/26/2001	Storm runoff	40400
Acid above Pueblo	8/3/2001	Storm runoff	4090
Pueblo above SR-502	8/4/2001	Storm runoff	22000
Pueblo above SR-502	8/9/2001	Storm runoff	33300
Pueblo above SR-502	8/11/2001	Storm runoff	30900
Pueblo above Acid	8/13/2001	Storm runoff	4460
Pueblo above SR-502	8/16/2001	Storm runoff	19300
Pueblo 3	4/30/2002	Base flow	24.8
Pueblo above SR-502	4/30/2002	Base flow	35
Pueblo above SR-502	4/30/2002	Base flow	39
Pueblo 3	7/29/2003	Base flow	11
Pueblo above Acid	8/11/2003	Storm runoff	47900
Pueblo above SR-502	8/26/2003	Storm runoff	8560
Pueblo above Acid	8/26/2003	Storm runoff	23400
Pueblo above Acid	8/30/2003	Storm runoff	6610

Location Name[1]	Sample Date	Field matrix	Total Suspended Solids, mg/L
Pueblo above Acid	9/3/2003	Storm runoff	1770
Acid above Pueblo	9/6/2003	Storm runoff	8300
Pueblo above Acid	9/6/2003	Storm runoff	28400
Pueblo above SR-502	9/6/2003	Storm runoff	41400

[1]Sampling locations shown in Figure 5
Data source: LA-13979-ENV (LANL, 2002b) and LANL Water Quality Data Base (LANL, 2003)

In addition, mobilization of Laboratory legacy materials in lower Pueblo Canyon has caused elevated levels of plutonium in runoff. Acid Canyon, a small tributary of Pueblo Canyon, was the original disposal site for liquid wastes generated by research on nuclear materials for the World War II Manhattan Engineer District atomic bomb project (LANL, 2002b, p. 181). Untreated radioactive industrial effluent was discharged into Acid Canyon from 1943 to 1951, when the Laboratory's Technical Area-45 (TA-45) treatment plant was completed. The TA-45 treatment plant then operated from 1951 to 1964 and discharged treated effluent with residual radionuclides. The facility was shut down and decommissioned in 1966, and was transferred to Los Alamos County soon afterwards. Several decontamination projects over the past few decades have removed radioactive contamination from Acid Canyon, but residual radioactivity associated with sediments in Pueblo Canyon includes an estimated 246 to 630 mCi of plutonium (Reneau et al., 1998). About two-thirds of this total is in the DOE-owned portion of lower Pueblo Canyon, which is to be transferred to the County in 2007. Although several studies have concluded that the plutonium in this canyon does not present a health risk to the public (LANL, 2002b, page 181), the issue continues to be controversial.

Los Alamos County and LANL costs for dredging and sediment cleanout and associated disposal of the ash-laden debris have skyrocketed since the Cerro Grande fire. Runoff and erosion problems have also been exacerbated by extensive rebuilding of burned communities in Pueblo Canyon and by new development on a large parcel of moderately steep and rocky land.

Water quality problems in the Pueblo watershed have been compounded by the erosive effects of urban stormwater flow from developed areas clustered on the mesa tops. The stormwater system for the community of Los Alamos was designed to collect and transport urban stormwater as rapidly as possible off the mesa tops and to the canyon bottoms, without any detention capability. This practice is a major contributor to the large peak flows and resulting erosion and potential contaminant transport in canyon bottoms. For example, the June 22, 2002 rainfall resulted in the second highest discharge on record (800 cfs) from Pueblo Canyon; the urbanized area accounted for about half of the runoff although it comprises only 20 percent of the watershed.

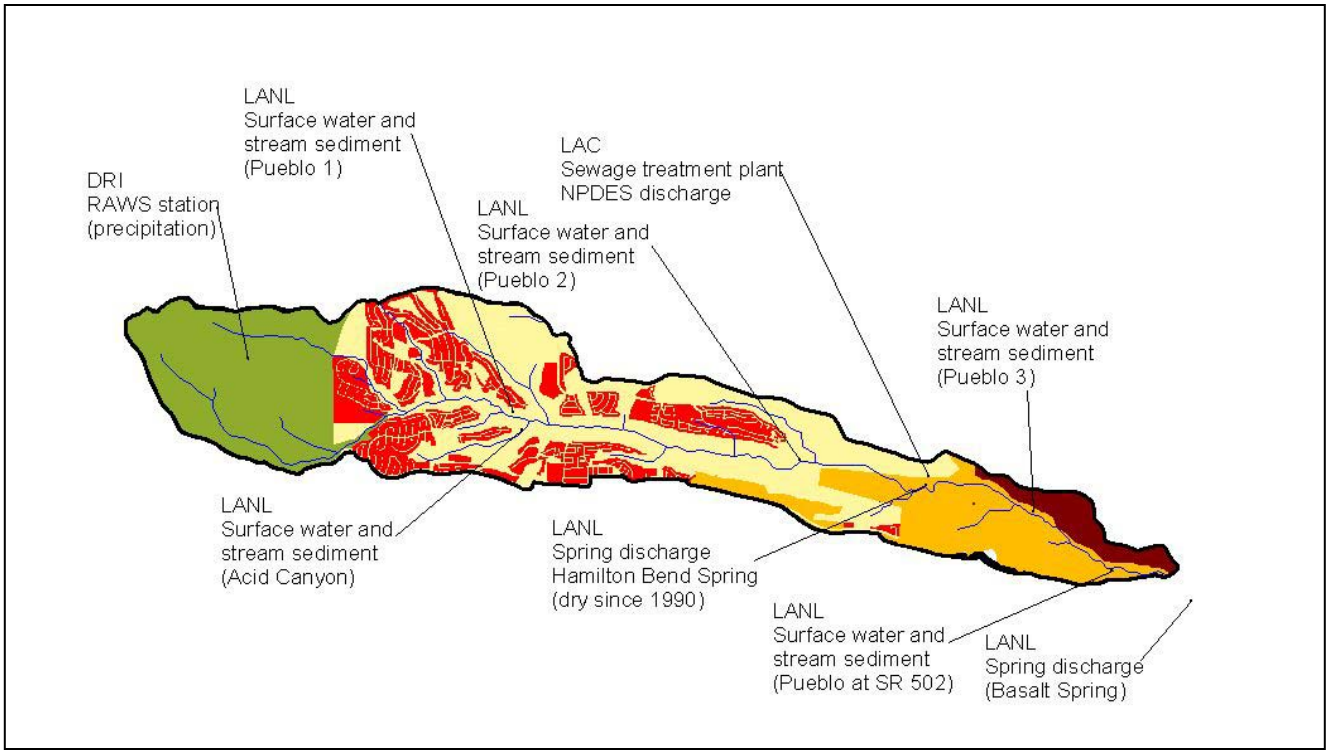

Figure 5. Monitoring Locations in the Pueblo Watershed

3. Current Watershed Restoration Activities

Current and recently completed activities of PPWP member organizations in the Pueblo watershed are listed in Table 7. Locations of completed activities are indicated on Figure 6, and locations of current activities are shown in Figure 7. Details on water-quality related responsibilities and activities of PPWP member organizations are provided in the WRAS for Pajarito Plateau Watersheds (PPWP, 2003). LANL provides detailed background information about its activities in the Pueblo watershed in LANL (1995 and 2002a).

Table 7. Past and Current Watershed Restoration Projects in the Pueblo Watershed

Project Description	Entities Involved	Location	Time Frame
North Road reconstruction, North Road culverts, Diamond Drive culvert	Los Alamos County	Middle Pueblo watershed	2001—2003
Acid Canyon cleanup	LANL	Acid Canyon	2001
Discontinued NPDES discharge (Larry R. Walkup pool)	Los Alamos County	Middle Pueblo watershed	2003
Riparian zone restoration	Volunteer Task Force Los Alamos County	North Pueblo canyon	April 2003
Ground cover restoration with seed balls	Volunteer Task Force Los Alamos County	Los Alamos County open space in North Pueblo Canyon	November 2002 to June 2003
Bank stabilization	LANL	Middle Pueblo watershed	2003

Forest management (thinning and mulching)	Los Alamos County	Upper, middle, and lower Pueblo watershed	2002 – present
Trail maintenance to reduce erosion	Volunteer Task Force Los Alamos County U.S. Forest Service National Park Service	Upper and middle Pueblo watershed	ongoing
Burned Area Emergency Rehabilitation (BAER) activities	U.S. Forest Service	Upper Pueblo watershed within Cerro Grande burned area	2000—2003
Planting aspens and ponderosa pine seedlings	Volunteer Task Force	Upper Pueblo watershed within Cerro Grande burned area	April to November 2003

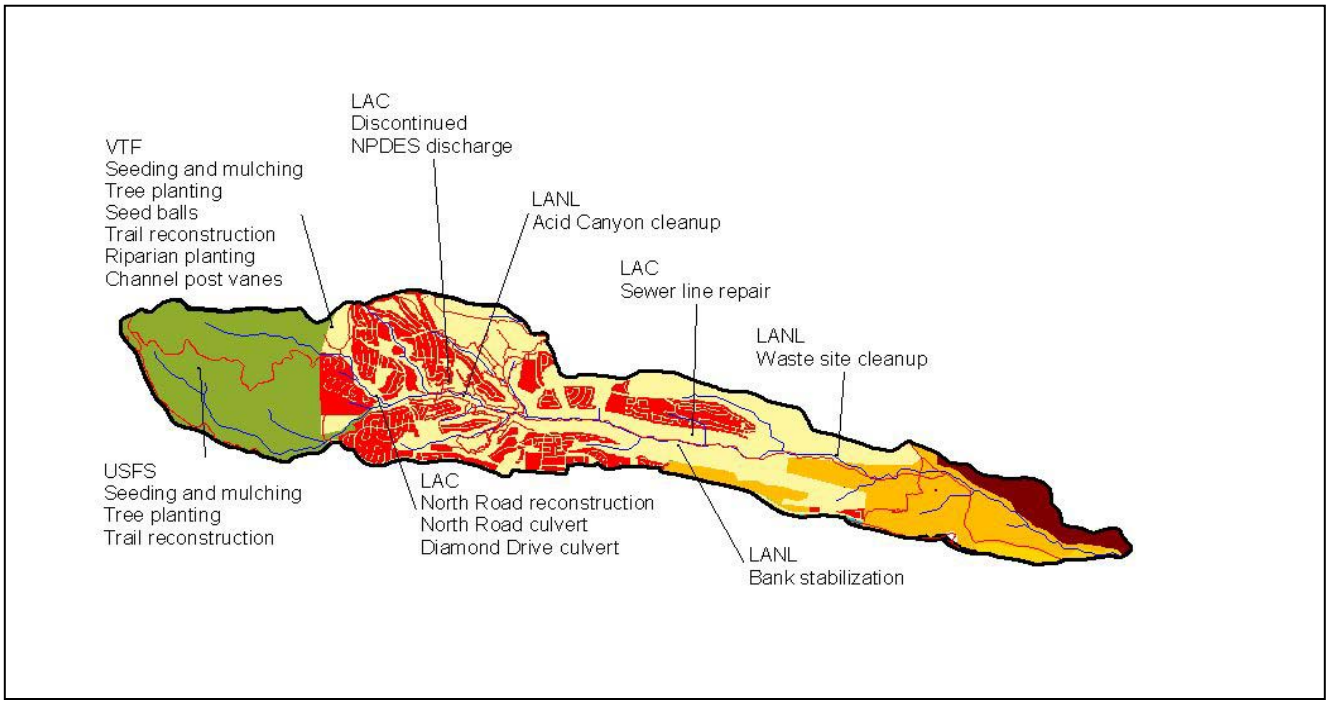

Figure 6. Past On-the-Ground Activities in the Pueblo Watershed

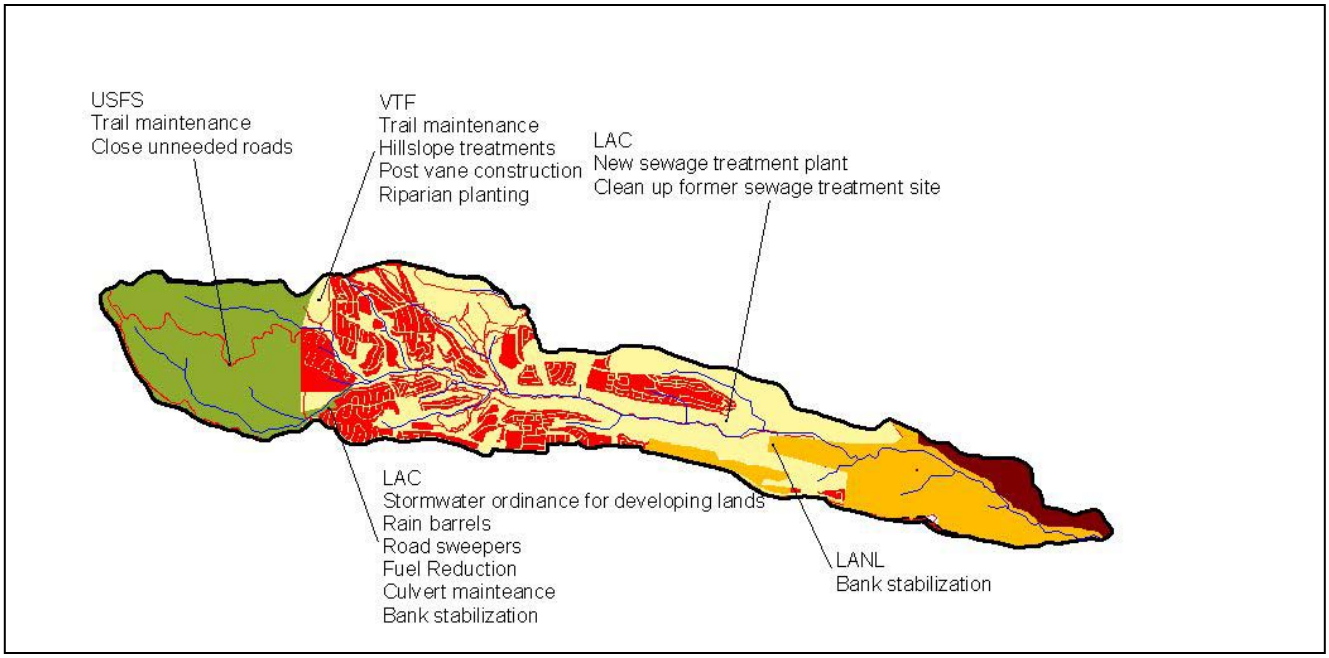

Figure 7. Ongoing and Proposed Activities in the Pueblo Watershed

4. Current Monitoring and Assessment Activities

Current monitoring activities and recently completed assessments in the Pueblo watershed are described briefly below. More information on water-quality monitoring and assessment activities of PPWP member organizations is provided in the WRAS for Pajarito Plateau Watersheds (PPWP, 2003).

NMED/SWQB. The NMED/SWQB uses a rotating basin system approach for monitoring the quality of surface waters in the state. Priorities for monitoring are driven by the 303(d) list of streams requiring TDMLs, a product of the New Mexico Unified Watershed Assessment and the Nonpoint Source Management Program. Those reaches showing impacts and requiring a TDML are targeted for more intensive monitoring. Pueblo Canyon has been proposed for listing but is not currently a targeted stream. Thus, NMED/SWQB does not conduct any monitoring of the canyon flow.

NMED/DOB. The NMED/DOE Oversight Bureau conducts routine sampling of environmental media, including surface water in Pueblo Canyon, as part of the NMED Agreement in Principal (AIP) DOE Oversight Program. The NMED/DOE Oversight Bureau has placed 40 cross-sections in lower Pueblo Canyon to continue to monitor for stream-channel adjustments (Ford-Schmid and Englert, in press; Englert et al., in review).

DOE/LANL. For many years before the Cerro Grande fire, the Laboratory and the US Geological Survey (USGS) collected environmental data on sediment, surface water, and groundwater within Pueblo Canyon. The USGS established sediment sampling stations within Pueblo Canyon in the 1950s and has sampled these stations regularly since 1954. The number of stations was reduced after active discharges were discontinued in the 1960s. The stations that currently comprise the monitoring network are sampled annually. Surface water also has been sampled within the watershed; a sampling station is located at the confluence with Los Alamos Canyon. After the fire and before the summer monsoon season, samples of ash and debris from the burned areas in the upper portion of the watershed were collected to provide background information. Additional sampling of the sediments, surface water, and groundwater in the lower portions of Pueblo Canyon was conducted to provide baseline information prior to any potential flood events.

The Laboratory monitors surface water from regional and Pajarito Plateau stations to evaluate the potential environmental effects of its operations (LANL, 2002b, Chapter 5, Section B). Base flow samples are collected where effluent discharges or spring discharges maintain persistent flows for at least part of the year. The Laboratory also monitors the water quality of periodic natural runoff that occurs as spring snowmelt and summer storm runoff. Sampling data collected during and following the Cerro Grande fire are reported in LANL (2000).

Under the NPDES program, the Laboratory's ongoing industrial activities are covered by the EPA's Storm Water Multi-Sector General Permit for Industrial Discharges, under which LANL monitors stormwater runoff at numerous stream gaging stations. One of the 69 stations sampled in 2001 (Station E060) is in Pueblo Canyon for the purpose of monitoring the quality of surface flows exiting Laboratory property. This gage recorded the presence of flow every day in 2001, with a total of 850 ac-ft and an instantaneous maximum of 1440 cfs (LANL, 2002b, Table 5-1, p. 215).

U.S. Forest Service. The USFS BAER implementation team leader remains in Los Alamos and continues to monitor post-fire recovery and the effectiveness of the BMPs that were implemented in the area burned by the Cerro Grande fire, including the upper part of the Pueblo watershed.

Los Alamos County. Los Alamos County does not have any monitoring program for surface water quality. LANL monitors drinking water quality for the county. Los Alamos County monitors effluent discharge under its NPDES permit for the Bayo Canyon sewage treatment plant. In addition, the Engineering and Project Management Department commissioned an assessment of post-fire runoff conditions in the upper Pueblo watershed as part of the planning for the North Road Reconstruction Project (Watershed West, 2002). The county's planned restoration activities following the Cerro Grande fire are listed in Los Alamos County (2001).

Volunteer Task Force. A substantial volunteer effort has been coordinated by the Volunteer Task Force, a nonprofit group that was organized as part of the post-Cerro Grande fire response. The VTF has monitored the effectiveness of its projects using community volunteers and students from Los Alamos and other regional public schools. The VTF has focused on monitoring the recovery of vegetation in upper Pueblo Canyon through bi-annual sampling on 26 transects in

the burned area. Other projects include measuring seedling survival rates, ground cover recovery following treatment with seed balls, bark-beetle induced mortality studies, invasive species monitoring, and changes in stream channel morphology. Monitoring includes baseline sampling prior to project implementation. Pre- and post-project photo documentation are part of all monitoring projects. Results of the studies are posted on the VTF web site (www.volunteertaskforce.org).

5. Current Outreach Activities

The composition of the PPWP is technically diverse, with regular participation by practicing hydrologists, engineers, and regulatory personnel from a number of jurisdictions. In addition, the local Los Alamos population is highly educated in technical fields and generally willing to volunteer its expertise in support of worthy community service projects. As a consequence, the Los Alamos community is a rich source of local talent in the watershed management arena. Sharing of skill sets and lessons learned among Partnership members occurs through its monthly meetings, PPWP-sponsored speakers bureaus and forums, and member participation in VTF education projects.

In addition, organizational members of PPWP each have their own community outreach programs to address natural resource issues within their jurisdiction. Activities aimed at outreach, education, and involvement are critical to promote widespread awareness of and sensitivity to watershed issues and can be expected to have a direct beneficial impact on the quality of water in the watershed. "Public" is defined very broadly to include the general public, representatives of government agencies and elected bodies, and others interested in or affected by the condition of watersheds on the Pajarito Plateau. PPWP members themselves are a valuable asset in informing their families, friends, and neighbors.

Outreach programs relating directly to the Pueblo Canyon watershed include those administered by LANL, DOE, NMED, Los Alamos County, and the Volunteer Task Force. Each is summarized below.

LANL Environmental Restoration Project's Communications and Outreach Team, http://erproject.lanl.gov/outreach.html. The team's purpose is provide a framework for presenting understandable and consistent information to interested parties during the investigation and cleanup of areas that may have been contaminated in Los Alamos County. This is accomplished in part through the preparation and distribution of Fact Sheets on specific issues, frequent public meetings with posters, presentations, and informal discussions; and technical information made available on the web site. Pueblo Canyon issues targeted by the team in the past couple years are cleanup of the remaining residual radioactivity in Acid Canyon and investigations of remobilization of residual radioactivity in lower Pueblo Canyon. http://erproject.lanl.gov/Fire/Data/Canyons/Pueblo_Canyon.html

Goals for the LANL/ER Community Outreach efforts include:

- Broaden the base of involved individuals and groups;
- Continue to build trust by focusing on personal contact, dialogue, and mutual education;
- Obtain meaningful public input in decisions regarding watershed issues;

- Implement cost-effective ways to involve the public early in the watershed management process;
- Promote sustainability within PPWP member programs by incorporating sustainability principles into their activities and programs whenever possible.

Northern New Mexico Citizens Advisory Board (NNMCAB). This is a community advisory group funded by the U.S. Department of Energy, charged to provide recommendations on cleanup and waste management plans to the DOE about the Laboratory. The NNMCAB was a strong advocate for the Acid Canyon cleanup, and instrumental in convincing the DOE to fund this project.

Los Alamos County has a Public Information Officer who ensures that pertinent items are placed on the County's web site. This includes information on current and proposed construction projects within the Pueblo watershed. The County also holds frequent public meetings and poster sessions on its planned activities. The County recently created a new position, the Open Space Specialist. Among other duties, the Open Space Specialist also engages students from Los Alamos and regional schools through the watershed restoration projects.

The PPWP outreach programs, which are implemented largely by the Volunteer Task Force, are designed to meet a set of overlapping goals:

Education/Awareness – Collectively, the members of the Partnership possess knowledge and experience in a broad array of subjects related to water quality and watershed management. The Partnership serves as a mechanism for sharing this expertise throughout the broader community. Educational programs focus both on both adults as well as on children in regional schools.

Participation – The Partnership's outreach program does not simply consist of a transfer of information. Many activities sponsored by the Partnership or by members of the Partnership require the active involvement of a volunteer workforce. The Partnership uses creative and efficient means for capitalizing on the skills and enthusiasm of both adult and child volunteers.

Information Clearinghouse – The Partnership maintains a web site and links to related resources that constitute a continually evolving clearinghouse of information on state-of-the-art practices for promoting watershed quality.

6. Implementation Opportunities

6.1 Overview

The PPWP's short-term objective is to focus its efforts on managing runoff from areas with extensive impervious surfaces or highly erosive soils. Its strategy is to work with the US Forest Service, Los Alamos County, and the local community to develop and implement a multi-faceted approach of reducing storm runoff, harvesting runoff for vegetation establishment, reducing tree densities, improving grass cover, and implementing channel treatments to reduce

the velocity of runoff and to stabilize banks.

The proposed initiative is designed to mitigate erosion and stormwater peak flows through the development of a design manual for best management practices (BMPs) tailored to the county's environment, on-the-ground implementation of a combination of BMPs, development of a stormwater management plan with related ordinances and changes to the development code, and community education and participation in all aspects of these efforts. By reducing erosion and runoff from the mesa tops and by reducing peak flows in the canyon, the transport of sediment and associated contaminants can be significantly reduced and the riparian environment can be stabilized.

The potential range of actions that could be taken include enforcing existing regulations, developing BMP guidelines, and implementing demonstration projects employing BMPs for:

- riparian and streambank stabilization,
- runoff and erosion controls for roads and construction sites,
- tree thinning combined with the establishment of a healthy ground cover of grasses in areas with exposed soil,
- establishment of wide vegetative buffer zones between sediment sources and watercourses
- small on-site retention/infiltration ponds
- rainwater harvesting and tree catchment systems
- check dams
- public detention facility

The potential range of implementation tools include the following:

- Development standards
- Local ordinances and guidelines
- Operations and maintenance practices
- Water quality monitoring
- Inspection, compliance, and enforcement
- Public education
- Interagency cooperation
- Local stormwater control requirements
- Water and sediment quality standards
- Land use planning and open space protection
- Floodplain management strategies
- Land clearing and grading controls
- Local drainage studies

The PPWP decision-making process for implementation of these tools employs the use of GIS to visualize the spatial distribution of characteristics affecting or reflecting surface water quality. Monthly PPWP meetings and public forums provide opportunities for PPWP members to present proposed implementation plans and to receive feedback from their colleagues and counterparts in other jurisdictions, as well as from the community.

The underlying basis of the watershed restoration action strategy for Pueblo Canyon is to undertake projects to reduce the impacts of high runoff volumes and peak flow rates from intense summer rainstorms. These are the major contributors to sediment and contaminant transport and channel degradation in the watershed. The upper watershed was completely and severely burned in the Cerro Grande Fire, with complete loss of all vegetative cover. Subsequent mitigation measures used to treat the burned area have reduced stormwater flows from the portion managed by Santa Fe National Forest to the extent that is economically feasible. However, residential and commercial development in the middle watershed continue to be a major factor in maintaining high peak flows and volumes from summer storms. High-energy water draining from the upper and middle portions of the watershed results in sediment transport and channel instability in the lower portion.

6.2 Proposed Projects

The projects proposed in this section address these issues by developing a stormwater management plan that targets the subwatersheds and land use categories that produce the greatest volumes of runoff and/or eroded sediments. Concurrent with the development of a countywide plan, established BMPs will be implemented in selected developed areas of the Pueblo watershed to slow the rate of runoff, thereby reducing peak flows and associated soil erosion and sediment transport (Figure 6). Anticipating future development within the watershed, the plan and associated ordinance will restrict increases in runoff volumes by requiring measures to reduce runoff rates and volumes from newly developed areas. A BMP design manual will be compiled to support and guide these on-the-ground efforts, providing a suite of BMPs to be used for different conditions and problems. The stormwater plan, ordinance and BMP design manual will be available online as well as in print form.

Tasks associated with each of these activities are listed below:

Stormwater Management Plan, BMP Design Manual, and Ordinance

Task 1. Stormwater Management Plan for Los Alamos County. Develop a stormwater management plan for private land and county-owned lands in Los Alamos County.

1a. Stormwater problem assessment. Assess and quantify the magnitudes and sources of runoff and eroded sediments in individual microsheds of the Pueblo watershed. Quantify the impacts of inadequate control of runoff and eroded sediments in terms of ongoing maintenance requirements, construction projects, and degradation of habitat and ecosystem health. Prioritize focus areas by ranking microsheds, categories of land use, and developed and undeveloped parcels according to the contribution of each to stormwater and sediment loads.

1b. Stormwater BMPs. Identify and select BMPs appropriate to mitigate the problems identified above. These will include not only BMP designs, but also operation and maintenance schedules, evaluation criteria for proposed construction projects, effectiveness monitoring techniques, and spill detection and response.

1c. Prioritization list. Develop and maintain a list of specific activities to implement BMPs for high-priority focus areas as resources allow. This list is to be used by the county government as a guide to identify and pursue potential resources to implement the highest priority stormwater management projects.

1d. Formal documentation. These components will be documented in a formal written stormwater management plan to be considered by the County Council and to be incorporated into the county's comprehensive plan. The stormwater management plan will define the responsibilities of individual County departments for initiating and maintaining stormwater-related activities, and will be updated on an annual basis.

Task 2. Stormwater BMP Design Manual. Develop a user-friendly manual for selecting and designing site-specific BMPs on construction projects, utility projects, utility maintenance, open space management, and developed parcels, including energy-dissipation BMPs. Extract appropriate BMP designs into a separate brochure for owners of developed residential and commercial properties. These documents are intended to provide a resource that will assist contractors and others in meeting new requirements developed under Task 3.

Task 3. Stormwater Ordinance. Codify the stormwater plan requirements, including implementation and maintenance of appropriate BMPs, in one or more ordinances and in the county development code. Draft, review, and finalize a proposed stormwater ordinance for consideration by the Los Alamos County Council.

On-the-Ground Stormwater and Erosion Control Projects. Precise locations of these projects will be determined based on site assessments conducted as part of Task 1, with the objective of using them in the highest-priority problem areas. They will also serve as demonstration projects for proof of principle to members of the community and local government entities.

Task 4. Design and implement a post vane sequence in the north branch of Pueblo Canyon.

- Use induced meandering techniques to channel flows away from eroding banks and to reduce sediment scour.
- Construct a sequence of four post vanes to stabilize one-half mile of stream channel.
- Stabilize the bank and create a sediment filter buffer along the base of the hillslope with grasses, shrubs, and riparian trees, initially held in place with jute matting or other protective measure.

Task 5. Riparian Vegetation: Establish riparian vegetation along the branches of Pueblo Canyon. To increase cover and improve wildlife habitat, about 250 willows, box elders, and cottonwoods will be planted together with native seed mix along a mile of channel in the north and south branches of Pueblo Canyon. This task will extend the coverage of vegetation planted under the existing 319 grant. The channels along these stretches were severely widened and scoured by postfire floods but are presently zones of sediment deposition with large, relatively barren terraces and point bars.

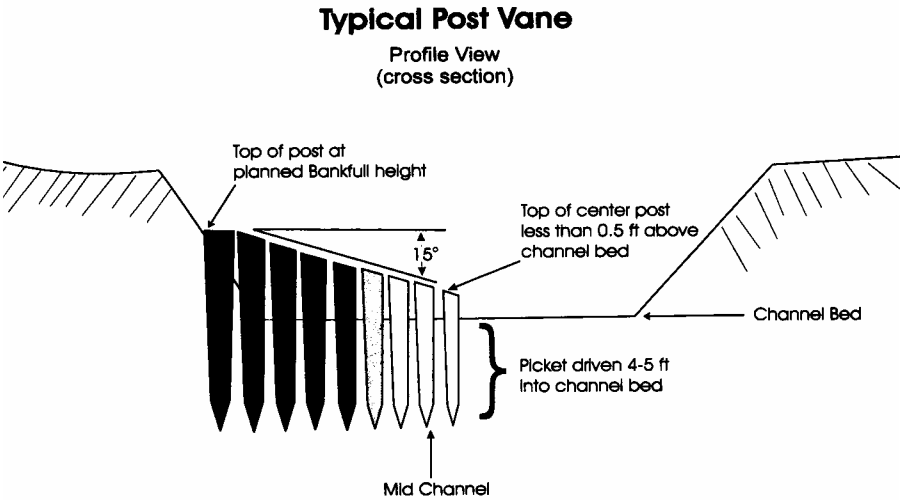

Figure 8. Typical Post-Vane Structure (from *Introduction to Induced Meandering*, Zeedyk, 2003)

Task 6. Hillslope Stabilization: Construct 400 energy dissipation devices on hillslopes in the Pueblo Watershed. This technique has been successfully applied by the Volunteer Task Force (VTF) in the adjacent Rendija watershed and in the lower Pajarito watershed in White Rock. Fifth grade students in Los Alamos schools will build "one-rock dams" on hillslopes where rill density is greater than one per 10 feet. Vegetative strip buffers will be established behind the one-rock dams with a native seed mix covered with mulch to prevent the seeds from washing away.

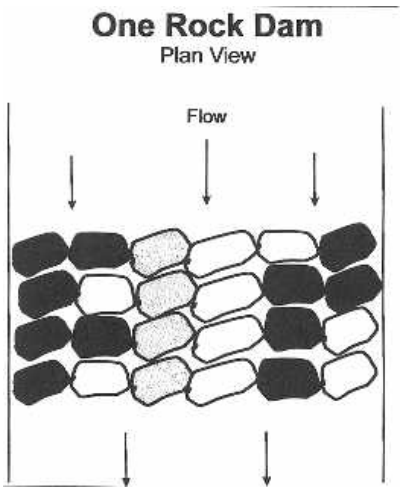

Figure 9. Plan View of One-Rock Dam (from *Introduction to Induced Meandering*, Zeedyk, 2003)

Task 7. Trail Maintenance: Design and implement a project aimed at mitigating erosion from steep portions of the Perimeter and Homestead Crossing trails. Install water bars and grade dips to dissipate water energy and reduce erosion on about two miles of these trails.

Task 8. Rainwater Collection and Delivery Systems: Procure and distribute 200 rain barrels to targeted properties in the Pueblo Watershed. Top priority will be given to areas with shallow bedrock, high percent impervious surfaces, and gutters that presently discharge to streets or gullies. In order to educate residents about the benefits of this activity and about how to install and maintain rain barrels and their associated rainwater distribution systems, this project will be closely coordinated with the outreach efforts in task 9. Volunteers will collect performance data on the rain barrels on a continuing basis.

Task 9. Outreach/Education: Outreach and education will be a prerequisite to all on-the-ground elements of this project. It will be essential in order to promote effective public involvement. The outreach program will involve school-age children and their teachers as well as residents, businesses, and County personnel. The school portion of this task is an expansion of the successful VTF program already in place. Public outreach will be conducted through the county's established outreach program.

6.3 Proposed Monitoring and Assessment Activities

Rill density. Members of the Volunteer Task Force will inventory rill density on hillslopes along the main drainages in Pueblo watershed in rills per mile and cumulative cross-sectional rill area per mile. Selected areas with high rill density will be treated with one-rock dams. Two years after treatment, students will repeat the rill density measurements. A similar approach will be used to evaluate the effectiveness of trail maintenance measures, by monitoring rill densities and cross-sectional areas above and below treated and untreated sections of trails.

Applicable to:
Task 6 Hillslope stabilization
Task 7 Trail maintenance

Repeat photography: Photo points will be established at two locations for each of the 4 post vane projects, 10 locations along treated trails, and 20 locations within the hillslope treatment areas. Photos will be repeated at minimal intervals of one and two years after treatment.

Applicable to:
Task 4 Induced meandering
Task 6 Hillslope stabilization
Task 7 Trail maintenance

Ground cover: Monitoring vegetative recovery will be accomplished by members of the Volunteer Task Force. Percent cover and stem densities will be measured at the end of each summer. The effectiveness of the hillslope stabilization projects will be quantified by calculating runoff volumes using the Runoff Curve Number method, and sediment loss using the Universal Soil Loss Equation.

Applicable to:
Task 4 Induced meandering

Task 5 Riparian vegetation
Task 6 Hillslope stabilization

Stream channel cross-sections: Using methods established with the current Section 319 grant, students will monitor changes in stream channels below the post vane structures in the north branch of Pueblo Canyon. Five cross sections are currently established downstream from the site. An additional two sections will be placed upstream, and four more will be established downstream. The sections will be measured twice per year. Stability of the stream bank and bank vegetation, sediment transport, and the shape of the channel will be monitored. In addition, NMED/DOE Oversight Bureau has placed 40 cross-sections in lower Pueblo Canyon, which it plans to continue to monitor for stream-channel adjustments (Ford-Schmid and Englert, in press; Englert et al., in review).

Applicable to:
Task 4 Induced meandering
Task 5 Riparian vegetation
Aggregate effectiveness of all tasks

Seedling survival: Effectiveness of riparian planting will be accomplished by the Volunteer Task Force working with students from Mountain Elementary School. Students will survey the riparian trees six months, one year, and two years after planting. They will calculate the percent survival of trees by species and by site characteristics. At year two, students will measure canopy cover as a measure of soil protection in the planted area.

Applicable to:
Task 4 Induced meandering
Task 5 Riparian vegetation

Sediment transport: Movement of sediment and larger materials will be measured by students from Los Alamos Public Schools using a simple technique developed by Luna Leopold. Colored fingernail polish will be applied to gravels and rocks of various sizes in stream channels, and the locations of the rocks carefully recorded. Students will return following storm events to locate the rocks and measure transport distance as a function of size and starting location. A similar method will be applied to monitor sediment transport on hillslope and trail projects.

Applicable to:
Task 4 Induced meandering
Task 6 Hillslope stabilization
Task 7 Trail maintenance

Onsite retention of rainwater. Water balances will be calculated for individual storm events on each of the properties in which the rain collection and distribution systems are installed in order to quantify the reduction in runoff from the property. Followup interviews and site inspections will be used to field-check assumptions made in these calculations (e.g., about proper installation and maintenance).

Applicable to:
Task 8 Rainwater collection and distribution systems

Storm water quality: LANL and the NMED/DOE Oversight Bureau are expected to continue their stormwater monitoring at their stations in middle and lower Pueblo Canyon. Samples are analyzed for radiochemical, chemical, trace metals, and organic constituents, including gross alpha, selenium, sediment, and PCBs. Comparison of pre-treatment and post-treatment surface water quality for storms of comparable rainfall characteristics will be a measure of BMP effectiveness. Summaries of data will be provided on an annual basis.

Applicable to:
Aggregate effectiveness of all tasks

Precipitation response. Storm hydrographs will be produced for at least 5 storm events in the watershed each year, using LANL streamflow discharge records. The hydrographs will be normalized to an area-weighted average rainfall depth over the watershed, and hydrograph characteristics such as peak flow, time to peak, and total runoff volume will be determined as qualitative indicators of watershed improvement.

Applicable to:
Aggregate effectiveness of all tasks

6.4 Proposed Outreach Activities

Several members of the PPWP are actively involved in education and outreach (Section 5). The PPWP outreach program is designed to complement and expand on those existing efforts. The outreach program will be led by the Volunteer Task Force. Table 8 summarizes outreach and educational activities in which the Partnership currently participates, or into which it hopes to expand over the next year.

Table 8. Partnership Outreach and Educational Activities

PROPOSED ACTIVITY
Sponsor a speakers bureau to conduct presentations and field trips for community and school groups.
Prepare presentation materials, including poster presentations that can be set up at key community areas – Farmers Markets, Post Office, churches, grocery stores, volunteer events.
Develop brochures and facts sheets on watershed issues, such as stormwater and erosion control BMPs.
Expand the PPWP web site as a clearinghouse for watershed information.
Train volunteers (community members, girl/boy scouts, garden clubs) to conduct surveys of watershed conditions.
Train volunteers to conduct reseeding and reforestation activities.
Carry out reseeding/reforestation with volunteer workforce.
Carry out post-planting surveys with volunteer workforce.
Sponsor demonstration projects on storm water management and erosion control

6.5 Proposed Implementation

Table 9. Proposed Success Measures, Management Targets, and Implementation Dates

Project	**Measures of Success**	**Management Target**	**Target Date**
Task 1 Stormwater management plan	County Council considers a stormwater management plan as part of the County's Comprehensive Plan	Prioritized list of stormwater related projects for implementation by the County, defined roles and responsibilities for County entities and landowners	September 2006
Task 2 BMP design manual	BMP design manual readily available in printed form and posted on web site, brochures distributed to property owners	Information readily available to assist landowners and county workers in mitigating impacts of their activities on the watershed, in accordance with new ordinance or development code requirements	April 2006
Task 3 Ordinance	County Council passes ordinance governing stormwater management for future land-disturbing activities	Enforceable targets; peak runoff, total runoff, and sediment erosion from disturbed lands not to exceed pre-disturbance levels	April 2007
Task 4 Induced stream meandering	Four post vane structures stabilizing one-half mile of stream channel	Stop channel widening and reduce sediment transport by 75%	June 2006
Task 5 Riparian vegetation	250 trees planted along with native seed mix along 1 mile of stream channel	Stabilize bank along 1 mile of channel	April 2006
Task 6 Hillslope stabilization	400 one-rock dams constructed on hillslopes bordering one mile of stream channel in steep subwatershed; native seed and mulch strips on upgradient side of each rock dam	Peak shaving; reduce rill density by 50%; reduce soil loss to stream channel by 75%	May 2007
Task 7 Trail maintenance	Improvements made to 2 miles of trail; placement of 50 water diversion structures on trails	Reduce erosion along trails by 80%	September 2006
Task 8 Rainwater collection and distribution systems	200 rainbarrels with distribution systems installed on targeted properties	Peak shaving and reduction of total runoff from individual properties by 50%	June 2006
Task 9 Outreach/Education	A public informed about the need for stormwater management and erosion control and how individual property owners can assist	1,000 hours of donated time to learn about stormwater management	May 2007

6.6 Funding Opportunities

Education and Outreach:

- National Park Service Cooperative Agreements for Curriculum Development
- Los Alamos National Laboratory Foundation
- Patagonia, Inc. Environmental Grants Program
- L. L. Bean Foundation
- Environmental Protection Agency Environmental Education Grant Program

Water Quality Improvement and Watershed Restoration

- Environmental Protection Agency Section 319 Water Quality Grant Program
- The Home Depot Forestry Grant Program
- Captain Planet Foundation

Grant Strategies
PPWP will continue to work with the Volunteer Task Force to seek funding for education, outreach, and restoration projects. VTF has enlisted as volunteers several experienced grant writers to assist in the process of grant writing.

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Appendix A

PPWP Members and Participants in the Pueblo Canyon WRAS Development Process

Organization	*Department*
Los Alamos County	Engineering and Project Management
Los Alamos County	Los Alamos County Utilities
Los Alamos County	Public Works Department
Los Alamos National Laboratory	Ecology Group
Los Alamos National Laboratory	Environmental Restoration Project
Los Alamos National Laboratory	Water Quality and Hydrology Group
National Park Service	Bandelier National Monument
Neptune and Company	N/A
New Mexico Environment Department	DOE Oversight Bureau
New Mexico Environment Department	Surface Water Quality Branch
Northern New Mexico Citizens' Advisory Board	N/A
Private citizens	N/A
San Ildefonso Pueblo	N/A
Santa Clara Pueblo	N/A
U.S. Department of Energy	Albuquerque Area Office
U.S. Department of Energy	Los Alamos Site Office
U.S. Forest Service	BAER Implementation Team
U.S. Forest Service	Santa Fe National Forest
Volunteer Task Force	N/A

Compiled from PPWP meeting attendance records, May 2002 to November 2003