**CITY OF SANTA FE, NEW MEXICO**

**RESOLUTION NO. 2009-87**

**INTRODUCED BY:**

Rosemary Romero

**A RESOLUTION**

**APPROVING THE SANTA FE WATERSHED PLAN; AND AUTHORIZING THE IMPLEMENTATION OF THE SANTA FE WATERSHED PLAN.**

**WHEREAS,** the Santa Fe Municipal Watershed provides water for approximately 30,000 households and businesses within the City of Santa Fe and surrounding communities; and

**WHEREAS,** a total of 5,285 acres in the lower area of the watershed have been treated with mechanical thinning and pile burns from 2003-2006; and

**WHEREAS,** there is currently a need for a framework and funding mechanism for long term maintenance, including protection from catastrophic fires, soil erosion and invasive plants; and

**WHEREAS,** in 2007 the City of Santa Fe Water Division and Fire Department along with the United Stated Forest Service (USFS) Espanola District of the Santa Fe National Forest, the Nature Conservancy, and the Santa Fe Watershed Association requested approximately $70,000 in grant funding from the USFS Collaborative Forestry Restoration Program (CFRP grant #27-07) for development of a comprehensive 20-year watershed management plan for the

Santa Fe municipal watershed; and

**WHEREAS**, in March of 2008 the USFS CFRP accepted, under the terms of the grant funding, the final draft of the Santa Fe Municipal Watershed Management Plan developed by the project partners; and

**WHEREAS,** the Santa Fe Municipal Watershed Plan addresses four areas critical to the maintenance of the watershed: (i) vegetation management and fire use; (ii) water management; (iii) public awareness and outreach; and (iv) financial management based on Payment for Ecosystem Services; and

**WHEREAS,** the Payment for Ecosystem Services model funds the maintenance of forest restoration activities as an insurance polity against future threats to the municipal water supply, while promoting awareness and education about watershed health and protection, building collaboration between water consumers and forest managers and providing long-term; and providing long-term funding of watershed maintenance costs; and

**WHEREAS**, the City Water Division has requested from the New Mexico Finance Authority (NMFA) Water Trust Board approximately $1.3 million to cover the City's obligations under the Watershed Management Plan during the first five years, and this funding was approved by the NMFA on July 29, 2009; and

**WHEREAS**, after the first five years the City will implement the payment for Ecosystem Services model which will result in an incremental increase in water rates to pay for long-term maintenance of the watershed.

**NOW, THEREFORE, BE IT RESOLVED BY THE GOVERNING BODY OF THE CITY OF SANTA FE, MEXICO** that the Governing Body approves the Santa Fe Watershed Plan and the City is authorized to implement the Santa Fe Municipal Watershed Management Plan. The Santa Fe Municipal Watershed Management Plan is attached to the original Resolution in the City Clerk's Office.

PASSED, APPROVED, and ADOPTED this 9th day of September, 2009.

DAVID COSS, MAYOR

ATTEST:

YOLANDA Y. VIGIL, CITY CLERK

APPROVED AS TO FORM:

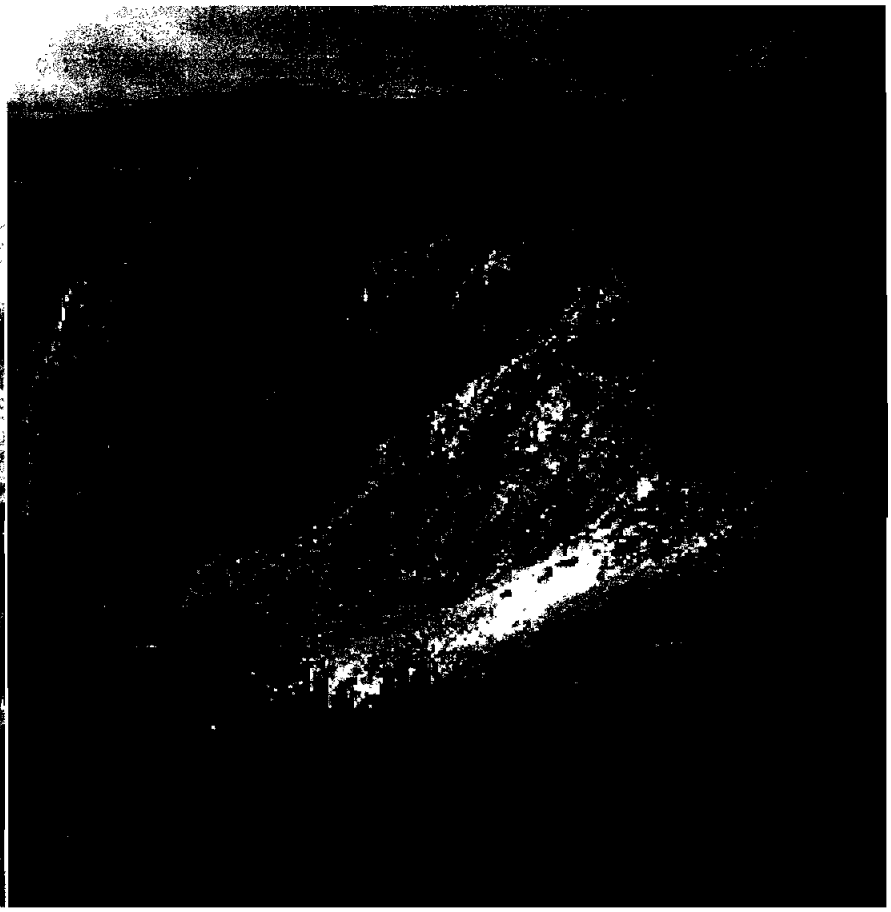
FRANK D. KATZ, CITY ATTORNEY

Jp/ca/jpmb/2009 res/watershed management plan

# Master Plan for the Municipal Watershed 2010-2029

## Prepared by the Santa Fe Watershed Association with funding from the USDA Forest Service Collaborative Forest Restoration Program

## Draft July 21, 2009

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This master plan provides a framework and recommendations for long term management, outreach, and funding for the Santa Fe Municipal Watershed. The plan addresses four areas critical to the maintenance of the watershed: (i) vegetation management and fire use; (ii) water management; (iii) public awareness and outreach; and (iv) financial management based on Payment for Ecosystem Services. The cost to retain the restored forest condition is estimated at $4.3 million, an average of $200,000 per year. In contrast, the avoided cost that would result from a 7,000 acre fire in the watershed is estimated at $22 million. The likelihood of such a fire is 1 in 5 in any given year.



Development of this plan was funded from the USDA Forest Service Collaborative Forest Restoration Program with a collaborative grant (CFRP #27-07) that included the Española Ranger District of the Santa Fe National Forest, the Santa Fe Watershed Association, the City of Santa Fe Water Division, City of Santa Fe Fire Department and the Nature Conservancy.

# Santa Fe Municipal Watershed
# 20 Year Protection Plan
# 2010-2029

## Executive Summary

### About this Plan

Like many cities throughout the western United States, Santa Fe's water supply is dependent upon forest health and protection from catastrophic wildfire. This master plan provides a framework and recommendations for long term management, outreach, and funding for the Santa Fe Municipal Watershed. The plan addresses four areas critical to the maintenance of the watershed: (i) vegetation management and fire use; (ii) water management; (iii) public awareness and outreach; and (iv) financial management based on "Payment for Ecosystem Services." This plan is unique in that it seeks to fund forest restoration activities using the Payment for Ecosystem Services model as an insurance policy against future threats, particularly of catastrophic fire, to the municipal water supply.

### About the Watershed

The Santa Fe Municipal Watershed provides water for approximately 30,000 households and businesses within the City of Santa Fe and surrounding communities. The municipal watershed comprises the upper 17,384 acres of the Santa Fe river basin. Two reservoirs hold approximately 4,000 acre feet, which is about one-third of the water used annually in the Santa Fe water system. The upper 10,000 acres of the municipal watershed are contained within the Pecos Wilderness Area. The lower 7,270 acres of the municipal watershed is dominated by ponderosa pine and piñon pine-juniper woodlands. In this lower area, 5,285 acres have been treated with mechanical thinning and pile burns using Congressionally-appropriated funding, with most of the work occuring between 2003 and 2006. The challenge now is to provide a framework and funding mechanism for long term maintenance, including protection from catastrophic fire, soil erosion, and invasive plants. This plan provides a framework for achieving these goals.

### The Need for Long Term Maintenance

One hundred years of fire suppression have rendered Southwestern forests overcrowded, vulnerable to pests and highly prone to stand replacement fires that strip steep slopes of soil protecting vegetation. The loss of forest cover decreases a watershed's capacity to regulate flow and control soil erosion. Research of the Los Alamos reservoir following the 2000 Cerro Grande fire (in which one third of the basin's mixed conifer forest were severely burned) measured a dramatic spike in the sedimentation rate. One year after the fire, reservoir sedimentation was 140 times higher than the previous 57 years, and remained significantly elevated throughout the five-year study period (Lavine et al. 2005). Reservoir sedimentation caused by soil erosion reduces the quantity and longevity of water supplies and substantially increases filtration costs. A 2002 study of 27 water suppliers across the U.S. demonstrated that water treatment costs increased significantly with progressive loss of forest cover (Ernst 2004).

Vegetation management is critical to restoring forests, reducing the risk of fire and maintaining water quality throughout the western U.S. Following massive soil erosion caused by the Hayman (2002) and Buffalo Creek (1996) fires in Colorado, Denver Water was forced to undertake a costly program to remove sediment from mountain reservoirs and unclog pipes. Projected to cost $31 million, the Utility estimates it has already spent more money clearing sediment that flowed into reservoirs after fires than would have been required to treat the areas before the fires.

## Payment for Ecosystem Services

Ecosystems naturally produce resources that are important for humans, such as water, wood, clean air, and insects that pollinate garden and fruit plants. "Ecosystem services" refer to these resources and the natural processes that produce them. Typically, these services are not paid for, nor are they included in conventional markets or economic analyses. Surface water for municipal use is an example of an ecosystem service that is neither paid for by the city nor individual water users. Water users pay for the services of capturing, treating, and delivering water, but they do not currently pay for the ecosystem services that produce this water. By attaching an economic value to these natural processes and services, water districts and municipalities can access a new source of revenue to support needed watershed protection. Payment for Ecosystem Services provides clear economic incentives for maintaining watershed health. This model of watershed protection has been implemented in major U.S. cities such as Seattle and New York City and has been shown to save millions of dollars in capital outlay and annual operating costs. The Santa Fe Watershed plan is unique in that it seeks to use the Payment for Ecosystem Services model to fund the maintenance of forest restoration activities as an insurance policy against future threats to the municipal water supply. The advantages of having beneficiaries pay for ecosystem services are (i) awareness and education about watershed health and protection; (ii) genuine collaboration between water consumers and forest managers; and (iii) long term funding of true watershed maintenance costs.

## Collaborative Planning

This plan was developed in collaboration with the Española Ranger District of the Santa Fe National Forest, City of Santa Fe Fire Department, City of Santa Fe Water Division, The Nature Conservancy, and the Santa Fe Watershed Association. The Española Ranger District of the Santa Fe National Forest consulted with contractors who were responsible for preparing a watershed management plan, including vegetation management, fire use, and monitoring, in conjunction with consultants from the University of California Los Angeles, and University of Arizona Tree Ring Laboratory. The City of Santa Fe Wildland Urban Interface Specialist also participated in the vegetation management and fire use plans to ensure consistency with Santa Fe's Community Wildfire Protection Plan. The City of Santa Fe Water Division prepared the water management plan, and The Nature Conservancy designed the financial management. The Santa Fe Watershed Association was responsible for the education and outreach plan. A Technical Advisory Group comprised of independent scientists also met with project collaborators and consultants to review draft plans and provide input into the structure and content of the plan.

## Recommendations

### *1. Vegetation Management*

Recommendations for vegetation management within the Santa Fe municipal watershed are provided for three areas of the watershed: (i) the "lower-upper" watershed, comprised of 7,270 acres of ponderosa pine and piñon pine-juniper woodlands; (ii) wilderness area; and (iii) riparian areas within the watershed.

The overly dense mid-elevation ponderosa pine forests of the Santa Fe Watershed were prioritized for restoration and crown fire hazard reduction due to the importance of the watershed to the water supply of Santa Fe. A crown fire in the watershed would overload the water treatment plant with ash and potentially threaten the two dams and reservoirs used for water storage. Initial mechanical treatments of 5,285 acres of upland, pine-dominant forests in the watershed temporarily reduced the risk of crown fire, but maintenance treatments are vital for future forest health and protection of the water supply. The 10,000 acres of the watershed located within the Pecos Wilderness have not been treated and very little is known about the forests and potential for treatment in this area. The riparian corridor was not thinned, and is in relatively good functioning condition.

**Recommendations for Lower-Upper Watershed**

Initial mechanical treatments of 5,285 acres of upland, ponderosa pine dominant forests have temporarily reduced the risk of crown fire, but maintenance treatments are vital for future forest health and protection of the water supply. The Española Ranger District of the Forest Service has already burned man piles in the treated area, but additional pile and broadcast burning will be needed to prevent fuel accumulation within this range of the watershed. If approximately 1,000 acres are broadcast burned each year, the entire watershed will be burned every 7 years.

- Prescribed fire in the treated areas of the watershed, with 4 proposed burn entries (1 pile burn and 3 maintenance burns). Pile burns are proposed between 2003 and 2011. Maintenance burns are proposed at three intervals between 2005-2011; 2012-2019; and 2019-2026;
- Continue current smoke management practices as well as public outreach;
- Evaluate piñon-juniper woodland density and soil conditions and develop recommendations for future management;
- Protect Southwestern white pine during prescribed burns;
- Monitor for cheat grass and other invasive species.

**Recommendations for Wilderness Area**

The portion of the municipal watershed located within the Pecos Wilderness contains at least 10 vegetation classes, from alpine grasslands to pine and oak with yucca and cactus. For the purposes of fire management, the Wilderness Area can be divided into two vegetation zones: (i) lower elevation (<10,000 feet) mixed conifer forests (comprised of Gambel oak, ponderosa pine, and piñon pine), and (ii) the upper elevation (>10,000 feet) spruce-fir dominant forests. While this division into two zones is more accurately described as a gradient, the two types can be used as general guides for fire regimes.

- No treatment in the 4,107 acres of spruce-fir forest
- Evaluate the potential for fire and/or strategic hand thinning to break up fuels in 780 acres of mixed conifer, ponderosa pine, and Gambel oak
- Mechanical thinning of 188 acres on ridges immediately south and west of the Wilderness Area

**Recommendations for the Riparian Area**

The riparian community along the Santa Fe River above Nichols Reservoir is reasonably intact relative to other southwestern riparian zones, and relative to the pre-treatment conifer forest of the watershed. There are approximately 10 miles of stream from the headwaters to McClure Reservoir, and three miles of stream between the two reservoirs.

- No treatment from McClure Reservoir to Wilderness boundary
- Consider refining seasonal water release from McClure Reservoir
- Remove non-native tree species growing below Nichols Dam
- Continue monitoring for integrity of riparian function and for non-native species using the Proper Functioning Condition methodology.

## 2. *Water Management*

Crown fire within the watershed could degrade the storage capacity of the water supply reservoirs and cause irreparable damage to the forested areas of the watershed. The focus of the water management plan is to provide sustainable water yields from the watershed, improve water quality, and protect the longevity of Nichols and McClure watersheds. The water management plan provides a framework for long term monitoring that addresses three critical objectives for water management:

- Maintain a Reliable Water Supply
- Maintain a High Quality of Water
- Enhance Wildlife Habitat and Ecosystem Function.

For each of these objectives, the plan also recommends (i) critical parameters for regular analysis; (ii) secondary parameters if critical parameters exceed a threshold; and (iii) parameters considered, but not recommended.

## 3. *Outreach*

Outreach will target residents of the City and County of Santa Fe, water customers of the City of Santa Fe Water Division, and Santa Fe youth with a focus on two areas:

- Providing general watershed education, including forest and riparian ecology, natural and cultural history, and water issues, and
- Building support for the Payment for Ecosystem Services model.

The plan recommends offering watershed education to the general public through educational hikes within the watershed, a self-guided interpretive trail overlooking the watershed, a short video offering a virtual experience of the watershed, a website, and a bilingual brochure. The plan recommends providing youth education through single classroom visits to all 4th and 5th grade students in Santa Fe, multiple visit programs with a field trip for a smaller number of 4th and 5th graders, and watershed monitoring with middle and high school students. The plan also recommends conducting a survey with Santa Fe residents to assess the attitudes and knowledge of Santa Fe residents toward watershed management and the Payment for Ecosystem Services model, staffing information tables, writing articles for existing organizational newsletters, developing public service announcements and 30-second television spots, and placing an information page in the phone book.

### *4. Financial Management*

Congress has allocated more than $7 million in federal earmarks for planning and restoration of forest conditions in the watershed, with $1.5 million per year going toward thinning of 5,285 acres in the lower upper watershed between 2003 and 2006. In addition, the Santa Fe National Forest has allocated a portion of its budget for watershed restoration before and since these appropriations. Annual maintenance with prescribed fire is needed to keep fuels at the reduced level. The cost to retain the restored forest condition over 20 years is estimated at $4.3 million, an average of $200,000 per year, depending on the level of maintenance needed in any given year, with diminishing cost over time. In contrast, the avoided cost, estimated by calculating the expense that would result from a 7,000 acre fire in the watershed is $22 million. The likelihood of such a fire in the watershed is estimated to be 1 in 5 in any given year. The avoided cost includes full-scale fire suppression and dredging of ash-laden sediment from the two reservoirs.

While federal funding has supported hazardous fuel reduction through earmarks and Forest Service appropriations, much of the Forest Service's budget has been and likely will increasingly be focused on fire suppression. As funding declines, cost-share agreements that leverage federal funding by providing matching funds will become more important. A Payment for Ecosystem Services agreement between the City of Santa Fe and the Santa Fe National Forest would more likely ensure that the Forest Service will be able to continue its management activities at a higher rate within the watershed than might be possible otherwise, even as funding declines in the region.

The City of Santa Fe has recently instituted a five-year utility service rate increase in order to pay for construction of the Buckman Direct Diversion Project. Because gaining public support for an additional rate increase associated with Watershed Management Plan PES would be difficult at this time, the watershed management partners are pursuing New Mexico Finance Authority, Water Trust Board funding to cover the City's PES obligations for the first five years of project implementation. Within this initial five-year period, outreach and education efforts will be focused on building public approval for PES and acceptance of the nominal rate increase associated with the Watershed Management Plan that would go into effect in 2014, when the Buckman Direct Diversion Project will be complete.

- Use the Payment for Ecosystem Services model to develop a local, sustainable source of funding that accounts for true costs of watershed management.

- Initiate two phases of for PES: Phase 1: New Mexico Water Trust Board pays for ecosystem services during the first 5 years of the plan, until the Buckman diversion rate increases are complete; Phase 2: After the Buckman Diversion rate increases cease, assess a fee to each water consumer based on use, projected at $0.13 per 1,000 gallons per month.

- List fees as a separate item on the water bill. During Phase 1, the fee will appear as a credit, with funding from the New Mexico Water Trust Board. During Phase 2, the fee will be assessed back on water usage. We recommend a fee based on water use, rather than a flat fee for all users, so that low-income and conservative water users are charged equitably. Based on the projected cost for watershed maintenance, this fee would be $0.13 per 1,000 gallons of water per month. An average household uses approximately 50,000 gallons of water per year, which would result in an annual fee of $6.50, or a monthly fee of $0.54. Lower end water users use approximately 24,100 gallons per year, resulting in an annual fee of $3.13, while higher end users can use as much as 72,200 gallons per year, resulting in an annual fee of $9.40.

- Create agreements and mechanisms for payment between the City of Santa Fe and the U.S. Forest Service. These would include: a new Memorandum of Understanding for watershed management; a Collection Agreement that would be re-established every 5 years; and an annual review of work plans, budgets, and project implementation per the terms of the Collection Agreement.

# Santa Fe Watershed Plan
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# Santa Fe Municipal Watershed
## *Introduction and Context*

Throughout the western United States, more than 100 years of fire suppression, grazing, and timber harvesting have led to changes in the structure of many forests of the western United States and have increased the risk for catastrophic crown fire. Many municipal watersheds are dependent upon these same forests for sustained ecosystem services, such as water quantity and quality. These watersheds are vulnerable to crown fires that could strip steep slopes of soil-protecting vegetation and overload reservoirs with sediments. In cities impacted by severe crown fire, such as Los Alamos, New Mexico and Denver, Colorado, sediment loads following fire showed dramatic spikes in sedimentation rates, with the Cerro Grande fire leading to sedimentation rates 140 times higher than the previous 57 years. Increased sedimentation within reservoirs reduces the quantity and longevity of water supplies and substantially increases filtration costs. Protection of municipal water supplies thus is linked to forest health in many western cities, including the Santa Fe Municipal Watershed.

Congress has allocated $7 million in federal earmarks for planning and restoration of forest conditions in the Santa Fe watershed, with $1.5 million going toward thinning of 5,285 acres in the lower upper watershed between 2003 and 2006. Annual maintenance with prescribed fire is needed to keep fuels at the reduced level. The cost to retain the restored forest condition over 20 years is estimated at $4.3 million, an average of $200,000 per year, depending on the level of maintenance needed in any given year, with diminishing cost over time. In contrast, the avoided cost, estimated by calculating the expense that would result from a 7,000 acre fire in the watershed is $22 million. The likelihood of such a fire in the watershed is estimated to be 1 in 5 in any given year. The avoided cost includes full-scale fire suppression and dredging of ash-laden sediment from the two reservoirs.

While federal funding has supported hazardous fuel reduction through earmarks and Forest Service appropriations, much of the Forest Service's budget has been and likely will increasingly be diverted to fire suppression. As funding declines, cost-share agreements that leverage federal funding by providing matching funds will become more important. A Payment for Ecosystem Services agreement between the City of Santa Fe and the Santa Fe National Forest would more likely ensure that the Forest Service will be able to continue its management activities within the watershed, even as funding declines in the region.

The City of Santa Fe has recently instituted a five-year utility service rate increase in order to pay for construction of the Buckman Direct Diversion Project. Because gaining public support for an additional rate increase associated with Watershed Management Plan PES would be difficult at this time, the watershed management partners are pursuing New Mexico Finance Authority, Water Trust Board funding to cover the City's PES obligations for the first five years of project implementation. Within this initial five-year period, outreach and education efforts will be focused on building public approval for PES and acceptance of the nominal rate increase associated with the Watershed Management Plan that would go into effect in 2014, when the Buckman Direct Diversion Project will be complete.

This master plan provides a framework and recommendations for long term management, outreach, and funding for the Santa Fe Municipal Watershed. The plan addresses four areas critical to the maintenance of the watershed: (i) vegetation management and fire use; (ii) water management; (iii) public awareness and outreach; and (iv) financial management based on "Payment for Ecosystem Services." This plan seeks to fund forest restoration activities using the Payment for Ecosystem Services model as an insurance policy against future threats, particularly of catastrophic fire, to the municipal water supply.

# Santa Fe Municipal Watershed
*Vegetation Management Plan*

## *Background and Context*

More than 100 years of fire exclusion from suppression and grazing have altered forest structure and increased crown fire hazard in many forest types throughout the Western United States. Ponderosa pine forests have experienced particularly dramatic changes and have been the primary focus of forest restoration in the Southwest (Allen et al. 2002). However, other forest types, such as spruce-fir or aspen/mixed conifer, are naturally dense, historically burned in crown fires, and may not require restoration (Margolis et al. 2007). Recent crown fires in ponderosa pine forests have resulted from increased forest density combined with warming temperatures (Westerling et al. 2006). These crown fires have caused extensive and severe hydrologic damage in many watersheds across the region. Post-crown fire flooding can be orders of magnitude greater than pre-fire flows (e.g., Veenhuis 2002) and has resulted in catastrophic debris flows in some locations (e.g., Cannon and Reneau 2000). Climate change is predicted to further threaten water supplies and forests through drought induced forest die-off (Breshears et al. 2005), longer fire seasons with more large fires (Westerling et al. 2006), and reduced snowpack and altered stream flow (Barnett et al. 2008).

The overly dense ponderosa pine forests of the Santa Fe watershed were prioritized for restoration and crown fire hazard reduction because of the importance of the watershed to the water supply of Santa Fe. A crown fire in the watershed would overload the water treatment plant with ash and potentially threaten the two dams and reservoirs used for water storage. Initial mechanical treatments of 5,800 acres of upland, pine-dominant forests in the watershed temporarily reduced the risk of crown fire, but maintenance treatments are vital for future forest health and protection of the water supply. The 6,600 acre Wilderness Area in the upper reaches of the watershed has not been treated and very little is know about the forests and potential for treatment in this area. The riparian corridor also has not been treated, and is in relatively good functioning condition.

## *Scope of this Plan*

This plan presents an integrated set of recommendations for vegetation management for the Santa Fe Municipal Watershed. This area includes the portion of the watershed located above the Water Treatment Plant (hereafter know as the upper watershed). The upper watershed is divided into two management areas: (1) the lower-upper watershed, and (2) the upper-upper watershed (hereafter known as the Wilderness Area) (Figure 1). Management recommendations focus on somewhat different objectives for the two areas. For the lower-upper watershed the objective is long-range maintenance of the restored part of the forest. For the Wilderness Area (including adjacent forests) and the lower-upper riparian corridor we present potential strategies for management of these untreated portions of the forest. These recommendations emphasize the use of thinning, fire management, and other tools to both maintain forest health and reduce the impact of severe fire on the water supply. In addition to providing recommendations for managing the Santa Fe Municipal Watershed, the model proposed here can also

contribute to the broader pool of forest management knowledge, as there is little post-thinning forest management experience in the region.

## Summary of Recommendations

| *Table 1. Summary of Recommendations for Vegetation Management* | |
|---|---|
| **Lower-Upper Watershed** | • Prescribed Fire in Treated Areas of watershed, with 4 proposed burn entries<br>• Continue current smoke management practices as well as public outreach<br>• Evaluate fire hazard and post-fire erosion potential in piñon juniper woodlands within lower watershed and adjacent properties<br>• Protect Southwestern white pine during prescribed burns<br>Continue current post-treatment monitoring (by RMRS through 2009) paying special attention to invasive species (i.e., cheat grass). |
| **Wilderness Area (and adjacent mixed-conifer forests)** | • No treatment in 4,017 acres of spruce-fir<br>• Potential for fire on south slopes to break up fuels and restore forests in 1000 acres of mixed conifer or ponderosa pine (pending additional data)<br>• Potential for mechanical thinning of a ¼ mile wide fuel break in mixed conifer vegetation of 172 acres on ridges immediately south and west of Wilderness Area to be used as anchor point for fire management |
| **Riparian Area (lower-upper watershed)** | • No treatment from McClure Reservoir to Wilderness boundary<br>• Consider refining seasonal water release from McClure Reservoir<br>• Remove non-native tree species growing below Nichols Dam<br>• Continue monitoring for integrity of riparian function and for non-native species using the Proper Functioning Condition methodology |

## Recommendations

### *Vegetation management Plan for the "Lower-Upper" Watershed*

#### *Ecological Context*

The primary tool for managing the lower-upper watershed zone is fire, through both naturally occurring wildfires and prescribed burns. The most important objective of the Santa Fe watershed burn plan is to minimize the risk of high intensity fire by reducing fuel loads. Maintenance burning is necessary for two reasons. First, burning will reduce the fuel loads that were produced during thinning. Second, burning will maintain the reduced risk of high intensity fire by preventing the re-accumulation of biomass in treated forest stands.

Ideally, the long-term burn periodicity in the watershed should be similar to the historical fire regime return interval. Balmat and others (2005) reconstructed fire intervals in the lower-upper watershed from 1600 through 1849 using fire scar data. They found a median fire interval of 15 years, minimum of 3 years and a maximum of 40 (20% scarred). A study by Finney and others (2005) found that fuel treatments significantly reduced fire severity when the treatments occurred between 3 and 9 years before a wildfire, with fire severity increasing with time since treatment. They suggest that the history of the fuel treatments is less important than the time since last treatment. The study also makes the case that it may take repeated prescribed burns before wildland fire can play its desired role in forest management. In order to prevent a return to stand conditions that support a crown fire, prescribed fire should be reintroduced into thinned forests early and often.

The long-term goal is to burn the entire treated area in the watershed at a burn interval that will prevent fuel accumulation, especially the establishment of thickets of young trees that increase crown fire hazard. An approximate schedule of an average of 700 acres of broadcast burn per year will accomplish a prescribed burn of the entire watershed every 10 years. This fire interval falls within range of historical fire frequency for natural fires in the watershed, and is near the 3 to 9 year return interval suggested by Finney and others (2005). The clock on the period of burn interval begins as soon as thinning treatments are complete in any particular area.

A primary concern of burning more than 1,000 acres per year is the issue of increasing runoff and sedimentation to the Santa Fe River. However, paired basin monitoring of watershed treatments to date have shown no increase in sedimentation or ash-laden runoff after mechanical thinning or pile burning (Grant 2004). Now that mechanical treatments are complete on 5,285 acres, sedimentation is not predicted even with modeling of natural fire events in the lower-upper watershed under extreme weather conditions. Based on these predictions of sedimentation, no threshold is set to define the maximum number acres that can be burned if suitable conditions exist.

### *Restoration and Treatment History*

Of the 7,270 acres comprising the lower upper watershed, an area of 5,285 acres was treated by mechanical thinning between 2002 and 2006. A *Prescribed Fire Plan,* prepared by the Española Ranger District Office of the Santa Fe National Forest (Isakson 2006), covers those portions of treated forest which have not been pile burned (1,548 acres) or broadcast burned (200 acres).[1] The treated area lies between 7,400 and 9,800 feet in elevation with an average slope of 45%. Trees have been thinned to a density ranging between 50 and 100 trees per acre. Fuel loads are estimated at 2 to 6 tons/acre on south aspects with limited thinning, 10 to 36 tons/acre on south aspects with heavy thinning, 40 to 50 tons/acre on north aspects with heavy thinning, and 18 to 27 tons/acre in masticated areas. The suppression goals for this phase of prescribed burning are to control 90% of the high intensity wildfires at 10 acres or less and 90% of the low intensity wildfires at 20 acres or less.

**Smoke**

The USFS Prescribed Fire Plan outlines multiple smoke monitoring and mitigation options to ensure compliance with New Mexico Environment Department-Air Quality Bureau (NMED – AQB) standards for smoke emissions from prescribed fire. These include:

- *Smoke monitoring.* Smoke monitoring of volume, lifting and dispersal to be recorded on standard forms required by NMED – AQB that is reported hourly to the burn boss. Trigger point: the burn boss must consider a change in action (including shutting down the burn) if the smoke monitoring device (located on Upper Canyon Rd) exceeds the 24hr EPA smoke limit.
- *Identification of sensitive areas.* The City of Santa Fe and surrounding areas, the I-25 corridor and the Pecos Wilderness area are all listed as areas sensitive to smoke.
- *Smoke mitigation options.* Seven management options are listed in the burn plan to help the burn boss reduce smoke dispersal to sensitive areas, including adjusting the daily burn window, reduced burn block sizes, and taking breaks after days with heavy smoke production.

A separate smoke monitoring plan (USFS 2002) describes detailed visual and instrumented smoke monitoring and mitigation, and lists an additional 10 smoke sensitive areas extending as far away as Taos and the Wheeler Peak Wilderness, NM. Smoke dispersion modeling (SASEM) is outlined (Hudnell 2000) for multiple burn prescriptions and results indicate that National Ambient Air Quality Standards are not expected to be exceeded during any prescribed burn scenario. This is in contrast to the modeled wildfire scenario, which does predict that air quality standards would be exceeded.

These preparations for potential air quality problems due to smoke seem to have been effective based on the monitoring report for April – December 2003 (Barkmann 2003). During this period the 24-hr average recorded by the real-time instrumentation never exceeded the federal standard (for particulates less than 2.5 microns in diameter) and the 1-hr average reached the "unhealthy for sensitive groups" threshold for only six 1-hr periods. These data cover 17 burn days and 650 acres of pile burning.

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[1] These figures are as of May 2008.

*Recommendations*

We support the Forest Service schedule of four prescribed fire entries into the watershed to move stand conditions toward those that will allow natural, low-intensity fires to burn. The first entry will burn piled dead and down woody fuels within a broadcast burn perimeter. The second and third entry will be broadcast burns using backing fires, and the fourth entry using a head fire.

Some prescribed burning has already occurred in the thinned portion of the watershed (Table 2). Of the 5,285 acres mechanically thinned, two-thirds were cut by chainsaw and the resulting debris gathered into piles. As of spring 2008, 1,548 acres of piles have been burned. The remaining 2,446 acres of piles will be burned within broadcast burn blocks. Areas that have been shredded into chunks by machines, rather than cut by hand, do not leave fuels that require piling and burning, and can be broadcast burned directly after treatment. As of spring 2008, 200 acres have already been broadcast burned once, and another 7,070 acres require a first broadcast burn. The second entry (initial broadcast burn of thinned area) should be accomplished by 2011 in the watershed.

The method of broadcast burning for the second and third fire entries uses a "backing fire" to maximize fire control in what are sometimes moderate to heavy horizontal surface fuels and ladder fuels. At this point, fuels are sufficiently reduced such that the fourth entry fire can be a "head fire," which is faster and is less expensive to conduct than the backing fires.

**Table 2. Summary of Treatments in Lower Portion of Santa Fe Watershed (acres are approximate)**

| Treatment Type | Time Frame | Completed Acres | Remaining Acres |
|---|---|---|---|
| Mechanical Treatment | 2003-2006 | 5,285 | 0 |
| Cut and Pile | 2003-2006 | 3,994 | 0 |
| Masticated | 2003-2006 | 1,291 | 0 |
| 1st Entry Pile Burn | 2003-2011 | 1,548 | 2,446 |
| 2nd Entry Broadcast Burn: backing fire | 2005-2011 | 200 | 7,070 |
| 3rd Entry Broadcast Burn: backing fire | 2012-2019 | 0 | 7,270 |
| 4th Entry Broadcast Burn: head fire | 2019-2026 | 0 | 7,270 |

Prescribed burning must be implemented when weather and fuel conditions are safe: dry enough to adequately burn the fuels, yet wet enough to prevent an escaped wildfire, and during proper wind direction and dispersal conditions so that areas sensitive to smoke are not affected. Burn-season weather conditions will affect the pace at which the burn schedule is accomplished. Individual dry years or a prolonged drought may significantly hamper the pace of burning. Under optimal weather and smoke dispersal conditions about 80 acres can be broadcast burned per day. At least 13 days of appropriate burning conditions will be needed each year to reach 1,000 acres of burning. The burn schedule must be flexible enough that more acres can be burned in suitable weather to make up for the lack of burning in unsuitably dry periods.

**Burn Seasonality**

The Prescribed Fire Plan calls for burning at three times of year: "Broadcast burning with piles will occur when fuel and moisture conditions allow, but will generally be in fall, winter, or after summer monsoons have begun. First entry broadcast burning will occur in the late summer or fall when environmental parameters can be met." Considering the fuel loads still on the ground, these are the safest seasons for prescribed burning in this watershed. Climatic conditions are unstable in the spring, with the potential for sudden, high winds followed by a predictably dry and warm early summer pre-monsoon period. There also tends to be an abrupt transition from very snowy conditions, preventing an efficient burn, to risky dry conditions with unpredictable winds.

Understory plants in low-intensity fire adapted forests recover quickly after fire, and although there is some evidence that response of understory plants varies by burn season, there is not yet a consensus on which seasons are likely to produce the best response. Historical fires (1600-1849) occurred predominantly in the late spring and early summer before the onset of the monsoon rains (Balmat et al. 2005). Fall burns can encourage the growth of exotics, such as Dalmatian toadflax and cheatgrass (Abella and Covington 2004). Monitoring to detect changes in abundance of non-native invasive species could be focused on areas burned in the fall.

**Smoke**

To mitigate the effects of smoke from fire management in the watershed we recommend the continuation of current smoke management practices combined with continued public outreach.

**Other Long-term Maintenance Concerns**

- *Post-treatment monitoring.* We recommend continuing the current monitoring of treatment (prescribed fire) effects on the flora and fauna per the contract between RMRS and USFS Espanola District. RMRS has been monitoring since 2002 and is contracted to do so until all areas have received the initial burn treatment (estimated through 2009). The following variables are monitored: small mammal populations, avian populations, vegetation (canopy cover, tree density by species and size, fuel loads, ground cover, shrub cover). A summary of the results of the RMRS monitoring can be found here: http://www.fs.fed.us/r3/sfe/projects/plansReports/index.html. A summary table and narrative of prior monitoring in the watershed (through 2006) is also included (Appendix 2). We recommend an evaluation of the need for future monitoring of the effects of the maintenance burns (2009 – 2020). This evaluation should address whether the monitoring data already collected is sufficient to describe negative effects of the treatments on the forest and watershed, and could be used to guide future adaptive management.

- *Evaluate piñon-juniper stands in the lowest part of the watershed.* At the lower parts of the watershed, piñon-juniper predominates and poses a separate set of management challenges which are not comprehensively addressed in this study. A plan for the treatment of the piñon-juniper

stands in the lower part of the watershed should be considered, including prescribed burning if deemed necessary. These woodland stands should be inventoried to evaluate their condition, including whether density is within a historical range of variability, whether a fire occurring in the piñon-juniper stands could carry into the untreated stands above or into the city. An assessment of whether the understory is robust enough to minimize soil erosion should also be made, and if needed, some lop and scatter treatments should be considered to improve grass and forb cover in order to reduce soil erosion. Collaboration with adjacent landowners (TNC and others) containing relatively large proportions of the PJ zone will be necessary to accomplish effective evaluations, planning and treatments.

- *Continue to protect Southwestern white pine.* During planning of restoration treatments a concern was expressed for the fate of Southwestern white pines in the watershed, because populations have suffered in the West in recent years due to the exotic white pine blister rust. White pines in the watershed have been reproducing successfully in spite of the threat of blister rust and thus the Santa Fe Watershed has been identified as a possible sub-regional refugia for this tree species. The protection of southwestern white pines should continue to be an objective throughout long-term prescribed burning maintenance.

- *Protect against invasive grasses and forbs.* A lag in the population expansion of undesirable invasive species into restored forests has been reported in some treatment areas. In particular, the establishment of cheat grass (*Bromus tectorum* L.) is a concern, due to the ability of cheat grass stands to significantly alter fire regimes. Most notably, cheat grass can compete vigorously with native grasses during a drought, and forest restorations that occur during a dry period should be aware of the potential for cheat grass invasion.

## *Vegetation Management Plan for the Wilderness Area within the Watershed*

### *Ecological Context*

**Forest Vegetation**

For purpose of fire management, the vegetation of the Wilderness Area can be divided into two general types: 1) the lower elevation (<10,000 ft) mixed conifer forests and 2) the upper elevation (>10,000 ft) spruce-fir dominant forests (Figs. 1 & 2).[2] The general difference in vegetation types was very evident from on-the-ground field reconnaissance. This "division" is more accurately described as a gradient that

[2] The best existing vegetation map contains 10 vegetation classes present in the Wilderness Area (Figure 2). The relatively coarse scale of the map combines vegetation types that may in fact have differing fire regimes. For example, Gambel oak, ponderosa pine and piñon pine are all combined into a mixed conifer type. The map thus should be used with caution when trying to identify areas for fire management.

varies with aspect and slope position. These two variables affect the local radiation and moisture balance that ultimately determines which tree species can survive at a particular site in the absence of disturbance. The two general vegetation types defined above are used in subsequent discussions of vegetation and fire regimes.

**Spruce-Fir Zone**

The dominant trees in this zone are roughly 150-300 yrs old, with the peak number of trees establishing between 1760 and 1800 (Margolis et al. 2007b). Age data for the sub-dominant, smaller diameter trees is not available. Without these data we can not assess whether there have been changes in stand-density, and consequently crown fire hazard, which may have resulted from forest management over the last century. It appears likely, however, that fire suppression effects on stand-density in the spruce-fir have been minimal for three reasons: (i) there are relatively few successful ignitions in this zone; (ii) crown fires burning in spruce-fir are virtually impossible to suppress; and (iii) sub-alpine, spruce-fir vegetation types naturally increase in tree density with time following stand-replacing disturbance. Thus, the human induced increase in crown fire hazard that has been problematic in ponderosa pine forests (Allen et al. 2002) is less likely to have occurred in these upper elevation spruce-fir forests (Sibold et al. 2006).

**Mixed-Conifer Zone**

Tree age data are not available for the mixed-conifer zone. Without these data or other quantitative measures of forest structure we relied upon aerial photos to make a qualitative assessment of whether there has been a change in the mixed conifer forests from historical conditions. The photos revealed a visually striking increase in tree cover on south-facing slopes in the mixed conifer forest from 1935 to 2005 (Figure 4). The cessation of surface fire due to grazing and fire suppression, similar to what occurred in the adjacent ponderosa pine forests, provides the most likely mechanism for the observed increase in tree cover. The changes evident in these photos provide the best available data for justification of treatments in the mixed conifer zone of the Wilderness Area based on the objective of forest restoration, while also serving to reduce crown fire risk.

**Fire Regimes**

All ignitions within the Wilderness Area are managed with the appropriate suppression response. Active suppression began when the US Forest Service began managing the area as a closed municipal watershed in 1932. Six lightning ignitions have been reported between 1961 and 2000 and were suppressed (unpublished USFS GIS records). Thus, no fires greater than one acre have burned in the Wilderness Area for at least 47 years based on these records. Coarse-scale (1km resolution) fire regime condition class data indicate that 30% of the Wilderness Area is in class 3 (high departure from historical vegetation and disturbance regime conditions) (Table 3) (Hann et al. 2003). However, the coarse scale of this remotely sensed model and the lack of local ground truthing is a limitation.

Table 3. Fire Regime Condition Classes for the Santa Fe Watershed Wilderness Area. (Minimum mapping unit is $1km^2$)

| Fire Regime Condition Class | area (acres) | % of total area |
|---|---|---|
| 0-35 yrs; Condition Class 1 | 1326 | 20 |
| 0-35 yrs; Condition Class 2 | 140 | 2 |
| 0-35 yrs; Condition Class 3 | 290 | 4 |
| 35-100+ yrs; Condition Class 1 | 2738 | 42 |
| 35-100+ yrs; Condition Class 2 | 383 | 6 |
| 35-100+ yrs; Condition Class 3 | 1719 | 26 |

## Historical Conditions

Historically, fire was a relatively common, important ecological process in the Wilderness Area (Margolis et al. 2007b). The tree-ring record reveals two types of historical fire regimes: (i) a stand-replacing fire regime with no evidence of surface fire and (ii) a mixed-severity fire regime with evidence of surface fire and smaller patches of stand-replacing fire. These two types of fire regimes were generally separated along vegetation and elevation boundaries.

The historical fire regime in the upper elevation (>10,000 ft) spruce-fir dominated forests was characterized by relatively widespread stand-replacing fire. The last widespread fire in these upper elevation vegetation types burned as a stand-replacing fire in 1685. Due to the stand-replacing nature of this type of fire regime, which kills and burns tree-ring evidence of prior fires, no fire return interval statistics could be derived for historical fire in the spruce-fir zone.[3]

Fire-climate analyses suggest that an extreme single-year drought was associated with the last large stand-replacing fire. Similar forest types in the adjacent Tesuque watershed burned in two stand-replacing fires in the late 19th century (Margolis et al. 2007a). This may suggest that sufficient fuel existed over 100 years ago in the upper elevations of the Santa Fe watershed to support a large fire (assuming that the forest was similar in age to the Tesuque watershed at the time of the last fire) and that an additional 120 years of fuel has accumulated in the Wilderness Area since then.

The historical fire regime in the lower elevation (<10,000 ft) pine and mixed-conifer forests in the Wilderness Area was characterized by both repeated surface fire (as evidenced by individual trees with multiple fire scars) and stand-replacing fire in small (<100 acres) patches in some locations. The last fire documented by fire scars was in 1879 and the last widespread fire was in 1842. Widespread surface fire in the Wilderness Area occurred less frequently (estimated average interval of 33 years, see Table 4)

[3] Methods do exist to reconstruct landscape-scale fire frequency estimates (natural fire rotation) in crown fire regimes, but this requires more forest age data than is currently available.

than in the mid-elevation ponderosa pine dominated forests of the lower-upper watershed (estimated average fire interval is 16 yrs, Balmat et al. 2005).

**Table 4. Santa Fe Wilderness Area Mixed-Conifer Fire Interval Statistics, 1595-2006**

| Filter | Number of intervals | Mean fire interval | Median fire interval | Weibull median fire interval | Minimum interval | Maximum interval |
|---|---|---|---|---|---|---|
| all scars | 18 | 15.56 | 15.5 | 13.56 | 1 | 31 |
| 10% | 9 | 31.11 | 30 | 29.69 | 15 | 71 |
| 20% | 7 | 34.71 | 30 | 33.31 | 16 | 71 |
| 25% | 6 | 40.5 | 31 | 37.18 | 16 | 94 |

Tree ring analysis of the historical fire regime indicates that the frequency of fire varied considerably over the last 400 years (Table 4). Small fires (recorded only by single trees) occurred somewhere within the study area as frequently as one year apart (all scars, minimum interval = 1 yr), whereas widespread fires (scarring >25% of recording trees) were not recorded during a 94 year fire gap between 1748 and 1842. This range of fire intervals emphasizes the need to consider variability during fire restoration. Strong relationships between variability in reconstructed measures of climate (drought, precipitation and El Niño) and fire occurrence indicate that much of the historical variability in fire frequency was driven by the inherent variability of climate in the Southwest. This relationship breaks down in the 20th century, when no fires were recorded in the study area. Future, managed fire regimes would be most natural if these two processes (fire occurrence and climate variability) were re-coupled.

### *Restoration and Treatment History*

The Wilderness Area within the watershed has not received any restoration treatments.

### *Recommendations*

In this section we identify criteria and general locations where treatments are recommended, and where there is the potential for treatment pending additional data. Treatments may include mechanical thinning on strategic ridgetop locations immediately adjacent to the Wilderness boundary or prescribed fire, and naturally ignited fire used for resource benefit. We used these criteria to map recommended treatments within and adjacent to the Wilderness Area (Figure 3) and to quantify a range of acres in each treatment and recommendation class.

The criteria cover the two primary objectives of the forest management in the watershed: (i) reduce the risk of catastrophic crown fire for protection of the water resource and (ii) maintain or restore forest health. Decisions regarding the criteria are based on available forest structure and age data (presented above), current and historical fire regime data (presented above), and general knowledge of fire behavior in southwestern montane forest types (Table 5). We used the concept of historical range of variability (HRV): the ecological conditions, and the spatial and temporal variation in these conditions that are relatively unaffected by people (Landres et al. 1999), to determine where areas were in a "natural state" (based on HRV) when considering the objective of forest health. We considered three treatment types:

(i) fire, (ii) hand thinning, and (iii) mechanical thinning immediately adjacent to the Wilderness boundary.

Fire and thinning treatments were both "not recommended" (Table 5) in the spruce-fir zone so we combined these two categories into a single "not recommended for treatment" category on the map (Figure 3). Potential fire treatments in mixed-conifer forests on south-facing slopes within the Wilderness Area and between the Wilderness Area and McClure were combined and mapped as one "potential fire" category (Figure 3).

| Table 5. Summary of Criteria for Treatment Recommendations | |
|---|---|
| Fire Treatment **not recommended** | • Forests are in natural state (based on HRV of fire regime) OR<br>• Forests are in unnaturally dense state and crown fire is likely if burned without prior treatment OR<br>• Forests naturally burned in crown fire and will likely do so if burned now |
| Hand thinning **not recommended** | • Forests are in natural state (based on HRV of forest age and structure) |
| Fire treatment **potential** | • South-facing slopes that can be burned while opposing N-facing slopes have low fire risk (i.e., they still have snow on the ground). Evidence of 20th century increase in forest density, based on field observations and aerial photos. |
| Hand thinning **potential** | • Forests are in unnaturally dense state (based on HRV) AND<br>• Areas are in strategic locations (e.g., ridges) that would reduce the risk of fire from adjacent watersheds from entering the Santa Fe watershed or facilitate the management of fire within the Wilderness Area |
| Mechanized thinning **potential** | • Areas are in strategic ridgetop locations immediately adjacent to the Wilderness boundary, where fire has the highest probability of entering the Santa Fe watershed based on a range of prevailing wind directions (S - W) and public access to land that may lead to increased ignitions. |

*Summary of the Wilderness Area recommendations (including adjacent forests)*

- *Wilderness Area spruce-fir zone*

We do **not recommend** treatment for the 4,017 acres of spruce-fir vegetation in the upper Santa Fe watershed Wilderness Area due to the natural state of the forest and fire regime as compared to the historic range of variability derived from tree-rings. However, it must be recognized that this forest naturally burns as catastrophic fire and the predicted warmer future climate will likely increase the fire risk in this forest (e.g., Westerling et al. 2006). To address the potential post-fire watershed effects a hydrologic model should be used with differing crownfire scenarios. The GIS-based hydrology model AGWA is recommended for this post-fire risk assessment: http://www.tucson.ars.ag.gov/agwa/index.php?option=com_frontpage&Itemid=1

- *Wilderness Area mixed conifer zone (and adjacent forests above McClure Reservoir)*

There is **potential for fire on south-facing slopes** (pending additional data) of an estimated 1000 acres of mixed conifer, ponderosa pine and Gambel oak vegetation in the lower portion of the Wilderness Area and above McClure reservoir. These potential treatments would be aimed at breaking up contiguous fuels to reduce crown fire risk within the mixed conifer zone and maintaining or restoring areas with historical evidence of frequent surface fire regimes. Identified areas immediately upstream of the main water supply reservoir are of highest priority. These treatments would further reduce the risk of post crown-fire effects on McClure reservoir. The remaining area in the mixed conifer zone is likely too steep, dense and inaccessible to burn efficiently and without the risk of escaped crown fire into the adjacent spruce-fir zone. We need stand-level data on vegetation type and fuel structure (crown base height, crown spacing, surface fuel loads), and crown fire risk in adjacent stands to ultimately explicitly recommend these fire treatments. Collection and analysis of these data should be high priority.

- *Forested areas immediately outside of the Wilderness Area boundary*

To reduce the risk of fire from entering the upper watershed from adjacent watersheds, there is potential for **mechanical thinning** of an estimated 172 acres in mixed conifer forests on the ridges immediately adjacent to the south and west of the Wilderness boundary. These boundaries have the highest risk of fire due to public access and prevailing wind direction. This fuel break alone would not likely prevent crown fire spread into the watershed, but would be an anchor used for fire management in the dense forests immediately outside the watershed.

### *Monitoring*

We recommend monitoring any new treatments for adaptive management. Monitoring should occur before the treatment, immediately after the treatment, and 3 and 7 yrs following the treatment. The same variables should be monitored for the potential treatments within the Wilderness Area: 1) Mechanical thinning adjacent to the Wilderness Area boundary and 2) Prescribed fire or Fire Used for Resource Benefit inside the Wilderness Area and between the Wilderness boundary and McClure reservoir. Monitoring in each of these treatment areas should include (but not be limited to) the following variables:

- Fuel load
- Tree density
- Canopy cover, and
- Understory cover.

Monitoring plots that are representative of the treated area (i.e., similar aspect, slope, and forest type) should be permanently established at a ratio of 1 plot per 20 acres of treatment, not to exceed 20 plots per treatment area. In addition, to control for forest changes due to climate variability, additional control plots should be established in adjacent untreated forest with similar vegetation and physiographic characteristics (3 control plots per vegetation and physiographic setting – not to exceed 6 plots per treatment area). We recommend that all monitoring data be placed in a publicly accessible permanent archive in the New Mexico Forest and Watershed Restoration Institute at Highlands University.

## *Vegetation Management Plan for the Riparian Corridor of the Watershed*

### *Ecological Context*

Riparian zones comprise the vegetation systems adjacent to rivers where dynamic processes of erosion, deposition, and water flow occur. Typically, riparian communities occupy a small portion of the landscape, but contain the majority of plant diversity in the landscape. There are approximately 10 miles of stream from the headwaters to McClure Reservoir, and three miles of stream between the two reservoirs. The riparian community along the Santa Fe River above Nichols Reservoir is reasonably intact relative to other southwestern riparian zones, and relative to the pre-treatment conifer forest of the watershed. The 1998 Tolisano study of the riparian zone stated that "the overall hydrologic and ecological features suggest a resilient and healthy riparian ecosystem." Several prior studies have characterized existing conditions of the riparian community in the watershed. Their salient findings are summarized below and in Appendix 1.

- The upper reach of the Santa Fe River is fairly undisturbed and near historical conditions (Tolisano 1998).
- The middle reach of the Santa Fe River (from the McClure Reservoir to a point within the Wilderness Area) is periodically recharged with overbank surface flows, has a shallow ground water table, and supports more species and structural diversity (Tolisano 1998).
- The lower reach of the Santa Fe River used the BLM's Proper Functioning Conditions methodology to assess riparian health. Tolisano described the reach between dams as "properly functioning hydrologic and ecologic features" with "adequate levels of biological diversity" and "highly diverse in composition and structure." However, below Nichols Reservoir, Tolisano observed more degraded conditions, with little overbank flooding and presence of non-native invasive species (Tolisano 1998).
- Though vegetation communities are fairly diverse throughout the riparian corridor, five species account for 90% of the trees sampled: aspen, ponderosa pine, mountain alder, white fire, and Douglas fir (RMRS nd).
- Flooding has been reduced below the McClure Dam enough that the upper portions of the floodplain have become drier and more suitable for conifer establishment than riparian vegetation (Blue Earth 2000).

### *Restoration and Treatment History*

Various agencies and scientists have made recommendations for the riparian community over the history of the restoration project for the Santa Fe watershed. The merits of these recommendations are discussed below. To date, there have not been any treatments to the riparian corridor.

*1. Fuel reduction/thin conifers to reduce fire risk.* One potential restoration treatment is the thinning of ponderosa pine trees and other conifers within the riparian community in order to lower the threat of crown fire. The Forest Service Record of Decision (2001) calls for creating openings in the riparian community between the two reservoirs. A Forest Service document by Cassidy (2000) suggest that in both the riparian zone between the reservoirs, and above McClure to the Wilderness boundary, that the

density and size of conifer trees, especially ponderosa pines, suppress riparian species' regeneration and present a crown fire threat. Cassidy suggests that the removal of smaller conifer trees (12 to 16" dbh) and a burn-only scenario are inadequate to address the problem; and proposes removal of conifer trees up to 24" dbh and the reintroduction of cool fires into the riparian zone. Given the need to remove the biomass from the site and the impact of skidding or other surface removal, he suggested helicopter removal of trees as the best treatment option (Cassidy 2000).

What the historical structure and composition of tree species in the riparian was like in its historical range of variability is unclear. It is our assessment that the historical structure of the riparian community below the Wilderness boundary was sufficiently disrupted by human activities, especially by fuel wood cutting and intensive domestic grazing, that it is not possible to usefully reconstruct reference structures through tree-ring analysis. Pittinger (2000) suggests that the current riparian community established only 50 to 60 years ago. Given the human disruption of the past, it is more advisable to base 'restoration' on current conditions, than on reconstructed pre-settlement conditions.

The question of the desirable ratio of conifer trees to riparian vegetation is probably best asked in relation to fire risk. In terms of reduction of overall fire risk, the riparian zone is now effectively isolated from a spreading crown fire by thinning of the surrounding ponderosa pine forest. The likelihood of fire originating in the riparian zone and spreading into adjacent stands of conifers is low. Thinning conifers and removing the biomass would involve practical difficulties, considerable time and money, and disturbance impacts on the riparian community.

Moreover, given the low densities of adjacent thinned stands, the riparian zone offers an important refuge for wildlife seeking high density vegetation stands. Dodd et al. (2006), for example, recommend maintenance of such refuges of high-quality habitat in restored ponderosa pine forests for Abert squirrel (*Sciurus aberti*) populations. Since the riparian zone has been documented as largely within proper functioning conditions, and given the difficulties of removal of biomass, we do not recommend removal of any conifer trees from the riparian zone in the near term.

2. *Planting trees and shrubs.* The Forest Service Record of Decision (2001) calls for planting additional trees and shrubs in the riparian zone, while retaining all willow, alder and cottonwoods in the riparian community. The Tolisano report also recommended planting of deciduous riparian species such as cottonwoods, alders, maple and box-elder trees below McClure Reservoir.

The riparian community appears to be in recovery from human impacts that were historically quite severe. Cutting of firewood and domestic grazing resulted in the past in nearly denuded areas around the Santa Fe River, as documented in photographs taken of the area early in the 20th century. Since there is insufficient information on species composition prior to human activities, and since the community is functioning well, it seems advisable to allow natural processes to shape the composition of the riparian community rather than artificially alter composition. Continued monitoring of riparian species populations should guide the decision to plant native species. We do not recommend planting in the riparian zone at this time.

3. *Burn areas within the riparian community.* The "Monitoring Forest Treatments in the Santa Fe Municipal Watershed" (2003), discusses the TAG proposal that the effects of fire on riparian ecosystem be explored, including the suggestion of a small-scale study of the effects of fire on riparian sites. The

TAG concluded that the study should be postponed until the main watershed thinning was complete. Now that the thinning is largely accomplished, is it appropriate to conduct a controlled experiment that tests the effect of fire on the current structure of the riparian community?

The probability of high-intensity fire entering the riparian corridor from adjacent forests is low, now that the matrix of conifer forest surrounding it has been thinned to a low density. The effects of fire on upland riparian zones in the West is poorly characterized (Reeves et al. (2006). However, the moist conditions of the riparian zone, and the presence of deciduous trees such as aspen with lower levels of volatile compounds than conifer trees, makes it less likely that fire would travel up the corridor under most climatic conditions. If portions of the riparian corridor were to burn naturally, they are likely to recover rapidly (Reeves et al. 2006). If there is a prolonged and severe drought, the vulnerability of the riparian zone to crown fire should be reassessed, particularly with regard to dead and down fuel load. We do not recommend burning with prescribed fire within the riparian zone at this time.

*4. Down trees to mimic windfall.* Dead trees often falls across streams in complex patterns that enhance stream condition. Downed logs partially lying across streams can protect banks from erosion, dissipate stream energy, form pools, and store sediment. Stream banks can thereby store more moisture and nutrients. Cutting and dropping some ponderosa pine trees into the streambed has been suggested in order to introduce debris into the river.

The Tolisano Report documented fallen branches, whole trees, and other woody debris along the stream throughout the watershed, and characterized the dead and down load as "representative of properly functioning or optimal ecological conditions." Pittinger (2000) indicates the value of large woody debris, and the beaver dams that exist between the two reservoirs, in creating pools for trout. It was Tolisano's opinion that there is already enough downed wood to represent a potential fire threat during a drought.

There appears to be no critical need for changing the structure of debris in the stream at this time, since the riparian community was recently given high marks for function. In addition, the RMRS sampling documented the presence of a number of dead standing trees, which will be falling in the future, some of which may fall into the stream. We believe it is preferable to let natural processes of tree mortality and fall help to shape the streambed in the future, and we do not recommend felling additional trees for this purpose.

*5. Bring back the river otter.* The suggestion has been made, in the Tolisano report and elsewhere, to reintroduce the river otter to the Santa Fe River. The NM Department of Game and Fish is now in the midst of an effort to restore otters to the Rio Grande and Gila Rivers. The Santa Fe River, however, falls very short of an adequate prey base or an adequate flow to support an otter population, which would be isolated from other populations in the State in any case (Stuart 2006). We do not recommend otter reintroduction.

*6. Release water from McClure Reservoir.* Spring flooding is a key natural process in southwestern riparian communities. On a regular basis, flooding brings sediment and nutrients, both of which encourage seedling germination. Flooding can favor species that require a mineral seedbed, and disperse seeds, such as those of cottonwoods.

The City Water gauge above McClure Reservoir, which measures the pulse of flow in spring from snowmelt, provides information that reflects the natural streamflow unaltered by dams. This gauge documents a fairly long record of year-round water flows, which, as expected, reach a maximum in spring during snowmelt (City of Santa Fe data). The average flow over this period, which contains some data reconstructed from reservoir levels and releases from the lower dam, is 425 acre feet per month, with a minimum of 0 acre feet per month, and a maximum of 4,820 acre feet per month (May, 1973). Although the latter value is an extreme value from a wet period, monthly flows in spring in the 2-3,000 acre feet per month value range are not uncommon. During dry periods maximum monthly values do not usually exceed ~ 1,000 acre feet per month at high flow in spring, and can be much lower. Stream flows are greatest, in general, during the three months that reflect snowmelt, i.e., April, May and June.

Streamflow modification is the most common form of restoration in southwestern riparian systems, as restoration of natural process is favored over structural modification (Follstad Shah 2007). One goal of restoration is to reestablish the natural processes that keep communities within their natural range of variability over time. This approach reduces the uncertainty that accompanies human choices in restoration work. The upper gauge streamflow data can be used to shape the release of water from the upper dam into the reach between the two reservoirs. Such a release of water in the spring period when snowmelt would have naturally occurred, would mimic a natural process that helped shape the riparian community in that stream reach. We recommend refining the spring release from McClure, a release of water from the upper dam that mimics the annual peak flows in springtime. The benefits to riparian features should be used as a guide to timing and quantity of releases.

One benefit of higher peak flows between the reservoirs should be a reduction in conifer seedling establishing within the floodplain. Sustained flows throughout the growing season between the reservoirs should also benefit riparian species establishment. In addition, fires appear to have occurred in upland riparian zones with a frequency similar to the ponderosa pine forest matrix (Arno and Peterson 1983). Peak flows may sweep away and accelerate decay of the high fuel loads in parts of the riparian zone, and sustained summer flows would keep dead and down fuels moist throughout the natural fire season. Higher peak flow may also destabilize and, in time, fell some of the large established conifer trees in the riparian zone.

In the long-run, it would also be advisable to consider the ecological impacts of releases from Nichols Dam on the riparian zone below. Although there are water storage considerations that are not an issue for between-reservoirs release, the more degraded riparian corridor below Nichols Dam may benefit also from spring water releases.

Changing the pattern of springtime releases from the reservoirs, however, must be considered carefully. Tolisano, while noting the benefit of natural levels of flooding in springtime for the riparian community, also pointed out that current release levels appear to be adequate to produce a healthy community. Any adjustment of release flows should be accompanied by intensive monitoring of PFC parameters, especially bank stability.

*6. Remove Invasive Species.* A final riparian issue is the presence of non-native invasive tree species below Nichols Reservoir. Russian olive and Siberian elms are currently growing around the decommissioned Two-Mile Dam, and populations of the invasive forb Toadflax have been observed in this area (Tolisano 1998, Pittenger 2000). Without treatment, it is likely that invasive non-native species that occur in the lower reach of the watershed riparian zone will soon disperse and establish farther up the river. It is not altogether clear what the role of these invasive trees is in the riparian ecosystem, for example, whether or not they are deleterious or beneficial to native bird populations. Nevertheless, it seems best to err on the side of caution in regard to the spread of non-native trees farther into the upper watershed.

## *Recommendations*

The riparian community in the Santa Fe watershed is, on the whole, in relatively good condition. Judged by both the standard of crown fire risk and general ecological integrity, the riparian community is in need of little treatment. The lowest portion of the riparian community in the watershed is the most degraded. We recommend the following:

- *The reach from McClure Reservoir to the Wilderness Boundary*
  **No treatments** are necessary in this reach of the river, but continued monitoring of structural conditions and proper functioning condition are recommended.

- *From Nichols to McClure Reservoirs*
  Consider refining the pattern of seasonal water release from McClure Reservoir based on ecological impacts to the riparian community. Variability in annual streamflow, as reflected in the gauge above McClure Reservoir, should be eflected in variability in the releases. This action should be accompanied by continuing monitoring to ensure that PFC values are not negatively affected over time.

- Below Nichols Reservoir
  Remove non-native tree species found growing below Nichols Dam. Below Nichols Dam (below the water supply intake), treat stumps of Russian olive with short-lived herbicide to prevent resprouting; periodically revisit the treatment to prevent reestablishment of non-native tree species.

- *Monitoring*
  On-going monitoring of the ecological integrity and functioning of the riparian community is essential. Virtually all documents created for the restoration treatment plan suggest that monitoring be part of the long-range management of the watershed. We recommend continued use of the Proper Functioning Condition methodology, particularly since there is existing baseline data. Two system components need on-going monitoring attention: 1) the integrity of riparian function, and 2) the populations of non-native tree and other invasive plant species, which can disperse and establish quickly, and destabilize riparian communities along the length of the river above Nichols Reservoir. We also recommend that monitoring track changes in riparian conditions that may result from drought and warming trends. We recommend that all monitoring data be placed in a permanent archive in the New Mexico Forest and Watershed Restoration Institute at Highlands University.

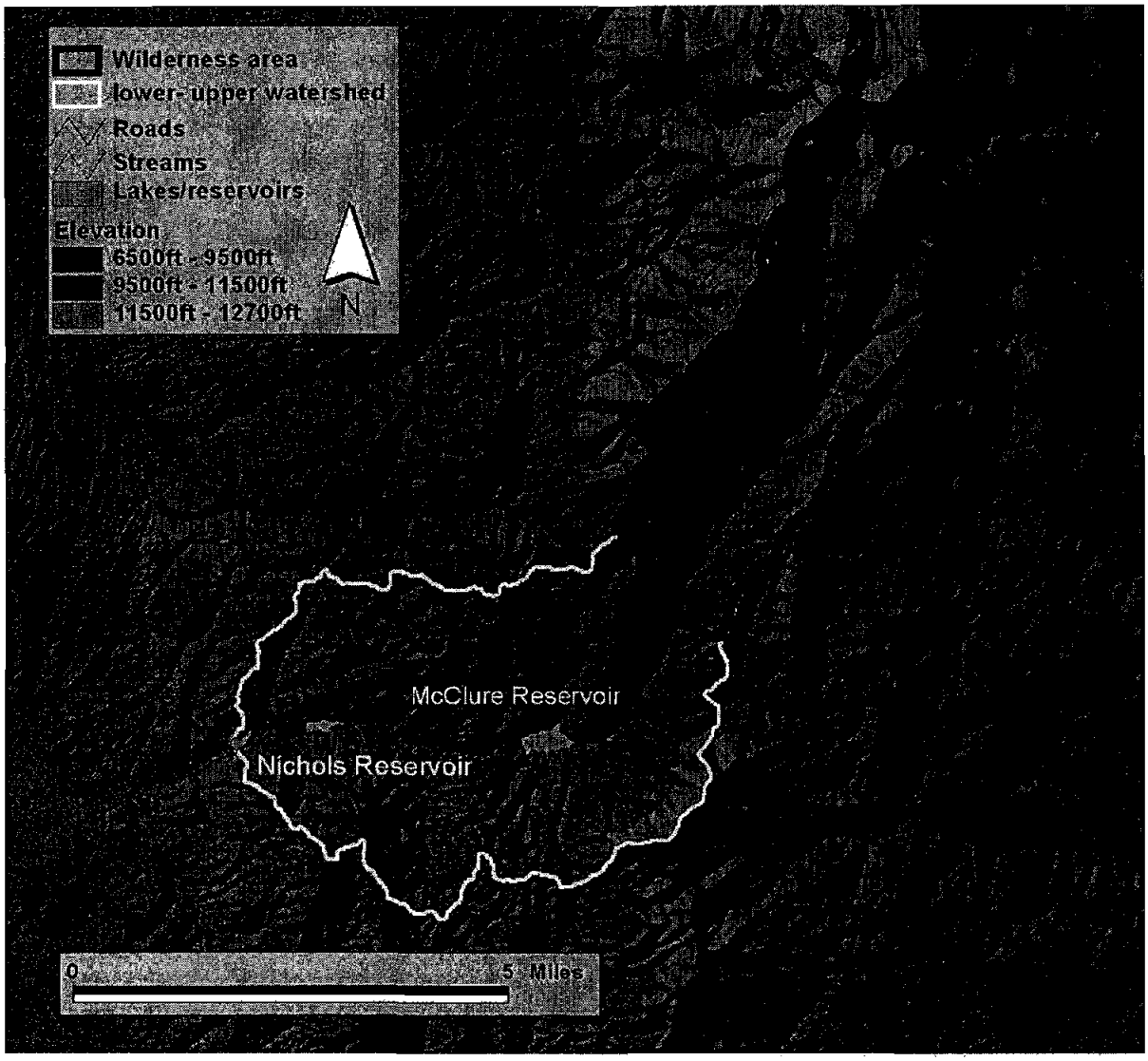


Figure 1. Shaded relief digital elevation map of the upper Santa Fe Watershed, NM. The two management areas discussed in the text are delineated in black (the wilderness area) and white (the lower-upper watershed).

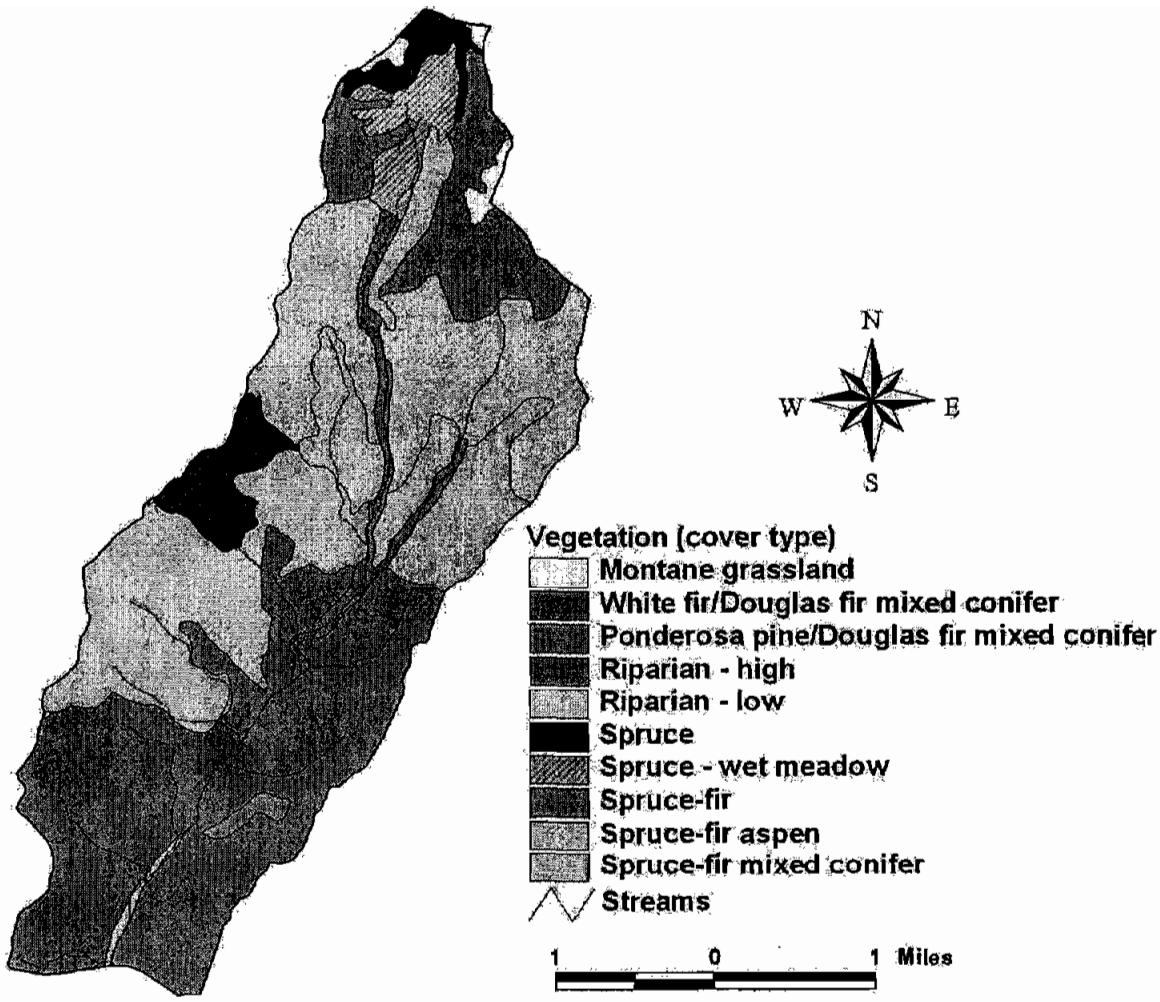


Figure 2. Vegetation types of the Santa Fe Watershed Wilderness Area.

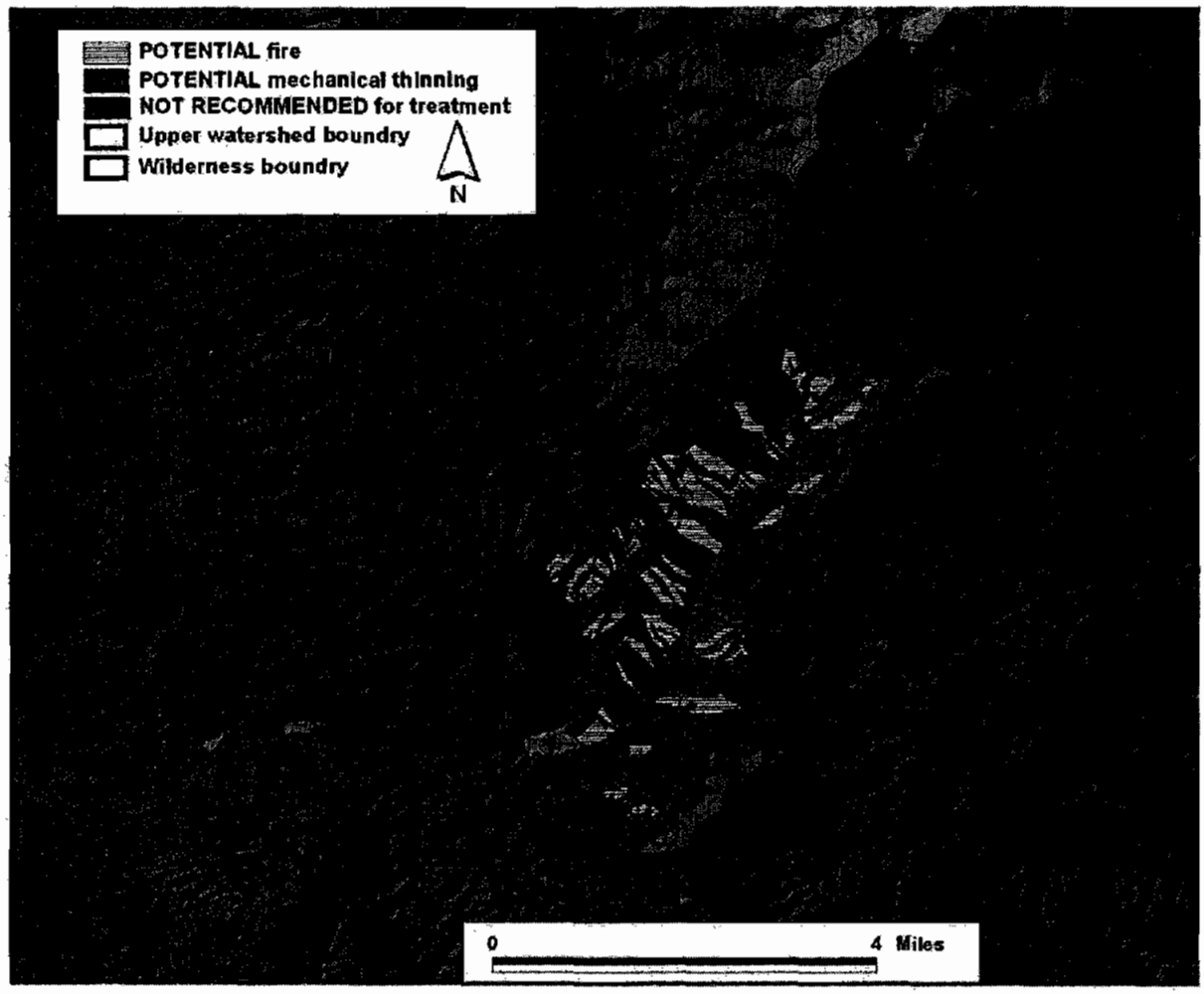


Figure 3. Treatment recommendation map for the upper Santa Fe Watershed Wilderness Area and mixed-conifer forest above McClure Reservoir.

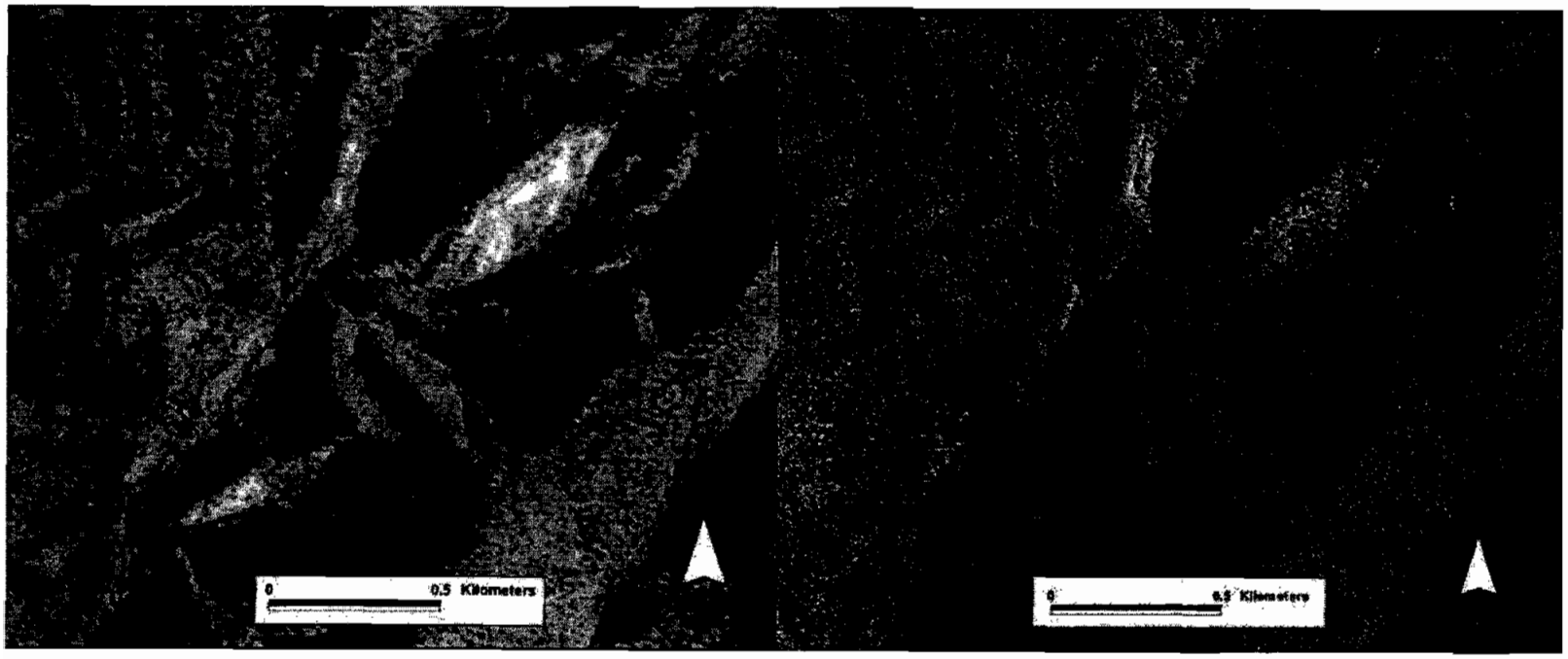


Figure 4. Comparison of aerial photos (1935 on the left, 2005 on the right) from the mixed conifer zone of the Santa Fe Watershed Wilderness Area indicates increased forest cover on south and east-facing slopes over the 70-year period. Photos from the U.S.F.S. Santa Fe National Forest S.O., courtesy of Julie Luetzelschwab.

## Appendix 1: Background Information on the Riparian Zone

This appendix presents a summary of recent findings regarding ecological conditions in the Riparian Zone of the Santa Fe Municipal watershed.

**Tolisano report.** The Tolisano Report (1998) characterized existing conditions in three stretches of the Santa Fe River: lower, middle and upper. The upper reach of the river courses through the very steep portion of the watershed, where canyon walls dip steeply to the river, confining the riparian zone to a narrow strip. This part of the riparian community is fairly undisturbed and likely near historical conditions. The middle reach of the river was defined by Tolisano as the reach from McClure Reservoir to a point within the Wilderness, thus encompassing the reach from McClure to the Wilderness boundary and extending above it. The river in this reach emerges from the steeply cut canyon, and spreads out into a wider floodplain. In this section, the floodplain is recharged with overbank surface flows periodically, has a shallow ground water table, and supports more species and higher structural diversity.

The reach between the reservoirs, Tolisano's 'lower reach,' was characterized by "a mix of properly functioning riparian conditions." Tolisano used the BLM's Proper Functioning Conditions (PFC) methodology to measure riparian community health (BLM 1993). For the reach between the dams, the PFC ratings for canopy cover, vegetation width, structural diversity, ground diversity, were all graded as "properly functioning hydrologic and ecological features"—reflecting "adequate levels of "biological diversity, ecological structure and resilience, growth, vigor, and regenerative capacity to ensure the long term viability of the ecosystem", and site diversity, channel stability and canopy cover ranked at "optimal condition"—reflecting "high levels" of those traits. Tolisano described this portion of the riparian community as "highly diverse in composition and structure," with a wide riparian zone with multiple canopy layers, numerous shrubs and an abundant understory of saplings, shrubs and herbaceous plants. River banks are "highly stable" and sediment effectively dispersed downstream. Tolisano notes that the riparian zone between the two reservoirs is dependant upon the timing and quantity of water releases from McClure, and that the condition of the riparian community in this reach seems to reflect an adequate release pattern.

Below Nichols Reservoir, however, Tolisano observed more degraded conditions. There is little overbank flooding in this reach, although the width of the riparian zone continues to be reasonably wide, reflecting an adequate water table. Non-native invasive species, such as Russian olive and Siberian elms, have moved into the riparian community below Nichols Reservoir. Tolisano notes that these species could easily travel upstream and invade the upper river communities, and that this would significantly reduce the quality of wildlife habitat of the riparian community.

**Rocky Mountain Research Station data.** Rocky Mountain Research Station sampled vegetation in the riparian community as part of the monitoring effort that accompanied forest treatments. The data documents that, although the community is fairly diverse,

five species account for 90% of the trees found in the sampled riparian community: aspen (Populus tremuloides) (113/acre - 27% of all trees), ponderosa pine (Pinus ponderosa) (89/acre - 21%), mountain alder (Alnus tenuifolia) (70/acre - 17%), white fir (Abies concolor) (64/acre - 15%), and Douglas fir (Pseudotsuga menziesii) (44/acre - 10%). Other tree species found on the site in smaller numbers include narrowleaf cottonwood (Populus angustifolia) (16/ac), Rocky Mountain maple (Acer glabrum) (8/ac), limber pine (Pinus flexilis) (6/ac), Rocky Mountain juniper (Juniperus scopulorum) (4/ac), Gambel oak (Quercus gambelii) (3/ac), chokecherry (Prunus virginiana) (1/ac), piñyon pine (Pinus edulis) (1/ac) and snowberry (Symphoricarpos spp.) (1/ac).

The study documented dead standing trees in the riparian zone, 26/acre for snags larger than ~ 5" and 93/acre for snags smaller than ~ 5". Aspen are the most numerous snags (average dbh 9" [diameter breast height]), ponderosa pine (average dbh 6"), Doug fir (average dbh 5"), cottonwood (average dbh 11"), and white fir (average dbh 7"). Most are relatively small size snags, which tend to fall more rapidly than larger snags.

The largest live trees on the site are ponderosa pine, with 20% of trees over 16" dbh. Of the other four most common trees, there were few large trees: only 7% of white fir, 3% of Douglas fir, and 5% of aspen were larger than 16" dbh; no mountain alder trees were larger than 5" dbh. Nearly 75% of the aspen are smaller than 8" dbh. In general, especially in moist sites, size reflects age, and, together with what we know about human impacts in the past, the data support the case that most trees in the riparian community established fairly recently.

**Blue Earth Existing Conditions Report** (Pittenger 2000). This report documented in detail the species composition and distribution of the various types of riparian communities found in the watershed. The author discusses the issue of water release from McClure Dam and its effect on the community. He notes that flooding has been reduced enough that the upper portions of the floodplain have become drier and more suitable to conifer establishment than riparian vegetation: "The floodplain has essentially become abandoned and now comprises a terrace." In addition, sampling was conducted in August, at which time there was no water flowing in the riverbed, and water occurred in isolated pools only. The report points out both the benefits of flow regulation—reduced destructive effects of flooding, such as destruction of beaver dams at peak flow—and the disadvantages—reduced overbank flows that favor establishment of riparian species.

# Appendix 2: Summary of NEPA Monitoring in the Santa Fe Watershed, as of October 2006

| NEPA implementation monitoring in the Santa Fe Municipal Watershed, revised 10/06 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Resource or Issue** | **Parameters** | **Methods** | **Timing & Frequency** | **Responsible Group** | **Funding** | **Annual Cost** | **Baseline Data** |
| **Water:** Are treatments adversely affecting water quality such that we are not in compliance with Federal/State and Forest Plan standards, and Clean Water Act regulations? Are treatments resulting in beneficial increases in water yield or unacceptable peak flow events that may alter the stream channel morphology? | | | | | | | |
| Water Quality | Stream flow, turbidity, temperature, precipitation | Paired Basin Study | 15 mins at gauging stations. Precip. at 2 higher elevations. TSS data limited | City of Santa Fe | City of Santa Fe | $30,000 | 3 years pre-treatment data |
| Water Chemistry | pH, temp, turbidity, conductance, dissolved oxygen, metals, ammonia, nitrate, nitrogen, phosphorus, suspended & dissolved solids, major cations and anions, organic compounds, fecal coliform bacteria, radionuclides, cyanide. | 3 sites on SF river, per approved Quality Assurance Project Plan | 3x per year (spring, summer, fall) | NMED | NMED | $4,500 | NMED |
| Peak Stream Flows in Side Drainages | Stream flow | Use Parshall flume and flow gauge in paired subdrainages (treated & untreated). Rain gauge between drainages | 15 min. intervals, March-Oct | City of Santa Fe | City of Santa Fe | See "water quality" above | |
| SF River geomorphology | Stream width, depth, cross-section, area, entrenchment, channel bottom, particle size, bank erodibility, hazard index, relative elevations of thalweg, water's edge, bankful at each habitat unit (pools, riffles, runs, glides), cross section area of pools | Use Rogsen method. Record measurements at 2 cross-sections and along 1 stream reach | Annually each summer | NMED | NMED | See "water quality" | Blue Earth 2000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SOIL:** Are treatments adversely affecting the soil such that we are not in compliance with Forest Plan standards for acceptable soil loss and maintenance of long-term soil productivity? | | | | | | | |
| Soil Erosion, Loss | Erosion rate (tons/acre/yr) | RUSLE at data collection points from RMRS wildlife study | Annually | Santa Fe National Forest, Española Ranger District | SFNF | $1-2,000 | RMRS pre-treatment data |
| **Ground Vegetation:** Are treatments meeting the objective of increasing vegetative ground cover, in order to stabilize the soil, filter sediment runoff, improve nutrient cycling, increase biological diversity and carry future surface fires? | | | | | | | |
| Understory Ground Cover | Grasses, forbs, shrubs | % vegetative ground cover, RMRS plots; species info on woody veg only. Photo points | Annually | RMRS | See "Wildlife habitat & diversity" below | | RMRS pre-treatment data |
| **Fire:** Are prescribed burns resulting in escaped crown fires outside fire lines? Are they staying within burn prescriptions and behaving as predicted in the EIS? Are mitigations being followed? | | | | | | | |
| Escaped Crown Fires resulting from prescribed burns; unexpected fire behavior | Unexpected fire | Recorded observations of fire behavior | During and after burn, until fire is out | SFNF Española Ranger District | SFNF | Part of normal fire monitoring budget | Data since project start |
| Prescribed fire | Energy Release Component (ERC), fuel moistures, Palmer Drought Index (PDI) | Record 3-5 day ERC, fuel moistures and PDI; other weather. | Just prior to ignition | SFNF Española Ranger District | SFNF | Part of normal fire monitoring budget | Data since project start |
| **Air:** Are prescribed burns adversely affecting air quality such that we are not in compliance with Federal/state and Forest Plan standards and Clean Air Act regulations? Is smoke from prescribed burning resulting in adverse impacts to *public health or visibility?* | | | | | | | |
| Smoke from Burning; Environmental Compliance | Particulate matter (PM-10), TEOM, and smoke (visual) | PM-10 monitors along Upper Canyon Road, visually monitor smoke plume | Daily during burns until smoke subsides | SFNF Española Ranger District | SFNF | Approx. $400 extra from normal burn monitoring | Data since project start |
| Smoke from Burning: Health and Safety | Air quality warnings; alerts or travel way visibility impacts | Record air quality alerts and visibility impacts | During burns until smoke subsides | SFNF Española Ranger District | SFNF | See above | Report and EIS data |
| **Fuels & Forest Vegetation:** Are treatments effective in meeting the fuel reduction objectives by breaking up fuel continuity in the overstory and reducing the density of understory ladder fuels? | | | | | | | |
| Fuel Hazard: Dense ladder fuels and canopy cover | Basal area, trees/acre, diameter class distribution, % canopy cover | Stand exam plots, stratified random sample | Annually for 2 years after thinning & burning | SFNF Española Ranger District | SFNF | $1,000/year | USFS 1998 stand exam |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Forest & Riparian Vegetation**: Are invasive non-native plants increasing in the riparian areas where treatments caused soil disturbance? Are bark beetles infesting the cut trees on the forest floor and posing a threat to live trees? | | | | | | | |
| Invasive plants | Exotic species, herbaceous & woody | Sample treated areas, count and map invasive plants. Note observations on map, report to field biologist | Survey at appropriate seasons for ID. Report as species observed | SFNF Española Ranger District | SFNF | $2,000 | Tolisan o 1998 |
| Insect infestations | Ips beetles in cut/down logs; infested standing trees | Observation by qualified specialist | | SFNF Española Ranger District | SFNF | Part of project costs | Data since project start |
| ***Wildlife Habitat & Diversity***: Are treatments resulting in a loss of key habitat features such as large snags, down logs or riparian hardwood species, or reducing vegetative cover in the drainage bottoms/corridors? Are treatments resulting in an increase or decrease of existing aquatic insects, fish, beavers, birds, or small mammals, which may indicate an improvement or decline in biological diversity? | | | | | | | |
| Key Wildlife Habitat Features | Large snags, down logs and hardwoods | Stand exam plots, stratified random sample; include MSO restricted habitat | Annually for 2 years after thinning & burning | SFNF Española Ranger District | SFNF | Part of stand exams | 1998 stand exam |
| Key Wildlife Habitat Features | Canopy cover in drainage bottoms | Stand exam plots, stratified random sample; MSO restricted habitat | Annually for 2 years after thinning & burning | SFNF Española Ranger District | SFNF | Part of stand exams | 1998 stand exam |
| Overstory and Understory | Overstory tree species; Woody understory species at RMRS points, species; other understory species not recorded. | Stand exams for appropriate area | Annually for 2 years after thinning & burning; Veg data collected annually | SFNF Española Ranger District; RMRS ground vegetation | SFNF; RMRS | Part of stand exams | 1998 stand exam; RMRS data since 2002 |
| Aquatic insects & fish | Species richness, composition, % Ephemeroptera, tolerance/intoleran ce, % filterers,% clingers | Multi-habitat approach, EPA rapid bioassessme nt, 3 sites on upper SF River | Annually in summer | NMED | NMED | See "water quality" | Tolisan o 1998, NMED 2000, Blue Earth 2000, SFHS 1996-2000 |
| | Trout numbers, size, and condition by species | EPA rapid bioassessme nt, record #, size, weight by species on 3 sites | Annually each summer | NMED | NMED | See "water quality" | Tolisan o 1998, NMED 2000, Blue Earth |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | upper SF River | | | | | 2000, SFHS 1996-2000 |
| Wildlife *populations*; biological diversity | Abundance and *species richness of* breeding birds & small mammals | RMRS | Multiple measurements spring/summer | RMRS | RMRS | $100,000 | Baseline 2 years pre-treatment |
| Wildlife populations; biological diversity | Abundance of active beaver colonies | Count active beaver dams | Annually | SFNF Española Ranger District | SFNF | $1,000 | Baseline 3 yrs pre-treatment |
| **Heritage Resources:** Are treatments adversely affecting heritage resources such that we are not in compliance with Forest Plan standards and National Historic Preservation Act regulations? | | | | | | | |
| Site preservation | Heritage resource sites | Sampling 20% of known sites | Annually after thinning & burning | SFNF Española Ranger District | SFNF | $3,000 | Arch. Survey |

| **Monitoring & Communication Added to the Santa Fe Municipal Watershed Project through the Process of Adaptive Management** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Social:** What is public perception of the project? How has public perception changed since project was first proposed? | | | | | | | |
| Public perception | Change in Approval/disapproval of project among interested public. | 30-50 Interviews w/ persons identified by SF, SFNF, Watershed group; snowball sample, interviews of DEIS commentator | As soon as possible and after project completion | | | $3-5,000 estimate | Comments on DEIS; Citizen complaints |
| Collaborative Forestry: How do we maintain open communication between the scientific community, the larger community, and the Santa Fe National Forest regarding the conduct of the Santa Fe Municipal watershed project? | | | | | | | |
| ***Entity*** | ***Function*** | ***Composition*** | ***Meetings*** | ***Public Outreach Opportunities*** | ***Funding*** | | |
| Santa Fe Watershed Association | Observes project, feeds issue questions to TAG to provide feedback to SFNF, provides public outreach | Non-profit with professional staff and broad membership | For those related to this project, see below | website www.santafewatershed.org provides frequent updates on project. | Foundations, donations, etc. | | |
| Technical Advisory Group | Scientific panel oversees data collection and interpretation, observes treatments and provides feedback to | Volunteers with appropriate background invited by SFWA | Every six months | Part of meeting is open to public | None. Partners provide endorsement for grant seeking efforts. | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | SFWA | | | | | | |
| Implementation Team | Forum for regular communication between resource managers, monitors and other stakeholders | SFNF, SFWA, agencies performing monitoring, staff of elected representatives, City | Monthly | None; purpose is to provide forum for open communication among named participants, decide collectively who to provide public outreach on a given issue and how | Individual agencies/ organizations | | |

## Literature Cited


Abella, S. R and W.W. Covington. 2004. Monitoring an Arizona Ponderosa Pine Restoration: Sampling Efficiency and Multivariate Analysis of Understory Vegetation. Restoration Ecology 12: 359-367.

Allen,C.D., M. Savage, D.A. Falk, K.F. Suckling, T.W. Swetnam T. Schulke, P.B. Stacey, P. Morgan, M. Hoffman, and J.T. Klingel. 2002. Ecological restoration of Southwestern ponderosa pine ecosystems: A broad perspective. Ecological Applications 12: 1418-1433.

Arno, S.F. and T.D. Peterson. 1983. Variation in estimates of fire intervals: a closer look at fire history on the Bitterroot National Forest. USDA Forest Service Research Paper INT-301.

Balmat, J., C. H. Baisan, and T.W. Swetnam. 2005. Sensitivity of Semi-Arid Southwestern Forests to Climate-Induced Disturbances: Fire History in Northern New Mexico. Final Report for NPS project No. CA124800002UAZ99.

Barkmann, G. 2003. Report on air quality monitoring related to burning in the Santa Fe Municipal Watershed for the period April-December 2003. On file at the USFS Espanola District Office, Espanola, NM.

Barnett,T.P., Pierce,D.W., Hidalgo,H.G., Bonfils,C., Santer,B.D., Das,T., Bala,G., Wood,A.W., Nozawa,T., Mirin,A.A., Cayan,D.R., and Dettinger,M.D. 2008. Human-induced changes in the hydrology of the western United States. Science 319: 1080-1083.

Breshears,D.D., Cobb,N.S., Rich,P.M., Price,K.P., Allen,C.D., Balice,R.G., Romme,W.H., Kastens,J.H., Floyd,M.L., Belnap,J., Anderson,J.J., Myers,O.B., and Meyer,C.W. 2005. Regional vegetation die-off in response to global-change-type drought. Proceedings of the National Academy of Sciences of the United States of America 102: 15144-15148.

Bureau of Land Management, USDI. 1993. Process for assessing Proper Functioning Condition. TR 1737-9 1993.

Cannon, S.H. and S.L. Reneau. 2000. Conditions for generation of fire-related debris flows, Capulin Canyon, New Mexico. Earth Surface Processes and Landforms 25: 1103-1121.

Cassidy, R. 2000. Santa Fe Watershed Project: riparian corridor potential treatments and mitigation measures. (unpublished).

Cram, D.S., T.T. Baker, and J.C. Boren. 2006. Wildland Fire Effects in Silviculturally Treated vs. Untreated Stands of New Mexico and Arizona. USDA Forest Service Rocky Mountain Research Station Research Paper RMRS-RP-55.

Dodd, N.L., E.R.E. Schweinsburg, and S. Boe. 2006. Landscape-scale forest habitat relationships to tassel-eared squirrel populations: Implications for ponderosa pine forest restoration. Restoration Ecology 14: 537-547.

Finney, M.A., C.W. McHugh, and I. C. Grenfell. 2005. Stand- and landscape-level effects of prescribed burning on two Arizona wildfires. Canadian Journal of Forest Research 35: 1714-1722.

Follstad Shah, J.J., C.N. Dahm, S.P. Gloss, and E.S. Bernhardt. 2007. River and riparian restoration in the Southwest: Results of the National River Restoration Science Synthesis Project. Restoration Ecology 15: 550-562.

Grant, P. 2004. Monitoring Forest Treatments in the Santa Fe Municipal Watershed: Final 319 Grant Report. Santa Fe Watershed Association, Santa Fe, NM.

Hann, Wendel, Havline, Doug, Shlisky, Ayn, et al. 2003. Interagency and the Nature Conservancy fire regime condition class website. USDA Forest Service, US Department of the Interior, The Nature Conservancy, and Systems for Environmental Management [frcc.gov].

Hudnell, L. 2000. NEPA specialist report: Santa Fe Watershed Air Report. On file at the USFS Espanola District Office, Espanola, NM.

Isackson, D. 2006. Prescribed Fire Plan. USFS Santa Fe National Forest, Espanola Ranger District. Updated 2008 by B. Skeen, R. Tingle, E. Zaharis, and L. Garcia.

Landres, P.B., P. Morgan, and F.J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. Ecological Applications 9: 1179-1188.

Margolis, E.Q., T.W. Swetnam, and C.D. Allen. 2007a. A stand-replacing fire history in the Southern Rocky Mountains. Canadian Journal of Forest Research 37:2227-2241.

Margolis, E.Q., T.W. Swetnam, C.D. Allen, and K. Beeley. 2007b. Response of Western Mountain Ecosystems to Climatic Variability and Change: The Western Mountain Initiative – Upper Santa Fe Watershed. Final Report for Cooperative Agreement No. H1200050003.

Pittenger, J. 2000. Report on existing biological conditions and analysis of effects of alternatives for the Santa Fe Municipal Watershed Project. Blue Earth Ecological Consultants, Santa Fe, NM.

Reeves, G.H., P.A. Bisson, B.E. Rieman, and L.E. Benda. 2006. Postfire logging in riparian areas. Conservation Biology 20: 994-1004.

Santa Fe National Forest, USDA Forest Service, Southwestern Region. 2001. Santa Fe Municipal Watershed Project: Final Environmental Impact Statement. US Department of Agriculture.

Sibold,J.S., T.T. Veblen, and M.E. Gonzalez. 2006. Spatial and temporal variation in historic fire regimes in subalpine forests across the Colorado Front Range in Rocky Mountain National Park, Colorado, USA. Journal of Biogeography 33: 631-647.

Stuart, J. 2006. Feasibility Study: Potential for Restoration of River Otters in New Mexico. New Mexico Department of Game and Fish. (unpublished document).

Tolisano, J. 1998. Inventory and analysis of the riparian ecosystem in the Santa Fe Municipal Watershed. College of Santa Fe, Santa Fe. (unpublished report).

Unpublished data. Karen Bagne, source. Santa Fe Watershed Monitoring Data. USDA Forest Service Rocky Mountain Research Station, Albuquerque.

Veenhuis, J.E. 2002. Effects of wildfire on the hydrology of Capulin and Rito de los Frijoles Canyons, Bandelier National Monument, New Mexico.

Westerling,A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam, 2006. Warming and earlier spring increase western US forest wildfire activity. Science 313: 940-943.

# Santa Fe Municipal Watershed
# Water Management Plan

## Background and Context

The Santa Fe Municipal Watershed provides critical surface water to city residents' water supply. Protection of water quantity and quality is a shared goal of the City of Santa Fe and the Santa Fe National Forest, which manages the upper 17,000 acres of the watershed. The City and Forest Service both recognize that high-intensity fire risk and overgrown dense forests are strong threats to watershed health and the long term viability of water supplies.

The overly dense ponderosa pine forests of the Santa Fe watershed were prioritized for restoration and crown fire hazard reduction because of the importance of the watershed to the water supply of Santa Fe. A crown fire in the watershed would overload the water treatment plant with ash and potentially threaten the two dams and reservoirs used for water storage. Initial mechanical treatments of 5,800 acres of upland, pine-dominant forests in the watershed temporarily reduced the risk of crown fire, but maintenance treatments are vital for future forest health and protection of the water supply.

Monitoring of water quantity, quality, and ecosystem health to date, beginning with the previous watershed restoration project in 2002, demonstrates a healthy watershed. Paired basin monitoring within the watershed has shown a moderate increase in streamflow and no increase in turbidity as a result of thinning activities. While the Santa Fe River water quality hasn't been impacted adversely from past management activities, continual assessment of Santa Fe river water supply requires ongoing monitoring to assess the impacts of management activities and allow adaptive management.

## Scope of this Plan

This water management plan provides a framework for long term monitoring that will help the City maintain a reliable, high quality water supply. Because ecosystem health of the upper watershed riparian corridor is directly related to both water quality and quantity within in the Santa Fe River within the upper watershed, this plan also specifies measures for ecosystem monitoring and potential habitat enhancement within the riparian corridor. The monitoring proposed in this plan will help address three critical objectives for water management:

- Maintain a Reliable Water Supply
- Maintain a High Quality of Water
- Enhance Wildlife Habitat and Ecosystem Function.

For each of the above objectives, we provide recommendations for three categories of monitoring parameters:

1. Critical parameters recommended for regular analysis

2. Secondary parameters recommended if critical parameters exceed a threshold, and
3. Parameters considered, but not recommended

## Summary of Recommendations

| Table 1. Summary of Recommendations for Water Management | |
|---|---|
| Maintain a Reliable Water Supply | • Regularly monitor stream flow, precipitation, reservoir level, and reservoir bathymetry. |
| Maintain a High Quality of Water | • Regularly monitor 10 critical parameters for water quality below the Nichols Reservoir and/or at the water treatment plant. |
| Enhance Wildlife Habitat and Ecosystem Function | • Utilize the Rapid Stream Riparian Assessment methodology to identify areas and criteria for habitat enhancement |

## Recommendations

### *Maintain a Reliable Water Supply*

#### *Monitoring History*

As part of the forest thinning project, a paired basin study was established to evaluate the impacts of forest management activities on stream flow. In this study, discharge and other parameters such as turbidity were measured in two adjacent basins for a period of four years; one basin served as a control, while the other was thinned to the prescribed level of tree density and composition. The monitoring data showed a moderate increase in stream flow, while stream turbidity was not affected as a result of thinning activities. While the Santa Fe River hasn't been impacted adversely from past management activities, continual assessment of Santa Fe river water supply an monitoring of future management activities requires ongoing monitoring of stream flow, as well as expanded monitoring of precipitation.

There are a number of established stream gage stations within the watershed with substantial discharge records and proposed additional precipitation monitoring will be conducted at some of these same locations. The following is a summary of stream gage stations currently or previously operated in the watershed, as well as the extent of the discharge record:

- Santa Fe River Above McClure Reservoir (automated, 1998-current)
- Santa Fe River Near Santa Fe, below McClure Reservoir (automated, 1930-current)
- Santa Fe River Below Nichols Reservoir (automated, 1998-current)
- North Paired Basin Study (automated, 2001-2004)
- South Paired Basin Study (automated, 2001-2004)

The Following is a summary of precipitation and weather stations operated in the watershed, as well as the extent of the data records:

- NRCS SNOTEL snow pillow site near Santa Fe Ski Area (automated with telemetry, 1996-current)
- NRCS SNOTEL snow pillow site at Elk Cabin, above McClure Reservoir (automated with telemetry, 1996-current)
- Paired Basin Study Precipitation Gages (automated, 2002-2004)
- Nichols Reservoir Precipitation Gage (manual, 1996-current)
- Water Treatment Plan Precipitation Gage (manual, 1996-current)

All monitoring activities will be documented. If monitoring results indicate that laws, regulations, standards aren't being observed, objectives are not being met, or mitigations are not effective, the activity will be modified to remedy or ameliorate the problem. During forest management activities, monitoring results will be evaluated at a minimum on a monthly basis to provide feedback to resource managers. Annually, monitoring data will be consolidated and available for review by interested parties including technical science advisors. The Forest Service and the City will evaluate the monitoring results along with advice and comments received. The Forest Service and the City will periodically update the Water Management Plan, as it is important that any new relevant research be integrated into this adaptive monitoring strategy.

### *Recommendations*

We recommend a monitoring system that will provide information to help the City Water Division answer the following questions:

- How much water do we have in our reservoirs?
- How much water do we expect given the snowpack?
- How much of our annual water of 5040 ac-ft do we expect to use this year?
- Do we project either Nichols or McClure Reservoirs to spill? And if yes, approximately by how much?

- Do we need to operate the reservoirs to mitigate flood flows?
- Are we in a local drought (how does the precipitation to date compare to the average and to other drought years?
- How much water is being released to the Santa Fe River?
- Is forest management impacting on water quantity?
- How much sediment has filled Nichols and McClure Reservoir?
- Should we dredge the reservoirs?
- What is the size of the reservoir 'deadpool'?
- What watershed management strategies can maintain (perhaps improve) water quantity?
- Are there unexpected observed water quantity effects?

**Table 2. Summary of Water Supply Monitoring Recommendations**

| Parameter | Location | Frequency | Method | Agency Responsible |
|---|---|---|---|---|
| Stream Flow | Above McClure, Below McClure, below Nichols | Continuous, 15 minute | Field | City Water Division |
| Precipitation | SNOTEL (SF Lake & Elk Cabin), Above McClure, WTP | Continuous, 15 minute | Field | City Water Division |
| Reservoir Level | McClure and Nichols | Continuous, 1 hour | Field | City Water Division |
| Reservoir Bathymetry | McClure and Nichols | Every 20 years | Field | City Water Division |

**Critical parameters for regular analysis**

Critical parameters that require regular analysis for assessing water quantity include stream flow, precipitation, reservoir level, and reservoir bathymetry.

*Stream Flow*

Stream flow is important to assess the quantity of Santa Fe River supply, both for near and long-term management of the City's water utility, as well as assessing the impact of management activities on the stream system. There are several deficiencies at the existing gages within the watershed that should be resolved to improve the ability of these gages to provide adequate data. The Santa Fe River above McClure gage is submerged when

the reservoir level nears maximum capacity, and as a result doesn't record discharge during these periods. We recommend that a new gage be installed further upstream in order to avoid submersion problems. All three of the primary stream gages have automated data recording, but none of them are equipped with telemetry to transmit data for satellite uplink and subsequent on-line posting. To resolve this, SCADA telemetry should be installed at all three gages.

*Precipitation*

The majority of Santa Fe River discharge on most years is derived from snow melt runoff. As such, monitoring snow pack is a critical component to assessing and forecasting Santa Fe River water supply on an annual and seasonal basis. Although precipitation as rainfall has contributed significantly to reservoir storage on several occasions, and the rarity of these events preclude their incorporation in water supply planning scenarios, monitoring precipitation as rainfall is important for safe operation of the reservoirs.

In order to increase the quality and usefulness of precipitation data, we recommend that locations where precipitation as rainfall is currently being recorded be upgraded from manual measurements to automated logging with SCADA telemetry. In addition, the precipitation gages should be equipped to measure both snowfall and rain. The collected snowfall data will be used to complement snowfall already being collected by the NRCS at the snow pillow sites, while rainfall data will be used to compile an on-going record for identifying trends and future planning.

*Reservoir Level*

Reservoir level information is critical for proper management of the reservoirs, compliance with water right permits, and for delivery of adequate treated water the City water customers. In the past, reservoir levels were determined by visual inspection of a staff gage located on the reservoir outlet tower using a telescope, and reported in 100$^{th}$ of feet. Reservoir level monitoring has since been upgraded to an automated system using an ultrasonic sensor with SCADA telemetry to transmit real-time measurements to the water treatment plant for logging and reporting, however, there are currently some problems with telemetry signals reaching the water treatment plant from McClure reservoir. We recommend that the water utility install a SCADA repeater in order to ensure accurate transmittal of reservoir level data to the water treatment plant.

*Reservoir Bathymetry*

City's water utility has conducted several bathymetric surveys of the reservoirs in order to assess changes in storage capacity over time. The most recent reservoir bathymetry study was conducted in 1993. Reservoir bathymetry studies should be continued in the future in order to protect reservoir capacity and ensure safe operation of water utility works. In absence of a catastrophic runoff/erosion event that is deemed to have deposited significant material in either of the reservoirs, a regular interval for bathymetric studies should be approximately every 20 years. In the event that significant material is deposited

within a reservoir, then the water utility will conduct a bathymetric study at the earliest time afterward to asses impact to reservoir storage.

**Secondary parameters necessary if critical parameters exceed a threshold**

There are no water quantity parameters in this parameter.

**Parameters considered, but not recommended**

*Chloride Concentration as Proxy for Reservoir Evaporation*

Chloride concentrations among surface water can be used to estimate reservoir evaporation. Due to the climate regime, latitude and relative elevation of the reservoirs, the forested topography surrounding the reservoirs, as well as a lack of obvious evaporation mitigation strategies, reservoir evaporation is not deemed a significant concern that requires regular monitoring.

## *Maintain a High Quality of Water*

### *Monitoring History*

According to the Surface Water Quality Bureau (SWQB) Assessment Protocol (NMED 2008) conventional parameters that are monitored to assess the quality of the water in terms of supporting aquatic life are: temperature, turbidity, pH, dissolved oxygen, specific conductance and total phosphorus. The water treatment plant operators measure the first three parameters and also monitor total organic carbon at the outfall from Nichols Reservoir. The NMED SWQ Bureau conducted extensive sampling of the Santa Fe River three times a year at three locations: the wilderness boundary, above McClure Reservoir and above Nichols Reservoir from 2000 to 2007 (except for 2005). The site above Nichols Reservoir was initially at the Santa Fe near Santa Fe USGS gage, but was moved downstream to 500 ft above the reservoir to capture more of the drainage area of the watershed (particularly, the tributary Agua Sarca). An EPA contractor sampled Santa Fe Lake for a full suite of parameters in August of 2007. Results of the previous sampling by NMED were provided by Abe Franklin, NMED and are discussed for each parameter.

The 7 years of sample results show that the watershed is meeting all water quality standards, except for aluminum, which is naturally occurring and common in mountain streams. While the Santa Fe River has been healthy over the monitoring period, if a new activity occurs, such as additional forest treatments, the Santa Fe River quality should be monitored for the basic parameters to assess ecosystem health. Baseline data should be collected with the data loggers prior to the activity to determine diurnal fluctuations in pH, DO, EC and temperature that have not been characterized to date. All other parameters are monitored as part of the requirements for operating the Water Treatment Plant (WTP) on Upper Canyon Road.

*Recommendations*

We recommend a monitoring system that will help the City Water Division answer the following questions about water quality:

- Is forest management impacting water quality?
- Is the system's high water quality stable?
- Have project objectives been met, or movement made toward desired resource conditions?
- Were the assumptions, hypotheses or predictions made at the outset of the project close to the actual result?
- Do new water quality regulations impact current watershed management policies and actions?
- Are there unexpected observed water quality effects?
- What water management strategies can maintain (or perhaps improve) water quality?
- Are reservoir inversions or algal blooms occurring in the reservoirs? If yes, what water quality indicators may be used to anticipate the changes?

**Table 3. Summary of Recommendations for Water Quality Monitoring**

| Parameter | Location | Frequency | Method | Agency Responsible | Timing |
|---|---|---|---|---|---|
| Total Organic Carbon (TOC) | Below Nichols Reservoir | Once per month | Sample to lab | City Water Treatment Plant (WTP) | Current |
| Dissolved Organic Carbon (DOC) | Below Nichols Reservoir | Once per month | Sample to lab | WTP | Current |
| E. Coli, Giardia, Cryptosporidium | Below Nichols Reservoir | Once per month | Sample to lab | WTP | Until 3/09 and again between 2015-2017 |
| Temperature | Intake before treatment and 2 field sites | Continuous, 15 minute | Field | WTP/USFS/City | intake current, 2 field sites proposed |
| Dissolved oxygen | 2 sites* | Continuous, 15 minute | Field | USFS/City | Proposed** |
| pH | Intake before treatment and 2 field sites | Continuous, 15 minute | Treatment plant and field | WTP/USFS/City | intake current, 2 field sites proposed |
| Electrical conductivity | 2 field sites* | Continuous, 15 | Field | USFS/City | Proposed |
| Turbidity | Intake before treatment and below Nichols, plus 2 additional field sites | Continuous, 15 minute at intake, Weekly after treatments | Treatment plant and field | WTP/USFS/City | intake current, 2 field sites proposed |
| Alkalinity | Below Nichols Reservoir | Once per month | Sample to lab | WTP | Current |
| PCBs | 2 field sites* | Verify if present | Sample to lab | | Proposed |

* Two sites: USGS gage above McClure Reservoir and 500 meters above Nichols Reservoir

** Conditionally proposed if new activity occurs in Upper Watershed

**Critical parameters for regular analysis**

Critical parameters that require regular analysis for water quality include a total of 10 parameters, and monitoring will occur below the Nichols Reservoir or at the water treatment plant.

*Total Organic Carbon (TOC) and Dissolved Organic Carbon (DOC)*
TOC and DOC are important to water treatment operators because of the potential for organic carbon to form trihalomethanes (THMs) as a disinfection byproduct during chlorination. THMs are carcinogens and regulated by EPA. TOC and DOC are sampled once a month in raw water by the WTP below Nichols Reservoir as required by the EPA. DOC is more difficult to remove. Results of 89 TOC samples collected by NMED SWQB at three sites on the Santa Fe River from 2000 to 2007 averaged 4.8 mg/L with a max of 13.1 mg/L. While no specific standard is set for TOC, the standard for THMs is 80 µg/L. Although the Santa Fe River is usually low in turbidity, Total Organic Carbon (TOC) levels can be high during runoff events resulting in an increase in turbidity from biological growth or the presence of significant natural color. No additional monitoring of TOC or DOC beyond the sampling conducted by the WTP is recommended.

*E. coli, Giardia and Cryptosporidium*
E. coli, Giardia and Cryptosporidium in raw water have been sampled monthly by the WTP since April 2007 as required by the EPA Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). Monthly samples are collected at the outlet from Nichols Reservoir and submitted to a laboratory, which will continue until March 2009. Results of the sampling will determine the level of treatment required at the City WTP. If the mean concentration is less than .075 oocyst/L, then minimal treatment will be required and the two-year monthly sampling cycle will be repeated six years later (in 2015). Results to date, show very low detections of cryptosporidium. One sample in December of 2007 had 0.071/liter and a sample in September of 2008 had concentration of 0.08/liter. All other samples had no detection of cryptosporidium. These concentrations will not require additional treatment.

E. Coli samples have been collected by NMED SWQB at three locations on the SF River which show very low concentrations. The water quality standard (NMAC 20.6.4.121) for E. coli is 235 cfu/100 mL in a single sample and 126 cfu/100 mL for a monthly geometric mean. The highest concentration of E. coli detected was 5 cfu/100 mL in the SF River at the Wilderness Boundary in August of 2001 which is well below the standard. No additional monitoring of E. coli, Giardia or Cryptosporidium beyond the sampling conducted by the WTP is recommended.

*Temperature*
Water temperature impacts the "metabolism, behavior and mortality of fish and other aquatic organisms" (NMED 2008). Continuous measurement of temperature is necessary to determine the maximum daily temperatures, the duration of excessive temperatures and the diurnal and seasonal fluctuations of temperature that effect aquatic life. NM

Water Quality Standards (20.6.4.121.B1) for temperature is less than 20 °C for aquatic cold water fisheries.

Temperature is measured in raw water at the intake to the treatment plant continuously by the WTP. However, this location monitors the temperature of Nichols Reservoir (at the lake depth that the water is released) and is not characteristic of the condition of the Santa Fe River in the Upper Watershed. The maximum temperature measured in the Upper Santa Fe River Watershed by NMED SWQB was 17 °C in August of 2006 above Nichols Reservoir, however these periodic measurements did not characterize the diurnal and seasonal fluctuations that are important. A continuously recording data logger for temperature should be installed at the inflow to McClure Reservoir and at the gage between the reservoirs to assess the fluctuations in temperature. The data logger should be installed a year prior a proposed activity that could impair water quality to collect baseline data.

*Dissolved Oxygen (DO)*

Cold water aquatic species, particularly embryos and larvae, are more sensitive to dissolved oxygen concentrations than warmwater species. DO concentrations need to be at least 6 mg/L for healthy aquatic systems. Because DO is impacted by temperature and elevation, the percent saturation of DO is also important and it should approach 100%. Cold water can hold more oxygen than warm water.

DO and percent saturation has been measured at three sites in the Upper Watershed by NMEDSWQ Bureau three times a year (Franklin, 2008). Average DO measured in the Upper Watershed is about 11 mg/L, well above the standard that requires DO to be greater than 6 mg/L (NMWQCC 2007). The lowest DO concentration measured out of 134 samples collected in three sites in the Upper Watershed was 6.7 mg/L in April 2002 when percent saturation was 60%. However, the previous day and the following day DO was measured at 7.4 and 7.6 mg/L respectively. The percent saturation has averaged 87%. The NMED assessment protocol for DO (NMED 2008 Appendix F) provides minimum values of percent saturation for coldwater fisheries which ranges between 75 and 85 percent for early life stages. While the DO values have all met the water quality standards, the percent saturation is not always meeting the requirements for aquatic life. Two continuous recording devices to monitor dissolved oxygen at the inflow to McClure Reservoir and the gage between the two reservoirs are recommended. The data logger should be installed a year prior a proposed activity that could impair water quality to collect baseline data. The percent saturation can be estimated from the temperature and DO concentration.

*pH*

The water treatment plant and aquatic life are both sensitive to the pH of water. The treatment plan operators need to know the pH to adjust the alkalinity of the water to achieve good coagulation and produce stabilized water. The pH is measured continuously by the City WTP at the intake before treatment (out of Nichols Reservoir). NMED SWQ Bureau has also measured pH in Santa Fe River water in three locations,

three times a year. The pH should remain between 6.6 and 8.8 (NMWQCC, 2007). Measured pH at the three sites in the Upper Watershed average 7.3, with a maximum observed at 8.7 in the fall at the inflow into McClure and a minimum of 6.1 measured several times in the spring at the wilderness boundary and at the inflow to McClure Reservoir. The low alkalinity of the water results in a lack of buffering capacity for the water which allows the pH to be unstable.

The NMED SWQB Assessment Protocol (Appendix G) recommends continuous recording devices to monitor pH because, while fish can tolerate some fluctuation in pH, the duration of that change is important for assessing the impact. Two pH recording devices at the inflow to McClure Reservoir and at the gage between the two reservoirs are recommended. The data logger should be installed a year prior a proposed activity that could impair water quality to collect baseline data.

*EC (Conductivity)*
The specific conductance or electrical conductivity of water is an indicator of the total dissolved solids. It is a very inexpensive field check on water quality and could be used to indicate significant changes in water quality. EC has been recorded in the field by NMED SWQB at three sites, three times a year. EC measurements have ranged from 31 to 187 µmhos/cm in the Upper Watershed, less than the numeric criteria of 300 µmhos/cm or less (NMWQCC, 2007). An exceedence of this criteria would indicate a dramatic change in water quality and the need to test for parameters in the second category, including major cations and anions, TDS, heavy metals and nutrients. Two EC recording devices at the inflow to McClure Reservoir and at the gage between the two reservoirs are recommended. The data logger should be installed a year prior a proposed activity that could impair water quality to collect baseline data.

*Turbidity*
Turbidity is a principal physical characteristic of water and is an expression of the relative clarity of a liquid. It is caused by suspended matter or impurities that interfere with the clarity of the water. These impurities may include clay, silt, finely divided inorganic and organic matter, soluble colored organic compounds, and plankton and other microscopic organisms.

Clarity is important when producing drinking water for human consumption and in many manufacturing uses. Excessive turbidity, or cloudiness, in drinking water is aesthetically unappealing, and may also represent a health concern. Turbidity can provide food and shelter for pathogens. If not removed, turbidity can promote regrowth of pathogens in the distribution system, leading to waterborne disease outbreaks, which have caused significant cases of gastroenteritis throughout the United States and the world. Although turbidity is not a direct indicator of health risk, numerous studies show a strong relationship between removal of turbidity and removal of protozoa. (EPA 1999). Turbidity is measured in raw water at the intake to the treatment plant continuously by the WTP. Under EPA's Interim Enhanced Surface Water Treatment rule turbidity must be less than 1 NTU after filtration in any one sample.

Turbidity was measured at three sites three times a year in the Upper Watershed by the NMED SWQB from 2000 to 2007. The average turbidity from the samples collected by the NMED SWQB was 3.5 and the maximum was 41 NTU in August of 2006 at a site above Nichols Reservoir. NMED Water Quality Standards do not set specific numeric standards for turbidity, but state that "turbidity shall not exceed 10 NTU over background turbidity when the background turbidity is 50 NTU or less..." The NMED SWQB Assessment Protocol states that if turbidity is exceeding the standard in more than 15% of samples (for at least 7 samples), then the water is not fully supporting aquatic life. Except for the one high value of 41 NTU, all other samples (128) were at or below 10.2 NTU.

For monitoring the impact of forest treatments (thinning and prescribe burns) on water quality, turbidity is the parameter most likely to be impacted. However, two turbidity sensors were maintained in the paired watershed study from 2001 to 2006 and no significant increase in turbidity was noted in the treated watershed (WW and Ice Nine Consulting 2008). Turbidity did not exceed 50 NTU in the treated basin, but was as high as 200 NTU in the control (untreated basin).

Turbidity could be monitored at the two sites above McClure Reservoir and above Nichols Reservoir either with a turbidity meter or with field measurements weekly following prescribed fire or thinning activities. The data logger should be installed a year prior a proposed activity that could impair water quality to collect baseline data.

Alkalinity (Total Hydroxide, Carbonate, Bicarbonate)
Alkalinity is a measure of the ability of a solution to neutralize acids to the equivalence point of carbonate or bicarbonate. In affect, it is a measure of the buffering capacity of the water. Alkalinity is important to monitor for municipal water supplies because of its affect the amount of chemicals needed to achieve coagulation and also impacts the corrosion in distribution systems. Alkalinity is measured once a month by the City WTP below Nichols Reservoir.

NMWQCC does not have a standard for alkalinity, but EPA's national recommended water quality criteria for non priority pollutants lists a freshwater standard of 20 mg/L or more for alkalinity (EPA, 2006), except where natural concentrations are less. Of the 57 samples collected in the Upper Watershed, alkalinity ranged from 8 to 59 and averaged 19 mg/L. Bicarbonate ranged from 10 to 72 and averaged 23 mg/L in 57 samples collected in the Upper Watershed. No additional monitoring is recommended beyond the sampling already occurring by the City WTP.

*PCBs*
PCBs were detected in the outfall from Nichols Reservoir on May 3, 2007 at concentrations totaling 0.235 µg/L, which is above the standard of .064 µg/L for domestic water supply and 0.014 µg/L for aquatic life and wildlife habitat. No other locations were sampled. We recommend that surface water be sampled for PCBs at the two locations above each reservoir to verify these results and determine if further assessment is necessary. If samples show no detection of PCBs, then no further sampling

is recommended. If PCBs are detected, the NMED should be contacted to investigate the extent and source of contamination.

**Secondary parameters necessary if critical parameters exceed a threshold**

Nutrients such as nitrogen and phosphorus impact aquatic plant growth, which in excess can be harmful to fish. Nutrient loading in run-off could change with the reduction of forest vegetation to consume nutrients (Arvidson, 2006). The nutrient thresholds for mountain streams (NMED SWQB 2008 Appendix E) are 0.25 mg/L for total nitrogen and 0.02 mg/L for phosphorus. While these thresholds have been exceeded in samples collected by NMED between 2000 and 2007, it is only recommended that further sampling be conducted if exceedences of DO, pH and turbidity are identified (which would occur if excessive algal growth is impacting water quality). Therefore, nutrients of nitrate, nitrite, TKN and phosphorus are listed as secondary parameters.

*Total Nitrogen (TN)*
Total Nitrogen, including nitrate, nitrite, and TKN, is a nutrient for aquatic vegetation, such as algae. Excessive amount of aquatic vegetation is not beneficial to most streams because of the impact on dissolved oxygen, pH and turbidity. The NMED SWQB Appendix E Nutrient Assessment Protocol for Wadeable, Perennial Streams sets a nutrient threshold for total nitrogen (TN) at 0.25 mg/L. Many (27) of the samples (123) collected in the Upper Watershed for TKN had concentrations above this threshold and as high as 0.86 mg/L. If temperature, DO, EC and pH changes are significant water samples should be collected for TN.

All of the nitrate + nitrate samples are below the drinking water standard of 10 mg/L.

*Total Phosphorus (TP)*
Phosphorus is a nutrient for aquatic vegetation, such as algae. Excessive amount of aquatic vegetation is not beneficial to most streams because of the impact on dissolved oxygen, pH and turbidity. The NMED SWQB Appendix E Nutrient Assessment Protocol for Wadeable, Perennial Streams sets a nutrient threshold for phosphorus at 0.02 mg/L. This is below the detection limit of most of the phosphorus samples collected by NMED. Of the 22 samples analyzed for phosphorus with a low enough detection limit, 11 of the samples exceeded 0.02 mg/L. Most of the concentrations were below 0.1 mg/L and the highest was 0.87 mg/L. If temperature, DO, EC and pH changes are significant samples should be collected for TP.

*Ammonia*
Ammonia is toxic to aquatic species at concentrations that vary based on the pH and temperature of the water. The ammonia standard is lower at higher temperatures and higher pH values. In the Santa Fe River, the highest temperature recorded was 17 °C and the highest pH was 8.7 which would result in an ammonia criteria of 0.622 mg/L ammonia as N. Most of the 133 samples analyzed for ammonia were below detection

and the highest concentration reported was 0.35 mg/L. Because no waste stream enters the Santa Fe River in the Upper Watershed, ammonia is not a concern.

*Major Cations and Anions (Na, K, Ca, Mg, Cl, SO4) and Total Dissolved Solids (TDS)*
Major cations, anions and TDS are important for establishing the general quality of the water. The principal cations in surface water are usually calcium, magnesium, sodium and potassium. Principal anions include chloride, sulfate and carbonates. Of the 138 TDS samples collected at the three sites in the Upper Watershed, the maximum concentration of TDS was 194 mg/L and the minimum was 38, with an average of 88 mg/L. Because the TDS is low, the concentrations of major cations and anions are also low and do not pose a threat to aquatic life or human health. NMED Water Quality Standards for TDS for domestic use is 1,000 mg/L. No standard for TDS for aquatic life has been established because freshwater fish can tolerate a wide range of TDS values (up to 10,000 mg/L) (EPA 1986).

The drinking water standard for sulfate is 600 mg/L which is well above the highest sulfate concentration measured in the Upper Watershed of 26 mg/L. Sulfate fell below the detection limit in most samples. The drinking water standard for chloride is 250 mg/L, which was not detected in any samples collected in the Upper Watershed.

While the general chemistry is not a concern for the objectives of monitoring, the concentrations of major anions and cations can help scientists understand the source of water and changes in contributions of flow. If the EC levels change dramatically, a full suite of major cations and anions and TDS should be measured to help discern the source of the change.

*Hardness (calcium and magnesium)*
Hardness is important to measure in order to calculate water quality criteria for metals for aquatic life. Hardness has been measured by NMED SWQB at three sites, three times a year and the values are very stable. Unless a dramatic change in EC occurs, hardness does not need to be measured.

*Metals – ICP (including Al, Ag, As, Ba, Be, Cd, Cr, Cu, Fe, Pb, Mn, Ni, Se, Sb, Vn, Zn)*
Metals such as aluminum (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), selenium (Se), silver (Ag) and zinc (Zn) are harmful to aquatic life. Metals such as antimony (Sb), arsenic, barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), selenium (Se), uranium (U), and zinc (Zn) are toxic to humans.

The metals toxicity for aquatic life is based on the hardness of the water for Cd, Cr, Cu Pb, Ni and Zn. The average hardness measured in Santa Fe River water above McClure reservoir was 18 mg/L. Using the equations for criteria, where necessary, in the Water Quality Standards for New Mexico (NM WQCC, 2007) the metals standards were calculated as shown in Table 1. Aluminum is the only criteria which is consistently exceeding the standard of 87 μg/L. Aluminum is naturally occurring in the Santa Fe

River and commonly occurs in these concentrations in mountain streams (Michael 2008). No further sampling for metals is recommended unless a significant shift in EC is detected.

**Table 4. Numeric criteria for heavy metals in the upper Santa Fe watershed based on a hardness of 18 mg/L**

| Criteria | Domestic water supply criteria (µg/L) | Aquatic acute criteria (µg/L) | Aquatic chronic criteria (µg/L) | Highest concentration detected in the upper watershed (µg/L) |
|---|---|---|---|---|
| Aluminum | NA | 750 | 87 | 1,800 |
| Arsenic | 2.3 | 340 | 150 | ND |
| Dissolved Cadmium | 5 | 0.4 | .08 | ND |
| Dissolved Chromium | 100 | 142 | 18 | 7 |
| Dissolved Copper | 1300 | 2.7 | 2.1 | ND |
| Iron | 1000 | | NA | 900 |
| Dissolved Lead | 50 | 0.4 | 0.4 | ND |
| Mercury (dissolved for aquatic) | 2 | 1.4 | 0.77 | ND |
| Dissolved Nickel | 100 | 111 | 12 | 30 |
| Dissolved Selenium (total for aquatic) | 50 | | 20 | 5.0 |
| Dissolved Silver | NA | .17 | NA | ND |
| Dissolved Zinc | 7,400 | 28 | 28 | 40 |

*NA= Not Available in NMWQCC Standards; ND = Not Detected*

No domestic water supply or aquatic life criteria are established for molybdenum (Mo) which only has a criteria for irrigation. Cobalt (Co) and vanadium (Vn) only have criteria for irrigation and livestock watering. None of these uses occur in the upper watershed.

**Parameters considered, but not recommended**

*Soil Moisture*
Soil moisture will be measured with a cosmic ray probe as part of the paired watershed study. It is not generally included for water quality assessments, and no criteria or implications for soil moisture measurements are available. Soil moisture will vary depending on the slope aspect, degree of vegetation cover, recent precipitation events and proximity to stream.

*Total Coliform and Standard Plate count*
EPA uses E.Coli as a better indicator of human health hazards. Fecal coliform bacteria sampling usually applies to waste effluent that is discharging to surface water bodies. The standard is 500 c/100 ml for effluent entering the Rio Grande Basin (NMWQCC 20.3.2102)

*Bio-Chemical Oxygen Demand (BOD)*
BOD is a parameter usually measured in waste effluent that is discharging to a water body. The standard is 30 mg/L for effluent entering the Rio Grande Basin (NMWQCC 20.3.2102)

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*Chemical Oxygen Demand (COD)*
COD is a parameter usually measured in waste effluent that is discharging to a water body. The standard is 80 mg/L for effluent entering the Rio Grande Basin (NMWQCC 20.3.2102).

*pE (Redox)*
The reduction-oxidation process that may occur in the Santa Fe River will be monitored for their impact on dissolved oxygen, the primary concern for aquatic life. No other monitoring is recommended for Redox.

*Radionuclides, including gross Alpha and Beta*
Gross Alpha measured in 31 samples collected in the Upper Watershed averaged 1.9 pCi/L with a maximum of 4.8 pCi/L, below the standard of 15 pCi/L for domestic water supply. No standard is established for aquatic life. The NMWQCC (2007) standard for Combined Radium 226 and Radium 226 is 30pCi/L. EPA recommends a standard of 5pCi/L (http://www.epa.gov/safewater/radionuclides/index.html). The highest concentration of Radium 226 or 228 in 34 samples collected in the upper watershed was 0.9 piC/L, well below both limits. No standards are available for aquatic life and because the measured values are well below drinking water standards, monitoring for radionuclides are not recommended.

## *Enhanced wildlife habitat and ecosystem function*

### *Recommendations*

We recommend a monitoring system that will help the City Water Division answer the following questions about wildlife habitat and ecosystem function:

- What are the species of interest for ecosystem analysis and potential habitat enhancement?
- What is the current level of ecosystem health, generally and for the species of interest?
- What water management strategies can maintain (or perhaps improve) ecosystem health?
- How have changes in watershed management affected ecosystem health?
- Is the cutthroat trout population thriving?
- How is the cutthroat trout population impacting water quality?
- Are there unexpected observed ecosystem effects?

**Critical parameters for regular analysis**

The first goal with habitat enhancement is to identify and define the species of interest within the project area for which further habitat assessment and enhancement activities will be carried out, and to define the optimum functioning capacity for the riparian and aquatic zones within the project area, which will be accomplished largely through the first round of ecological monitoring, using Rapid Stream-Riparian Assessment (RSRA) methods. Based on results of ecological monitoring and evaluation of functional assessment of the riparian corridor, specific deficiencies in the riparian zone and in the stream course will be identified. The following a list of six geomorphologically distinct riparian areas along the Santa Fe River within the upper watershed where ecological monitoring will be conducted:

- Two reaches of the upstream of McClure reservoir
- Three reaches downstream of McClure reservoir
- One reach downstream of Nichols reservoir

The Rapid Stream-Riparian Assessment (RSRA) utilizes a primarily qualitative assessment based on quantitative measurements. It focuses upon five functional components of the stream-riparian ecosystem that provide important benefits to humans and wildlife, and which, on public lands, are often the subject of government regulation and standards. These components are: 1) water quality and pollution, 2) stream channel and floodplain morphology and the ability of the system to limit erosion and withstand flooding without damage, 3) the presence of habitat for native fish and other aquatic

species, 4) vegetation structure and composition, including the occurrence and relative dominance of exotic or non-native species, and 5) suitability as habitat for terrestrial wildlife, including threatened or endangered species. Within each of these areas, the RSRA evaluates between two and seven variables which reflect the overall function and health of the stream-riparian ecosystem (Appendix B) (Stacey et al 2007).

To address the deficiencies, specific habitat enhancement recommendations will be developed and compiled in a Habitat Enhancement Plan (HEP). With input form the City's partners and riparian and aquatic habitat experts, these recommendations will identify passive and active methods to affect measurable change in functioning capacity. Habitat enhancement activities in the riparian corridor and the stream course will be coordinated, as potential work in the stream course will necessitate removal or thinning of established vegetation along the banks of the river, modification of bank slope, and possible creation of new channel meanders which will require bank revegetation.

The HEP will consider methods that involve active work in the channel like installation of rock step and/or log plunge structures, riffles and pools, bank revetment, and induced meanders. More passive methods that may be effective in the channel involve operational changes in the way the City's water utility can release water from McClure and Nichols reservoirs, Specifically, releases of larger pulses of water may mimic pre-dam snowmelt and high intensity short duration storm flows, which have the potential to create some beneficial stream bank erosion and other deposits that will enhance overall aquatic habitat features. The HEP will also evaluate methods to enhance riparian habitat, like removal of invasive species, thinning of existing vegetation, and additional plantings to control erosion and improve habitat in disturbed areas.

Any active channel and riparian work called for in the HEP will require a survey, hydrologic analysis, possibly engineering drawings, and permit approval from regulatory agencies including the USACE and NMED.

**Secondary parameters necessary if critical parameters exceed a threshold**

No ecological monitoring parameters are in this category.

**Parameters considered, but not recommended**

No ecological monitoring parameters are in this category.

# Appendix 1: Recommended Monitoring Parameters for Water Management

| | Parameter | Purpose | Location | Sample Frequency | Method | Responsible Agency | Monitoring Status | Water Quality Standard | Reference/Explanation |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **Critical Parameters for Regular Analysis** | | | | | | | | |
| **1.1** | Stream Flow | Quantity | Above McClure, Below McClure, below Nichols | Continuous, 15 minute | Field | City WTP | Current | NA | |
| **1.2** | Precipitation | Quantity | SNOTEL (SF Lake & Elk Cabin), Above McClure, WTP | Continuous, 15 minute | Field | City WTP | Current | NA | |
| **1.3** | Reservoir Level | Quantity | McClure and Nichols | Continuous, 1 hr | Field | City WTP | Current | NA | |
| **1.4** | Reservoir Bathymetry | Quantity | Nichols and McClure Reservoirs | Once per 5-10 years | Field | City WTP | Current | NA | |
| **1.5** | TOC (Total Organic Carbon) | Quality | Below Nichols Reservoir | Once per 1 month | sample to lab | City WTP | Current | NA | Robert Gallegos, 2008 |
| **1.5 (cont.)** | DOC (Dissolved Organic Carbon) | Quality | Below Nichols Reservoir | Once per 1 month | sample to lab | City WTP | Current | NA | Robert Gallegos, 2008 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.6** | E. coli count | Quality | Below Nichols Reservoir | Once per 1 month | sample to lab | City WTP | Until 3/09, then another 2-year round of sampling in 6 years (2015) | <235 cfu/100 mL in single sample for surface water (NMAC 20.6.4.121), | Robert Gallegos, 2008 |
| **1.6 (cont.)** | Giardia/ Cryptosporidium | Quality | Below Nichols Reservoir | Once per 1 month | sample to lab | City WTP | Until 3/09, then another 2-year round of sampling in 6 years (2015) | < .075 oocysts/L no further sampling required for 6 years | Robert Gallegos, 2008 |
| **1.7** | Temperature | Quality | intake before treatment | Continuous, 15 minute | Field | City WTP | Current | < 20 C | Robert Gallegos, 2008 |
| **1.7 (cont.)** | Temperature | Ecological/BMP for forest treatments | 2 Sites* | Continuous, 15 minute | Field | USFS/City | conditionally proposed** | <20 C | NMED SWQB 2008 Assessment Protocol |
| **1.8** | DO | Ecological/BMP for forest treatments | 2 Sites* | Continuous, 15 minute | Field | USFS/City | conditionally proposed** | > 6 | NMED SWQB 2008 Assessment Protocol |
| **1.9** | pH | Quality | intake before treatment | Continuous, 15 minute | Treatment Plant | City WTP | Current | 6.6-9.0 | Robert Gallegos, 2008 |
| **1.9 (cont.)** | pH | Ecological/BMP for forest treatments | 2 Sites* | Continuous, 15 minute | Field | USFS/City | conditionally proposed** | 6.6-8.8 | NMED SWQB 2008 Assessment Protocol |
| **1.10** | EC (elec. cond.) | Ecological/BMP for forest treatments | 2 Sites* | Continuous, 15 minute | Field | USFS/City | conditionally proposed** | 300 umhos/cm | NMED SWQB 2008 Assessment Protocol |
| **1.11** | Turbidity | Quality | intake before treatment and below Nichols | Continuous, 15 minute | Field | City WTP | Current | 10 NTU | Robert Gallegos, 2008 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | once a month | | | | | | |
| **1.11 (cont.)** | Turbidity | Ecological/BMP for forest treatments | 2 Sites* | Measure after prescribed fire or other thinning weekly or with data logger | Field | USFS/City | conditionally proposed** | 10 NTU above background | NMED SWQB 2008 Assessment Protocol |
| **1.12** | Alkalinity (Total Hydroxide, Carbonate, Bicarbonate) | Quality | Below Nichols Reservoir | Once per 1 month | sample to lab | City WTP | Current | 20 mg/L for freshwater | Robert Gallegos, 2008 |
| **1.13** | PCBs | Quality and Ecological | 2 Sites* | Once to verify, if present, then need more exhaustive study | sample to lab | | conditionally proposed** | 0.064 ug/L | NMSWQB data shows PCBs detected at Nichols Outfall |
| **1.14** | Riparian Ecological Assessment | Ecological | 6 Sites | Once per 2 years | Field | City WTP | Proposed | NA | Peter Stacy, 2008 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **2** | **Secondary Parameters necessary if critical parameters exceed a threshold** | | | | | | | | |
| **2.1** | Total Nitrogen (TN) Nitrate + Nitrite and TKN | Ecological/BMP for forest treatments | 2 Sites* | if change in DO, EC, turbidity | sample to lab | USFS/City | Previous sampling 3 times a year from 2000 to 2007 | 0.25 mg/L threshold for aquatic life, 10 mg/L for public water supply | NMSWQB data shows no detect or < 1 mg/L |

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|---|---|---|---|---|---|---|---|---|---|
| **2.2** | Total phosphorus | Ecological/BMP for forest treatments | 2 Sites* | if change in DO, EC, turbidity | sample to lab | USFS/City | Previous sampling 3 times a year from 2000 to 2007 | 0.02 mg/L threshold for aquatic life | NMSWQB data shows exceedance of the phosphorus threshold, but TN is low |
| **2.3** | Ammonia | Ecological/BMP for forest treatments | 2 Sites* | if change in DO, EC, turbidity | sample to lab | USFS/City | Previous sampling 3 times a year from 2000 to 2007 | < 0.622 | NMSWQB data shows highest concentration at 0.35 mg/L |
| **2.4** | Major Anions and Cations (Na, K, Ca, Mg, Cl, SO4) and TDS | Ecological/BMP for forest treatments | 2 Sites* | if order of magnitude change in EC | sample to lab | USFS/City | Previous sampling 3 times a year from 2000 to 2007 | TDS 1,000 mg/L, SO4 600 mg/L, Cl 250 mg/L | NMSWQB data well below standards |
| **2.5** | Hardness (calcium and magnesium) | Ecological/BMP for forest treatments | 2 Sites* | if order of magnitude change in EC | sample to lab | USFS/City | Previous sampling 3 times a year from 2000 to 2007 | NA | used in establishing metals criteria |
| **2.6** | Heavy Metals | Ecological/BMP for forest treatments | 2 Sites* | if order of magnitude change in EC | sample to lab | USFS/City | Previous sampling 3 times a year from 2000 to 2007 | See Table 2 | NMSWQB data shows aluminum exceeds standard, but common element with very low standard, Zn exceeded standard once |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **3** | **Parameters considered, but not recommended** | | | | | | | | |
| **3.1** | Chloride, as proxy for evaporation | Quantity | None | | | | | | Reservoir evaporation not significant loss |
| **3.2** | Soil Moisture | Quantity | None | Continuous, 15 minute | Cosmic Ray Probe | | part of paired watershed study | | |
| **3.3** | Total Coli form | Quality | None | Past | sample to lab | | NA | NA, use E. coli now | NMSWQB data show no exceedences |
| | Standard Plate count | Quality | None | Past | sample to lab | | NA | NA, use E. coli now | NMSWQB data show no exceedences |
| **3.4** | BOD | Quality | None | | | | NA | NA | Applicable to waste streams |
| **3.5** | COD (chemical Oxygen Demand) | Quality | None | | | | NA | NA | Applicable to waste streams |
| **3.6** | pE (Redox) | Quality | None | | | | NA | NA | Applicable to waste streams |
| **3.7** | Radionuclides including gross Alpha and Beta | Quality | None | Past | sample to lab | | Previous sampling 3 times a year from 2000 to 2007 | 15 pCi/L for Gross Alpha, 30 pCi/L for Radium 226 and 228. | NMSWQB no exceedences |

Notes for Tables 1-3

| |
|---|
| *Two sites: USGS gage above McClure Reservoir and 500 meters above Nichols Reservoir |
| ** Conditionally proposed if new activity occurs in Upper Watershed, such as forest treatments in the Wilderness or other activity that could increase nutrient load |
| HQWS = High Quality Water Supply |
| EH = Ecosystem Health |
| References: Robert Gallegos, Personal Communication with Amy Lewis Oct 22, 2008 |
| New Mexico Environment Department Surface Water Quality Bureau (NMED SWQB) 2008. Procedures for Assessing Use Attainment for the State of New Mexico Integrated Clean Water Act §303(d)/§305(b) Water Quality Monitoring and Assessment Report: Assessment Protocol. January 23, 2008. |

# Appendix 2: Rapid Stream Riparian Analysis Indicator Variables and Reasons for Including them in the Protocol

| CATEGORY AND VARIABLE | JUSTIFICATION FOR INCLUSION IN RSRA ASSESSMENT |
|---|---|
| Water Quality: **Algal growth** | Dense algal growth may indicate nutrient enrichment and other types of pollution which may result in decreased dissolved oxygen in the water column and affect invertebrates and the ability of fish to spawn. |
| Water Quality: **Channel shading and solar exposure** | Solar exposure affects stream temperature and productivity. Decreased streambank vegetation cover, increased channel width, and reduced stream depth increases exposure, raises water temperatures and impacts aquatic life. Native trout usually require cool stream temperatures. |
| Hydrogeomorphology: **Floodplain connection and inundation frequency** | Channels that are deeply downcut or incised result in a reduced frequency of overbank flooding into the adjacent flood plain during peak runoff or stream flows. The absence of flooding lowers water tables, reduces nutrient availability in the floodplain, decreases plant germination, growth and survivorship, and may lead to the loss of riparian vegetation and the invasion of upland species. |
| Hydrogeomorphology: **Vertical bank stability** | Steep and unstable vertical banks dominate many southwestern streams, limiting the physical dynamics of aquatic ecosystems and increasing erosion and sediment loads through sloughing off of soils during high flow events. Steep banks may limit wildlife access to water. |
| Hydrogeomorphology: **Hydraulic habitat diversity** | Fish and aquatic invertebrate diversity and population health is related to habitat diversity. Features such as oxbows, side channels, sand bars, gravel/cobble bars, riffles, and pools can provide habitat for different species or for the different life stages of a single species. |
| Hydrogeomorphology: **Riparian area soil integrity** | Riparian soils reflect existing stream flow dynamics (e.g., flooding), management practices, and vegetation. It affects potential vegetation dynamics and species composition, as well as wildlife habitat distribution and quality. |
| Hydrogeomorphology: **Beaver activity** | Beavers are keystone species in riparian systems because they modify geomorphology and vegetation, and reduce variance in water flows and the frequency of floods. Beaver dams and adjacent wet meadows provide important fish and plant nursery habitat. |
| Fish/Aquatic Habitat Qualifier: **Loss of perennial flows** | Fish and most aquatic invertebrates require perennial or constant flows to survive. Streams that were originally perennial but are now ephemeral no longer provide habitat for these species unless there are refuges that never dry out (e.g., permanent pools). |
| Fish/Aquatic Habitat: **Pool distribution** | Fish use pools, with reduced current velocity and deep water, to rest, feed and hide from predators. Many species use gravel-bottomed riffles to lay their eggs. The number, size, distribution, and quality of pools, and pool to riffle ratios indicate the quality of fish habitat. 1:1 pools to riffle ratios are generally considered to be optimum. |
| Fish/Aquatic Habitat: **Underbank cover** | Underbank cover is an important component of good fish habitat, used for resting and protection from predators. A number of aquatic invertebrates also use these areas. Underbank cover usually occurs with vigorous vegetative riparian growth, dense root masses, and stable soil conditions. |
| Fish/Aquatic Habitat: **Cobble embeddedness** | Low levels of gravel and boulder embeddedness on the channel bottom increase benthic productivity and fish production. The filling of interstitial spaces between rocks with silt, sand, and organic material reduces habitat suitability for feeding, nursery cover, and spawning (egg to fry survival) by limiting space and macroinvertebrate production. Increased embeddedness often reflects increased sediment loads and altered water flow patterns. |
| Fish/Aquatic Habitat: **Diversity of aquatic macro invertebrates** | The density and composition of aquatic invertebrates are strong indicators of stream health, including temperature stresses, oxygen levels, nutrients, pollutants, and sediment loads. Larvae and adult macroinvertebrates provide critical food for fish and other invertebrate and vertebrate species in stream-riparian ecosystems. |

| CATEGORY AND VARIABLE | JUSTIFICATION FOR INCLUSION IN RSRA ASSESSMENT |
|---|---|
| Fish/Aquatic Habitat: **Large woody debris** | The amount, composition, distribution and condition of large woody debris (LWD) in the stream channel and along the banks provides important fish habitat for nursery cover, feeding, and protective cover. Streams with adequate LWD generally have greater habitat diversity, a natural meandering shape and greater resistance against high water events. |
| Fish/Aquatic Habitat: **Overbank cover and terrestrial invertebrate habitat** | Overhanging terrestrial vegetation is essential for fish production and survival, providing shade, bank protection from high flows, sediment filtering, and input of organic matter. Overbank cover also is important for terrestrial insect input (drop) into streams, which is a key source of food for fish. |
| Riparian vegetation: **Plant community cover and structural diversity** | High cover and structural diversity of riparian vegetation generally indicates healthy and productive plant communities, high plant species diversity and provides direct and secondary food resources, cover, and breeding habitat for wildlife. This affects avian breeding and foraging patterns in particular. Good structural diversity can also reduce flood impacts along banks. |
| Riparian vegetation: **Dominant shrub and tree demography (recruitment and age distribution)** | The distribution of size and age classes of native dominant species indicates recruitment success, ecosystem sustainability, and wildlife and fish habitat availability. When one or more age classes of the dominant species are missing, it indicates that something has interrupted the natural process of reproduction and individual plant replacement. In time, this may lead to the complete loss of the species in the area as older individuals die off and are not replaced by younger plants. |
| Riparian vegetation: **Non-native herbaceous and woody plant cover** | Non-native plant species profoundly influence ecosystem structure, productivity, habitat quality, and processes (e.g., fire frequency, intensity). Strong dominance by non-native plants may eliminate key attributes of wildlife habitat quality, and may limit ungulate and livestock use. |
| Riparian vegetation: **Mammalian herbivory impacts on ground cover** | Ungulate herbivores can affect riparian soils, ground cover, and general ecosystem condition. Utilization levels >10% in riparian zones retard vegetation replacement and recovery. Moderate and higher levels of grazing almost always increase soil compaction and erosion. |
| Riparian vegetation: **Mammalian herbivory impacts on shrubs and small trees** | Ungulate herbivores can affect recruitment of woody shrub and trees by clipping or browsing the growing tips of the branches. Continued high levels of utilization lead to the death of the plant and over time can cause the loss of all shrubs and trees in a local area. |
| Terrestrial Wildlife Habitat: **Riparian shrub and tree canopy cover and connectivity** | Riparian shrubs and trees often grow in dense patches that provide food, thermal cover, predator protection and nesting or breeding habitat for terrestrial wildlife, including many invertebrates, amphibians, reptiles, birds and mammals. These patches are often absent in riparian areas that have been heavily utilized by livestock and other ungulates, or that have been damaged by other human activities. As a result, many native wildlife species may no longer be able to survive in the area. Patches of dense vegetation, both native and exotic, also plays a key role in trapping sediment during periods of over-bank flow. |
| Terrestrial Wildlife Habitat: **Fluvial habitat diversity** | Natural processes create a diversity of fluvial landforms, including terraces, bars, oxbows, wet marshes and fluvial marshes, that provide habitats for different species of terrestrial wildlife. Conversely, in a highly degraded system with extensive erosion and downcutting, there may be only a single fluvial form: a straight and single-depth channel and steep banks without vegetation. |

## Literature Cited

Arvidson, Julie D. 2006. Relationship of Forest Thinning and Selected Water Quality Parameters in the Santa Fe Municipal Watershed, New Mexico. A Professional Project Report Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Water Resources, University of New Mexico. May 2006.

Environmental Protection Agency (EPA). 1986. Quality Criteria for Water. Office of Water, Regulations and Standards. 440-5-86-001. http://www.epa.gov/waterscience/criteria/library/goldbook.pdf

Environmental Protection Agency (EPA) 1999. Alternative Disinfectants and Oxidants Guidance Manual. EPA 815-R-99-014. (http://www.epa.gov/safewater/mdbp/mdbptg.html)

Environmental Protection Agency (EPA). 2006. National Recommended Water Quality Criteria. Office of Water, Office of Science and Technology. 4304T.

Stacy, P., Jones, A., Catlin, D., Duff, D., Stevens, L., and Gourley, C. User's Guide for the Riparian Assessment of the Functional Condition of Stream-Riparian Ecosystems in the American Southwest. 2007. University of New Mexico.

Michael, Tim. 2008. Personal Communication with Amy Lewis October 29, 2008.

New Mexico Water Quality Control Commission (NMWQCC). 2007. State of New Mexico Standards for Interstate and Intrastate Surface Waters. New Mexico Water Quality Control Commission 20.6.4.1 NMAC as amended through August 1, 2007.

New Mexico Environment Department Surface Water Quality Bureau (NMED SWQB) 2008. Procedures for Assessing Use Attainment for the State of New Mexico Integrated Clean Water Act §303(d)/§305(b) Water Quality Monitoring and Assessment Report: Assessment Protocol. January 23, 2008. (http://www.nmenv.state.nm.us/swqb/protocols/index.html)

Watershed West (WW) and Ice Nine Consulting. 2008. Santa Fe Watershed Paired Basin Study, Effects of Thinning and Prescribed Fire on Water Quality and Yield. Funded by the City of Santa Fe. March 2008.

**Santa Fe Municipal Watershed**
**Outreach Plan**

## Background and Context

Numerous non-profit groups, such as the Trust for Public Lands, Forest Trends and the Katoomba Group, offer guidelines for incorporating Payment for Ecosystem Services (PES) into watershed management plans. Open communication and accountability are critical in maintaining public confidence in water supply and management. For this reason, most publications recommend that proposed PES fees be made explicit to the public, following an aggressive outreach campaign. This underscores the importance of demonstrating to stakeholders that the benefits of the program are (or will be) greater than or equal to the costs of implementation.

The Santa Fe watershed supports more than 75,000 water users in the greater Santa Fe area. While the Santa Fe Municipal Watershed plan has engaged key agency and non-profit agencies in its development, success of the overall watershed management plan also is dependent upon community and political support. Currently, the Santa Fe Municipal Watershed is closed to the public, and little is known about the attitudes and knowledge of Santa Fe water users toward watershed management or a Payment for Ecosystem Services model for supporting management activities. The Outreach plan will gather information about community perspectives toward watershed management while simultaneously providing education to residents of the City and County of Santa Fe, water customers of Sangre de Cristo Water Division, and Santa Fe youth. Outreach will help water consumers understand the threats to Santa Fe's water supply and demonstrate that proactive watershed protection costs significantly less than addressing watershed degradation issues after catastrophic fire. Outreach will also address issues and concerns related to fire in the watershed, including concerns about smoke associated with prescribed fire. Outreach will be provided and shared by and among all cooperating agencies including the City of Santa Fe Fire Department, Sangre de Cristo Water Division, the Española Ranger District of the Santa Fe National Forest, and the Santa Fe Watershed Association.

## Scope of Plan

This plan targets residents of the City and County of Santa Fe, water customers of Sangre de Cristo Water Division, and Santa Fe youth with a focus on two areas:

- Providing general watershed education, including forest and riparian ecology, natural and cultural history, and water issues, and
- Building support for the Payment for Ecosystem Services model.

## Summary of Recommendations

| Table 1. Summary of Recommendations for Outreach | |
|---|---|
| **Watershed Education – General Public** | • Offer 5 educational hikes per year within the Santa Fe watershed<br>• Provide a self-guiding interpretive brochure for the Black Canyon nature trail, which overlooks the watershed<br>• Develop a 5-7 minute video tour to virtually experience the upper watershed<br>• Host a website about watershed management plans and activities<br>• Develop a brochure in Spanish and English to be distributed at community events and with water bills |
| **Watershed Education – Youth** | • Offer one classroom visit to all 4th and 5th grade students in Santa Fe with pre- and post-activities for teachers<br>• Offer multiple-visit programs to a subset of 4th and 5th grade classrooms that will include a field trip to the watershed<br>• Involve middle and high school students in watershed monitoring |
| **Support for Watershed Management and Payment for Ecosystem Services** | • Gather information about residents' knowledge and attitudes about the watershed and PES through a random survey of water users<br>• Provide and staff an information table at community events<br>• Write articles in a variety of existing organizational newsletters<br>• Develop public service announcements<br>• Develop 30 second television spots for distribution on a variety of cable networks<br>• Provide an information page in the community pages of the phone book |

## Community Context

Santa Fe has a population of 72,000 with an ethnic diversity of 50% White, 45% Hispanic and 5% other. Since 2000, the population has increased by 15% and it is expected to continue to grow. The median household income is $44,000 with 18% of the population below the poverty level (48 in state ranking). Sangre de Cristo water users include the population of the City as well as 10,000 users outside of the City limits.

## Outreach History

The Santa Fe Watershed Association has a history of community outreach. We have organized over 40 public meetings for the Upper Watershed Thinning project, the San Ysidro River Restoration Project, and the Santa Fe River Trail. The Association is actively involved in community and school education with programs in the classroom, after school and on the weekends.

## Recommendations

The goals of outreach to the Santa Fe community are to create greater awareness and sense of ownership toward the watershed, while fostering appreciation and support for watershed management and the proposed Payment for Ecosystem Services plan. This plan targets residents of the City and County of Santa Fe, water customers of Sangre de Cristo Water Division, and Santa Fe youth with a focus on two areas:

- Providing general watershed education, including forest and riparian ecology, natural and cultural history, and water issues
- Building support for the Payment for Ecosystem Services model.

The plan provides strategies for providing clear, consistent information about watershed management and the proposed Payment for Ecosystem Services model by creating opportunities for residents to learn more about the watershed's ecology and management and for youth to become stewards of the watershed. Outreach should transmit three key messages:

- Management of watershed vegetation improves the health of the forest and reduces the threat of catastrophic wildfire.
- Management of the watershed helps secure the City of Santa Fe's water supply and optimize water yields.
- The Santa Fe Upper Watershed provides ecosystem services that benefit residents and it costs money to protect these services.

Proposed outcomes from outreach include:

- Increased awareness of and increased understanding of the Santa Fe Watershed as a whole
- Increased understanding of forest ecology and management including fire and smoke education

- Increased knowledge of the sources, quality, and quantity, of the City's domestic water supply
- Increased support for City's *Payment for Ecosystem Services Plan*
- Increased appreciation of pristine nature of water in the watershed
- Increased appreciation on the part of residents for the City's watershed management, and
- Increased accountability on the part of the City to residents for watershed management.

Outreach will be provided by the City of Santa Fe Fire Department, Sangre de Cristo Water Division, the Española District of the Santa Fe National Forest, and the Santa Fe Watershed Association.

## *Community Education about Watershed*

### *Watershed Hikes*

The Santa Fe watershed is not currently open to the public. However, one of the easiest ways to get people interested in the watershed is to have them experience it directly. We recommend offering five guided hikes between June and October each year. Each hike would educate participants about its management. Four hikes would be walking tours; one would be a driving tour for accessibility. Each hike would provide an overview of the watershed's natural history, fire ecology, vegetation and water management, as follows:

- Natural history: local flora and fauna, and human impacts upon these
- Fire ecology: fire history and fire regimes of forest types within the watershed
- Vegetation management: the need for thinning and burning, smoke education, and management strategies in Wilderness Area versus lower vegetation zones
- Water management: reservoirs, river health, and mechanisms for preserving water quality

A handout with basic information on each subject would be available for all participants. The handout would be developed in collaboration with all partners, with the Forest Service providing information on fire ecology and vegetation management, and the City providing information about water management. Hikes would be led by the Santa Fe Watershed Association, with participation and support from City and Forest Service partners.

### *Black Canyon Nature Trail Brochure*

The Black Canyon trail in the Santa Fe National Forest is accessible to the public, and overlooks the Santa Fe watershed. We recommend creating a self-guiding interpretive trail brochure in English and Spanish that would educate the public about watershed management. Beginning at the Black Canyon Campground, the trail would have numbered markers correlating to a brochure that would highlight various details of the watershed, including current management plans. Unlike interpretive panels, a brochure can be easily updated and is not subject to vandalism. We recommend having students create the brochure using Forest Service guidelines.

### *Upper Watershed Video*

Most Santa Fe residents have never visited the upper watershed, which is closed to the public. We recommend creating a short five-seven minute video tour of the watershed that would allow residents to virtually experience the watershed while also learning about its management. The video would be used at community events, public meetings, on public access television, and on YouTube and would be available in English and Spanish.

### *Upper Watershed Website*

Websites currently are one of the most used public information sources. We recommend that the City of Santa Fe host a watershed website that would provide information about the watershed management plan, prescribed burns and smoke education, current monitoring data, scheduled outreach activities, video links, and contact information for all project partners.

### *Brochure*

A large part of the Santa Fe community does not have regular access to internet. We recommend developing a brochure that would be printed in both English and Spanish to describe basic information about the watershed and its management. The brochure would be distributed at a wide variety of community events, such as the rodeo, fishing derby, or Fiesta, that would reach a diverse cross-section of the Santa Fe community. The brochure would also be included in the water bill.

## ***Youth Education about Watershed***

### *Classroom Program*

Youth are the future stewards of the watershed. We propose offering single classroom visits to all students in the fourth and five grades within the City of Santa Fe. It is in these grades that that watershed ecology fits into the New Mexico subject standards. Each teacher would be allowed to choose a program related to watershed ecology and management, including forest and fire ecology, prescribed fire and smoke, erosion, dendrochronology, wildlife, native and invasive species, and cultural and historical context of the watershed. Each classroom visit would include an interactive activity, and all content would be correlated to state education standards. Additional activities would be made available for teachers prior to and/or following these classroom visits through the watershed website.

### *Field Program*

While multiple classroom visits with a corresponding field trip is a more effective means of educating youth than a single classroom visit, this approach is also more costly. We therefore recommend offering a more intensive education program to twelve classrooms. This program would offer two classroom presentations followed by a field trip to the watershed that would evaluate watershed health. The program would culminate in the development of a "management plan."

### *Monitoring Program*

Monitoring is an effective strategy to engage middle and high school students in watershed management. We propose to engage 80 middle and high school students from four schools in

forest and water monitoring. These students would visit the watershed regularly to collect monitoring data on water quality, vegetation, and wildlife indicators. Students would analyze this data and present the information on the watershed website and to the student congress of their school at the end of each year.

## *Support for Watershed Management and Payment for Ecosystem Services*

### *Survey*

There is currently very little information about Santa Fe residents' knowledge and attitudes about the watershed. We recommend gathering this information through a survey that would help us identify the issues of greatest concern to residents, and to learn what information would be most helpful for them to make informed choices. We recommend using a stratified random telephone survey to reach the various demographics of Santa Fe.

### *Community Events*

We recommend staffing tables and speaking at community events as another means of reaching diverse audiences within Santa Fe. Potential events would include church events, community days, farmers' markets, Fiesta, the River Festival and Fishing Derby. We recommend participation in 12 events per year.

### *Newsletter Articles*

Articles in a variety of organizations' newsletter would extend public outreach for little cost and would reach more readers than creating a newsletter that is dedicated to the management plan itself. We therefore recommend publishing ten articles per year in five publications.

### *Public Service Announcement*

Public Service Announcements are an inexpensive means of reaching a different population than print material. We therefore recommend creating and distributing Public Service Announcements with information and activities related to watershed management to community radio stations throughout the year.

### *Television Spots*

Cable television can reach a more diverse and larger audience than any other type of media outreach. We therefore recommend developing a 30-second spot for cable television that would be broadcast through Comcast. The 920 spots could be placed on the more than 40 channels offered.

### *Phone Book*

We recommend placing a one-page information page about the watershed in the community pages of the phone book. This information page would include general information and contacts for watershed management, water supply, fire updates, and emergency contact information.

**Santa Fe Municipal Watershed**
***Financial Management Plan***

## Background and Context

The Santa Fe Municipal Watershed provides critical surface water to city residents' water supply. Protection of water quantity and quality is a shared goal of the City of Santa Fe and the Santa Fe National Forest, which manages the upper 17,000 acres of the watershed. The City and Forest Service both recognize that high-intensity fire risk and overgrown dense forests are strong threats to watershed health and the long term viability of water supplies.

The greatest threat to the ecosystem services provided by the Santa Fe Municipal Watershed is fire in unmanaged forest. Congress has spent $7 million in federal earmarks for planning and restoration of forest conditions in the watershed, with $1.5 million per year going toward thinning of 5,285 acres in the lower upper watershed between 2003 and 2006. Annual maintenance with controlled fire is needed to keep fuels at the reduced level. The cost to retain the restored forest condition over 20 years is estimated at $4.3 million, an average of $200,000 per year, depending on the level of maintenance needed in any given year, with diminishing cost over time. In contrast, the avoided cost, estimated by calculating the expense that would result from a 7,000 acre fire in the watershed is $22 million. The likelihood of such a fire in the watershed is estimated to be 1 in 5 in any given year. The avoided cost includes full-scale fire suppression and dredging of ash-laden sediment from the two reservoirs.

To date, federal funding has supported the most expensive work to restore forest health in the Santa Fe watershed. This funding, through hazardous fuel reduction earmarks and appropriations, is subject to changing Congressional priorities and approval. Funding for upkeep of the treated forest areas is contingent upon annual Forest Service appropriations, and these appropriations have been declining because of the rising cost of fire suppression. As funding is directed to fire suppression, cost-share agreements that leverage federal funding by providing matching funds will become more important. A Payment for Ecosystem Services agreement between the City of Santa Fe and the Santa Fe National Forest would more likely ensure that the Forest Service will be able to continue its management activities within the watershed, even as available funding declines in the region.

Payment for Ecosystem Services (PES) programs provide clear economic incentives for stewardship of watersheds and promote greater awareness about the benefits provided by healthy watersheds, such as flood control and flow timing, water purification, sediment retention, fire protection and carbon storage. Studies of water utilities across the United States show that every dollar invested in watershed protection can save tens to hundreds of dollars in costs for new water treatment facilities (Johnson et al. 2000).

Research shows that the most effective PES programs engage and inform a variety of stakeholders. Key elements to effective PES programs include defining and valuing the ecosystem services, developing an agreement that guarantees those services to customers, and establishing a payment mechanism (Forest Trends and Katoomba Group 2008). A Payment for

Ecosystem Services program in the Santa Fe watershed would pay for vegetation management, water management, and outreach through a partnership between the City of Santa Fe and the Santa Fe National Forest.

The City of Santa Fe has recently instituted a five-year utility service rate increase in order to pay for construction of the Buckman Direct Diversion Project. Because gaining public support for an additional rate increase associated with Watershed Management Plan PES would be difficult at this time, the watershed management partners are pursuing New Mexico Finance Authority, Water Trust Board funding to cover the City's PES obligations for the first five years of project implementation. Within this initial five-year period, outreach and education efforts will be focused on building public approval for PES and acceptance of the nominal rate increase associated with the Watershed Management Plan that would go into effect in 2014, when the Buckman Direct Diversion Project will be complete.

## Scope of this Plan

The purpose of the financial management plan is to develop a financing framework to support forest management, water management, and outreach activities outlined in each respective plan. The financial management plan outlines the Payment for Ecosystem Services approach, whereby beneficiaries of the watershed (Santa Fe water consumers) will knowingly pay for ecosystem services. The financial plan also provides the economic context for previous watershed management activities, describes anticipated costs for all components of the plan, describes costs from catastrophic fire that can be avoided through fire and fuels management, and suggests agreements and mechanisms for payment necessary to finance the plan.

## Summary of Recommendations

| Table 1. Summary of Recommendations for Financial Management | |
|---|---|
| Payment for Ecosystem Services | Use the Payment for Ecosystem Services (PES) model to develop a local, sustainable source of funding that accounts for true costs of watershed management. |
| Income Sources for PES | Phase 1: New Mexico Water Trust Board pays for ecosystem services for first 5 years. Beginning in year 2, list the PES cost as a credit on water bill for education and visibility.<br><br>Phase 2: Assess a fee to each water consumer based on use, projected at $0.13 per 1,000 gallons per month. List the PES fee as a separate line item in water bill. |
| Agreements and Mechanisms for Payment | Draft a new Memorandum of Understanding between the City and USFS for watershed management. Develop a collection agreement between City and USFS every five years. Review work plans, budgets, and project implementation annually. |

## Payment for Ecosystem Services

### *General Context*

Ecosystems naturally produce resources that are important for humans, such as water, wood, clean air, and insects that pollinate gardens and fruit trees. "Ecosystem services" refer to these resources and the natural processes that produce them (Table 2). Typically, these services are not paid for, nor are they included in conventional markets or economic analyses. Surface water for municipal use is an example of an ecosystem service that is neither paid for by the city nor individual water users. Water users pay for the services of capturing, treating, and delivering water, but they do not currently pay for the ecosystem services that ensure that clean water is available. By attaching an economic value to these natural processes and services, water districts and municipalities can access revenue to support needed watershed management. Payment for

Ecosystem Services provides clear economic incentives for maintaining watershed health, and creates greater visibility and support for watershed management by asking water consumers to knowingly pay for the ecosystem services the watershed provides (McGrath and Greenwalt 2008).

Major U.S. cities such as Seattle and New York City have saved millions of dollars in capital outlay and annual operating costs with payments for ecosystems services to fund watershed protection (Ernst 2004). The Santa Fe Watershed plan seeks to use the Payment for Ecosystem Services model to fund the maintenance of forest restoration activities as an insurance policy against future threats to the municipal water supply. The advantages of having beneficiaries pay for ecosystem services are (i) awareness and education about watershed health and protection; (ii) genuine collaboration between water consumers and forest managers; and (iii) long term funding of true watershed maintenance costs (McGrath and Greenwalt 2008).

**Table 2. Ecosystem Services for Santa Fe**

| **Provisioning Services** | **Description** |
|---|---|
| Fresh water | Supplies 30% of water used in City of Santa Fe and auxiliary supply to County users in dry years |
| **Regulating Services** | |
| Flood control and flow timing | Forest cover maintains snowpack and, combined with dams, ensures year-round water |
| Water purification | Forest and woodland cover provide natural filtration of water |
| Sediment regulation | Plants and forest ground cover keep soil in place |
| Fire protection | Healthy lower elevation forests will burn at low-intensity and reduce possibility of catastrophic wildfire and sedimentation |
| Invasive species regulation | Healthy forests have no/very few sources for invasive species introduction |
| Climate regulation | Healthy forests store carbon and low-intensity fires prevent a massive release of carbon |

## *Calculating Avoided Costs from Watershed Protection*

Fire protection is a critical ecosystem service for the Santa Fe watershed and is achieved through the fuels treatments already completed and a proposed annual controlled burn program. The Payment for Ecosystem Services model acts as an insurance policy against threats to the water supply from catastrophic fire. One of the best ways to illustrate the value of a PES program is to compare the costs of maintenance and long term management with the alternative costs that would result from a catastrophic fire. A catastrophic wildfire in the Santa Fe watershed would result in four significant costs (Table 3):

- *Fire suppression.* Fire suppression costs in New Mexico have averaged $20,000 per acre for smaller fires and $220 per acre for larger fires. If lightening starts in the Santa Fe watershed and is contained quickly and at less than 100 acres, the cost is estimated to be from $50,000-$100,000. If a fire burns 7,000 acres within the Santa Fe watershed, the projected cost would be approximately $10 million. The costs of a fire on the scale of the 2000 Cerro Grande fire would increase exponentially.

- *Shut down of water treatment plant and providing alternate source of supply.* Experience from other fires has shown that filtration systems of water treatment plants become clogged with ash after fire and typically have to shut down for at least 2 months in order to clear the system. The water division estimates a projected cost of $1 million that would result from shutting down the water treatment facility for 2 months and providing an alternate supply of water from City wells.

- *Reservoir dredging and upland disposal of accumulated sediment.* Typically, reservoirs also need to be dredged following catastrophic wildfires in order to remove sediment. Following the Cerro Grande fire, reservoir sedimentation in Los Alamos was 140 times higher than the previous 57 years, and remained significantly elevated throughout a five year study period (Lavine et al. 2005). Similarly, the water division estimates that it would cost $10 million to dredge and dispose of sediment accumulated in both reservoirs in the Santa Fe watershed, based on estimates from the Army Corps of Engineers. The Forest Service estimates an additional $500,000 would be required to complete NEPA for actions required to restore sediment regulation.

- *Rehabilitating burned areas to limit soil erosion, ash flow, and invasive species spread.* Common rehabilitation steps after wildfire include soil stabilization with seeding, construction of temporary water flow devices, and control of invasive species. If a wildfire burned 7,000 acres within the Santa Fe watershed, the Forest Service projects rehabilitation costs would be approximately $500,000.

Taken as a whole, the projected cost from a 7,000 acre catastrophic wildfire is $22 million (Table 3). In contrast, the proposed cost for management of the watershed will be $4.3 million (Table 3, Appendix 2).

| Table 3. Costs of ecosystem services provided by the Santa Fe watershed | |
|---|---|
| **Provisioning Service** | **Cost** |
| Fresh Water | **$4.3 million over 20 years** (approximately $200,000 per year) for management of 17,000 acres of watershed |
| **Regulating Services** | **$22 million** estimated total avoided cost from a 7,000 acre fire |
| Water purification | $1 million avoided cost of shutting down water treatment plant for 2 months after fire |
| Sediment regulation | $10 million avoided cost of dredging 2 reservoirs to remove sediment; $500,000 for NEPA compliance to restore sediment regulation |
| Fire protection | $10 million avoided cost of a 7,000 acre wildfire |
| Invasive species regulation | $500,000 avoided cost to control invasive species spread after wildfire |

Lessons from other watersheds impacted by severe fire show that it is far more cost effective to maintain the watershed than to pay for costly remediation following fire (McGrath and Greenwalt 2008). In fact, studies of water utilities across the United States show that every dollar invested in watershed protection can save tens to hundreds of dollars in costs for new water treatment facilities (Johnson et al. 2000). For example, following the Hayman and Buffalo Creek fires in Colorado, the City of Denver was forced to undertake a costly program to remove sediment from mountain reservoirs and unclog pipes. The projected cost was $31 million to the water utility (Denver Post 2008).

## *Financial History*

More than $7 million of Congressionally-directed funding has already been spent for planning and restoration of forest conditions in the watershed. Between 2003 and 2006 the United States Congress earmarked $1.5 million per year of hazardous fuels reduction funding to thin 5,285 acres. Funds were also earmarked for an EIS to analyze the impacts of the treatment plan.

Funding for the Santa Fe National Forest follows trends that affect the Forest Service nationally. The Congressional Budget Office requires that the Forest Service allocate funds for fire suppression before other programs, basing that amount on a 10 year rolling average of actual expenditures. The percent of the agency budget that is directed to fire suppression increased from 13% in 1991 to 46% in 2008. In three of the last ten years, Forest Service spending on suppression topped $1 billion, and from 2008 to 2009, the 10 year rolling average will increase by $158 million. The effect of those reductions will be felt across the Forest Service and there is no projected end in sight to the increases in fire suppression funding. At the current rate of increase, the Forest Service is expected to spend 100% of its budget allocation on fire suppression in 15-20 years.

Each year Hazardous Fuel Reduction appropriations allocate funding to the Southwest Region of the Forest Service. The Southwest Region then allocates this funding to the 11 national forests in New Mexico and Arizona. Funding for fuels treatments was consistent through 2008, even as funding for other programs declined and as fire suppression costs increased. However, the prospect of sustained funding at a level sufficient to fully fund the management needs is doubtful, because an increasing proportion of the Forest Service must be spent on fire suppression rather than resource management programs. As funding for treatments becomes scarce and competition between projects on each national forest intensifies, cost-share agreements that will leverage federal funding by providing matching funds become more important. A Payment for Ecosystem Services agreement between the City of Santa Fe Water Division and the Santa Fe National Forest makes it more likely that the Forest Service will be able to continue funding management of the Santa Fe watershed even as its funding allocation declines.

## *Recommendations*

We recommend the following as a framework for financing the watershed management plan:

- Use the Payment for Ecosystem Services model to develop a local, sustainable source of funding that accounts for true costs of watershed management.

- Initiate two phases of for PES: Phase 1: New Mexico Water Trust Board pays for ecosystem services during the first 5 years of the plan, until the Buckman diversion rate

increases are complete; Phase 2: As soon as the Buckman Diversion rate increases cease, assess a fee to each water consumer based on use, projected at $0.13 per 1,000 gallons per month.

- List fees as a separate item on the water bill. During Phase 1, the fee will appear as a credit, with funding from the New Mexico Water Trust Board. During Phase 2, the fee will be assessed back on water usage.

Other Payment for Ecosystem programs have found that open communication and accountability are critical in maintaining public confidence in water supply and management. For this reason, most publications recommend that proposed PES fees be made explicit to the public, following an aggressive outreach campaign (McGrath and Greenwalt 2008). We recommend that the City include the PES fee as a separate line item in the water bill. This would promote the understanding and visibility of the PES program and would contribute to a more educated public about the true cost of maintaining ecosystem services in the watershed. The fee would be listed after initial outreach in Year 1. Beginning in Year 2, the fee would be listed within the water bill. While ecosystem services are paid for with Water Trust Board funding, the PES fee would appear as a credit on consumers' bills. In Phase 2 of the plan, the fee would be a real fee based on water use. Listing the fee as a credit during Phase 1 would allow four years for consumers to become familiar with the plan and the benefits and costs associated with implementing the PES plan.

We recommend a fee based on water use, rather than a flat fee for all users, so that low-income and conservative water users are charged equitably. Based on the projected cost for watershed maintenance, this fee would be $0.13 per 1,000 gallons of water per month. An average household uses approximately 50,000 gallons of water per year, which would result in an annual fee of $6.50, or a monthly fee of $0.54. Lower end water users use approximately 24,100 gallons per year, resulting in an annual fee of $3.13, while higher end users can use as much as 72,200 gallons per year, resulting in an annual fee of $9.40.

- Create agreements and mechanisms for payment between the City of Santa Fe and the U.S. Forest Service. These would include: a new Memorandum of Understanding for watershed management; a Collection Agreement that would be re-established every 5 years; and an annual review of work plans, budgets, and project implementation, based on the terms of the Collection Agreement.

## *Projected Cost*

### *Total Cost*

The total cost associated with implementation during Phase 1 (Years 1-5) of the Santa Fe Watershed Management Plan is estimated to be $2,518,705 (Table 4). Income sources for this phase include the Water Trust Board (47%), the US Forest Service (40%), the City of Santa Fe (12%), and the Santa Fe Watershed Association (1%) (Table 4, Figure 1). This money will be

allocated to vegetation management and monitoring (78% of 5-year budget), water management and monitoring (13%), and education and outreach (9%) (Figure 2).

The total investment in watershed maintenance over 20 years will be $6.3 million. Of this, just under $3 million will be generated by the Payment for Ecosystem Services (through the WTB in Phase 1, or through consumer fees in Phase 2). PES fees will contribute 46% of all costs, with the Forest Service contributing 36%, the City 16%, and the Santa Fe Watershed Association 2% (Appendix 1).

**Table 4. Total Cost for Phase 1 of Santa Fe Watershed Management Plan**

| Year | Total | WTB | USFS | City | SFWA |
|---|---|---|---|---|---|
| 2010 | $457,353 | $209,250 | $173,350 | $68,103 | $6,650 |
| 2011 | $809,153 | $393,110 | $357,010 | $52,783 | $6,250 |
| 2012 | $464,233 | $214,350 | $181,850 | $60,783 | $6,250 |
| 2013 | $459,833 | $217,950 | $178,850 | $56,783 | $6,250 |
| 2014 | $329,133 | $149,800 | $120,300 | $52,783 | $6,250 |
| **Total 5-Year Cost** | **$2,518,705** | **$1,184,460** | **$1,011,360** | **$291,235** | **$31,650** |

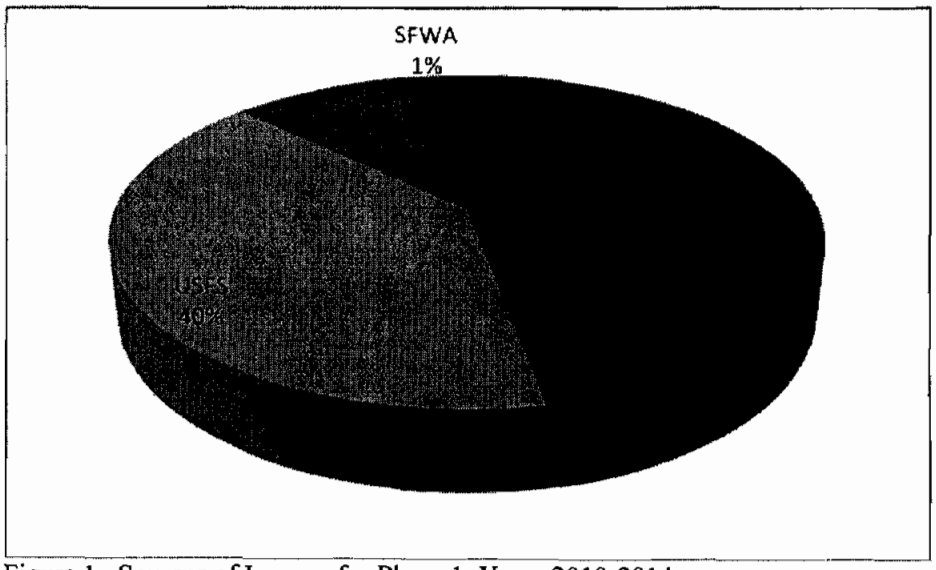


Figure 1. Sources of Income for Phase 1, Years 2010-2014

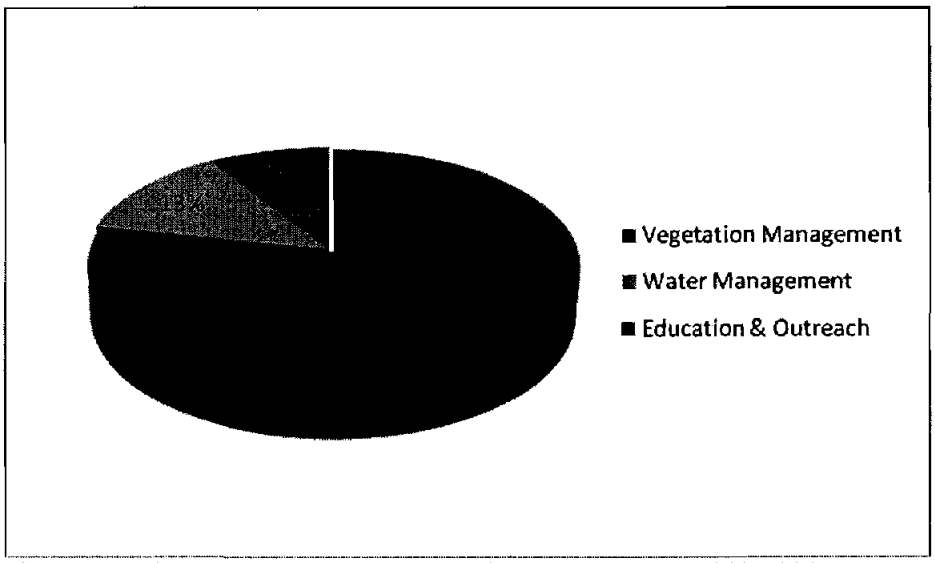

Figure 2. Estimated expenses, by activity for Phase 1, Years 2010-2014

## *Vegetation Management*

The $7 million in federal earmarks for hazardous fuel reduction in the Santa Fe watershed represents a considerable public investment. Annual maintenance with controlled fire will keep fuels at the reduced level. The cost to retain the restored forest condition over the first 5 years is nearly $2 million, with an additional $2.3 million over the remaining 20 years. Costs range from $150,000 and $700,000 per year, depending on the level of maintenance needed in any given year, with diminishing cost over time (Table 5, Appendix 2).

The projected costs of maintenance fire treatments were calculated with actual 2007 expense information and were not adjusted for inflation or fuel cost increases. These costs will be adjusted each year when the work plan is reviewed (Table 1). The cost estimates are intended to show projected cost changes over twenty years of annual broadcast burns across the 7,270 acre portion of the watershed. The estimates do not reflect Forest Service equipment, indirect, or overhead costs, many of which are covered out of the Fire Preparedness line item in the Interior and Related Agencies Appropriations Bill.

The costs for fuels management will be shared equally between the Forest Service and the City of Santa Fe (Table 5, Appendix 2). This cost share agreement will help continue the leveraging of federal earmarks for hazardous fuel reductions.

| Table 5. Cost of Vegetation Management During Phase 1 | | | |
|---|---|---|---|
| **Year** | **Total** | **WTB** | **USFS** |
| 2010 | $332,100 | $166,050 | $166,050 |
| 2011 | $697,420 | $348,710 | $348,710 |
| 2012 | $361,100 | $180,550 | $180,550 |
| 2013 | $341,100 | $170,550 | $170,550 |
| 2014 | $234,000 | $117,000 | $117,000 |
| **Total 5 Year Cost** | **$1,965,720** | **$982,860** | **$982,860** |

Initial costs for Year 1 include the costs for completing all NEPA-compliance activities for the watershed. It is more cost-effective to complete NEPA for the entire acreage, and completion of NEPA in Year 1 will allow more flexibility to capture burning windows. The ability to accomplish the full amount of targeted burning each year will depend entirely upon the weather and drought conditions. A flexible funding system will need to be developed to retain allocated funding in years when targets fall short, so that those funds are available in years when extra acres can be accomplished.

### *Water Management*

Cost for water management activities will be $322,735 for the first 5 years of the plan, or $1.15 million over 20 years (Table 6, Appendix 3). The majority of water management costs (85%) will be provided for by the City, with the WTB contributing 12%, and the Forest Service, 3% (Figure 3). During the first phase of the plan, WTB funding pays for the ecosystem services. During Phase 2 of the plan, water consumers will pay for these costs.

| Table 6. Cost of Water Management in Phase 1 | | | |
|---|---|---|---|
| **YEAR** | **WTB** | **USFS** | **CITY** |
| 2010 | $0 | $0 | $60,803 |
| 2011 | $20,000 | $5,000 | $49,483 |
| 2012 | $0 | $0 | $59,483 |
| 2013 | $20,000 | $5,000 | $53,483 |
| 2014 | $0 | $0 | $49,483 |
| **Total 5-Year Cots** | **$40,000** | **$10,000** | **$272,735** |

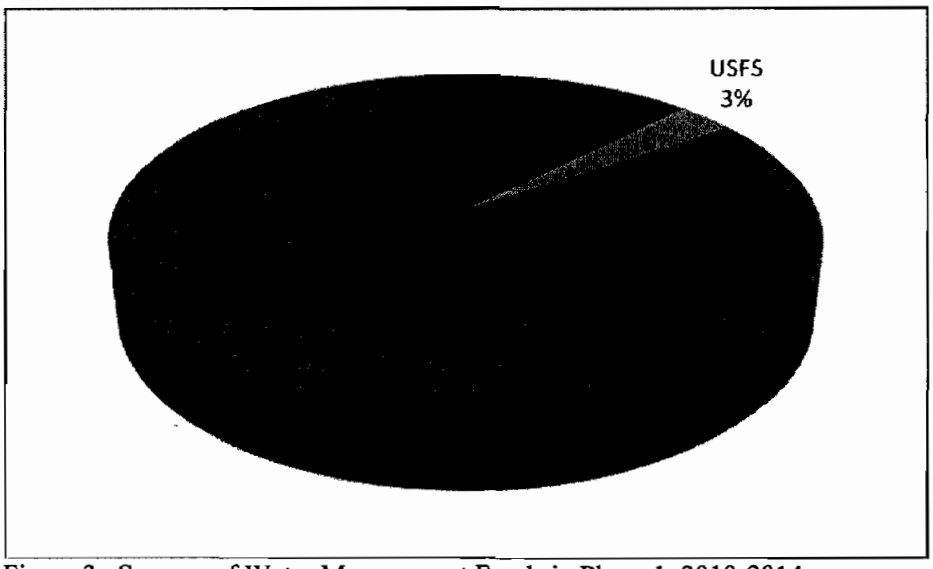

Figure 3. Sources of Water Management Funds in Phase 1, 2010-2014

## *Outreach*

Education and Outreach activities will cost $223,250 for the first 5 years of the plan, or $843,300 over 20 years (Table 7, Appendix 4). The majority of outreach costs will be funded by the WTB (73%), with the USFS contributing 5%, the City, 14%, and the Santa Fe Watershed Association (8%) (Table 7, Figure 4). In Phase 2 of the plan, Payments for Ecosystem Services consumer fees will provide revenue provided by the WTB in Phase 1 (Appendix 4).

**Table 7. Cost of Outreach and Education During Phase 1**

| Year | WTB | USFS | CITY | SFWA |
|---|---|---|---|---|
| 2010 | $43,200 | $3,100 | $7,300 | $6,650 |
| 2011 | $24,400 | $2,100 | $3,300 | $6,250 |
| 2012 | $33,800 | $2,100 | $1,300 | $6,250 |
| 2013 | $27,400 | $2,100 | $3,300 | $6,250 |
| 2014 | $32,800 | $2,100 | $3,300 | $6,250 |
| **Total 5-Year Cost** | **$161,600** | **$11,500** | **$18,500** | **$31,650** |

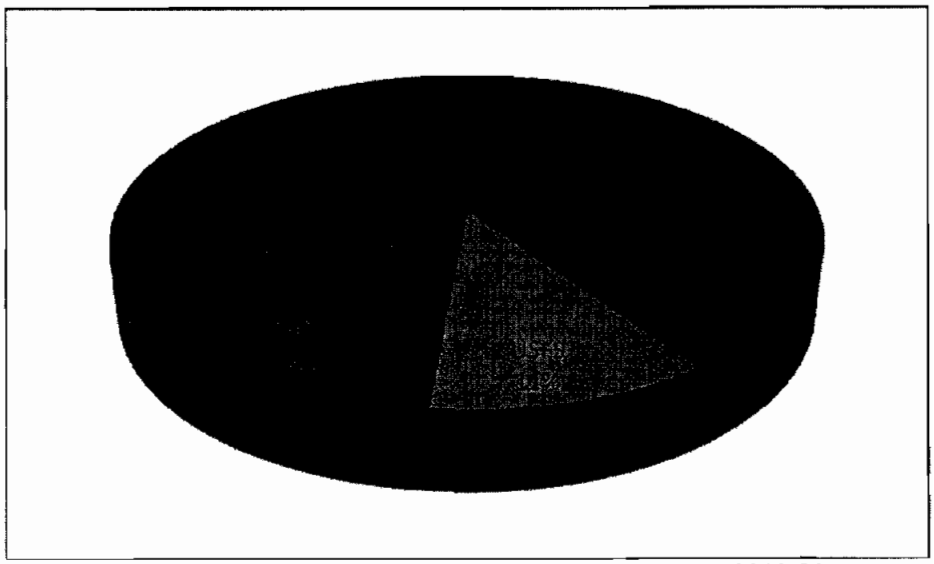

Figure 4. Sources of Education and Outreach Funds in Phase 1, 2010-2014

## Literature Cited


Denver Post. 2008. Thinking Ahead on the effects of Fire. Editorial posted April 11, 2008. Accessed July 31, 2008 at http://www.denverpost.com/opinion/ci_8883332

Ernst, C. 2004. Protecting the Source: Land Conservation and the Future of America's Drinking Water. Trust for Public Land, Washington, D.C., pp. 52. Accessed July 30 at www.TPL.org.

Forest Trends and the Katoomba Group. 2008. Payments for Ecosystem Services: Getting Started A Primer. Forest Trends, The Katoomba Group and the United Nations Environment Programme, Washington, DC, USA. Accessed July 31, 2008 at www.katoombagroup.org.

Johnson, N., A. White and D. Perrot-Maitre. 2000. Developing Markets for Water Services from Forests: Issues and Lessons from Innovators. Forest Trends, World Resources Institute and the Katoomba Group, Washington, D.C., USA. Accessed July 30, 2008 at www.katoombagroup.org.

Lavine, A., G.A. Kuyumjian, S.L. Reneau. D. Katzman and D.V. Malmon. 2005. A five-year record of sedimentation in the Los Alamos Reservoir, New Mexico, following the Cerro Grande Fire. Los Alamos Technical Publication LA-UR-05-7526 accessed on August 4, 2008 at http://catalog.lanl.gov.

McGrath, D. and T. Greenwalt. 2008. Protecting the City's Water: Designing a Payment for Ecosystem Services (PES) Program for the Santa Fe Municipal Watershed. New Mexico Forest Restoration Series, Working Paper 4. Las Vegas, NM: New Mexico Forest and Watershed Restoration Institute, www.nmfwri.org.

## Appendix 1: 20 Year Projected Cost: Santa Fe Watershed Management Plan

| Table A1. Total Cost for Santa Fe Watershed Management Plan Over 20 Years | | | | | |
|---|---|---|---|---|---|
| **Year** | **Total** | **WTB/PES** | **City** | **USFS** | **SFWA** |
| 2010 | $457,353 | $209,250 | $68,103 | $173,350 | $6,650 |
| 2011 | $809,153 | $393,110 | $52,783 | $357,010 | $6,250 |
| 2012 | $463,233 | $214,350 | $60,783 | $181,850 | $6,250 |
| 2013 | $459,833 | $217,950 | $56,783 | $178,850 | $6,250 |
| 2014 | $329,133 | $149,800 | $52,783 | $120,300 | $6,250 |
| 2015 | $317,353 | $143,900 | $48,103 | $119,100 | $6,250 |
| 2016 | $331,253 | $151,800 | $54,103 | $119,100 | $6,250 |
| 2017 | $269,533 | $127,400 | $46,783 | $89,100 | $6,250 |
| 2018 | $255,933 | $116,300 | $46,783 | $86,600 | $6,250 |
| 2019 | $252,533 | $109,400 | $52,783 | $84,100 | $6,250 |
| 2020 | $235,433 | $104,800 | $52,783 | $71,600 | $6,250 |
| 2021 | $218,533 | $93,900 | $46,783 | $71,600 | $6,250 |
| 2022 | $234,933 | $104,300 | $52,783 | $71,600 | $6,250 |
| 2023 | $244,533 | $144,900 | $46,783 | $76,600 | $6,250 |
| 2024 | $225,933 | $101,300 | $46,783 | $71,600 | $6,250 |
| 2025 | $235,033 | $101,900 | $52,783 | $74,100 | $6,250 |
| 2026 | $251,933 | $122,300 | $46,783 | $76,600 | $6,250 |
| 2027 | $219,083 | $93,900 | $47,333 | $71,600 | $6,250 |
| 2028 | $235,483 | $104,300 | $53,333 | $71,600 | $6,250 |
| 2029 | 245,083 | $114,900 | $47,333 | $76,600 | $6,250 |
| **Total 20-Year Cost** | **$6,291,290** | **$2,889,760** | **$1,033,270** | **$2,242,860** | **$125,400** |

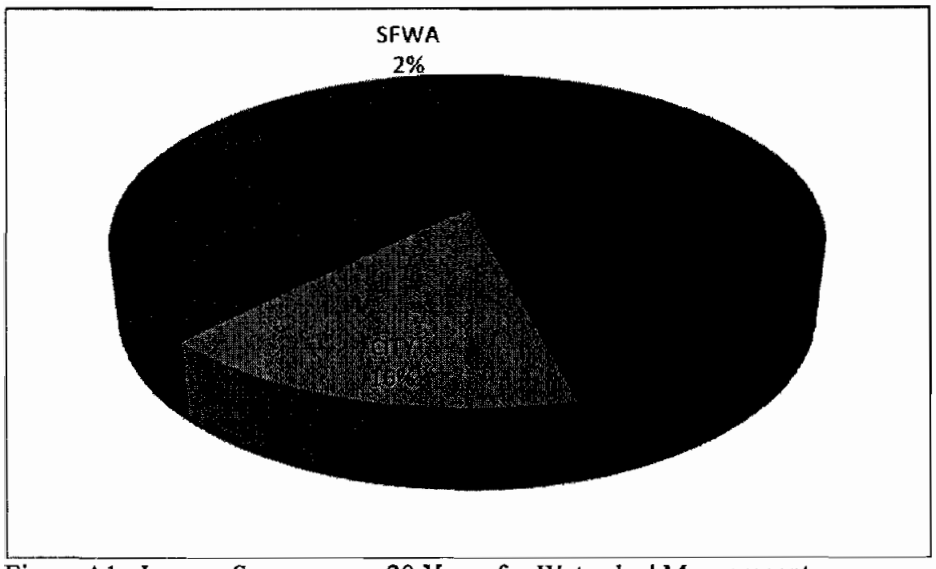

Figure A1: Income Sources over 20 Years for Watershed Management

## Appendix 2: 20 Year Projected Cost: Vegetation Management

Vegetation management costs will be shared equally between the City (through the WTB funding or a PES fee to consumers collected by the City) over the full 20 years of the plan.

| Table A2: 20 Year Projected Cost for Vegetation Management | | |
|---|---|---|
| **Year** | **WTB/PES** | **USFS** |
| 2009 | $166,050 | $166,050 |
| 2010 | $348,710 | $348,710 |
| 2011 | $180,550 | $180,550 |
| 2012 | $170,550 | $170,550 |
| 2013 | $117,000 | $117,000 |
| 2014 | $117,000 | $117,000 |
| 2015 | $82,000 | $82,000 |
| 2016 | $84,500 | $84,500 |
| 2017 | $82,000 | $82,000 |
| 2018 | $69,500 | $69,500 |
| 2019 | $69,500 | $69,500 |
| 2020 | $69,500 | $69,500 |
| 2021 | $69,500 | $69,500 |
| 2022 | $69,500 | $69,500 |
| 2023 | $69,500 | $69,500 |
| 2024 | $72,000 | $72,000 |
| 2025 | $69,500 | $69,500 |
| 2026 | $69,500 | $69,500 |
| 2027 | $69,500 | $69,500 |
| 2028 | $69,500 | $69,500 |
| 2029 | $69,500 | $69,500 |
| **Total 20 Year Cost** | **$2,162,860** | **$2,162,860** |

## Appendix 3: 20 Year Projected Cost: Water Management

| Table A3: 20 Year Projected Cost of Water Management | | | |
|---|---|---|---|
| **Year** | **WTB/PES** | **USFS** | **CITY** |
| 2010 | $0 | $0 | $60,803 |
| 2011 | $20,000 | $5,000 | $49,483 |
| 2012 | $0 | $0 | $59,483 |
| 2013 | $20,000 | $5,000 | $53,483 |
| 2014 | $0 | $0 | $49,483 |
| 2015 | $0 | $0 | $44,803 |
| 2016 | $0 | $0 | $50,803 |
| 2017 | $20,000 | $5,000 | $43,483 |
| 2018 | $0 | $0 | $43,483 |
| 2019 | $0 | $0 | $49,483 |
| 2020 | $0 | $0 | $49,483 |
| 2021 | $0 | $0 | $43,483 |
| 2022 | $0 | $0 | $49,483 |
| 2023 | $20,000 | $5,000 | $43,483 |
| 2024 | $0 | $0 | $43,483 |
| 2025 | $0 | $0 | $49,483 |
| 2026 | $20,000 | $5,000 | $43,483 |
| 2027 | $0 | $0 | $44,033 |
| 2028 | $0 | $0 | $50,033 |
| 2029 | $20,000 | $5,000 | $44,033 |
| **Total 20-Year Cost** | **$120,000** | **$30,000** | **$965,270** |

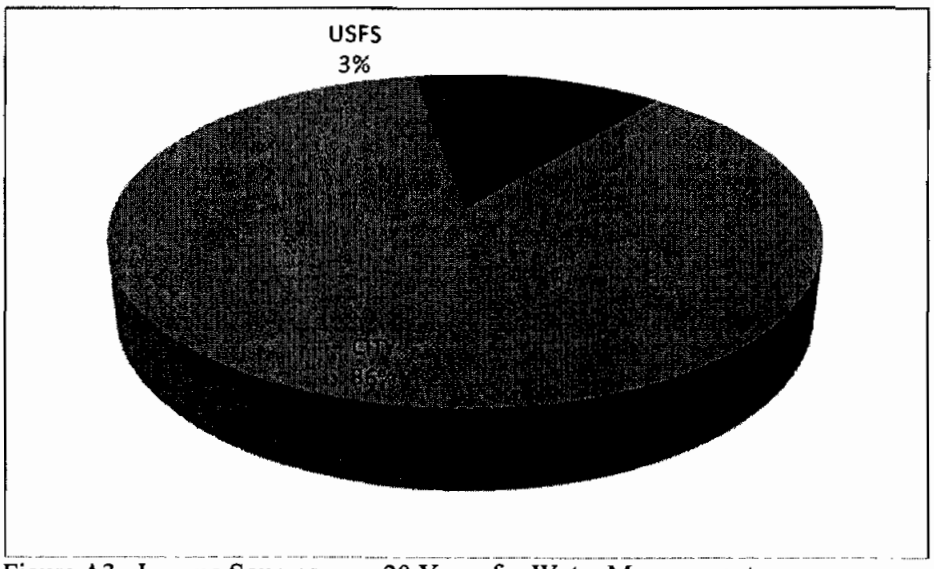


Figure A3. Income Sources over 20 Years for Water Management

## Appendix 4: 20 Year Projected Cost: Outreach and Education

| Table A4: 20 Year Projected Cost for Outreach and Education | | | | |
|---|---|---|---|---|
| **Year** | **WTB/PES** | **USFS** | **City** | **SFWA** |
| 2010 | $43,200 | $3,100 | $7,300 | $6,650 |
| 2011 | $24,400 | $2,100 | $3,300 | $6,250 |
| 2012 | $33,800 | $2,100 | $1,300 | $6,250 |
| 2013 | $27,400 | $2,100 | $3,300 | $6,250 |
| 2014 | $32,800 | $2,100 | $3,300 | $6,250 |
| 2015 | $26,900 | $2,100 | $3,300 | $6,250 |
| 2016 | $34,800 | $2,100 | $3,300 | $6,250 |
| 2017 | $25,400 | $2,100 | $3,300 | $6,250 |
| 2018 | $31,800 | $2,100 | $3,300 | $6,250 |
| 2019 | $27,400 | $2,100 | $3,300 | $6,250 |
| 2020 | $35,300 | $2,100 | $3,300 | $6,250 |
| 2021 | $24,400 | $2,100 | $3,300 | $6,250 |
| 2022 | $34,800 | $2,100 | $3,300 | $6,250 |
| 2023 | $25,400 | $2,100 | $3,300 | $6,250 |
| 2024 | $31,800 | $2,100 | $3,300 | $6,250 |
| 2025 | $29,900 | $2,100 | $3,300 | $6,250 |
| 2026 | $32,800 | $2,100 | $3,300 | $6,250 |
| 2027 | $24,400 | $2,100 | $3,300 | $6,250 |
| 2028 | $34,800 | $2,100 | $3,300 | $6,250 |
| 2029 | $25,400 | $2,100 | $3,300 | $6,250 |
| **Total 20-Year Cost** | **$606,900** | **$43,000** | **$68,000** | **$125,400** |

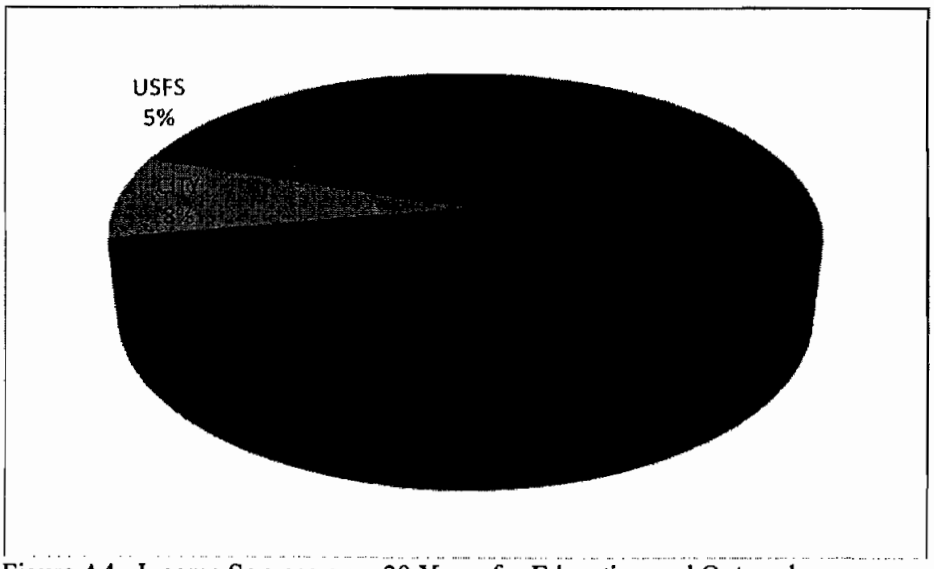


Figure A4: Income Sources over 20 Years for Education and Outreach

# Santa Fe Municipal Watershed
*Conclusion*

## Summary

Like many cities throughout the western United States, Santa Fe's water supply is dependent upon forest health and protection from catastrophic wildfire. Congress has spent $7 million in federal earmarks for planning and restoration of forest conditions in the Santa Fe watershed, with $1.5 million going toward thinning of 5,285 acres in the lower upper watershed between 2003 and 2006. Annual maintenance with prescribed fire is needed to keep fuels at the reduced level. The cost to retain the restored forest condition over 20 years is estimated at $4.3 million, an average of $200,000 per year, depending on the level of maintenance needed in any given year, with diminishing cost over time. In contrast, the avoided cost, estimated by calculating the expense that would result from a 7,000 acre fire in the watershed is $22 million. The likelihood of such a fire in the watershed is estimated to be 1 in 5 in any given year. The avoided cost includes full-scale fire suppression and dredging of ash-laden sediment from the two reservoirs.

While federal funding has supported hazardous fuel reduction through earmarks and Forest Service appropriations, much of the Forest Service's budget has been and likely will increasingly be diverted to fire suppression. As funding declines, cost-share agreements that leverage federal funding by providing matching funds will become more important. A Payment for Ecosystem Services agreement between the City of Santa Fe and the Santa Fe National Forest would more likely ensure that the Forest Service will be able to continue its management activities within the watershed, even as funding declines in the region.

The City of Santa Fe has recently instituted a five-year utility service rate increase in order to pay for construction of the Buckman Direct Diversion Project. Because gaining public support for an additional rate increase associated with Watershed Management Plan PES would be difficult at this time, the watershed management partners are pursuing New Mexico Finance Authority, Water Trust Board funding to cover the City's PES obligations for the first five years of project implementation. Within this initial five-year period, outreach and education efforts will be focused on building public approval for PES and acceptance of the nominal rate increase associated with the Watershed Management Plan that would go into effect in 2014, when the Buckman Direct Diversion Project will be complete.

This master plan provides a framework and recommendations for long term management, outreach, and funding for the Santa Fe Municipal Watershed. The plan addresses four areas critical to the maintenance of the watershed: (i) vegetation management and fire use; (ii) water management; (iii) public awareness and outreach; and (iv) financial management based on "Payment for Ecosystem Services." This plan seeks to fund forest restoration activities using the Payment for Ecosystem Services model as an insurance policy against future threats, particularly of catastrophic fire, to the municipal water supply.

## Next Steps

With the initial step of drafting the four components of this watershed management plan complete, the next steps will be to develop agreements and timeframes that will support the implementation of this plan.

- ✓ Develop an agreement between City officials, the City of Santa Fe water division, the Forest Service, and Santa Fe Watershed Association that will (i) formalize support for the Payment for Ecosystem Services program, (ii) make explicit the budgeting and billing mechanisms to be employed, and (iii) address means of garnering public support for the PES program given Buckman Diversion water rate increases.

- ✓ Develop an implementation plan with a timeframe for implementation of all aspects of the watershed management plan, and

- ✓ Determine a timeframe and mechanism for adaptive management within and beyond the 20 year time frame of the watershed management plan.