Acknowledgement of Contributors

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Executive Summary

The City of Las Vegas, New Mexico Forest Management and Maintenance Plan (FMMP) has been written by SEC, Inc. to define the direction of forest management on City-owned lands within the Gallinas Creek Watershed (hereafter referred to as "Watershed"). The plan is written for a 10-year time period and is focussed on five City-defined goals, which include:

- Protection of all water resources through fuels reduction work aimed at minimizing the risk of a catastrophic fire.
- Maintaining or improving forest health.
- Maintaining or improving habitat for a select number of avian species.
- Minimizing soil erosion and sedimentation.
- Maintaining forest aesthetics while implementing management.

The Watershed is managed by the City of Las Vegas Water Department, and is part of the upper Gallinas Watershed, which encompasses approximately 84 square miles and drains from the east side of the Sangre de Cristo Mountains. Water resources within the Watershed include Gallinas Creek and two water storage sites – Peterson and Bradner Reservoirs. The long-term health and integrity of the Watershed's resources, and especially Gallinas Creek and the reservoirs, is critical to the approximately 17,000 residents of Las Vegas because the creek and reservoirs are the community's primary source of domestic water.

Central to the development of the FMMP is an evaluation of current resource conditions. A timber inventory is an important part of this evaluation and identifies approximately 991 acres, with 874 acres classified as forest, and 117 acres classified as either open water, riparian, or grassland habitat. Ponderosa pine (*Pinus ponderosa*) is the dominant cover type on reservoir sites and south slopes. In general, these stands are 80 to 90-years old and even-aged. Insects and disease are light to moderate, and stocking is moderate with many small sawtimber-sized trees. The total estimated net volume in these stands is 151,926 cubic feet of pulpwood, and 2,650,951 board feet of sawtimber.

Mixed conifer species dominate steep, north slopes. These stands are variable in age and comprised of both even-aged and uneven-aged stands. Stands are moderately-to-heavily insect and disease infested, and heavily stocked with both pole and sawtimber-sized trees. These stands are recommended for management deferment because of operating constraints associated with the steep slopes. However, if future funding allows, these stands could be treated with a cable or helicopter logging system.

In addition to the timber inventory, portions of Gallinas Creek were observed to qualitatively assess the physical condition of the creek. These observations showed the creek to be in a healthy, functioning condition.

Forest management treatment priorities based on management goals are established to provide efficient plan implementation. These priorities are identified at the stand level and incorporate thinning (cutting or "felling" of trees) prescriptions and recommended thinning methods.

The highest priority stands include those surrounding the reservoirs, followed by those upstream of the City's water intake in Gallinas Creek, and finally those downstream of the intake. This prioritization system is based on potential impacts to water resources in the event of a fire.

The thinning prescription is to selectively "thin from-below," where a majority of the smaller trees should be thinned and the larger trees left standing. Hand crews are recommended to fell all trees and where feasible, a forwarder is recommended to move logs from the woods to a landing/loading site, where it can then be hauled off-site. Pile burning of excessive slash is also recommended.

In addition to thinning, specific recommendations are also provided for noxious weeds, insects and disease, wildlife, soils, water, roads, and aesthetics. Environmental protection is considered with all treatment recommendations through the incorporation of New Mexico State Forestry's "Best Management Practices" guidelines, which are designed to minimize soil erosion and protect water quality.

An economic analysis of the project is included to provide an estimate of the potential costs and revenues associated with implementation of the project recommendations. This analysis shows that the treatment costs should be approximately 444,323 dollars.

Lastly, a maintenance and monitoring plan is recommended to maintain Watershed health and integrity, and to determine if treatments were effective in moving toward desired conditions.

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Chapter 1: Introduction

PURPOSE STATEMENT

The City of Las Vegas, New Mexico Forest Management and Maintenance Plan (FMMP) defines the direction and guidelines necessary for implementation and maintenance of forest management on City-owned lands within the Gallinas Creek Watershed (hereafter referred to as "Watershed").

The plan is written for a 10-year time period and adopts an integrated approach to management focussed on reducing the risk of a high-severity crown fire and improving or maintaining the overall health and productivity of both forest and water resources.

FORMAT OF PLAN

Following the Introduction, *Chapter 2, Resource Description,* provides a description of current resources on the Watershed. Sections on timber, noxious weeds, insects and disease, wildlife, soils, and water and roads are included. These sections define baseline resource conditions that drive management. *Chapter 3, Management Practices,* defines a variety of management practices appropriate to the Watershed. These are included to educate and provide an informed basis for decision-making with respect to management goals. *Chapter 4, Management Recommendations,* includes the management recommendations for the Watershed, and includes treatment priorities based on management goals. Treatment costs are also covered. *Chapter 5, Maintenance and Monitoring Plan,* provides some recommendations for control and maintenance of oak populations, along with some restoration techniques for Gallinas Creek. Treatment evaluation through the monitoring and tracking of goal achievement is also included.

WATERSHED DESCRIPTION

The Watershed is managed by the City of Las Vegas Water Department, and is located in northwest San Miguel County, New Mexico, northwest of the community of Las Vegas (figure 1). The majority of the Watershed is surrounded by private land contained within the Las Vegas Land Grant. In addition, a small piece of land on the northern boundary is leased to the City by the Public Service Company of New Mexico.

The Watershed contains approximately 991 acres with 874 acres classified as forest and 117 acres classified as either open water, riparian or grassland habitat. These lands are all contiguous with the exception of one 30-acre tract located approximately 1.5 miles to the northwest of the primary holdings (this tract is not included on any figure maps).

In general, topography is characterized as moderately steep to steep, with approximately 56 percent of the forested acres classified as operable ground based on slopes of less than 45 percent. Elevations range from 6,780 feet in the central and southeast portions of the Watershed, to 7,760 feet on an upland site near the south-central boundary (figure 2).

Figure 1: LV Regional Location Map

Figure 2: LV Watershed Topo Map

The dominant forest cover type consists of relatively pure stands of ponderosa pine (*Pinus ponderosa*). Pinyon-juniper (*Pinus edulis-Juniperus scopulorum*), Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) are also found as associates. These stands are found on the eastern portions of the Watershed and on south-facing canyon sites in central and western portions of the Watershed. Most of these stands occur on slopes of less than 45 percent and are recommended for management.

Mixed stands dominated by Douglas-fir and white fir occur on north-facing canyon sites in central and western portions of the Watershed. Limber pine (*Pinus flexilis*) and ponderosa pine are also found as minor associates. These stands occur on steep slopes exceeding 45 percent and are currently recommended for management deferment because of operating constraints associated with the steep slopes. However, if future funding allows, these stands could be treated with a cable or helicopter logging system.

Gallinas Creek, a perennial tributary of the Pecos River, flows into and through the western half of the Watershed. Riparian sites adjacent to the creek are dominated by narrowleaf cottonwood (*Populus angustifolia*), alder (*Alnus* spp.), and various willow (*Salix* spp.) species.

The health and integrity of Gallinas Creek is critical to the approximately 17,000 residents of Las Vegas, as it is the community's primary source of domestic water. The creek also provides Storrie Lake State Park with approximately 90 percent of its water, which provides recreational opportunities to a variety of users and irrigates over 6,540 acres (Herrero and Sokoll 1994).

Two reservoirs - Peterson and Bradner Reservoirs - and the City's water treatment facility are located near the eastern boundary of the Watershed. These reservoirs are the City's primary water storage sites and have a combined approximate holding capacity of 632 acre-feet of water. The water coming into these reservoirs is appropriated from Gallinas Creek via an intake that diverts water to a settling basin, whereupon it is then gravity fed through a pipeline into the reservoirs.

In an effort to help prevent resource degradation, the Watershed has been fenced and public access prohibited. Livestock grazing is also prohibited, although trespass livestock occasionally access the land.

MANAGEMENT GOALS

The desired future condition for the Watershed is a healthy forest environment which provides maximum protection to the water resources. Embodied in the desired future condition are five management goals.

- Protect all water resources through the implementation of fuels reduction work aimed at minimizing the risk of a catastrophic fire.
- Maintain or improve forest health.
- Maintain or improve habitat for a select number of avian species.

- Minimize soil erosion and sedimentation from roads and treated areas.
- Maintain forest aesthetics while implementing management practices.

Protection of the Watershed's water resources, and thus the municipal water supply, is the primary management goal. This is best accomplished through fuels reduction work aimed at reducing the potential for catastrophic fire. Fire is a real concern due to steep topography and moderate-to-high forest stand densities. A catastrophic fire within the Watershed, or one on adjacent or upstream private or national forest lands, could severely compromise both water quality and quantity as a function of increased ash and sediment loading into Gallinas Creek. Indeed, the Viveash Fire of 2000 was a very real reminder as to just how vulnerable the Gallinas Creek Watershed is to fire. Although only 1.5 percent of the watershed burned, the level of ash contamination into Gallinas Creek prevented the City from diverting 112 million gallons of water to their storage reservoirs (personal communication, R. Tafoya, City of Las Vegas Water Department, 2001).

The water resources protection goal is highly compatible with the forest health goal. Properly implemented fuels reduction work will improve forest health through the removal of overstocked trees, insect and disease infested trees, and cull trees. This will reduce competition and lead to an increase in residual tree growth and quality. Treatments are also designed to improve or maintain wildlife habitat for a variety of avian species.

Fuel reduction treatments include site-specific prescriptions focussed on commercial and precommercial thinnings, and slash disposal treatments. Treatments are based on City-defined priorities, potential impacts to the Watershed in the event of a fire, access, and slope. All prescriptions incorporate New Mexico State Forestry's "Best Management Practices" guidelines (Water Quality Protection Guidelines For Forestry Operations in New Mexico 1994), which are designed to protect water quality and minimize soil erosion. Guidelines to minimize the visual impacts associated with management treatments are also recommended.

A technical committee of natural resource managers and educators has reviewed the plan and submitted formal questions and comments regarding content. The committee's questions and comments, as well as SEC's responses, are found in Appendix E.

Chapter 2: Resource Description

TIMBER

Relatively pure stands of ponderosa pine occur on sites surrounding the reservoirs, and on south-facing slopes within the canyon. Pinyon-juniper, Douglas-fir, and white fir are also found as minor associates of this stand type, with the pinyon-juniper concentrated primarily on dry, east aspects around the reservoirs, and the Douglas-fir and white fir occurring on various mesic, cooler microsites. These stands are primarily 80 to 90-years old, even-aged, lightly-to-moderately insect and disease infested, and moderately stocked with small sawtimber-sized trees.

Mixed stands dominated by Douglas-fir and white fir occur on the north-facing slopes within the canyon. Limber pine and ponderosa pine also occur as minor associates, but are confined primarily to rocky, exposed ridges and dry, warm sites. These stands are both even-aged and uneven-aged, moderately-to-heavily insect and disease infested, and heavily stocked with both pole and sawtimber-sized trees.

Common grass species in the ponderosa pine type include Arizona fescue (*Festuca arizonica*), mountain muhly (*Muhlenbergia montana*), pine dropseed (*Bleparoneuron tricholepsis*), and squirrel tail (*Sitanion hystrix*). Common shrub species include Gambel oak (*Quercus gambelii*), wavyleaf oak (*Quercus undulata*), mountain mahogany (*Cercocarpus* spp.), and skunkbush (*Rhus trilobata*). The oak species provide mast (acorns) and browse and are utilized by a variety of species, and the mountain mahogany is a highly preferred big-game browse species.

Common grass species in the mixed conifer type include Arizona fescue, mountain muhly, pine dropseed, brome (*Bromus* spp.), and sedge (*Carex* spp.). Common shrub species include kinnickinnick (*Arctostaphylos uva-ursi*), snowberry (*Symphoricarpos* spp.), and common juniper (*Juniperus communis*). A small number of pure Gambel oak stands also occur on rocky or previously disturbed sites. Oregon-grape (*Berberis* spp.) and currant (*Ribes* spp.) are also present.

With the exception of some oak stands, none of the understories are particularly abundant or diverse. This is a function of many stands having moderate-to-high stand densities and canopy closures, and/or heavy forest floor duff layers. These characteristics are inversely related to understory production as a function of the trees outcompeting the understory species for water, nutrients, and sunlight, and the duff inhibiting seedling establishment. Pinyon-juniper, where present, also produces volatile chemical compounds which are released into the soil inhibiting the growth of many other species.

Inventory Procedures

Prefield

Proper design of the forest inventory required some prefield office work. The first step of this work was to transfer the property's boundaries onto aerial photos. Forested stands were then delineated onto the photos based on species or species group, predominant tree size class, average canopy cover, and percent slope. Table 1 shows the stand delineation criteria and the vegetation type identifiers used in this process. For example, a P8 stand designation would identify a well-stocked (40-70% canopy cover) ponderosa pine sawtimber stand.

Table 1. Stand Delineation Criteria.

Dominant Cover Type	**Size Class**	**Canopy Cover (%)**
Open **O – Oak** P - Ponderosa Pine **DF - Douglas-fir** MC - Mixed Conifer	Seedling & Saplings (0.1" – 4.9" diameter)	1 - 10-39 2 - 40-70 3 - > 70
	Pulpwood (5" plus diameter for p-j, 5 – 9.9" diameter for all other species)	4 - 10-39 5 - 40-70 6 - > 70
	Sawtimber (10" diameter and larger, no p-j)	7 - 10-39 8 - 40-70 9 - > 70

A Geographic Information Systems (GIS) mapping program (Arcview 3.2) was utilized to transfer stand delineations from the aerial photography to a georeferenced base map to produce a stand type map (figure 3). This process assigned a number and acreage to every stand and identified a total forested area of 874 acres and a total non-forested area of 117 acres.

Field

An inventory of forest resources was initiated and completed in the summer of 2001 based on the preliminary stand delineation of cover types. Forested stands on operable ground of less than 45 percent were inventoried using a series of $1/20^{th}$-acre, $1/50^{th}$-acre, $1/100^{th}$-acre, and $1/300^{th}$-acre fixed-radius plots. At each sample point, data were collected on species, density, size, defect, and health of trees 1 inch in diameter or greater. The age and last 10 years of diameter growth were also measured on a sub-sample of inventoried species.

Additional information was recorded at all sample points to aid management planning and implementation. Noxious weeds were recorded where observed. Percent ground cover of understory species was estimated. Stand-level fuel models were identified for every stand on a scale of 1 to 13 (Anderson 1982). Structural stage, any of several developmental stages of stands described in terms of age and canopy closure, were noted and recorded (Hoover and Wills 1984).

Figure 3: LV Stand Type Map

Game sightings, game trails, springs and other important terrain features for wildlife were recorded. Soil features were recorded to identify erosion and/or some site factor that might constrain management. Slope features were recorded to determine the extent of the forest resource available for conventional management, and to establish a basis for allowable cut sustained yield estimates. Finally, riparian areas were qualitatively evaluated to determine the general health and function of these sites.

Walk-through inventories were conducted on steep slopes exceeding 45 percent, and for all openings. Openings were defined as a cover type with less than 10 percent canopy cover in trees greater than 12 feet in height. The walk-through inventories collected qualitative data on species composition, stand health, and all of the information discussed in the preceding paragraph.

Prefield stand delineation criteria were field-checked and corrected if necessary. Upon completion of the inventory, data were entered into Omnitali 8.4, a comprehensive timber inventory program used to estimate pulpwood cubic foot volume and sawtimber board foot volume. Pulpwood volume for pinyon-juniper was defined as trees 5 inches diameter root collar (drc) and greater. However, because of processing limitations in Omnitali, pinyon-juniper 5 to 9.9 inches drc were processed in cubic feet as pulpwood, and pinyon-juniper 10 inches plus drc were processed as sawtimber, also in cubic feet. The two volumes combined are presented as pinyon-juniper pulpwood, and are reported in cubic feet. Pulpwood volume for all species except pinyon-juniper were defined as trees 5 to 9.9 inches diameter breast height (dbh), and are also reported in cubic feet. Sawtimber volumes for all species except pinyon-juniper were defined as 10 inches plus dbh, and are reported in board feet. Volume equations (Hann and Bare 1978) for the Carson National Forest were used in the inventory program to calculate volumes.

Stand Data

Table 2 is a listing of all stands (including non-forested areas) by stand number, stand type (dominant overstory/understory species), stand age (overstory/understory age at dbh), acres, aerial photo location, structural stage, fuel model, and remarks. Stand numbers in the table correspond with the stand numbers on the stand type map.

Table 2. Stand Data.

Stand Number	**Stand Type**	***Stand Age**	**Acres**	**Aerial Photo** Location	**Structural Stage**	**Fuel Model**	****Remarks**
1	P7/DF5	80/35	13	3498-014	4A	2	poor access
2	P6	80	18	3498-014	3C	9	-
2A	P6	-	13	3498-014	3C	9	>45% slope
2B	P6	80	10	3498-014	3C	9	-
3	DF6	-	14	3498-014	3C	9	>45% slope
3A	P7/DF5	80/35	12	3498-014	4B	8	poor access
4	P8/P5	80/35	42	3498-014	4B	2	-
5	MC7/MC4	-	37	3498-014	4A	8	>45% slope

Table 2. Stand Data (continued).

Stand Number	**Stand Type**	***Stand Age**	**Acres**	**Aerial Photo** Location	**Structural Stage**	**Fuel Model**	****Remarks**
6	P7/P4	-	15	3498-014	4A	2	>45% slope
7	P8	80	20	3498-014	4B	9	poor access
8	P6	-	8	3498-014	3C	9	>45% slope
9	P7/P5	120/35	19	3498-014	3B	9	some overmature
10	P8/DF4	100/50	8	3498-014	4B	9	poor access
11	O3	-	5	3498-014	2	6	>45% slope
12	O3	-	3	3498-014	2	6	>45% slope
13	MC8/MC5	-	20	3498-014	4B	10	>45% slope; MT
14	MC8/MC5	-	22	3498-014	4B	10	>45% slope; MT
15	MC8/MC4	-	31	3498-014	4B	10	>45% slope; MT
16	DF8	-	10	3498-014	4B	9	>45% slope; MT
17	O3	-	5	3498-014	2	6	>45% slope
18	P7/MC4	-	26	3498-014	4A	7	poor access
19	O3	-	4	3498-014	2	6	>45% slope
20	MC7	-	12	3498-014	4A	8	>45% slope; MT
21	P7	80	41	3498-014	4A	2	MT pockets
23	Open	-	57	3498-014	1	3	riparian
24	P7/P4	90/30	10	3498-014	4A	2	-
25	P6	80	9	3498-014	3C	9	old church
26	MC8	-	122	3498-014	4B	10	>45% slope
27	MC7	-	8	3498-107	4A	6	>45% slope
28	MC7	-	8	3498-107	3B	7	>45% slope; burn
29	MC8	-	28	3498-107	4B	8	>45% slope
30	P8	110	5	3498-107	4B	9	pipeline corridor
31	P8	90	23	3498-107	4B	9	-
32	P7/PJ7	90	5	3498-107	4A	7	heavy bear sign
33	P8	110	10	3498-107	4B	9	-
34	Reservoir	-	12	3498-107	-	-	-
35	P5/P1	110/20	7	3498-107	3B	9	noxious weeds
36	P7	110/30	38	3498-107	4A	7	heavy bear sign
37	P5	-	19	3498-107	3B	9	>45% slope; MT
37A	P5	110	29	3498-107	3B	9	MT
38	P6/PJ1	50/15	25	3498-107	3C	9	high stocking
39	P5/PJ1	80/15	8	3498-107	3B	9	-
40	P7/P1	-	7	3498-107	2	6	>45% slope; MT
41	P7/P2	110/40	15	3498-107	3B	9	rocky
42	Reservoir	-	12	3498-107	-	-	-
43	P4/PJ1	65/30	59	3498-107	3A	6	heavy oak
45	P5	80	13	3498-107	3B	9	rocky
46	P5		18	3498-107	3B	9	rocky; steep
47	Open	-	6	3498-107	1	2	H2O Tx Facility
48	Open	-	30	3498-107	1	2	noxious weeds

*Stand age not recorded for stands occurring on slopes greater than 45 percent

**** MT equals dwarf mistletoe**

Table 3 shows the distribution of stands by cover type, acres, size class, canopy cover, and percent slope.

Table 3. Acreages by Cover Type, Size Class, Canopy Cover, and Percent Slope.

Size Class	Canopy Cover (%)	Cover Type							
		Ponderosa pine		Mixed conifer/ Doug-fir		Reservoir		Open/Oak	
		<45%	>45%	<45%	>45%	<45%	>45%	<45%	>45%
Seedling and Sapling	1 - 10-39	-	-	-	-	24	-	93 open	-
	2 - 40-70	-	-	-	-	-	-	-	-
	3 - >70	-	-	-	-	-	-	-	17 oak
Pole Timber	4 - 10-39	59	-	-	-	-	-	-	-
	5 - 40-70	75	19	-	-	-	-	-	-
	6 - >70	62	21	-	14	-	-	-	-
Saw Timber	7 - 10-39	179	22	-	65	-	-	-	-
	8 - 40-70	108	-	-	233	-	-	-	-
	9 - >70	-	-	-	-	-	-	-	-
Total Acres		**483**	**62**	**0**	**312**	**24**	**0**	**93**	**17**

Inventory Summary

Stand Structure and Distribution

Omnitali calculated mean tree size and basal area per acre (cross sectional diameter of trees in square feet per acre) for all inventoried species. The mean height for pulpwood is 32.9 feet with an average diameter of 6.9 inches, and the mean height for sawtimber is 49.0 feet with an average dbh of 12.7 inches. The average basal area for pulpwood is 34 square feet per acre, and for sawtimber 75 square feet per acre, for a total basal area value of 109 square feet per acre. In general, regeneration is adequate, with approximately 285 ponderosa pine seedlings/saplings per acre.

Volume

Inventory data show that the property is moderately stocked with pulpwood and commercial sawtimber. The majority of pulpwood volume is concentrated in the ponderosa pine, with significantly lesser volume in the Douglas-fir, juniper, and pinyon pine, respectively. Sawtimber volume is also concentrated in the ponderosa pine, with significantly lesser volume in the Douglas-fir, pinyon pine, and juniper, respectively. Estimated net volumes on inventoried ground of less than 45 percent are **151,926** cubic feet of pulpwood, and **2,650,951** board feet of sawtimber.

A further breakdown of the Watershed-wide timber data can be found in the Omnitali Inventory Outputs in Appendix A.

Allowable Cut

Allowable cut is a sustained yield concept that dictates the amount of timber harvested should not exceed the amount grown. Ten-year allowable cut estimates have been calculated using the methodology described by Fletcher et al. (1989), which uses radial increment data and current net volume to project growth.

The 10-year allowable cut for ponderosa pine and mixed conifer species (pinyon-juniper excluded) on operable ground of less than 45 percent is approximately **59,264** cubic feet of pulpwood, and **458,615** board feet of sawtimber.

The allowable cut calculations make the assumption that the last 10-years growth is representative of the total growth rate, and that future 10-year growth will equal past 10-year growth. However, growth rates should increase, at least in the short term, if management recommendations are implemented in overstocked stands exhibiting high levels of competition. This is because growth rates of most species are negatively impacted by density-related competition. Growth of ponderosa pine, for example, is strongly reduced by overstocking. However, this species remains physiologically young and responds well to thinning up to an age of at least 200 years (Schubert 1974).

The allowable cut estimates were calculated as a general guideline to define harvest levels that should maintain current stand volumes. However, in order to reduce fire hazard as quickly as possible, implementation of management recommendations will require exceeding the allowable cut in the short term. In this case, a post-treatment inventory should be completed to enable the calculation of a new sustainable allowable cut.

Fuel Models

Fuels, weather, and topography combine to determine how hot and fast a fire burns. Fuel conditions are defined by quantity and arrangement and have been categorized into 13 descriptive fuel models (Anderson 1982). The models represent the surface (dead) fuels in which a fire is most likely to burn, and the corresponding fire severity associated with the fuels during the most severe period of the fire season.

The fuel models are classified into four groups, these are grass (models 1, 2, and 3), shrubs (models 4, 5, 6, and 7), timber (models 8, 9, and 10), and logging slash (models 11, 12, and 13). The dominant fuel models on recommended treatment sites include models 2 and 9. Fuel model 2 is a “grass-dominated” fuel which supports surface fires in fine herbaceous material and litter. Fuel model 9 is a “timber litter” model which supports surface fires in needles and small-diameter woody material.

Fires burn differently in the different fuel models under the same weather conditions. The Forest Service uses the 13 fuel models as one of their inputs in the BEHAVE

computer model to estimate flame height and rate of spread for a wildfire. During average worse (not extreme) fire conditions when dead fuel moisture averages 8 percent, live fuel moisture is 100 percent, and the effective wind speed is 5 miles per hour, a fire in model 9 has a predicted flame length of 2 to 3 feet, and will spread at a rate of approximately 495 feet/hour (USDA Forest Service 2001).

A fire hazard map based on each stand's fuel model can be found in figure 4.

Canopy Cover

Canopy cover was one of the prefield stand delineation attributes, and was field checked and corrected when necessary during the inventory. This was done in part because canopy cover is an important factor affecting crown fire spread and intensity. At over approximately 40 percent canopy cover, tree crowns are generally close enough together to allow fire to rapidly "jump" from tree to tree as a "running crown fire."

Canopy cover values on forested acres within the Watershed are 10 to 39 percent on 325 acres, 40 to 70 percent on 435 acres, and greater than 70 percent on 114 acres. This indicates that the probability of a crown fire on at least 549 forested acres, or approximately 63 percent of the Watershed's forests, is quite high.

NOXIOUS WEEDS

A noxious weed is a non-native plant that generally interferes with the management objectives of a site (Lee 1999). Noxious weeds compromise landscape integrity by outcompeting and displacing native vegetation. They can also increase soil erosion, reduce biodiversity, limit opportunities for recreation, and decrease land values. Once established on a site, lost production and control costs can be significant.

One noxious weed species was observed during the inventory – field bindweed (*Convolvulus arvensis*). This species is present in portions of stands 35 and 48. A noxious weed control strategy in which the bindweed is eradicated and grass species are planted is recommended, both as a soil conservation measure and a flood control measure.

Noxious weed control recommendations will be further discussed in Chapter 4 – Management Recommendations.

Figure 4: LV Fire Hazard Map

INSECTS AND DISEASE

Insect and disease levels are currently light to moderate; however, where present they conflict with the goal of forest health. As such, stand management prescriptions that include harvesting of insect and disease infested trees will help to "clean up" the forest. Harvesting recommendations will also take advantage of two ecological generalizations.

- Diversity enhances stability – A diverse forest does not provide a uniform food or habitat source sufficient to support a catastrophic outbreak. Diversity in this sense means age, size, and species variability amongst trees.
- Vigorous trees have lower susceptibility – Vigorous trees can move through susceptible stages of development quickly, and they have greater surplus energy to expend on defensive strategies. Vigorous trees are generally free from insects, disease, and competition.

Three damaging insects and four damaging diseases were identified during the inventory. Insects include the spruce budworm (*Choristoneura occidentalis*), bark beetles (*Dendroctonus* spp. and *Ips* spp.)), and pinyon needle scale (*Matsucoccus acalyptus*). Disease pathogens include broom rusts (*Chrysomyxa arctostaphyli* and *Melampsorella caryophyllacearum*), various wood-rot fungi, true mistletoe (*Phoradendron* spp.), and dwarf mistletoe (*Arceuthobium* spp.). Table 4 lists the various insects and disease by tree species infected.

Table 4. Insects and Disease by Tree Species Infected.

Tree Species	**Insect**			**Disease**			
	Pinyon needle scale	Bark beetles	Spruce budworm	True mistletoe	Dwarf mistletoe	Wood-rot fungi	Broom rusts
Pinyon Pine	x	x			x		
Juniper				x			
Ponderosa Pine		x			x		
Douglas-Fir		x	x		x	x	
White Fir			x			x	x

The following is some basic biology relating to these pests.

Pinyon Needle Scale

Pinyon needle scales are small, black bumps on the surface of one-year old pinyon needles. The tiny insects feed on the sap of one-year old needles, effectively killing them. Needle scale infested pinyon can be recognized by an abundance of brown, dead

needles, and heavy infestations often kill small trees and predispose larger trees to attack by other insects, especially bark beetles, which can kill trees.

Several insecticides are registered for use as a control agent for pinyon needle scale. With any insecticide, read the directions on the label and take precautions to properly apply the chemical.

Bark Beetles

Bark beetles are native to the forests of western North America and are considered by many to be the most important insect pest of New Mexico's forests. Bark beetles are present in the pinyon pine, ponderosa pine, and Douglas-fir.

Bark beetles attack recently downed material, freshly cut slash, and live trees. During early stages of an outbreak, attacks are generally limited to trees under stress from injury, poor site conditions, fire damage, overcrowding, root disease or old age. However, as beetle populations increase, attacks may involve most large trees in an outbreak area. Attacks often kill a tree outright.

Attacks are generally initiated in early-to-mid summer by adult males (*Ips* spp.) or females (*Dendroctonus* spp.) who attempt to bore into the cambium (inner bark) of a tree. The first evidence of a successful attack includes a reddish boring dust found in bark crevices or at the base of a tree. Globules of resin called pitch tubes may also be present at the bore hole. The resin is the tree's defensive attempt to expel the beetle. If an attack is successful, the beetle will excavate egg galleries and mate, and the female will then lay her eggs in the galleries. Newly hatched larvae will then feed on the phloem tissue (food conducting cell layer within the cambium) and can effectively kill the tree by girdling it. Adults also contribute to the tree's death by introducing a blue-stain fungus into the cambium, which inhibits water conduction.

Bark beetle infestation levels are currently low to moderate, and the risk of an epidemic outbreak should decrease with harvesting aimed at increasing the health and vigor of residual trees.

Western Spruce Budworm

The western spruce budworm is the most widely distributed and destructive forest defoliator in western North America. Low-to-high levels of budworm were noted in both the Douglas-fir and white fir. Budworm larvae defoliate trees by eating newly produced needles. The new needles are the most important in producing food for the tree, so the immediate effect of defoliation is a reduction in growth. As defoliation progresses, both in extent and duration, more significant impacts are likely. The foliage, especially the branch tips, turn brown and die. Twigs, branches, or entire tops of trees may be killed. During long-running outbreaks, which are three to five years or more, about one tree in four will die. Nonfatal defoliation may also lead to infestation by the Douglas-fir beetle (*Dendroctonus pseudotsugae*) or other bark beetles. These in turn can also kill the tree.

Budworms are present from late June to early August. After mating, females lay masses of overlapping green eggs on the undersides of needles. The masses consist of 25 to 40 eggs that hatch in about 10 days. The young larvae do not feed but move to crevices under bark scales or lichens where they spin silken shelters called hibernaculae. There they remain dormant throughout the winter. In late April or May, the larvae migrate to the foliage, where they mine old needles or feed on host tree flowers. In a week or two, they enter developing buds, the habit that gives them their name. As the new needles lengthen, the rapidly growing larvae continue to feed. It is during this stage that most of the damage occurs. They web the new foliage loosely together and feed inside, where they are somewhat protected from predators.

Budworms like forest stands that are dense, dominated by host species of all sizes, surrounded by similar forests, and stressed. Silvicultural practices that thin forests, convert them to non-host species, or limit host species to one size help prevent serious damage.

Mistletoes

True mistletoe was observed in the juniper, and dwarf mistletoe was observed in the pinyon pine, ponderosa pine, and Douglas-fir.

Mistletoes are parasitic plants that rob water and nutrients from their host. The disease has several negative impacts including loss of tree vigor and growth, reduced quality and quantity of seed, increased susceptibility to drought stress, and mortality.

Dwarf mistletoe seeds are explosively ejected from berries and can travel 40 to 50 feet from the plant. They are covered with a sticky substance which allows them to adhere to the bole (trunk) or branches of a new host. After making contact, the seed produces a radicle (root-like structure) which taps into the cambium allowing the mistletoe to absorb water and carbohydrates. The mistletoe grows, matures, and is capable of producing seed after three to six years.

The presence of mistletoe can be recognized by small or large green-to-yellow aerial shoots on infected boles or branches. The disease will cause infected branches to curl and swell creating a cluster known as witches' brooms. Witches' brooms are also characteristic of other diseases and therefore not diagnostic in and of themselves.

Heavy mistletoe infections can reduce tree growth by 30-60 percent of that in non-infected trees (Johnson 1982). In addition, the sticky seeds of mistletoe can pass easily from overstory trees to regeneration of the same species. Once a tree is infected, its reduced vigor also makes it susceptible to attack by bark beetles, such as the mountain pine beetle or the Douglas-fir beetle.

Heavy mistletoe infections are difficult to control, nonetheless, management of infected stands is highly recommended. In the most heavily infected stands, a group selection cut is the recommended silvicultural treatment. Natural seeding from uninfected adjacent

stands is then relied upon to regenerate the cut area, or seedlings may be planted.

Wood-Rot Fungi

Hundreds of species of wood-rot fungi naturally occur in Southwestern forests. These fungi enter the trees through frost cracks, wounds, or broken branches. Wood-rotting fungi can account for serious volume losses, and predispose trees to windbreak and windthrow. The best control recommendation for fungal diseases is to maintain healthy, vigorous stands, and to remove infected trees during silvicultural operations.

Broom Rusts

Minimal amounts of broom rust were noted in the white fir. These rusts – a fungal disease – often kill tops, reduce growth, and may occasionally kill a tree. Indicators of broom rusts include dead tops and witches' brooms similar to those of mistletoe.

No chemical or biological controls are available for broom rust. As with the above-mentioned wood-rot fungi, the best control recommendation is to maintain healthy, vigorous stands, and to remove infected trees during silvicultural operations.

WILDLIFE

Avian Emphasis Wildlife Species

City Water Department personnel have identified bird species, in general, as emphasis wildlife management species. Given this latitude, SEC, Inc. has focussed this section of the FMMP on improving habitat for native birds ranked by New Mexico Partners in Flight (2000) as a priority for conservation. These species represent those imperiled because of low population numbers, habitat loss or degradation, and/or some other factor.

The Partners in Flight (PIF) priority species rankings are on a statewide basis according to the habitat type in which the species are associated. Three PIF-defined terrestrial habitat types occur within the Watershed. These include ponderosa pine forest, mixed conifer forest, and middle elevation riparian woodland. This analysis excludes the mixed conifer and riparian habitat types, as these communities are not recommended for any current management.

The PIF priority species that could potentially occur in the Watershed were compiled from the New Mexico Department of Game and Fish Biota Information System database (BISON-M version 7, 2001). The database was queried according to San Miguel County bird species known to occur in the ponderosa pine habitat type. The results of this process identified 15 San Miguel County PIF priority management species. These species are listed in table 5.

Table 5. San Miguel County PIF Priority Bird Species – Ponderosa Pine Habitat Type.

Highest Priority	Priority	High Responsibility
Northern goshawk (*Accipiter gentilis*)	Lewis's woodpecker (*Melanerpes lewis*)	Western wood pewee (*Contopus sordidulus*)
Mexican spotted owl (*Strix occidentalis lucida*)	Williamson's sapsucker (*Sphyrapicus thyroideus nataliae*)	Plumbeous vireo (*Vireo plumbeus*)
Virginia's warbler (*Vermivora virginiae*)	Dusky flycatcher (*Empidonax oberholseri*)	Hepatic tanager (*Piranga flava*)
Grace's warbler (*Dendroica graciae graciae*)	Pygmy nuthatch (*Sitta pygmaea melanotis*),	Dark-eyed junco (*Junco hyemalis*),
	Western bluebird (*Sialia mexicana bairdi*)	Broad-tailed hummingbird (*Selasphorus platycercus platycercus*).

Additional Representative Species: Band-tailed pigeon (*Columba fasciata fasciata*)

An investigation of habitat requirements for each of the PIF-identified bird species was conducted to determine the potential affects of recommended management treatments (BISON-M version 7, 2001, New Mexico Partners in Flight 2000). Habitat information was either not available, or disparate enough that a solid management strategy to benefit the birds could not be identified.

Fortunately, a landscape-scale habitat strategy for all the PIF-identified ponderosa pine bird species has been defined by PIF (New Mexico Partners in Flight 2000). While this definition is not perfectly suited to this analysis, it is helpful. The definition states that the following forest structure is optimal for the identified bird species:

- 25 – 30 percent mature ponderosa pine savanna.
- 30 – 60 percent uneven-aged ponderosa pine and other trees, with an oak understory.
- 15 – 25 percent open meadow.

This definition of optimal habitat concurs with some generally accepted wildlife tenets that say the number of species occurring in a habitat is largely a function of the age and size structure of the forest, and the interspersion of patches that differ in species composition, tree density, and size-class distribution (Hunter 1990).

The interspersion of disturbance-related vegetation, such as oak, contributes significantly to the Watershed's ponderosa pine habitat diversity and heterogeneity. Aside from riparian sites with a narrowleaf cottonwood overstory, oak stands provide the only deciduous forest habitat in the Watershed. Additionally, a study in Arizona by Rosenstock (1998) found that the occurrence of oaks was an important variable affecting

bird distribution in ponderosa pine.
Snags (standing dead trees) and down logs, while not directly mentioned in the PIF habitat definition, provide important habitat for many bird species and other wildlife (Smith 2000). Snags are particularly important for cavity-nesting birds (Newton 1994). Snags also serve to regulate insect populations by benefiting bat and bird species with a feeding preference for insects. Down logs are an important habitat element for small mammals, especially mice, shrews, voles, and weasels (Goodwin and Hungerford 1979). These species in turn serve as part of the prey base for the northern goshawk and the Mexican spotted owl. Snags and down logs were not directly quantified during the field inventory, but in general are quite low in the ponderosa pine.

From the field inventory and research conducted in this analysis, it appears that ponderosa pine bird species richness is currently limited by the homogeneous stand conditions. These conditions include a generally even-aged structure, a moderate density of small trees, a minimum of large trees, a relatively uniform canopy closure, and a minimum of snags and down logs.

The implementation of management recommendations in this plan should move the Watershed's ponderosa pine stands closer to the PIF-recommended habitat. Harvesting will favor large trees and create greater uneven-aged structure. Oak will also increase as a response to some overstory removals, and openings will remain approximately the same or slightly increase as a function of group selection cuts aimed at controlling dwarf mistletoe. Snags will not be cut unless they pose a hazard to worker safety, and down logs will increase as a function of not removing all cut trees.

Threatened and Endangered Wildlife Species

The Bison-M database (version 7, 2001) was queried to identify Federal and State of New Mexico threatened and endangered (T&E) species known to occur in San Miguel County. A list of these species can be found in table 6.

Table 6. Federal and New Mexico T&E Species Known to Occur in San Miguel County.

Common Name	Scientific Name	Status
Brown pelican	*Pelecanus occidentalis carolinensis*	Federal & State endangered
Southwestern willow flycatcher	*Empidonax traillii extimus*	Federal & State endangered
White-tailed ptarmigan	*Lagopus leucurus altipetens*	State endangered
Arkansas River shiner	*Notropis girardi*	State endangered
Paper-shell mussel	*Utterbackia imbecillis*	State endangered
Mountain plover	*Charadrius montanus*	Federal threatened

Mexican spotted owl	*Strix occidentalis lucida*	Federal threatened

Table 6. Federal and New Mexico T&E Species Known to Occur in San Miguel County (continued).

Common Name	Scientific Name	Status
Bald eagle	*Haliaeetus leucocephalus*	State threatened
Common black hawk	*Buteogallus anthracinus anthracinus*	State threatened
American peregrine falcon	*Falco perigrinus anatum*	State threatened
Boreal owl	*Aegolius funereus*	State threatened
Broad-billed hummingbird	*Cynanthus latirostris*	State threatened
White-eared hummingbird	*Hylocharis leucotis borealis*	State threatened
Gray's vireo	*Vireo vicinior*	State threatened
Baird's sparrow	*Ammodramus bairdii*	State threatened
Suckermouth minnow	*Phenacobius mirabilis*	State threatened
Least shrew	*Cryptotis parva*	State threatened
American marten	*Martes americana*	State threatened
Lake fingernailclam	*Musculium lacustre*	State threatened
Long fingernailclam	*Musculium transversum*	State threatened

According to Bill Hays of the New Mexico Department of Game and Fish, no Federal or State-listed T&E species in table 7 are known to occur in the Watershed (personal communication, 2001). However, potential habitat for the Mexican spotted owl and the southwestern willow flycatcher do occur in or near the project area, and occasional migratory bald eagles have been observed around Bradner and Peterson Reservoirs in the winter (personal communication, R. Tafoya, City of Las Vegas Water Department, 2001).

The Mexican spotted owl nests and roosts primarily in mixed conifer forests dominated by uneven-aged stands, a multi-layered canopy, high stand densities, high canopy closures, numerous snags, and downed woody material (BISON-M, version 7, 2001). The owl is predominantly carnivorous, and forages primarily on small rodents in mixed conifer and ponderosa pine habitats. Suitable mixed conifer owl habitat does occur on north aspects within the canyon, and in higher elevation forests outside the project area.

Implementation of recommended treatments could have a small positive effect on potential spotted owl habitat. This is a function of thinning in the ponderosa pine which will increase prey habitat by leaving some down logs on site, and increase prey species

forage as a response to reduced stand densities.
The southwestern willow flycatcher is a neotropical migratory bird found in riparian habitats where dense groves of willows or other plants are present, often with a scattered overstory of cottonwood (BISON-M, version 7, 2001). These riparian communities provide nesting, foraging, and migratory habitat throughout the breeding range of the flycatcher. This habitat occurs on both City-owned portions of Gallinas Creek and upstream on private and national forest lands in small patches along the narrow riparian corridor of the creek.

Proposed activities should have no effect on potential flycatcher habitat because they would occur outside the riparian vegetation zone. Future planting of native vegetation as a streamside restoration technique (discussed in Chapter 5 – Maintenance and Monitoring Plan) could benefit potential flycatcher habitat.

The bald eagle is primarily water-oriented, and the majority of the populations occurring in New Mexico are found near streams and lakes (BISON-M, version 7, 2001). This species is common within San Miguel County as a winter migrant (BISON-M, version 7, 2001), and has been observed around Bradner and Peterson Reservoirs. No year-round eagles or nest sites are known to occur within the Watershed.

Thinning around Bradner and Peterson Reservoirs should have minimal or no effect on any eagle populations as snags and most large trees used for roosting and perching will be retained unless they represent a hazard to worker safety.

With the exception of the occasional bald eagle, no T&E wildlife species are known to occur within the Watershed. If in the future such a species is found, care should be taken to protect both the species and its habitat.

Threatened, Endangered and Rare Plant Species

The current website of the New Mexico Rare Plant Technical Council (version 15, 2001) lists one Federal and State of New Mexico endangered plant species, and three rare plant species in San Miguel County which are found in habitats similar to those on the Watershed. Rare species are those of management concern because of limited distribution, habitat loss or degradation, and/or some other factor. The endangered species is the Holy Ghost ipomopsis (*Ipomopsis sancti-spiritus*). The rare species are Sapello Canyon larkspur (*Delphinium sapellonis*), spiny aster (*Eurybia horrida*), and Weatherby's spike moss (*Selaginella weatherbiana*).

Holy Ghost ipomopsis is found in only one canyon in the upper Pecos River drainage of the southern Sangre de Cristo Mountains. It grows on relatively dry, steep, west to southwest-facing slopes in open ponderosa pine or mixed conifer forest at 7,730-8,220 feet.

Sapello Canyon larkspur is found in six New Mexico counties in the Jemez, Sandia, and southern Sangre de Cristo mountains. It grows in canyon bottoms and aspen groves at

8,000-11,500 feet.

Spiny aster is known to occur in four New Mexico counties, with many large, healthy populations in the upper Canadian River Basin. The plant has a tremendous ecological amplitude, and grows on sandy shales from the upper montane conifer forest at approximately 10,700 feet down to juniper savanna at approximately 4,100 feet.

Weatherby's spike moss is known to occur in three New Mexico counties on exposed or shaded granitic rock outcrops, ledges, cliffs, or rock crevices from 5,200 to 9,900 feet. The known range of this species is very limited, and additional field work is needed to determine the distribution and abundance of this rare plant.

At this time, no T&E or rare plant species are known to occur within the Watershed. If in the future such a species is found, care should be taken to protect both the species and its habitat.

SOILS

Soils represent the productive potential of forests. Plants receive mechanical support from the soil, essential elements and water. Plants also become the source of nutrients for animals, either directly or indirectly. As such, soil is the foundation for all life. All the soils on the property have the potential for erosion problems if improperly managed. As such, management activities should be designed to minimize the impacts on this important resource. To do this, land managers must know and understand the soil's capabilities and limitations.

The San Miguel County, New Mexico soil survey conducted and prepared by the U.S Department of Agriculture (1981), in cooperation with the New Mexico Agricultural Experiment Station provides the soils information used in this plan. The survey delineates areas of soil which have similar use and management requirements. This level of delineation is sufficient for resource planning, but intensive use of small areas should include further on-site investigation.

There are six soil map units identified on the property, three of which are classified as forest soils and contain most of the forest stands. These soils, in descending order of productivity, include the following:

Forest Soils

Rocio-Dargol-Stout association – 5 to 35 percent slopes

This association occurs primarily on sites around Peterson reservoir and on the south-facing slopes within the canyon. It is classified as 35 percent Rocio stony loam, 25 percent Dargol stony loam, and 20 percent Stout cobbly sandy loam, with the remaining 20 percent comprising a variety of soils. The Rocio soil is on the less steep slopes, the Dargol soil is on the steeper slopes, and the Stout soil is on benches and ridges.

The Rocio soil is deep and well drained. It has a high available water holding capacity, a medium runoff potential, and a moderate water erosion potential. The Dargol soil is moderately deep and well drained. It has a moderate water capacity, a medium runoff potential, and a moderate water erosion potential. The Stout soil is very shallow to shallow and well drained. It also has a very low available water holding capacity, a medium runoff potential, and a moderate water erosion potential.

This association typically supports ponderosa pine with an understory of grass; however, past fire and cutting history have allowed both Gambel oak and wavyleaf oak to occupy many understory sites. This unit has a moderately low productivity, and can produce approximately 7,630 board feet (International rule) of merchantable timber per acre from a fully stocked, even-aged stand 80 years old.

Limitations to management include the shallow nature of the Stout soil. The Rocio, Dargol, and Stout portions of the soil are classified as good, fair, and poor, respectively for woodland wildlife species.

Kiln-Rock outcrop complex – 10 to 35 percent slopes

This complex occurs in portions of stands 18 and 16, which are located on upland sites within the canyon. It is 50 percent Kiln stony loam and 25 percent rock outcrop. The additional 25 percent of the complex is comprised of various soils.

The Kiln soil is shallow and well drained. It has a very low available water holding capacity, a medium runoff potential, and a moderate water erosion potential.

This complex typically supports ponderosa pine with an understory of grass; however, past fire history has allowed both Gambel oak and wavyleaf oak to occupy many understory sites. This unit has a low productivity, and can produce approximately 7,630 board feet (International rule) of merchantable timber per acre from a fully stocked, even-aged stand 80 years old.

Management constraints on this complex include the shallow nature of the soil and the rock outcrops. This complex is rated as fair for woodland wildlife species.

Rock outcrop-Haploborolls complex – 30 to 75 percent slopes

This complex occurs primarily east of Peterson reservoir and on the steep, north-facing slopes within the canyon. It is classified as 50 percent rock outcrop and 40 percent Haploborolls, with the remaining 10 percent comprising a variety of soils.

Soil survey information on this soil complex is very limited. The rock outcrop could be expected to provide unique habitat for a variety of wildlife. The Haploboroll properties are highly variable.

Management constraints on this soil complex include steepness of slope and the rock outcrops. In the absence of additional information, management needs to be conservative, i.e., soil conservation measures need to be carefully considered. This complex is not classified for woodland wildlife habitat.

Grassland Soils

Partri loam – undulating

This soil occurs on a small area primarily around the water treatment plant. It is a deep, well drained soil with a very high water capacity, a medium runoff potential, and a moderate water erosion potential.

Although this soil primarily supports grass, a small number of ponderosa pine have encroached into some areas. Productivity of this soil is moderate, with total grass production in favorable years approximating 1,500 pounds per acre (dry weight).

This is an easily managed soil with no significant constraints. This soil is classified as poor openland wildlife habitat.

Moreno-Brycan association – 3 to 9 percent slopes

This association occurs at the toe of some canyon slopes and adjacent to portions of Gallinas Creek. It is 45 percent Moreno loam and 35 percent Brycan loam. The remaining 20 percent of the association is comprised of various soils.

The Moreno and Brycan soils are both deep and well drained, and have a very high available water holding capacity, a medium runoff potential, and a moderate water erosion potential.

This association typically supports a variety of mountain grasses and riparian vegetation. It has a moderate productivity, with total grass production in favorable years approximating 1,100 to 1,500 pounds per acre (dry weight). Conservation of this soil is important as it serves to moderate runoff from adjacent slopes.

This is an easily managed soil association, with no significant constraints. The Moreno portion of this soil is not classified for woodland wildlife habitat; the Brycan portion of the soil represents good woodland wildlife habitat. Both soil types are classified as fair openland wildlife habitat.

Ustifluvents – flood plain sites

This soil occurs on a small flood plain site to the northwest of the water treatment facility and south of the highway. Periodic flooding from Gallinas Creek historically occurred in the mid-summer monsoon months, but is now prevented by a levee associated with the construction of State Highway 65.

Soil survey information on this soil type is very limited. This soil historically supported grass, but ponderosa pine is currently occupying the site.

In the absence of additional information, management on this soil complex needs to be conservative, i.e., soil conservation measures need to be carefully considered. This soil is not classified for either wetland or woodland wildlife habitat.

The soils data show that, in general, water erosion hazards are moderate for the property. As such, soil erosion conservation measures are recommended with all management activities, and can be found in the "Management Recommendations - Soils" section of Chapter 5.

A soil description map and a slope classification map can be found in figures 5 and 6, respectively.

WATER

Mean annual precipitation, as recorded for the period 1949-1968, averaged 14.5 inches at the Las Vegas Airport (U.S Department of Agriculture 1981), which is just slightly lower in elevation than the Watershed, and as such should be fairly representative. Almost 50 percent of this precipitation fell during the months of July and August during the summer monsoon period. Average annual snowfall is approximately 36 inches in the mountain foothills, but much greater in the high country from which the vast majority of Gallinas Creek's water originates.

Perennial water on the property includes Gallinas Creek, a water treatment settling basin in the canyon, and two water storage reservoirs - Bradner and Peterson Reservoirs - which serve as the primary source of the City's domestic water supply. A large number of intermittent streams also flow into the canyon and provide water to Gallinas Creek during spring runoff and summer monsoon rain events.

In addition to the previously discussed timber resources, portions of Gallinas Creek were walked during the inventory to assess the condition of the creek. These observations, though limited, showed the system to be in a state of equilibrium with respect to streamflow forces and channel aggradation/degradation processes. The stream's channel network also appeared to be adjusting in form and slope to handle runoff events with limited perturbation to the channel and riparian community. Specifically, the following conditions were noted:

- A variety of substrates within the stream, including cobble, gravel, sand, and silt.
- Pools, runs, riffles, and plunges at various points along the stream.
- Stream sinuosity which is synonymous with diversity and responsible for above-noted conditions.
- Generally stable banks.
- A healthy riparian plant community with strong recruitment/reproduction of willow, and to a lesser extent cottonwood.

- A wide floodplain.

Figure 5: LV Soil Description Map

Figure 6: LV Slope Classification Map

Overall, the City-owned portions of the creek appear to be in a healthy, functioning condition. However, certain types of activities and/or events on any portion of the watershed have the potential to compromise the integrity of the creek by modifying flow rates, sediment deposition, and nutrient cycling processes. Examples include resource damaging fire, improper road construction, poor timber harvest practices, noxious weed infestations, and overgrazing.

The forest activities planned over the next 10 years have the potential to negatively impact Gallinas Creek and the reservoirs by increasing sedimentation into the water. As such, activities that minimize and prevent soil disturbance are included in appropriate sections of Chapter 4 – Management Recommendations. These recommendations will be critical in reducing future impacts to water and fish resources and in promoting the preservation of the currently healthy riparian communities.

Further information on water quality can be found in Appendix B: Water Quality for the Gallinas Watershed. This information is from the Gallinas River Watershed Natural Resource Plan (Herrera and Sokoll 1994).

ROADS

Roads are a vital part of forest management. They provide access for watershed management, timber harvest, cultural treatments, and fire suppression. At present, the property has a very limited number of high standard roads. Two roads are present near the north ends of the reservoirs, and a single administrative access road runs through approximately two-thirds of the canyon bottom. State Highway 65 also runs through small sections of stands 2A, 2B, 6, and 8.

All of these roads are well graded and drained, but need to be periodically monitored and maintained. Emphasis should be placed on establishing erosion control structures where needed, and on maintaining the existing roads. Additionally, because roads are expensive to build, and because roads and log transportation have the greatest potential for contributing sediment and material to water resources (Smith et al. 1997), no new roads are recommended. However, two “skid trails” on the west side of each reservoir should be constructed to facilitate the removal of cut material from treated stands. These trails should be permanently closed upon completion of management activities around the reservoirs.

Chapter 3: Management Practices

SILVICULTURAL PRACTICES

Silviculture is the art and science of manipulating forest stands to achieve human objectives, including the production of various goods and services (Kohm and Franklin 1997). Central to the practice of silviculture in the Southwest are three recognized regeneration harvest methods: clearcut and shelterwood methods for use with even-aged management systems, and selection for use with uneven-aged management systems. Clearcutting is not recommended for the property due to high sedimentation potentials and aesthetics. Shelterwood and selection harvests could be utilized, and are briefly discussed below.

Even-Aged Management Systems

Even-aged stands are those where all trees are of the same age or age class. A stand is considered even-aged if the difference in age between the oldest and youngest trees do not exceed 20 percent of the length of rotation, which is defined as the period during which a single crop or generation is allowed to grow (Smith 1986).

Shelterwood

This method involves the gradual removal of the mature stand in a series of partial cuttings near the end of the rotation. Occasionally, but not always, a preparatory cut is required to improve the vigor of prospective seed trees or to open the stand up to encourage decomposition of heavy duff layers. An establishment cut aimed at creating available growing space for regeneration follows. Ideally, this cut is timed to coincide with a year in which the desired species bear abundant seed. After seedlings have become established, one or more overstory removal cuttings are conducted to release the new seedlings from suppression and competition with the overstory trees. This regeneration harvest method provides for a sustained yield of timber and income, and is appropriate in the ponderosa pine and mixed conifer cover types.

Uneven-Aged Management Systems

Uneven-aged stands are defined as those containing trees of at least three well-defined age classes; “well-defined” means differing in total height and age, not just in stem diameter (Smith 1986).

Selection

The selection method removes a portion of a stand’s mature timber as single individuals or in small groups. This method typically provides a continuous large tree stand component and maintains high aesthetic value. It also provides for a sustained yield of timber and income and is appropriate in the ponderosa pine and mixed conifer cover

types.

Selection cuts are the recommended natural regeneration harvest for all treated stands within the Watershed. Individual selection should be the norm, and group selection, whereby all trees in a small group are removed, should be utilized in pockets of heavily infected dwarf mistletoe trees. Group selection patch size should not exceed 2.5 acres.

LOGGING PRACTICES

Logging practices are highly variable as a function of timber types, silvicultural prescriptions, site characteristics, and management goals. However, four basic processes are common to getting any timber out of the woods. These include the felling (cutting) of standing trees, the limbing and bucking of trees, the moving of trees from the woods to a landing (loading site), and the loading and transportation of logs to a mill or processing facility.

Trees can be felled either manually with a chain saw or mechanically with specialized harvesting equipment. Chain saws are commonly used in smaller timber, on heavily stocked sites, and on steep slopes. Shearers and feller-bunchers are commonly used in larger timber and on operable slopes of less than 45 percent. A shearer is a modified tractor with a front-mounted cutter blade actuated by a hydraulic cylinder. The blade acts as a wedge and fells a tree perpendicular to the long axis of the carrier. Feller-bunchers are similar to shearers, but differ in that they grasp and hold a tree vertically during cutting, and then carry and place the tree in a pile. This allows the "bunching" of a sufficient number of trees to build an optimum payload for removal of trees to a landing site.

After felling, trees need to be limbed and bucked. Limbing is the process of cutting the branches from a felled tree. Bucking is the process of cutting a felled and limbed tree into logs of various lengths. Limbing and bucking are typically done in the woods where a tree is felled, or at a landing site.

The moving of trees or logs from the woods to a landing site is generally accomplished with a skidder. Skidding is the process whereby whole trees or bucked logs are dragged along the ground behind a power source, typically a tractor, to the landing. Forwarders can also be used to transport logs, but are not very common in the region. Forwarding is the process whereby bucked logs are moved to a landing by towing or carrying the wood free of the ground.

When trees or logs arrive at a landing they are limbed and bucked, if this step has not already been done in the woods, and then loaded onto a truck for transportation to a mill or processing facility. Loading is typically accomplished with any of a variety of loading machines, including forklift loaders and crane loaders.

The production of a logging operation is often determined by the ability of a contractor to balance the felling, woods transport, and loading operations. From a production

standpoint, each of these elements must be matched to the others to ensure that no portion of the operation experiences excessive down time.

The recommended logging practices for the Watershed include both mechanized and manual operations, and are further discussed in Chapter 4 – Management Recommendations.

CULTURAL PRACTICES

Cultural practices include any treatment designed to improve the health and vigor of individual trees or stands. In the Southwest, four types of cultural treatments are commonly used; these include precommercial and commercial thinning, salvage cutting, reforestation, and prescribed fire.

Precommercial and Commercial Thinning

Precommercial thinning is a type of selective cut typically conducted to control stand density. Species composition and stand health can also be managed if desired or necessary. Thinning benefits include increased growth and yield as a function of reduced competition, increased stand resiliency as a function of improved health, and often a more aesthetically appearing stand.

The term "precommercial" implies that no money is made from a harvest, and unless a market can be found for small diameter products (generally talking about 3-9" dbh trees), most thinning of this type will require an investment.

Commercial thinnings are conducted for the same reasons as precommercial thinnings, but differ in that merchantable trees (typically 9-10 inch plus dbh trees) are cut and sold in hopes of generating a profit.

Thinning, conducted in a responsible way, will complement the Watershed protection and forest health goals, and is recommended as the fuel reduction treatment method for the Watershed. Specific thinning prescriptions and guidelines are presented under appropriate sections in Chapter 4 – Management Recommendations.

Salvage Cutting

Salvage cuttings are conducted to remove dead or dying trees or those at risk of dying from some environmental factor other than competition between trees. Examples of salvage cuts include the removal of insect and disease infested trees (sanitation cutting), and trees that have died from fire or windthrow.

Salvage cuts needs to be conducted in a timely fashion to check the spread of insects and disease, and to remove dead or dying merchantable material before it rots.

Reforestation

When a site is depleted of trees through logging, fire, or some other agent, it is generally desirable to ensure that new trees become established. The establishment of these trees is called reforestation. In New Mexico, there are two basic ways to reforest a site; these include natural seeding and seedling planting.

Natural seeding is incorporated into silvicultural regeneration harvest methods. The idea is to leave an appropriate number of trees after a harvest to provide a natural seed source for a new stand. If the best trees are retained on site, traits that have evolved through time will be passed on to the new stand. This improves the genetic stock of the stand and promotes a healthier forest. The thinning recommendations for the Watershed rely on natural regeneration to restock thinned sites.

Seedling planting is appropriate for sites where natural seeding has been unsuccessful, or for large tracts of land where trees have been lost. Seedlings are available as either bareroot or containerized stock and are planted by hand or machine. Advantages of seedling planting include the opportunity to buy genetically improved stock and the ability to ensure that a new stand is established quickly. The major disadvantages are high cost and unpredictable success because of weather variations and/or browsing pressure.

Site preparation of the ground needs to be considered with all reforestation methods. Heavy equipment, if properly matched to the constraints of the site, will often accomplish site preparation work.

Prescribed Fire

Prescribed fire is not currently recommended for the Watershed because of high tree stocking levels, the potential to lose control of a burn, and the social problems associated with public perceptions to burning. However, the absolute use of fire should not be excluded as a future management tool. This is because research shows that western coniferous forests co-evolved with fire and are dependent upon various fire regimes to maintain optimum health and diversity.

Prescribed fire is a planned burn designed with specific objectives in mind and conducted under a tight set of constraints. Benefits can include improved nutrient cycling processes, increased water yields, and improved wildlife habitat and aesthetics. The benefit of greatest interest in ponderosa pine forests is an increase in soil nitrogen, which is often limiting in forest environments and has a strong influence on productivity. Increased nitrogen availability leads to higher nutrient concentrations in both understory and overstory species, and greater ponderosa pine seedling establishment and growth (Krammes 1990).

A low-intensity broadcast (across the landscape) burn in the ponderosa pine should be considered after the recommended fuel reduction objectives are achieved. A properly conducted burn would improve the overall health and productivity of burned stands, and the risks associated with burning will be greatly reduced at this time as a function of

reduced stand densities.

ENVIRONMENTAL PROTECTION

Best Management Practices

The state of New Mexico has developed a "Best Management Practices" (BMPs) publication entitled *Water Quality Protection Guidelines for Forestry Operations in New Mexico* (1994). The BMP guidelines focus on the protection of water and the overall integrity of the forested landscape. They are common sense practices which most managers and loggers readily comply with. The BMPs include management recommendations for roads, streamside management zones, stream crossings, and timber harvesting.

The application of New Mexico's BMPs is included under appropriate sections in Chapter 4 – Management Recommendations.

Spill Kits

A spill kit is a set of tools designed to contain and clean up petroleum-based leaks and spills associated with the mechanized equipment of a logging operation. A spill kit should contain an assortment of absorbents, as well as repair putty and plugs for small leaks.

Absorbents consist of pads, pillows, socks, and booms that are designed to absorb oils, coolants, solvents, water, and hydraulic fluids. Leaks in steel drums and fuel tanks can be contained with epoxy repair putty. For larger holes, wooden cones can be pounded into the container to provide a tight seal. Shovels for digging up contaminated soil should also be a part of any kit, along with bags for proper disposal of absorbents.

A spill kit is recommended as a part of any hired logger's equipment. One large kit, capable of absorbing over 20 gallons of material, should be maintained at every active landing.

Slash Disposal

Slash can be either beneficial or detrimental to the productivity of a site based on the amount of slash left in the woods, the timber type, and other biotic and abiotic site characteristics.

Some of the advantages of slash include retention and cycling of on-site nutrients, increased soil organic material, soil stabilization, conservation of soil moisture, and a site for the establishment of shade tolerant species. Disadvantages include greater fuel loading in the event of a fire, an impediment to regeneration of shade intolerant species, an impediment to wildlife in their feeding, the potential for a build-up of damaging insects, and aesthetics.

Slash can be treated in a number of ways, which include lopping and scattering in the woods, broadcast burning in the woods, piling and burning, and chipping or grinding. Typically it is left in the woods and lopped and scattered, or piled and burned in the woods or at a landing after curing.

Slash disposal in the form of piling and burning is recommended for the Watershed. This should be done as a hazard fuel reduction measure, and will help to reduce the likelihood of a serious fire. Chipping or grinding of slash material could also be undertaken, but is not recommended due to the additional equipment required (a chipper or grinder), the disturbance associated with this equipment, and the cost.

Specific recommendations for slash disposal are covered under the "Slash Disposal" section of Chapter 4 – Management Recommendations.

ADJACENT LANDS MANAGEMENT

Private Lands

Private lands surround the majority of the Watershed, and management on these lands could have direct positive or negative benefits to the Watershed. With respect to timber harvest on non-municipal or non-federal lands, New Mexico State Forestry has legally mandated regulations. The regulations require a harvest permit for the removal of commercial species on any area(s) totaling 25 acres or more in a calendar year. Harvest permit applications must be completed and submitted to the Las Vegas District of New Mexico State Forestry before the commencement of harvesting. Upon receipt, District personnel review permits and make approval or denial based upon merit and adherence to the law. Provisions within the regulations define, amongst other things, harvest unit sizes, slash treatment practices, erosion control practices, and tree utilization standards. After harvesting commences, State Forestry personnel make formal inspections of harvest activity to ensure compliance with the permit. Non-compliance may bring a written "Notice of Deficient Condition" outlining needed actions and timeframes for remedy of work. A failure to correct deficiencies may bring criminal penalties.

The private lands to the southwest of the Watershed pose the greatest threat to the City's Watershed. This is because the prevailing summer wind is from the southwest, and a fire started in this area could be pushed by winds toward the Watershed. As a result, City personnel, in cooperation with State Forestry, should consider public education outreach activities to encourage timber sale activity or fuels reduction work on private lands within or adjacent to the Watershed, especially on lands to the southwest.

For further information regarding the status of forest management activity on private lands, contact Louie Casaus - Las Vegas District - New Mexico State Forestry - at 505-425-7472.

Santa Fe National Forest Lands

A Santa Fe National Forest action currently being monitored by the City is the proposed Gallinas Municipal Watershed Wildland-Urban Interface Project. While not technically an adjacent landowner, the scale of this project and the potential impacts to City-owned lands warrants comment. The project includes approximately 13,000 acres of fuels reduction work in the watershed upstream of City-owned lands. The project's goal is similar to the City's, and proposes to treat the area by thinning or prescribed fire or both to reduce the risk of catastrophic fire.

The project goals are admirable, as a large fire in any part of the watershed would be disastrous to the City's water supply. However, prescribed fire can escape control measures and threaten the water supply, residential areas, and resources in and around the watershed. Risks are highest in heavily stocked stands and in those occurring on steep slopes, two common conditions on the watershed. Ash and sediment are also issues, as they could easily enter streams and ultimately the City's water intake.

To help minimize the chance of a prescribed fire escaping, the Forest Service proposes to burn in blocks of 200-500 acres. These burns would occur over a period of 5-10 years as funding allows. By conducting small, prescribed burns over a period of time, the amount of ash that could potentially enter watercourses should be reduced. This is because each burn site will be allowed to recover before the next burn commences (personal communication, J. Larson, U.S. Forest Service, 2002).

In conjunction with the fuels reduction work, 4.1 miles of temporary road are proposed for construction (and then closure upon project completion), and 4.3 miles of existing road are proposed for improvement. This is an issue as roads typically produce 90 percent of the erosion associated with forest activities, and some level of sediment recruitment from roads built near streams is almost certain. Additionally, the closure of roads is difficult as public resentment often ensures that at least some closed roads will continue to receive use, and the use of any road will serve as a source of sedimentation and increased fire risk (ignition sources). Despite this, closure of existing roads in the watershed should be encouraged to help reduce sediment loads and fire risk, and improvement and maintenance of all roads should be encouraged to reduce sediment.

The City and the Forest Service are working together as the planning progresses, and the City has developed its own alternative focussed on mechanical thinning and helicopter logging. This alternative has been formally submitted to the Forest Service for consideration.

For further information on the status of this project, contact Julie Larson of the Pecos/Las Vegas Ranger District – Santa Fe National Forest – at 505-757-6121. She can also be reached by e-mail at julielarson@fs.fed.us.

Chapter 4: Management Recommendations

TIMBER

Treatment Priorities

Forest management treatment priorities based on City direction, potential impacts to water resources in the event of a fire, access, and slope have been established to provide efficient plan implementation. These priorities have been identified at the stand level and incorporate site-specific prescriptions together with the information developed from the wildlife analysis. This approach allows the manager to identify the recommended order of stands to treat, and for a given stand, the types of practices needed.

Recommended timber treatments include commercial and precommercial thinnings on approximately 478 acres of the Watershed, along with slash disposal treatments. Two stands are also recommended for noxious weed eradication and native grass seeding, and are discussed in the "Noxious Weeds" section of this chapter.

Stands ranked as a high priority (priority 1 in table 7) for thinning include those surrounding Bradner and Peterson reservoirs. Stands occurring to the east of the reservoirs are the highest priority, as slopes on these sites are steep and run directly into the reservoirs. A fire on these sites could potentially contribute the greatest volume of sediment into the reservoirs, as there are no barriers to impede soil movement.

The remaining reservoir stands should be thinned after the eastern stands. These sites are a lower priority (priority 2 in table 7) than the above-mentioned stands due to a lesser probability of sediment entering the reservoirs. This relates to the topography of these stands, which have less steep slopes, and the fact that old ditches run the length of each reservoirs western boundary. These ditches could effectively trap a significant volume of eroded material.

Despite the ditches, a severe fire in any of the reservoir stands would immediately impair the City's water supply by introducing ash from burning material directly into the reservoirs. Furthermore, post-burn effects would almost certainly include some level of additional ash and sedimentation from accelerated erosion. With all priority 1 and 2 stands, immediate thinning is recommended to help protect the forest and water resources.

Stands ranked as a medium priority for thinning (priority 3 in table 7) include all operable (less than 45 percent slopes) stands in the canyon that occur upstream of the City's water intake and settling basin. A severe fire upstream of the intake would directly impact the City water supply, as this is the lower stretch of Gallinas Creek from which water for the reservoirs is drawn. Thinning in these stands should commence immediately after the priority 1 and 2 areas have been thinned, or if budgets allow in

conjunction with the priority 1 and 2 thinnings.
Stands ranked as a low priority for thinning (priority 4 in table 7) include the remaining south-facing stands downstream of the intake and settling basin. These stands have received the lowest thinning priority because a fire in these stands should have a minimal, if any, impact to the City water supply, as the water in this section of Gallinas Creek is below the City intake. These stands should be treated in the next 5 to 10-years, or sooner if budgets allow.

The lowest priority stands include those where management goals dictate no treatment. All the north-facing mixed conifer stands on slopes greater than 45 percent have been placed in this category because of the high cost associated with harvesting on steep ground. However, if future budgets allow, thinning in these stands should be considered. Treatments would be highly beneficial as the stocking levels and steep slopes present very high fire hazards. A cable logging or helicopter operation could be used.

Table 7. Stand Thinning Priorities.

Stand Number	Priority	Stand Type	Acres	*Remarks
37	1	P5	19	>45%; MT
41	1	P7/P2	15	rocky
46	1	P5	18	rocky; steep
31	2	P8	23	hi fire risk – near highway
32	2	P7/PJ7	5	-
33	2	P8	10	-
35	2	P5/P1	7	noxious weeds
36	2	P7	38	-
37A	2	P5	29	rocky
38	2	P6/PJ1	25	high stocking
39	2	P5/PJ1	8	-
40	2	P7/P1	7	>45%; MT
43	2	P4/PJ1	59	heavy oak
45	2	P5	13	rocky
1	3	P7/DF5	13	poor access
2	3	P6	18	access contingent upon stand 4
2B	3	P6	10	poor access
3A	3	P7/DF5	12	poor access
4	3	P8/P5	42	access needs investigation
7	3	P8	20	poor access
9	3	P7/P5	19	relict overstory
10	3	P8/DF4	8	poor access
21	3	P7	41	MT pockets
24	4	P7/P4	10	-
25	4	P6	9	old church – protect

* MT equals dwarf mistletoe

A thinning priority map highlighting stands ranked as priority 1, 2, 3, and 4 can be found in figure 7.

Figure 7: LV Thinning Priority Map

Thinning Prescription

The thinning prescription is to selectively "thin from-below," where a majority of the smaller trees should be thinned (cut or "felled") and many of the larger trees left standing. The majority of the felled trees should be less than 10 inches in diameter, as these are the tree sizes most common to the property. To the extent possible, and without sacrificing prescription objectives, retain snags and trees over 16 inches in diameter, along with pinyon-juniper and the largest mast-producing oaks for wildlife and aesthetics.

A post-thinning basal area of approximately 40 to 60 square feet per acre is recommended. This will result in pulpwood stands having a residual spacing of approximately 15 feet, and sawtimber stands having a residual spacing of approximately 27 feet (based on a residual basal area of 50 square feet per acre). The spacing recommendation is useful but is only a guideline; when possible, the thinning should aim to create a variable density mosaic that mimics natural fire disturbance patterns in ponderosa pine forests.

The top priority cut trees should include those acting as ladder fuels. Ladder fuels are the small understory trees growing beneath larger trees. These small trees provide for a continuous vertical fuel arrangement that encourages crown fire initiation by carrying surface fire into the crowns of overstory trees.

The second priority cut trees should include those that are infested/infected with insects or disease. Pockets of heavy dwarf mistletoe of 2.5-acres or less should be totally eliminated with a group selection cut, and isolated from non-infected trees by a distance of 50 feet to prevent further spread of this pest. In heavily infected dwarf mistletoe stands greater than 2.5 acres in size, the most heavily infected trees should be removed and a small number of lightly infected trees should be retained.

The lowest priority cut trees should be those exhibiting poor form and/or vigor. Poor form is expressed by forked tops, a crook or sweep in the bole, a non-uniform taper, or some sort of environmental damage. Poor vigor is expressed by a poorly developed dying crown, dead tops, or the presence of insects and disease. Poor form and vigor can be related to a variety of circumstances, including genetics and environmental stresses.

Existing stand structure also needs consideration when designating trees for removal. Stand structure cut-tree/leave-tree considerations vary with every stand, but include such factors as prevailing wind direction (some level of post-harvest windthrow is always a possibility), shading, slope, fuel arrangement and continuity, and potential fireline locations.

A leave-tree mark using paint on all leave trees is recommended to help ensure that the thinning prescription is met, and that the desired outcome is achieved. The value of designating leave trees with paint can not be overstated, as no mark places all cut-tree/leave-tree decisions solely upon the cutter.

After treatment, thinned sites should contain approximately 85 trees per acre in the 5-inch plus diameter classes. Forest structure, on a total acres treated basis, will shift from being dominated by trees less than 10 inches diameter, to one dominated by trees greater than 10 inches in diameter, resembling a more mature forest.

Thinning Methods

The recommended thinning method is to use hand crews to manually fell all trees, and a forwarder to mechanically transport logs from the woods to a landing site. Felled trees should be limbed and bucked in the woods, and slash material lopped and scattered, or piled and burned. In stands that can not be accessed by a forwarder, all trees should be hand-felled in a staggered pattern along the slope of the contour to help reduce erosion, and then limbed and left on-site.

The advantage of this method is that it represents the lowest impact ground-based approach that accounts for removal of material from the woods. The disadvantage is less worker safety as opposed to a more mechanized operation. The time needed to complete treatments will also be greater than with a more mechanized operation, which increases both the cost and the chance of experiencing a severe fire prior to treatment completion.

To facilitate removal of material from around the reservoirs, two low-impact "skid trails" should be constructed from stand 31. Both trails would run in a southerly direction, one along the west side of Peterson Reservoir, and one along the west side of Bradner Reservoir. Each respective trail should continue southward to a point near the southern boundary of the reservoir stands. Stream crossing sites on the intermittent streams flowing into the reservoirs would require culverts, and possibly berms or hay bales to mitigate the possible effects of sedimentation into the streams (final trail design and location will require further on-site investigation). All material removed from the reservoir stands would be transported via this trail system to a landing site near the highway in stand 31, where it could then be hauled off-site.

The immediate advantage of the trail system is a transportation corridor enabling the removal and sale of thinned material. Additional advantages, at least while the trails were open, would be the creation of a fire fuelbreak and better access to the reservoir stands in the event of a fire. Disadvantages include the initial cost to build the trails (which should be offset by the ability to sell material) and periodic trail maintenance.

Upon completion of the reservoir treatments, it is recommended that the Bradner trail be rehabilitated and permanently closed. The Peterson trail could also be closed, but might be left open for the fuelbreak and fire advantages discussed above. A decision to keep this trail open would also allow Water Department personnel to better patrol the southern portions of the reservoir sites.

This is the only new trail system of significance recommended for the Watershed. In stands in the canyon, forwarders can operate on very small skid trails, which should be identified before operations and then rehabilitated and closed upon completion of

treatments. The landing site in the canyon should be somewhere away from Gallinas Creek in stand 23.

Also, the utilization of material in stands 2 and 4 is contingent upon access into stand 4, whose access route lies on private land and will require permission from the landowner before a forwarder can be used in these stands.

A further discussion of roads and skid trails is included in the "Soils" and "Roads" sections of this chapter.

Table 8 shows the recommended stand thinning method, based on utilizing contour felling and a forwarder, for every stand in the Watershed prioritized for treatment.

Table 8. Stand Thinning Method.

Stand Number	Priority	Stand Type	Acres	Remarks
37	1	P5	19	>45%; contour fell; trees left
41	1	P7/P2	15	forwarder; trees removed
46	1	P5	18	forwarder; trees removed
31	2	P8	23	forwarder; trees removed
32	2	P7/PJ7	5	forwarder; trees removed
33	2	P8	10	forwarder; trees removed
35	2	P5/P1	7	forwarder; trees removed
36	2	P7	38	forwarder; trees removed
37A	2	P5	29	forwarder; trees removed
38	2	P6/PJ1	25	forwarder; trees removed
39	2	P5/PJ1	8	forwarder; trees removed
40	2	P7/P1	7	>45%; contour fell; trees left
43	2	P4/PJ1	59	forwarder; trees removed
45	2	P5	13	forwarder; trees removed
1	3	P7/DF5	13	poor access; contour fell; trees left
2	3	P6	18	access/thinning method unknown
2B	3	P6	10	poor access; trees left
3A	3	P7/DF5	12	poor access; trees left
4	3	P8/P5	42	access/thinning method unknown
7	3	P8	20	poor access; trees left
9	3	P7/P5	19	forwarder; trees removed
10	3	P8/DF4	8	poor access; trees left
21	3	P7	41	forwarder; trees removed
24	4	P7/P4	10	forwarder; trees removed
25	4	P6	9	forwarder; trees removed

Slash Disposal Treatments

In stands accessible to a forwarder, all felled trees should be limbed and bucked in the woods, and slash material lopped and scattered to a height of 2 feet or less. In heavily stocked stands where lopping and scattering would result in the surface fuel model

increasing, hand piling of slash for later burning is recommended. Additionally, all slash 50 feet in from the south/southwest boundaries of stands 36, 37A, 43, 45, and 46 should be piled and burned as these stands are at high fire risk because of private lands to the south and the prevailing wind. Slash 50 feet in from the northeast boundary of Stand 25, which is adjacent to State Highway 65, should also be piled and burned as this stand is at high fire risk because of the highway.

The placement of slash piles is critical, and should be in openings to avoid the scorching of leave trees when the piles are burned. Furthermore, building piles on top of old stumps or logs should be avoided so that both the amount of smoke and the chance for "creep" is reduced when the piles are burned.

Piles should be constructed in tepee-shaped formations a minimum of 5-feet high by 5-feet wide, and a maximum of 8-feet high by 8-feet wide. Opening size should dictate pile size, with larger openings accommodating larger piles. Small material should be placed at the bottom of piles and large material, which should not exceed 6 inches diameter, should be placed on the outside of piles, large end up. Piles should be compacted by standing on or pushing material together to compress it.

Pile burning should occur in the winter when snow is on the ground, or during an extended wet weather period. Pile burning needs to be continuously monitored, and as the piles burn down, should be consolidated to help ensure complete and timely consumption. Burned piles should be seeded where necessary. Seeding recommendations are included in the "Soils" section of this chapter.

Prior to any pile burning, a burn permit from the New Mexico Environment Department Air Quality Bureau must be obtained. They can be contacted at 505-827-1494. As a courtesy, also contact local fire departments and the Las Vegas Office of the New Mexico Forestry Division. The Forestry Division number is 505-425-7472.

Utilization

To the maximum extent possible, wood produced from thinning operations should be removed and utilized. A buyer for sawtimber should certainly be sought to help offset project costs. Limited markets also exist for small-diameter logs, which are used for specialized products such as latillas and vigas, posts and poles, and log home timbers. Under the right market conditions, these products can command a higher value than sawlogs. Firewood sales are also big business in the Las Vegas area and some firewood could be marketed and sold. Free-use firewood/pole areas might also be considered to promote the project and help the community. To facilitate removal, firewood should be cut into 2 to 3-foot lengths, and poles into 10-foot lengths.

NOXIOUS WEEDS

As discussed previously, noxious weeds were observed during the inventory in portions of stands 35 and 48. Only field bindweed was noted; however, other noxious weed

species may occur. As such, a noxious weed management program consisting of control and prevention is recommended.

Control includes any method designed to contain, reduce, or eliminate noxious weeds. This means you identify and treat both the environmental conditions that led to the infestation and the infestation itself. Control typically involves the use of one or more of the following methods: cultural, mechanical, biological, and chemical. The following is a brief description of these various methods (Walton 1998):

- Cultural control includes management that favors the growth and maintenance of desirable vegetation. This could include thinning, prescribed fire, planting, etc.
- Mechanical control includes anything that physically disrupts weed growth. This includes hand pulling, mowing, tilling, shredding, and mulching. These methods will succeed only if applied at the proper growth stage. As a rule of thumb, destroy plants before they flower and set seed.
- Biological control includes managed grazing by livestock (cattle, sheep, goats) or use of proven plant pathogens (disease) or insects. Biological control is generally a slow process that requires the application of other control methods to limit weed spread while the plant pathogen or insects are becoming established.
- Chemical control entails the use of herbicides to disrupt plant growth. Herbicides often provide excellent results but need to be carefully chosen for the specific job at hand.

Prevention includes all measures employed to prevent weeds from becoming further established on the property. Specifically, the following preventative measures are recommended (Walton 1998):

- Be on the lookout for new plants in fields, irrigation ditches, and roadsides. Identify all weeds that are not recognized and take action to eradicate those identified as noxious.
- Use only certified weed-free seed, hay, and straw. Be very critical of hay and straw bought for feed or ground cover.
- Practice minimal disturbance of soil in road maintenance, ditch digging, or any type of dirt construction. Sow certified weed-free grass seed on all disturbed areas to retard erosion and provide ground cover. A good ground cover of competitive grasses will help keep weeds out (further discussed in "Soils section of this chapter).

A herbicide control treatment is recommended for the Watershed. Control will likely require continuous treatment for a number of consecutive years as bindweed seed remains viable in the soil for approximately 50 years, and infested areas are probably inundated with seed.

For further assistance with noxious weed control, contact LeRoy Jons at the Las Vegas Field Office of the Natural Resources Conservation Service. His number is 505-425-3594.

INSECTS AND DISEASE

Insect and disease problems are best managed in a preventative way by maintaining healthy, vigorous forests. Forest health has been addressed with the thinning prescription. One additional recommendation is included here.

- Lop and scatter slash material left in the woods to a height of 2 feet or less and try to minimize the diameter of all slash left on-site to prevent bark beetle outbreaks. Small material has minimal habitat value to beetles and it will cure quickly. To the extent possible, try to utilize all material greater than 4 inches in diameter. In addition to helping prevent beetle outbreaks, this will also help to reduce fuel loads.

WILDLIFE

Wildlife recommendations have been incorporated into the thinning prescription as a tool to enhance habitat for emphasis species. Additional recommendations include the following:

- If any Federal or State of New Mexico T&E plant or animal species are discovered during project implementation, stop work in the immediate vicinity of the species and contact SEC, Inc. for a biological evaluation.
- In addition to the tree retention criteria discussed in the thinning prescription, also retain all den, roost, and nest trees.
- When cutting trees over 12 inches in diameter, leave 2-3 stumps per acre at a height of 12 inches above the ground to serve as plucking posts for raptors and feeding and "lookout stations" for small rodents.
- Seed all disturbed ground with a wildlife food mix of grasses and forbs. Use only certified weed-free seed mixes.

SOILS

For most practical purposes, soil is considered a non-renewable resource. Disturbances which cause erosion, compaction, nutrient loss, or some other type of damage often mean the loss of viable land for the future growth of forests or other crops.

Most soils on the property have a moderate potential for erosion as a function of their physical properties and slope steepness. Therefore, protection of this critical resource is of the utmost importance. Recommendations to protect soils include the following:

- Properly design and mark all road and skid trail locations prior to the commencement of operations. Provide for maintenance of roads as needed (road location, design, and maintenance is discussed under the "Roads" section of this chapter).
- Keep heavy equipment associated with thinning off slopes greater than 45 percent. In areas exceeding 45 percent slope, fell trees with hand crews and leave

them on-site, defer treatment of the steep ground entirely, or cable or helicopter log the site.

- Provide drainage features on all disturbed ground to minimize erosion losses. Drainage treatments could include the placement of slash in skid trails, or the building of waterbars.
- Seed all disturbed ground, except for permanent roads, with a certified weed-free seed mix. The recommended seed mix is blue wildrye (*Elymus glaucus*) at 10.4 pounds/acre, perrenial rye (*Lolium perenne*) at 1.3 pounds per/acre, yellow sweetclover (*Melilotus oficinalis*) at 0.7 pounds/acre, and alfalfa (*Medicago sativa*) at 1.0 pound/acre. The first two grasses are for soil stabilization, and the last two are for wildlife, but will also help in stabilization. With thinning and burning operations, broadcast seed immediately after treatments before soils can crust over. With the rehabilitation of skid trails, broadcast seed in the last week of June, the first two weeks of July, or sometime in October or November just before the onset of winter precipitation. Best results are typically achieved by harrowing or raking seed into the soil.
- Refrain from thinning, or shut active thinning down during extremely wet times of the year. This will minimize rutting of areas and help reduce compaction. Chronically wet areas may be logged in the winter when the ground is frozen.
- Use a large-diameter rubber-tired forwarder to minimize compaction.

WATER

Recommendations to protect water quality include the use of streamside management zones (SMZs), appropriate stream crossing methods, and native plantings (discussed in Chapter 5 – Maintenance and Monitoring Plan) adjacent to Gallinas Creek.

A SMZ is a buffer of minimally disturbed or undisturbed vegetation adjacent to a perennial body of water. These zones should extend a minimum distance of 50 feet from all sides of perennial water to naturally filter sediment and maintain shade. Streamside management zones should be greater than 50 feet where there are steep slopes or erodible soils.

Stream crossing methods include culverts, bridges, or fords. The appropriate stream crossing method is a function of stream size, cost of construction and maintenance, amount of use, how the road approach lies with respect to the stream, the soil, and available equipment and materials. Culverts are the most common stream crossing structures and are recommended for the stream crossings associated with the proposed trails around the reservoirs.

ROADS

Roads are the primary source of erosion and sedimentation on a timber harvest operation. As such, emphasis needs to placed on maintaining existing roads, and properly locating and designing the reservoir trail system. Recommendations relating to maintenance, location, and design of roads and trails are presented here, and include the following:

Maintenance

- Avoid using roads during wet periods if excessive rutting and damage to erosion control features is likely.
- Maintain erosion control features with periodic inspections and maintenance.
- Inspect and clean all culverts before and after heavy runoff events.
- Grade primary use roads annually to improve running surface and improve drainage.

Location

- Minimize the number of roads built through comprehensive road planning.
  - Locate roads on stable geology, including well-drained soils and rock formations that tend to dip into the slope.
  - Fit roads to topography by following contours and locating roads on natural benches or ridges. Generally keep road grades at 8 percent or less and avoid long, continuous grades.
  - Locate roads a safe distance from streams; provide adequate SMZs.
  - Avoid wet areas, including moisture-laden or unstable toe slopes, swamps, wet meadows, and natural drainage channels.
  - Designate skid trail locations prior to treatment operations so that the trail density does not exceed 20 percent of the total operation area.
  - Reclaim old roads, or use existing roads except in cases where such use would aggravate an erosion problem.

Design

- Provide adequate drainage from the surface of all roads by using outsloped or crowned roads, insloped roads with ditches and cross drains, or rolling grade dips.
- Place slash and/or waterbars on active skid trails when operations are complete, heavy rains are imminent, or the winter season precludes finishing the operation.
- Consider gravelling mainline roads to improve access, stability, and monitoring of drainage structures during rainy periods.
- Minimize the number of stream crossings and choose stable stream crossing sites.

AESTHETICS

A number of practices are recommended to help reduce the visual impact created from logging; these include the following:

- Retain a professional forester to mark all stands scheduled for treatment. Stand boundaries should be marked, along with all “leave” trees. This will help to ensure that the thinning prescription is met and should leave a more aesthetic residual stand.
- Create thinning boundaries and openings as a repetition of natural shapes to complement and blend into the landscape.

- Apply selection cuts as described in the thinning prescription. This will help to maintain aesthetics because trees will be removed either singly or in small groups and a continuous large tree component will be retained. Selection cutting will also promote uneven-aged stands and leave a more "natural" looking forest.
- Keep stump heights as low as possible, with the exception of the previously discussed wildlife stumps. This will maximize volume from each tree and help aesthetics.
- Utilize pile burning to remove some of the slash from the woods and leave a nicer looking site. This will also reduce fuel loading and encourages greater wildlife use as animals can move through stands freely.
- Hire the best, most conscientious logger available. Check references, conduct pre-harvest meetings, and monitor the progress of active sales as often as possible.

ECONOMICS

An economic analysis of the project is included to provide an estimate of the potential costs and revenues associated with implementation of the project recommendations. A number of assumptions were required in the analysis; these include the following:

- Treatment costs are the only costs estimated. Planning and administrative costs are not included in the analysis as the planning costs have been largely accounted for, and the administrative costs will be a function of who actually oversees the project work. An estimate of administrative costs for SEC to oversee the project is approximately 20 percent of the total cost.
- Treatment costs vary according to the logging method utilized, site conditions, and contractor costs. All treatment costs are based on the recommendations in the FMMP, along with available information gathered from SEC, and the field experience of SEC foresters.
- Timber prices (stumpage) equal log values minus logging costs and profits. Log values are determined by lumber prices minus milling costs and profits. Lumber, like most commodities, is governed by supply and demand. A number of factors influence supply including resource availability, market price, and weather. New housing starts have the greatest impact on lumber demand, and this in turn is influenced by the general health of the economy, which is in a recession. The result is that timber markets are moderately depressed at present, and stumpage values represent the best available information for current market conditions.
- Revenues are based on tree removal volume estimates for those stands that can be accessed by a forwarder. Removal of material from stands 2 and 4, whose access is currently unclear, are also included in the analysis.
- Tree removal volume estimates have been reduced by 15 percent to account for defect and cull material that a contractor is unable to utilize.

The project treatment cost and revenue estimates are summarized in table 9.

Table 9. Project Treatment Cost and Revenue Estimates.

Activity	Acres	Cost/Acre ($)	Total Cost ($)	Total Revenue ($)
Skid Trail Layout	396	5	1,980	-
Marking	478	60	28,680	-
Thinning/Piling	478	600	286,800	90,143
Forwarder	396	142	56,232	-
Pile Burning	478	150	71,700	-
Total Cost/Revenue	**-**	**-**	**445,392**	**90,143**

As table 9 shows, the project cost is approximately 445,392 dollars. If SEC were to manage the project, an estimated administrative cost of approximately 89,000 dollars would be required, for a total project sum of 534,392 dollars. This value minus the expected revenue from forest products gives a total estimated project cost of 444,249 dollars. If the City receives the Federal Emergency Management Agency grant relating to this project, then the total project costs should be covered.

Chapter 5: Maintenance and Monitoring Plan

MAINTENANCE

Oak Control

Most of the ponderosa pine stands contain a significant Gambel oak and wavyleaf oak understory component. Studies and observation have shown that these species can increase and dominate a site following overstory removals by logging or fire. This is a function of decreased competition amongst residual species, the ability of oak to sprout from its root system, and the species tolerance to sunlight. It is estimated that over half the area potentially available for commercial growth of ponderosa pine on the San Juan National Forest of Colorado has been taken over by oak (Harper et al. 1985).

A moderate level of post-harvest oak control will likely be required to prevent a significant increase in this species and to help "fireproof" the Watershed. Three basic techniques exist to control oak; these include fire, mechanical treatment, and herbicidal treatment. Fire is difficult to use due to a lack of trained personnel, the unpredictable nature of burning, and the fact that oak sprouts vigorously after fire. Mechanical treatments are far from perfect as oak quickly sprouts after mechanical dozing. A herbicide represents the last, and best, control option.

There is no easy oak control solution for the Watershed, especially when considered within the social context of the community. This is because any chemical use in the Watershed will be sure to cause public alarm and distrust, and a criticism of the project from some in the community. Nonetheless, if an oak control strategy is necessary, a herbicide is recommended as it can be safely used, and the efficacy of proper herbicidal applications is very high.

Arsenal Applicators Concentrate (AC) is the recommended herbicide for oak control within the Watershed. Imazapyr, the active ingredient in Arsenal AC, is readily absorbed through foliage and roots and translocated throughout targeted species. It controls vegetation by inhibiting amino acid synthesis, and is effective at low application rates, thus putting minimal chemical burden on the environment (personal communication, B. Bailey, BASF Corporation, 2001).

Imazapyr is also highly stable in the soil, exhibiting extremely limited off-site movement via soil leaching or water runoff (Minogue 2001). In arid climates imazapyr breaks down into harmless molecules in approximately one to two years as a function of microbial degradation in the soil (Minoque 2001).

Imazapyr has been thoroughly tested for harmful effects (bioaccumulation, mutagenicity, carcinogenicity) on a variety of vertebrate and invertebrate species, and is practically non-toxic to birds, fish, and aquatic invertebrates, and only slightly toxic to algae and diatoms (personal communication, B. Bailey, BASF Corporation, 2001).

A foliar spray is recommended on small-diameter "scrub" oak. It should be applied with a backpack sprayer in a ratio of 1.5 percent Arsenal AC and 98.5 percent water. On stems greater than 2-inches diameter, a "hack and squirt" application using a hatchet and syringe is recommended. The hatchet is used to make a cut in the stem, and a 1 milliliter solution of 50 percent Arsenal AC and 50 percent water is applied for every 3 inches of stem diameter (personal communication, B. Bailey, BASF Corporation, 2001).

The oak control recommendations are included as a maintenance topic because the need for control measures, and the possible extent of control, will only be known after the thinnings are completed and the oak response measured. If indeed oak control is needed and desired, target young and mid-aged stands which have yet to produce mast, and start by selecting a few experimental sites to measure the efficacy of treatments.

Further information on Arsenal can be found in Appendix C.

Streambank Stabilization

No streambank stabilization areas were identified as requiring erosion control at the present time. However, high flow events or floods could certainly compromise portions of Gallinas Creek in the future. As such, the following narrative is included to serve as a guideline for possible maintenance of the creek in the future.

Erosion control in or adjacent to stream channels has traditionally been accomplished through the use of engineered structures like riprap or concrete-lined channels. In the past decade, these approaches have lost favor with many organizations because they are expensive and often socially unacceptable. Bioengineering, in contrast, has recently gained favor as a viable erosion control strategy. Bioengineering uses live plants alone or in combination with dead or inorganic materials to produce living, functioning erosion control systems. In addition to erosion control, bioengineering can also enhance water quality, fisheries, wildlife, and aesthetics.

SEC recommends a bioengineering application for any possible streambank stabilization work. In planning such a project, a number of questions need to be answered. These include the political, economic, climatatological, biological, physical, and edaphic (soils) components of the project.

Political considerations include the acquisition of appropriate permits from the U.S. Army Corp of Engineers and the New Mexico Environment Department's Surface Water Quality Bureau. With the possible exception of vegetation plantings only, a Clean Water Act Section 404 and 401 permit from these agencies will be required before work commences. Information regarding the Corp of Engineers permitting process can be had by contacting Andy Rosenau in Albuquerque at 505-342-3282. The Environment Department contact is Delbert Trujillo in Santa Fe at 505-827-2867.

Economically bioengineering is generally less expensive than a traditional engineering approach. However, unlike a traditional approach, bioengineering projects require post-

treatment monitoring and management of the site. Post-treatment management will often require remedial plantings and some repair work early in the project's history. Once established, bioengineering projects are generally more self-sustaining and resilient than traditionally engineered projects.

Climatological, biological, and edaphic properties data have been addressed in Chapter 2. The remaining unanswered questions involve the physical (and possibly some additional edaphic) parameters of a project. The average daily flow for the period 1926 to 1992, as recorded at the U.S. Geological Survey Stream Gage Station 08380500 near Montezuma, is 19.3 cubic feet per second (cfs) (Herrera and Sokoll 1994)). Low and high daily flows for the period 1927 to 1992, as recorded from this same gage station, are 5.3 cfs in January and 53.2 cfs in April and May (Herrera and Sokoll 1994). This is important because it guides the design of a project with respect to what kinds of materials to use. In other words, the protection capability of the design model needs to match the erosion potential of each treated stream reach. Qualitative data based on the knowledge of City Water Department personnel, high water marks, and information from local vegetation and soils that indicate flood periodicity can also be used to guide project design.

Edaphic properties and bank geometry play a major role in bioengineering. Depending upon the type of treatment implemented, vertical cutbanks may or may not require grading prior to planting. If grading is required, the angle will be dictated by the soil (most slopes that accommodate revegetation are less than 1-1.2 vertical:1 horizontal).

Bioengineering in the Watershed could consist solely of vegetation or a combination of vegetation and engineered structures. The following bioengineering design models highlight some different approaches that could be used.

Live Stakings

This approach entails the planting of dormant, but live cuttings (stems) along actively eroding stretches of the creekbed. Cuttings aid erosion control through the development of root systems that help to hold the soil together and by dissipating the water's energy against the deforming plant rather than the soil. Cuttings also enhance aquatic and riparian values by improving water quality through the trapping of sediment, by moderating water and bank temperatures, by facilitating the colonization of other species, by providing forage and cover for different wildlife species, and by improving the aesthetics of an area.

Advantages of live stakings include relatively low cost and an aesthetically pleasing treatment that has multiresource values. In spite of these advantages, there are several constraints associated with the use of live stakings. The following questions, noted by Allen and Leech (1997), must be addressed before any live staking project is undertaken:

- How close to the surface is the permanent water table? Species recommended for planting (willow and cottonwood) need to be in permanently wet or very moist soil.

- Does sunlight fall on eroding banks? Species recommended for planting need at least partial sunlight to grow as they are intolerant to shade.
- Is bedrock close to soil surface? Soil into which the cuttings are planted must be at least four feet deep to ensure that root systems can become established. This can be checked with a probe.
- Is the stream channel stable upstream of the erosion site? If the stream cuts behind the upper end of the cuttings, the entire bank can erode.
- How wide is the stream channel at the erosion sites when compared with stable channels upstream and downstream? The channel where cuttings will be planted should not be narrower than stable channels upstream or downstream; otherwise, vegetation could choke the channel and cause other erosion problems.

If the above questions are answered, and live stakings are both appropriate and desired, then willow and cottonwood are recommended for planting. The stems of these species can be used because when dormant they store root hormones and food reserves (carbohydrates) that promote sprouting of roots and stems during the growing season.

Willow and cottonwood cuttings could be collected from existing populations on the property. This would reduce overall project costs and ensure that the best adapted genetic stock is planted. If collecting from the property is decided upon, care should be taken to disperse harvesting areas so that no one stand is compromised. The ratio of willows to cottonwood to cut and then plant should correspond to what is being seen on the property in naturally regenerating stands. Collection and planting of cuttings should be scheduled for late winter to ensure dormancy of the tree stock when it goes into the ground. This is very important as planting survival rates are much higher for dormant cuttings as opposed to actively growing cuttings.

Treatment areas should be planted from cutbank areas to the water's edge and extend a short distance both up and downstream from the treated stretch. Willows should be planted closest to the water's edge and extend back toward the bank. Willows are the only woody species appropriate at the water's edge because they are flood-tolerant and well suited to deformation from high water. Cottonwoods should be planted behind the willow beginning in a zone not expected to be under water for more than three continuous weeks during the year.

Planted cuttings should be oriented at approximately a 20 percent downstream angle as measured from the cutbank. The planting configuration should be either random or offset rows to affect a natural look. Spacing of planted species could vary from one to four feet based on the number of cuttings on hand, the size of the cuttings, and the overall strength desired. Large cuttings and tight spacing will provide the greatest strength. Live stakings with woody vegetation can be expected to withstand streamflow velocities between 6-8 cfs (U.S. Army Corp of Engineers 1989). Further instructions on the collection and planting of cuttings can be found in Appendix D. This information comes from the Los Lunas, New Mexico Plant Materials Center.

Live Stakings – Riprap or Gabions

Live stakings combined with riprap represent a significantly stronger design model than live stakings alone. Riprap is simply a layer of angular stone designed to protect and stabilize erosion prone areas. If riprap is used with live stakings, it should be placed at the bed/bank interface to prevent undercutting and at both ends of the treatment to prevent erosion. The subgrade surface on which the stone is placed may have to be cut or filled to accommodate the rock. The stone should then be underlain with a layer of gravel, sand, or some synthetic to prevent soil movement into or through the riprap. The strength of riprap can be increased by enclosing the stone in wire and staking the entire structure (technically called a gabion). Live stakings would be employed as described in the preceding section. If chosen, the stakings could be interplanted through the riprap or gabions to hide the rock and improve the aesthetics, strength, and wildlife values of the project. The riprap or gabion structure should be designed to withstand a peak flow expected to occur from at least a 10 percent chance storm.

Rock and Brush Check Dams

Serious gully erosion was not noted on the property. Nonetheless, a short section on upland erosion control is included to treat actively eroding sites not noted during the inventory, or to maintain any future problem sites.

Gullies develop when surface runoff is concentrated a t a nickpoint. Nickpoints are abruptly changing elevational and slope gradient areas that lack protective vegetative cover (Brooks et al. 1991). The fall of water over the nickpoint causes it to be undermined and start migrating uphill (headcutting). Simultaneously, the force of falling water dislodges sediment below the nickpoint and transports it downhill, lengthening and deepening the gully in a downhill direction (downcutting).

A series of rock and brush check dams are recommended for any actively eroding gully. Check dams are built in the gullies to trap sediment that is carried down the gully during periodic flow events. Brooks et al. (1991) note four ways in which sediment that backs up behind the dam helps to stabilize the site, these include:

- Develops a new channel bottom with a gentler gradient than the original channel bottom, thus reducing the velocity and erosive force of the gully flow.
- Stabilizes the side slopes of the gully and encourages their adjustment to the natural angle of repose, thereby reducing further erosion of the channel banks.
- Promotes the establishment of vegetation on the gully slopes and bottom.
- Stores soil water so that the water table is raised, enhancing vegetation growth outside of the gully.

Check dams are a relatively inexpensive, effective technique for gully erosion.

MONITORING

Monitoring is an adaptive management strategy used to determine effects of treatments. Monitoring should occur both during plan implementation to ensure that treatments are being conducted as planned, and upon completion of a project to determine if treatments were effective in moving toward desired conditions.

Treatment Implementation

Monitoring during plan implementation should include periodic on-the-ground thinning inspections and record keeping of all activities. Inspection findings should be recorded with a formal inspection form and copies of inspection reports supplied to the contractor and timber purchaser. For timber that is sold, the timber purchaser needs to supply copies of scale (the measurement of downed logs) tickets to the sale administrator. This enables a tracking of volumes removed by species and helps to ensure accurate payments on timber sold. In addition, records should include all costs and income associated with a sale, sale contract(s), sale dates, thinning prescriptions, and acres treated. Maps and databases should be updated following treatments.

Post-Treatment

Structured forest health inspections should be scheduled on an annual basis, except as noted below, for the first two years after treatments, and every three years after that. Site-specific inspections should also occur after any potentially damaging natural event such as wildfire or flooding. With each scheduled inspection, data should be gathered on insects and disease, soil conditions, noxious weed responses to control treatments, oak responses to thinning treatments, and the health and integrity of Gallinas Creek. Adjacent lands management should also be monitored. Each of these topics are briefly discussed below.

Insects and Disease

- Monitor down green logs in May or June to determine whether or not they are attracting *Ips* beetles. If so, adjust the timing of thinning to occur after July 1.
    - Monitor forest health for any damaging insects or disease on scheduled basis.

Soil Conditions

- Monitor soil erosion (movement) to ensure it is within acceptable limits. If erosion is excessive, take corrective action to remedy the problem.
- After two full growing seasons, inspect seeded sites to ensure vegetative ground cover. Apply native grass seed where determined necessary to re-vegetate specific bare soil areas for erosion and sediment control.

Noxious Weeds

- Inspect all treated noxious weed sites to measure efficacy of treatments. Retreat as necessary.

Oak Responses to Thinning

- Monitor oak response to thinning to determine if oak is creating an unacceptable fire hazard.
- If a herbicide control is used, select a few sites as experimental controls and monitor efficacy of treatments. Amend treatments as necessary.

Water

- Monitor water quality in key locations to aid in identifying and correcting any problems and to ensure that water quality will continue to meet drinking water standards.
- Monitor changes in peak flows before and after thinning, as well as subsequent changes in stream morphology, to determine whether treatments are causing any detrimental affects to the stream channel.
- Monitor changes in fine sediment levels in the streambed, and the amount of turbidity resulting from project implementation.

Adjacent Lands Management

- Monitor private forest lands management on adjacent Watershed lands by requesting approved harvest permit application information from the Las Vegas District of the New Mexico Forestry Division.
- Monitor the proposed Santa Fe National Forest Gallinas Municipal Watershed Wildland-Urban Interface Project. Provide project input at appropriate stages of the planning process. The Forest Service contact for this project is Julie Larson at 505-757-6121 or julielarson@fs.fed.us.

Literature Cited

Allen, H. H., and J. R. Leech. 1997. "Bioengineering for streambank erosion control; Report 1, Guidelines," Technical Report EL-97-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Anderson, H.E. 1982. Aids to determining fuel models for estimating fire behavior. General Technical Report INT-122. Ogden, UT: U.S. Dept of Ag. For Serv., Intermountain For. Ran. Ex. Sta., 22.

Bailey, Bill. 2001. BASF Corporation. Personal communication. Phone conversation. 24 October.

Brooks, K.N., Ffolliott P.F., Gregerson H.M., and J.L. Thames. 1991. Hydrology and the management of watersheds. Iowa State University Press. Ames, Iowa, 392p.

Fletcher, R.A., Emmingham, W.H., and S. Woodard. 1993. Stand volume and growth: getting the numbers. Extension Circular 1190, Oregon State University Extension Service. Corvallis, OR. 23p.

Goodwin, J.G. Jr., C.R. Hungerford. 1979. Rodent population densities and food habitats in Arizona ponderosa pine forest. USDA Forest Service Research Paper RM-214.

Hann, D.W., and B.B. Bare. 1978. Comprehensive tree volume equations for major species of New Mexico and Arizona: II. Tables for unforked trees. USDA For. Serv. Res. Pap. INT-210, 127p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Harper, K.T., F.J. Wagstaff, and L.M. Kunzler. 1985. Biology and management of the Gambel oak vegetative type: a literature review. General Technical Report INT-179. Ogden, UT: U.S. Dept of Ag. For Serv., Intermountain For. Ran. Ex. Sta., 31.

Hays, Bill. 2001. New Mexico Department of Game and Fish. Personal communciation. Phone conversation, 9 October.

Herrera, M., and C. Sokoll. 1994. Gallinas River Watershed Natural Resource Plan. Paper presented to the Energy, Minerals, and Natural Resources Department. September.

Hoover, R.L., and D.L. Wills, ed. 1984. Managing forested lands for wildlife. Colorado Division of Wildlife in Cooperation with USDA Forest Service, Rocky Mountain Region, Denver, Colorado, 459 pp.

Hunter, M.L. 1990. Wildlife, forests, and forestry, principles of managing forests for biological diversity. Prentice Hall, Englewood Cliffs, NJ.

Johnson, D.W. (Ed.) 1982. Forest pest management training manual. Forest pest management. Rocky Mountain Region, USDA Forest Service, Lakewood Colorado.

Kohm, K.A., and J.F. Franklin, eds. 1997. Creating a forestry for the 21st century: the science of ecosystem management. Island Press. Washington D.C. 475 p.

Krammes, J. S., tech coord. 1990. Effects of fire management of Southwestern natural resources. General Technical Report RM-191. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 293p.

Larson, Julie. 2002. U.S. Forest Service. Personal communication. E-mail, 9 January.

Lee, R.D. 1999. New Mexico's invasive weeds. New Mexico State University College of Agriculture and Home Economics. 57p.

Minoque, P. 2001. What happens to imazapyr? Timberlines. Vol. 3, No. 2:3-4.

New Mexico Department of Game and Fish (Online). 2001. Biota Information System of New Mexico. Santa Fe, NM: Biota Information System of New Mexico Home Page. http://nmnhp.unm.edu/bisonm/bisonquery.php (Version 7, 2001).

New Mexico Partners in Flight. 2000. Draft land bird conservation plan for the State of New Mexico. Compiled by Christopher Rustay. Albuquerque, NM. 200p.

New Mexico Rare Plant Technical Council (Online). 1999. New Mexico Rare Plants. Albuquerque, NM: New Mexico Rare Plants Home Page. http://nmrareplants.unm.edu (Version 15, March 2001).

Newton, I. 1994. The role of nest sites in limiting the numbers of hole-nesting birds: a review. Biological Conservation. 70:265-276.

Rosenstock, S.S. 1998. Influence of Gambel oak on breeding birds of ponderosa pine forests of northern Arizona. Condor. 100:485-492.

Schubert, G.H. 1974. Silviculture of Southwestern ponderosa pine: the status of our knowledge. Research Paper RM-123, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 60p.

Smith, D.M. 1986. The practice of silviculture. John Wiley & Sons. New York, NY. 572p.

Smith, J.K. (ed.). 2000. Wildland fire in ecosystems: effects of fire on fauna. USDA Forest Service General Technical Report RMRS-GTR-42(1).

Tafoya, Robert. 2001. City of Las Vegas Water Department. Personal communication. Phone conversation. 21 August.

U.S. Army Corps of Engineers. 1989. Environmental engineering for local flood control channels," Engineering Manual 1110-2-1205, 15 November. Washington, DC.

USDA Forest Service. 2001. Santa Fe Municipal Watershed Project Draft Environmental Impact Statement. U.S. Department of Agriculture, Forest Service, Southwestern Region, Espanola Ranger District, Santa Fe National Forest.

U.S. Department of Agriculture (USDA). Soil survey of San Miguel County Area, New Mexico. 1981.

Walton, R.G. Northern New Mexico integrated weed management program, noxious weeds; a threat to northern New Mexico, 1998. A publication of the Northern New Mexico Noxious Weed Management Committee. 5p.

Water Quality Protection Guidelines For Forestry Operations in New Mexico. 1994. New Mexico Energy, Minerals, and Natural Resources Department. 48p.