

**Final Groundwater Restoration Plan  
for the Chino, Cobre, and  
Tyrone Mine Facilities**



**New Mexico Office of Natural Resources Trustee**

4910-A Alameda Boulevard NE  
Albuquerque, NM 87113  
505-243-8087  
[www.onrt.state.nm.us](http://www.onrt.state.nm.us)

January 4, 2012

---

# Contents

<b>Executive Summary .....</b>	<b>S-1</b>
<b>Chapter 1    Introduction.....</b>	<b>1-1</b>
1.1    Trustee Responsibilities and Authorities .....	1-2
1.2    Summary of Groundwater Natural Resource Damage Settlement for FMI Mines .....	1-2
1.3    Summary of Natural Resource Injuries.....	1-3
1.4    Need for Restoration under CERCLA .....	1-3
1.5    Coordination and Public Involvement .....	1-4
1.5.1    Coordination with the responsible party .....	1-4
1.5.2    Public participation .....	1-4
<b>Chapter 2    Overview of the Sites .....</b>	<b>2-1</b>
2.1    Mine Facilities and Water Resources .....	2-1
2.1.1    Chino Mine .....	2-1
2.1.2    Tyrone Mine .....	2-5
2.1.3    Cobre Mine .....	2-8
2.2    Overview of Site Histories.....	2-10
2.2.1    Chino Mine .....	2-10
2.2.2    Tyrone Mine .....	2-12
2.2.3    Cobre Mine .....	2-12
2.3    Summary of Remedial Actions .....	2-13
<b>Chapter 3    Injury Evaluation and Estimation of Groundwater Damages .....</b>	<b>3-1</b>
3.1    Injury Assessment Strategy .....	3-1
3.2    Groundwater Injury Determination .....	3-1
3.2.1    Hazardous substance sources.....	3-2
3.2.2    Identity of hazardous substances .....	3-2
3.2.3    Relevant standards .....	3-5
3.2.4    Identification of injured groundwater plumes .....	3-5
3.2.5    Examples of water quality standard exceedences.....	3-6
3.3    Pathway Determination.....	3-9
3.3.1    Primary pathways for groundwater contamination.....	3-10

3.4	Groundwater Injury Quantification .....	3-11
3.4.1	Baseline conditions .....	3-11
3.4.2	Extent of injured groundwater .....	3-13
3.4.3	Duration of release .....	3-18
3.4.4	Likelihood of future recovery .....	3-19
3.4.5	Quantifying compensatory restoration.....	3-19
<b>Chapter 4</b>	<b>Restoration Goals and Project Evaluation .....</b>	<b>4-1</b>
4.1	Goals for Restoration .....	4-1
4.2	Evaluation Criteria for Restoration Alternatives .....	4-1
4.2.1	Screening criteria .....	4-1
4.2.2	Evaluation criteria.....	4-2
4.3	Developing Project Tiers for the Draft RP .....	4-2
4.4	Final Evaluation after Public Comment Period .....	4-3
<b>Chapter 5</b>	<b>Groundwater Restoration Projects .....</b>	<b>5-1</b>
5.1	Tier 1 Projects.....	5-1
5.1.1	San Vicente Creek Mill Option 2 .....	5-3
5.1.2	Santa Clara Wellhead Protection .....	5-4
5.1.3	Santa Clara Gravity Sewer Improvements.....	5-6
5.1.4	Silver City North/Blackhawk Sewer Line Extension .....	5-7
5.1.5	Bayard Reuse .....	5-9
5.1.6	Hurley Sewer Lines Replacement.....	5-11
5.2	Tier 2 Projects.....	5-12
5.2.1	Hanover-Fierro Wastewater Collection and Disposal System.....	5-14
5.2.2	North Hurley Sewer Line Extension.....	5-15
5.2.3	Silver City Indian Hills Sewer Line Extension.....	5-16
5.2.4	Silver City Ridge Road East Sewer Line Extension.....	5-18
5.3	Projects Considered but Not Recommended for Funding .....	5-19
5.3.1	Grant County Liquid Waste Groundwater Protection .....	5-19
5.3.2	Grant County Water Conservation .....	5-22
5.3.3	Grant County Water Conservation Plan Development.....	5-22
5.3.4	San Vicente Creek Mill Options 1 and 3 .....	5-23
5.3.5	Silver City Mountain View/Southwest Area Sewer Line Extension.....	5-24
5.3.6	Cameron Creek and Twin Sisters Creek Watershed Improvements.....	5-24
5.3.7	Carlisle Mine Site .....	5-25
5.3.8	Cleanup of Pacific Ridge Abandoned Mine Sites within Pinos Altos Mining District .....	5-25
5.3.9	Cleanup of Old Silver City Dump Site .....	5-25
5.3.10	Regional Water Supply and Distribution.....	5-25

<b>Chapter 6</b>	<b>Agencies and Organizations Consulted .....</b>	<b>6-1</b>
<b>Chapter 7</b>	<b>Public Comments and Trustee Responses .....</b>	<b>7-1</b>
7.1	Comments Received .....	7-1
7.2	Response to Comments .....	7-6
<b>References .....</b>		<b>R-1</b>
<b>Appendix: Complete Project List</b>		

---

## Executive Summary

The New Mexico Office of Natural Resources Trustee (ONRT) has engaged in a cooperative Natural Resource Damage Assessment and Restoration (NRDAR) process for the Freeport-McMoRan Copper & Gold Inc. (FMI) mine sites near Silver City, New Mexico. Groundwater resources have been injured by hazardous substances released from three copper mining facilities owned by FMI. The mines include:

- ▶ **Chino Mine:** Located approximately 12 miles east of Silver City, New Mexico, this mine is east of the Continental Divide in the Mimbres watershed. Open-pit mining began in 1910. The mine was temporarily closed in January 2002 but has since reopened. The estimated areal extent of groundwater plumes at the Chino Mine was 13,935 acres.
- ▶ **Cobre Mine:** Located approximately 3 miles north of Hanover, New Mexico, this is the smallest of the three mine sites. The mine is east of the Continental Divide in the Mimbres watershed. The mine has a long history of iron ore production. Commercial copper production by underground methods began in 1858; underground copper mining ended in 1971. The mine was closed from 1982 to 1993 due to low copper prices and went on standby in 1999. Although the mine has received approval to resume mining and expand operations, it has not yet resumed mining. The estimated areal extent of groundwater plumes at the Cobre Mine was 528 acres.
- ▶ **Tyrone Mine:** Located approximately 10 miles southwest of Silver City, New Mexico, the open-pit mine straddles the Continental Divide and the Mimbres and Gila River basins. Turquoise, copper, and fluorspar were mined in the area from the late 1870s through the early 1900s. Open-pit copper mining began in 1967. Since 1992, the mine has been solely a copper leaching operation. The estimated areal extent of groundwater plumes at the Tyrone Mine was 6,280 acres.

ONRT undertook a groundwater assessment for these three mines. As part of this assessment, ONRT assessed and quantified injuries to groundwater resources and successfully brought claims against FMI for groundwater damages. FMI paid \$13 million to settle allegations that the company injured groundwater resources as a result of discharges of hazardous substances from the Chino, Cobre, and Tyrone mines.

In this Groundwater Restoration Plan (RP) for the Chino, Cobre, and Tyrone Mine Facilities, ONRT identifies and evaluates proposed restoration projects and determines which projects would best compensate the public for injuries to groundwater resources that resulted from the release of hazardous substances from the three mines. ONRT solicited a broad range of potential restoration projects from local, state, and federal agencies; nonprofit organizations; and stakeholder groups. ONRT identified 18 potential restoration projects that were described in the

Draft RP. During the public comment period, an additional three projects were identified and included in the evaluation process. All projects were re-evaluated after the public comment period to take into account the additional information obtained during the public comment period. Projects were evaluated using screening and evaluation criteria developed by ONRT that are consistent with federal regulations. To be considered for further evaluation, a project had to meet the following criteria:

- ▶ Be technically and administratively feasible
- ▶ Affect groundwater resources, either directly or indirectly
- ▶ Provide an overall net environmental benefit
- ▶ Comply with applicable and relevant federal, state, local, and tribal laws and regulations.

Projects that passed the screening criteria were assessed using a set of evaluation criteria that were designed to evaluate which projects best provided cost-effective, appropriate compensation for injured groundwater resources. Projects were evaluated based on the following set of criteria:

- ▶ Potential for long-term success and a low risk of failure
- ▶ Feasible and cost-effective operations, maintenance, and monitoring
- ▶ Ability to proceed without NRDAR funding
- ▶ Proximity to the injury (Gila and/or Mimbres water basins)
- ▶ Cost-effectiveness compared to other projects that provide similar benefits
- ▶ Consistency with regional planning and federal and state policies
- ▶ Likelihood to provide benefits quickly after project implementation.

Based on an evaluation of the proposed restoration projects, ONRT selected a diverse, regional portfolio of groundwater restoration projects that would yield maximum benefits to regional groundwater resources and are consistent with current approaches to regional water planning in the area. Projects that are suitable for funding were grouped into two funding tiers. Tier 1 projects have top priority for funding (Table S.1); Tier 2 projects will be considered for funding if funding is available after Tier 1 projects have received funding.

Projects presented as Tier 1 projects were ranked highest based on application of the screening and evaluation criteria outlined above. Tier 1 projects will be funded in two rounds: a first round of funding is expected to be provided in 2012 and a second round of funding is expected to be made available in the second half of 2012 or 2013. The funding amounts for the second round may be adjusted depending on the availability of funds at that time. Tier 2 projects meet the screening and evaluation, but were ranked lower than the Tier 1 projects. If funding is available after completing the Tier 1 projects, Tier 2 projects will be considered for funding. Given the large number of projects in Tier 1 and Tier 2 (and a cumulative cost for these projects that far exceeds the settlement funding available), ONRT placed Tier 3 projects from the Draft RP into the category of “not recommended for funding” for the Final RP.

**Table S.1. Restoration projects selected for funding as Tier 1 projects**

<b>Project title (location)</b>	<b>Project description</b>	<b>Proposed funding</b>
<b>Proposed for first round of funding</b>		
San Vicente Creek Mill Option 2 (Silver City)	Full offsite removal of hazardous substances at the San Vicente Creek Mill to avoid ongoing groundwater contamination	\$4,800,000
Santa Clara Wellhead Protection (southwest of Village of Santa Clara)	Construct structures to prevent infiltration of contaminants into drinking water wells and groundwater	\$109,000
Santa Clara Gravity Sewer Improvements (along Cameron Creek in Village of Santa Clara)	Improve and protect main sewer lines in Santa Clara to prevent re-occurrence of sewage spills into Cameron Creek and associated alluvial groundwater	\$316,000
Silver City North/Blackhawk Sewer Line Extension (Silver City)	Extend a sewer line to enable additional household connections and eliminate use of faulty septic systems that contaminate groundwater	\$310,000
<b>Proposed for second round of funding</b>		
Bayard Reuse (City of Bayard)	Develop infrastructure to enable groundwater conservation by using treated wastewater for irrigation	\$4,000,000 <sup>a</sup>
Hurley Sewer Lines Replacement (Town of Hurley)	Replace failing clay sewer pipes with modern impermeable materials to avoid groundwater contamination	\$1,375,000 <sup>a</sup>
<b>Anticipated total cost for Tier 1 projects</b>		<b>\$10,910,000</b>
a. Funding amounts may be adjusted depending on availability of funds.		

Additional information can be requested by contacting:

Ms. Rebecca de Neri Zagal  
 Executive Director  
 New Mexico Office of Natural Resources Trustee  
 4910-A Alameda Boulevard NE  
 Albuquerque, NM 87113

An electronic version of the Final RP is posted on the Natural Resource Damage Assessment website: [www.onrt.state.nm.us/ChinoCobreTyrone.html](http://www.onrt.state.nm.us/ChinoCobreTyrone.html).

---

# 1. Introduction

This Final Groundwater Restoration Plan (RP) for the Chino, Cobre,<sup>1</sup> and Tyrone Mine Facilities describes projects that will improve groundwater resources and services in the general vicinity of Silver City, New Mexico. The projects are meant to compensate for the injuries to groundwater resources when hazardous substances,<sup>2</sup> including copper and other heavy metals, were released from three copper mining facilities owned by Freeport-McMoRan Copper & Gold Inc. (FMI)<sup>3</sup> in Grant County, New Mexico. The mines include:

- ▶ Chino Mine – located approximately 12 miles east of Silver City
- ▶ Tyrone Mine – located approximately 10 miles southwest of Silver City
- ▶ Cobre Mine – located approximately 3 miles north of Hanover.

These facilities are referred to as “the Sites” throughout this plan. Their locations are shown in Chapter 2 (Figure 2.1).

The restoration projects described in this plan were identified by the New Mexico Office of Natural Resources Trustee (ONRT) through discussions with local, state, and federal agencies; nonprofit organizations; and stakeholder groups. ONRT is the state agency that implements New Mexico’s NRDAR Program. The purpose of this program is to compensate the public through environmental restoration for injuries to natural resources. Restoration projects are paid for with damage settlement funds received from responsible parties.

---

1. The Cobre Mine is also known as the Continental Mine.

2. The term “hazardous substance” refers to a hazardous substance as defined in Section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), federal Natural Resource Damage Assessment and Restoration (NRDAR) regulations 43 CFR § 11.14(u). This includes hazardous substances designated or listed by Sections 311(b)(2)(A) and 307(a) of the Federal Water Pollution Control Act (i.e., the Clean Water Act, or CWA), by Section 102 of CERCLA, by Section 3001 of the Solid Waste Disposal Act (i.e., the Resource Conservation and Recovery Act, or RCRA), or Section 112 of the Clean Air Act.

3. FMI is used in this document to collectively refer to any or all of the following entities: the Freeport-McMoRan Corporation, Freeport-McMoRan Chino Mines Company, Freeport-McMoRan Tyrone Inc., Freeport-McMoRan Tyrone Mining LLC, and Freeport-McMoRan Cobre Mining Company.



The purpose of this RP is to inform the public about the groundwater resources that were injured by releases of hazardous substances at the Sites and to present the restoration projects that will compensate the public for these injuries. ONRT released a Draft RP on September 20, 2011, and held a 60-day public comment period. ONRT considered written comments received during the comment period (including comments received during a public meeting held in Silver City) prior to publishing this revised, Final RP. This RP includes a summary of comments received and Trustee responses to those comments (Chapter 7). The restoration actions described in this document are conceptual. Detailed designs and costs will be developed for restoration projects that have been selected for funding prior to implementation.

This introductory chapter explains the responsibility and legal authority of ONRT to develop this plan, summarizes the settlement that occurred between FMI and the State of New Mexico, and describes the role of public involvement in developing this RP.

## **1.1 Trustee Responsibilities and Authorities**

ONRT's authority to pursue NRDAR is identified in the New Mexico Natural Resources Trustee Act [NMSA 1978, §§ 75-7-1 et seq.] and in the following federal statutes:

- ▶ CERCLA, as amended [42 U.S.C. § 9601 et seq.]
- ▶ CWA [33 U.S.C. §1251 et seq.]
- ▶ Oil Pollution Act of 1990 (OPA) [33 U.S.C. 2701–2761 et seq.].

As part of ONRT's NRDAR responsibilities, ONRT assessed and quantified groundwater injuries associated with the Sites and successfully brought claims against FMI for groundwater damages. A copy of the settlement consent decree can be found at <http://onrt.state.nm.us/documents/FMI-NMConsentDecreessignedbyJudge021111.pdf>.

## **1.2 Summary of Groundwater Natural Resource Damage Settlement for FMI Mines**

ONRT and FMI reached a \$13 million settlement for the injuries to groundwater resources resulting from the release of hazardous substances from the Sites. The settlement includes \$12,794,000 for the restoration of groundwater resources, plus an additional \$206,000 for the reimbursement of outstanding damage assessment costs paid to ONRT. The New Mexico Legislature appropriated \$1,500,000 for interstate water litigation. There is currently \$11,294,000 available for groundwater restoration planning and implementation.

A settlement for injuries to other natural resources, including birds and wildlife, is in the process of negotiation between FMI, ONRT, and the U.S. Department of the Interior Fish and Wildlife Service. Once settled, a restoration plan for projects to address these other natural resources will be prepared at a later date and made available for public review.

### **1.3 Summary of Natural Resource Injuries**

Groundwater monitoring data reviewed by ONRT showed that hazardous substances from the Sites had contaminated groundwater, resulting in injuries to groundwater, as defined in the federal NRDAR regulations [43 CFR § 11.14(v)].

Specific definitions of injury to groundwater resources include:

- ▶ Concentrations of substances in excess of drinking water standards, established by Sections 1411–1416 of the Safe Drinking Water Act (SDWA), or by other federal or state laws or regulations that establish such standards for drinking water, in groundwater that was potable before the discharge or release [43 CFR § 11.62(c)(1)(i)]
- ▶ Concentrations of substances sufficient to have caused injury as defined in paragraphs (b), (d), (e), or (f) of this section to surface water, air, geologic, or biological resources, when exposed to groundwater [43 CFR § 11.62(c)(1)(iv)].

### **1.4 Need for Restoration under CERCLA**

The objective of the NRDAR process is to compensate the public, through environmental restoration, for natural resources that have been injured, destroyed, or lost as a result of the release of hazardous substances into the environment. Damage settlements for resource restoration can only be used to restore, rehabilitate, replace, or acquire the equivalent of these natural resources. The amount, or “scale,” of restoration required to compensate for these losses depends on the spatial extent and severity of resource injuries, the time period over which resources have been injured, and the time required for resources to return to baseline conditions.

This RP has been developed to evaluate and select restoration projects designed to compensate the public for injuries that have occurred to groundwater resources at the Sites. Selected restoration projects will be implemented over a period of time, depending on the project type.

In a process distinct from the NRDAR activities undertaken by ONRT, remediation actions (termed “response actions”) will be conducted under the oversight of the New Mexico Environment Department (NMED) with the objective of controlling exposure to released

hazardous substances in order to protect human health and the environment. Because response actions at the Sites are ongoing, ONRT has chosen to focus on restoration alternatives that will not conflict with or be put at risk from any planned or proposed response actions.

## **1.5 Coordination and Public Involvement**

### **1.5.1 Coordination with the responsible party**

The assessment process for the Sites was conducted as a cooperative assessment with FMI. Cooperative assessments (like this one) can increase the cost-effectiveness of the process by facilitating the sharing of information and avoiding the duplication of study efforts. Input from FMI was sought and considered throughout the assessment process. However, ONRT had the final authority to make determinations regarding injury and restoration for groundwater resources.

### **1.5.2 Public participation**

The Draft RP was published on September 20, 2011. A press release of the availability of the Draft RP and request for public comments also was released on September 20, 2011. The public was invited to comment on the content of the Draft RP and to propose additional potential projects to restore injured groundwater resources. The public comment period for the Draft RP was September 20, 2011 through November 3, 2011, with an extension to November 18, 2011. A public meeting was held on October 4, 2011, in Silver City, New Mexico. At this meeting, ONRT presented information about the restoration process and the projects described in the Draft RP and answered questions about the Draft RP.

Copies of the Draft RP were made available at the following locations:

The Public Library  
515 West College Avenue  
Silver City, NM 88061

Bayard Public Library  
1120 Central Avenue  
Bayard, NM 88023

Gila Valley Library  
400 Highway 211  
Gila, NM 88038

An electronic version of the Draft RP was posted on the natural resource damage assessment website: [www.onrt.state.nm.us/ChinoCobreTyrone.html](http://www.onrt.state.nm.us/ChinoCobreTyrone.html).

---

## 2. Overview of the Sites

This chapter overviews the mine facilities, water resources, and mining history and summarizes remedial actions for the three Sites: Chino, Tyrone, and Cobre mines.

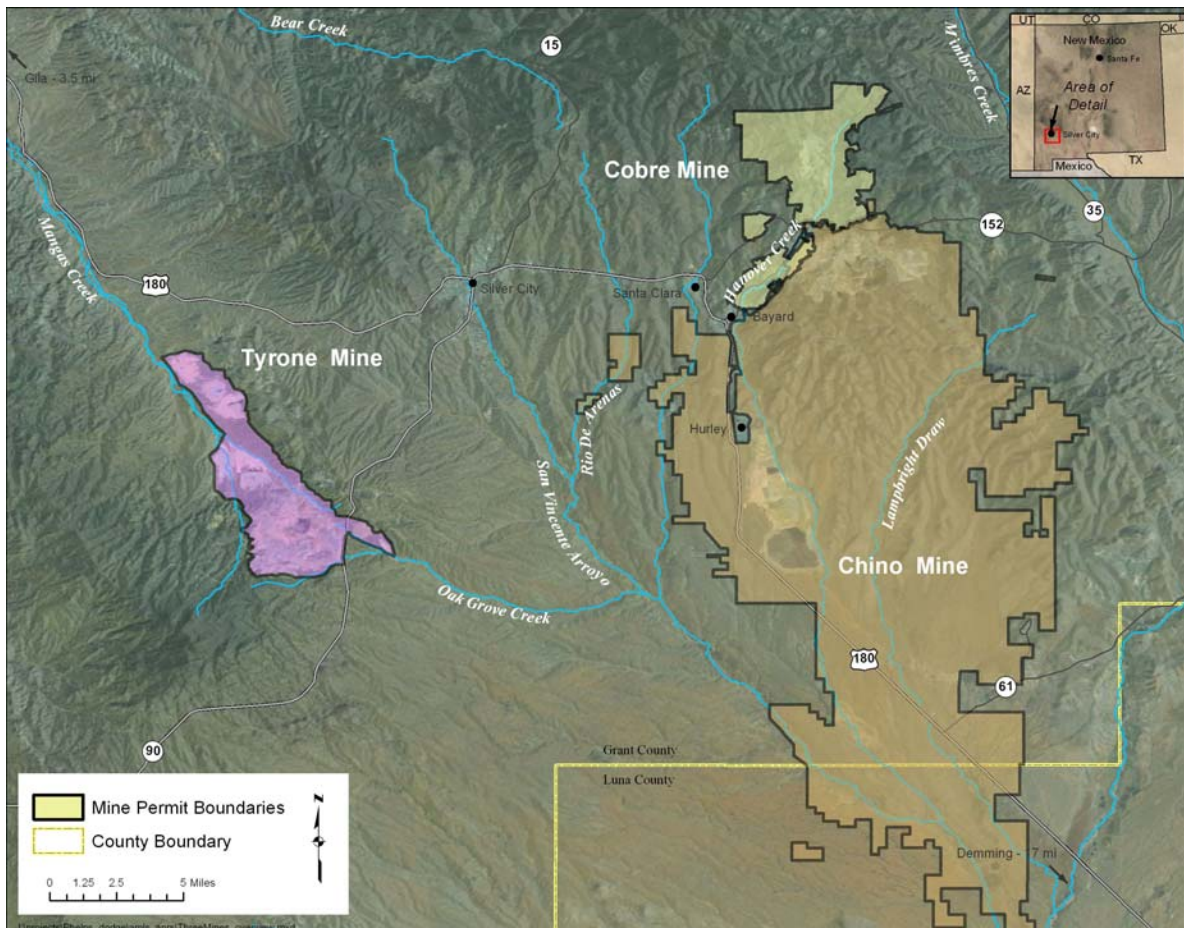
### 2.1 Mine Facilities and Water Resources

The Sites, located in southwestern New Mexico, are open-pit and underground copper and iron mining, beneficiation, and processing facilities owned and operated by FMI (Figure 2.1).

#### 2.1.1 Chino Mine

The Chino Mine is located approximately 12 miles east of Silver City in Grant County, New Mexico. The site includes the following mine areas and associated facilities (Daniel B. Stephens & Associates, 1999; Golder Associates, 2008) (Figure 2.2):

- ▶ North Mine Area
  - Santa Rita Pit and associated stockpiles
  - West of pit area (West, South, and Upper South Stockpile areas; Ivanhoe Concentrator and Former Precipitation Plant; Groundhog Mine Area; Bull Frog Tailing Area)
  - Lampbright Stockpile Area
  - Solvent Extraction/Electrowinning (SX/EW) Plant and mine water/stormwater/process water reservoirs (e.g., Reservoirs 3A, 5, and 8)
- ▶ Middle Whitewater Creek Area
- ▶ South Mine Area
  - Hurley Smelter
  - Lake One
  - Axiflo Lake
  - Old Tailings Impoundment Area (Impoundments 1, 2, B, C, 6W, 4, and 6E)
  - Tailings Impoundment 7 Area
  - Lower Whitewater Creek Area (south of Tailings Impoundment 7 along creek).



**Figure 2.1. Overview of the Chino, Tyrone, and Cobre mines.**

### Surface water resources

The Chino Mine is east of the Continental Divide in the Mimbres watershed. The Mimbres River is a closed-basin desert stream and a well-defined river channel that terminates approximately 10 miles east of Deming, New Mexico (NMWRRRI, 2000). Major drainages at the Chino Mine include Whitewater Creek, Hanover Creek, and Lampbright Draw. Hanover Creek is an ephemeral stream that originates northeast of the Chino Mine and joins Whitewater Creek near the Ivanhoe Concentrator. Whitewater Creek is an ephemeral stream that runs from the North Mine Area to the South Mine Area. Whitewater Creek flows into the San Vicente Arroyo south of the mine. Lampbright Draw is an ephemeral stream draining the eastern portions of the North Mine Area that flows south and eventually joins the San Vicente Arroyo (M3 Engineering & Technology, 2001).



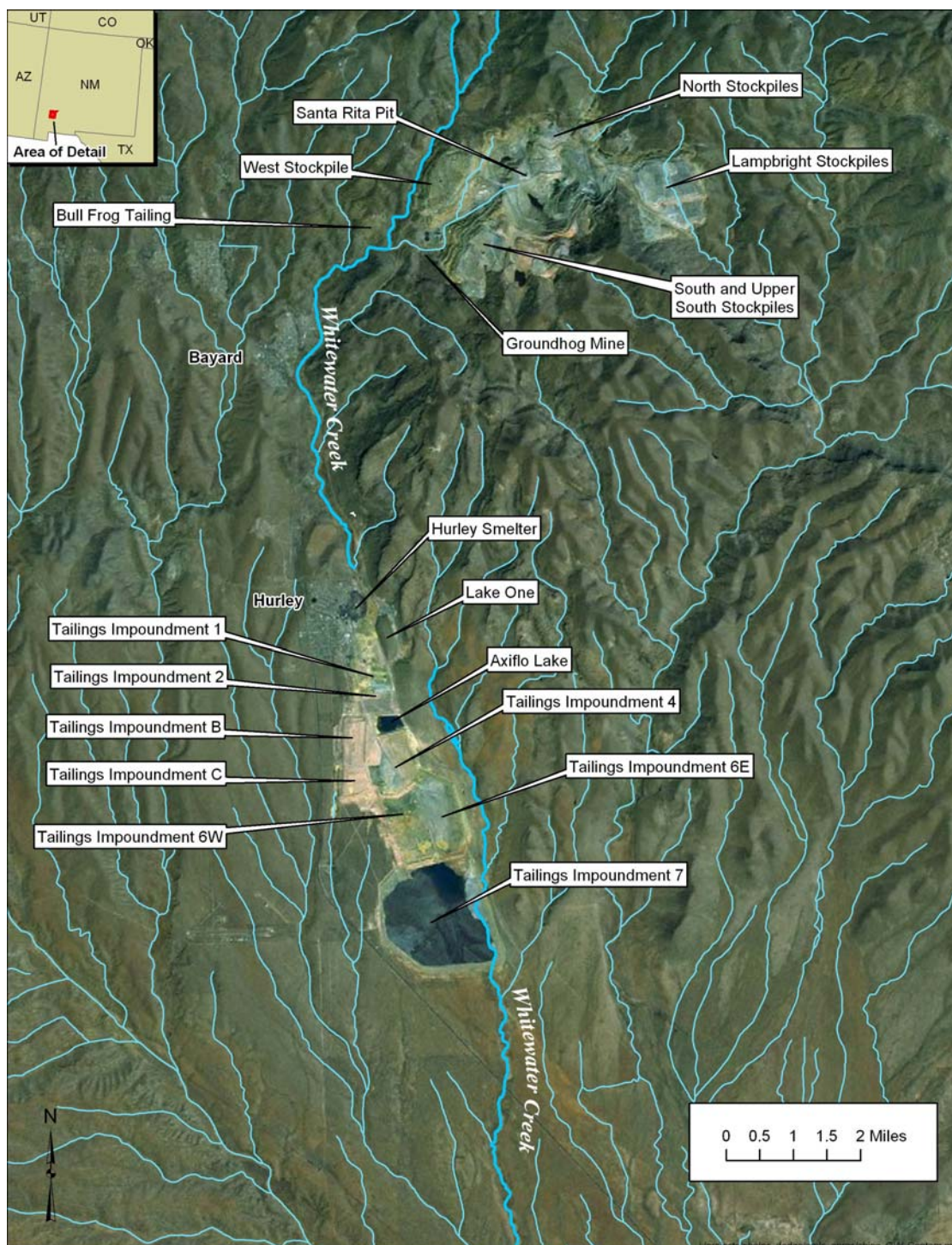


Figure 2.2. Hydrologic features and mine facilities at the Chino Mine.

## Geology and groundwater resources

The major aquifers at the Chino Mine include the Gila Conglomerate, igneous and sedimentary rock units, and Quaternary alluvium.

The geology and hydrogeology of the Chino Mine vary widely in the three major geographic areas of the site: the North Mine Area, the Middle Whitewater Creek Area, and the South Mine Area. The ability of rocks to contain and transmit groundwater is a function of the geology of rock (rock type), the amount of open pore spaces or fractures/faults in the rock, the amount of water that infiltrates from the surface, and the groundwater gradient.

The *North Mine Area* contains a complex array of igneous (plutonic and volcanic) and sedimentary rock units and numerous near-vertical, north-to-northeast trending faults (Golder Associates, 2008). The oldest rocks in the area are sedimentary rocks (generally sandstones, limestones, and shales) that were deposited during the Paleozoic (570 to 230 million years ago) and Cretaceous (140 to 65 million years ago) periods. The ore body is largely hosted in the Santa Rita Stock, a plutonic igneous rock that ranges from granodiorite to quartz monzonite in composition (similar to granite). The stock was intruded into the older sedimentary rocks. After the mineralization of the copper deposit, volcanic rocks, including rhyolite tuffs and basaltic-andesitic lava flows, blanketed the igneous intrusion south of what is now the Santa Rita Pit area (see Figure 2.2). The Santa Rita Stock was extensively fractured and cut by intrusive dikes, especially in the areas west of the pit. The composition of the dikes is similar to that of the stock.

The rocks in the North Mine Area generally have low primary porosity and hydraulic conductivity, although higher values can exist in the sedimentary units. Groundwater flow in the plutonic and volcanic units in the North Mine Area is predominantly through the abundant fractures.

The *Middle Whitewater Creek Area* is located geographically between the North and South Mine areas and extends from Gold Gulch in the north (near the Town of Bayard) to the Town of Hurley in the south (see Figure 2.2). The most important aquifer in the Middle Whitewater Creek Area is the alluvium along Whitewater Creek (Golder Associates, 2008). In the north end of the area, the underlying bedrock is principally igneous (quartz diorite sill), and south of Bayard the bedrock consists largely of volcanic tuffs. The thickest alluvium (> 100 feet) is located around Bayard. South of Bayard the alluvium varies from approximately 5 to 20 feet thick and from 500 to 3,000 feet wide.

The *South Mine Area* geology and hydrogeology are dominated by the Gila Conglomerate. Alluvium of varying thickness lines and underlies Whitewater Creek in this area. Volcanic rocks outcrop to the east of the tailings impoundments, and limestones outcrop on the western side of the impoundments. The Gila Conglomerate was formed essentially as an alluvial fan, filled



streambeds and lakes, and is composed of gravel on the large end to clays on the small end (Golder Associates, 2008). The Gila Conglomerate in Grant County is divided into upper and lower units. The upper part of the upper unit has the highest porosity and ability to transmit water and is the most important aquifer in the area (Trauger, 1972). The Gila Conglomerate pinches out on the north end, near Lake One, and thickens to the south, where it is approximately 500-feet thick south of Tailings Impoundment 7 and up to 1,000-feet thick farther to the south (Figure 2.2).

### **2.1.2 Tyrone Mine**

The Tyrone Mine is located approximately 10 miles southwest of Silver City, New Mexico, in southwest Grant County. The site includes the following mine areas and associated facilities (Daniel B. Stephens & Associates, 2004) (Figure 2.3):

- ▶ Mine/Stockpile Area
  - Main Pit, Gettysburg Pit, Copper Mountain Pit (and several smaller pit areas)
  - SX/EW Plant
  - Pregnant Leach Solution (PLS) Collection Impoundments
  - Mill and Concentrator Facilities
  - Former Precipitation Plant Area and Acid Unloading Area
  - Leach Stockpiles (Nos. 1, 1A, 1B, 2, 2A, 3, East Main, Gettysburg Out Pit, and Gettysburg In Pit stockpiles)
  - Waste Stockpiles (Nos. 1C, 1D, 3B, a portion of the 2B, Savanna, and Upper Main stockpiles)
- ▶ Oak Grove Wash/Brick Kiln Gulch Area
  - No. 1 Leach Stockpile
  - Burro Mountain Tailings Impoundment
- ▶ Mangas Valley
  - Nos. 1, 1A, 1X, 2, 3X, and 3 Tailings Impoundments.

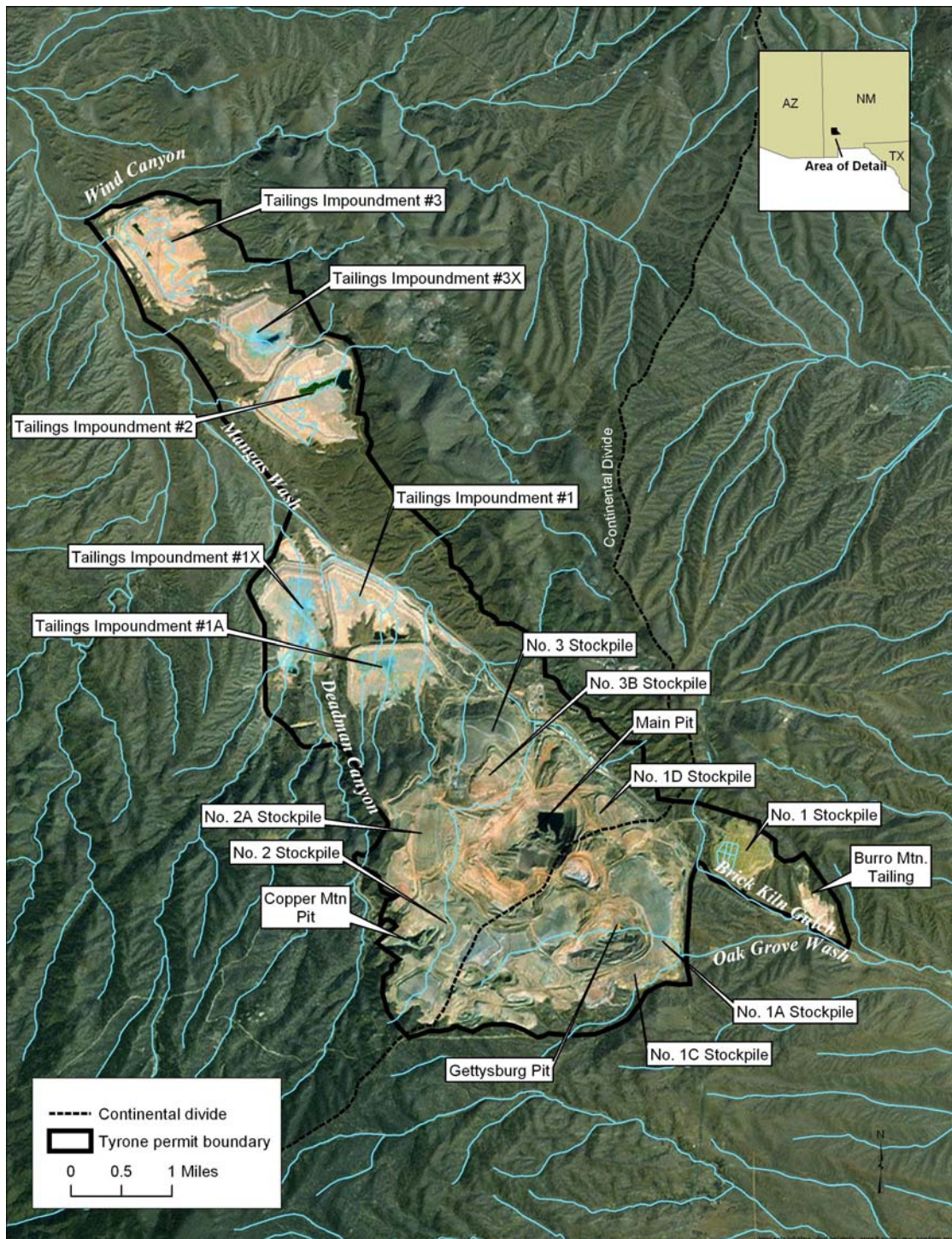


Figure 2.3. Hydrologic features and mine facilities at the Tyrone Mine.

### **Surface water resources**

The open pit straddles the Continental Divide (Figure 2.3). Before open-pit mining, the pit area drained toward the northwest into Mangas Creek, an ephemeral stream that flows north into the Gila River, and toward the southwest into Brick Kiln Gulch and Oak Grove Wash, which flow into the Mimbres River. Because open-pit mining and associated dewatering operations have altered the hydrologic regime, some groundwater that would have flowed into the Gila and Mimbres basins is now captured by pit dewatering operations (M3 Engineering & Technology, 2001).

### **Geology and groundwater resources**

The most important hydrogeologic units at the Tyrone Mine are the Gila Conglomerate, alluvium along the creeks and washes, and the igneous rocks in and around the open pit and stockpiles. The copper ore body is contained in a granite-like igneous rock and is bounded by several major faults on the western, eastern, and southern sides (Daniel B. Stephens & Associates, 1999). This igneous rock (quartz monzonite) is located under and around the open pit and stockpiles, along the eastern flanks of Deadman Canyon, and near the 1A leach stockpile in Oak Grove Wash.

As noted for the Chino Mine, the Gila Conglomerate is a sedimentary rock with a range of porosities and is derived from the physical weathering of local mountains. The most permeable portion of the Gila Conglomerate, the upper Gila, is located under the northern end of the No. 3 leach stockpile in uppermost Mangas Wash just downgradient of the stockpile, and downgradient of the No. 1 and 1A stockpiles in Oak Grove Wash (see Figure 2.3).

The younger alluvial material is the most porous material on the site and was deposited directly on the Gila Conglomerate. Alluvium lines Deadman Canyon, Oak Grove Wash/Brick Kiln Gulch, small tributaries of the upper Mangas Wash under and downgradient of the No. 3 leach stockpile, and Mangas Wash under and downgradient of all the tailings impoundments (see Figure 2.3 for locations). Groundwater is present in the alluvium but is not necessarily continuous in underlying, lower-permeability, igneous rocks or the Gila Conglomerate (i.e., the upper portions of the regional aquifers are not saturated with groundwater). Shallow groundwater that is not directly connected to underlying regional groundwater is called “perched.” Perched water in the Tyrone Mine area may feed groundwater to deeper regional groundwater (Daniel B. Stephens & Associates, 1997c, 2004).

Igneous rocks on the western side of the site have been upthrown hundreds of feet along the Sprouse-Copeland Fault, a regional, nearly vertical, north-trending fault in the upper/middle portion of Oak Grove Wash, and moved directly against the Gila Conglomerate (Daniel B. Stephens & Associates, 1999). The regional Mangas Fault runs in a northwesterly direction on the eastern side of the Mangas Wash and Brick Kiln Gulch. The Gila Conglomerate is thickest

on the northeastern side of the Mangas Fault and is only a few feet thick on the southwestern side. Faulting can increase the porosity of adjacent rocks due to the increased fracturing associated with the fault. The large differences in groundwater levels across faults at the Tyrone Mine suggest that they inhibit groundwater flow between different rock types across the faults (Daniel B. Stephens & Associates, 1997c).

### **2.1.3 Cobre Mine**

The Cobre Mine is located approximately 3 miles north of Hanover, New Mexico, in Grant County. The site includes the following main mine facilities (Shepherd Miller, 1999; M3 Engineering & Technology, 2001; Telesto Solutions, 2005) (Figure 2.4):

- ▶ Continental Pit
- ▶ Continental underground mine and workings
- ▶ West, East, South, Buckhorn, and Union Hill Waste Rock Disposal Facilities (WRDFs)
- ▶ Low-grade and high-grade ore stockpiles
- ▶ Main tailings impoundment
- ▶ Magnetite tailings impoundment.

### **Surface water resources**

The site drains into Hanover Creek and the Mimbres River watershed. Hanover Creek headwaters are in the Pinos Altos Range to the north of the site. The creek is perennial only for a short distance adjacent to the Towns of Hanover and Fierro, possibly due to contributions from local septic system outfalls, and downstream of Fierro Spring (Shepherd Miller, 1999; M3 Engineering & Technology, 2001). Hanover Creek flows into Whitewater Creek, which flows southward to the Chino Mine. Ephemeral drainages on the mine site include Grape Gulch, Poison Spring Drainage, and Buckhorn Gulch. These drainages usually flow only after summer thunderstorms (M3 Engineering & Technology, 2001). Perennial springs and seeps exist on the site, including Fierro Spring; seeps in Grape Gulch, Gap Canyon, and Poison Spring, which are located upstream of the mine; and Buckhorn Gulch Spring and seeps along Hanover Creek, which are downstream of mining activity.

### **Geology and groundwater resources**

Even though the Cobre Mine is the smallest of the three sites, it has the most complex geology. More than 30 types of igneous rock exist at the site, including sills, dikes, stocks and plugs, older sedimentary rocks, younger volcanic rocks, and more recent alluvium (M3 Engineering & Technology, 2001). The alluvium is limited to an approximately 0.75-mile stretch of Hanover



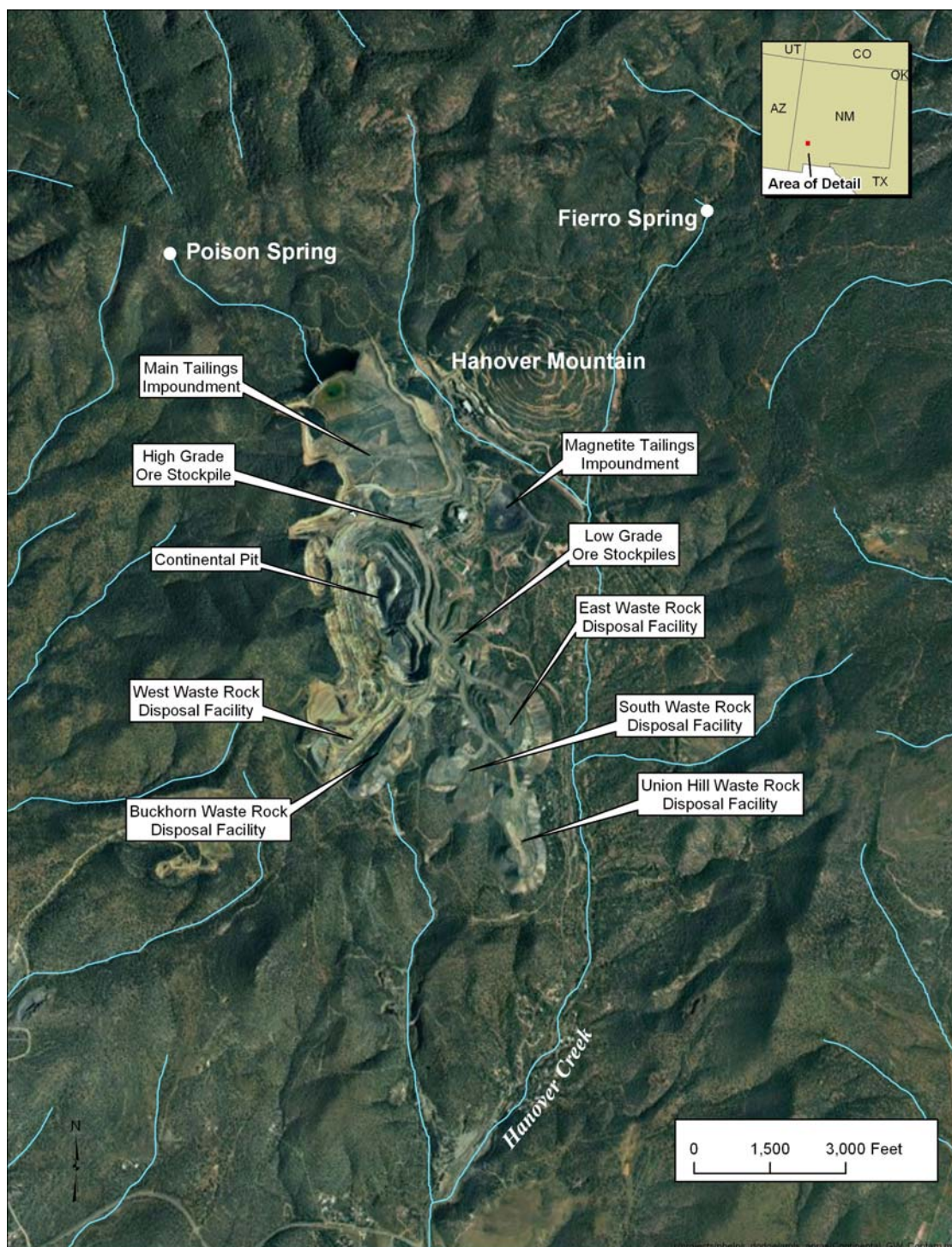


Figure 2.4. Hydrologic features and mine facilities at the Cobre Mine.

Creek downstream of Fierro Spring (Figure 2.4). Shallow perched groundwater exists in alluvium, terrace gravels, and weathered rock in Grape Gulch, Poison Spring, and upper Buckhorn Gulch and generally flows to the south or southeast. Two of the main springs in the area, Fierro and Poison springs, discharge perched groundwater (M3 Engineering & Technology, 2001).

Regional groundwater exists in the upper bedrock units (Colorado Formation and Beartooth Quartzite) and in the lower bedrock unit (older Paleozoic sedimentary rocks and the Hanover-Fierro intrusive stock) (Shepherd Miller, 1999; M3 Engineering & Technology, 2001). Groundwater in the upper bedrock unit flows to the south and southwest from the Pinos Altos Range and does not appear to be affected by mining-related groundwater dewatering. Groundwater in the lower bedrock unit on the site generally flows radially toward the underground workings (M3 Engineering & Technology, 2001) north of the Barringer Fault, where most of the upper bedrock unit has been eroded. On the southern side of the fault, groundwater flows to the south, and both the upper and lower bedrock units exist (Shepherd Miller, 1999).

## **2.2 Overview of Site Histories**

The following sections provide an overview of the site histories for the Chino, Tyrone, and Cobre mines.

### **2.2.1 Chino Mine**

Open-pit mining at Chino began in 1910. As of 1998, the Santa Rita Pit was approximately 1,500 feet deep, 1.8 miles in diameter, and covered more than 1,500 acres (M3 Engineering & Technology, 2001). The pit is actively dewatered by pumping groundwater wells to allow access to the ore. The pumping creates a cone of depression in the groundwater table, with the lowest groundwater elevations below the open pit. As a result, surrounding groundwater flows toward the pit (M3 Engineering & Technology, 2001). Mine dewatering water from the underground mine was historically discharged directly to Whitewater Creek (Golder Associates, 2008).

In 1911, a mill and concentrator were built near the current Hurley smelter site. The ore was extracted from the open pit and ground at the mill. In the flotation process, the ground ore is suspended in water and flotation chemicals (including a substance similar to pine sap), and air is bubbled through the mixture. The flotation chemicals attach to the copper sulfide minerals in the ground ore, air bubbles attach to the flotation chemicals, and the copper sulfide concentrate floats to the top of the flotation cells. The concentrate is skimmed from the top and sent to a smelter for sulfur removal. The material that does not float to the top (more than 99% of the ore) becomes

waste, which is referred to as tailings. The Hurley smelter was completed in 1939. Lake One was created in 1910 by damming Whitewater Creek to store water for the mill (Integrated Analytical Laboratories, 2009). Waste from the smelter (slag) was deposited on the northwestern side of Lake One. In 1982, a new mill and concentrator (the Ivanhoe Concentrator) near the open pit replaced the original Hurley mill and concentrator. Tailings from the flotation operation have been deposited east of Hurley in piles and impoundments along and near the former Whitewater Creek drainage.

In 1936, leaching operations of low-grade ore stockpiles were initiated near the open pit. Copper was extracted from leach solutions at precipitation plants. In 1988, the SX/EW plant was constructed east of the open pit, and additional leaching activities began (M3 Engineering & Technology, 2001). In the leaching process a sulfuric acid solution (pH 1.7 to 2.5) is applied to the top of the stockpiles. This solution percolates through the piles to form a high-copper PLS, which is collected at the bottom of the stockpiles. The PLS is then transferred to uncovered solution ponds and pumped to the SX/EW plant. An organic solvent is added to the PLS (SX), and the copper-bearing organic solvent solution is stripped of copper in the EW process, where the copper is precipitated onto a 99.9% pure metallic copper cathode. The stripped but still acidic PLS, known as raffinate, is recycled for further stockpile leaching (Dresher, 2001).

In 1997, 99,900 tons of copper were produced by flotation, and an additional 69,100 tons of copper were produced by the SX/EW process. In 2001, production rates dropped to 18,300 tons of copper by flotation and 59,900 tons of copper by SX/EW (U.S. Securities and Exchange Commission, 2002). The copper mill and flotation operation were shut down temporarily in March 2001. In January 2002, the Chino Mine was temporarily closed (U.S. Securities and Exchange Commission, 2002) but has since reopened. Primary extraction of ore from the pit by flotation continues, and the tailings are deposited in the active Tailings Impoundment 7. Flotation concentrate is currently sent to a smelter in Arizona (Golder Associates, 2008). Leaching of stockpiles and operation of the SX/EW plant are also ongoing. FMI is required by NMED to continue actively dewatering the open pit to prevent formation of a contaminated pit lake.

Located within the permit boundary of the Chino Mine, the Groundhog Mine is a historical underground polymetallic (zinc, lead, copper, silver) mine (see Figure 2.2). Lead carbonate was first mined along the Groundhog Fault in the late 1860s. Controlling interest in the three claims that make up the mine was sold to ASARCO in 1928, and mining continued into the 1970s. In 1994, ASARCO sold the property to Phelps Dodge. As a condition of the sale, ASARCO moved the stockpiles from Bayard Canyon to the San Jose shaft area and covered them with a thin layer of soil. One uncovered stockpile (Groundhog No. 5) remains (M3 Engineering & Technology, 2001).

### **2.2.2 Tyrone Mine**

In the late 1870s through the early 1900s, a number of companies mined turquoise, copper, and fluorspar in the Tyrone Mine area. Phelps Dodge consolidated the mining claims in the area by 1913 and developed a large-scale underground operation that shut down in 1921, with sporadic operations from 1921 to 1929 and from 1941 to 1950.

Open-pit copper mining began in 1967 when excavations were made to expose and mine the ore. By September 1969, 95 million tons of overburden had been removed from the Tyrone pit to allow the mining of copper ore to begin (SARB, 1999). In February 1999, the Tyrone open pit was approximately 1,400 feet deep and covered an area of about 1,400 acres. Parts of the pit have been partially or completely backfilled. The pit is actively dewatered, which induces groundwater flow toward the pit (M3 Engineering & Technology, 2001).

Initially, copper was recovered from the ore using flotation methods, with an initial mill and concentrator capacity in 1969 of 29,000 tons of ore per day. In 1972, the concentrator capacity was expanded to 50,000 tons per day (SARB, 1999). The copper concentrator operated from 1969 to 1992, and the concentrate was shipped offsite for smelting (M3 Engineering & Technology, 2001). The flotation process produced tailings as a by-product, which was then piped to one of six tailings impoundments in the Mangas Valley (SARB, 1999).

Stockpile leaching operations began in 1972 on the No. 1 stockpile, with copper extracted from the leach solution in a precipitation plant. Additional leaching operations began in 1984, with the opening of the SX/EW plant (SARB, 1999). In 2003, Discharge Permit 166 allowed the discharge of up to 35 million gallons per day of leach solution to the No. 2 leach stockpile and up to 49 million gallons per day of PLS to the SX/EW plant (NMED, 2003).

Since 1992, Tyrone has been solely a copper leach operation. From 1997 to 2001, annual production of copper through the SX/EW process at the Tyrone Mine ranged from 76,400 to 82,600 tons. An additional 2,600 tons of copper were produced by the precipitate process in 1997, but no precipitate copper has been produced since (U.S. Securities and Exchange Commission, 2002). In 2010, 202 million tons of ore were produced using SX/EW methods at an average ore grade of 0.28% (Freeport-McMoRan Copper & Gold, 2010).

### **2.2.3 Cobre Mine**

The Cobre Mine has a long history of copper and iron ore production. Commercial copper production by underground methods at the site began in 1858, and approximately 1 million pounds of copper were produced over a three-year period (M3 Engineering & Technology, 2001). The Modoc and Republic mines, located near the present-day Continental Pit and owned by the United States Smelting, Refining, and Mining Company (USSR&M), produced iron ore



(magnetite) from the early 1900s through 1974. Magnetite production peaked at 200,000 tons per year from 1916 to 1931. The magnetite tailings impoundment stored magnetite ore from 1967 to 1982. Underground mining of copper ore from a skarn deposit under what is now the Continental Pit began in 1947. The copper ore was extracted by USSR&M and processed using flotation methods at their Bullfrog Mill, located approximately 6 six miles south of the mine. Underground copper mining ended in 1971, shortly after open-pit extraction began at the Continental Pit in 1967.

The current phase of copper mining at the site began in 1964 with underground extraction and flotation operations at the Nos. 1 and 2 flotation mills (started in 1967 and 1973, respectively). The mine was closed from 1982 to 1993 due to low copper prices and went on standby in 1999 (Telesto Solutions, 2005). Although the mine has received approval to resume mining and expand operations (including excavation of Hanover Mountain, and expansion of the South WRDF and the Continental Pit), it has not yet resumed mining (as of 2011) (Telesto Solutions, 2005).

## **2.3 Summary of Remedial Actions**

FMI has conducted a number of remedial actions at the Sites, as listed in Table 2.1. Table 2.1 includes remedial measures completed by late 2009/early 2010 and some planned future remedial actions. The general types of remedial actions include groundwater pumping to maintain open-pit capture zones; regrading, covering, and revegetating tailings impoundments; installing groundwater and seep capture systems; limited removals of waste rock piles; restoration of Oak Grove Wash; and improvements in PLS collection systems. These remedial measures generally do not eliminate currently injured groundwater but could limit the future expansion of injured groundwater.

**Table 2.1. List of general remedial actions taken as of January 2010 at the Chino, Tyrone, and Cobre mines**

Mine site	Area	Current or completed remedial actions	Potential effect on groundwater injury
Chino Mine	Open Pit	Groundwater pumping (in perpetuity, with future treatment); upgraded PLS collection with steel raffinate tank.	Limits future expansion of injured groundwater around pit
	North Mine Area	<i>Lampbright Area/Reservoir 8</i> : drained PLS from Reservoir 8 (formerly unlined), cleaned out sediment, made lined concrete collection system with concrete and high-density polyethylene pipes and liners and stainless steel tank for PLS; pumpback systems using converted monitoring wells; after PLS spill (booster tank) on north slope of Lampbright, cleaned contaminated sediment, power-washed outcrops, installed warning system to shut down booster; installed French drain and pump north of Lampbright; lengthened trench near Sump 3. <i>SX/EW Area</i> : upgraded PLS collection with steel raffinate tank. <i>West/South Stockpiles</i> : built dams in paleochannels on west side; upgraded dams with new pumps and backup pumps. <i>South Stockpile</i> : upgraded PLS collection system, installed French drains. <i>Lucky Bill</i> : Reclaimed waste rock pile.	Size of spill area is diminishing; could decrease concentrations in injured groundwater near Lampbright and prevent formation of injured groundwater mound in future
	Middle Whitewater Creek Area	None.	NA
	South Mine Area	<i>Lake One, Axiflow Lake, smelter, old tailings impoundments, Impoundment 7</i> : Lake One regraded; smelter reclamation completed; conducted cleanup of house yards in Hurley; reclaiming Impoundments B, C, and 6 West (3-foot cover, revegetation); pumping injured groundwater from south toe of Impoundment 7 to top of Impoundment 7. <i>South of Impoundment 7/Distributary Area</i> : no plans for reclamation.	Limits future expansion of injured groundwater near old tailings areas
Tyrone Mine	Open Pit	Groundwater pumping (in perpetuity, with future treatment).	Limits future expansion of injured groundwater around pit
	Deadman Canyon	Water from pumpback well at seep 5E sent to No. 2A stockpile; removed the <i>United States Natural Resources, Inc. (USNR) Stockpile</i> and put on 2B waste pile; capture of contaminated seeps.	Could improve groundwater quality under former USNR stockpile area; limits future expansion of plumes associated with stockpiles

**Table 2.1. List of general remedial actions taken as of January 2010 at the Chino, Tyrone, and Cobre mines (cont.)**

Mine site	Area	Current or completed remedial actions	Potential effect on groundwater injury
Tyrone Mine (cont.)	East Side/Oak Grove	Capped <i>7A and 1C waste piles</i> : regrading and covering slopes; installed pumpback capture systems for 7A, 7A west, and other piles and some alluvial groundwater; removed southeast side of <i>1C waste stockpile</i> . <i>Oak Grove Wash</i> : rebuilt to create free-flowing stream (now water of the United States under CWA); installed capture systems across wash, smaller systems along Brick Kiln. <i>1A/1B leach stockpiles</i> : covered, regraded, and revegetated No. 1 and pumpback systems; covered Burro Mountain; moved some material from 1A to 1B; surface PLS collection structures upgraded.	Lessened extent of PLS plume in Oak Grove Wash, but alluvial groundwater becomes recontaminated after rain events; could limit future extent of injured groundwater from stockpiles; improves quality of stream
	No. 3 Stockpile	Installed two pump-back lines (L and EL) across upper Mangas Wash and many pumping wells – pumps to PLS pond; hydrocarbon remediation – pumping free product on perched water table.	Limits future expansion of injured alluvial and regional groundwater
	Mangas Valley	Installed line of pumpback wells north of 1X tailings; capped Nos. 1, 2, 3X, 3 impoundments (capped tops and sides, side slopes 3:1, stormwater channels around impoundments). Extracting diesel fuel oil (leak in distribution pipeline at diesel tank farm) with skimmer pump – migrated to regional aquifer (poor well casings).	Limits future expansion of injured alluvial groundwater; limits increase in diesel fuel contaminant concentrations in groundwater
Cobre Mine	Continental open pit and underground workings	Closure of shafts and adits, including Hanover Empire Zinc area (only covered if less than threshold acid-generating values); collecting seeps and stormwater; reclaimed Pearson Barnes area (revegetation unsuccessful); reclaimed Slate, Bullfrog, Copper Flat, Kearny; removed hydrocarbon-contaminated soils on east side of pit.	Limits future expansion of injured regional groundwater
	Tailings impoundments	Removed reclaim pond on <i>main tailings impoundment</i> (send water to Chino); removing (selling) <i>magnetite tailings</i> ; installed dust cover on main tailings area (only 6 inches thick).	Could decrease injured groundwater under tailings impoundment and in underground workings
	Waste rock facilities	Collecting seeps on south side of West waste rock facility, sending to Chino; covered much of West WRDF; collecting seeps on east side of East WRDF and Union Hill; upgraded seep collection systems in Poison Hill drainage (collects mine and natural seeps).	Reduces infiltration through piles, which could reduce future extent of injured groundwater

Sources: Daniel B. Stephens & Associates, 1997a, Table 2-2; Kurt Vollbrecht and Clint Marshall, NMED, personal communication, December 17, 2009 and January 20, 2010.

---

### **3. Injury Evaluation and Estimation of Groundwater Damages**

ONRT evaluated injuries to groundwater resulting from releases of hazardous substances at the Sites. ONRT also quantified the extent of groundwater injury over time in order to determine the amount of restoration that would be required to compensate for the injury. This chapter describes the injury quantification approach for groundwater resources.

#### **3.1 Injury Assessment Strategy**

The injury assessment strategy followed the general approach described in the NRDAR regulations developed for CERCLA [43 CFR § 11]. The categories of injury include the concepts of “injury,” “destruction,” and “loss,” as described in 43 CFR § 11.14(v).

To assess injury, ONRT used a three-part approach that included (1) evaluating the area where injury had occurred and the time periods over which injury had occurred; (2) developing an appropriate “metric” to quantify resource debits; and (3) quantifying the amount of injury using the selected metric.

#### **3.2 Groundwater Injury Determination**

This section describes injuries to groundwater resources and explains how the injuries were assessed and quantified. The evaluation focused on injured groundwater resources at the Sites that resulted from the release of hazardous substances from mining-related sources. The amount of injured groundwater is based on quantification of groundwater with concentrations of hazardous or related substances in excess of federal or New Mexico water quality standards.

The relevant definitions of groundwater injury for the Sites are:

- ▶ Concentrations of substances in excess of drinking water standards, established by sections 1411-1416 of the SDWA, or by other federal or state laws or regulations that establish such standards for drinking water, in ground water that was potable before the discharge or release [43 CFR § 11.62(c)(1)(i)].
- ▶ Concentrations of substances sufficient to have caused injury as defined in paragraphs (b), (d), (e), or (f) of this section to surface water, air, geologic, or biological resources, when exposed to ground water [43 CFR § 11.62(c)(1)(iv)].

### **3.2.1 Hazardous substance sources**

Mining differs from other industrial processes in that one of the principal sources of hazardous substances is the material itself (ore, waste rock, tailings). The other general source of hazardous substances is the chemicals added as part of the mining process, such as the low pH, sulfuric acid solution (“raffinate”) that is applied to the top of the stockpiles to leach copper. The primary sources of hazardous substances at the Sites include:

- ▶ Walls of the underground workings and open pits
- ▶ Mine wastes, including tailings, waste rock, and spent ore leach piles
- ▶ Ore and leach stockpiles
- ▶ Mine waters (PLS, raffinate, tailings supernatant water, seepage from wastes and mined materials, stormwater that contacts mine wastes).

The primary sources of hazardous substances can cause injury to groundwater and surface water, which in turn can become secondary sources of hazardous substances to downgradient groundwater.

### **3.2.2 Identity of hazardous substances**

The potential for mining sources to leach hazardous substances is estimated by laboratory leach tests. Concentrations of hazardous substances in seepage or groundwater samples taken downgradient of known hazardous substance sources confirm that releases have occurred. Hazardous substances have been identified in laboratory leach tests, mine waste seepage, and groundwater at all three mine sites.

#### **Hazardous substances in laboratory leach test samples**

At the Chino Mine, waste rock samples were subjected to humidity cell tests, which simulate the leaching of substances from mine wastes to groundwater. These tests demonstrated that the hazardous substances cadmium, cobalt, copper, manganese, and selenium had leached from the source material to groundwater at concentrations in excess of the State of New Mexico groundwater standards for human health and domestic water supply (State of New Mexico, 2011, 20.6.2.3103 NMAC, Subparts A and B). Detectable concentrations of the hazardous substances antimony, barium, beryllium, chromium, lead, mercury, silver, and thallium were also observed in the leachate from the same tests (Golder Associates, 1998).

At the Tyrone Mine, samples representative of the pit wall, stockpiles, and tailings were subjected to the short-term synthetic precipitation leaching procedure (SPLP) and longer-term (humidity cell) leach testing (Daniel B. Stephens & Associates, 1997b, 1997d). The leach test results showed that the hazardous substances arsenic, cadmium, copper, iron, lead, manganese,

and zinc had leached into groundwater from the source material at concentrations in excess of State of New Mexico groundwater standards for human health and domestic water supply. In addition, the SPLP leachate included detectable concentrations of the hazardous substances cobalt and zinc (Daniel B. Stephens & Associates, 1997d, 1999).

At the Cobre Mine, tailings samples were subjected to the SPLP test. These tests showed that the hazardous substances arsenic, cadmium, copper, lead, and manganese had leached into the groundwater from the source material at concentrations in excess of State of New Mexico standards for human health and domestic water supply. The SPLP leachate also contained detectable concentrations of the hazardous substances cobalt and zinc (Daniel B. Stephens & Associates, 1997b).

### **Hazardous substances in mine leachate and groundwater samples**

Using water quality databases supplied by FMI and NMED for groundwater wells, seeps, and springs at the Chino, Tyrone, and Cobre mines, the following hazardous and related substances were detected at elevated concentrations and were, in most cases, above relevant human-health-based water quality standards<sup>1</sup>:

- ▶ Antimony
- ▶ Arsenic
- ▶ Beryllium
- ▶ Cadmium
- ▶ Chromium
- ▶ Cobalt
- ▶ Copper
- ▶ Ferrous and ferric sulfate
- ▶ Lead
- ▶ Manganese
- ▶ Nickel
- ▶ Selenium
- ▶ Sulfate
- ▶ Sulfuric acid
- ▶ Thallium

---

1. There are no federal or New Mexico water quality standards for sulfuric acid, ferrous sulfate, or ferric sulfate. Cobalt was detected at levels above the New Mexico irrigation standard of 0.05 milligrams per liter. Nickel was detected at levels above the federal lifetime health advisory of 0.1 milligrams per liter (U.S. EPA, 2009). Measured concentrations for the remainder of the hazardous substances on the list were compared to health-based New Mexico or federal standards. Toluene concentrations did not exceed standards but reached as high as 0.26 milligrams per liter in groundwater at the Chino Mine. Data ranged from 1980 to 2006.

- ▶ Toluene
- ▶ Zinc.

### **Use of sulfate concentrations to determine groundwater injury**

As described in this section, exceedence of the sulfate standard is considered an injury because sulfate is a product of reactions resulting from the release of hazardous substances:

Injury means a measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a discharge of oil or release of a hazardous substance, or exposure to a product of reactions resulting from the discharge of oil or release of a hazardous substance [43 C.F.R. § 11.14(v)].

There are three ways in which sulfate is a product of reactions resulting from the release of hazardous substances at the Sites:

1. Sulfate derives from the release of hazardous substances at the Sites through the formation of acidic leachate from stockpiles, waste rock, and pit walls. The acidic, metal- and sulfate-rich solution that forms is referred to as acid mine or acid rock drainage (“acid drainage”), and it is one of the most serious environmental issues at mine sites (U.S. EPA, 1994). Acid drainage occurs at all three Sites, especially at the open pits and stockpiles. The exposure of mined materials (e.g., wall rock, waste rock, tailings, stockpiles, ore) to air and water starts the leaching process. At the Chino Mine, the main sulfide mineral in the ore and surrounding rocks is an iron sulfide mineral called pyrite (Golder Associates, 2008). When pyrite is exposed to oxygen and water, it generates sulfuric acid, a listed hazardous substance. The sulfuric acid, which contains sulfate, leaches hazardous substances from other metal sulfides that contain copper, lead, cadmium, zinc, and other metals and metalloids. The metal sulfides in waste rock and tailings are themselves listed hazardous substances (e.g., cadmium and compounds, lead sulfide, copper and compounds, zinc and compounds). When these sulfide minerals are exposed to air and water, they produce leachate that contains elevated concentrations of sulfate and metals (Plumlee, 1999).
2. Raffinate, the leaching solution for the stockpiles, contains sulfuric acid and ferrous and ferric sulfate (Dames & Moore, 1983). After the raffinate has percolated through the piles, it contains sulfuric acid, ferrous and ferric sulfate, and copper, and is known as PLS. Sulfuric acid, ferrous sulfate, and ferric sulfate are listed hazardous substances and all contain sulfate. Leakage of PLS has contaminated groundwater in Oak Grove Wash at the Chino Mine and in the upper Mangas Wash and Deadman Canyon at the Tyrone Mine (Daniel B. Stephens & Associates, 1997a; Golder Associates, 2008).

3. Acidic and non-acidic leachate derived from mined materials can evaporate and form highly soluble metal sulfate salts (Nordstrom and Alpers, 1999), which are also listed hazardous substances (e.g., cupric sulfate, ferric sulfate, ferrous sulfate, zinc sulfate). Such salts often form on the walls of open pits and underground workings and on the surfaces of waste rock and tailings impoundments. When they dissolve, for example, after a summer thunderstorm or snowmelt, they rapidly produce leachate with elevated concentrations of sulfate and metals.

In summary, sulfate forms from leaching of primary mined materials, from dissolution of metal sulfate salts, and from the addition of raffinate to the leach piles. Because sulfate is ubiquitous at the Sites and a product of reactions resulting from the release of hazardous substances, exceedence of the sulfate standard was used as the overall measure of injury at the Sites.

### **3.2.3 Relevant standards**

The relevant water quality standards for evaluation of groundwater injury are the SDWA maximum contaminant levels (MCLs) and secondary maximum contaminant levels (SMCLs), and the State of New Mexico human health groundwater standards. Table 3.1 summarizes the relevant standards for hazardous or related substances identified at the Sites. The New Mexico standards are applied to dissolved concentrations (State of New Mexico, 2011).

### **3.2.4 Identification of injured groundwater plumes**

ONRT considered all groundwater affected by mining activities with sulfate concentrations exceeding 250 milligrams per liter to be injured because sulfate levels in this water exceeded federal SDWA standards. For the injury quantification phase, areas were classified as either having no injury (if sulfate concentrations were below 250 milligrams per liter) or being completely injured (if sulfate concentrations were above 250 milligrams per liter).

Injury to groundwater was evaluated using water quality data supplied by FMI and NMED. The groundwater plumes were determined by identifying the areas where groundwater exceeded the federal sulfate standard. The areal extent was determined by mapping the projection of plumes on the land surface. Areas with sulfate concentrations above 250 milligrams per liter were considered to be in the plume, whereas areas with concentrations below 250 milligrams per liter were considered to be outside the plume. Using sulfate concentrations resulted in delineation of the largest plumes of any other individual hazardous substance. However, there were some limited areas where concentrations for other hazardous substances outside of the sulfate plumes exceeded standards.



**Table 3.1. Water quality standards used to determine groundwater injury for the Sites (mg/L)**

<b>Analyte</b>	<b>State of New Mexico standard<sup>a</sup></b>	<b>Federal SDWA standard<sup>b</sup></b>
Antimony	–	0.006
Arsenic	0.1	0.01
Beryllium	–	0.004
Cadmium	0.01	0.005
Chromium	0.05	0.1
Copper	1.0	1.3 <sup>c</sup>
Lead	0.05	0.015 <sup>c</sup>
Selenium	0.05	0.05
Sulfate	600	250
Thallium	–	0.002
Toluene	0.75	1
Zinc	10.0	5.0

a. 20.6.2.3103 NMAC, Subparts A and B (human health and domestic water supply only).

b. Federal MCL for all but sulfate and zinc (SMCL).

c. Action level (the concentration of a contaminant that, if exceeded, triggers treatment or other requirements that a water system must follow; U.S. EPA, 2009).

Sources: State of New Mexico, 2011; U.S. EPA, 2009.

The plumes were mapped separately in alluvial and regional aquifers. Rock types in the regional aquifers included the Gila Conglomerate, granite, volcanics, sedimentary rocks, and igneous sills and dikes. Table 3.2 lists the identified contaminant plumes in groundwater at the Sites.

### **3.2.5 Examples of water quality standard exceedences**

Table 3.3 contains examples of exceedences of New Mexico and federal human health-based water quality standards for the Chino, Tyrone, and Cobre mines. Wells listed in Table 3.3 were selected based on the longest period of record for a given area at each mine site. Examples were selected from both regional and alluvial plumes. The most common analyte that exceeded water quality standards was sulfate. Some of the highest measured sulfate concentrations were in the Chino open-pit area, with values more than 300 times the federal drinking water standard and almost 140 times the New Mexico groundwater standard.

**Table 3.2. Identified groundwater plumes in alluvial and regional aquifers at the Sites**

<b>Mine site</b>	<b>General area</b>	<b>Plume name and aquifer type</b>	<b>Geologic unit</b>
Chino	Open Pit	Open Pit Regional	Volcanics, Santa Rita Stock, metasedimentary, sills and dikes
	North Mine Area	Lampbright Regional	Mix of sedimentary, sills and dikes, volcanics
		West and South Stockpiles Regional	Mostly sills and dikes (West Stockpile); volcanics (South Stockpile)
	Groundhog Mine Area	Groundhog Alluvial	Alluvium
	Middle Whitewater Creek Area	Middle Whitewater Alluvial	Alluvium
		Middle Whitewater Regional	Volcanics
	South Mine Area	Lake One Area Regional	Upper Gila Conglomerate
			Volcanics
		Old Tailings Impoundment Area – Regional	Upper Gila Conglomerate
		Bolton Wellfield – Regional	Volcanics
		Eastern edge of Old Tailings and Tailings Impoundment 7 – Regional	Volcanics
		Old Tailings Impoundment Area – Regional	Upper Gila Conglomerate
		Tailings Impoundment 7 Area – Regional	Upper Gila Conglomerate
		South of Tailings Impoundment 7 Area – Regional	Upper Gila Conglomerate
		South Whitewater Area – Regional	Upper Gila Conglomerate
Tyrone	Open Pit	Open Pit Regional	Granite
	Deadman Canyon	Deadman Canyon Alluvial	Alluvium
	East Side	East Side Alluvial	Alluvium
		East Side Regional	Gila Conglomerate
	Mangas Valley	Mangas Valley Alluvial	Alluvium
		Mangas Valley Regional	Gila Conglomerate
	No. 3 Stockpile	No. 3 Stockpile Alluvial	Alluvium
		No. 3 Stockpile Regional	Gila Conglomerate

**Table 3.2. Identified groundwater plumes in alluvial and regional aquifers at the Sites (cont.)**

Mine site	General area	Plume name and aquifer type	Geologic unit
Cobre	Continental Pit	Continental Pit Regional	Limestone, granite, shale, siltstones
	WRDFs	West Waste Rock Regional	Limestone, shale
		Buckhorn Waste Rock Regional	Limestone, shale
		East Waste Rock Regional	Hanover-Fierro Stock (granite)
		South Waste Rock Regional	Dolomite, granite
		Union Hill Waste Rock Regional	Dolomite, granite
	Hanover Creek	Hanover Creek Alluvial	Alluvium

**Table 3.3. Examples of water quality exceedences in groundwater from the Chino, Tyrone, and Cobre mines**

Mine site	General area	Plume name and aquifer type	Example wells	Period of record	Selected concentration ranges (mean value), (mg/L)
Chino	North Mine Area	Open Pit Regional	459-98-05	1999–2006	Sulfate = 13,600–83,400 (31,800); cadmium = 0.523–1.39 (0.817); copper = 359–1,100 (684); lead = 0.086–17 (3.52)
		West and South Stockpiles Regional	WD-6S (West Stockpile)	1989–2003	Sulfate = 1,869–12,100 (4,470); cadmium = 0.09–4.86 (0.787); copper = 0.004–7.02 (0.376); lead = 0.005–1.51 (0.456)
	Middle Whitewater Creek Area	Middle Whitewater Alluvial	B-40 (southern end)	1982–2005	Sulfate = 290–1,200 (857); copper = 0.004–2.2 (0.20); lead = 0.006–0.42 (0.07)
	South Mine Area	Old Tailings Impoundment Area – Regional	DM-14D (near Bolton wellfield)	1982–2001	Sulfate = 1,280–1,979 (1,620); copper = 0.001–1.3 (0.13); lead = 0.003–0.049 (0.015)
Tyrone	Deadman Canyon	Deadman Canyon Alluvial	TWS-28 (most downstream end)	2003–2004	Sulfate = 649–945 (785); cadmium = 0.005–0.012 (0.008); copper = 33.2–50.6 (39.6)
	East Side	East Side Regional	MB-18D (Upper Oak Grove Wash)	1995–2004	Sulfate = 1,050–7,350 (2,720); cadmium = 0.02–1.0 (0.24); copper = 2.2–276 (140)
	No. 3 Stockpile	No. 3 Stockpile Regional	6-2R (Upper Mangas Wash)	1991–2005	Sulfate = 340–1,280 (707); cadmium = 0.032–0.29 (0.08); copper = 0.01–4.56 (1.31)

**Table 3.3. Examples of water quality exceedences in groundwater from the Chino, Tyrone, and Cobre mines (cont.)**

<b>Mine site</b>	<b>General area</b>	<b>Plume name and aquifer type</b>	<b>Example wells</b>	<b>Period of record</b>	<b>Selected concentration ranges (mean value), (mg/L)</b>
Cobre	Continental Pit	Continental Pit Regional	MW-2 (ore stockpile)	2007–2009	Sulfate = 1,100–1,430 (1,200)
	WRDFs	West Waste Rock Regional	MW-20	2006–2009	Sulfate = 1,700–2,500 (1,960)
	Hanover Creek	Hanover Creek Alluvial	MW-12 (Hanover Creek area)	2007–2009	Sulfate = 2,250–2,550 (2,390); manganese = 0.664–0.755 (0.710)

Data sources: Electronic databases provided to Stratus Consulting by FMI and NMED, 2006–2008.

Cadmium concentrations also exceeded health-based water quality standards in groundwater at the Chino Mine (North Mine Area) and the Tyrone Mine (Deadman Canyon, the East Side, and the No. 3 Stockpile area). Copper and lead concentrations exceeded New Mexico and/or federal water quality standards in regional groundwater at the Chino Mine and in alluvial and regional groundwater at the Tyrone Mine. Sulfate concentrations in groundwater samples at the Cobre Mine regularly exceeded both federal and New Mexico water quality standards, and some of the samples also had manganese exceedences.

### **3.3 Pathway Determination**

Federal regulations at 43 CFR Part 11 define pathway as:

Pathway means the route or medium through which oil or a hazardous substance is or was transported from the source of the discharge or release to the injured resource [43 CFR § 11.14(dd)].

Hazardous substances from sources at the Sites (see Section 3.2.1) are transported to groundwater from infiltration of contaminated surface runoff; seepage from the walls of open pits and underground workings, waste rock, stockpiles, tailings, and leach piles; and leaks from mine water, stormwater, or process water reservoirs. Injured groundwater can then expose downgradient biologic, geologic, and surface water resources.

### **3.3.1 Primary pathways for groundwater contamination**

Hazardous substances move from mining-related sources through natural resources, such as groundwater, to receptors, such as surface water. Two site-specific examples of ways in which groundwater can become injured and then injure other resources are provided in this section [see also a similar discussion for the Chino Mine in Golder Associates (2008), Section 5.1].

#### **Stockpiles or waste rock to alluvial and regional groundwater**

At the Chino and Tyrone mines, ore stockpiles are leached by infiltrating raffinate, natural precipitation (rain and snow), and stormwater runoff. At the Cobre Mine, no ore stockpiles exist, but the same pathway process functions at the WRDFs via infiltration of rain and snow and leaching of hazardous substances. The resulting liquid leachate has elevated concentrations of hazardous and related substances, including sulfate, cadmium, copper, lead, and zinc. The majority of the leachate from the ore stockpiles at the Chino and Tyrone mines is captured as PLS and processed at the SX/EW facility. However, some of the leachate leaks to groundwater under the unlined facilities (no stockpiles or waste rock facilities are lined at any of the Sites). Escaped leachate and PLS have injured alluvial groundwater in Deadman Canyon and alluvial and regional groundwater in Oak Grove Wash at the Tyrone Mine. Escaped PLS and leachate from the No. 3 stockpile at the Chino Mine have injured alluvial “fingers” under and downgradient of the stockpile, and this groundwater has further injured alluvial groundwater in Mangas Wash. Contaminants in alluvial groundwater can enter surface water in zones where surface water and alluvial groundwater mix, thereby exposing surface water and biological resources.

#### **Tailings areas to alluvial and regional groundwater**

All three mine sites have tailings in unlined impoundments. Hazardous and related substances in the tailings are leached by tailings supernatant (water sitting on top of tailings impoundments), which can include water pumped with the tailings and natural precipitation. In addition, before the tailings impoundments at the Tyrone Mine were remediated, the concentrations of hazardous substances increased during the summer dry season in small ponds on top of the impoundments. Metal-sulfate salts are formed by evaporation and dissolve rapidly during a thunderstorm event, resulting in high concentrations of metals in the ponds. Water associated with the tailings impoundments has infiltrated to underlying alluvial and regional groundwater. The injuries identified in regional groundwater at the Chino South Mine Area and in alluvial groundwater in Mangas Wash at the Tyrone Mine are due, at least in part, to infiltration through tailings.

As discussed above, contaminants in alluvial groundwater can enter surface water in zones where surface water and alluvial groundwater mix, thereby exposing surface water and biological resources.

## 3.4 Groundwater Injury Quantification

### 3.4.1 Baseline conditions

Baseline conditions are those that existed at the Sites absent the release of hazardous and related substances:

Baseline means the condition or conditions that would have existed at the assessment area had the discharge of oil or release of the hazardous substance under investigation not occurred. [43 CFR § 11.14(e)].

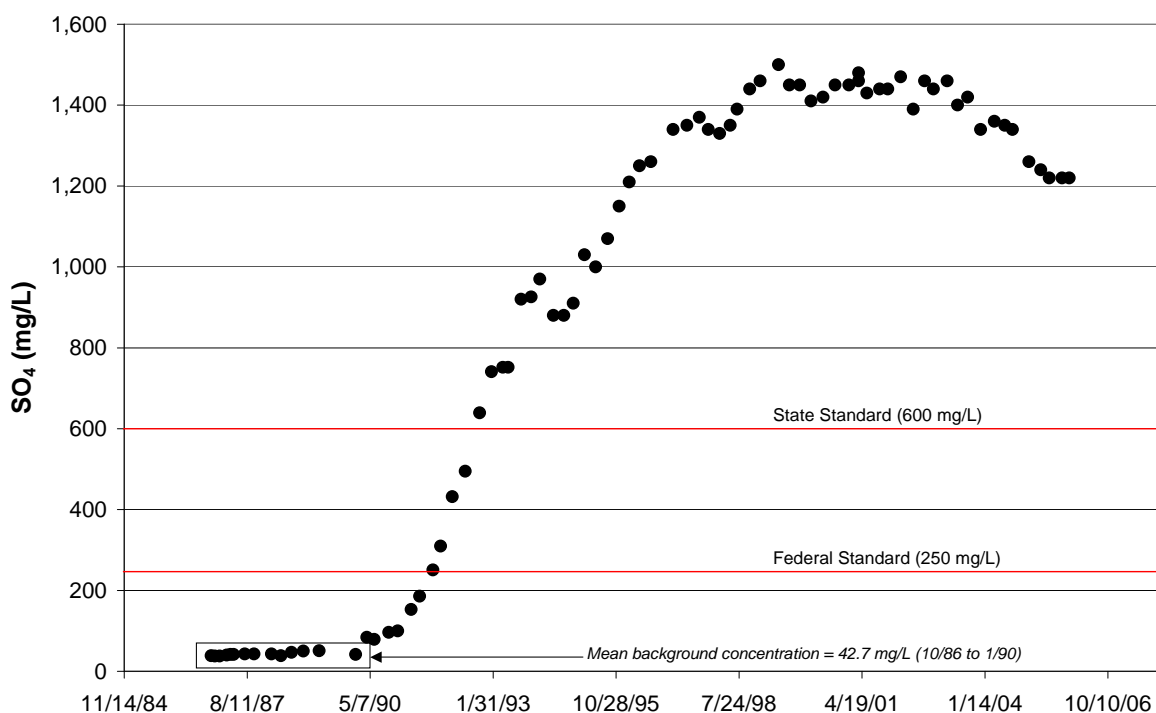
According to Trauger (1972), regional groundwater in Grant County is a calcium-bicarbonate-type water with low sulfate concentrations (7–56 milligrams per liter), and alluvial groundwater is a calcium-bicarbonate-sulfate-type water with elevated nitrate and moderate sulfate concentrations (119 milligrams per liter). Studies of baseline groundwater quality have been conducted by consultants for FMI, including Daniel B. Stevens & Associates (1997a) for the Tyrone Mine, Golder Associates (1999, 2004) for the Chino Mine, and Shepherd Miller (1999) for the Cobre Mine. The results show that water quality is potable outside the influence of the mining areas. Manganese concentrations were naturally elevated in the Chino North Mine Area (Golder Associates, 1999) and the Cobre Mine (Shepard Miller, 1999). A study of 165 domestic wells in the vicinity of the Sites showed that trace metal concentrations in all sampled wells away from mining influence were below primary drinking water standards and therefore potable, although elevated concentrations of sulfate and total dissolved solids (TDS) were present in some areas (Golder Associates, 2004). Baseline groundwater quality in the Chino South Mine Area had low sulfate concentrations in all regional geologic units, including 46 milligrams per liter in the Gila Conglomerate, 55 milligrams per liter in volcanic rocks, and 65 milligrams per liter in limestone units (Golder Associates, 1999).

Plots of constituent concentrations over time can be used to estimate baseline groundwater quality in locations not affected by mining activity or wells affected only after mining activities began. There are many wells in regional aquifers outside of identified plumes with sulfate concentrations below federal and New Mexico standards. For example:

- ▶ Chino Mine well SX-6 (located on the northeastern side of the open pit and SX/EW areas, inside but topographically below the cone of depression; depth = 300 feet)
  - Sulfate concentrations ranged from 9.4 to 136 milligrams per liter throughout the period of record (1990–2003)

- ▶ Chino Mine well 459-96-03 (located north of the open pit outside the cone of depression; depth = 220 feet)
  - Sulfate concentrations ranged from 123 to 154 milligrams per liter throughout the period of record (1999–2005)
- ▶ Tyrone Mine well C111.1 (located in channel on northwestern toe of the No. 3 stockpile; depth = 210 feet)
  - The average sulfate concentration was 113 milligrams per liter from December 1990 through September 1996; concentrations increased after this time and peaked at 1,590 milligrams per liter in February 2003.

Figure 3.1 shows sulfate concentrations in another regional well (7AS) in the South Mine Area at the Chino Mine. Concentrations were low through January 1990 (the mean sulfate value was 42.7 milligrams per liter between 1986 and early 1990). Deposition of tailings into Tailings Impoundment 7 began in mid-1988 (Golder Associates, 2008). Concentrations in well 7AS peaked at 1,500 milligrams per liter in mid-1999 and remained above 1,200 milligrams per liter through at least 2005.



**Figure 3.1. Concentrations of sulfate in well 7AS at the Chino Mine, located on the west side of Tailings Impoundment 7. The well is 222 feet deep and in the Gila Conglomerate.**

Data source: Golder Associates, 2006.

Most or all the alluvial aquifers at all three mine sites have been injured from mining activity. Baseline water quality for the alluvial aquifer relies largely on studies in nearby areas that have not been affected by mining, as noted above. There are a limited number of upgradient alluvial aquifer wells at the Sites, and sulfate concentrations are generally low. For example:

- ▶ Tyrone Mine alluvial well TWS-35 in upper Deadman Canyon (11.3 feet deep) had sulfate concentrations ranging from approximately 30 to 115 milligrams per liter, with all but one value below 100 milligrams per liter.
- ▶ Chino Mine alluvial well 526-2000-4D, located on the far east side of the Middle Whitewater Area (200 feet deep). Sulfate concentrations in 2001–2006 ranged from 18.8 to 40.9 milligrams per liter. The shallower associated well, 526-2000-4S, is in the injured portion of the alluvial aquifer and has sulfate concentrations ranging from 1,340 to 1,930 milligrams per liter.

In summary, baseline concentrations of sulfate, the parameter used to measure groundwater injury at the Sites, and metals were lower than relevant water quality standards. This groundwater was potable prior to the release of hazardous substances at the Sites. Therefore, the groundwater injury definition has been met at the Sites, and no areas were excluded from injury because of baseline exceedences.

### **3.4.2 Extent of injured groundwater**

The calculation of groundwater injury focused on sulfate and took into account baseline groundwater quality. Groundwater that was pumped and used in mine processes was not counted as injured groundwater because it avoided the use of clean surface water or groundwater. Examples of pumped water include dewatering water pumped from the Tyrone and Chino open-pit areas and PLS pumped from recovery wells in Oak Grove Wash at the Tyrone Mine. However, water that was pumped from the active tailings area at the Chino Mine (Tailings Impoundment 7) was counted as injured because it was released to the Mangas Valley rather than used in mine processes.

For the Chino and Tyrone mines, average groundwater sulfate concentrations in alluvial and regional wells were used to delineate the extent of groundwater injury at the Sites. Wells with sulfate concentrations exceeding the federal SDWA standard of 250 milligrams per liter were identified on geographic information system (GIS) maps of each mine site. The maps delineated regional and alluvial injury separately. Plumes were hand-drawn using the maps showing sulfate exceedences. Areas under mine installations, including open pits, waste rock, stockpiles, and tailings impoundments, were included in the plumes.



For the Cobre Mine, a different approach was used to delineate groundwater injury because only limited groundwater monitoring data were available (groundwater monitoring began in 1995; Telesto Solutions, 2007). ONRT and FMI agreed during the settlement process that it was reasonable to assume that all alluvial groundwater on the site downgradient of mining sources exceeded the sulfate water quality standard after 1981. For the regional aquifer, Telesto Solutions (2007) assumed that water derived from precipitation infiltrating the waste rock piles would injure regional groundwater a certain distance downgradient of the piles. The distance was determined using an assumed infiltration rate for the piles (5% of total precipitation), maximum leachate concentrations measured in longer-term humidity cell tests, and a specific yield in the regional aquifer of 2% (Telesto Solutions, 2007). The East, Union Hill, South, West, and Buckhorn Waste Rock facilities were included in the analysis.

In some cases, injured alluvial groundwater overlies injured regional groundwater (e.g., downgradient of the No. 3 Stockpile at the Tyrone Mine). In these instances, both injuries were counted because two layers of injured groundwater existed at those locations. Figures 3.2–3.4 depict the areal extent of injured groundwater in alluvial and regional aquifers at the Chino, Tyrone, and Cobre mines, respectively.

Table 3.4 summarizes the areal extent of injured groundwater at the Sites. The Chino Mine had the largest areal extent of injured alluvial and regional groundwater, at 13,935 acres. The Tyrone Mine had an injured areal extent of 6,280 acres, and the Cobre Mine had an areal extent of 528 acres of injured groundwater. The extent of regional groundwater was larger than that of alluvial groundwater at all three sites. The total areal extent of injured regional groundwater was 19,299 acres, while the total areal extent of injured alluvial groundwater was 1,444 acres.

In addition to injured groundwater, ONRT accounted for water that was pumped from Tailings Impoundment 7 at the Tyrone Mine and not used in the flotation operations. The concentrator at the Tyrone Mine was closed from March 2001 to June 2004. During this time, water was pumped from the impoundment at a rate of 3,222 acre-feet per year and released to the Mangas Valley tailings impoundments. The total volume pumped while the concentrator was closed was 10,600 acre-feet. Information on the pumped volumes and duration of pumping was provided by FMI during the settlement process.

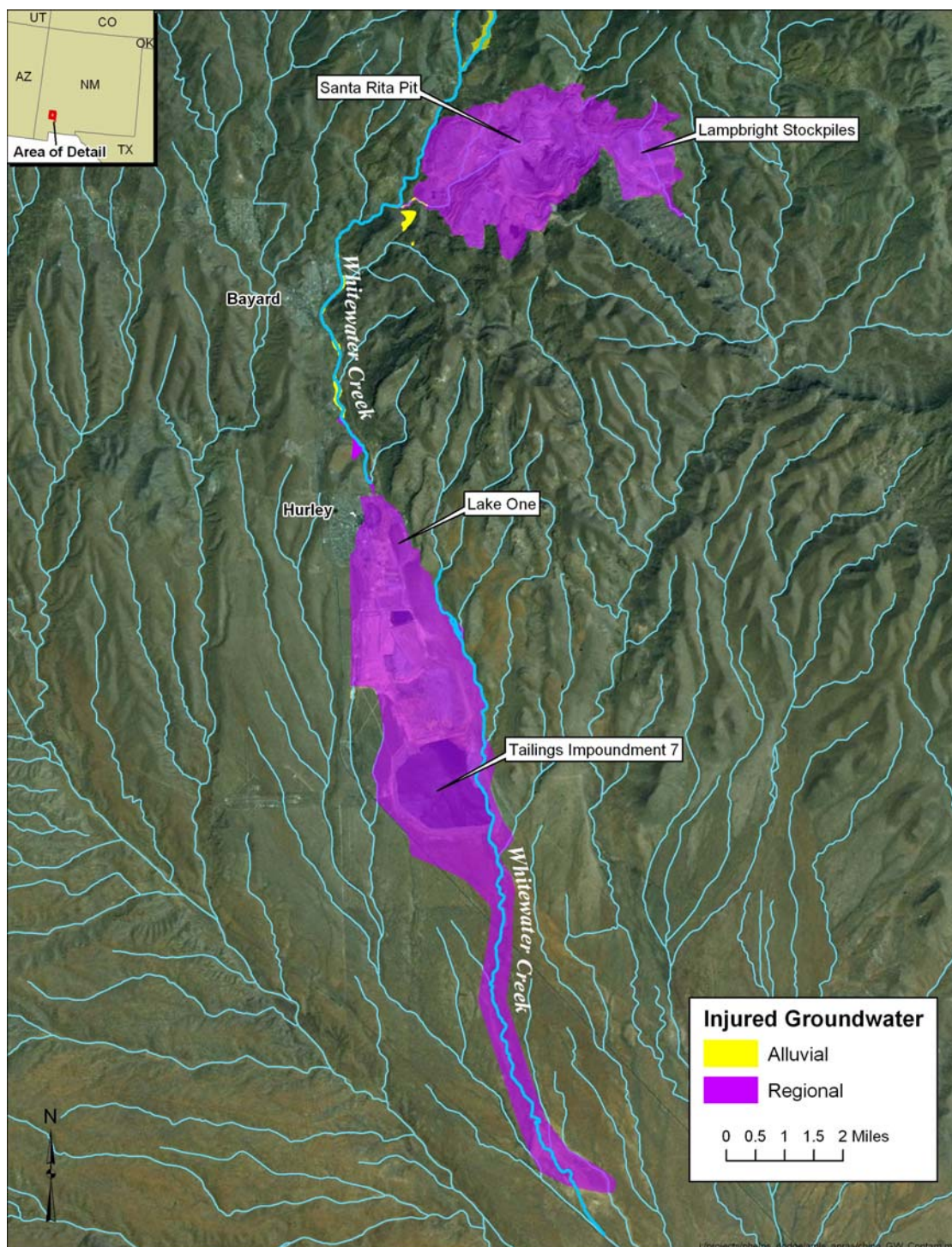


Figure 3.2. Areal extent of injured alluvial and regional groundwater at the Chino Mine.



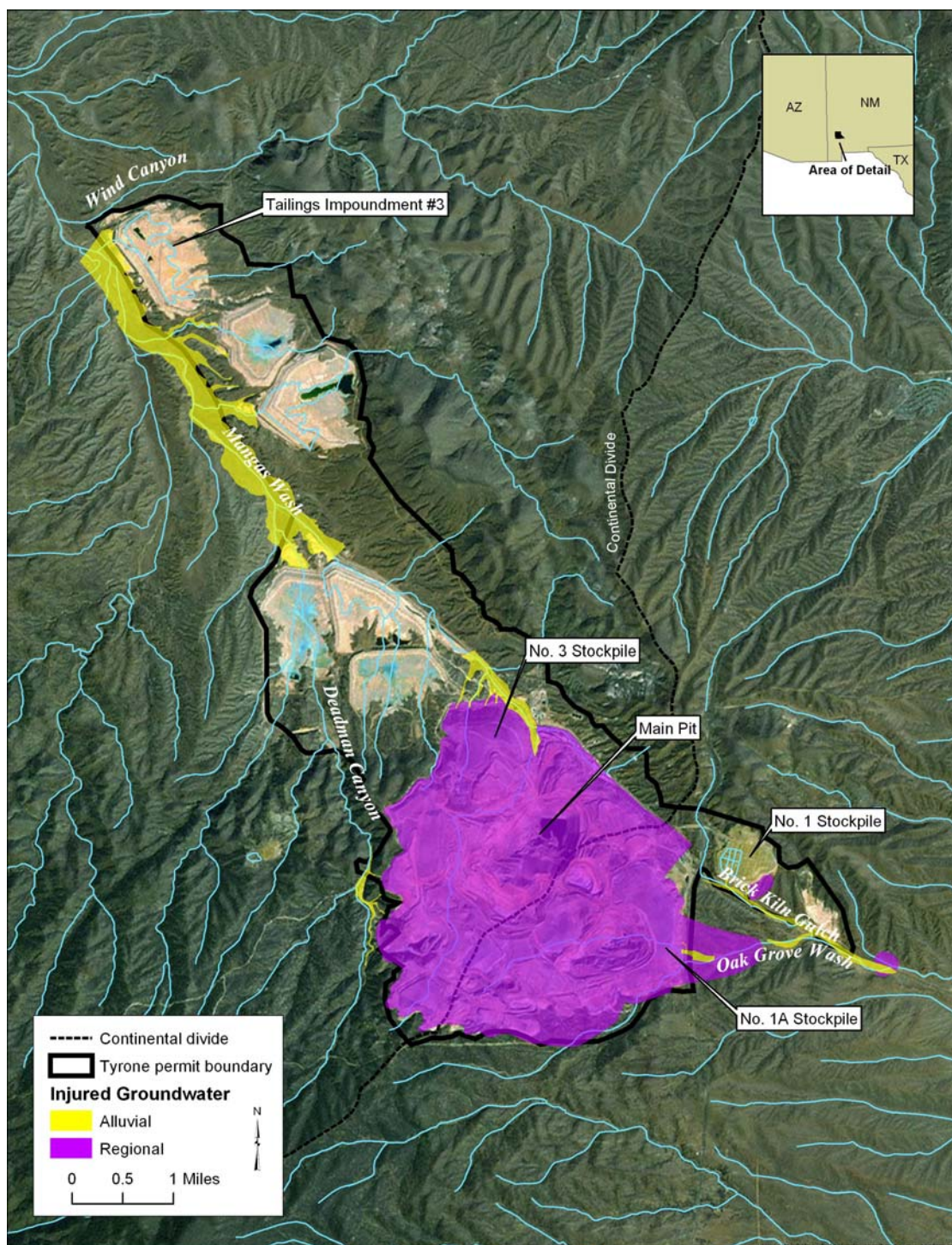


Figure 3.3. Areal extent of injured alluvial and regional groundwater at the Tyrone Mine.



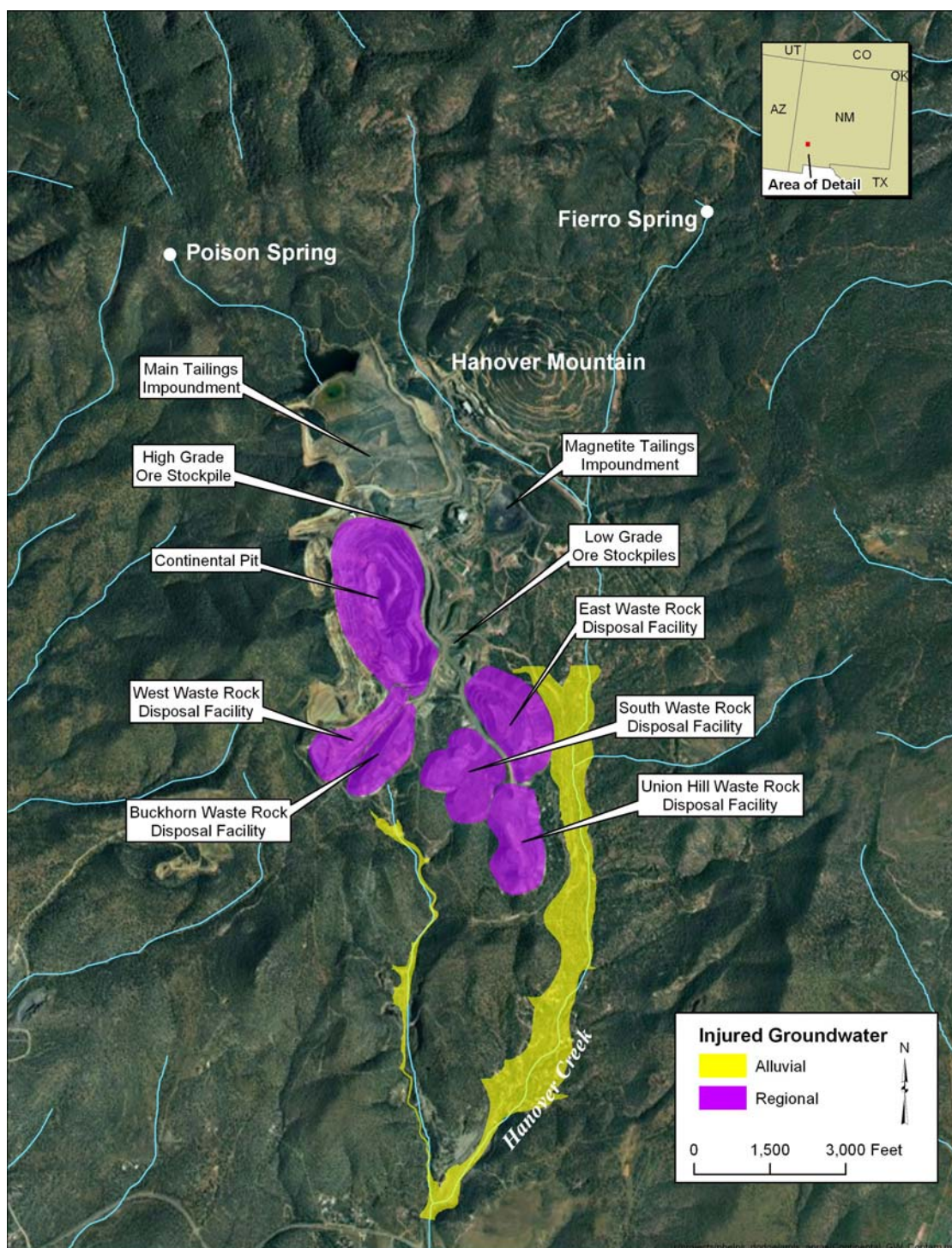


Figure 3.4. Areal extent of injured alluvial and regional groundwater at the Cobre Mine.

**Table 3.4. Areal extent of injured groundwater at the Chino, Tyrone, and Cobre mines**

<b>Mine site</b>	<b>Aquifer type</b>	<b>Injured areal extent (acres)</b>
Chino	Regional groundwater	13,718
	Alluvial	217
	Sum	13,935
Tyrone	Regional groundwater	5,253
	Alluvial	1,027
	Sum	6,280
Cobre	Regional groundwater	328
	Alluvial	200
	Sum	528
<b>Total injured areal extent:</b>		<b>20,743</b>

### 3.4.3 Duration of release

For the assessment, groundwater injury was quantified starting in 1981. Although groundwater injury likely existed before 1981 at all Sites, especially in areas around the pits and older tailings impoundments, ONRT limited their quantification of injury to the time period following the enactment of CERCLA legislation in December 1980. Groundwater quality samples at the Sites were collected as early as the late 1970s/early 1980s in some locations. Many of these samples revealed mining-related exceedences from the first sampling efforts. Some samples near the edges of plumes and away from primary sources initially had low concentrations of hazardous and related substances and later had exceedences of water quality standards (see discussion of baseline water quality in Section 3.4.1). In these instances, shorter durations of injury were incorporated into the injury quantification.

As part of the settlement process, ONRT and FMI agreed in 2008 that groundwater injuries were expected to continue for a significant period into the future. Although future implementation of remedial actions at the Site may shorten the time period of groundwater injury in limited locations, ONRT assumed a “reasonable worst case scenario” of continued injury for 100 years, through 2108, for the purpose of evaluating and quantifying injury.

### **3.4.4 Likelihood of future recovery**

The injured groundwater consists of plumes of sulfate and metals in alluvial and regional aquifers. Unlike organic compounds, inorganic compounds such as metals do not degrade thermally or bacterially in groundwater. Although sulfate can be converted to other sulfur compounds, such as sulfide, under highly reducing conditions, there are many wells at the Sites with more than 20 years of relatively constant and elevated sulfate concentrations. Concentrations of some inorganic compounds at mine sites, such as nitrate, which derives from blasting agents used to excavate open pits and underground workings, can decrease over time if blasting operations cease. However, the sources of sulfate and metals at the Sites still remain and are still leaching contaminants to groundwater. It is highly unlikely that concentrations of these constituents will decrease markedly over time. These characteristics of the groundwater injury plumes support an assumption that injury will last for at least 100 years at the Sites.

### **3.4.5 Quantifying compensatory restoration**

To develop an estimate of monetary damages necessary to offset the quantified groundwater injury and compensate the citizens of the State of New Mexico, ONRT used the “cost of replacement and/or acquisition of equivalent natural resources” approach described in the CERCLA natural resource damage assessment regulations at 43 C.F.R. 11.80 (b). ONRT chose the cost of acquiring water rights in two watersheds in New Mexico as the measure of “acquiring equivalent natural resources.” To develop an estimate of the cost to acquire the equivalent water resources, ONRT utilized the following information:

- ▶ The estimated volume of injured groundwater. This estimate was developed using a set of assumptions about factors such as aquifer porosity and saturated thickness of injured groundwater that allowed ONRT to translate estimates of the areal extent of injured groundwater to a volume of injured groundwater in different locations.
- ▶ Estimates of when groundwater injury began for each plume (start date), and when groundwater may be considered not injured based on remedial actions and natural attenuation (recovery path).
- ▶ The cost to acquire equivalent groundwater resources.
- ▶ An economic discount rate that accounts for the duration of injury. ONRT applied a 3% discount rate, which is standard practice in economic analysis and natural resource damage assessment applications (NOAA, 1999).

To develop the cost to acquire equivalent water resources, ONRT used recent estimates of the cost to acquire water rights in the Silver City region of New Mexico. A water right allows the holder to use a certain amount of water, typically measured in acre-feet,<sup>2</sup> each year into the future. To estimate the amount of water rights necessary to provide an amount of water equivalent to what was injured, ONRT developed an estimate of how much water is provided over time by a 1 acre-foot water right. This estimate applied the 3% annual discount factor, which accounts for the fact that a water right provides a certain volume of water over time to the owner of the right. The resulting volume measure is described as “discounted” acre-feet. Using information on the amount of groundwater injured and the discounted acre-feet of water provided by a 1 acre-foot water right, ONRT estimated the number of acre-feet of water rights necessary to compensate for the injured groundwater and the associated cost of acquiring these water rights. In this manner, the cost to acquire equivalent water resources was the measure of damages used to help develop the final restoration settlement amount of \$12,794,000.

---

2. An acre-foot of water is the amount of water necessary to cover 1 acre of land to a depth of 1 foot. This is equivalent to 325,851 gallons of water.

---

## **4. Restoration Goals and Project Evaluation**

This chapter describes the process used by ONRT to evaluate and ultimately select restoration projects for implementation. The process included (1) identifying goals for restoration, (2) developing criteria for evaluating identified projects, (3) using the criteria to group projects into proposed tiers for funding for the Draft RP, and (4) conducting a final evaluation of projects incorporating information received during the public comment period.

### **4.1 Goals for Restoration**

ONRT's goal under NRDAR is to compensate the public for the loss of groundwater and groundwater services that were injured as a result of hazardous substance releases from FMI mining facilities. ONRT decided to fund a diverse, regional portfolio of groundwater restoration projects that would provide a maximum benefit to regional groundwater resources. This is consistent with current approaches to regional water planning in the area.

### **4.2 Evaluation Criteria for Restoration Alternatives**

ONRT developed screening and evaluation criteria to be used to evaluate the proposed restoration alternatives. The criteria used in the RP are based on the guidance for restoration project selection provided by the NRDAR regulations developed for CERCLA (43 CFR § 11.82). The criteria also reflect additional guidance for restoration project selection found in the regulations developed by the National Oceanic and Atmospheric Administration (NOAA) for restoration planning under the OPA (15 CFR § 990.54).

#### **4.2.1 Screening criteria**

ONRT used the following screening criteria to determine whether proposed projects met minimum standards of acceptability. To be deemed acceptable, a project must comply with all of these criteria. The project must:

- ▶ Be technically and administratively feasible
- ▶ Affect groundwater resources, either directly or indirectly
- ▶ Provide an overall net environmental benefit
- ▶ Comply with applicable and relevant federal, state, local, and tribal laws and regulations.



#### **4.2.2 Evaluation criteria**

Following the project screening process, ONRT applied the evaluation criteria listed below to evaluate potential restoration projects. For the Final RP, the evaluation criteria were grouped according to their priority to ONRT – projects that rated above-average for high priority criteria were given a greater preference for funding than projects that rated above-average for lower priority criteria. A project was evaluated regarding whether it:

- ▶ High-priority criteria:
  - Has a high potential for long-term success and a low risk of failure
  - Has feasible and cost-effective provisions for operations, maintenance, and monitoring
  - Would be unlikely to proceed without NRDAR funding
- ▶ Medium-priority criteria:
  - Is close to where the injury occurred (Gila and/or Mimbres water basins)
  - Is cost-effective compared to other projects that provide similar benefits
  - Is consistent with regional planning and federal and state policies
- ▶ Low-priority criterion:
  - Is likely to provide benefits quickly after project implementation.

### **4.3 Developing Project Tiers for the Draft RP**

As noted earlier, ONRT would like to fund a diverse, regional portfolio of groundwater restoration projects. To that end, a wide range of restoration project ideas were identified through an informal scoping outreach effort to local, state, and federal agencies; nonprofit organizations; and stakeholder groups (see Chapter 6 for outreach contacts). ONRT originally identified 18 projects for the Draft RP; an additional 3 projects were identified during the public comment period (see the appendix for the full project list). ONRT used the screening and evaluation criteria outlined above to evaluate each project.

As listed above, one of the criteria that ONRT considered was, “Is cost-effective compared to other projects that provide similar benefits.” To conduct a complete cost-effectiveness analysis across all restoration projects would require ONRT to have data on the volume of groundwater improved or benefited by each project, in units that can be compared fairly across projects. ONRT realized early in the evaluation process that these data were not readily available for all projects. For example, a project proposed to clean up contaminated mine waste at the abandoned

San Vicente Creek Mill site will clearly benefit groundwater in that area; however, estimates of the volume of groundwater that would benefit are not available and would require an unreasonable (costly) effort to obtain through additional sampling and modeling.

Instead of conducting a cost-effectiveness analysis across all restoration projects, ONRT conducted an analysis that evaluated the relative cost-effectiveness of individual projects within project categories where this information was available. For example, ONRT could assess cost-effectiveness for groundwater protection projects that included main line sewer improvements (including sewer extensions) and replacement of substandard septic systems. The metric used for these projects was cost per household whose wastewater would now be treated adequately and not pose a threat to groundwater. For groundwater conservation projects, including low-water-use appliances and reuse of water, ONRT assessed cost-effectiveness based on the estimated cost per acre-foot per year of groundwater conserved.

For each criterion (including cost-effectiveness within a category), projects were evaluated and assigned a rating of below average, average, or above average, based on available project information. For example, a project outside the Gila or Mimbres basin would receive a below-average rating for the criterion, “Is close to where the injury occurred.” Projects were placed into “tiers” based on how they were evaluated versus the criteria. Projects placed into Tier 1 had more above-average ratings (especially for the high priority criteria) and fewer below-average ratings compared to projects placed into Tier 2 or Tier 3.

For the Draft RP, ONRT proposed that Tier 1 projects would have top priority for funding, with any remaining funds going to Tier 2 or Tier 3 projects.

## **4.4 Final Evaluation after Public Comment Period**

Based on comments and additional information received during the public comment period, ONRT re-evaluated the projects described in the Draft RP and also evaluated additional projects that were submitted during the public comment period. For the Final RP, ONRT similarly retained the Tier 1 and Tier 2 classifications (Tier 1 projects will be funded first; Tier 2 projects will be considered for funding if funding is available). However, given the large number of projects in Tier 1 and Tier 2 (and a cumulative cost for these projects that far exceeds the settlement funding available), ONRT placed Tier 3 projects from the Draft RP into the category of “not recommended for funding” for the Final RP.

Notable changes in project evaluation between the Draft RP and Final RP are described below. This list includes projects that were included as Tier 1 projects in the Draft RP but are not recommended for funding in the Final RP, and projects that were selected as Tier 2 in the Draft RP but were moved to Tier 1 for the Final RP.

- ▶ **San Vicente Creek Mill Option 3.** In the Draft RP, San Vicente Creek Mill Option 3 (which includes partial offsite removal of hazardous substances at the San Vicente Creek Mill with onsite capping for the remainder) was proposed as a potential Tier 1 project. During the public comment period, ONRT learned that similar caps in nearby locations had failed during large storm events, resulting in contaminant releases. Compared to Option 2 (full removal), Option 3 scored lower for the high-priority criteria of “high potential for long-term success and low risk of failure” and “provisions for operation, maintenance, and monitoring are feasible and cost-effective” and also scored lower for the medium-priority criteria “cost-effective compared to other projects that provide similar benefits” and “consistent with regional planning and federal and state policies.” Thus, ONRT selected San Vicente Creek Mill Option 2 (full removal) for funding.
- ▶ **Grant County Liquid Waste Groundwater Protection and Grant County Water Conservation projects.** In the Draft RP, these two projects were both included as proposed Tier 1 projects. The Grant County Liquid Waste Groundwater Protection project proposed providing funding to replace faulty septic systems and cesspools. The Grant County Water Conservation project proposed developing a water conservation program that provides rebates for water-saving appliances. The public expressed little interest in these projects during the public comment period, suggesting that participation in these projects could be low. Furthermore, the Southwest New Mexico Council of Governments (SWNMCOG) previously implemented a septic replacement program that resulted in low participation rates. Thus, these projects were evaluated for the Final RP as not passing the screening criteria “is technically and administratively feasible” due to the difficulty with implementing these programs when they have low-participation rates.
- ▶ **Silver City Mountain View/Southwest Area Sewer Line Extension project.** In the Draft RP, this project was included as a proposed Tier 2 project that would receive funding if funding were available. During the public comment period, ONRT learned from the NMED that groundwater in the vicinity of this project was not being threatened by faulty septic systems and, thus, the proposed sewer line extension project would have minimal groundwater benefit. Thus, this project was evaluated for the Final RP as not passing the screening criteria “nexus to groundwater resources” because the project is unlikely to provide groundwater benefits.
- ▶ **Silver City North/Blackhawk Sewer Line Extension.** In the Draft RP, this project was included as a proposed Tier 2 project that would receive funding if funding were available. During the public comment period, ONRT learned from the NMED that groundwater in the vicinity of this project is being contaminated by faulty septic systems. Thus, this project would provide a clear groundwater benefit. This project had the highest cost-effectiveness of all the sewer line extension projects, based on the cost per number of households connected.

---

## 5. Groundwater Restoration Projects

ONRT considered a broad set of potential restoration projects to compensate for injuries to groundwater resources. The projects were identified through outreach to local, state, and federal agencies; nonprofit organizations; and stakeholder groups (see Chapter 6 for a detailed list of contacts). After identifying 21 projects (see the appendix for the full project list), ONRT used the screening and evaluation criteria outlined in Chapter 4 to evaluate the projects.

The remainder of this chapter presents descriptions of the proposed restoration projects. These projects are presented in two tiers. Section 5.1 describes projects selected as Tier 1 projects. These are the projects that best meet the evaluation and screening criteria and represent a diverse, regional portfolio of groundwater restoration projects. Section 5.2 describes projects selected as Tier 2 projects. Tier 2 projects meet the screening and evaluation criteria, but were ranked lower than the Tier 1 projects. If funding is available after completing the Tier 1 projects, Tier 2 projects will be considered for funding.

Section 5.3 describes the projects considered but not recommended for funding.

### 5.1 Tier 1 Projects

Projects presented as Tier 1 projects were ranked highest based on application of the screening and evaluation criteria. ONRT expects that these projects will be funded in 2012 and 2013.<sup>1</sup> The bundle of Tier 1 projects represents a diverse, regional portfolio of groundwater restoration projects that would provide a maximum benefit to regional groundwater resources. These projects include a range of project types and project locations. Tier 1 reflects the public's request to fund the most protective of the three San Vicente Creek Mill Cleanup restoration options – Option 2 (full offsite disposal); it also includes a large, regional project of interest, the Bayard Reuse project, as well as four other projects that will benefit groundwater resources.

This section includes descriptions of the six Tier 1 restoration projects. A first round of funding will be provided to the following projects: San Vicente Creek Mill Option 2, Santa Clara Well Head Protection, Santa Clara Gravity Sewer Improvement, and Silver City North/Blackhawk Sewer Line Extension. A second round of funding is expected to be made available in the second half of 2012 or 2013 and includes the Bayard Reuse and Hurley Sewer Line projects. The funding amounts for the second round may be adjusted depending on the availability of funds at that time. Table 5.1 summarizes the Tier 1 projects.

---

1. Funding of projects is contingent on project sponsors fulfilling all requirements by the State of New Mexico and by ONRT, including permit approvals, completion of engineering designs, etc. Project funding may be modified for Tier 1 projects should current cost estimates prove to be inaccurate.

**Table 5.1. Restoration projects selected for funding (Tier 1)**

Project title (location)	Project description	Proposed funding	Draft RP evaluation	Final RP evaluation	Comments
<b>Selected for first round of funding</b>					
San Vicente Creek Mill Option 2 (Silver City)	Full offsite removal of hazardous substances at the San Vicente Creek Mill to avoid ongoing groundwater contamination	\$4,800,000	Tier 1 – Alternative A	Tier 1	Option 2 (full offsite removal) preferred because of greater long-term groundwater benefits
Santa Clara Wellhead Protection (southwest of Village of Santa Clara)	Construct structures to prevent infiltration of contaminants into drinking water wells and groundwater	\$109,000	Tier 1	Tier 1	
Santa Clara Gravity Sewer Improvements (along Cameron Creek in Village of Santa Clara)	Improve and protect main sewer lines in Santa Clara to prevent reoccurrence of sewage spills into Cameron Creek and associated alluvial groundwater	\$316,000	Tier 1	Tier 1	
Silver City North/Blackhawk Sewer Line Extension (Silver City)	Extend a sewer line to enable additional household connections and eliminate use of faulty septic systems that contaminate groundwater	\$310,000	Tier 2	Tier 1	Additional information indicated that project will provide a clear groundwater benefit
<b>Selected for second round of funding</b>					
Bayard Reuse (City of Bayard)	Develop infrastructure to enable groundwater conservation by using treated wastewater for irrigation	\$4,000,000 <sup>a</sup>	Tier 1	Tier 1	Funding will be made available after costs are known for first-round projects
Hurley Sewer Lines Replacement (Town of Hurley)	Replace failing clay sewer pipes with modern impermeable materials to avoid groundwater contamination	\$1,375,000 <sup>a</sup>	Tier 1	Tier 1	
<b>Anticipated total cost for Tier 1 projects</b>		<b>\$10,910,000</b>			
a. Funding amounts may be adjusted depending on availability of funds.					

### **5.1.1 San Vicente Creek Mill Option 2**

#### **Restoration objective**

The purpose of this project is to reduce groundwater contamination by cleaning up and restoring the San Vicente Creek Mill site.

#### **Project description**

The San Vicente Creek Mill is the site of former milling and smelting operations for lead, silver, copper, and gold (from the 1880s to the 1940s). A tailings pile with approximately 22,000 cubic yards of material covers an estimated 70,000 square feet on the site, and a slag pile at the site covers an estimated 217,800 square feet with a depth up to 30 feet. Water quality at the site is threatened by erosion of the tailings pile and the subsequent transport of heavy metals such as lead to surface water and groundwater. Tailings have been deposited in the San Vicente Creek floodplain and have been observed up to 1,000 feet away from the site. Groundwater and surface water at the site are integrally related with groundwater contributing to the San Vicente Creek during wetter parts of the year and recharging groundwater during drier parts of the year (NMED, 2010). No action is proposed for the slag pile as it is stable and does not appear to pose a hazard to the environment.

Of the three San Vicente restoration options, Option 2 (full offsite disposal) is the most protective and most expensive. This option removes all contaminated material and disposes of the contaminated material at an offsite location. Restoration activities would include determining the extent of tailings and contaminated soil onsite and offsite; excavating and consolidating tailings and contaminated soil; transporting all contaminated materials to an appropriate offsite disposal facility (approximately 50,000 cubic yards); restoring disturbed areas by replacing removed soil; and reseedling with an appropriate native or adaptive seed mixture. NMED will provide oversight for this project.

#### **Project location**

The project is located in Grant County on the southern portion of the Town of Silver City and along the western bank of San Vicente Creek.

#### **Expected benefits and timeframe of benefits**

This project will benefit groundwater by removing a source of contamination. Contaminants in tailings and contaminated soil will no longer be transported via stormwater to groundwater and surface water. As indicated above, Option 2, the most comprehensive in terms of expected benefits, would remove and dispose of all contaminated tailings and soils to an appropriate offsite disposal facility (estimated at 50,000 cubic yards). This project provides ancillary benefits

to other natural resources, such as wildlife, that will have reduced exposure to contamination. Benefits will be realized over time, as the contaminated groundwater eventually diminishes over time.

### **Overview of maintenance and monitoring**

Offsite disposal areas would be maintained by the disposal facility. Monitoring for project success could include testing to ensure successful contaminant removal and revegetation success.

### **Estimated cost**

The estimated cost for Option 2 (full offsite disposal) is \$4,800,000. This includes a 10% contingency and New Mexico gross receipts tax.

### **ONRT evaluation**

The San Vicente Creek Mill Option 2 ranked above average due to its location in proximity to the injury; fewer long-term operations and maintenance requirements; high potential for long-term success; consistency with regional planning; and because it would be unlikely to proceed without NRDAR funding. This project has a high potential for long-term success because all contaminants will be removed offsite to a maintained disposal facility. Option 2 is the most expensive of the three San Vicente restoration options; however, it has very low costs associated with operations and maintenance.

San Vicente Creek Mill Option 2 was highly endorsed by the public. Commenters cited protection of groundwater resources, concerns with funding and maintenance for the long-term oversight of the onsite disposal cell under Option 3, concerns of environmental hazard to a nearby vegetable garden, and ancillary benefits (such as public recreation) as justification for supporting this option (see Chapter 7).

This project will receive funds during the first round of Tier 1 funding.

## **5.1.2 Santa Clara Wellhead Protection**

### **Restoration objective**

The purpose of this project is to protect groundwater used for drinking water by sealing and protecting two wellheads for the Village of Santa Clara.

### **Project description**

There are no enclosures over two wellheads near the Village of Santa Clara, resulting in increased risk of contamination of groundwater supplies used for drinking water. Two buildings will be constructed to enclose each exposed wellhead. The buildings will be designed to provide a watertight seal for the wellheads, year-round protection from the elements, and protection from outside sources of potential contamination or infestation. The Village of Santa Clara will be the lead agency for the project, and they will contract for professional design services.

### **Project location**

The project is located approximately 5 miles southwest of the limits of the Village of Santa Clara.

### **Expected benefits and timeframe of benefits**

The buildings over the wellheads are expected to minimize the risk of contamination of groundwater due to stormwater runoff, other non-potable fluids or foreign materials, and access by insects, rodents, birds, and other pests surrounding the wellhead penetrations. This will also provide the added benefit of safe drinking water for the Village of Santa Clara. This project is estimated to protect approximately 107 million gallons of water per year (330 acre-feet per year). This project avoids risk – the true benefits of the project occur over the time period when risks are avoided.

### **Overview of maintenance and monitoring**

The buildings will be built using metal components with a manufacturer's warranty of up to 20 years. The buildings are expected to have a minimum life of 20 years. Annual maintenance of the two buildings will be required to ensure that the metal siding and roofing fasteners remain water tight, seals remain weather resistant, and roof access and doors remain weather tight. The Village of Santa Clara will be responsible for maintenance activities.

### **Estimated cost**

The estimated cost for design and construction of two buildings to enclose the wellheads is approximately \$109,000. This includes a 15% contingency and New Mexico gross receipts tax. The Village of Santa Clara will cover operations and maintenance costs.

### **ONRT evaluation**

The Santa Clara Wellhead Protection project ranked above average due to its location in proximity to the injury; its inclusion of feasible and cost-effective provisions for operations,



maintenance, and monitoring; its cost-effectiveness as a drinking water protection and improvement project; and because it would be unlikely to proceed without NRDAR funding. The Village of Santa Clara estimates that this project will protect approximately 107 million gallons of water per year (330 acre-feet per year) at an estimated cost of approximately \$109,000. This estimate assumes the full volume of drinking water is at risk of contamination. Overall, this project is a cost-effective drinking water protection and improvement project based on the large volume of water protected at a low cost.

This project will receive funds during the first round of Tier 1 funding.

### **5.1.3 Santa Clara Gravity Sewer Improvements**

#### **Restoration objective**

The purpose of this project is to reduce groundwater contamination by improving and protecting the Village of Santa Clara's main sewer lines located along Cameron Creek.

#### **Project description**

Several sewer lines in the Village of Santa Clara are prone to stormwater damage and sewer flow constriction, which results in contamination of surface and groundwater resources. The project will replace an existing sewer line that runs perpendicular to Cameron Creek at the intersection with Mill Street and will encase the sewer line at Mill Street in concrete with a new concrete low-water crossing. The concrete crossing will be constructed over the encased sewer line, and a concrete toe wall will be built at the downstream end to prevent the concrete crossing and sewer line from washing out.

The project will also replace existing sewer lines that are constricted by tree roots located adjacent to Cameron Creek north of Fellner Street and will replace manholes. The Village of Santa Clara will also purchase a sewer line cleaning machine (rodder) for regular maintenance of all sewer lines. The Village of Santa Clara will be the lead agency for the project, and they will contract for professional design services.

#### **Project location**

The project is located within the Village of Santa Clara.

#### **Expected benefits and timeframe of benefits**

This project is expected to significantly reduce groundwater contamination as a result of sewer line leaks and overflow along Cameron Creek, which occurs first at the surface level and then into the groundwater system. This project is expected to avoid storm flow damage and overflows

that could result in up to 16,000 gallons of raw sewage per day (0.05 acre-feet per day) entering Cameron Creek when sewer line breaches occur. Improvements to the Village of Santa Clara's sewer lines will decrease contamination of downstream water and groundwater supplies.

### **Overview of maintenance and monitoring**

The concrete crossing at Mill Street will provide protection of the perpendicular sewer line crossing for an expected project life of 40 years, with minimal maintenance required. Following storm events, the Village of Santa Clara will be responsible for removing any debris that is deposited on the crossing.

The replacement of sewer lines and manholes will have an expected life of approximately 40 years. Maintenance of these sewer lines and manholes will be undertaken by the Village of Santa Clara and will include regular line cleaning, which will be made easier with the new sewer line cleaning machine.

### **Estimated cost**

The total cost of this project is approximately \$316,000. This includes a 20% contingency and New Mexico gross receipts tax. This does not include estimates for monitoring and maintenance costs, which will be undertaken by the Village of Santa Clara.

### **ONRT evaluation**

The Santa Clara Gravity Sewer Improvements project ranked above average due to its location in proximity to the injury; its cost-effectiveness as a groundwater protection project; and its likelihood to provide benefits quickly after project implementation. With regards to cost-effectiveness, the project benefits 54 residences and costs approximately \$5,900 per residence served. In addition, the project benefits will occur quickly after the project is implemented and the sewer line cleaning machine is purchased.

This project will receive funds during the first round of Tier 1 funding.

## **5.1.4 Silver City North/Blackhawk Sewer Line Extension**

### **Restoration objective**

The purpose of this restoration project is to extend sewer service to a neighborhood that is currently required to use septic systems for wastewater treatment.

### **Project description**

Residents in the northern part of Silver City are required to have septic systems, although they are served by the Town of Silver City water system. Septic systems require regular maintenance and may contribute contaminants to groundwater. The project would extend the municipal sewer system to approximately 40 residences currently using septic systems. The project does not include sewer connections to each home; however, the Town of Silver City has indicated a willingness to fund stubbing services to individual residences as an in-kind match. The abandonment of the existing septic system would be the responsibility of each homeowner.

The project work will be completed on land that is a publically dedicated right-of-way that is owned by the Town of Silver City. The residents in this part of the town have expressed interest in connecting to the municipal sewer system and the town has an ordinance requiring the connection. Silver City will be the lead agency for the project and will contract for professional design and implementation services.

### **Project location**

The project is located in the northern part of the Town of Silver City.

### **Expected benefits and timeframe of benefits**

Benefits to groundwater will include reduced potential for contamination from those homes with faulty septic systems. Benefits will be realized as soon as the project is completed, when septic systems are properly abandoned, and will last an estimated 40 to 60 years. Approximately 3.3 million gallons per year of wastewater (10 acre-feet per year) from more than 40 residences will be treated by the Silver City wastewater treatment plant rather than by septic systems.

### **Overview of maintenance and monitoring**

Operations and maintenance for the sewer line will be the responsibility of the Town of Silver City.

### **Estimated cost**

The estimated cost for this sewer line extension is \$310,000. This includes a 12% contingency and New Mexico gross receipts tax. The Town of Silver City has indicated that if this funding is insufficient to cover the entire project costs, the town will evaluate the opportunity to fund the difference. Cost estimates do not include individual connections; however, the Town of Silver City has indicated a willingness to fund stubbing services to individual residences as an in-kind match.

## **ONRT evaluation**

The Silver City North/Blackhawk Sewer Line Extension project ranked above average in terms of its location in proximity to the injury; its cost-effectiveness as a sewer line extension project; and because it is unlikely to proceed without NRDAR funding. This project is expected to benefit 40 residences and costs approximately \$7,700 per residence served.

This project will receive funds during the first round of Tier 1 funding.

### **5.1.5 Bayard Reuse**

#### **Restoration objective**

The purpose of this project is to conserve groundwater resources by reuse of treated wastewater within the City of Bayard.

#### **Project description**

The project involves building an addition onto the existing Bayard wastewater treatment plant to allow for municipal reuse of treated (non-potable) water. Targeted locations for the reuse water include the Snell Middle School fields and the new cemetery when it is completed (expected within five years, by 2016). Other locations may be added in the future. The SWNMCOG has indicated that the Bayard Reuse project is an exceptional regional project and other towns in the area can feed into this project.

The new facilities will be designed to accommodate current flows from the existing wastewater treatment plant (approximately 219 million gallons per year or 673 acre-feet per year) and would be expandable to accommodate increased flows in the future. The project would include a filter pump building and a storage tank. In addition, approximately 4,700 linear feet of effluent transmission lines will run to the Snell Middle School and approximately 2,200 linear feet of effluent transmission lines will run to the City of Bayard's proposed cemetery. This project would replace the need for periodically permitted discharge of wastewater to the Chino Mine. The City of Bayard will be the lead agency for the project and will contract for professional design and implementation services.

#### **Project location**

This project is located within the City of Bayard. The land for the project is owned by the City of Bayard, with the exception of a portion owned by the Cobre school system.

### **Expected benefits and timeframe of benefits**

This project would conserve groundwater by reusing treated water for irrigation instead of the City's potable water, thus reducing the demand for potable water from groundwater sources. Use of reclaimed water to irrigate the Snell Middle School fields is expected to save approximately 8.7 million gallons of groundwater per year (27 acre-feet per year); irrigation of the planned cemetery could save an additional 41.8 million gallons per year (128 acre-feet per year).

This project provides an ancillary benefit of creating a permanent point of discharge for the Bayard regional wastewater treatment plant. The plant currently discharges to tailings ponds at the Chino Mine; the permit for this discharge expires January 2014 and the conditions for the permit can be changed each time the agreement is negotiated. Establishing a permanent discharge point for the treatment plant will create a more stable management position for the wastewater treatment facility.

### **Overview of maintenance and monitoring**

The City of Bayard will be responsible for operations and maintenance costs for this project. These costs are estimated to be \$39,000 per year.

### **Estimated cost**

The project is expected to cost \$4 million. This includes a 10% contingency and New Mexico gross receipts tax. The City of Bayard has spent \$224,000 on planning and engineering to date; this will be considered an in-kind contribution to the project. In addition, the City of Bayard will assume the costs for operations and maintenance, estimated at \$39,000 per year.

### **ONRT evaluation**

The Bayard Reuse project ranked above average due to its location in proximity to the injury; its high potential for long-term success and low risk of failure; its consistency with regional planning; and because it would be unlikely to proceed without NRDAR funding. This project has a high potential for long-term success by creating a permanent infrastructure to allow reuse of wastewater and a reduction in groundwater demand. Once the addition is built and reclaimed water is available, it will be immediately available for use at the Snell Middle School. In the longer term, when the proposed city cemetery is completed, reuse water will be available to irrigate the grounds. Overall, this project expects to conserve significant groundwater resources through the long-term reuse of treated wastewater. However, ONRT did not use relative cost-effectiveness as a factor in project selection because of the small number of groundwater conservation projects to which it could be compared and uncertainty regarding the amount and timing of irrigation savings at the proposed cemetery.

The Bayard Reuse project will be funded in the second round of Tier 1 funding. ONRT anticipates that this project will receive \$4 million in funding; however, funding amounts for this project may be adjusted depending on availability of funds.

### **5.1.6 Hurley Sewer Lines Replacement**

#### **Restoration objective**

The purpose of this restoration project is to protect groundwater by replacing failing sewer lines with new sewer lines.

#### **Project description**

The Town of Hurley sewer main was constructed using clay pipe. Many sections are degraded and have failed, causing backups into private residences and posing a threat to groundwater quality. Hurley has identified eight high-priority areas where the clay pipe should be replaced; identification and prioritization for replacement would be based on the effect on sewer system performance.

Restoration activities include replacing failing, vitrified clay sewer pipes and sewer manholes. All the pipes that need to be replaced are collector lines from individual services. The old and failing pipes would be removed and replaced with new materials that will prevent groundwater degradation. The Town of Hurley will be the lead agency for the project and will contract for professional design and implementation services.

#### **Project location**

This project is located in the Town of Hurley.

#### **Expected benefits and timeframe of benefits**

Benefits to groundwater will include reduced threat or incidence of sewer water entering the groundwater due to pipe breaks or backups to users. The benefits will occur immediately following construction and will be realized over the long term. The sewer lines targeted for replacement collect an estimated 9.1 million gallons per year (28 acre-feet per year) from 72 residences and one commercial enterprise.

### **Overview of maintenance and monitoring**

Maintenance and monitoring will be the responsibility of the Town of Hurley. The costs for maintaining the new sewer lines are expected to be substantially less than for maintaining the current clay pipes.

### **Estimated cost**

This project will cost an estimated \$1,375,000. This includes an 8% contingency and New Mexico gross receipts tax.

### **ONRT evaluation**

The Hurley Sewer Lines Replacement project ranked above average in terms of its location in proximity to the injury; its likelihood to provide benefits quickly after project implementation; and because it is unlikely to proceed without NRDAR funding. With regards to providing important benefits rapidly after project implementation, this project is expected to reduce and prevent groundwater contamination by replacing failing clay pipes with modern materials. Benefits to groundwater would occur immediately following completion of this project and would continue for the life expectancy of the new sewer pipes. This project benefits 72 residences and one commercial enterprise and costs approximately \$16,700 per residence served.<sup>2</sup>

The Hurley Sewer Lines Replacement project will be funded in the second round of Tier 1 funding. ONRT anticipates this project will receive \$1,375,000 in funding; however, funding amounts for this project may be adjusted depending on availability of funds.

## **5.2 Tier 2 Projects**

Projects selected as Tier 2 projects were evaluated less favorably than the Tier 1 projects based on application of the screening and evaluation criteria. If there is funding remaining after completing Tier 1 projects, these Tier 2 projects will be considered for funding. Selection of a project within Tier 2 will depend on the amount of available funding and project status at the time that any additional funds are available. These projects are listed alphabetically and not in an order of prioritization. Table 5.2 summarizes the Tier 2 projects.

---

2. Cost estimate converts commercial enterprise to household equivalent using expected discharge: one commercial enterprise using 3,200 gallons per day is equivalent to approximately 10.5 residences, each residence using 300 gallons per day.

**Table 5.2. Restoration projects selected for funding if funds are available (Tier 2).** Selection of a project within Tier 2 will depend on available funding and project status. Projects are listed alphabetically – this order does not represent ONRT’s priorities for funding.

Project title (location)	Project description	Estimated cost	Draft RP evaluation	Final RP evaluation	Comments
Hanover-Fierro Wastewater Collection and Disposal System (Towns of Hanover and Fierro)	Extend wastewater infrastructure to enable additional household connections and eliminate use of faulty septic systems that contaminate groundwater	\$3,937,000 <sup>a</sup>	Not included in Draft RP	Tier 2	Project could be done in phases. Hanover portion alone would be approximately \$2 million.
North Hurley Sewer Line Extension (North Hurley)	Extend a sewer line to enable additional household connections and eliminate use of faulty septic systems that contaminate groundwater	\$521,000 <sup>a</sup>	Tier 2	Tier 2	
Silver City Indian Hills Sewer Line Extension (north of Silver City)		\$2,060,000 <sup>a</sup>	Not included in Draft RP	Tier 2	Project could be in phases. Cain/Arrowhead Road extension would be \$927,000 and Cottonwood Road extension would be \$1,134,000.
Silver City Ridge Road East Sewer Line Extension (south of Silver City)		\$2,990,000 <sup>a</sup>	Not included in Draft RP	Tier 2	Project could be in phases. Mobile/Mountain View Drive extension would be \$1,395,000 and Sky View/Pheasant Drive extension would be \$1,595,000.

a. Funding amounts may be adjusted depending on availability of funds.



### **5.2.1 Hanover-Fierro Wastewater Collection and Disposal System**

#### **Restoration objective**

The purpose of this restoration project is to extend sewer service from the regional wastewater treatment plant located in the City of Bayard to neighborhoods in the residential communities of Hanover and Fierro. The project could also be expanded to include the residential community of Vanadium.

#### **Project description**

The Hanover-Fierro area lacks a community sewage collection and treatment system. All residential structures utilize individual systems consisting of cesspools, holding tanks, or septic tanks and leach fields. Most of these systems were never properly constructed and are not in compliance with state regulations. Due to the rocky terrain and steep slopes in the area, effluent from the septic tanks and cesspools often drain to the Hanover Creek or contaminate groundwater. This restoration project would construct a pressure sewer system to convey sewerage from 158 households in the Hanover and Fierro area to the regional wastewater treatment plant located in the City of Bayard. The project will include proper abandonment of the existing cesspool or septic tank and installation of a new septic tank. The residents will be required to maintain the septic systems.

The project work will be completed on land that is a publically dedicated right-of-way as well as private, state, and railroad properties that may require easement acquisition. It is not clear if there is an ordinance in place that can be enforced to require residents to connect to the sewer system or if the residents have expressed interest in connecting to the municipal sewer system.

#### **Project location**

The residential communities of Hanover and Fierro are north of the City of Bayard in the northwest portion of Grant County.

#### **Expected benefits and timeframe of benefits**

Benefits to groundwater will include reduced potential for contamination from those homes with faulty septic systems and cesspools. Benefits will be realized as soon as the project is completed, provided that septic systems are properly abandoned, and will last an estimated 40 years.

#### **Overview of maintenance and monitoring**

Operations and maintenance for the sewer line will be the responsibility of the Hanover Mutual Domestic Water Consumers Association. Operation of individual septic systems will be the responsibility of the homeowners.

### **Estimated cost**

The estimated cost for this sewer line extension to residences in Hanover and Fierro is \$3,937,000. The project can be broken into three phases of construction. For implementation of Phase 1, extension of the sewer line to residences in the Hanover only (61 residences), the project cost is \$2,079,000. Project costs include a 12% contingency and New Mexico gross receipts tax.

### **ONRT evaluation**

The Hanover-Fierro Wastewater Collection and Disposal System was evaluated as a whole and as a phased project, where Phase 1 is the extension of the sewer line to Hanover. Both the whole project and Phase 1 (Hanover only) ranked above average in terms of its location in proximity to the injury and because it is unlikely to proceed without NRDAR funding. ONRT did not receive information as to whether there is an ordinance in place that can be enforced to require residents to connect to the sewer system or if the residents have interest in connecting to the municipal sewer system. In addition, ONRT was concerned about the challenges in acquiring easements to complete the piping for this project and the ability of homeowners to maintain and operate individual septic systems. For these reasons, the project ranked below average in terms of high potential for long-term success and low risk of failure. In terms of cost-effectiveness, the Hanover-Fierro Wastewater Collection and Disposal System is expected to benefit 158 low to moderate income residences at a cost of approximately \$24,900 per residence. The Hanover phase of the project is expected to benefit 61 residences at a cost of approximately \$34,100 per residence. This project is less cost-effective (on a per residence basis) than the sewer line extension and improvement projects selected for Tier 1.

## **5.2.2 North Hurley Sewer Line Extension**

### **Restoration objective**

The purpose of this restoration project is to design and construct a local community wastewater collection system for approximately 10 residences.

### **Project description**

North Hurley is an unincorporated community in Grant County that relied on septic systems and cesspools for wastewater treatment. Since 1993 wastewater treatment improvements have been made throughout the town, including building sewer mains, large-capacity septic tanks, and wetlands. Future plans include developing a central residential wastewater collection location and transporting liquid wastes to the new regional wastewater treatment plant in Bayard. Approximately 10 residences in North Hurley have been excluded from these sewer

improvements and still rely on septic systems; these residences are located in an area with shallow groundwater.

The project would add the 10 residences that still rely on septic systems to the centralized wastewater treatment system. This would be done by constructing a small-capacity lift station on private land and extending sewer lines to the residences. The existing residential septic systems would be abandoned.

### **Project location**

The project is located in the Town of Hurley along the edge of North Hurley Road.

### **Expected benefits and timeframe of benefits**

Benefits to groundwater will include reduced potential for contamination from faulty septic systems. The benefits would be realized upon completion of the upgrade.

### **Overview of maintenance and monitoring**

Maintenance and monitoring for this project will be the responsibility of Grant County, which is the owner of the sewer system.

### **Estimated cost**

The estimated cost for adding these 10 residences to the sewer system, including construction of a new lift station, is approximately \$521,000. The estimate includes a 12% contingency and New Mexico gross receipts tax.

### **ONRT evaluation**

The North Hurley Sewer Line Extension project ranked above average in terms of proximity to injury. The project was ranked below average in terms of cost-effectiveness. In terms of cost-effectiveness, the North Hurley Sewer Line Extension project is expected to benefit 10 residences at a cost of approximately \$52,100 per residence. This project is less cost-effective (on a per residence basis) than the sewer line extension and improvement projects selected for Tier 1. It is unknown if there is a sewer service line connection ordinance.

## **5.2.3 Silver City Indian Hills Sewer Line Extension**

### **Restoration objective**

The purpose of this restoration project is to extend sewer service to a neighborhood that is currently required to use septic systems for wastewater treatment.

### **Project description**

Residents in the Indian Hill area, located north of Silver City, do not have municipal sewer and are required to have septic systems. Septic systems require regular maintenance and may contribute contaminants to groundwater. The project would extend the municipal sewer system to two areas of the Indian Hills community: 27 residences along Cain and Arrowhead roads and 29 residences along Cottonwood Road. The project includes bringing the sewer service line to each resident's property line and the abandonment of the existing septic system.

The project work will be completed on land that is a publically dedicated right-of-way and may require easement acquisition. The Town of Silver City would require residents within the city limits to connect to the sewer system. For the residences located outside city limits, the town would request that the county adopt an ordinance to require these residents to connect. The residents have expressed interest in connecting to the municipal sewer system. Silver City will be the lead agency for the project and will contract for professional design and implementation services.

### **Project location**

This project is located north of Silver City along Cain, Arrowhead, and Cottonwood roads.

### **Expected benefits and timeframe of benefits**

Benefits to groundwater will include reduced potential for contamination from those homes with faulty septic systems. Benefits will be realized as soon as the project is completed, when septic systems are properly abandoned, and will last an estimated 40 to 60 years. Approximately 5.2 million gallons per year of wastewater (16 acre-feet per year) from 56 residences will be treated by the Silver City wastewater treatment plant rather than by septic systems.

### **Overview of maintenance and monitoring**

Operations and maintenance for the sewer line will be the responsibility of the Town of Silver City.

### **Estimated cost**

The estimated cost for this sewer line extension is \$2,060,000. The estimated cost for the Cain/Arrowhead extension is \$927,000 and the estimated cost for the Cottonwood extension is \$1,134,000. Project costs include a 12% contingency and New Mexico gross receipts tax.

### **ONRT evaluation**

The Silver City Indian Hills Sewer Line Extension was separated into two phases and evaluated: the Cain/Arrowhead phase and the Cottonwood phase. Both phases ranked above average in

terms of its location in proximity to the injury; its likelihood to provide benefits rapidly after project implementation; and because it is unlikely to proceed without NRDAR funding. The Cain/Arrowhead phase of the project is expected to benefit 27 residences at a cost of approximately \$34,300 per residence. The Cottonwood phase of the project is expected to benefit 29 residences at a cost of approximately \$39,100 per residence. This project is less cost-effective (on a per residence basis) than the sewer line extension and improvement projects selected for Tier 1.

## **5.2.4 Silver City Ridge Road East Sewer Line Extension**

### **Restoration objective**

The purpose of this restoration project is to extend sewer service to a neighborhood that is currently required to use septic systems for wastewater treatment.

### **Project description**

Residents in the Ridge Road East area, located south of Silver City, do not have municipal sewer and are required to have septic systems. Septic systems require regular maintenance and may contribute contaminants to groundwater. The project would extend the municipal sewer system to two areas of the Ridge Road East community: 79 residences along Mobile Drive and Mountain View Drive and 83 residences along Sky View Drive and Pheasant Drive. The project includes bringing the sewer service line to each resident's property line and the abandonment of the existing septic system.

The project work will be completed on land that is a publically dedicated right-of-way and may require easement acquisition. The Town of Silver City would require residents within the city limits to connect to the sewer system. For the residences located outside city limits, the town would request that the county adopt an ordinance to require these residents to connect. The residents have expressed interest in connecting to the municipal sewer system. Silver City will be the lead agency for the project and will contract for professional design and implementation services.

### **Project location**

This project is located south of Silver City along Mobile Drive and Mountain View Drive and along Sky View Drive and Pheasant Drive.

### **Expected benefits and timeframe of benefits**

Benefits to groundwater will include reduced potential for contamination from those homes with faulty septic systems. Benefits will be realized as soon as the project is completed, when septic

systems are properly abandoned, and will last an estimated 40 to 60 years. Approximately 15.1 million gallons per year of wastewater (46 acre-feet per year) from 162 residences will be treated by the Silver City wastewater treatment plant rather than by septic systems.

### **Overview of maintenance and monitoring**

Operations and maintenance for the sewer line will be the responsibility of the Town of Silver City.

### **Estimated cost**

The estimated cost for this sewer line extension is \$2,990,000. The estimated cost for the Mobile/Mountain View Drive extension is \$1,395,000 and the estimated cost for the Sky View/Pheasant Drive extension is \$1,595,000. Project costs include a 12% contingency and New Mexico gross receipts tax.

### **ONRT evaluation**

The Silver City Ridge Road East Sewer Line Extension was separated into two phases and evaluated: the Mobile/Mountain View Drive phase and the Sky View/Pheasant phase. Both phases ranked above average in terms of its location in proximity to the injury; its likelihood to provide benefits rapidly after project implementation; and because it is unlikely to proceed without NRDAR funding. The Mobile/Mountain View Drive phase of the project is expected to benefit 79 residences at a cost of approximately \$17,700 per residence. The Sky View/Pheasant phase of the project is expected to benefit 83 residences at a cost of approximately \$19,200 per residence. These two project phases are less cost-effective (on a per residence basis) than the sewer line extension and improvement projects selected for Tier 1.

## **5.3 Projects Considered but Not Recommended for Funding**

The groundwater restoration projects described in this section were evaluated by ONRT but not recommended for funding (Table 5.3).

### **5.3.1 Grant County Liquid Waste Groundwater Protection**

Homes in the Arenas Valley and the Mimbres Valley depend on onsite liquid waste disposal systems, such as septic systems, for wastewater disposal and treatment. It is likely that some of these liquid waste disposal systems are failing and are contaminating groundwater. This restoration project proposed replacing faulty septic systems (or other substandard systems such as cesspools) with upgraded septic systems that protect groundwater.

**Table 5.3. Restoration projects not recommended for funding.** Projects are listed alphabetically.

Project title (location)	Project description	Estimated cost	Draft RP evaluation	Final RP evaluation	Comments
Cameron Creek and Twin Sisters Creek Watershed Improvements (U.S. Forest Service lands on Cameron and Twin Sisters Creek)	Watershed improvement through slow-release structures, prescribed burning, and reseedling	\$8,000,000	Tier 3	Not recommended	Project primarily benefits surface water and terrestrial resources
Carlisle Mine Site (Carlisle Creek – tributary to the Gila River)	Clean up abandoned mine leaching hazardous substances into Carlisle Creek	\$2,000,000– \$3,000,000	Tier 3	Not recommended	Project is in a very early stage of development with limited information available
Cleanup of Old Silver City Dump Site (Silver City)	Clean up old dump site in Silver City	Cost unavailable	Not recommended	Not recommended	No known contaminants impacting groundwater; determination of possible contamination would require a study
Cleanup of Pacific Ridge Abandoned Mine Sites (Pinos Altos Mining District)	Clean up contaminated soils at the Pacific Ridge abandoned mine sites	Cost unavailable	Not recommended	Not recommended	No known nexus to groundwater resources; determination of nexus would require a study
Grant County Liquid Waste Groundwater Protection (Grant County)	Replace failing septic systems and eliminate cesspools to avoid groundwater contamination	\$400,000– \$1,530,000	Tier 1	Not recommended	Public interest in these two projects was insufficient to justify program creation
Grant County Water Conservation (Silver City, Bayard, Santa Clara, Hurley)	Develop a water conservation program that provides rebates for water-saving appliances	\$3,000,000	Tier 1	Not recommended	
Grant County Water Conservation Plan Development (Silver City, Bayard, Santa Clara, Hurley)	Develop a water conservation plan to increase funding opportunities for water conservation	\$100,000– \$200,000	Tier 3	Not recommended	
Regional Water Supply and Distribution (Grant County)	Develop regional water supply and distribution system to meet demand for drinking water	Cost unavailable	Not recommended	Not recommended	A water distribution and water use project without a clear benefit to groundwater

**Table 5.3. Restoration projects not recommended for funding (cont.).** Projects are listed alphabetically.

<b>Project title (location)</b>	<b>Project description</b>	<b>Estimated cost</b>	<b>Draft RP evaluation</b>	<b>Final RP evaluation</b>	<b>Comments</b>
San Vicente Creek Mill Option 1 (Silver City)	Onsite capping of hazardous substances at the San Vicente Creek Mill	\$900,000	Tier 3	Not recommended	This option is least protective of groundwater compared to the preferred Option 2 for San Vicente Creek Mill
San Vicente Creek Mill Option 3 (Silver City)	Partial removal of hazardous substances at the San Vicente Creek Mill with onsite capping	\$2,140,000	Tier 1 – Alternative B	Not recommended	Because of the risk of cap failure, this project is less protective of groundwater compared to the preferred Option 2 for San Vicente Creek Mill
Silver City Mountain View/Southwest Area Sewer Line Extension (Silver City)	Extend a sewer line to enable additional household connections and eliminate use of faulty septic systems	\$747,000	Tier 2	Not recommended	Additional information indicated that the project will provide a minimal groundwater benefit



In the Draft RP, this project was proposed as a Tier 1 project. In order for this project to be successful, it requires public participation. Due to limited public interest expressed in this project during the public comment period, this project failed to pass ONRT's screening criterion for administratively feasible during the final evaluation.

### **5.3.2 Grant County Water Conservation**

Grant County is dependent on groundwater for both drinking water and commercial uses. Implementation of a water conservation project would provide a cost-effective means to reduce demand for groundwater. This project proposed to help fund a water conservation project by providing incentives for community members to upgrade old appliances with more water-efficient versions, potentially including but not limited to toilets, washing machines, and showerheads, and providing incentives to encourage Xeriscaping and replacing swamp coolers with heat pump refrigeration. Funds for this project would be used to provide rebates to community members who install water-saving devices or to fund direct distribution programs for high-efficiency toilets or other devices.

The success of this project depends on the level of participation of community members. In the Draft RP, this project was proposed as a Tier 1 project. Due to limited public interest expressed in this project during the public comment period, this project failed to pass ONRT's screening criterion for administratively feasible during the final evaluation.

### **5.3.3 Grant County Water Conservation Plan Development**

Grant County is dependent on groundwater for both drinking water and commercial uses. Implementation of water conservation plans would provide a cost-effective means to reduce demand for groundwater. This project proposed to develop water conservation plans for communities in Grant County, including Silver City, Bayard, Santa Clara, and Hurley. Some of these communities have not developed water conservation plans for several years, and developing up-to-date plans would provide increased opportunities for these communities to obtain funds from programs such as the New Mexico Water Trust Board and the Mortgage Finance Administration.

There was uncertainty of the benefits that would derive from the water conservation plans, compared to projects that provide more direct benefits to groundwater. The success of this project depends on the success of implementing the water conservation plans. Because of the high uncertainty of this project (which affects all criteria), ONRT did not complete the evaluation.

### 5.3.4 San Vicente Creek Mill Options 1 and 3

The San Vicente Creek Mill is the site of former milling and smelting operations for lead, silver, copper, and gold (from the 1880s to the 1940s). A tailings pile with approximately 22,000 cubic yards of material covers an estimated 70,000 square feet on the site, and a slag pile at the site covers an estimated 217,800 square feet with a depth up to 30 feet. Water quality at the site is threatened by erosion of the tailings pile and the subsequent transport of heavy metals such as lead to surface water and groundwater. Tailings have been deposited in the San Vicente Creek floodplain and have been observed up to 1,000 feet from the site. Groundwater and surface water at the site are closely connected. No action is proposed for the slag pile as it is stable and does not appear to propose a hazard to the environment.

Three cleanup options were proposed for this restoration project. These options were evaluated separately because they would result in different levels of benefit and different costs. As described in Section 5.1.1, Option 2 (complete offsite disposal) was selected for funding as a Tier 1 project. Below, we describe the two options not selected for funding.

**Option 1:** This option would consolidate and contain contaminants onsite (estimated 50,000 cubic yards); no contaminants would be removed from the site. Restoration activities include determining the extent of tailings and contaminated soil onsite and offsite; excavating tailings and contaminated soil; regrading and encapsulating tailings onsite under a 3-foot soil cover; and redesigning and strengthening the run-on diversion stormwater channel and stormwater retention berm. This option did not include funding for ongoing monitoring and maintenance of the capped areas. Option 1 is least protective of groundwater compared to the preferred Option 2 for the San Vicente Creek Mill and was not recommended for funding.

**Option 3:** This option is an intermediate restoration option that includes a combination of onsite and offsite disposal. Restoration activities would include determining the extent of tailings and contaminated soil onsite and offsite; excavating and transporting materials with lead concentrations greater than 1,000 parts per million (ppm) to an appropriate offsite disposal facility (estimated at 20,000 cubic yards); excavating and consolidating remaining contaminated soils with lead concentrations ranging from 400 to 999 ppm (estimated at 30,000 cubic yards); and regrading and reseeding the remaining disturbed areas using suitable soil and an appropriate seed mixture (native or approved adaptive mixture). Option 3 is less protective of groundwater compared to the preferred Option 2 for the San Vicente Creek Mill and was not recommended for funding because of the risk of cap failure.

### **5.3.5 Silver City Mountain View/Southwest Area Sewer Line Extension**

Residents in the Town of Silver City southwest of Mountain View Road are required to have septic systems, although they are served by the Town of Silver City water system. Septic systems require regular maintenance and may contribute contaminants to groundwater. The proposed project is to extend the municipal sewer system to approximately 55 residences currently using septic systems.

This project failed to pass ONRT's screening criteria because additional information indicated that the project will provide minimal groundwater benefit.

### **5.3.6 Cameron Creek and Twin Sisters Creek Watershed Improvements**

This project would restore habitat and slow surface water flow on 19,000 acres of U.S. Forest Service land. This land has been degraded by erosion, reducing the function of the historical floodplain. In addition, the surrounding forest poses a wildfire threat.

Restoration activities would include constructing retention structures in upland areas of the watershed to help slow the flow of surface water and allow it to infiltrate into groundwater or move more gradually to Cameron Creek and Twin Sisters Creek. Slowing the flow of surface water will reduce the impacts of erosion, allow more water to infiltrate to the groundwater aquifers, and provide the creeks with a more steady flow of surface water, effectively increasing flows over a longer time and reducing the severity of flooding from any single storm event. Over the long term, these retention structures will fill with sediment and then function as small floodplain areas; it is expected they will still serve to slow the flow of surface water and enhance infiltration.

Other restoration activities will include prescribed fire and mechanical and herbicide treatments to reduce the amount of flammable fuels present in the floodplain. Reducing the fuel load in the forest will help reduce the threat of a catastrophic wildfire and help restore the area to more closely match the historical ecosystem condition.

This project was not recommended for funding because it primarily benefits surface water and terrestrial resources, although some groundwater benefits may occur. There was a lack of certainty that the water retention structures will result in significant increases in groundwater infiltration. The difficulties in quantifying the potential groundwater benefits from this project also led to a below-average rating for cost-effectiveness.

### **5.3.7 Carlisle Mine Site**

Carlisle Creek is an intermittent stream that discharges to the Gila River. An abandoned mine that is generating acidic mine tailings is located along the stream and is contaminating the creek. Some contamination is also reaching groundwater. Restoration activities would remove or contain this source of contamination. This project is in an early phase of development, and more information is required to fully describe and evaluate the benefits.

The Carlisle Mine Site project was not recommended for funding because it is in an early phase of development, making it difficult to quantify benefits to groundwater or to assess the cost-to-benefit ratio. Lack of information makes this a riskier project. This project is also located farther from the area of injury than other proposed projects.

### **5.3.8 Cleanup of Pacific Ridge Abandoned Mine Sites within Pinos Altos Mining District**

The proposed project includes removing sources of contamination at several abandoned mine sites located southwest of Pinos Altos. Restoration or remedial actions would include removing or capping approximately 820,000 cubic yards of contaminated soils. Contaminants from this site may be reaching surface water in the area.

The project failed to pass ONRT's screening criteria because at this time there is no known nexus to groundwater resources, and thus, no certainty that this project would provide benefits to groundwater resources.

### **5.3.9 Cleanup of Old Silver City Dump Site**

The proposed project includes characterizing and cleaning up an old dump site in Silver City. At this time, no specific restoration actions have been proposed. The dump drains into San Vicente Creek, which recharges groundwater.

The project failed to pass ONRT's screening criteria because there are no known contaminants impacting groundwater and thus, no certainty that this project would provide benefits to groundwater resources.

### **5.3.10 Regional Water Supply and Distribution**

The proposed project includes development of a regional water supply and distribution system to meet drinking water demands in Grant County, including the municipalities of Bayard, Hurley, Santa Clara, Silver City, and nearby unincorporated areas. The focus of the project is to improve

existing water distribution infrastructure, construct new water distribution infrastructure, and make new water sources available for municipal use.

The project failed to pass ONRT's screening criteria because it is strictly a water distribution and water use project and does not have a nexus to improving, conserving, or restoring groundwater resources.

---

## 6. Agencies and Organizations Consulted

### Agencies and government entities consulted

---

#### State

New Mexico Environment Department/Ground Water Quality Bureau (Superfund Oversight Section, Mining & Environmental Compliance Section, Remedial Oversight Section, Pollution Prevention Section)

New Mexico Environment Department/Surface Water Quality Bureau

New Mexico Environment Department/Solid Waste Bureau

New Mexico Environment Department/Construction Programs Bureau

New Mexico Environment Department/Liquid Waste Program

New Mexico State Forestry Division

#### Local

City of Bayard, New Mexico

Town of Hurley, New Mexico

Town of Silver City, New Mexico

Village of Santa Clara, New Mexico

Grant County, New Mexico

Grant County Soil and Water Conservation District, New Mexico

Gila National Forest, New Mexico

---

### Organizations and stakeholder groups consulted

---

Gila Resources Information Project (GRIP)

Gila Basin Irrigation Commission

Upper Gila Watershed Alliance

The Nature Conservancy

---

---

## **7. Public Comments and Trustee Responses**

The initial public comment period on the Draft RP was from September 20, 2011, through November 3, 2011. ONRT extended the public comment period to November 18, 2011. A public meeting was held on the Draft RP in Silver City, New Mexico, on October 4, 2011. Twenty-two comments were received; 10 of which were received at the public meeting.

ONRT acknowledges and thanks all individuals who took the time to attend the public meeting and/or provide comments on the Draft RP. As noted throughout this document, this RP focuses solely on projects that will improve groundwater resources and services in the general vicinity of Silver City, New Mexico, as compensation for injuries to groundwater resources resulting from the release of hazardous substances at the Sites. ONRT is required to evaluate each public comment within the context of whether the project proposed or supported by a commenter will help improve groundwater resources and services. The following sections review the comments received and provide ONRT's responses.

### **7.1 Comments Received**

The Draft RP presented two alternative groundwater restoration packages for public review and consideration. The main difference between the two alternatives is that Restoration Alternative A included the San Vicente Creek Mill Option 2 restoration project, which is the most protective and most expensive of the three San Vicente restoration options. ONRT requested that the public provide input on preferences for the alternatives. In addition, the public was asked to consider how proposed projects could leverage funds from other sources. The comments summarized below in Tables 7.1 and 7.2 reflect these requests.

Table 7.1 provides a summary of comments from the public meeting and Table 7.2 provides the written comments on the Draft RP. Complete copies of the written comments are available to the public on request and can be accessed by contacting:

Ms. Rebecca de Neri Zagal  
New Mexico Office of Natural Resources Trustee  
4910-A Alameda Boulevard NE  
Albuquerque, NM 87113

**Table 7.1. Summary of comments from the October 4, 2011 public meeting in Silver City**

Organization	Comments related to project selection
GRIP	<p>Multiple comments:</p> <ul style="list-style-type: none"> <li>▶ Prefers full removal of tailings/soils at San Vicente Creek Mill Option 2. Concerned about adequacy and funding of operations and maintenance activities for the onsite disposal of waste. GRIP has been looking for funding for cleanup of the San Vicente Creek Mill for a long time without success.</li> <li>▶ Asked if FMI could accept the tailings and contaminated soil from the San Vicente Creek Mill project.</li> </ul>
Sierra Club	<p>San Vicente Creek Mill project should be used as an example for copper mining cleanup costs, especially with upcoming discharge permit legislation associated with copper mining. Supports full removal of tailings/soils at San Vicente Creek Mill Option 2 and emphasized the importance of project as cost precedent for future mining remediation sites.</p>
NMED	<p>Noted importance of the wastewater-related proposals to decrease nitrate loading to groundwater, a local groundwater concern.</p>
Esperanza Hills LLC	<p>Multiple comments:</p> <ul style="list-style-type: none"> <li>▶ Prefers full removal of tailings/soils at San Vicente Creek Mill Option 2 but realizes that the cost associated with Option 2 decreases the funding available for other proposed projects. Believes that groundwater contaminated by lead and arsenic (as in the case of the Mill) should take priority over other projects that prevent and/or minimize nitrate contributions to groundwater. Concerned about the funding for operations and maintenance associated with Option #3 for San Vicente Creek Mill.</li> <li>▶ Questioned the need and benefit of a water conservation project in this area.</li> </ul>
Town of Silver City	<p>Explained the current ordinance that requires Silver City residents to connect to new sewer lines implemented as a result of the two proposed Silver City Sewer Extension projects. Silver City may be able to establish a payment plan to fund connection costs.</p>
SWNMCOG	<p>Multiple comments:</p> <ul style="list-style-type: none"> <li>▶ Presented new sewer line extension project in the Hanover-Fierro area.</li> <li>▶ Indicated that there is a real need for water and wastewater infrastructure projects in the mining district, but there is a serious lack of funding sources and opportunities. Three primary funding programs have been used in the past: the Colonias Infrastructure Fund, the U.S. Department of Agriculture Rural Development, and the Community Development Block Grant. These programs may be used for leveraging funds.</li> <li>▶ Stated that the Bayard Reuse project is an exceptional regional project of immense regional importance. Bayard needs full funding. The Hanover project would feed into Bayard.</li> <li>▶ The SWNMCOG has experience with a septic-replacement program similar to the proposed Liquid Waste Groundwater Protection project: it involved 51 residences, and only 4 were qualified for the project (income, property deeds, and other factors took a toll on the success of the project). It was difficult to get people interested in the program.</li> </ul>



**Table 7.1. Summary of comments from the October 4, 2011 public meeting in Silver City (cont.)**

Organization	Comments related to project selection
City of Bayard	<p>Multiple comments:</p> <ul style="list-style-type: none"> <li>▶ Indicated that funding programs mentioned in the comment above only provide a very small amount of funding. The Bayard Reuse project needs the entire estimated amount or it cannot proceed. The City of Bayard has exhausted other funding opportunities; it has no funding leverage left and does not have the ability to raise additional funds. Bayard could cut the project in half, which would construct only the building, but then it couldn't send the water anywhere.</li> <li>▶ Stated that 2,500 homes are already being serviced by the Bayard Wastewater Treatment Plant and others will be connected, including the 158 homes in the Hanover-Fierro area.</li> </ul>
Trumm Engineering	<p>Removal of the cemetery and its infrastructure from the Bayard Reuse project would only reduce the cost of the project by about \$200K. The project has been designed to accommodate future wastewater reuse plans by other nearby communities. More communities are expected to connect to the Bayard Wastewater Treatment Plant in the future. This really is a regional project.</p>
Resident of Faywood	<p>Volunteered to find information on interest in Liquid Waste Groundwater Protection project. Is aware of four communities, two farms, and Casa Adobe.</p>
Identity of commenter not available	<p>Estimated that about 50% of the Hanover-Fierro onsite systems have been impacting Hanover Creek and that ~ 65% of the residents are below the poverty level. Stated that the sewer extension project for these communities could look for other funding sources, but it would be extremely tough to find any other sources. Residents have small lots that are not appropriate for onsite wastewater disposal systems, which is why these communities have a centralized water system. There have been 38 liquid waste violations so far. The contamination is what drove the need for the centralized water system.</p>

**Table 7.2. Summary of written public comments on the Draft RP**

Organization	Comments
Indian Hills Property Owners Association	Homeowners in the city part of Indian Hills pay taxes and would like to be considered for the Silver City sewer connection.
Esperanza Hills LLC	Appreciates that San Vicente Creek Mill Options 2 and 3 are considered for funding. Prefers Alternative A with Option 2 for the San Vicente Creek Mill site but acknowledges that Alternative B with Option 3 for the San Vicente site could be effective if the community commits to monitoring and maintenance. States concern over the San Vicente area because tailings wash directly down to an organic farm. Strong proponent of the San Vicente Trail, which is just east of the tailings and has suffered long delays because of fears of pollution from the tailings. For Option 3, supports separating what is removed from the site and what is capped on the site based on a standard of 800 ppm of lead rather than 1,000 ppm. In the U.S. Environmental Protection Agency (EPA) screening levels, the allowed level is 400 ppm for residential areas and 800 ppm for industrial outdoor workers. If 800 ppm were the limit, even a failure of the capping could not create a serious hazard.
Grant County Trails Group	Supports a complete removal and cleanup of the San Vicente Legacy Mine site and tailings through ONRT's groundwater damages settlement fund. Full removal would benefit the Town of Silver City's goals of developing the San Vicente Trail Creek portion of the Silver City River Walk Trail.
Private Citizen #1	Multiple comments regarding the San Vicente Creek Mill project: <ul style="list-style-type: none"> <li>▶ San Vicente mill tailings have no other funding resources for cleanup, and all of the other proposed Tier 1 projects have alternative funding resources.</li> <li>▶ If the San Vicente mill tailings are not fully removed, a sampling program is needed that checks for groundwater contamination over next 20–30 years.</li> <li>▶ There is a large community garden 100 yards downstream of San Vicente mill tailings; vegetables from garden watered by a well are sold at farmers market on a weekly basis.</li> </ul>
Private Citizen #2	Favors Alternative A, complete removal and cleanup of the hazardous substances at the San Vicente Creek Mill site. States there is no other source of funding for this cleanup and that once contaminants are removed, young and old will be able to use open space for walking and bike riding, bird watching, and ecological educational purposes.
Office of the State Engineer	Conservation (municipal or agricultural) should be couched in terms of consumption, not demand. Using consumption, the savings from low-flow toilets is lower than the 1.5 gallons suggested in the Draft RP. Other practices, such as converting "bluegrass" lawns to Xeriscape or replacing swamp coolers with heat pump refrigeration can result in real, and very significant, savings. Low-flow appliances can save a municipality pumping and treatment costs but probably would do very little, if anything, to conserve groundwater.
Private Citizen #3	Favors Alternative A, complete removal and cleanup of the hazardous substances at the San Vicente Creek Mill site. States there is no other source of funding for this cleanup.

**Table 7.2. Summary of written public comments on the Draft RP (cont.)**

Organization	Comments
Private Citizen #4	Strong support of complete removal of the San Vicente Creek Mill tailings; this may be a one-time opportunity. Full removal will protect and revitalize the town's only waterway and protect the right of children to play and swim in river.
GRIP	<p>Multiple comments regarding the San Vicente Creek Mill project:</p> <ul style="list-style-type: none"> <li>▶ Supports full removal of the San Vicente tailings (Option 2) because it is unclear if the NMED will be able to guarantee long-term monitoring of the site if partial removal is selected and provides best long-term restoration and protection of groundwater and surface water.</li> <li>▶ GRIP has been exploring the possibility of the FMI's Grant County mine accepting tailing materials, which would reduce transportation costs and overall costs of the alternative.</li> <li>▶ If liability is an issue as it relates to FMI accepting the San Vicente tailing materials, EPA's Region 6 Superfund Division director has indicated that a "Good Samaritan" type agreement could be used, which should be explored with EPA if appropriate.</li> <li>▶ GRIP expresses disappointment that \$1.5 million was taken from ONRT-FMI settlement funds for Rio Grande water rights litigation through the Attorney General's Office.</li> </ul>
Private Citizen #5	Supports full cleanup of the San Vicente Creek Mill (Restoration Alternative A). Avid hiker and birder of the San Vicente Creek for many years and believes full cleanup is the best alternative for a safe and healthy environment, not only for wildlife but for people who visit this wonderful area so close to downtown Silver City.
Private Citizen #6	As a resident of Silver City and a frequent hiker in the San Vicente Creek area, this citizen voiced support for Restoration Alternative A, the full cleanup and restoration of the San Vicente Creek Mill.
Private Citizen #7	Supports Restorative Alternative A to clean up San Vicente Creek Mill site tailings. Believes that a partial removal is not suitable and requests ONRT to remove all contaminants because the town of Silver City needs to further improve a trail along this riparian area. States that one day citizens will be able to walk along San Vicente Creek with their pets and children without worrying.

## 7.2 Response to Comments

ONRT received numerous comments during the public review process.<sup>1</sup> Comments and ONRT's responses to each comment are outlined below.

**Comment:** Three commenters specified their support of the Bayard Reuse Project as an exceptional regional project that has exhausted other funding opportunities including loan options.

**Response:** ONRT appreciates the support expressed for the Bayard Reuse Project. This project has been selected as a Tier 1 project.

**Comment:** Sixteen commenters indicated preference for funding the San Vicente Creek Mill – Option 2 restoration project (complete offsite disposal) instead of Option 3 (combination of onsite and offsite disposal). The main reasons for preferring the San Vicente Creek Option 2 included:

- ▶ Comprehensive cleanup would do the most to protect groundwater resources
- ▶ Complete offsite disposal would benefit Silver City's goals of developing the San Vicente Trail Creek portion of the Silver City River Walk Trail
- ▶ Concerns that tailings pose an environmental hazard to vegetables grown nearby or to surface water used for recreation
- ▶ Concerns that there was not adequate funding or provisions for long-term oversight of the onsite disposal cell under Option 3.

**Response:** ONRT is committed to using groundwater natural resource damage assessment settlement funding to select restoration projects that will provide the most effective benefits to groundwater resources. Because of the permanent, long-term benefits to groundwater that would result from the complete removal of contaminants from the San Vicente Creek Mill site, ONRT has selected the San Vicente Creek Mill Option 2 as a Tier 1 project. ONRT evaluated the possibility of encapsulating some portion of the tailings in an onsite disposal cell (Option 3) and developing a binding contract with NMED to provide long-term oversight of the cell. However, ONRT was concerned that severe weather events in the region could result in breaches to the cap and subsequent release of contaminants to surface water and groundwater, even with adequate long-term oversight. To avoid the risk of future groundwater contamination, ONRT has selected Option 2, which will completely remove contaminants from the site.

---

1. Several commenters included multiple topics in their comments.

Multiple commenters expressed support for Option 2 because of a desire to develop recreational activities in the area (such as a walking trail). Although ONRT appreciates the public's desire for recreational improvements, ONRT's decision was based solely on which project option would provide the greatest long-term benefit to groundwater.

One commenter asked if FMI could take the tailings and contaminated soil from the San Vicente Creek Mill project. ONRT does not know at this time whether FMI has the ability or interest to accept these tailings. ONRT will continue to pursue any feasible opportunities for cost savings for this project.

One commenter requested that the San Vicente Creek Mill project be used as an example for costs associated with the cleanup of mines. This RP is not intended to set a precedent for mining cleanup costs. As such, ONRT did not select Option 2 with the intention of developing a cost precedent for future mining remediation sites. At the conclusion of the project, the total cost expenditures associated with implementing Option 2 will be available to the public.

**Comment:** One commenter requested that Indian Hills be considered for the Silver City sewer connection. Indian Hills is an old subdivision on the north side of Silver City that was developed with onsite wastewater systems.

**Response:** During the public comment period, the Town of Silver City submitted a proposal to construct sewer line extensions to serve portions of Indian Hills that do not currently have municipal sewers. The proposal included the Cain/Arrowhead and Cottonwood areas of Indian Hills. ONRT evaluated the Indian Hills sewer extension line projects and placed these projects into Tier 2, based on a higher cost per household compared to the sewer line extension and improvement projects included in Tier 1.

**Comment:** The Hanover-Fierro Wastewater Collection and Disposal System was presented as a new project at the October 4, 2011 public meeting, and ONRT was asked to evaluate it.

**Response:** ONRT evaluated the Hanover-Fierro Wastewater Collection and Disposal System in two ways – as a first phase which would include only the Hanover portion of the project and as a full project that would include the entire Hanover-Fierro project. ONRT placed these projects into Tier 2, based on a higher cost per household compared to the sewer line extension and improvement projects included in Tier 1.

**Comment:** The Office of the State Engineer suggested that water conservation projects should be considered in terms of consumption, as opposed to demand, and suggested that Xeriscaping and replacing swamp coolers with heat pump refrigeration would conserve more groundwater than low-flow appliances.

**Response:** ONRT agrees with the Office of the State Engineer that a water conservation project should be considered in terms of consumption. Given the relatively small population of Silver City, low-income levels compared with the state and national average, and the lack of expressed interest in water conservation projects, ONRT concluded that there would likely be insufficient participation to make a water conservation project feasible. Therefore, this project was moved to the “not recommended for funding” category for the Final RP.

**Comment:** One commenter expressed interest in a liquid waste groundwater protection project. Understanding that adequate participation was necessary to fund this type of project, the commenter volunteered to find information regarding interest in the project in the Faywood area.

**Response:** ONRT did not receive further information regarding interest in a liquid waste groundwater protection project during the public comment period. ONRT also received information from the SWNMCOG that a similar project that they supported had low participation rates. Because of the likelihood of low participation, this project was moved to the “not recommended for funding” category for the Final RP.

---

## References

Dames & Moore. 1983. Ground Water Monitoring Study, Chino Mill Near Hurley, New Mexico. Prepared for Kennecott Minerals Company. January 19.

Daniel B. Stephens & Associates. 1997a. Closure/Closeout Plan, Tyrone Mine. Daniel B. Stephens & Associates Inc. Prepared for Phelps Dodge Tyrone, Inc., Tyrone, NM. December 19. Albuquerque, NM.

Daniel B. Stephens & Associates. 1997b. Preliminary Materials Characterization Tyrone Mine Closure / Closeout. Daniel B. Stephens & Associates Inc. Prepared for Phelps Dodge Tyrone, Inc., Tyrone, New Mexico. April 30.

Daniel B. Stephens & Associates. 1997c. Preliminary Site-Wide Groundwater Study: Tyrone Mine Closure / Closeout. Prepared for Phelps Dodge Tyrone, Inc., Tyrone, NM. May 31.

Daniel B. Stephens & Associates. 1997d. Supplemental Materials Characterization, Tyrone Mine Closure / Closeout. Daniel B. Stephens & Associates Inc. Prepared for Phelps Dodge Tyrone, Inc., Tyrone, New Mexico. October 31.

Daniel B. Stephens & Associates. 1999. Revised Closure/Closeout Plan, Tyrone Mine. Daniel B. Stephens & Associates Inc. Prepared for Phelps Dodge, Tyrone, Inc., Tyrone, NM. April 30. Albuquerque, NM.

Daniel B. Stephens & Associates. 2004. Stage 1 Abatement Plan Proposal Tyrone Mine Facility. Prepared for Phelps Dodge Tyrone, Inc., Tyrone, NM. Albuquerque, NM. October 15.

Dresher, W.H. 2001. How hydrometallurgy and the SX/EW process made copper the “green” metal. *Innovations*(August).

Freeport-McMoRan Copper & Gold. 2010. 2010 Annual Report. Freeport-McMoRan Copper & Gold Inc., Phoenix, AZ. Available: [http://www.fcx.com/ir/AR/2010/FCX\\_AR\\_2010.pdf](http://www.fcx.com/ir/AR/2010/FCX_AR_2010.pdf). Accessed August 23, 2011.

Golder Associates. 1998. Waste Rock Characterization, Chino Mine. Prepared for Chino Mines Company, Hurley, New Mexico. August 10.

Golder Associates. 1999. Comprehensive Groundwater Characterization Study: Phase 3 Report. Prepared for Chino Mines Company, Hurley, New Mexico. January.

Golder Associates. 2004. Chino Mines – Sitewide Stage 1 Abatement Plan. Submitted to Chino Mines Company, Hurley, New Mexico. April 22.

Golder Associates. 2006. Chino Mine groundwater quality database (in Access). Received by Stratus Consulting in July 2006 during the settlement process.

Golder Associates. 2008. Chino Mines Company Site Wide Stage 1 Abatement Final Investigation Report. Submitted to Freeport McMoRan, Chino Mines Company, Hurley, NM. July 18.

Integrated Analytical Laboratories. 2009. Chain of Custody, Soil Cores.

M3 Engineering & Technology. 2001. End of Year 2001 through Year 2006 Closure/Closeout Plan: Continental Mine. Volumes 1–3. Prepared by M3 Engineering & Technology Corporation for Cobre Mining Company, Hurley, NM. April.

NMED. 2003. Public Notice – Phelps Dodge Tyrone Inc. Application for Discharge Permit Renewal (DP-166). Ground Water Quality Bureau. New Mexico Environment Department. March.

NMED. 2010. Site Inspection Reassessment. San Vicente Creek Mill. CERCLIS #: NMD980879415. Grand, County New Mexico. Superfund Oversight Section, Ground Water Quality Bureau, New Mexico Environment Department. September.

NMWRRI. 2000. Trans-International Boundary Aquifers in Southwestern New Mexico. Prepared for U.S. EPA and the International Boundary and Water Commission – U.S. Section. New Mexico Water Resources Research Institute. March. Available: <http://wrri.nmsu.edu/publish/otherhrrpt/otherhrrpt.html>. Accessed August 31, 2011.

NOAA. 1999. Discounting and the Treatment of Uncertainty in Natural Resource Damage Assessments. *Technical Paper 99-1*. Prepared by the Damage Assessment and Restoration Program Damage Assessment Center, Resource Valuation Branch, National Oceanic and Atmospheric Administration, Silver Spring, MD.

Nordstrom, D.K. and C.N. Alpers. 1999. Geochemistry of acid mine waters. In *The Environmental Geochemistry of Mineral Deposits Part A: Processes, Techniques, and Health Issues*, G.S. Plumlee and M.J. Logsdon (eds.). Society of Economic Geologists, Littleton, CO. pp. 133–160.



- Plumlee, G.S. 1999. The environmental geology of mineral deposits. In *The Environmental Geochemistry of Mineral Deposits Part A: Processes, Techniques, and Health Issues*, G.S. Plumlee and M.J. Logsdon (eds.). Society of Economic Geologists, Littleton, CO. pp. 71–116.
- SARB. 1999. Geochemical Evaluation of Tailings and Stockpiles, Tyrone Mine. Prepared for Phelps Dodge Tyrone, Inc., Tyrone, NMo. SARB Consulting Inc. December 22.
- Shepherd Miller. 1999. Baseline Characterization of the Hydrology, Geology, and Geochemistry of the Proposed Continental Mine Expansion Project, Cobre Mining Company, Inc. Prepared for Cobre Mining Company, Inc., c/o Chino Mines, Hurley, NM. December.
- State of New Mexico. 2011. New Mexico Administrative Code (NMAC) Title 20 Environmental Protection, Chapter 6 Water Quality, Part 2 Groundwater and Surface Water Protection. Available: <http://www.nmcpr.state.nm.us/nmac/parts/title20/20.006.0002.htm>. Accessed August 31, 2011.
- Telesto Solutions. 2005. Stage 1 Ground Water Abatement Plan. Prepared for Cobre Mining Company, Hurley, NM. February. Fort Collins, CO.
- Telesto Solutions. 2007. Groundwater debit calculations for the Continental Mine. Technical Memorandum to Mr. Dahlva Moellenberg from Walter Niccoli. March 15.
- Trauger, F.D. 1972. Water Resources and General Geology of Grant County, New Mexico. Hydrologic Report 2. New Mexico State Bureau of Mines and Mineral Resources.
- U.S. EPA. 1994. *Technical Document: Background for NEPA Reviewers: Non-coal Mining Operations*. EPA/530/R-95/043. Office of Solid Waste. U.S. Environmental Protection Agency.
- U.S. EPA. 2009. *2009 Edition of the Drinking Water Standards and Health Advisories*. EPA/822-R-09-011. Office of Water, U.S. Environmental Protection Agency.
- U.S. Securities and Exchange Commission. 2002. Form 10-K for the Fiscal Year Ended December 31, 2001: Phelps Dodge Corporation (a New York Corporation).

---

## A. Complete Project List

### Complete list of groundwater restoration projects identified by ONRT

Project category	Project title
Abandoned Site Cleanup	San Vicente Creek Mill Option 1
	San Vicente Creek Mill Option 2
	San Vicente Creek Mill Option 3
	Cleanup of Pacific Ridge Abandoned Mine Sites within Pinos Altos Mining District
	Carlisle Mine Site
	Cleanup of Old Silver City Dump Site
Groundwater Conservation	Bayard Reuse
	Grant County Water Conservation
	Grant County Water Conservation Plan Development
Main Line Sewer Improvement	Hurley Sewer Lines Replacement
	North Hurley Sewer Line Extension
	Hanover-Fierro Wastewater Collection and Disposal System
	Silver City Mountain View Road Sewer Line Extension (southwest area of city)
	Silver City Blackhawk Sewer Line Extension (north area of city)
	Silver City Indian Hills Sewer Line Extension (Cain/Arrowhead and Cottonwood area)
	Silver City East Ridge Road Area Sewer Line Extension (Mobile/Mountain View Drive and Sky View/Pheasant Drive Area)
Replace Substandard Septic Systems	Santa Clara Gravity Sewer Improvements
	Grant County Liquid Waste Groundwater Protection
Watershed Improvement	Cameron Creek and Twin Sisters Creek Watershed Improvements
Drinking Water Protection/Improvement	Regional Water Supply and Distribution
	Santa Clara Wellhead Protection