UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS, TX 75202-2733

EPA REGION 6 ANNOUNCES THE COMPLETION OF THE DRAFT FINAL REMEDY SYSTEM EVALUATION (RSE) REPORT

for

HOMESTAKE MINING COMPANY SUPERFUND SITE CIBOLA COUNTY, NEW MEXICO

Enclosed for your review and comment is the draft final RSE report prepared for the Homestake Mining Company Site. This document dated December 19, 2008, was prepared by Environmental Quality Management (EQM) under a contract with the United States Environmental Protection Agency. Also attached to this report is a transmittal letter from the EPA Office of Solid Waste and Emergency Response to Region 6 briefly describing the RSE process that was followed during the preparation of this report.

Please let us know if you find any errors or if you have comments on the RSE report. Comments are accepted from stakeholders until January 30, 2009. Please note this report is an independent evaluation of the ground water treatment system at Homestake Mining Company Site by EQM. The findings and the recommendations provided in this report are solely EQM's.

Please email your comments to appaji.sairam@epa.gov.

If you have any questions, please contact Sai Appaji at (214) 665-3126.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
SOLID WASTE AND EMERGENCY
RESPONSE

December 22, 2008

Mr. Sairam Appaji
Remedial Project Manager
U.S. Environmental Protection Agency, Region 6
Mail Drop 6SF-RL
1445 Ross Avenue
Suite 1200
Dallas, Texas 75202

RE: Transmittal of Draft Final Remediation System Evaluation for the Homestake Mining Company

Dear Mr. Appaji:

The purpose of this letter is to deliver the draft final Remediation System Evaluation (RSE) report for the Homestake Mining Company (HMC) located in Grants, New Mexico. The RSE report was prepared on behalf of the U.S. Environmental Protection Agency's Office of Research and Development (ORD) and Office of Superfund Remediation and Technology Innovation (OSRTI) for EPA Region 6. The purpose of the RSE was to provide an independent and comprehensive review of the groundwater extraction and treatment system to determine if protectiveness and/or cost improvements are possible without reducing overall protection of human health and the environment, in accordance with the U.S. Army Corps of Engineers Remediation System Evaluation instruction guide (http://www.environmental.usace.army.mil/rse_checklist.htm) and per the scope of work prepared by RTI, Task Order 35, Work Order 1, Task 1.

The draft final RSE has undergone two rounds of review from EPA ORD, EPA OSRTI, EPA Region 6, and the New Mexico Environment Department (NMED) in an effort to correct factual and grammatical errors, to clarify the basis for various recommendations, and to identify topics that were not fully addressed in the RSE report. All report comments and subsequent report revisions have been submitted to EPA Region 6 through prior correspondence and all changes to the report are documented with EPA Region 6. This draft final report reflects changes as a result of the two rounds of review described above, however, it is emphasized that this report reflects the independent opinion of the Contractor, and does not represent endorsement by EPA.

Because certain topics may not have been addressed to EPA ORD's and OSRTI's satisfaction, we may request additional technical evaluation of specific topics. This follow-on evaluation will likely take place under a separate effort with the U.S. Army Corps of Engineers, NMED, or EPA Region 6. Below is a list of several topics that may require additional evaluation:

- An evaluation of the overall remediation strategy to determine if protectiveness of human health and the environment is being achieved in the most efficient and cost effective manner and if alternative strategies are available that would offer optimized short-term and long-term protection of human health and the environment;
- A review of the groundwater extraction and injection system to determine if groundwater flow and contaminant plume capture is being achieved;
- A review of the groundwater monitoring network to determine if adequate spatial and temporal groundwater monitoring is being achieved;
- A review of the efficacy of the large tailings pile flushing/dewatering system and a review of alternative source control/treatment technologies for the large tailings pile. This analysis may include an evaluation of potential negative impacts of large tailings pile flushing such as mobilization of additional contaminants to the subsurface aquifers;
- A review of the current and proposed spray irrigation system to determine if sufficient evaporative capacity exists or will exist with construction of the 3rd pond and if alternative strategies are available; and
- A review of the efficacy and human health and ecological risks posed by the down gradient irrigation systems.

Any additional follow-on studies will be coordinated with EPA Region 6 and NMED and be initiated in early 2009.

Please feel free to contact me or David Reisman (ORD) if you have any questions regarding the draft final RSE. I can be reached at 617-918-8362 or yager.kathleen@epa.gov, and David can be reached at 513-569-7588 or reisman.david@epa.gov.

Best regards,

Kathleen M. Yager
Environmental Engineer

cc: David Reisman, ORD
David L. Mayerson, NMED
Jerry Schoeppner, NMED

Environmental Quality Management, Inc.
1800 Carillon Boulevard
Cincinnati, Ohio 45240
(513) 825-7500
FAX (513) 825-7495
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December 19, 2008

Mr. David Reisman
Task Order Manager/Work Order Manager
US EPA/NRMRL
26 West Martin Luther King Drive
Cincinnati, Ohio 45268

Subject: Draft Final RSE Report
Homestake Superfund Site, Milan, NM
Contract No. EP-C-05-060 ("STREAMS")
Technical Support Task Order 35, Work Order #4
PN 030257.0004

Dear David:

Enclosed please the Draft Final Remediation System Evaluation Report for the Homestake Superfund Site, Milan New Mexico. Three hard copies were sent to NMED as requested by David Mayerson.

Sincerely,

ENVIRONMENTAL QUALITY MANAGEMENT, INC.

William E. Thompson
Project Manager

Enclosures

cc: Sai Appaji (EPA Region 6)
Kathleen Yager (EPA Hq)
David Mayerson (NMED)
Jerry Schoeppner (NMED)
Scott Guthrie(RTI)

REMEDIATION SYSTEM EVALUATION (RSE)

Homestake Superfund Site
Milan, New Mexico

Report of the Remediation System Evaluation

Site Visit Conducted June 24 and 25, 2008

DRAFT FINAL REPORT

December 19, 2008

REMEDIATION SYSTEM EVALUATION (RSE)

Homestake Mining Company Superfund Site
Milan, New Mexico

Report of the Remediation System Evaluation

Site Visit Conducted June 24 and 25, 2008

DRAFT FINAL REPORT

Prepared By:
Environmental Quality Management, Inc.
1800 Carillon Blvd.
Cincinnati, OH 45240

Prepared For:
U.S. Environmental Protection Agency
Office of Research and Development
Cincinnati, OH

December 19, 2008

NOTICE

Work described herein was performed by Environmental Quality Management, Inc. (EQ) for the U.S. Environmental Protection Agency (USEPA). The work was performed under EPA Contract No. EP-C-05-060, Task Order 35, Work Order 2, Research Triangle Institute, Raleigh, North Carolina. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

EXECUTIVE SUMMARY

A Remediation System Evaluation (RSE) was conducted in 2008 for the Homestake Mining Company (HMC) Superfund Site in Milan, New Mexico. A RSE involves a team of expert scientists and engineers conducting a third-party evaluation of operations. It is a broad evaluation that considers the goals of the remedy, site conceptual model, above-ground and subsurface performance, and site closure strategy. The evaluation includes reviewing site documents, visiting the site, and compiling a report that includes recommendations to improve the system.

The HMC Superfund Site is located in Cibola County, New Mexico, approximately 5.5 miles north of the Village of Milan on Highway 605. HMC operated a mill at the site from 1958 until 1990. The mill was decommissioned and demolished between 1993 and 1995. Seepage from mill tailings wastes (i.e., Large Tailings Pile and Small Tailings Pile) resulted in the contamination of groundwater with radiological and non-radiological contaminants, including uranium, thorium-230, radium-226 and radium-228, selenium, molybdenum, sulfate and total dissolved solids (TDS), among others.

Groundwater in four aquifer units has been contaminated with uranium, selenium, and other contaminants by past HMC actions. The affected aquifers are:

1. The Alluvial Aquifer: an up to 60-foot thick alluvial unit extending from the water table to the underlying Chinle Formation.
2. The Upper Chinle Aquifer: an average 20-foot thick continuous sandstone layer within the Chinle Formation (principally shale).
3. The Middle Chinle Aquifer: an average 40-foot thick continuous sandstone layer, within the Chinle Formation.
4. The Lower Chinle Aquifer: an average 120-foot thick zone of discontinuous fractures within the Chinle Formation.

A fifth aquifer, the San Andres Aquifer, the most important regional aquifer, does not appear to have been directly affected by contaminants from the Site.

Potential receptors of contaminants in groundwater include previous and current users of water supply wells in five Subdivisions located south and southwest of the HMC site. All but nine of these users have been connected to the City of Milan public water supply. Numerous wells formerly used to supply drinking water are still used to irrigate crops.

The groundwater remediation system has been in operation in one form or another since 1977. The system currently has several components to restore groundwater quality to action levels established by the Nuclear Regulatory Commission (NRC). System components include collecting contaminated groundwater, treating some of the collected water through a reverse osmosis treatment plant, disposing of some of the water in evaporation ponds, supplying some of the water to irrigate cropland, and injecting fresh water from the San Andres Aquifer, groundwater from the Alluvial Aquifer and Chinle Aquifers with low concentrations of uranium, selenium and other contaminants and treated product water to aid in containment and cleanup activities. Additionally, HMC operates a program to remove uranium and associated

contaminants from the Large Tailings Pile. This system includes injection of water using wells and recovery of water using extraction wells and drains. The purpose of the system is to flush contaminants from the Large Tailings Pile. Flushing of the Large Tailings Pile is intended to provide source control for the principal contaminants in groundwater.

The objectives of the current remediation effort are:

1. Limit radon emissions from the tailings piles
2. Remediate contamination in soil that resulted from windblown tailings
3. Remediate groundwater to levels stipulated in the NRC License SUA-1471 and the NMED DP-200
4. Dewater the large tailings pile to remove this area as a continuing source of groundwater contamination
5. Prevent the consumption of contaminated groundwater by residents of the five Subdivisions adjacent to the site.

Past and ongoing actions have resulted in the decreasing in the size and reducing the mass of contaminants in the Alluvial Aquifer and reduction in contaminant mass but not size of Chinle Aquifers plumes. Remediation will not be achieved until NRC action levels have been met. At the time of this evaluation, HMC's goal for the Alluvial Aquifer is to achieve action levels established based on background conditions by the U.S. Nuclear Regulatory Commission (NRC) and agreed to by the New Mexico Environment Department and the U.S. Environmental Protection Agency.

The RSE Team did not identify significant short-comings or limitations to the efforts being conducted by HMC. The recommendations made by the RSE Team and summarized below are not intended to imply a deficiency in the work of the designers, operators or managers but are offered as constructive suggestions in the best interest of all stakeholders.

1. To assure continued efforts to remediate the west and south plumes in the Alluvial Aquifer, HMC should develop a plan of attack including impact of changes of the groundwater remedial effort on future water treatment and disposal.

2. To assist efforts to improve the rate of groundwater clean-up, HMC should consider terminating pumping from the Chinle Aquifers until the Alluvial Aquifer action levels have been achieved at the subcrops. This effort will have to be matched by termination of pumping from local private wells (this action is beyond HMC's control alone).

3. To reduce the potential threat to human health of nine residences in Valle Verde still using wells, HMC should consider taking actions necessary to provide drinking water from an alternate source (e.g., City of Milan).

4. To improve water treatment, if full-scale operation of the reverse osmosis unit is initiated, HMC should evaluate the effectiveness of the clarifier and sand filter system with the anticipated increase in flow. Additional clarification and/or sand filtration capacity may

be necessary. Also, to improve the efficiency of the primary pH control system at the water treatment plant, HMC should not switch to using lime solely for pH control as this would result in an increase in solids load to the reactor/clarifier and sand filtration systems.

5. To eliminate perceived human health and environmental risks posed, HMC should consider termination of the irrigation systems for treatment of water.

6. To improve handling of water to be evaporated, HMC should proceed with efforts necessary to obtain approval for installation of additional evaporation pond capacity.

7. To address deterioration of pond liners, HMC should evaluate methods to provide protection to the exposed liner to assure its integrity.

8. To assure environmental protection after remedial actions are complete, HMC should take such actions as are necessary to evaluate and demonstrate the effectiveness of entombment of all wastes in Evaporation Pond #1.

9. To assure human health and environmental protection associated with spray from the evaporation ponds and dust from collection ponds, HMC should attempt to quantify the contaminants present in spray and dust and implement engineering controls to control the potential threat. Installation of additional evaporation capacity should eliminate the on-going concerns about spray.

10. To assure human health and environmental protection from contaminants in soil around the evaporation ponds and irrigation areas, HMC should conduct such evaluations as necessary to evaluate conditions and take all action necessary to remediate any problem identified.

11. To assure human health and environmental protection potentially caused by current practice to dispose of purge water onto the ground, HMC should consider terminating this practice at any sampling location where the NRC action levels are exceeded. The purge water should be treated through the RO unit for re-use or be disposed in the Evaporation Ponds.

ACRONYMS AND ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
CAP	Corrective Action Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COCs	Contaminants of Concern
CPG	Certified Professional Geologist
CSM	Conceptual Site Model
DP	Discharge Permit
EQM	Environmental Quality Management, Inc.
gpm	gallons per minute
FS	Feasibility Study
HDPE	High Density Polyethylene
HMC	Homestake Mining Company
MCL	Maximum Contaminant Level
mg/l	milligrams per liter
NMED	New Mexico Environment Department
NRC	Nuclear Regulatory Commission
OU	Operable Unit
pCi/l	pico-Curies per liter
PE	Professional Engineer
POC	Point of Compliance
PRB	Permeable Reactive Barrier
RO	Reverse Osmosis
ROD	Record of Decision
RSE	Remediation System Evaluation
TDS	Total Dissolved Solids
USEPA	U.S. Environmental Protection Agency

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Figures (continued)

References for Figures

[a] Hydro-Engineering, LLC, March 2008, 2007 Annual Monitoring Report / Performance Review for Homestake's Grants Project Pursuant to NRC License SUA-1471 and Discharge Plan DP-200

[b] MFG, Inc, December 2006, Grants Reclamation Project, Groundwater Corrective Action Program (CAP) Revision

[c] Hydro-Engineering, LLC, October 2003, Grants Reclamation Project Background Water Quality Evaluation of the Chinle Aquifer

[d] Homestake Mining Company, June 2008, Site Visit Handout

[e] Kleinfelder, Inc., January 2007, Environmental Report for the Construction of Evaporation Pond # 3 and Associated Operations Boundary Expansion

[f] Hydro-Engineering, LLC, November 2007, Support of Temporary Diversion at the Grants Reclamation Site

[g] Homestake Mining Co., June 30, 2008, Ground Water Status Report

1.0 INTRODUCTION

1.1 Purpose

The Remedial System Evaluation (RSE) Team provided labor, equipment, materials, and travel necessary to complete a RSE for the Homestake Mining Company (a subsidiary of Barrick Corp.) (HMC) Superfund Site in Milan, New Mexico. The purpose of the RSE is to evaluate the performance of the current groundwater remediation system to determine if specific cost and/or protectiveness improvements are possible within the required regulatory process for the Site. The RSE is a broad evaluation that considers the goals of the remedy, the site conceptual model, the above ground and subsurface performance, and the site closure strategy.

The RSE Team is a group of scientists and engineers, independent of the Site and USEPA, conducting a third party evaluation of site operations and alternative approaches to meet the remedial goals. The RSE Team followed the U.S. Army Corps of Engineers RSE Instruction Guide.

The remedial action objectives for groundwater remediation [Operable Unit (OU) #1] are defined in Nuclear Regulatory Commission (NRC) License SUA-1471 and NRC-approved groundwater Corrective Action Plan (CAP), the New Mexico Environment Department (NMED) Discharge Permits DP-200 and DP 725, the 1983 Stipulation of Agreement between the USEPA and HMC and the 1989 ROD. The remedial action objectives for decommissioning the mill, surface reclamation, long-term stabilization of the tailings and closure (OU#2) are defined in the NRC License SUA-1471. The objectives of the remedial activities contained in the NRC License and NMED permit are:

(1) Limit radon emissions from the tailings piles

(2) Remediate contamination in soil that resulted from windblown tailings

(3) Remediate groundwater to levels stipulated in the NRC License SUA-1471 and the NMED DP-200

(4) Dewater the large tailings pile to remove this area as a continuing source of groundwater contamination

(5) Prevent the consumption of contaminated groundwater by residents of the five Subdivisions adjacent to the site. It must be noted here that background groundwater quality may not meet criteria considered to be protective of human health.

This report documents the RSE Team's evaluation of the HMC Site. The RSE was conducted and prepared using information provided in existing documents (Section 1.3) and during a Site Visit on June 24 and 25, 2008. Following the Site Visit and after further evaluation of the available information, the RSE Team requested additional information and clarification from HMC in July 2008. Selected photographs taken during the Site Visit can be found in Appendix A.

Figures presented in this report are taken directly from various reports and documents prepared by HMC and have been selected to support the RSE Team's understanding of the Site and systems. The figures are in Appendix B and references have been provided in the Table of Contents to facilitate the reader's ability to locate the source of the materials presented.

Appendix C contains comments provided by the USEPA and NMED on earlier draft RSE reports. As a result of these comments, the organization of this Draft Final RSE Report has been modified from earlier drafts and thus specifically innumerate comments may be difficult to locate in this Draft Final Report. The most significant changes involved the creation of a new section called "6.0 Alternatives" with the elimination of Section 4.8 called "Alternate Technologies and Approaches." This change resulted in renumbering and reorganization of Recommendations (Section 7.0) and Summary (Section 8.0).

1.2 Team Composition

The RSE Team conducting the Site Visit consisted of the following individuals:

- Robert Amick, PE, Project Manager/Senior Environmental Engineer, Environmental Quality Management, Inc. (EQ)
- William Thompson, CPG, Senior Hydrogeologist, EQ
- Charles Schick, CPG, Hydrogeologist, EQ
- Edward Wise, PE, Senior Chemical Engineer, EQ

The RSE Team was accompanied by the following USEPA representatives:

- David Reisman, Office of Research and Development (ORD)
- Kathy Yager, Technology Innovation Office
- Robert Ford, ORD
- Sai Appaji, Region 6

1.3 Documents Reviewed

Table 1 lists the principal documents reviewed by the RSE Team. The efforts made by USEPA's Sai Appaji and HMC's Allan Cox and his staff to provide these materials are appreciated. The documents on Table 1, especially those that are highlighted, provide the basis for the description of conditions (specifically Sections 1.5 and 2.0) presented in this report.

1.4 Persons Contacted

The following individuals associated with the Site were present during the Site Inspection:

- Allan Cox, HMC Site Manager
- Dan Kump, PE, HMC Senior Project Engineer
- George Hoffman, PE, Hydro-Engineering, LLC
- Ken Barker – Environmental Restoration Group

Table 1.
Reviewed Documents

Title	Author	Date
Record of Decision, Homestake Mining Company, Radon Operable Unit, Cibola County, New Mexico	U.S. Environmental Protection Agency - Region 6/CH2M Hill	September 1989
Ground-Water Monitoring and Performance Review for Homestake's Grants Project, NRC License SUA-1471 and Discharge Plan DP-200, 1999	Hydro-Engineering, LLC	February 2000
First Five-Year Review Report for Homestake Mining Company Superfund Site, Cibola County, New Mexico	U.S. Environmental Protection Agency, Region 6/CH2M Hill	September 2001
Statistical Evaluation of Chinle Aquifer Quality at the Homestake Site Near Grants, NM	Environmental Restoration Group, Inc.	October 2003
Statistical Evaluation of Alluvial Groundwater Quality Upgradient of the Homestake Site Near Grants, NM	Environmental Restoration Group, Inc.	October 2003
Background Water Quality Evaluation of the Chinle Aquifers	Homestake Mining Co. and Hydro-Engineering, LLC	October 2003, Revised June 2004
Semi-Annual Environmental Monitoring Report, January - June	Homestake Mining Company of California	2005
2004 Annual Monitoring Report / Performance Review for Homestake's Grants Project Pursuant to NRC License SUA-1471 and Discharge Plan DP-200	Hydro-Engineering, LLC	March 2005
2005 Annual Monitoring Report / Performance Review for Homestake's Grants Project Pursuant to NRC License SUA-1471 and Discharge Plan DP-200	Hydro-Engineering, LLC	March 2006
Second 5-Year Review Report for Homestake Mining Company Superfund Site	U.S. Environmental Protection Agency - Region 6	September 2006
Grants Reclamation Project, Groundwater Corrective Action Program (CAP) Revision	MFG, Inc.	December 2006
Environmental Report for the Construction of Evaporation Pond #3 (EP3) and Associated Operations Boundary Expansion	U.S. Nuclear Regulatory Commission	January 2007
Support of Temporary Diversion at the Grants Reclamation Site	Hydro-Engineering, LLC	November 2007
2007 Annual Monitoring Report / Performance Review for Homestake's Grants Project Pursuant to NRC License SUA-1471 and Discharge Plan DP-200	Hydro-Engineering, LLC	March 2008
Health Consultation, Homestake Mining Company Mill Site	Agency for Toxic Substances and Disease Registry	May 2008
Draft Discharge Permit Renewal and Modification, Homestake Mining Company, DP-725	New Mexico Environment Department	May 2008
Ground Water Status Report, June 30, 2008	Homestake Mining Co.	June 2008
Discharge Permits 200 and 201	New Mexico Environment Department	Various

Shaded documents are sources of figures used in this RSE.

1.5 Site Location, History, and Characteristics

1.5.1 Location

The HMC Superfund Site (the Site) is located in Cibola County, New Mexico, approximately 5.5 miles north of the Village of Milan, at the intersection of Highway 605 and Country Road 63 (Figure 1.2-1). The Site is the location of a former uranium mill and the property owned by HMC at the time of uranium mill operations. Subsequently, HMC acquired additional land to obtain access to locations where various actions can be or have been undertaken to address remediation of contaminated groundwater that extends beyond the Site boundaries.

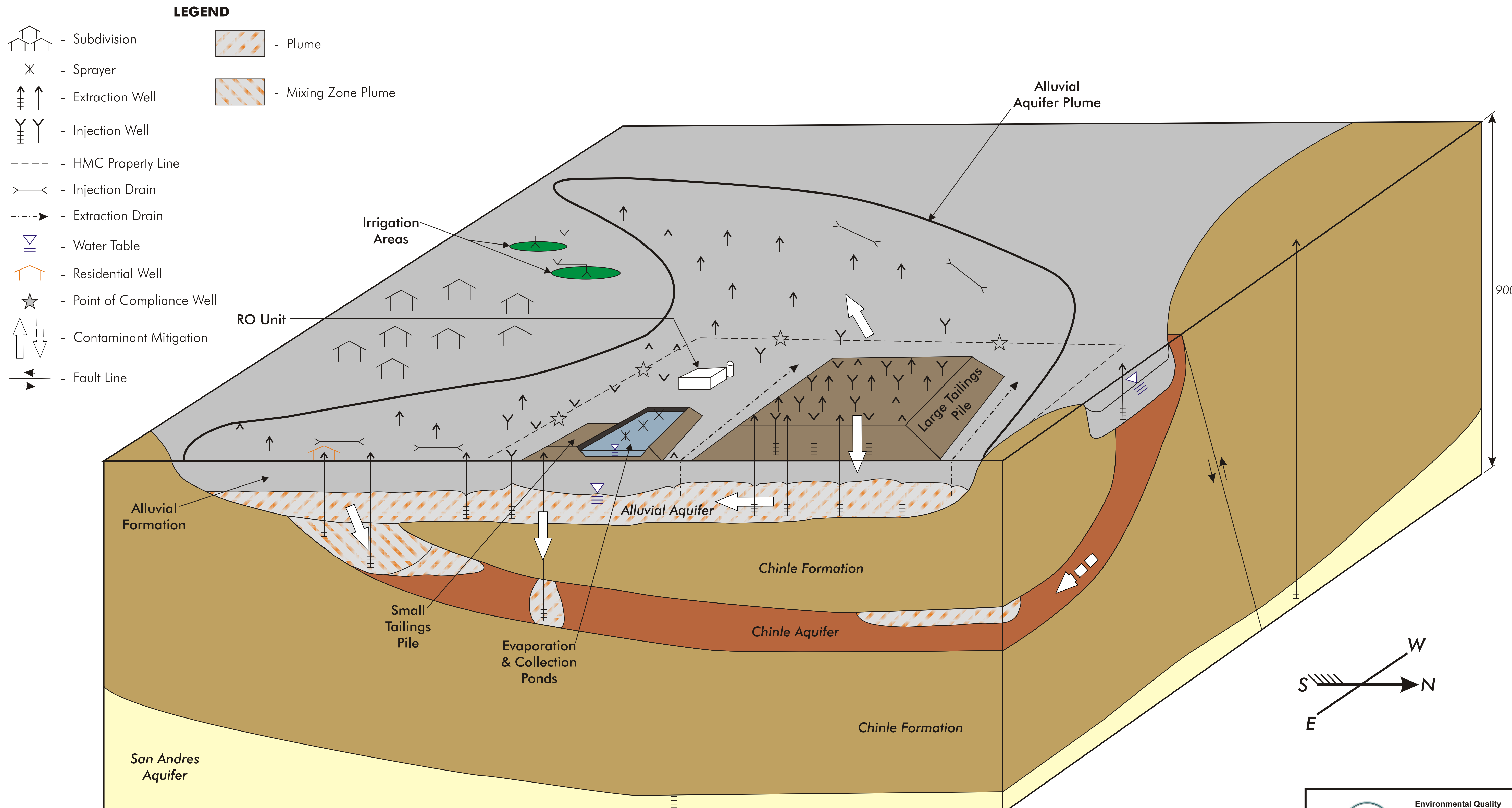
HMC operated the mill from 1958 until 1990. The mill was decommissioned and demolished between 1993 and 1995. The Site currently includes two tailings piles (i.e., Large Tailings Pile and Small Tailings Pile), a groundwater extraction and injection system, tailings flushing and dewatering systems, a Reverse Osmosis (RO) water treatment plant, two lined collection ponds, two lined evaporation ponds, associated equipment and structures, and office building and related support structures. At the time of the Site Visit, HMC was undertaking actions necessary to permit a third lined evaporation pond. Figure 1 is an aerial photograph of the Site.

The Large Tailings Pile covers an area of about 170 acres and is 85 to 100 feet high. It contains an estimated 21 million tons of mill tailings. The Small Tailings Pile covers an area of about 40 acres and is 20 to 25 feet high. It contains approximately 1.2 million tons of mill tailings. Prior to placement of tailings the ground was leveled and prepared and no liner was installed. Seepage from the tailings piles has resulted in the contamination of groundwater with radiological and non-radiological contaminants, including uranium, thorium-230, radium-226 and radium-228, selenium, molybdenum, sulfate, nitrates, and total dissolved solids (TDS), among others.

1.5.2 Hydrogeologic Setting

As indicated in Section 1.1, this RSE report contains numerous diagrams and figures in Appendix B that establishes HMC’s conceptual site model (CSM) of the Site. HMC’s CSM was reviewed and evaluated by the RSE Team. To support the material presented in this report, the RSE Team has prepared and includes its own CSM. The CSM (Figure CSM-1) on the next page is a stylized representation of the Site and surrounding areas representing conditions at the time of the Site Visit. The size of the Site is difficult to grasp from this or any other figure. To assist the reader’s orientation, the Large Tailings Pile is about 1 mile long from east to west, about a third mile wide from north to south and the pile is about 100 feet high. The southwesterly extent of the Alluvial Aquifer plume shown on Figure CSM-1 is about 2 miles long from the west end of the Large Tailings Pile and the south eastern extent of the plume is also about 2 miles from the Large Tailings Pile. The Chinle Aquifer is three separate aquifers; the deepest (the Lower Chinle Aquifer extends to about 600 feet below land surface. The San Andres Aquifer is over 800 feet below the Site.

The CSM includes various components of the groundwater remediation system (e.g., injection/extraction wells, drains, the groundwater treatment plant, etc.) to help the reader



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HMC SUPERFUND CONCEPTUAL SITE MODEL

DRAWN	SRL	11/20/08
CHECKED	BT	11/20/08
APPR		

REV	DESCRIPTION	DATE	APPROVED

REVISIONS

APPROX. SCALE:
1" = 1.5 Miles
*unless noted

ORIG SIZE	PROJECT NO.	DWG NO.	REV
B	030257.0004	CSM-1	0

visualize the relationship of these components to the hydrogeologic setting. A second CSM presented in Section 2.0 of this report focuses on the remedial system.

Five aquifers exist beneath the Site. These are:

1. The Alluvial Aquifer
2. The Upper Chinle Aquifer
3. The Middle Chinle Aquifer
4. The Lower Chinle Aquifer
5. The San Andres Aquifer

1.5.2.1 Alluvial Aquifer

The Alluvial Aquifer includes the San Mateo Alluvial Aquifer immediately beneath the Site that merges with the Rio San Jose Alluvial Aquifer to the west and the Lobo Canyon Alluvial Aquifer to the southeast. The Alluvial Aquifer is located within an alluvial formation extending from land surface to the underlying Chinle Formation. The alluvial formation includes sediments deposited by streams with material ranging in size from clay to sand to gravel and boulders. At some locations, especially in the Rio San Jose part of the formation, basaltic lava flows are present. The alluvial formation is up to 120 feet thick.

The Alluvial Aquifer is an unconfined aquifer indicating that the groundwater is in direct communication with the atmosphere through permeable material of the alluvial formation. The Alluvial Aquifer is defined as the saturated thickness of the alluvial formation extending from the contact with the Chinle Formation up to the water table, which is about 50 feet below the ground surface in the area of the Tailings Piles. The saturated thickness of the Alluvial Aquifer ranges up to 60 feet southwest of the Large Tailings Pile. Figure 15 maps the configuration of the Alluvial Aquifer. The map depicts a large area extending from Highway 605 west/northwest beneath Felice Acres to Valle Verde where the elevation of Chinle Formation extends above the elevation of the water table resulting in absence of the Alluvial Aquifer. Regionally, groundwater flow in the Alluvial Aquifer is from the northeast to the southwest. However, locally the direction of groundwater flow is controlled by the location of the Chinle bedrock high and the locations of groundwater extraction and injection systems operating as part of the groundwater remediation system. Figures 18 and 4.2-1 depict the configuration of the water table in the Alluvial Aquifer in 2005 and 2007. The red arrows show the direction a particle of water or entrained contaminant moves in the Alluvial Aquifer.

1.5.2.2 Chinle Aquifers

Within the Chinle Formation are three recognized zones of increased permeability and porosity that are functionally aquifers for domestic wells in the area. The three aquifers are: 1) Upper Chinle, 2) Middle Chinle and 3) Lower Chinle. Although the Chinle Formation is a regionally extensive shale formation, layers of continuous sandstones and areas of fractured shale result in zones of increased permeability. These aquifers are separated and bounded by shale. Groundwater flow direction and hydraulic properties of each Chinle Aquifer are distinct. Two major northeast-southwest trending faults, an eastern fault and a western fault, result in hydraulic changes to the Upper and Middle Chinle Aquifers. Figures 2-1, 2-2, 2-3 are a site location map and structural cross sections that depict the relationship between the Chinle Aquifers and the Site. Across the region, these faults have pulled the Chinle Formation apart and dropped each eastern block downward. In the local area these faults have resulted in a block of Chinle Formation being dropped to the north and east beneath the Site. The tilted attitude of the Chinle Formation between the faults produces areas (referred to as subcrops) where the Chinle Aquifers directly contact the Alluvial Aquifer.

Upper Chinle Aquifer

The Upper Chinle Aquifer is an approximately 20-foot thick continuous sandstone layer. The Aquifer dips eastward between the two faults and northeastward east of the faults. No Upper Chinle Aquifer exists west of the faults. Figure 2-6 is a map depicting the areal extent of the Upper Chinle Aquifer. The area of blue horizontal lines on the map shows where the Upper Chinle Aquifer is in direct contact and communication with the Alluvial Aquifer.

Prior to remediation activities, the natural direction of groundwater flow was to the south between the faults and to the north and east to the east of the faults. As depicted in Figure 5.2-1, groundwater flow currently is toward collection wells (CE2, CE5, CE6, CE11 and CE12) located near the evaporation ponds and to an irrigation supply well (CW53) located in Felice Acres. The potentiometric surface of the Aquifer is mounded immediately east of the eastern fault due to the injection of freshwater at CW13. The blue arrows show the direction a particle of water or entrained contaminant moves in the Upper Chinle Aquifer.

Middle Chinle Aquifer

The Middle Chinle Aquifer is an approximately 40-foot thick continuous sandstone layer. The Aquifer dips eastward between the two faults and northeastward east of the faults. As illustrated in Figure 2-8, the Middle Chinle Aquifer is only in direct hydraulic communication with the Alluvial Aquifer in an area west of the western fault and south of Felice Acres. The area of red horizontal lines on the map depicts where the Middle Chinle Aquifer is in direct contact and communication with the Alluvial Aquifer.

Prior to groundwater remediation, the natural groundwater flow direction in the Middle Chinle Aquifer was northerly between the faults and westerly in areas west of the faults where the Middle Chinle actually discharged to the Alluvial Aquifer. As depicted in Figure 6.2-1, groundwater flow direction is currently toward the Large Tailings Pile as the result of injection of fresh water south of Felice Acres (well CW30) and the extraction of groundwater north of the Large Tailings Pile (wells CW1 and CW2). Pump-test data confirm that the fault separated blocks of the Middle Chinle Aquifer are not hydraulically connected except for an area south of Felice Acres where the displacement is not significant along the eastern fault. The red arrows show the direction a particle of water or entrained contaminant moves in the Middle Chinle Aquifer.

Lower Chinle Aquifer

The Lower Chinle Aquifer is an up to 120-foot thick discontinuous zone of fractures within the Chinle Formation that provides secondary porosity sufficient to increase permeability. As depicted in Figure 2-10, the Lower Chinle Aquifer has an attitude consistent with the Middle Chinle Aquifer. The Aquifer subcrops with the Alluvial Aquifer west of Valle Verde and about a half mile south of Felice Acres. As depicted on Figure 7.2-1 the area of blue horizontal lines indicates where the Lower Chinle Aquifer is in direct contact and communication with the Alluvial Aquifer. Prior to and during groundwater remediation, the groundwater flow direction in the Lower Chinle Aquifer has remained northerly. The blue arrows show the direction a particle of water or entrained contaminant moves in the Lower Chinle Aquifer.

The Mixing Zone

Under natural conditions (i.e., no extraction or injection conducted as a part of the groundwater remediation program), water from the Chinle Aquifers flows upward into the overlying Alluvial Aquifer in the subcrop areas. Over the years, the extraction of groundwater from the Chinle Aquifers for remediation and for potable, irrigation and stock-watering uses from wells in the Subdivisions has resulted in groundwater from the Alluvial Aquifer moving into and mixing with water of the Chinle Aquifers. In these "mixing zones," water quality is very different than the source water (i.e., either Alluvial Aquifer or Chinle Aquifer). For example, water in the Chinle Aquifers is characterized by low concentrations of calcium, uranium, nitrate and TDS. By contrast the overlying Alluvial Aquifer has relatively higher concentrations of these constituents.

Separate action levels have been established for the mixing zone (Section 3.3). Uranium for example, has an Alluvial Aquifer action level of 0.16 mg/l, an Upper Chinle Aquifer action level is 0.09 mg/l and a mixing zone action level is 0.18 mg/l.

1.5.2.3 San Andres Aquifer

The San Andres Aquifer is a confined limestone aquifer and is the most important regional aquifer. The Aquifer is separated from the Alluvial Aquifer at the Site by several hundred feet of low permeability shale of the Chinle Formation. The San Andres and Alluvial Aquifers are only in direct hydraulic communication in an area west of the Site along Highway 122 (Figure 8.0-1). The East and West Faults (see Section 1.5.2.2) are present in the San Andres Formation but water levels in wells on either side of the faults do not show that the faults have any significant affect on the flow of water in the Aquifer. Regionally, groundwater flow is to the east (Figure 8.0-1). The red arrows show the direction a particle of water moves in the San Andres Aquifer.

1.5.3 Description of Groundwater Plumes

HMC is currently monitoring groundwater-quality conditions for 10 contaminants of concern (COCs) identified by the NRC for remediation following earlier investigations conducted under direction of the NRC of tailings pile and groundwater quality conditions. Refer to Section 3.3 (Action Levels) for the list and associated action levels. The action levels have been revised over the history of actions at the Site. To minimize confusion, the following sections are presented using only the current action levels discussed further in Section 3.3. As used herein, plume is defined to mean those areas where groundwater samples from wells contain a constituent at a concentration greater than the NRC action level.

Inspection of available groundwater-quality data identifies that uranium and selenium are the COCs considered by NRC that have or had the maximum extent in the groundwater systems. The presence of elevated concentrations of selenium in local water supply wells in the 1970s triggered the remedial action being undertaken by HMC. The following sections provide an overview of groundwater-quality conditions for uranium and selenium at and near the HMC Site. Trends in the concentrations of other constituents (e.g., chloride, nitrate, sulfate, TDS, etc.) are available in the HMC annual monitoring reports.

1.5.3.1 Alluvial Aquifer

Uranium data and contours for 2007 in the Alluvial Aquifer are presented on Figure 4.3-53. The light green pattern shows where uranium concentrations are higher than the current action level (i.e., 0.16 mg/l). The areas between the shaded patterns on the contaminant distribution maps in this report may also be contaminated but at concentrations less than the current NRC action levels. Uranium concentrations are higher than the action level in the area of the Large and Small Tailings Piles, and to the west beyond Pleasant Valley Estates one of five residential subdivisions close to the Site. A second plume, where uranium concentrations are higher than the action level, extends south of the Small Tailings Pile generally along Highway 605. The plume extends through Felice Acres and to the southwest. The location and configuration of this plume is affected by an area of Chinle Formation bedrock that displaces the Alluvial Aquifer. Figure 36 depicts the distribution of uranium in the Alluvial Aquifer in 1998 and 2005. The 1998 area of uranium concentration higher than the action level is enclosed by a red line. The 2005 area is colored light green. To compare with 2007 conditions refer to Figure 4.3-53. Two figures (Figures 4.3-61 and 4.3-66) present time trend graphs for wells in the uranium plume that extends from the Tailings Piles to south of Felice Acres. The wells depicted on Figure 4.3-61 are all located near the Small Tailings Pile and show significant decreases in uranium concentration. The wells depicted on Figure 4.3-66 are all south of Felice Acres and show changes in uranium concentration, but without significant decrease.

Figure 4.3-70 presents the distribution of selenium in the Alluvial Aquifer in 2007. The light green pattern shows where selenium concentrations are higher than the action level (i.e., 0.32 mg/l). Selenium concentrations are higher than the action level beneath the Large and Small Tailings Piles. One plume of selenium extends approximately 800 feet west of the Large Tailings Pile and a second plume extends to the south of the Small Tailings Pile along Highway 605. Figure 37 depicts the distribution of selenium in the Alluvial Aquifer in 1998 and 2005. The 1998 area of selenium concentration higher than the action level is enclosed by a red line. The 2005 area is colored light green. Figure 37 shows that selenium concentrations south of Felice Acres have been reduced to below the action level. To compare with 2007 conditions refer to Figure 4.3-70. Two figures (Figures 4.3-78 and 4.3-83) present time trend graphs for wells in the selenium plume that extends from the Tailings Piles to south of Felice Acres. The wells depicted on Figure 4.3-78 are all located near the Small Tailings Pile and show significant decrease in selenium concentration. The wells depicted on Figure 4.3-83 are all south of Felice Acres and show decreasing selenium concentrations.

1.5.3.2 Upper Chinle Aquifer

Uranium data and concentration contours for 2007 in the Upper Chinle Aquifer are presented on Figure 5.3-11. The blue shaded areas indicate where uranium concentrations are higher than the action level (i.e., 0.09 mg/l for the Aquifer and 0.18 mg/l for the mixing zone). Uranium concentrations are higher than the action level in the area of the Large and Small Tailings Piles, and extend hydraulically down gradient from where the Upper Chinle Aquifer contacts the Alluvial Aquifer in the subcrop to the north of Murray Acres. A second isolated plume is located in the proximity of well CE9 in Felice Acres. The RSE Team suggests that this isolated plume may reflect either cross-aquifer transfer from the Alluvial Aquifer to the Upper Chinle Aquifer through this or a neighboring well that was inadequately sealed or by migration from the subcrop. From 1997 to 2007, the trend for uranium in mixing zone wells indicated decreasing concentrations as illustrated in Figure 5.3-12. In non-mixing zone wells of the Upper Chinle Aquifer, the trend is also for decreasing uranium concentration, except at well CW3 located northeast of the Large Tailings Pile that had been used for groundwater extraction (Figure 5.3-13). This caused the plume of uranium to be pulled from the tailings pile area. Water is no longer being extracted at CW3 and since 2006, the concentration of uranium has correspondingly begun a return to the lower pre pumping concentration.

Selenium data and concentration contours for 2007 in the Upper Chinle Aquifer are presented on Figure 5.3-14. The blue shaded area indicates where selenium concentrations are higher than the action level (i.e., 0.14 mg/l for the mixing zone). Selenium concentrations are higher than the action level in the area of the Large Tailings Pile and beneath the collection pond along the subcrop toward the northeast corner of Murray Acres. From 1997 to 2007, the trend for selenium in the non-mixing zone wells monitored for this project is relatively unchanged as presented in Figure 5.3-16.

1.5.3.3 Middle Chinle Aquifer

Uranium data and concentration contours for 2007 in the Middle Chinle Aquifer are presented on Figure 6.3-11. The red shaded areas indicate where uranium concentrations are higher than the action level (i.e., 0.07 mg/l for the Aquifer and 0.18 mg/l for the mixing zone). Uranium concentrations are higher than the action level west of the west fault near wells CW17 and CW55 near County Road 63. A second plume is located in the proximity of wells CE45, 498, 434 and CW55 in Felice Acres. Both uranium plumes in the Middle Chinle Aquifer are located hydraulically down gradient from where the Middle Chinle Aquifer contacts the Alluvial Aquifer in the subcrop areas. The RSE Team suggests that the plume beneath Broadview Acres may reflect cross-aquifer transfer from the Alluvial Aquifer to the Middle Chinle Aquifer through an inadequately sealed well. From 1997 to 2007, the trend for uranium in both the mixing zone and the Aquifer indicated decreasing concentrations as illustrated in Figure 6.2-12. Samples from wells surrounding the perimeter of these plumes (Figure 6.2-13) indicate the size of the plume is relatively constant and not increasing in size. The exception is a significant increase in uranium at well CW17 located west of the fault and north of County Road 63.

Selenium data and concentration contours for 2007 in the Upper Chinle Aquifer are presented on Figure 6.3-14. The pink shaded areas indicate where selenium concentrations are higher than the action level (i.e., 0.07 mg/l for the Aquifer and 0.14 mg/l for the mixing zone). Selenium concentrations are higher than the action level in the Middle Chinle Aquifer west of the fault and Large Tailings Pile. Two isolated areas where selenium concentrations are higher than the mixing zone action level are at wells 493 and CW28. The RSE Team suggests that these plumes may be associated with inadequately sealed wells. From 1997 to 2007, the distribution and concentration trends for selenium for both mixing zone and the Aquifer are similar. As shown in Figures 6.3-15 and 6.3-16, the perimeter of the plumes is stable and the interior wells indicate a decreasing trend. The exception is well CW17 where selenium spiked during the 2006 and 2007 sampling events.

1.5.3.4 Lower Chinle Aquifer

Uranium data and concentration contours for 2007 in the Lower Chinle Aquifer are presented on Figure 7.3-8. The blue shaded areas indicate where uranium concentrations are higher than the action level (i.e., 0.03 mg/l for the Aquifer and 0.18 mg/l for the mixing zone). Uranium concentrations are higher than the action level in the immediate proximity of well 837 in Felice Acres and south of Felice Acres near wells 653, 538, CW41 and CW42. The RSE Team suggests that the plume at well 837 is probably associated with an inadequately sealed well and the other plume may be associated with proximity to the subcrop or to inadequately sealed wells. From 1997 to 2007, the trend for uranium in both the mixing zone and Aquifer is decreasing concentrations as depicted in Figures 7.3-9 and Figure 7.3-10. In particular, wells 653 and CW37 indicate a decreasing trend while surrounding wells indicate that plume is not spreading but remaining stable in aerial size.

Selenium data and concentration contours for 2007 in the Upper Chinle Aquifer are presented on Figure 7.3-11. Presently, selenium does not exceed the action level in any of the wells in the Lower Chinle Aquifer. From 1997 to 2007, the distribution and concentration trends for selenium for both the mixing zone and Aquifer are similar. As shown in Figures 7.3-12 and 7.3-13, the perimeters of the plumes indicate stability and the interior wells may be indicating a decreasing trend with time.

1.5.3.5 San Andres Aquifer

Concentrations of uranium, selenium sulfate and TDS in the San Andres Aquifer are presented on Figure 8.0-2 No action levels have been established by NRC for the San Andres Aquifer to be used to establish plumes. There is no direct pathway of contaminant migration from the Alluvial Aquifer to the San Andres at the Site because the San Andres does not subcrop beneath the Alluvial Aquifer plume. Transfer from the Alluvial Aquifer to the San Andres is possible at inadequately sealed wells.

1.5.4 Potential Receptors

Principal land use south and southwest of the Site is residential and agricultural. There are five residential Subdivisions located south and southwest of the Site: Felice Acres, Broadview Acres, Murray Acres, Pleasant Valley Estates, and Valle Verde. Much of the land immediately surrounding the former mill site was acquired by HMC, and this property has not been put into use, except for installation and operation of systems that are part of the groundwater remediation program. The land to the east, west and north is currently generally undeveloped.

As a result of a Stipulation of Agreement with the USEPA, HMC financed the extension of the Village of Milan's municipal water supply to the five Subdivisions in 1985. A 2007 survey conducted by HMC identified nine residences in the Valle Verde Subdivision that are not supplied by the Village of Milan water. Wells at these residences may be used as the primary source of potable water. The Alluvial Aquifer and the three Chinle Aquifers were used as domestic water sources for private wells maintained by the local residents.

In addition to potable use, water from private wells was and continues to be used for livestock watering and to irrigate crops. Currently, HMC is conducting irrigation of large plots of land using groundwater from the Alluvial and Upper and Middle Chinle Aquifers recovered as a part of the groundwater remediation system. The resulting hay is fed to livestock.

The RSE Team did not conduct human health or ecological risk assessments for the Site. Such evaluations have been completed by the Agency for Toxic Substances and Disease Registry (ATSDR) or are ongoing by USEPA Region 6. ATSDR concluded in its draft report the following :

- Groundwater from domestic wells may contain uranium and selenium at concentrations above the USEPA MCLs for drinking water. Domestic wells with concentrations above MCLs should not be used for drinking purposes.

- Groundwater from domestic wells may be used to irrigate vegetable crops. Root vegetables (e.g., radishes, carrots, etc.) should be washed and the outer skins be removed prior to consumption.

2.0 SYSTEM DESCRIPTION

2.1 System Overview

The groundwater remediation system currently operated by HMC has several components with the objective to restore groundwater quality to NRC action levels. Remediation involves collecting contaminated groundwater, treating some of the collected water through the RO plant, disposing of some of the water in evaporation ponds, supplying some of the water to irrigate cropland, and injecting fresh and low-concentration groundwater and RO product water to aid in containment and cleanup activities. Additionally, HMC operates a program to remove uranium and associated contaminants from the Large Tailings Pile. This system includes injection of water using wells and recovery of water using extraction wells and drains.

The Large Tailings Pile dewatering system provides source control of the principal contaminants in groundwater. The RSE Team has determined that the term "dewatering" does not adequately reflect the current objective of the operations at the Large Tailings Pile. For the remainder of this report the terms Large Tailings Pile flushing or contaminant removal system will be used. Figure 28 is a schematic diagram that shows the flow of water, including the average rate of flow in gallons per minute (gpm) during 2005, through the various components of the groundwater remediation system. Additionally a remedial system process flow diagram (Figure CSM-2) has been developed by the RSE Team to help facilitate the reader's understanding of this section of the report.

2.2 Extraction Systems

HMC operates several separate systems to extract (collect) groundwater as a part of the groundwater remediation system. Withdrawal of water using these collection systems is regulated under a New Mexico Office of the State Engineer Temporary Diversion Permit for 4,500 acre-feet per year (2,789 gpm average). The groundwater collection systems are presented below by aquifer, including tailings flushing.

2.2.1 San Andres Aquifer

Four San Andres Aquifer wells are used to supply fresh water for injection into the Alluvial, Upper Chinle, and Middle Chinle Aquifers (refer to Figure 8.0-1, Section 1.5.2.3). Two wells (#1 and #2 located just south and east of the Large Tailing Pile) were installed during operation of the mill and two wells (943 located about 1,000 feet north of the Large Tailings Pile and 951 located about three miles west of the Large Tailings Pile) were installed during implementation of the remediation program. Water from the San Andres wells is pumped to two water towers

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REV	DESCRIPTION	DATE	APPROVED

REVISIONS

DRAWN	D.TOMO	11/19/08
CHECKED	B.THOMPSON	11/20/08
APPROVED	B.THOMPSON	11/20/08
SCALE:	NONE	

HMC SUPERFUND SITE
TREATMENT SYSTEM CONCEPTUAL SITE MODEL PFD

ORIGINAL SIZE	PROJECT NO.	DWG NO.	REV
D	030257.0004	CSM-2	0

located along Route 605 south of County Road 63. The two towers impart head (i.e., pressure) sufficient to transport the water to the injection points. Current average rate of pumping is about 1,250 gallons per minute (gpm).

Concerns have been raised by local stakeholders that the potentiometric level of the San Andres Aquifer is being lowered as a result of HMC extraction. To evaluate this concern the RSE Team obtained hydrographs of San Andres Aquifer wells in Cibola and McKinley Counties from the U.S. Geological Survey's National Water Information System: Web Interface. Those hydrographs indicate declining potentiometric levels on a regional scale in the San Andres Aquifer since the late 1980s. Hydrographs of San Andres wells at the Site mirror the regional data.

2.2.2 Tailings Flushing

To reduce the mass of contaminants (e.g., uranium, selenium, etc.) available to leach into the Alluvial Aquifer about 233 gpm of water (the latest available figures are from 2005) from the Alluvial, Upper Chinle and Lower Chinle Aquifers are injected into the Large Tailings Pile. Injected water is extracted from the Large Tailings Pile using wells and drains. Tailings flushing and contaminant removal was initiated at a pilot scale in 1997; full scale operations began in 2002. At the time of the Site Visit there were about 140 wells in the Large Tailings Pile equipped with submersible pumps for extraction. The wells are screened to recover water from the tailings material and from the upper several feet of the underlying Alluvial Aquifer.

Currently, about 87 gpm of water is extracted using wells, and of that total, about 81 gpm with the highest TDS concentrations is pumped directly to evaporation ponds (Section 2.4.2). The remaining water (6 gpm) is treated at the RO plant (Section 2.4.1). Figure 29 shows the location of the tailings extraction wells. The system of wells has the flexibility to allow operation as either injection or extraction, as needed. Drains are installed along the perimeter of the Large Tailings Pile to collect water as a part of the Large Tailings Pile flushing program (Figure 29). Approximately 40 gpm of water are collected from the drains into sumps where the water is pumped to the evaporation ponds. HMC predicts that the Large Tailings Pile flushing and contaminant removal program will operate through at least 2012. At that time, HMC predicts through numeric modeling that the mass of uranium in the Pile will be reduced to a level where the concentration of uranium leaching to the Alluvial Aquifer will be sufficiently low (i.e., 2 milligrams of mass per liter of water discharged to the Alluvial Aquifer) to allow groundwater quality in the Alluvial Aquifer to achieve the NRC action levels at Alluvial Aquifer Point of Compliance (POC) wells located at the south and western Site boundary (Figure 49). In 2007, the weighted average uranium concentration in water extracted from the Large Tailings Pile was 11.7 mg/l, reduced from about 40 mg/l in 1997.

About 106 gpm of water used to flush the Large Tailings Pile are not extracted by the tailings pile extraction wells or perimeter drains. This water is discharged to the Alluvial Aquifer where it is managed as a part of the Alluvial Aquifer remediation system.

NRC determined that the Small Tailings Pile is not a significant source of contaminants for groundwater and therefore it is not being flushed. Various actions being undertaken by HMC to remove contaminated groundwater from the Alluvial Aquifer in the vicinity of the Small Tailings Pile addresses contaminants that may be released from it.

2.2.3 Alluvial Aquifer

About seventy-five (75) Alluvial Aquifer extraction wells are operated to recover contaminated groundwater. The well depths and screened intervals vary as affected by the location of the most permeable materials. Submersible pumps are used. The wells are located throughout the area of contamination with operating wells currently focused (about 38 wells) in the area immediately down gradient (i.e., south and southwest) of the Large Tailings Pile (Figure A). One Alluvial Aquifer well (P2), located north of the Large Tailings Pile, is used to divert up-gradient water at a rate of about 40 gpm for transfer to the drainage system farther west. Pumping from this well is intended to reduce the quantity of alluvial water flowing into the area of the Large Tailings Pile.

The configuration of the collection well network has evolved over time as part of HMC's overall strategy of hydraulic control of plumes, especially with a desire to keep contamination away from the residential areas. Currently about 780 gpm of water are pumped from Alluvial Aquifer wells. Water with the lowest concentration of contaminants (i.e., uranium concentration <0.44 mg/l and selenium concentration <0.12 mg/l) from wells generally located west and south of the Site is pumped to the irrigation system at about 455 gpm. The NMED is currently evaluating the concentrations of contaminants that can be in irrigation water with the potential for lowering allowable levels. Water with the highest levels of contamination from the area immediately down gradient of the Large Tailings Pile is pumped to the RO treatment plant at about 250 gpm (Section 2.4.1). The remainder water is injected into the Large Tailings Pile (5 gpm) or into more contaminated areas in the Alluvial Aquifer (34 gpm) (Section 2.3). The Alluvial Aquifer groundwater extraction system is projected by HMC to continue to be operated through at least 2017.

2.2.4 Upper Chinle Aquifer

In 2005, Upper Chinle extraction wells CE2, CE5, CE6, CE11 and CE12 removed an average of 75 gpm from the Aquifer to create a gradient back toward the tailings piles and evaporation ponds. Water for the irrigation system was extracted from well CW53 immediately south of Felice Acres. This was done to control water in the mixing zone at this location. In prior years, well CW3 was pumped for irrigation and water for re-injection. However, the quality of water at this location degraded due to the pumping activity and pumping from well CW3 was discontinued in 2005. The Upper Chinle Aquifer groundwater extraction system is projected by HMC to continue to be operated through at least 2017.

2.2.5 Middle Chinle Aquifer

In 2005, Middle Chinle Aquifer wells 498, CW44, CW45 and CW28 in the area of Felice Acres were used for the irrigation system. Water extracted from Middle Chinle Aquifer wells CW1 and CW2, located north of the Large Tailings Pile, is used for injection to the Upper Chinle Aquifer to control plume migration. The average rate of water collection from the Middle Chinle

Aquifer (including irrigation wells) is about 141 gpm. The Middle Chinle Aquifer groundwater extraction system is projected by HMC to continue to be operated through at least 2017.

2.2.6 Lower Chinle Aquifer

In 2005, water was collected from the Lower Chinle Aquifer wells 538, 653, CW29, CW42 located just south of Felice Acres for irrigation. The average rate of water collection from the Lower Chinle Aquifer is about 75 gpm. This is an average rate because water from the aquifer is used exclusively in the irrigation system that is operated approximately 8 months of the year. The Lower Chinle Aquifer groundwater extraction system is projected by HMC to continue to be operated through at least 2017.

2.3 Injection Systems

2.3.1 Large Tailings Pile

HMC operates a system to inject water into the Large Tailings Pile as a part of the groundwater remediation system. These discharges are controlled under terms of NMED Permit DP-200. About 155 wells are used to inject about 233 gpm of water into the Large Tailings Pile (Figure 29, Section 2.2.2). Water for injection is obtained from the Alluvial (5 gpm), Upper Chinle (127 gpm) and Middle Chinle (101 gpm) Aquifers. Figure B shows the locations of extraction wells used as source of water for injection into the Large Tailings Pile. The tailings injection program is expected by HMC to continue through at least 2011.

Pumps are not used to inject water into the Large Tailings Pile. A float-valve in each well keeps the well casing essentially full of water at all times. The weight of the column of water in the well, which is the distance from the water table to the top of the well casing, exerts the force necessary to push water into the formation.

New wells are installed as needed to allow HMC to focus contaminant removal. The location, depth of completion and screened interval are selected to fit HMC's goals at that time. Additionally, the pumps can be removed from the extraction wells and these wells can be converted to injection wells to allow HMC the flexibility to focus its contaminant removal effort.

2.3.2 Alluvial Aquifer

Water is injected into the Alluvial Aquifer to aid in flushing contaminants from the Aquifer, and to provide hydraulic barriers. About 115 injection wells and about 5,000 lineal feet of injection line are used. Figures C, D and E depict the locations of the injection systems. Figure B (Section 2.3.1) shows where water from the San Andres Aquifer and the Upper and Middle Chinle Aquifers is injected into the Alluvial Aquifer. Figure C shows where water from the Alluvial Aquifer is injected into the Alluvial Aquifer. About 1,229 gpm of water from the San Andres (1,150 gpm), Alluvial (34 gpm), Upper Chinle (5 gpm) and Middle Chinle (40 gpm) Aquifers are injected. Alluvial Aquifer injection is projected by HMC to continue through at least 2017. About 198 gpm of treated water from the RO plant is injected via wells and lines in the area of highest uranium and selenium contamination south of the Small Tailings Pile. Figure D shows where treated water from the RO system is injected into the Alluvial Aquifer. Figure E shows the locations of the wells and lines. The Alluvial Aquifer injection system is projected by HMC to continue to be operated through at least 2017.

Pumps are not used to inject water into the Alluvial Aquifer. A float valve in each well keeps the well casing essentially full of water at all times. The weight of the column of water in the well, which is the distance from the water table to the top of the well casing, exerts the force necessary to push water into the formation.

2.3.3 Chinle Aquifers

Injection in the Upper Chinle Aquifer is performed in well CW13 east of the east fault to keep water levels higher on that side of the fault to control offsite migration from the area immediately south of the ponds and tailings pile (Figure 5.2-1, Section 1.5.2). Injection at wells CW46, CW5, and CW25 is used to increase flushing of contaminants extracted by wells CE2, CE5, CE6, CE11 and CE12. An estimated average annual volume of 57 gpm flows into all these wells (approximately 8 gpm for each) in to promote extraction and hydraulic control.

Injection in the Middle Chinle Aquifer is performed in wells CW14, CW30 and CW36 to flush the aquifer in the area beneath Felice Acres (Figure 6.2-1, Section 1.5.2). The average rate of injection into all of these wells is 46 gpm. Historically, other wells have been used for injection; well CW14 was the first injection well into the Middle Chinle.

To date, no water has been injected into the Lower Chinle Aquifer.

The Chinle Aquifer injection systems are projected by HMC to continue to be operated through at least 2017.

2.4 Irrigation Systems

Groundwater with uranium concentrations less than 0.44 mg/l and selenium concentrations less than 0.12 mg/l from the Alluvial, Middle Chinle and Lower Chinle Aquifers is used in an irrigation system. As indicated in Section 2.2.3 allowable contaminant levels may be lowered by NMED. The contaminants in the irrigation water are remediated by sorption to the soil or by incorporation into crops. The irrigation system includes two flood irrigation areas (120 and 24 acres) and two center-pivot irrigation areas (100 acres and 150 acres). The locations of the wells from which water is extracted for irrigation and the four irrigation areas are shown on Figure 6. A total of 1,034 acre-feet of water was applied to these areas in 2005; this is equivalent to the average annual total rate of 641 gpm. The total application rate for the eight month growing season was approximately 961 gpm. The irrigation program is projected by HMC to continue through at least 2017.

2.5 Treatment Systems

2.5.1 Reverse Osmosis Treatment System

A RO treatment system was designed and constructed in 1999. The RO unit is used to provide HMC with a source of low TDS water to assist flushing of the Alluvial Aquifer immediately down gradient from the tailings piles. Water from the Large Tailings Pile and Alluvial Aquifer is treated through the RO unit. The feed water to the RO plant flows through a reactor clarifier. Lime and/or caustic are added to increase the pH of the water to about 10 S.U. This precipitates various salts and reduces the dissolved solids loading on the RO membranes. The water then goes through sand filters for particulate removal. Sulfuric acid is added to neutralize the pH to approximately 7.0 S.U. and the water flows into one of two RO trains. The RO trains contain high pressure ultra-filtration membranes where dissolved solids of virtually all types are removed and concentrated into a reject/brine solution. The brine is transferred to the evaporation ponds for concentration. The water flows through one of two RO filtration units that are operated in parallel for removal of dissolved solids, including COCs. Each RO unit has a maximum capacity of about 300 gpm. One RO unit is a single stage unit, the other a two stage (high and low pressure). The RO units produce two waste streams, a very clean (low dissolved solids) stream of about 250 to 260 gpm and a brine stream that has a very high level of dissolved solids at about 49 gpm. The water from the RO membranes is routed to a product tank. It is then transferred to the various injection wells. The clean stream is injected into various wells, while the high dissolved solids stream is transferred to the evaporation ponds. Refer to Figure WB for a process diagram of the RO Unit. RO treatment plant operations are projected by HMC to continue through at least 2015.

2.5.2 Evaporation Ponds

There are two lined evaporation ponds and two lined collection ponds with a total area of approximately 43.8 acres. The evaporation ponds are used to evaporate about 49 gpm of brine from the RO plant and 121 gpm of water from wells and drains at the Large Tailings Pile in 2005. The evaporation ponds are regulated by New Mexico Discharge Plan DP-725. The ponds system concentrates the dissolved solids through evaporation of the water. As the dissolved solids concentrate a point of saturation is reached and the solids precipitate out of solution and settle in the ponds. This settling occurs primarily in the winter months. The dissolved solids levels of water in the ponds are extremely high; in the range of 100,000 ppm (10%) in the summer and 60,000 ppm (6%) in the winter. Evaporation pond operation is expected by HMC to continue through at least 2015.

The brine stream from the RO plant is transferred to Evaporation Pond #1 (i.e. larger east pond) (refer to Figure 1, Section 1.5.1). The water from Pond #1 gravity cascades into Evaporation Pond #2 (i.e., the smaller west pond). To enhance evaporation, both ponds have spray evaporation systems. Pond #1 has a system of high efficiency blowers. These units are adapted from snow-making equipment. Pond #1 also has a less efficient system of spray evaporation headers. Pond #2 has a system of spray evaporation headers. Water is pumped through a header system and sprayed vertically upward into the air. Both systems suffer from high corrosion and blockage due to the extremely high levels of dissolved solids.

Two collection ponds are located between the RO unit and Evaporation Pond #2. Solids from the RO plant clarifier are collected in these ponds.

HMC is in the process of obtaining necessary approvals from NRC and NMED to construct Evaporation Pond #3 to be installed north of County Road 63 and within 1,800 feet of state highway NM 605 (referred to as Alternative C on Figure 1A). The pond is square in shape and would disturb approximately 30 acres of land including the access corridor and earthen containment dike. The pond is anticipated to provide 26.5 acres of surface area for the evaporation and water storage. The pond will be constructed as an at-grade facility, with cut and fill designed to be in rough balance. The pond will have a double high density polyethylene (HDPE) liner with a leak detection/collection system. Any water collected in the detection/collection system will be pumped back to the pond. Water will cascade from Pond #2.

2.6 Groundwater Monitoring System

Currently 47 wells are a part of the groundwater monitoring system required by NRC (Figure 49). These include 4 Alluvial Aquifer background wells, 4 Alluvial Aquifer POC wells, and 24 Alluvial Aquifer, 6 Upper Chinle Aquifer, 3 Middle Chinle Aquifer, 2 Lower Chinle, and 4 San Andres Aquifer monitoring wells. Additionally, HMC obtains samples from about 180 other wells as a part of its own program to provide data to facilitate operational decisions for the groundwater remediation system. Groundwater sampling is conducted throughout the year. Groundwater samples are obtained using submersible pumps that are installed in each well. Standard sampling protocol requires purging of three well volumes of water that is discharged to ground surface prior to sample collection. The samples are filtered on site and sent off site for chemical analysis for the 10 NRC required analytes (Section 3.3). The results are reported annually.

2.7 Groundwater Diversion Permit

Integral parts of the groundwater remediation system at HMC are State permits that control the diversion and use of groundwater. Figures 5-1 and 5-2 present historical and proposed future groundwater diversion and consumptive use of groundwater by HMC. Termination or significant reduction of either diversion or consumptive-use conditions would result in loss of the right to divert and use the groundwater with a subsequent proportional alteration of the active groundwater remediation system.

3.0 SYSTEM OBJECTIVES, PERFORMANCE AND CLOSURE CRITERIA

3.1 Current System Objectives and Closure Criteria

The current objectives of the remedial activities at HMC considered for evaluation as a part of the RSE are:

- Remediate groundwater to levels stipulated in the NRC License SUA-1471 and the NMED DP-200;
- Flush the Large Tailings Pile to remove it as a continuing source of groundwater contamination; and
- Prevent exposure of the public to consumption of contaminated groundwater by residents in the Subdivisions.

During the June 24 and 25, 2008, Site Visit, representatives of HMC defined their current strategy to achieve these objectives to be:

- Reduce the weighted average concentration of uranium in water leaching from the Large Tailings Pile to 2 mg/l.
- Clean-up the "west" and "south" uranium plumes in the Alluvial Aquifer (Figure 4.3-53, Section 1.5.3).
- Use low TDS water from the RO unit to improve the rate of contaminant recovery from the Alluvial Aquifer in the most contaminated areas.
- Use withdrawal and injection strategy to keep contaminants away from subdivisions and to "push" the contamination back to the vicinity of the Large Tailings Pile.

To manage its program to achieve these objectives, HMC developed a regional groundwater model, including 7 layers representing 5 aquifers and 2 aquitards to assess various remediation scenarios and to evaluate groundwater movement. MODFLOW-96 is used to simulate groundwater flow and MT3DMS is used to simulate contaminant transport. The model was last updated in 2005 and was used at that time to simulate several scenarios of injection/extraction of water from the Large Tailings Pile to predict when this activity may be terminated. At least annually, non-digital techniques are used to evaluate system operations to determine any need for operating changes.

The RSE Team evaluated the results of tailings seepage modeling contained in the 2005 CAP, but did not conduct any model validation. Additionally, the RSE Team did not conduct independent groundwater modeling to validate HMC's projections of tailings pile leaching, when NRC action levels will be achieved, or to test alternative injection/extraction scenarios.

3.2 Treatment System Operation Standards

No treatment system standards are applicable to the HMC Site, because there are no direct discharges from any part of the treatment system to surface waters. HMC's objective for treatment is to obtain the lowest possible TDS effluent to assist flushing of the Alluvial Aquifer.

3.3 Action Levels

Table 2 contains the groundwater action levels for the Site established by the NRC and currently agreed to by the NMED and the USEPA. The groundwater cleanup levels were established for constituents within a specific aquifer unit utilizing establishment of upgradient background conditions. These action levels are applied at POC well locations S4, D, P and X (Alluvial Aquifer) (refer to Figure 49, Section 2.2.2). All Alluvial Aquifer compliance wells are located on the HMC Site. No POC wells have been identified by NRC in the Chinle Aquifers. The Chinle Aquifers action levels must be achieved by HMC at all locations.

Table 2
Current Groundwater Action Levels

Constituent	Groundwater Cleanup Levels (mg/l)				
	Alluvial Aquifer	Chinle Mixing Zone	Upper Chinle Aquifer	Middle Chinle Aquifer	Lower Chinle Aquifer
Uranium	0.16	0.18	0.09	0.07	0.03
Selenium	0.32	0.14	0.06	0.07	0.32
Vanadium	0.02	0.01	0.01	NA	NA
Molybdenum	0.10	0.10	0.10	0.10	0.10
Radium 226+228	5 pCi/l	NA	NA	NA	NA
Thorium 230	0.3 pCi/l	NA	NA	NA	NA
Sulfate	1,500	1,750	914	857	2,000
Chloride	250	250	412	250	634
TDS	2,734	3,140	2010	1,560	4,140
Nitrate	12	15	NA	NA	NA

N/A = Not Applicable

4.0 FINDINGS AND OBSERVATIONS FROM THE RSE SITE VISIT

The RSE Team found a very complex and highly integrated groundwater remediation system involving several aquifers and remedial components. The Site is well maintained and functional. The Site is staffed by a conscientious and dedicated team of managers and support staff willing to freely share its knowledge with the RSE Team. The observations and recommendations (Section 6) are not intended to imply a deficiency in the work of the designers, operators or managers but are offered as constructive suggestions in the best interest of the HMC, the EPA, the NMED, the NRC, and the public.

4.1 Tailings Flushing

Data provided during the Site Visit indicate that the average concentration of uranium being extracted during flushing of the Large Tailings Pile in 2007 was 11.7 mg/l. This is down from an average of 40 mg/l when full-scale dewatering and tailings flushing began in 2002. These data demonstrate that HMC has significantly affected the Large Tailings Pile as a continuing source of groundwater contamination. HMC has calculated that about 138,000 pounds of uranium, 4,100 pounds of selenium, 326,000 pounds of molybdenum and 34,000 pounds of sulfate had been removed from the Large Tailings Pile via wells and drains through 2007. These contaminants have collected and concentrated in the evaporation ponds. While uranium is of principal concern, reductions in concentrations of other contaminants in the tailings are also occurring.

Some stakeholders have suggested that the tailings flushing effort may mobilize contaminants other than those addressed by the NRC action levels. The RSE Team reviewed water-quality data in the NMED files for the Site. No identifiable trend for release of contaminants not currently addressed was identified.

The extraction wells and drains used to collect contaminants from the Large Tailings Pile are not designed to prevent migration of contaminants into the Alluvial Aquifer. In 2005 about 100 gpm of water injected into the Large Tailings Pile migrated to the Alluvial Aquifer for management by the Alluvial Aquifer remediation system. The subsurface control systems, discussed in Section 4.2, complement the wells and drains at the Large Tailings Pile.

4.2 Subsurface Performance and Response

4.2.1 Capture Zones

During the Site Visit the RSE Team was informed that HMC is using computer modeling to predict capture zones, measured water levels in wells, and professional judgment to establish its capture strategy. The strategy is evaluated at least annually and changes are made as necessary to conform to HMC's project objectives. No independent modeling was conducted as a part of the RSE to develop alternative capture strategies.

4.2.1.1 Alluvial Aquifer

Using a network of extraction and injection wells and injection lines, HMC has established a hydraulic divide in the Alluvial Aquifer (Figure 4.2-6, Section 15.2.1) that extends across the width of the Aquifer and is located 750 to 1,500 feet south and west of the Large Tailings Pile. Groundwater and entrained contaminants south of the divide flow to the west and south. Groundwater and contaminants north of the divide flow toward the groundwater recovery wells located immediately south and west of the Large Tailings Pile. The tailings piles and the evaporation and collection ponds are all located north of the hydraulic divide. The highest concentrations of uranium and selenium are located north of the divide.

The most current water-table map (Figure 4.2-1, Section 1.5.2.1) shows that the extraction and injection systems in the west and south uranium/selenium plumes are designed to push water and contaminants along the length of the plume from one side (nominally the north side) of the plume to be collected along the other side. The RSE Team finds that the rate of injection and extraction are balanced is such a way as to result in a net zero change in the water-table map. Regional groundwater flow and contaminant migration in the Alluvial Aquifer in the west and south plumes continues to be west and south. Therefore, continued implementation of this approach for the west and south uranium/selenium plumes may not allow HMC to achieve its objective to remediate groundwater to levels stipulated in the NRC License SUA-1471 and the NMED DP-200 or to prevent exposure of the public to consumption of contaminated groundwater by residents in the Subdivisions.

HMC uses one Alluvial Aquifer well (P2) located north of the Large Tailings Pile to control the flow of groundwater onto the Site in the San Mateo Alluvial Aquifer. On average 40 gpm of water is pumped and discharged to the San Jose Aquifer north of the west plume. This about 67% of the total estimated flow in the San Mateo Alluvial Aquifer. This effort reduces the volume of unaffected water entering a site requiring remediation. The RSE Team observes that if this water were allowed to flow to the Site, it would exert pressure to drive contaminated water from beneath the Large Tailings Pile toward Alluvial Aquifer extraction wells southwest of the tailings pile.

4.2.1.2 Chinle Aquifers

Because the Chinle Aquifers subcrop under the plumes of contamination in the Alluvial Aquifer, changes in the capture zones in the Alluvial Aquifer and the Chinle Aquifers caused by HMC may directly affect changes in the interaction of groundwater flowing between the Alluvial and Chinle Aquifers. The RSE Team observes that pumping from the Chinle Aquifers by HMC and the local residences may prevent HMC from adequately controlling migration of contaminants in the Alluvial Aquifer.

Upper Chinle Aquifer

Groundwater injection and collection wells are installed in areas proximal to the subcrop and mixing zones with the objective of preventing contaminants from the Alluvial Aquifer from further impacting the Upper Chinle Aquifer. As previously discussed, graphs of constituent concentrations over time indicate decreasing trends for the mixing zone and no further impact to the non-mixing zone in the Upper Chinle Aquifer. .

Middle Chinle Aquifer

Similar to the Upper Chinle Aquifer, groundwater injection and collection wells are installed in areas proximal to the subcrop and mixing zones with the objective of preventing contaminants from the Alluvial Aquifer from further impacting the Middle Chinle Aquifer. Likewise, graphs of constituent concentrations over time indicate decreasing trends for the mixing zone and no further impact to the non mixing zone in the Middle Chinle Aquifer.

Lower Chinle Aquifer

Pumping is being performed in the Lower Chinle Aquifer in the area south of Felice Acres where the unit is shallow and subcrops with the Alluvial Aquifer. The water quality is used for irrigation.

4.3 Component Performance

4.3.1 Groundwater Extraction and Injection Systems

4.3.1.1 Extraction Systems

Extraction is affected using wells and drains around the Large Tailings Pile. HMC has encountered major operational difficulties with the submersible centrifugal pumps used for extraction. The groundwater in the Alluvial Aquifer and Large Tailings Pile causes significant build up of mineral precipitates within the wells, resulting in clogging the pump intake and the impeller blades. (Information on the composition of the precipitate was not available to the RSE Team, however, data from a NMED database indicates that calcium and sulfate are naturally present in high concentration in groundwater at the Site.) The precipitate eventually causes the pumps to fail. Just over $120,000 was spent in 2007 for pump replacement. Over the years HMC found Grundfos® submersible pumps provide the greatest reliability. No specific information was available to the RSE Team to evaluate the effect of mineral precipitates on well screens. Replacing the centrifugal pump system with a jet eductor system was evaluated by the RSE Team and found to potentially result in even greater maintenance problems (e.g., inflexibility to modify wells from injection to extraction, potential need to run miles of pipe from a single pump to wells on a manifold system, and the potential that stoppage of one pump would affect several extraction locations.).

HMC utilizes miles of aboveground piping to move water around the Site. During the winter this piping may become frozen causing part of the groundwater remediation system to operate at less than optimal efficiency. Additionally, this pipe is subject to deterioration by the sun. However, even considering these problems, the RSE Team recognizes that the size of the remedial system and its intended flexibility, especially on the Large Tailings Pile, require that piping be left exposed to the elements and be easily moved. Placing piping on the surface also permits HMC to easily inspect the piping and to make any necessary repairs quickly.

Some stakeholders have suggested that the groundwater extraction system operated by HMC causes land subsidence resulting in damage to homes and other structures. No information was available to the RSE Team to determine why structural damage is occurring. Conditions associated with subsidence (e.g., significantly lowered water levels, compressible soils, etc.) are not present.

4.3.1.2 Injection Systems

HMC uses a unique system to inject water into wells. A float valve set near the top of the well maintains a column of water that exerts sufficient pressure to push water through the well screens into the Large Tailings Pile or aquifer. The RSE Team finds this to be a novel and effective approach to minimize pumping costs. Water is delivered to the injection wells from two water towers for storage of San Andres Aquifer water and by pumps from the RO unit or extraction wells. Cold weather can affect water flow in aboveground piping and may adversely affect the float valves.

To facilitate its groundwater control and tailings pile flushing programs, HMC is permitted to withdraw about 2,800 gpm from all sources to facilitate the groundwater remediation and Large Tailings Pile flushing systems. In 2005, the average withdrawal rate was about 2,500 gpm (89.5% of allowable). HMC returns about 641 gpm (25.6%) to the groundwater system via irrigation. The rest is re-circulated to maintain hydraulic control and for aquifer flushing. Figure 28 (Section 2.1) is a schematic diagram of the movement of water of the Site. HMC estimates that groundwater flow in the Alluvial Aquifer has increased by about 330 gpm as a result of its activities. This increased flow will result in some level of dilution of the contamination observed in the plume.

4.3.2 Reverse Osmosis Plant

The maximum available treatment capacity of the treatment plant is 600 gpm through two parallel RO filtration trains. The RO units are operating efficiently, but at about half capacity. Only one of the two trains is operated at a time. HMC indicated during the Site Visit that the primary factor in limiting operating capacity of the treatment plant is lack of capacity to manage/dispose of the brine. In part to overcome this limitation, HMC has proposed installing a new evaporation pond (i.e., Evaporation Pond #3) to increase evaporative capacity and allow for both trains of the RO units to be operated simultaneously. As noted above, only one RO train is operated at a time. The other is either in standby mode or undergoing maintenance. It is unclear to the RSE Team what the average influent flow rate will be if both trains could be operated simultaneously since HMC did not indicate that any back-up systems would be installed. The rated capacity is 600 gpm; however, down time for either of the units will reduce this theoretical maximum. If the average flow rate would be 500 to 550 gpm, production (requiring evaporation) would increase from the current 49 gpm to about 82 to 90 gpm (33 to 41 gpm increase).

During the Site Visit, HMC indicated that the primary purpose for operation of the RO unit was to produce low TDS water to be used to facilitate remediation of the Alluvial Aquifer. HMC considers low TDS water to be "aggressive" when injected into the Alluvial Aquifer. This aggressive water would have a greater capacity to mobilize and take uranium and other contaminants into solution for hydraulic transport. Increasing RO unit capacity will provide HMC with up to 300 gpm of additional aggressive water to be used to address contaminants in the Alluvial Aquifer. Use of more aggressive water is consistent with the ROD goal to remediate groundwater to NRC action levels.

Information on future use of the RO unit (e.g., treatment of recovered Chinle Aquifers water, treatment of Alluvial Aquifer water currently being disposed via irrigation, etc.) was not available to the RSE Team. The RSE Team can envision that treatment of these waters will be required to achieve the remedial goals. The treatment capacity of the current treatment unit (i.e., 600 gpm) may limit future groundwater extraction strategies. Plans for future expansion of the treatment system are unknown.

The RO plant has a pretreatment system wherein the pH of the water is raised to about 10 S.U. Increasing the pH causes solids to be precipitated, reducing the dissolved solids loading to the RO units. HMC originally designed the pretreatment system to use caustic soda (i.e., sodium hydroxide). A burned lime (i.e. calcium oxide) slaker system was added later to reduce costs by using more cost-effective lime instead of sodium hydroxide. The precipitated solids are removed through settling in a reactor/clarifier and by filtration in sand beds. The system conceptual design indicated that the bulk of the precipitated solids would be removed in the reactor/clarifier, with sand filters to remove small amounts of solids. Excessive suspended solids carryover has been a problem for HMC. To reduce the suspended solids load to the sand filters, citric acid was added to the reactor/clarifier to enhance settling of the solids; but this was marginally effective. Excessive carryover caused blockage of the sand filters, which required frequent back washing. HMC has switched to a proprietary flocculating agent to improve settling efficiency, and reduce the suspended solids load on the sand filters. Sand filter blockage continues to be a problem, but to a lesser extent. This problem may become serious if HMC installs additional evaporative capacity and doubles the operating capacity of the RO system. Flow rates through the system will double and carryover of suspended solids from the reactor/clarifier will increase. No information is available to the RSE Team to evaluate back-up systems to address sand filter blockage.

4.3.3 Evaporation Ponds

HMC relies completely on evaporative capacity for disposal of wastewater; there is no ability to directly discharge this waste to surface water. The existing evaporation pond system is substantially undersized for current operating conditions. HMC has compensated for this by installing and operating spray-evaporation systems in the existing evaporation ponds. While this has increased evaporation rates, it has resulted in high operating costs associated with electricity and equipment replacement costs caused by the highly corrosive wastewater. Additionally, spray evaporation has resulted in the release of salts and other contaminants to soil beyond the ponds (see Section 5.4), which may require remediation.

During the Site Visit, the RSE Team observed that the synthetic liner in Evaporation Pond #1 was cracked due to exposure to the sun. HMC was undertaking efforts to protect the liner from exposure by spraying water on the liner. Residual solids were observed to be caking the liner offering protection.

HMC has made application to the NMED to install a third evaporation pond to facilitate HMC's ability to increase the capacity of the existing groundwater remediation and Large Tailings Pile flushing programs. The worth of the third pond with respect to its usefulness to improve the effectiveness of the groundwater remediation system is presented herein.

The evaporative surface area of the proposed third pond is 26.5 acres. Using a pan evaporation rate for the Grants area of 80 inches per year (University of Arizona's Geotechnical, Rock and Water Resources Library web site), the new pond is designed to evaporate an additional 77 gpm of water. The existing evaporation ponds are 43.8 acres in size. The pan evaporation rate from these ponds is 127 gpm following similar calculations. These ponds are actually evaporating 170 gpm (the increase presumed due to spraying). The net result due to spraying, therefore, is about 33 gpm.

The increased evaporative capacity required after increasing RO treatment is 33 to 41 gpm (Section 4.3.2). The new pond evaporative capacity of 77 gpm appears adequate to handle the flow from the additional RO unit and the flow currently evaporated by the sprayers in Ponds #1 and #2 (i.e., 41 gpm RO + 33 gpm spray elimination = 74 gpm total new capacity needed vs. 77 gpm capacity proposed to be added). This means spray evaporation could be discontinued in Ponds #1 and #2.

As indicated in Section 4.3.2, HMC wants to increase RO treatment capacity to increase the amount of low TDS water that will be used to remediate the Alluvial Aquifer. While it is not suggested that any of this addition water at up to 300 gpm, will be ultimately discharged to the evaporation ponds, the RSE Team can envision this possibility after flushing of the Large Tailings Pile is terminated. Currently about 121 gpm is going to the ponds from the Large Tailings Pile. If this rate is exceeded from groundwater (including the irrigation systems), pond capacity will be insufficient without resumption of spray evaporation or implementation of alternative evaporation strategies.

The RSE Team finds that the proposed location for installation of Pond #3 may affect HMC's program to control movement of Alluvial Aquifer water to the Site in the San Mateo Aquifer. HMC should evaluate its plans for Pond #3 and it goals of Alluvial Aquifer water control to assure compatibility.

4.3.4 Irrigation Systems

HMC uses flood and center-pivot systems to irrigate acreage. Groundwater containing less than 0.44 mg/l of uranium and 0.12 mg/l of selenium obtained from the Chinle Aquifers and the extremities of the Alluvial Aquifer plum is used. Note that NMED is currently re-evaluating acceptable concentrations of uranium and other contaminants that can be in the irrigation water. During the Site Visit it appeared that the pivot systems were working effectively, but the flood systems were not being used. Use as irrigation water can be an effective way to handle water with low concentrations of uranium, selenium and other contaminants; however, land application of these contaminants will result in soil contamination and bioaccumulation of metals in the alfalfa being grown. Over application could result in a buildup of salts in the soil that make it toxic to grass or cause development of a near surface low permeability layer that prohibits migration of water to the root zone. The irrigation systems cannot be used for at least four months each year during the non-growing season. During this period it is necessary for HMC to significantly reduce the rate of groundwater extraction from the west and south uranium plumes.

The human health and ecological risk of irrigation of groundwater containing uranium, selenium and other metals to croplands has been raised by several stakeholders. Information available to the RSE Team indicates that the risk is low.

4.3.5 Solids Handling

HMC does not dispose of solids as waste to an off-site location. Solids are generated and accumulated in the Collection Ponds from RO unit reactor/clarifier system. These solids are transferred to Evaporation Pond #2 as Collection Ponds #1 and #2 fill. At the time of the Site Visit, the RSE Team found a significant accumulation of solids in the Collection Ponds. The solids were exposed to the atmosphere and may dry out to the point that some of these solids may be blown from the Site. This condition was not observed during the Site Visit. No solids were observed in the evaporation ponds during the Site Visit, except as related to the HMC efforts to address cracks in the liner.

Solids are also concentrated in the Evaporation Ponds from groundwater and tailings flushing water. As of the end of 2007, HMC estimated that at least 177,000,000 pounds of solids have accumulated in the ponds. About 98% (by weight) of these solids are sulfates.

4.3.6 System Controls

The lime system was installed to off set the caustic system. The caustic system was originally the only pH control mechanism. When the lime system was installed the control system for pH adjustment was not changed to lime. In effect, the lime is added at a low fixed rate and the automatic pH control system adds additional caustic to adjust pH to the appropriate level.

4.3.7 Monitoring Systems

HMC utilizes a computer-based system to manage operations of the RO plant. The system provides up to date status information on the operation. Housed in a control room at the RO plant the system provides information on flow rates through various equipment and components, material usage rates, pump systems' operating status, etc. Additionally, HMC operates a computer based system that tracks the water balance of the groundwater remediation system including Large Tailings Pile flushing. Figure WB (Section 2.5.1) is an example of the output of the water balance monitoring system for the week of June 23, 2008, the period of the RSE Site Visit.

HMC utilizes an extensive network of monitoring wells in the Alluvial and Chinle Aquifers to evaluate both the quality of water and the direction and rate of groundwater and contaminant migration. Currently, HMC obtains groundwater samples from about 200 wells (47 required by NRC). HMC monitors an additional 180 wells to help define Site conditions and effects of various operational changes. Many of these wells include private wells in the Subdivisions. In view of the size of the affected area, the number of aquifers involved, the locations of the plumes and requirements to protect human health, the RSE Team finds the number and location of monitoring wells used by HMC to be appropriate.

4.4 Components or Processes That Account for Majority of Annual Costs

Table 3 presents a summary of the cost expenditures of HMC in calendar year 2007 as identified in HMC's accounting system. The table does not include legal fees that are beyond costs associated with operation of the groundwater remediation system. Total expenditures associated with operation of the groundwater remediation system including Large Tailings Pile flushing in 2007 were $3,651,359. HMC has set aside about $3,500,000 for construction of Evaporation Pond #3.

4.4.1 Utilities

Total utilities cost for 2007 was $522,762 or 14.3% of the total expenditures. Electricity, which is utilized for operating the pumps and motors, comprises the majority (94.6%) of the utility costs.

4.4.2 Labor

Site labor and subcontracted labor and services account for $1,248,379 of the total 2007 expenditures. This amount is 34.2% of the total expenditures, which is within an expected range for a site this complex.

4.4.3 Parts and Supplies

Parts and related supplies accounts for 14.5% ($530,800) of the total 2007 expenditures. These costs include pump replacement and various parts and equipment for the RO units, evaporation ponds, tailings flushing system, irrigation system. These costs are high due to the corrosive nature of the groundwater and tailings water handled at the Site.

Table 3.
Calendar Year 2007 Expenditures

Budget Item	2007 Cost	Notes
Water Treatment		
Salaries and fringe benefits	$458,279	
Fuel	$22,641	
Chemicals and reagents	$304,500	45% caustic soda, 21% copper sulfate, 10% lime
Pumps	$120,111	
Parts, supplies, freight	$54,797	
Utilities	$522,762	65% general electric, 20% RO Plant electric, 9.6% irrigation system electric
Parts, supplies - tailings	$43,682	
Parts, supplies - wells	$154,666	
Parts, supplies - evaporation	$26,388	
Parts, supplies - RO plant	$98,460	
Parts, supplies - lime system	$11,186	
Parts, supplies - irrigation system	$5,660	
Install new wells	$432,767	77% for new irrigation well
Vehicles	$68,391	
Heavy Equipment repair & maintenance	$25,235	
Laboratory	$78,012	
Consulting fees	$234,492	
Other outside services	$233,311	22% pump maintenance, 15% RO plant instrumentation, 16.7% for irrigation system electrical service
Misc. expenses	$5,051	
Subtotal	$2,900,391	
Monitoring & Regulatory Reporting		
Laboratory	$23,647	
Parts, supplies	$15,830	
Consulting fees	$40,617	
Other outside services	$7,090	
Subtotal	$87,184	
Other		
Security and Maintenance	$6,447	
Property	$63,374	Taxes, surveying, title work, land acquisition, etc.
General & Administrative (G&A) - salaries and benefits	$274,590	
G&A - other	$111,803	Supplies, travel, training, etc.
G&A - non-accrual costs	$207,570	
Subtotal	$663,784	
Total 2007 costs incurred	***$3,651,359***	

4.4.4 Well Installation

The cost for new well installation in 2007 accounted for 11.8% of the total expenditures. Of this amount 77% was for installation of one new irrigation well.

4.5 Regulatory Compliance

HMC appears to be in compliance with requirements of its NRC and NMED permits.

4.6 Treatment Process Excursions, Upsets, and Accidental Contaminant Releases

The only excursion observed during the Site Visit was blowing of contaminated spray from Evaporation Pond #1. The sprayers used to increase the rate of water evaporation place contaminants at a sufficient height above the pond to be blown by the wind beyond the limits of the Pond. Salt encrustation was noted on the ground and vegetation east of Pond #1. The amount of salt did not appear to be sufficient to have adversely affected the ability of plants to grow. Residual levels of uranium and other contaminants in soil require further evaluation and remediation, if necessary.

Local stakeholders are concerned that water from the evaporations ponds may be affecting the Subdivisions. The RSE Team saw no direct evidence of this during the Site Visit, but cannot rule out that this excursion may occur under some weather conditions.

4.7 Safety Record

No information was found by the RSE Team to indicate anything but an excellent safety record at the HMC Site.

4.8 Project Close-Out

The RSE Team was informed during the Site Visit that after groundwater remediation is complete and after the Large Tailings Pile has been closed, HMC will investigate soil quality in the irrigation areas and downwind of Evaporation Pond #1. If "unacceptable levels" of uranium or other contaminants are present, soil remediation will be completed.

After all groundwater remediation actions are complete, HMC will collect all materials associated with past milling and remediation efforts (e.g., wells, RO unit, piping, remaining buildings, any contaminated soil at the irrigation areas or downwind of Evaporation Pond #1, etc.) and encapsulate these wastes in the evaporations ponds. Necessary cap material, including a radon barrier will be placed over the waste material at that time. Some stakeholders have raised concerns about the long-term safety of encapsulation of these wastes after the remedial action is terminated. The RSE Team is in agreement in view of the degraded conditions of the evaporation pond liner observed during the Site Visit.

5.0 EFFECTIVENESS OF THE SYSTEM TO PROTECT HUMAN HEALTH AND THE ENVIRONMENT

Under the standard RSE Report outline, effectiveness to protect human health and the environment is presented respective to the potential points of human and environmental exposure. These points of exposure are groundwater (Section 5.1), surface water (Section 5.2), air (Section 5.3), soil (Section 5.4), wetlands and sediment (Section 5.5) and crops (Section 5.6). For this RSE Report an additional section (Section 5.7) has been prepared that evaluates the overall effectiveness of the remedial system operated by HMC with respect to HMC's stated goals to achieve the remedial objectives established in the NRC license.

5.1 Groundwater

Historic contamination of the Alluvial, Upper Chinle, Middle Chinle and Lower Chinle Aquifers resulted in contamination of potable water-supply wells. Under its Stipulation of Agreement with the USEPA, HMC provided potable water to all residents, except nine as recently determined by HMC. The current groundwater remediation effort is focused on preventing further migration of contaminated groundwater into the five subdivisions where groundwater was historically used for potable and agricultural purposes and remediating groundwater quality to NRC action levels.

To judge the effectiveness of the groundwater remediation program, it is necessary to compare past groundwater quality conditions with more current conditions. Figure 36 and 37 (Section 1.5.3) show the uranium and selenium plumes in the Alluvial Aquifers in 1998 and 2005. In both cases the plumes have become smaller over time indicating that the systems are resulting in improved conditions. (Similar historic trends are also evident for other COCs.) The plumes in the Alluvial and Chinle Aquifers are still areally extensive. Thus, the groundwater remedial system will have to operate for several more years before the NRC action levels are achieved in all aquifers.

In the Upper and Middle Chinle Aquifers reduction in contaminant mass has occurred, but plume size has not significantly decreased. Refer to Section 1.5.3 for time-trend graphs demonstrating this condition. The graphs show a reduction in the overall concentration (i.e., mass) of uranium in each Aquifer. Significant remediation of the Chinle Aquifers will most likely not occur until contaminant migration from the Alluvial Aquifer is eliminated. Continued pumping from the Chinle Aquifers by HMC and residents in the five Subdivisions will continue to provide a pathway for contaminants to migrate from the Alluvial Aquifer to the Chinle Aquifers, either through the subcrops or by transfer down inadequately sealed wells.

The groundwater remediation program being implemented by HMC is not static. Changes in operation of individual injection and extraction wells are made continually, resulting in changes in the configuration of the water table (Alluvial Aquifer) or potentiometric regime (Chinle Aquifers) causing flow direction of groundwater and entrained contaminants to be modified. The resulting change in flow direction may cause groundwater samples being collected from a single monitoring well to contain higher concentrations of a constituent than previously observed. It may be interpreted in the short term that the groundwater injection/extraction program is not being effective. Only longer term observations can accurately evaluate effectiveness.

The groundwater remediation system at the Site includes extensive flushing of contaminants from the Large Tailings Pile as a source control effort. This activity will result in the temporary concentration of contaminants in all Evaporation Ponds, with subsequent accumulation of all solids in Evaporation Pond #1. Without proper closure of Evaporation Pond #1, this area may become a future source of groundwater contamination threatening human health and the environment.

5.2 Surface Water

There is minimal surface water at the HMC site during most of the year. The elevation of the water table is significantly below the bottom of any local streams throughout the year indicating that contaminated groundwater cannot discharge and contaminate streams. Run-off of salts and other contaminants at the irrigation areas and downwind of Evaporation Pond #1 may occur locally during heavy rainfall events.

5.3 Air

Air monitoring is conducted by HMC at several locations for radiological parameters, including radon. Information provided by HMC during the Site Visit indicates that radiological exposure to the local residents is low. The USEPA will be conducting additional evaluation of the radiological effects of the Site on human health.

In addition to potential radiological exposures, exposures may be occurring through migration of spray from the evaporation ponds during operation of the spray evaporation systems and via blowing of water-treatment solids from the collection ponds. No information was available to the RSE Team to evaluate the spray evaporation systems or solids from the collection ponds for protectiveness of human health and the environment.

5.4 Soil

Application of contaminated groundwater via flood and center-pivot irrigation contributes uranium, selenium and other contaminants and salts to soil. Information provided during the Site Visit indicates that soil sampling conducted by HMC has determined that there are increased levels of contaminants in the upper few inches of soil at the irrigation areas. HMC indicated that it would evaluate soil at the irrigation sites following completion of the groundwater remediation effort and would take all actions necessary to remediate any problem.

Spraying of water in the Evaporation Ponds to increase the rate of evaporation is causing water and entrained contaminants to disperse to the land downwind (i.e., east) of the pond. Information provided by HMC during the Site Visit indicates that HMC is aware that soil may be contaminated from this source. HMC indicated that as a condition of is NRC license that it would evaluate soil down wind of the ponds following completion of the groundwater remediation effort and would take all action necessary to remediate any problem. The RSE Team did not observe stressed vegetation down wind of the ponds during the Site Visit suggesting that the current threats to human health from this source are low.

Contamination of soil may be occurring during groundwater sampling efforts. Purge water from wells is routinely allowed to be discharged to the ground. The purge water contains will contribute uranium, selenium and other contaminants and salts to soil.

5.5 Wetlands and Sediments

No wetlands or sediments are at risk to site-related contamination.

5.6 Crops

Use of contaminated water to grow feed crops may result in uptake by the crop of metals (e.g., uranium, selenium, etc.). Studies conducted by HMC do not indicate any potential concerns about this practice.

5.7 Overall System Evaluation

During the Site Visit, HMC identified four system goals to achieve the overall objectives for site remediation defined in the ROD. This section presents the RSE Team's findings with respect to the effectiveness of HMC's efforts to achieve its own goals.

5.7.1 Reduce Average Concentration of Uranium from the Large Tailings Pile

Using computer modeling, HMC has calculated that when the weighted average concentration of uranium in water leaching from the Large Tailings Pile is lowered to 2 mg/l, the source of contaminants to the Alluvial Aquifer will have been effectively eliminated with regard to achieving the NRC action levels at the POC. The information available to the RSE Team demonstrates that the weighted average uranium concentration of water in the Large Tailings Pile as been reduced by about 47.5% to date. Thus, the RSE Team finds that the current tailings pile flushing and contaminant removal program is having a positive effect toward achieving HMC's goal. The RSE Team did not conduct any independent computer modeling to validate that the 2 mg/l conditions will be achieved or that this concentration will result in achieving the NRC action levels at the POC.

5.7.2 Clean Up the West and South Plumes in the Alluvial Aquifer

For this report "clean up" means achieving NRC action levels at all points beyond the POC. Historical groundwater quality results demonstrate that the west and south uranium plumes and associated plumes of other constituents have diminished in size. Thus, the RSE Team finds that the current program of injection and extraction are resulting in an improvement of conditions. However, HMC has not cleaned up either plume to meet NRC action levels at the POC. The RSE Team did not conduct independent modeling necessary to validate if HMC's goal of achieving clean up by 2017 will be met.

5.7.3 Use Low TDS Water from the RO Unit to Improve the Rate of Contaminant Recovery

HMC is applying low TDS water from the RO Unit to the area immediately south and west of the Tailings Piles. The RSE Team agrees that low TDS water offers good potential for mobilization and solubilization of uranium and other contaminants in the Alluvial Aquifer. However, no specific data are available to the RSE Team to determine if the concentrations of contaminants are being significantly lowered where RO treated water is being used.

5.7.4 Keep Contaminants Away from Subdivisions

The size of the plume is being reduced in and around the Subdivisions. However, the contaminant distribution maps demonstrate that contaminants remain in the both the Alluvial and Upper Chinle Aquifers in the Subdivisions at concentrations exceeding the NRC action levels. While RSE Team cannot conclude that the stated objective has been achieved, HMC efforts have greatly reduced the level of contaminants in groundwater at the Subdivisions.

The RSE Teams finds that there is a competing interest that may prevent or at least delay HMC's ability to achieve this goal; continued use of Alluvial and Chinle Aquifers water for potable and non-potable uses, such as irrigation by others. Potable use of groundwater was significantly reduced as a result of the Stipulation of Agreement between HMC and the USEPA to provide potable water, but the Agreement does not prevent residents of the Subdivision from continuing use of groundwater for non-potable purposes. The effects of continued pumping in the Subdivisions will have to be balanced by HMC actions to prevent plumes from migrating in the Alluvial Aquifer toward the Subdivisions and from being drawn into the Chinle Aquifers at the subcrops or through inadequately sealed wells.

6.0 ALTERNATIVES

This section provides a description of and discusses alternative approaches identified by stakeholders and the RSE Team for consideration at the HMC Site to facilitate or improve conditions to achieve the remedial objectives. It must be noted here that the existing remedial system has been developed over about 30 years as the result of a series of regulatory decisions and reactions. During that time, the art of groundwater remediation has evolved bringing new technologies on line that may be applicable to the Site.

The material presented herein should not be considered an exhaustive assessment of alternatives similar to that which is conducted during a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Focused Feasibility Study (FS). The discussion reflects the thoughts, ideas, and opinions of the RSE Team based on: 1) the information available to the Team from the documents listed on Table 1; 2) information obtained during the Site Visit; and 3) the professional experiences of the Team members. The alternatives are presented and discussed in four parts: Tailings Pile (Section 6.1), Groundwater Remediation (Section 6.2), Water Treatment (Section 6.3) and Waste Disposal (Section 6.4).

6.1 Tailings Pile

HMC selected a program to flush contaminants from the Large Tailings Pile as the way to eliminate the pile as a source of contaminants to the Alluvial Aquifer with subsequent potential transport to the Chinle Aquifers. The recovered contaminants are collected and are transferred for encapsulation at the location of Evaporation Pond #1.

Alternatives available to address the tailings as a source, in addition to the on-going approach, include, among others: 1) removal of the tailings for off-site disposal; 2) installation of a low-permeability cap; 3) in-situ fixation of contaminants in the tailings piles; 4) increase rate of contact between water currently being used for flushing with the contaminants; 5) utilization of amended water to increase flushing rates, and 6) improvement of the capacity to collect discharge from the Large Tailings Pile.

6.1.1 Tailings Removal for Off-Site Disposal

Some stakeholders have suggested that HMC remove the Tailings Piles for disposal at some other location. The RSE Team finds that implementation of this action alone will not allow HMC to achieve its objective to remediate groundwater to levels stipulated in the NRC License or to prevent exposure of the public to consumption of contaminated groundwater. Removal of the Tailings Piles does not directly address any contaminants remaining in the groundwater system and does not address any contaminants that are accumulated in the evaporation ponds. Back-of-the-envelop calculations suggest removal of the tailings material will cost in excess of $2 billion (even assuming a very low cost of $100/ton for excavation, transportation and disposal) and may result in potential human exposure to the excavation and transport workers and to the public between the Site and the ultimate disposal facility.

6.1.2 Install Low-Permeability Cap

Some stakeholders have suggested that a low permeability cap be installed on the Large Tailings Pile to prevent infiltration of rainwater and snow melt, which will mobilize contaminants in the pile for migration to the Alluvial Aquifer. The RSE Team finds that implementation of this action will not eliminate the Large Tailings Pile as a source of contamination of the Alluvial Aquifer in the short term and thus may not allow HMC to achieve its objectives to remediate groundwater to levels stipulated in the NRC License; to flush the Large Tailings Pile to remove it as a continuing source of groundwater contamination; and to prevent exposure of the public to consumption of contaminated groundwater. Back-of-the-envelop calculations suggest that installation of a low permeability cap will cost $ 27.4 to 45.7 million dollars (assumes capping cost of $150,000 to $250,000 per acre for installation with a size of 183 acres including top and sides).

6.1.3 In-Situ Fixation

The RSE Team has identified in-situ fixation of contaminants in the Large Tailings Pile as a possible means to eliminate the pile as a source of contaminants. In-situ fixation could involve the placement of chemicals that would convert the soluble contaminants to insoluble forms or result in filling the pores of the tailings to eliminate pathways of migration. Implementation of in-situ fixation alone will not allow HMC to achieve its objective to remediate groundwater to levels stipulated in the NRC License or to prevent exposure of the public to consumption of contaminated groundwater. There is insufficient information available to the RSE Team concerning chemical speciation and material distribution (especially the location of low-permeability slimes) to allow development of an even a back of the envelope cost for implementation.

6.1.4 Increase Contact with Flushing Water

HMC has indicated that contact of water with low-permeability slimes is the most troublesome aspect of the flushing process. During the Site Visit it was inquired if HMC had considered using application of flushing water at the surface of the pile using trenches. HMC indicated that it currently has no plans to use alternate methods of tailings flushing, but trenches may be considered further. Delivery of flushing water by trenches has the same limitation as that encountered using wells, specifically low-permeability slimes. The RSE Team does not have sufficient information of the distribution of slimes in the tailings pile to evaluate this option further.

6.1.5 Use Amended Water

Some stakeholders have suggested that HMC use less groundwater during its Large Tailings Pile flushing and contaminant removal program. To reduce the volume of water used, it may be necessary to add amendments to the water to improve the rate of contaminant removal. No data are available to the RSE Team, including such conditions as uranium (and other contaminant) mass in the pile and uranium and other metal speciation, to allow further evaluation of the effectiveness of replacing site groundwater with amended water.

Presently HMC uses water from the Alluvial and Chinle Aquifers as the source of water for tailings flushing. This water has a different geochemical characteristic than water that was originally present in the tailings material. Pumping and injection of the water will have caused the pile to become oxygenated. Oxygenated conditions are known to be desirable when attempting to mobilize uranium. Near the end of the flushing process it may be desirable for HMC to consider injecting a non-oxygenated water to reverse the solubilization process. The RSE Team does not have sufficient information to evaluate this condition further.

6.1.6 Improve Collection of Discharge

About 45% (106 gpm) of the water injected into the Large Tailings Pile is not collected by extraction wells in the Large Tailings Pile or by peripheral drains around the pile. Consequently, contaminated water is allowed to leach to the Alluvial Aquifer and potentially to the Upper Chinle Aquifer through the subcrop that is beneath the Large Tailings Pile. Presently HMC uses extraction wells in the Alluvial Aquifer to collect this water for subsequent treatment through the RO unit.

Some stakeholders have suggested construction of horizontal wells/drains under the Large Tailings pile to improve the rate of collection of flushing water. The sheer size of the Large Tailings Pile may limit use of horizontal wells/drains. The limiting condition to installation of these systems is the thickness of the pile. The drilling string used to install horizontal wells is located from the surface using a magnetometer to direct the actions of the driller to maintain the proper location of the drill sting. The magnetometer is best at finding the drill string at a depth of three or so feet below ground surface. The Large Tailings Pile is up to 100 feet high. Thus, it would not be possible to use the magnetometer to determine the location or attitude of the drill string. The horizontal well could drift upward into the tailings material, it could intercept existing wells, or it could be deflected by cobbles and boulders in the alluvial formation to an almost vertical orientation.

6.1.7 Conclusion

The RSE Team supports HMC's on-going efforts at the Large Tailings Pile to flush and collect COCs. The current system of flushing to extract contaminants from the Large Tailings Pile was limitations. However, thousands of pounds of contaminants have been removed to date. It is yet to be known if the process can achieve a sufficiently low concentration of contaminants in the water leaching from the pile after active flushing is terminated to allow HMC to achieve the NRC action levels in all aquifers. Further, HMC modeling efforts predict contaminant concentration rebound that may occur for up to 50 years into the future after active flushing is terminated. HMC's modeling indicates that rebound will not be sufficient to exceed the NRC action levels in the Alluvial Aquifer, but the increased concentrations may exceed the Upper Chinle Aquifer action levels. This is of concern as the Upper Chinle Aquifer subcrops beneath the Large Tailings Pile.

None of the alternatives presented above are clearly desirable in comparison with the on-going efforts. None will completely or immediately eliminate the Large Tailings Pile as a source of contaminants. During implementation of any of the alternatives listed above, even complete removal, COCs will continue to be released to the Alluvial Aquifer. Detailed computer simulation is needed to predict if the resultant concentrations of COCs released from the Large Tailings Pile will allow HMC to achieve the NRC Alluvial Aquifer and Upper Chinle Aquifer action levels.

6.2 Groundwater Remediation

Remediation of groundwater falls within two broad sets of options. These are 1) in-situ methods, or 2) and ex-situ or extraction methods.

6.2.1 In-Situ Treatment

A wide variety of in-situ (i.e., in-place) methodologies have been used and tested to remediate uranium, selenium, and other metals in soil and groundwater. These methodologies include: 1) permeable reactive barriers (PRB); 2) bioremediation (including biomineralization, microbial reduction, biosorption and phytoremediation); 3) chemical extraction using salts, acids and solvents; and 4) natural attenuation that relies on natural processes to sorb soluble contaminants to naturally occurring mineral surfaces.

To some extent in-situ processes are on-going at the Site. Surely there is some amount of natural attenuation occurring in the aquifers as dissolved COCs interact with natural minerals. HMC's irrigation program to treat groundwater with "low" concentrations of COCs is in part a phytoremediation approach. Plants are used to remove contaminants from water. Natural attenuation is also occurring at the irrigation plots.

HMC indicated during the Site Visit that pilot testing of bioremediation for in-situ treatment was conducted and found to be unsuccessful. No information was provided to the RSE Team to determine which bioremediation technique was evaluated or why HMC considered bioremediation to be unsuccessful.

Each in-situ method listed above seems to be successful within a limited range of site conditions. The HMC site represents a wide range of conditions, including: 1) the large size of the plume in the Alluvial Aquifer (i.e., several square miles); 2) the contamination of three rock aquifers; 3) contaminants extending to more than hundred feet below ground surface; and 4) a desert climate. To address this range of conditions several different in-situ techniques would be expected to be needed to be successful.

The RSE Team suggests that PRB is potentially application in the immediate downgradient vicinity of the Large Tailings Pile. PRB involve placement, using trenches or wells, through the thickness of the aquifer of a material that reacts with contaminants in the water as the water passes through the reactive medium. The reactive material may be a reducing or an ion exchange agent. As the contaminated groundwater passes through the barrier contaminants are removed from solution and are no longer present in form that can be released back into the water. Installation of PRB downgradient of the Large Tailings Pile might provide a backup technology to address continued releases of COCs from the Large Tailings Pile after active remediation is terminated.

6.2.2 Groundwater Extraction

Generally referred to as “pump and treat,” the effort being conducted by HMC to remediate contaminated groundwater in the Alluvial, Upper Chinle, Middle Chinle and Lower Chinle Aquifers involves the extraction of contaminated water for above-ground treatment. Extraction is conducted using about a hundred vertical wells. To facilitate the rate of capture, water is injected into the plume. HMC currently injects water using wells and several thousand feet of infiltration trenches. A large volume of San Andres Aquifer water, in addition to smaller volumes of Chinle Aquifers water and some Alluvial Aquifer water, is injected. HMC also uses RO water to assist remediation of the most highly contaminated Alluvial Aquifer water.

HMC’s initial groundwater management efforts focused on isolating the five Subdivisions from contaminated groundwater. Now HMC is attempting to produce an extraction and recovery scheme that hydraulically pushes the Alluvial Aquifer plume back toward its origin at the Large Tailings Pile. HMC is using computer modeling to predict capture zones and measured water levels in wells and professional judgment to establish its capture strategy. The strategy is evaluated at least annually and changes are made as necessary to conform to HMC’s project objectives. The RSE Team did not conduct independent modeling to validate HMC’s strategy or to develop alternative schemes.

6.2.3 Conclusion

The RSE Team observes that pump and treat has been on-going in one form or another at the Site for about 30 years and HMC predicts that pump and treat will continue for at least nine more years. The experience of the RSE Team suggests that this length of operation is not unusual when dealing with metals in groundwater. The RSE Team observes that the current efforts immediately downgradient of the Large Tailings Pile are effective in controlling the most highly contaminated water in the Alluvial Aquifer. Control in the Upper Chinle Aquifer beneath the Large Tailings Pile is not demonstrated.

The plumes in the Alluvial Aquifer have been reduced over time, but both the west and south plumes still extends almost two miles from the POC. Additionally, the RSE Team observes that HMC is aware that at least 330 gallons of injected water is not recovered from the Alluvial Aquifer and is flowing to the west and south.

The RSE did not involve construction of a computer model to test various pump and treat configurations. But considering the volume of contaminated groundwater remaining in four aquifers, the RSE Team expects that it will be necessary for HMC to adjust its priorities from flushing using large volumes of San Andres water to extraction of water from all aquifers. Increased extraction will have a resultant impact on water treatment and disposal.

6.3 Water Treatment

HMC treats recovered water through a treatment plant and by using the water as a part of a crop irrigation program.

6.3.1 Groundwater Treatment Unit

HMC uses chemical flocculation and RO to remove dissolved solids, including COCs from Alluvial Aquifer water and some flush water from the tailings pile is also treated. The process produces a large volume of essentially solid wastes during the flocculation process and high TDS brine from the RO process. The solids are collected in two collection ponds. The brine is discharged to the evaporation ponds. HMC only uses water treatment to provide low TDS water to be used to flush the Alluvial Aquifer in the vicinity of the Large Tailings Pile. During the Site Visit HMC indicated that the RO treatment system was not an integral part of its program to manage contaminated groundwater throughout the Alluvial and Chinle Aquifers plumes. Also during the Site Visit HMC indicated that it did not seriously consider any technology but RO for treatment. The RSE Team has identified several operation concerns with the current treatment plant (Section 4.2.2).

Some stakeholders have suggested that the RO technology and associated pre-treatment is inefficient and results in an un-necessarily large waste stream with its related impact on the size of evaporation ponds. Ion exchange technology is the proposed alternative.

The RSE Team does not have sufficient information about the chemistry of the influent waters to the current treatment system to evaluate ion exchange as an alternate treatment method. But, a condition that may limit the effectiveness of ion exchange at this Site is the amount of calcium and sulfate naturally present in the waters of the area. Concentrations of both can exceed a thousand parts per million. Additionally, the ion exchange medium is selective respective to the contaminant removed. At this Site the COCs include both positively charged ions (cations) (e.g., uranium, selenium, radium, etc.) and negatively charged ions and radicals (anions) (e.g., sulfate, nitrate, etc.). These cannot be treated by one exchange medium. It will be necessary to establish a treatment train using a range of different ion exchange media to effectively remove all COCs of concern.

6.3.2 Irrigation

On a yearly average HMC treats over 600 gpm of Alluvial Aquifer and Chinle Aquifers water containing less than 0.44 mg/l of uranium and less than 0.12 mg/l of selenium through an irrigation system used to grow hay for sale as feed. The water is treated by sorption of COCs to soil particles and uptake of COCs by the hay.

Irrigation has raised concerns to various stakeholders respective to protection of animal health during consumption of the feed, potential environmental threats caused by accumulation of metals in soil and threats to Alluvial Aquifer water when water exceeding the NRC action levels is used. Information available to the RSE Team suggests that none of these concerns is supported by facts.

6.3.3 Conclusion

The RSE Team agrees that the current RO treatment system is achieving its objective. The current system can be improved and the RSE Team is concerned about the lack of back-up systems when HMC attempts to operate the system at full capacity.

The RSE Team also agrees that the current irrigation system is achieving its objectives. In any case, NMED is re-evaluating this practice and may reduce the concentrations of COCs that can be in irrigated water. If NMED requires a change, HMC will have to establish an alternative treatment approach or it will have to revise its groundwater capture strategy.

The RSE Team envisions that HMC's overall water treatment strategy will have to be modified if irrigation is terminated due to NMED restricts and when treatment is needed to polish recovered groundwater from the extremities of the Alluvial Aquifer plume and from the Chinle Aquifers. The RSE Team did not obtain information about HMC's plans for future changes to the water treatment system.

6.4 Waste Disposal

Wastes generated by HMC are accumulated in collection ponds (i.e., treatment plant solids) and in evaporation ponds (i.e., tailings pond flush water) and treated water from the RO plant is injected to flush the Alluvial Aquifer. In the ponds residual water from the treatment plant and water from the Large Tailings Pile is eliminated by evaporation. After the remedial process is complete, HMC plans to eliminate all water through evaporation and to collect all solid wastes into Evaporation Pond #1 where the wastes will be entombed. During the Site Visit the RSE Team asked if HMC had considered recovery of uranium and other metals from the ponds. HMC periodically considers metals recovery, but it is not currently economically viable.

6.4.1 Solid Waste

There are only two options available to HMC for disposal of solid wastes: 1) concentration and on-site disposal and 2) collection and off-site disposal. The solids may have to be handled as radioactive wastes if shipped off site. The RSE has no information on the amount of solids in the collection ponds and cannot predict the volume of solids to be generated until the remedial goals are achieved.

The RSE Team did not review HMC's final closure plan for entombment of the solid wastes at Evaporation Pond #1. The effectiveness of long-term on-site management is in question in view of the degraded condition of the liner of Evaporation Pond #1 observed during the Site Visit.

6.4.2 6.4.2 Water

Water generated from flushing the Large Tailings Pile and during RO treatment is pumped to Evaporation Pond #1 where is evaporated to the air. Evaporation occurs directly from the surface of Ponds #1 and #2 and by spraying the water into the air to increase the evaporative surface area. The spraying practice has resulted in discharge of solids from the ponds to down wind soil.

To eliminate the need for spray evaporation and to increase treatment capacity, HMC as requested installation of a third evaporation pond. The RSE Team has calculated that construction of the third pond will achieve HMC's objectives. The three ponds increase HMC's evaporative capacity to 204 gpm. The RSE Team envisions that this capacity may have to be increased to meet future changes in HMC's groundwater capture scheme.

Several evaporation systems are commercially available as potential alternative to the ponds. These include, among others, mechanical vapor compression, thermal, vacuum distillation, falling film, and short-path evaporators. While technologies differ, all of these evaporator systems require a power source for operation with an associated utility cost to HMC. Most of these systems have an evaporative capacity of a few hundred gallons per hour. HMC's current two pond system evaporates over 7,400 gallons per hour (gph); the third pond will add 4,500 gph. The highly corrosive water and the resulting large volume of solid wastes may make any commercially available evaporator system infeasible.

6.4.3 Conclusion

The RSE Team is in general agreement with HMC's program for management of solid and liquid waste, if Evaporation Pond # 3 is installed. Concerns about migration of contaminants as dust from the collection ponds or as spray from the spray evaporators are concerns of local stakeholders and the RSE Team that require further evaluation by HMC.

7.0 RECOMMENDATIONS

From information obtained in available Site documents and observations made during the Site Visit, the RSE Team has identified several recommendations for consideration by HMC. The recommendations are grouped as Tailings Pile (Section 7.1), Groundwater Remediation (Section 7.2), Waste Treatment (Section 7.3), Waste Disposal (Section 7.4), and Other (7.5) for those recommendation that do not seem to applicable to the other four categories.

7.1 Tailings Pile

1. No specific recommendations are made with regard to the flushing program being conducted by HMC to address the Large Tailings Pile as a source of contaminants found in groundwater considering the success already demonstrated based on the mass of contaminants removed. However, HMC efforts to demonstrate that the NRC action levels will be achieved after flushing is terminated remains of concern to many stakeholders. The RSE Team recommends that additional modeling efforts be completed to validate HMC's predictions.

7.2 Groundwater Remediation

1. The RSE Team makes no specific recommendations to improve effectiveness of the groundwater injection and extraction systems with regard to operation of any specific extraction well, injection well, drain, or injection line. The RSE Team observes that the approach currently utilized by HMC is highly flexible and under continual re-evaluation and modification. However, HMC's future plans are unclear to the RSE Team. Specifically, what efforts will HMC implement to improve effectiveness of remediating the west and south plumes in the Alluvial Aquifer. Additionally, HMC has not provided an evaluation of the impact of changes of the groundwater remedial effort on future water treatment and disposal needs. Thus, the RSE Team recommends HMC should develop a plan of attack, including impact of changes of the groundwater remedial effort on future water treatment and disposal.

2. The plumes in the Alluvial and Chinle Aquifers remain areally extensive after about 30 years of efforts to remediate groundwater. HMC predicts that the groundwater remedial system will have to be operated for nine more years (at a minimum) before the NRC action levels are achieved in all aquifers. Remediation of "elemental" contaminants, such as selenium, uranium and other metals, is very challenging. At this Site the challenge is increased by such factors as the number of aquifers involved, the size of the plume in the Alluvial Aquifer, the physical make up of the alluvial formation, and the uncontrolled use of groundwater by others. To assist efforts to improve the rate of groundwater clean-up HMC should consider terminating pumping from the Chinle Aquifers until the Alluvial Aquifer action levels have been achieved at the subcrops. This effort will have to be matched by termination of pumping from local private wells (this action is beyond HMC's control alone). Cessation of

Chinle Aquifer pumping will allow the natural upward hydraulic gradient to be achieved producing a natural barrier to migration of contaminants to the Chinle Aquifers through the subcrop areas. Additionally, inadequately sealed wells will no longer be conduits for contaminant migration. HMC should reinstate its program to remediate the Chinle Aquifers after the Alluvial Aquifer achieves the NRC action levels.

3. Public health has been protected by HMC efforts to connect residences of the five Subdivisions to the City of Milan water supply for potable uses. It was recently determined that nine residences in the Valle Verde Subdivision continue to use wells for drinking water. Ongoing groundwater monitoring has not shown that these well users are at risk; however, continued pumping from wells in Valle Verde could affect the groundwater flow patterns sufficiently to result in movement of the uranium plume. To reduce this potential threat to human health the RSE Team suggests that HMC consider taking actions necessary to provide drinking water from an alternate source (e.g., City of Milan).

7.3 Water Treatment

1. The pretreatment problem associated with operation of the current RO system may become serious, if HMC installs additional evaporative capacity and doubles the operating capacity of the RO system. Flow rates through the system will double and carryover of suspended solids from the reactor/clarifier will increase dramatically. The RSE Team recommends that HMC proceed with a study to evaluate the effectiveness of the clarifier and sand filter system with the anticipated increase in flow. It is likely that additional clarification and/or sand filtration capacity will be required.

   The current primary pH control system is an area of in-efficiency. Approximately 50-75% of operating cost could be saved if the primary pH control system was switched to lime. The caustic pH adjustment system should remain in place, but be used as an emergency backup system. As mentioned previously, lime adds additional load to the reactor/clarifier and sand filter systems. These systems are already overloaded. HMC should not immediately switch to using lime solely for pH control as this would result in an increase in solids load to the reactor/clarifier and sand filtration systems. Rather, this switch should be considered while increasing reactor/clarifier and sand filtration capacity is evaluated.

2. HMC should consider termination of the irrigation systems for treatment of water. (This practice may be restricted by NMED after further evaluation.) This practice involves placement of groundwater containing uranium and other metals at concentrations exceeding the NRC Alluvial Aquifer action levels. Soil and feed crops may be contaminated as a result of this practice.

7.4 Waste Disposal

1. The long-term effectiveness of the groundwater remediation system may be limited by HMC's ability to evaporate water from the waste streams generated during the Large

Tailings Pile flushing and operation of the RO unit for treatment of groundwater from the Alluvial Aquifer. Without increasing the capacity to handle these waste streams, the closure schedule currently envisioned by HMC (i.e., all actions terminated by 2017) may not be met. To allow HMC to meet its goals for groundwater remediation, HMC should proceed with efforts necessary to obtain approval for installation of additional evaporation pond capacity. The increased evaporative capacity will enable HMC to increase its ability to treat groundwater from the Alluvial Aquifer (and possibly other aquifers). The RSE Team is concerned about HMC's use of spray evaporation to achieve necessary evaporation rates. Considering the issues of spray operations raised by local stakeholders and the potential for human health and environmental exposure, complete elimination of this practice seems appropriate. Construction of a third evaporation pond will help HMC eliminate the need for spray evaporation.

2. During the Site Visit, the RSE Team observed that the synthetic liner in Evaporation Pond #1 was cracked due to exposure to the sun. HMC was undertaking efforts to protect the liner from exposure by spraying water on the liner. After the water evaporates or drains into the pond, residual solids were observed to be caking the liner offering protection. This action appears to be only a temporary fix. The RSE Team recommends that HMC evaluate alternative methods to provide protection to the exposed liner to assure its integrity.

3. After remediation is complete HMC proposes to encapsulate all wastes in Evaporation Pond #1. HMC should take such actions as are necessary to evaluate the effectiveness of this plan and to demonstrate protection of human health and the environment. The RSE Team is concerned about the integrity of the liner after observing that it is cracked by exposure to the elements.

4. Exposures may be occurring through migration of spray from the evaporation ponds during operation of the spray evaporation systems and via blowing of water-treatment solids from the collection ponds. The spray and dust could contain uranium and other metals that may present a threat to human health and the environment. HMC should attempt to quantify the contaminants present in spray and dust to assure human health and the environment are protected or HMC should implement engineering controls to control the potential threat.

5. Residual levels of uranium and other contaminants in soil around the evaporation ponds and irrigation areas may require further evaluation and remediation. HMC indicated during the Site Visit that it would conduct such evaluations following completion of the groundwater remediation effort and would take all action necessary to remediate any problem identified. HMC should carry-out this effort.

7.5 Other Considerations

1. Groundwater sampling protocol allows HMC to dispose of purge water generated during groundwater sample to the ground. At some locations this purge water may contain high levels of contaminants (e.g., uranium, selenium, etc.) resulting in potential soil contamination. The RSE Team recommends terminating this practice at any sampling

location where the NRC action levels are exceeded. The purge water could be treated through the RO unit for re-use or be disposed in the Evaporation Ponds.

8.0 SUMMARY

The RSE Team found a well-operated groundwater remediation and tailings flushing program at the complex HMC Superfund Site in Milan, New Mexico. This Site is complex because the contaminated groundwater is distributed over a large area (several square miles), four interconnected aquifers are affected, and the source of contamination is a large tailings pile containing an estimated 21 million tons of mill tailings. The groundwater remediation and tailings flushing systems operated by HMC have significantly decreased the mass contaminants in the Large Tailings Pile and have significantly reduced the size of the selenium plume in the Alluvial Aquifer and have controlled the spread of the uranium plume in the Alluvial Aquifer. The uranium and selenium plumes in the Upper, Middle and Lower Chinle Aquifers are being controlled.

The RSE is limited to conditions as they existed at the time of the Site Visit. It is beyond the abilities of the RSE Team to judge and evaluate decisions made over the 30-year period preceding the Site Visit and the RSE Team can not consider conditions that may develop in the future.

To evaluate the current groundwater remediation system it was necessary to judge HMC's efforts to achieve the goals of the ROD. With respect to the three objectives that are applicable to this effort the RSE Team makes the following observations.

1. Remediate groundwater to levels stipulated in the NRC License SUA-1471 and the NMED DP-200 – On-going efforts are improving the quality of groundwater in the Alluvial, Upper Chinle and Middle Chinle Aquifers. HMC has not yet demonstrated achievement of the NRC action levels at the POCs in the Alluvial Aquifer and at all locations in the Chinle Aquifers.
2. Dewater the Large Tailings Pile to remove this area as a continuing source of groundwater contamination – Contaminants levels in the Large Tailings Pile have been significantly reduced. HMC has not yet eliminated the Large Tailings Pile as a source of contamination.
3. Prevent the consumption of contaminated groundwater by residents of the five Subdivisions adjacent to the site – Potable water has been made available by HMC to all but 9 local residents. Until groundwater action levels achieve the NRC action levels, consumption of contaminated groundwater is still possible.

The RSE Team did not identify significant short-comings or limitations to the efforts being conducted by HMC considering the long history of development of the current remedial system. Several recommendations are provided to improve the current system and to facilitate future operational decisions.

APPENDIX A

PHOTOGRAPHS

LARGE TAILING PILE

Extraction and injection (red stripped) wells (looking northwest)

Aboveground piping (looking east)

Toe drain collection sump with tailings pile behind (looking northeast)

Large Tailings Pile in distance behind RO plant with aboveground
piping in the foreground (looking northeast)

EVAPORATION AND COLLECTION PONDS

Evaporation Pond # 1 with sprayers on from Large Tailings Pile (looking southeast)

Evaporation Pond #2 from the Large Tailings Pile (looking southeast)

Collection ponds #1 and #2 from Large Tailings Pile (looking south)

Evaporation Pond #1 with sprayers (looking northeast)

Evaporation Pond #1 showing pumping of water to cover liner with brine (yellow-white color) (looking northwest)

Evaporation Pond #2 liner showing effects of exposure to air and sun

Control panel

Evaporation Pond #2 (looking west from Pond #1)

Collection Pond #1 showing sludge and various discharge lines (looking south)

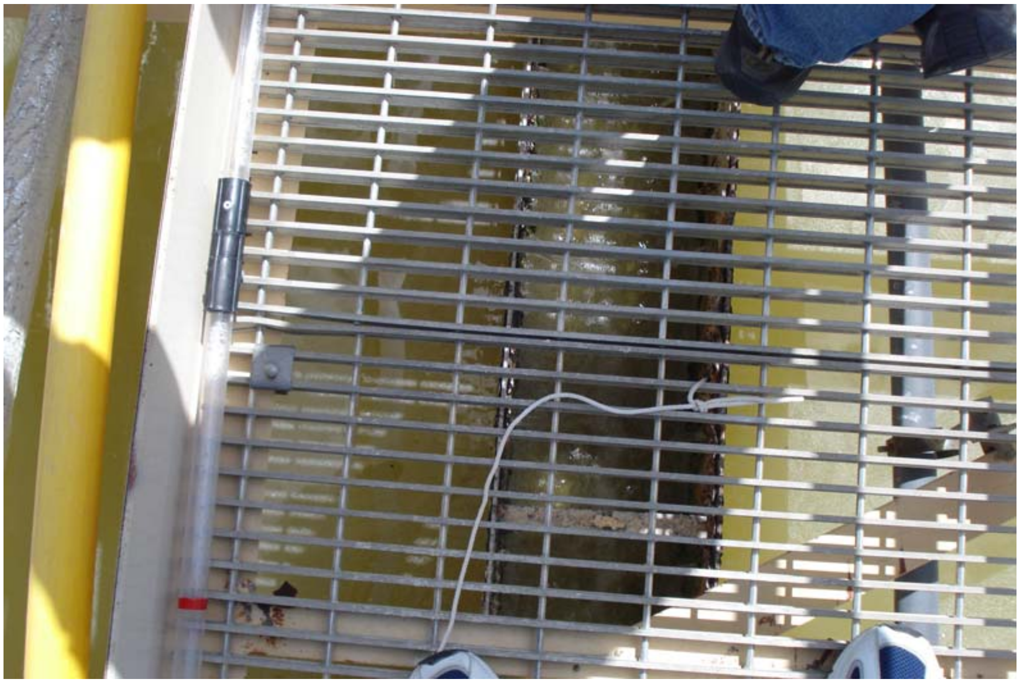
Collection Pond #1 (looking east)

Collection Pond #2 (looking east)

REVERSE OSMOSIS TREATMENT PLANT

RO Plant from Large Tailings Pile (looking southwest)
(Clarifier to the left and lime slaker unit to the right)

Reactor Clarifier (from top)



Clarifier Overflow (from top)

RO Unit Pumps with RO Membrane Filters to the Right

RO Membrane Filters (from side)

APPENDIX B

HMC FIGURES

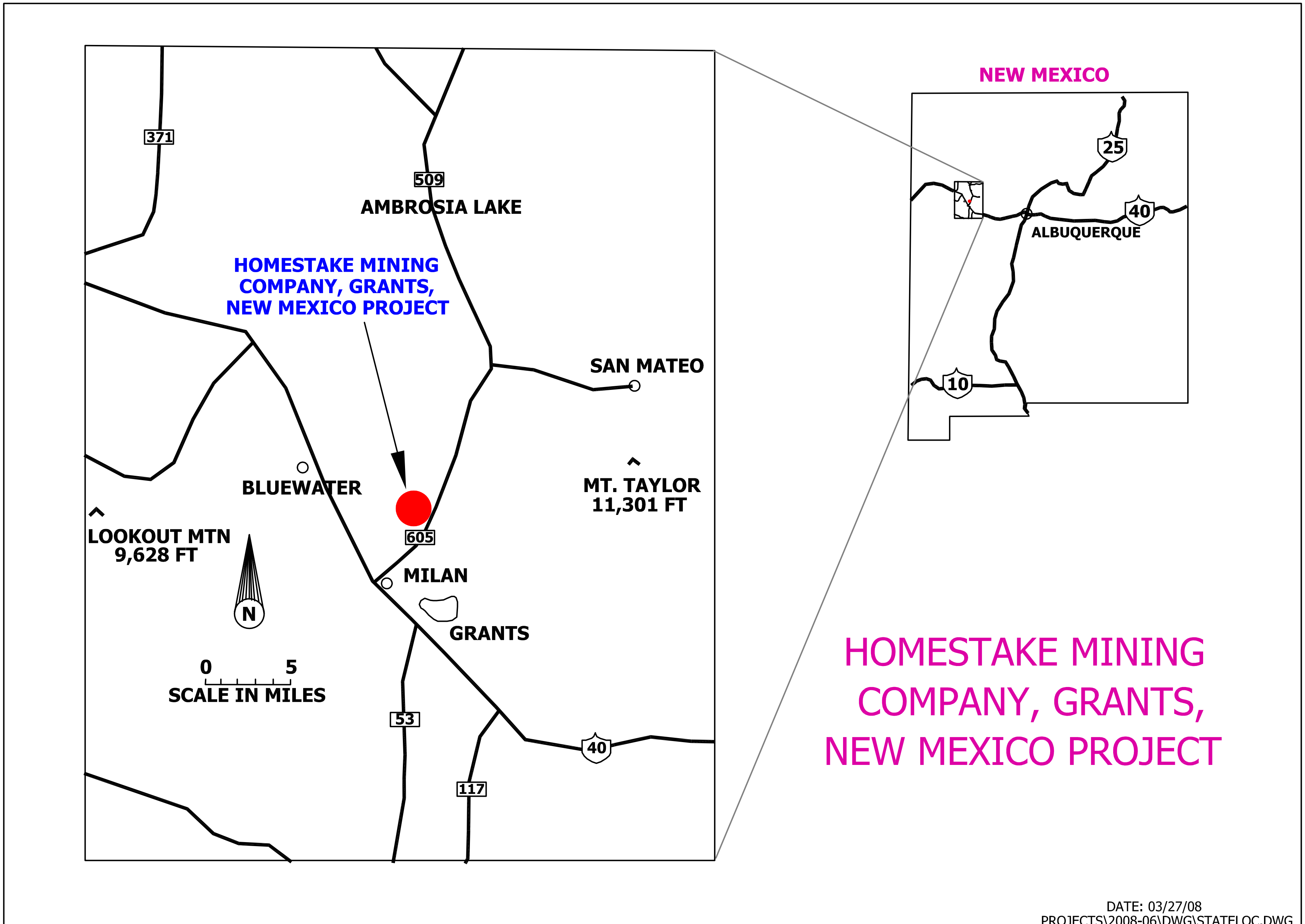
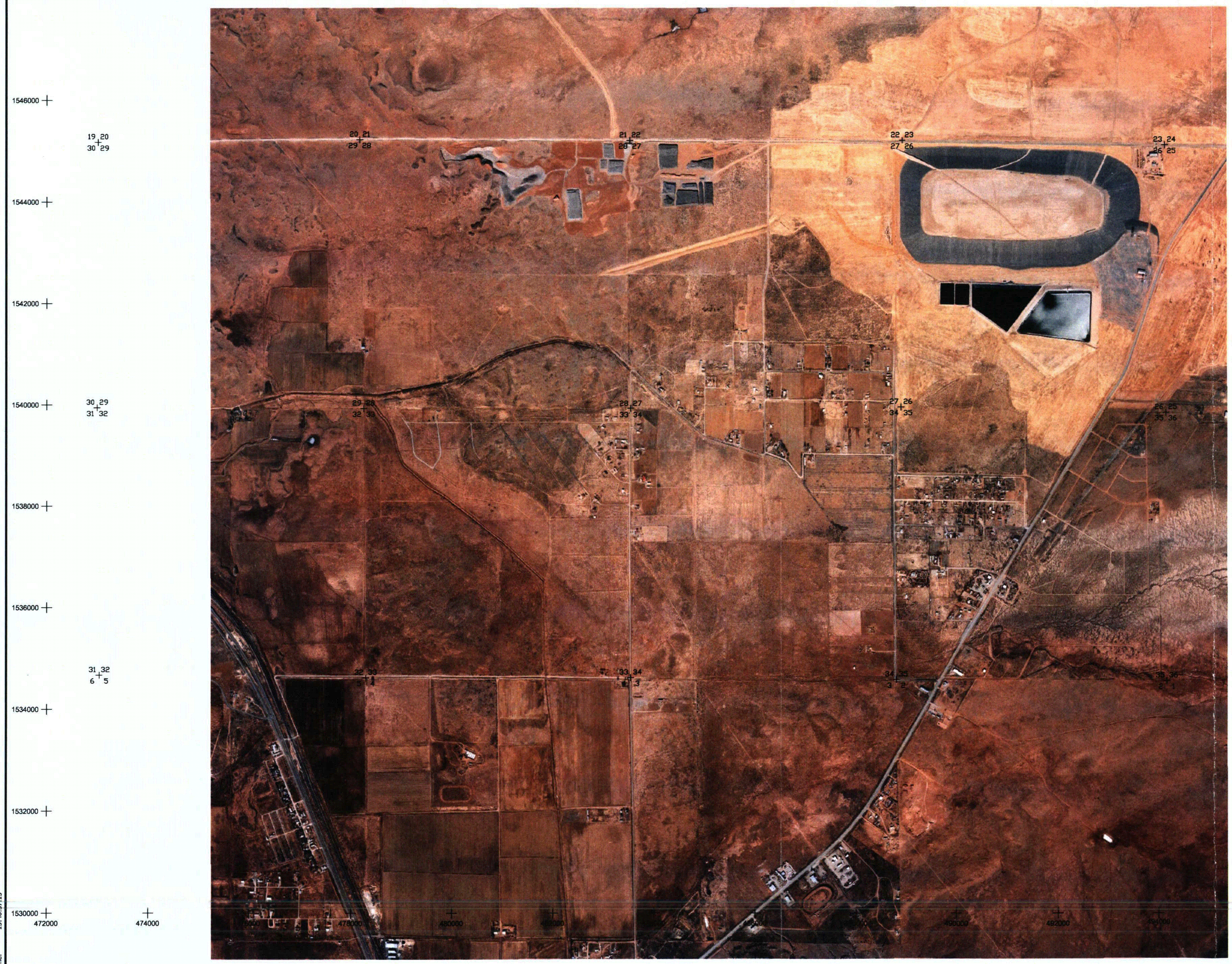


FIGURE 1.2-1. LOCATION OF THE GRANTS PROJECT



LEGEND:

1536000	NAD 27, NEW MEXICO STATE PLANES, WEST ZONE COORDINATES
35 36 / 2 1	SECTION CORNER

NORTH

SCALE IN FEET

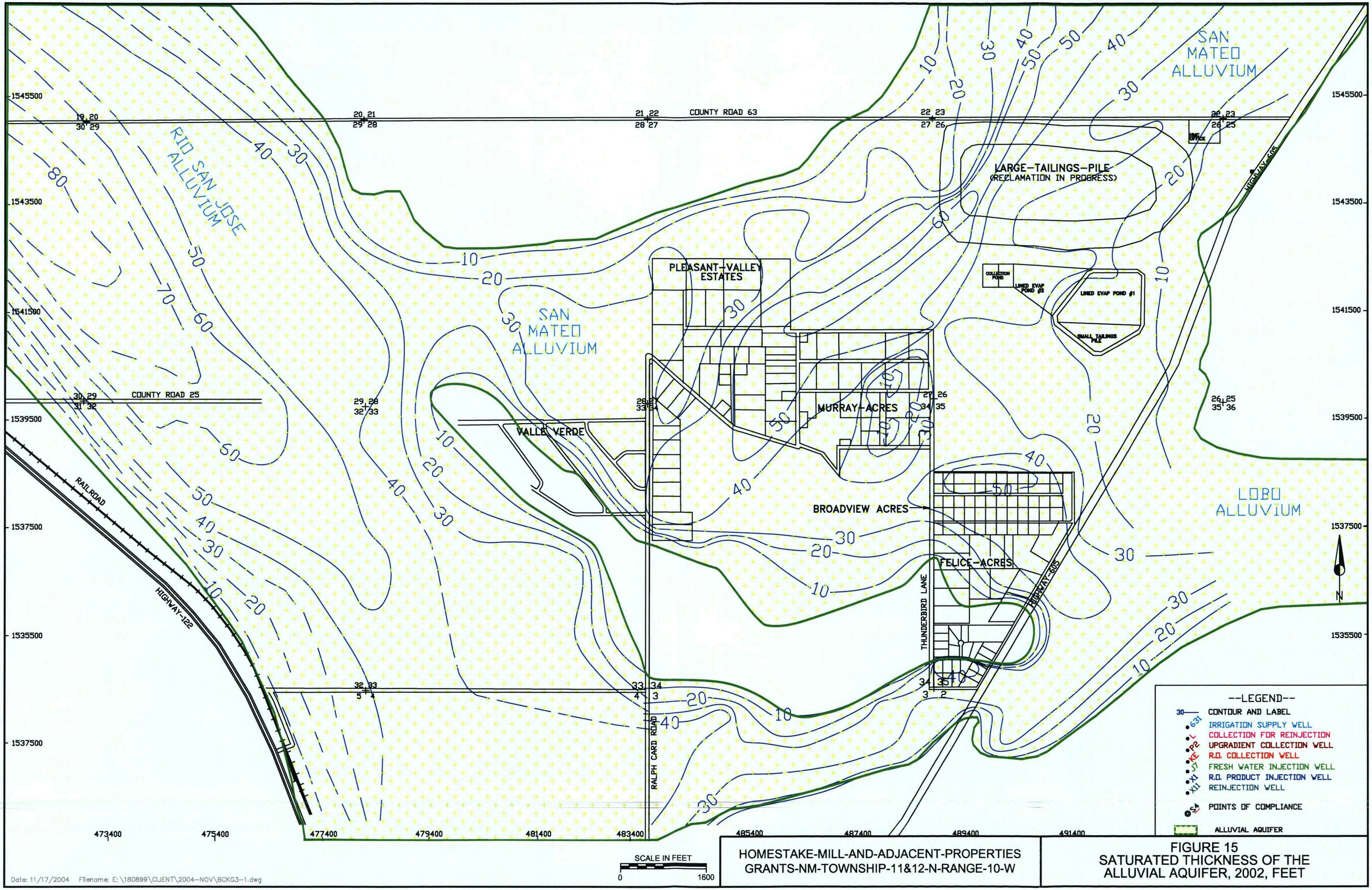
0 2000

FIGURE 1
GRANTS MILL SITE AND ADJACENT PROPERTIES AERIAL PHOTO

MFG, Inc.
consulting scientists and engineers

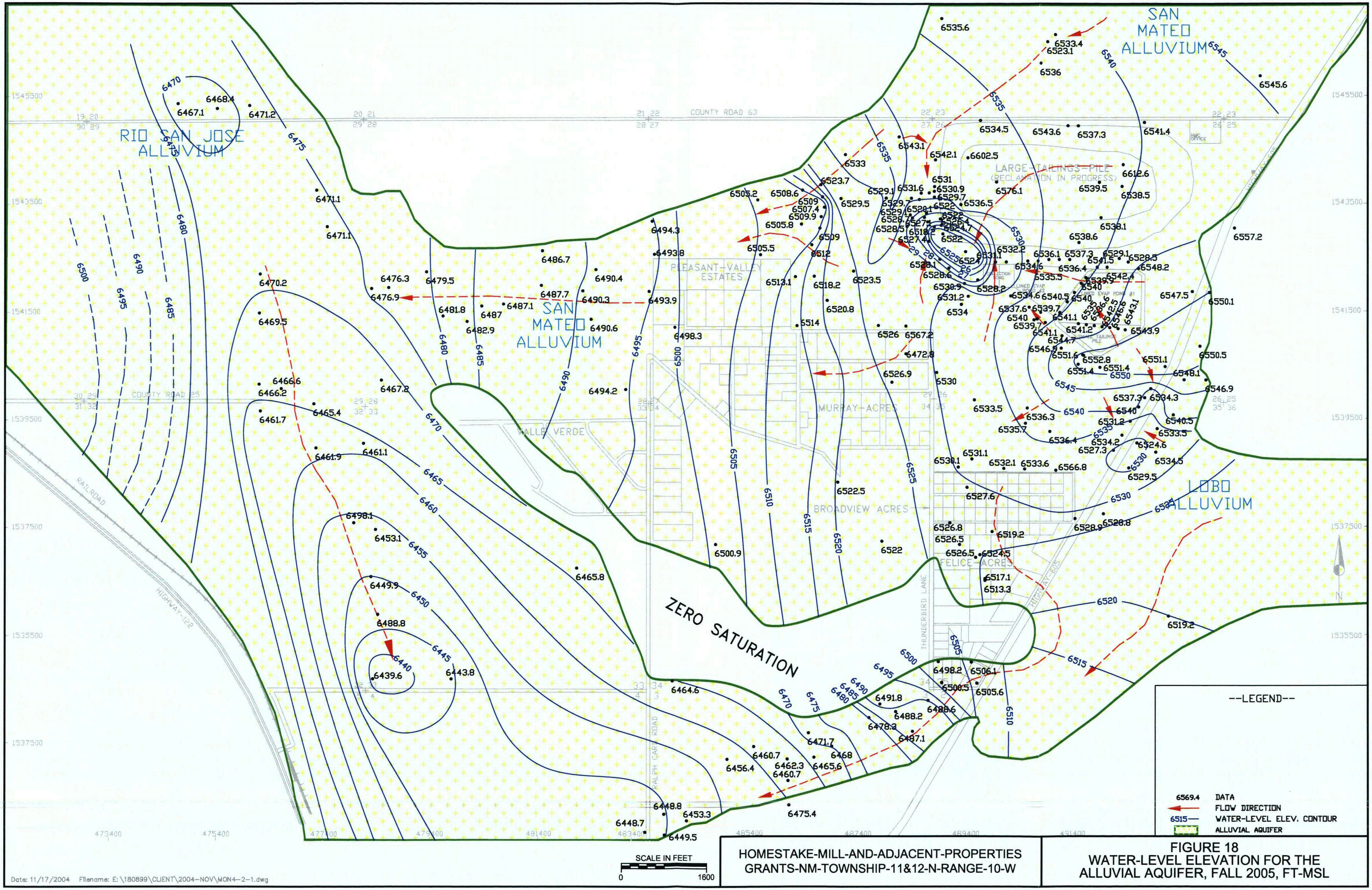
Date:	NOVEMBER 2006
Project:	180899
File:	AERIAL.dwg

Filename: E:\180899\AERIAL.dwg
Date: 10/24/2006
Time: 13:46:37.13



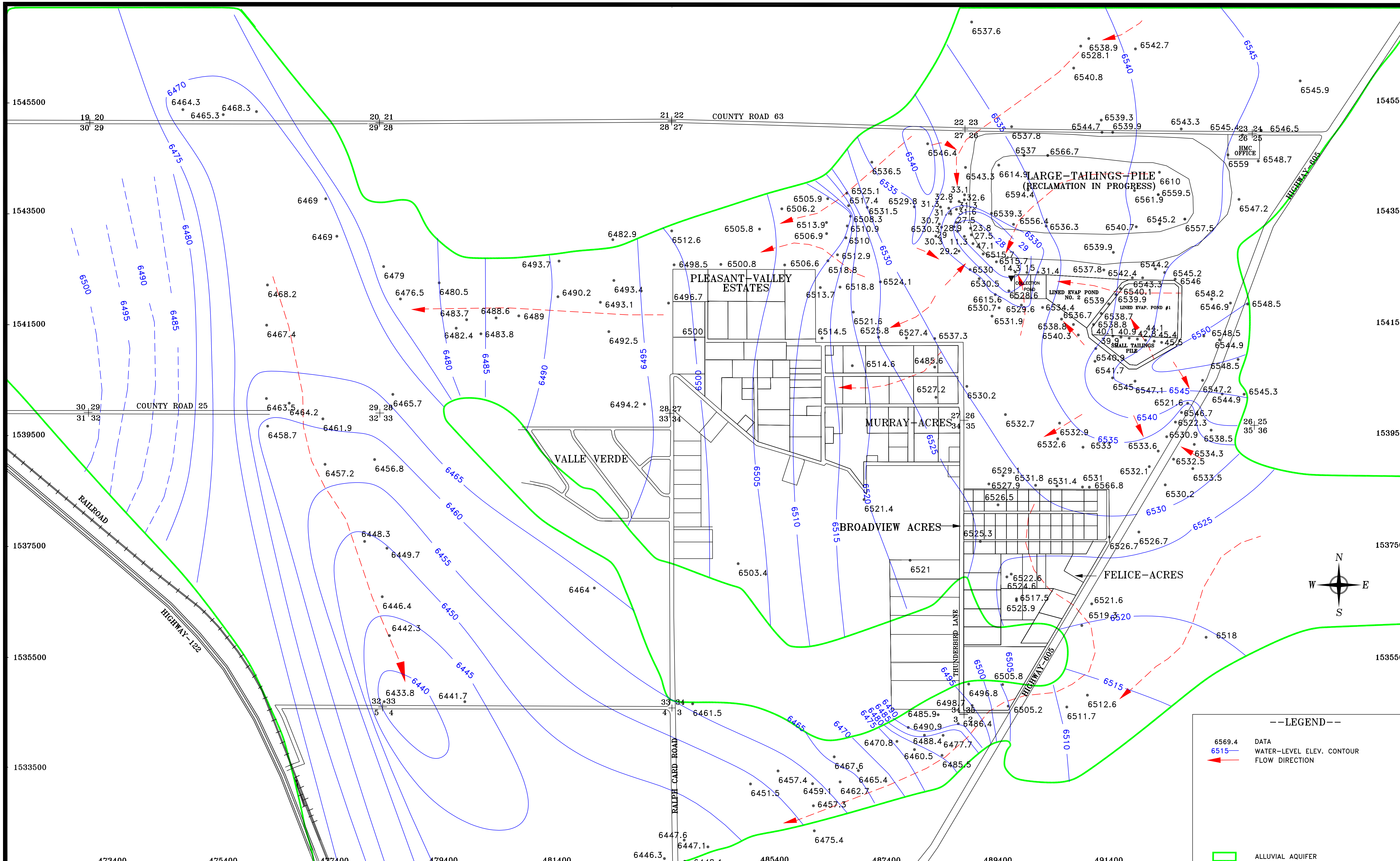
HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 15
SATURATED THICKNESS OF THE ALLUVIAL AQUIFER, 2002, FEET



HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 18
WATER-LEVEL ELEVATION FOR THE
ALLUVIAL AQUIFER, FALL 2005, FT-MSL



SCALE: 1"= 1600"
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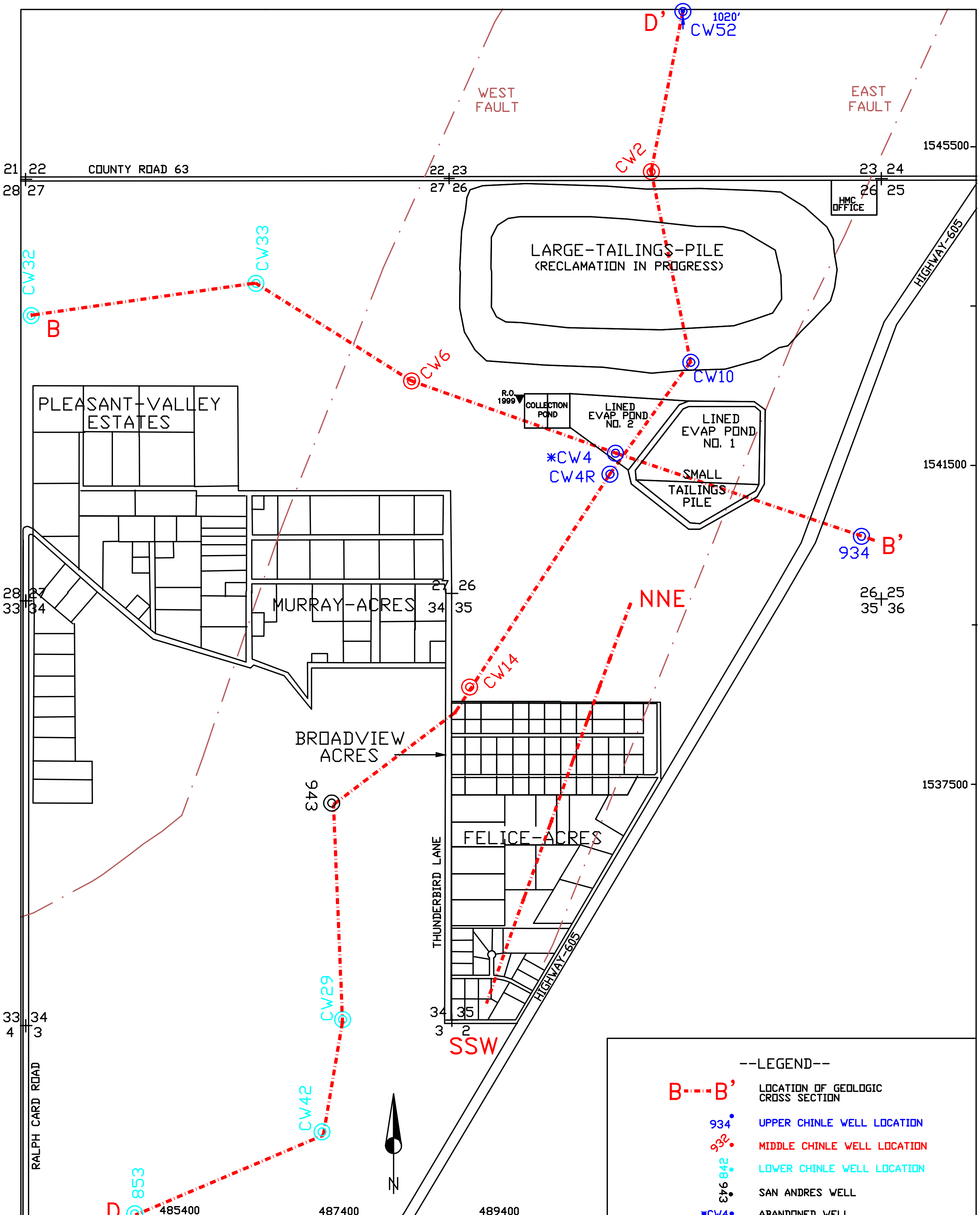
DATE: 03/28/08

HOMESTAKE MILL AND ADJACENT PROPERTIES

GRANTS, NM TOWNSHIP-11&12-N-RANGE-10-W

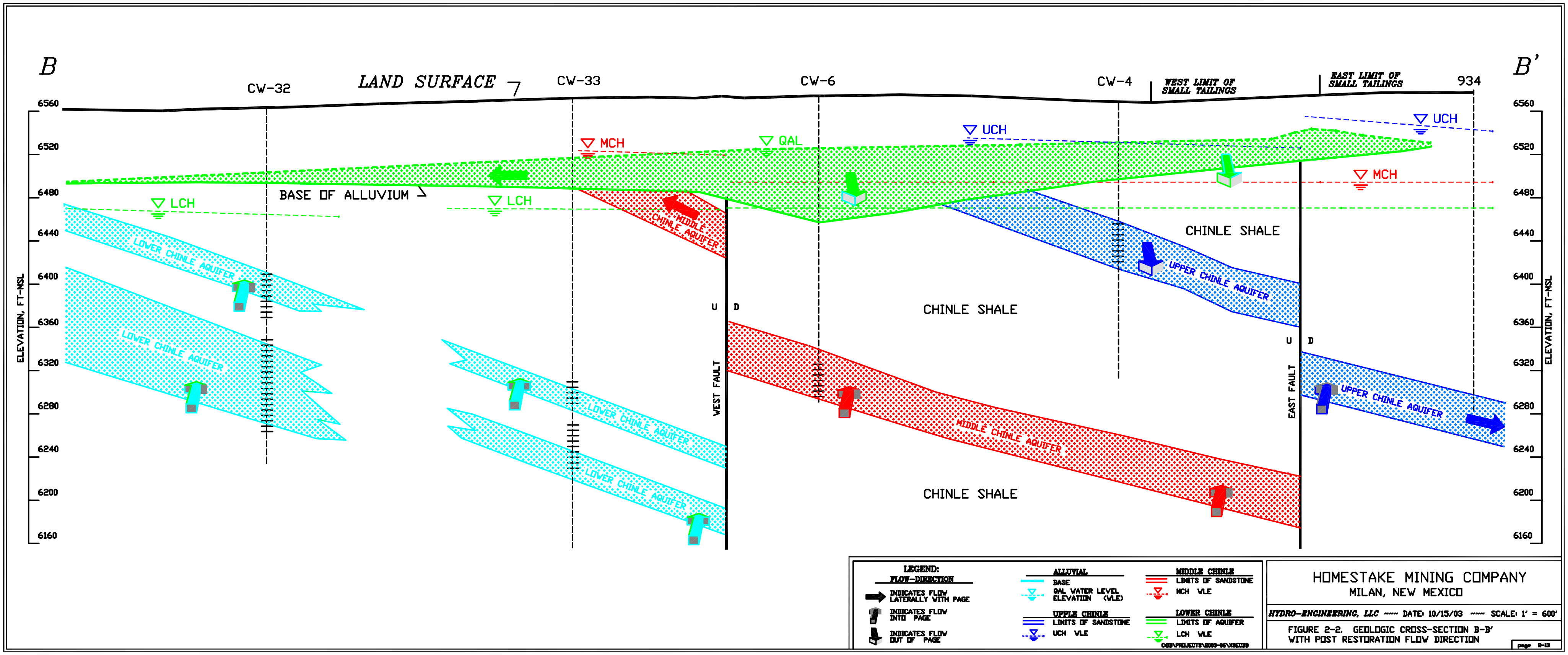
FIGURE 4.2-1. WATER-LEVEL ELEVATIONS OF THE ALLUVIAL AQUIFER, FALL 2007, FT-MSL

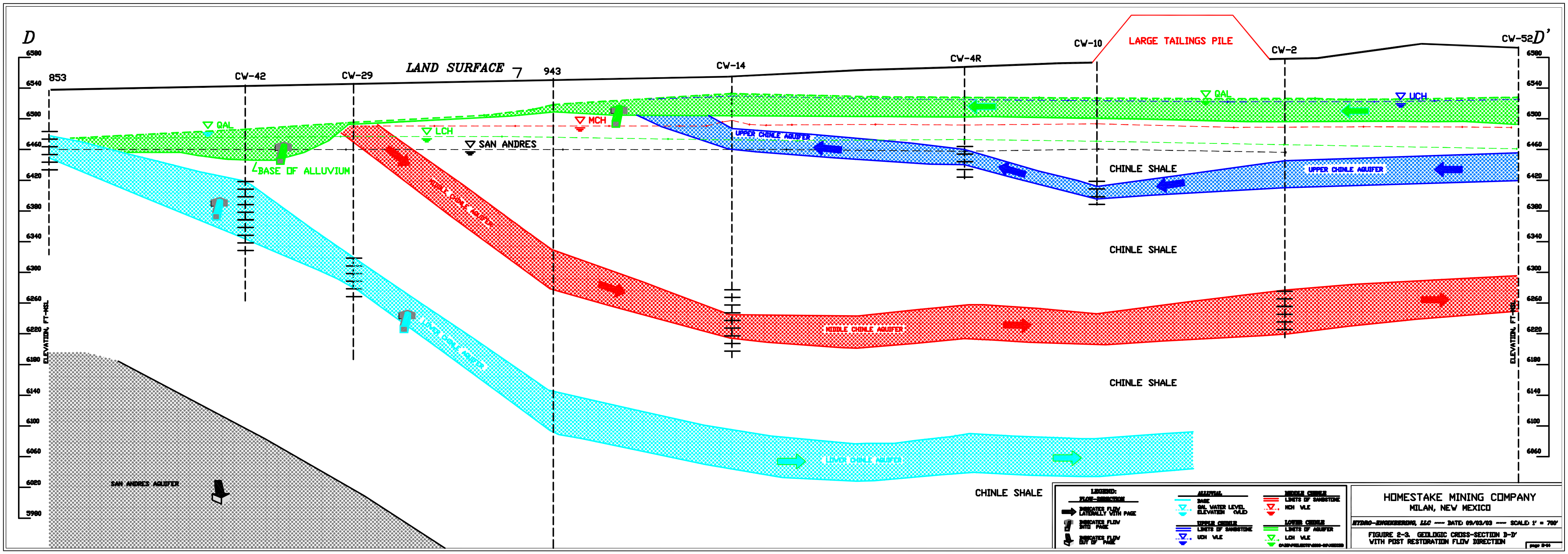


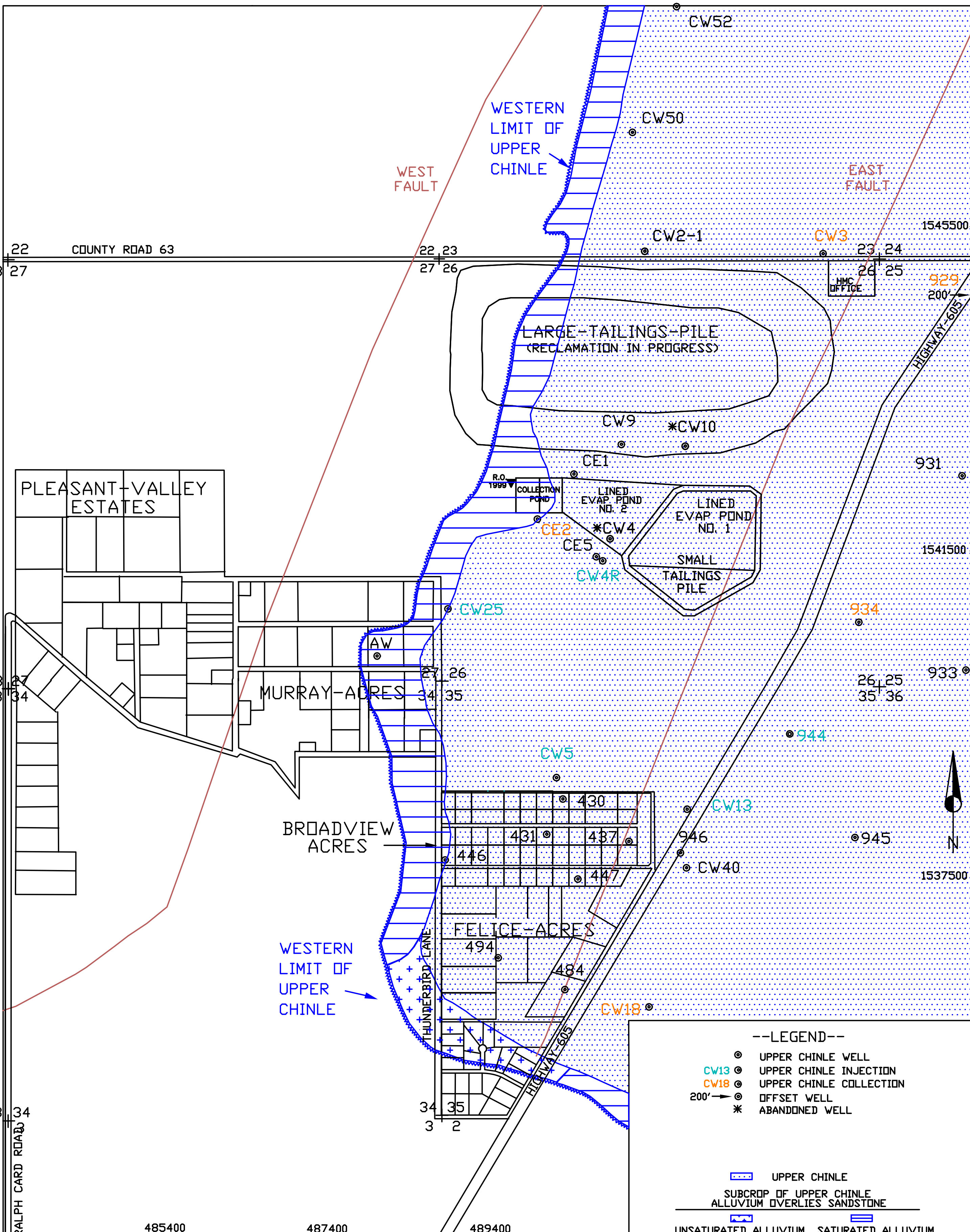
SCALE: 1"=1600' | HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W | DATE: 10/13/03

FIGURE 2-1. LOCATIONS OF GEOLOGIC CROSS SECTIONS

c:\dd\projects\2003-06\geoxsect


B
B'
LAND SURFACE
CW-32
CW-33
CW-6
CW-4
WEST LIMIT OF SMALL TAILINGS
EAST LIMIT OF SMALL TAILINGS
934
ELEVATION, FT-MSL
6560
6520
6480
6440
6400
6360
6320
6280
6240
6200
6160
MCH
QAL
UCH
LCH
BASE OF ALLUVIUM
LOWER CHINLE AQUIFER
MIDDLE CHINLE AQUIFER
UPPER CHINLE AQUIFER
CHINLE SHALE
U D
WEST FAULT
EAST FAULT
LEGEND:
FLOW-DIRECTION
INDICATES FLOW LATERALLY WITH PAGE
INDICATES FLOW INTO PAGE
INDICATES FLOW OUT OF PAGE
ALLUVIAL
BASE
QAL WATER LEVEL ELEVATION (WLE)
UPPLE CHINLE
LIMITS OF SANDSTONE
UCH WLE
MIDDLE CHINLE
LIMITS OF SANDSTONE
MCH WLE
LOWER CHINLE
LIMITS OF AQUIFER
LCH WLE
C:\00\PROJECTS\2003-06\XSEC3B
HOMESTAKE MINING COMPANY
MILAN, NEW MEXICO
HYDRO-ENGINEERING, LLC ~~~ DATE: 10/15/03 ~~~ SCALE: 1' = 600'
FIGURE 2-2. GEOLOGIC CROSS-SECTION B-B' WITH POST RESTORATION FLOW DIRECTION
page 2-13

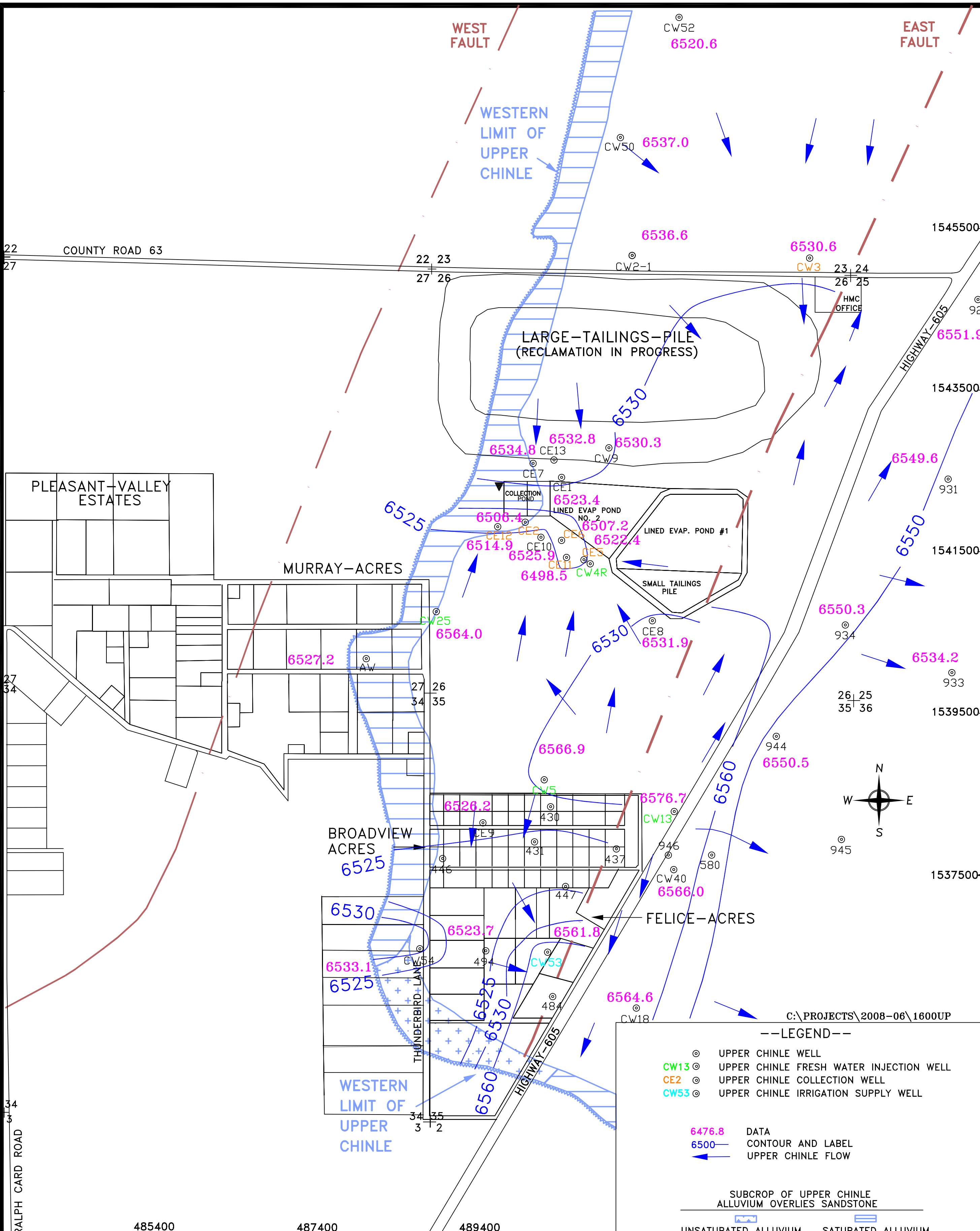

D
D'
853
CW-42
CW-29
LAND SURFACE
943
CW-14
CW-4R
CW-10
LARGE TAILINGS PILE
CW-2
CW-52
QAL
UCH
MCH
LCH
SAN ANDRES
BASE OF ALLUVIUM
UPPER CHINLE AQUIFER
CHINLE SHALE
MIDDLE CHINLE AQUIFER
LOWER CHINLE AQUIFER
SAN ANDRES AQUIFER
ELEVATION, FT-MSL
6580
6540
6500
6460
6420
6380
6340
6300
6260
6220
6180
6140
6100
6060
6020
5980
LEGEND:
FLOW-DIRECTION
INDICATES FLOW LATERALLY WITH PAGE
INDICATES FLOW INTO PAGE
INDICATES FLOW OUT OF PAGE
ALLUVIAL
BASE
QAL WATER LEVEL ELEVATION (VLE)
UPPER CHINLE
LIMITS OF SANDSTONE
UCH VLE
MIDDLE CHINLE
LIMITS OF SANDSTONE
MCH VLE
LOWER CHINLE
LIMITS OF AQUIFER
LCH VLE
HOMESTAKE MINING COMPANY
MILAN, NEW MEXICO
HYDRO-ENGINEERING, LLC ---- DATE: 09/03/03 ---- SCALE: 1' = 700'
FIGURE 2-3. GEOLOGIC CROSS-SECTION D-D' WITH POST RESTORATION FLOW DIRECTION



SCALE: 1"=1600' | HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W | DATE: 10/04/03

FIGURE 2-6. AREAL EXTENT OF THE UPPER CHINLE AQUIFER AND WELL LOCATIONS

c:\dd\projects\2003-06\UP1600

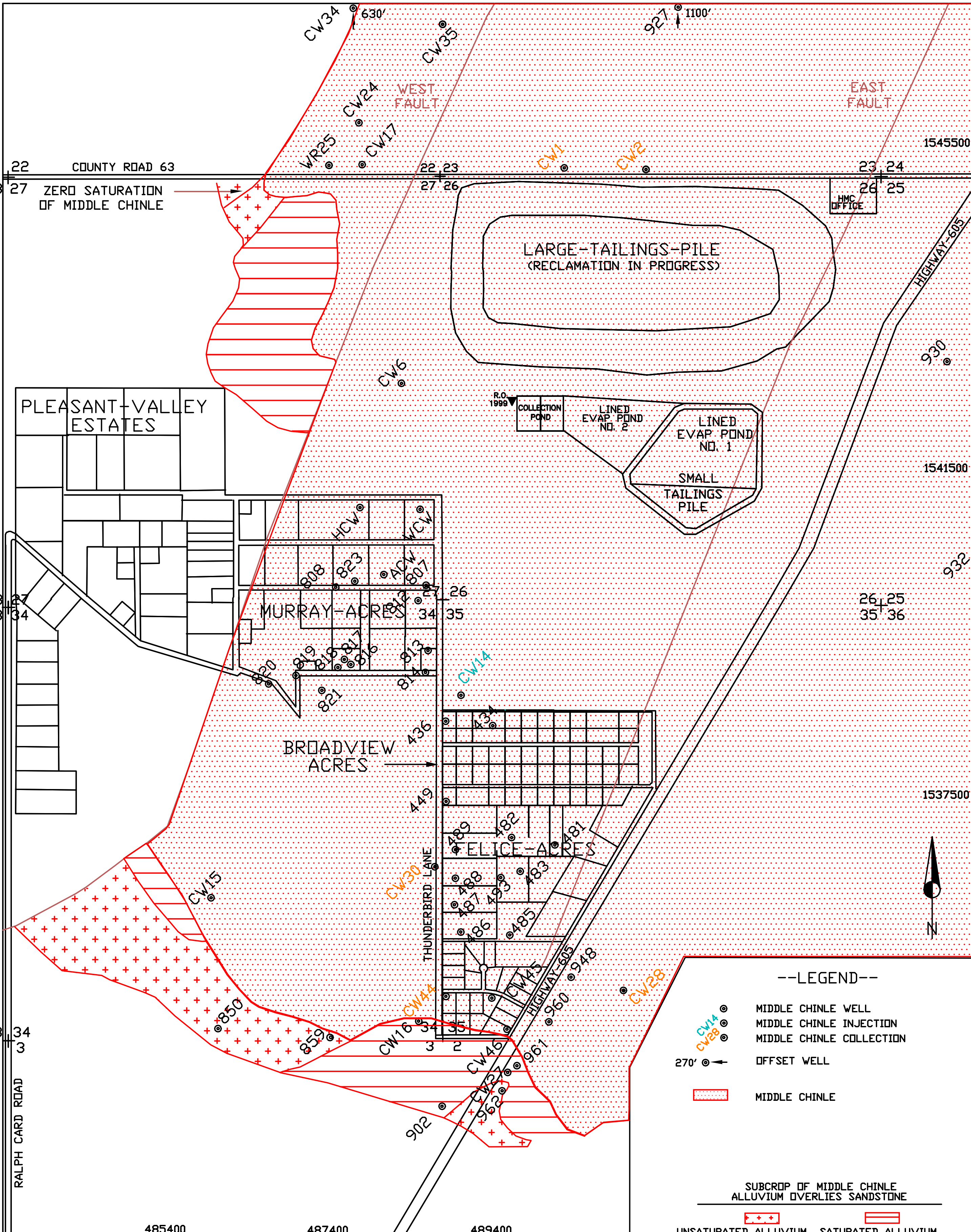


HOMESTAKE MILL AND ADJACENT PROPERTIES ~ GRANTS, NM ~ TOWNSHIP-11&12N, RANGE-10W

DATE: 03/05/08

FIGURE 5.2-1. WATER-LEVEL ELEVATIONS OF THE UPPER CHINLE AQUIFER, FALL 2007, FT-MSL

SCALE: 1"=1600'



SCALE: 1"=1600' | HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W | DATE: 10/17/03

FIGURE 2-8. AREAL EXTENT OF THE MIDDLE CHINLE AQUIFER AND WELL LOCATIONS

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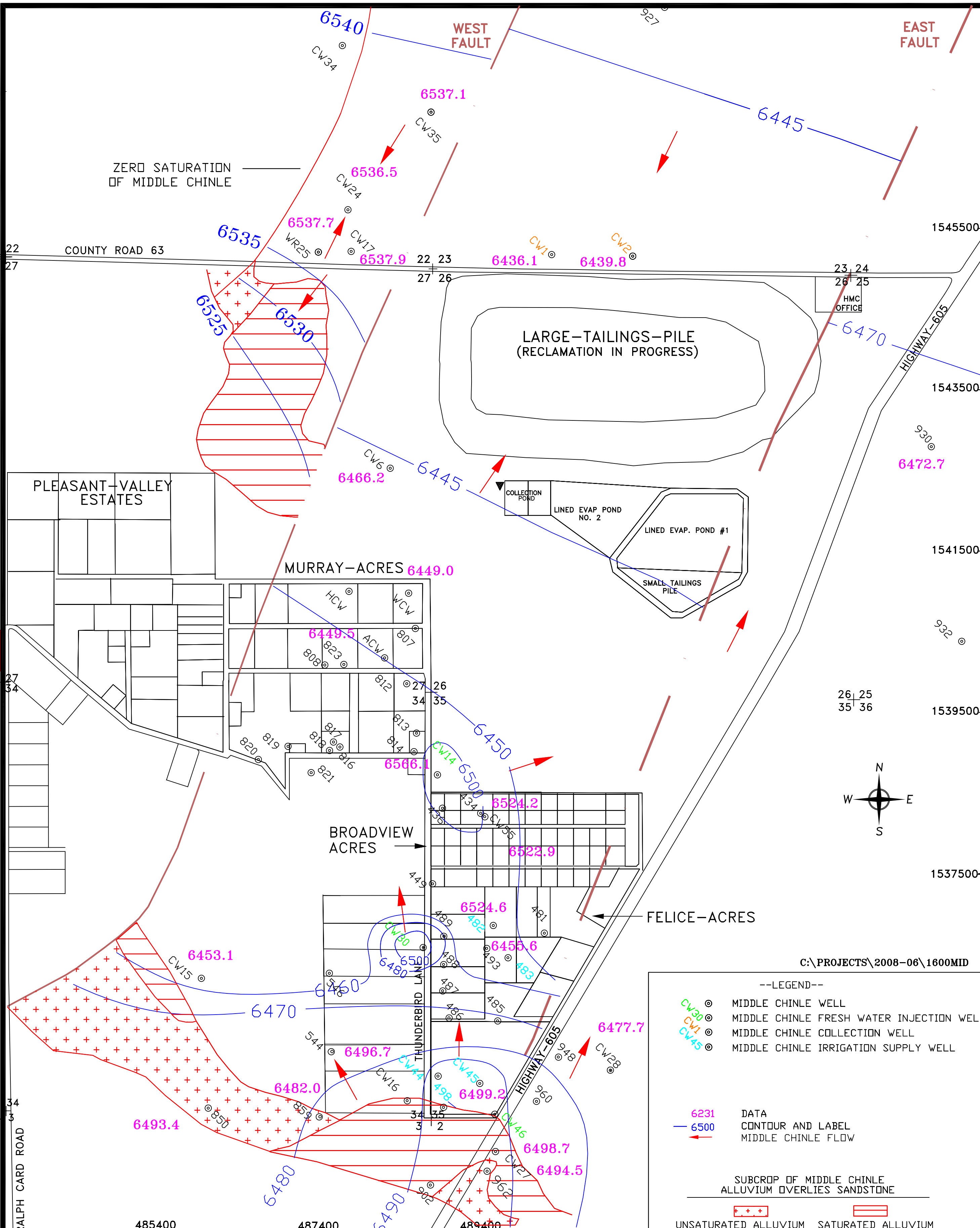


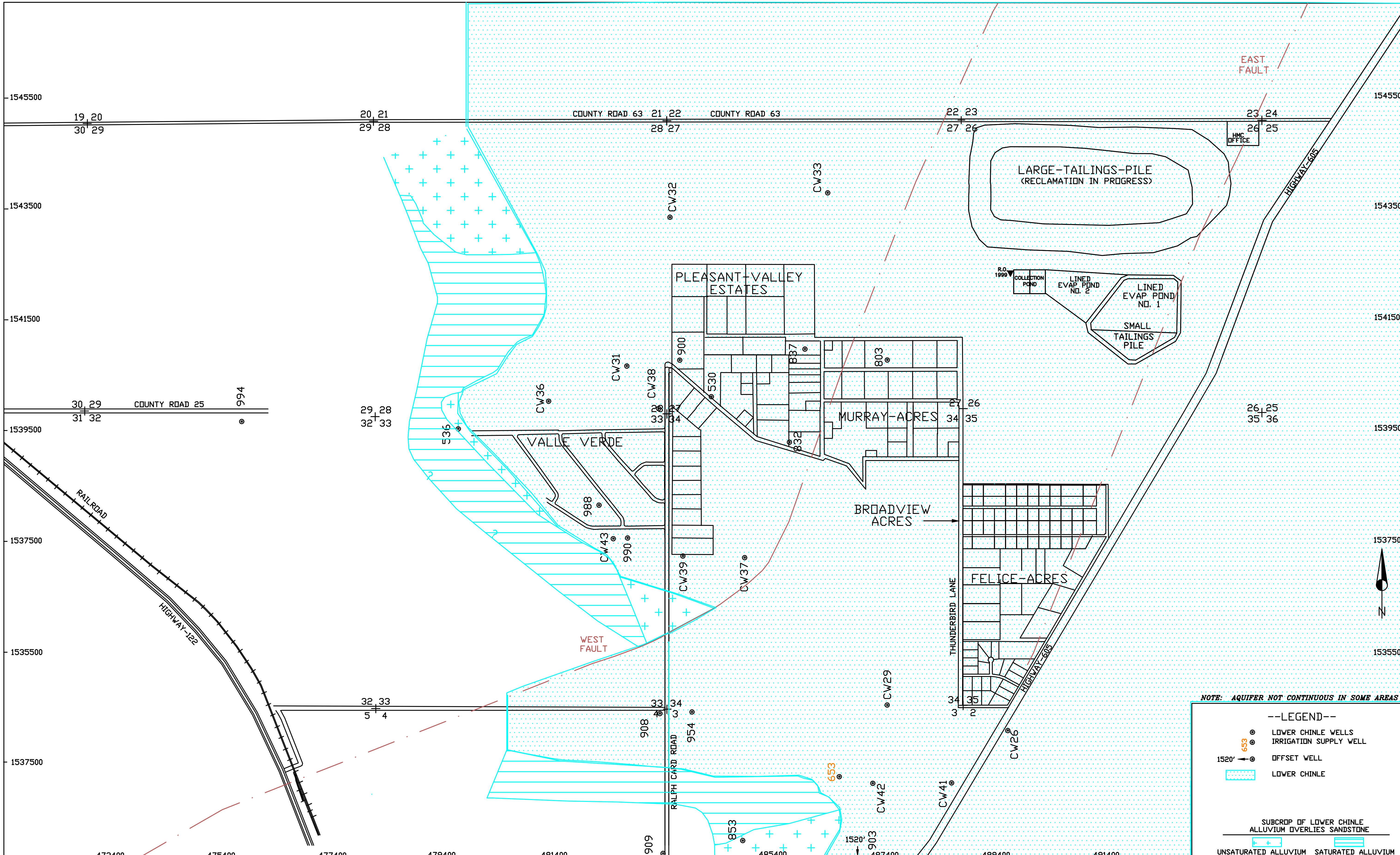
HOMESTAKE MILL AND ADJACENT PROPERTIES ~ GRANTS, NM ~ TOWNSHIP-11&12N, RANGE-10W

DATE: 03/05/08

FIGURE 6.2-1. WATER-LEVEL ELEVATIONS OF THE MIDDLE CHINLE AQUIFER, FALL 2007, FT-MSL

SCALE: 1"=1600'

PAGE: 6.2-3



SCALE: 1"=1600'

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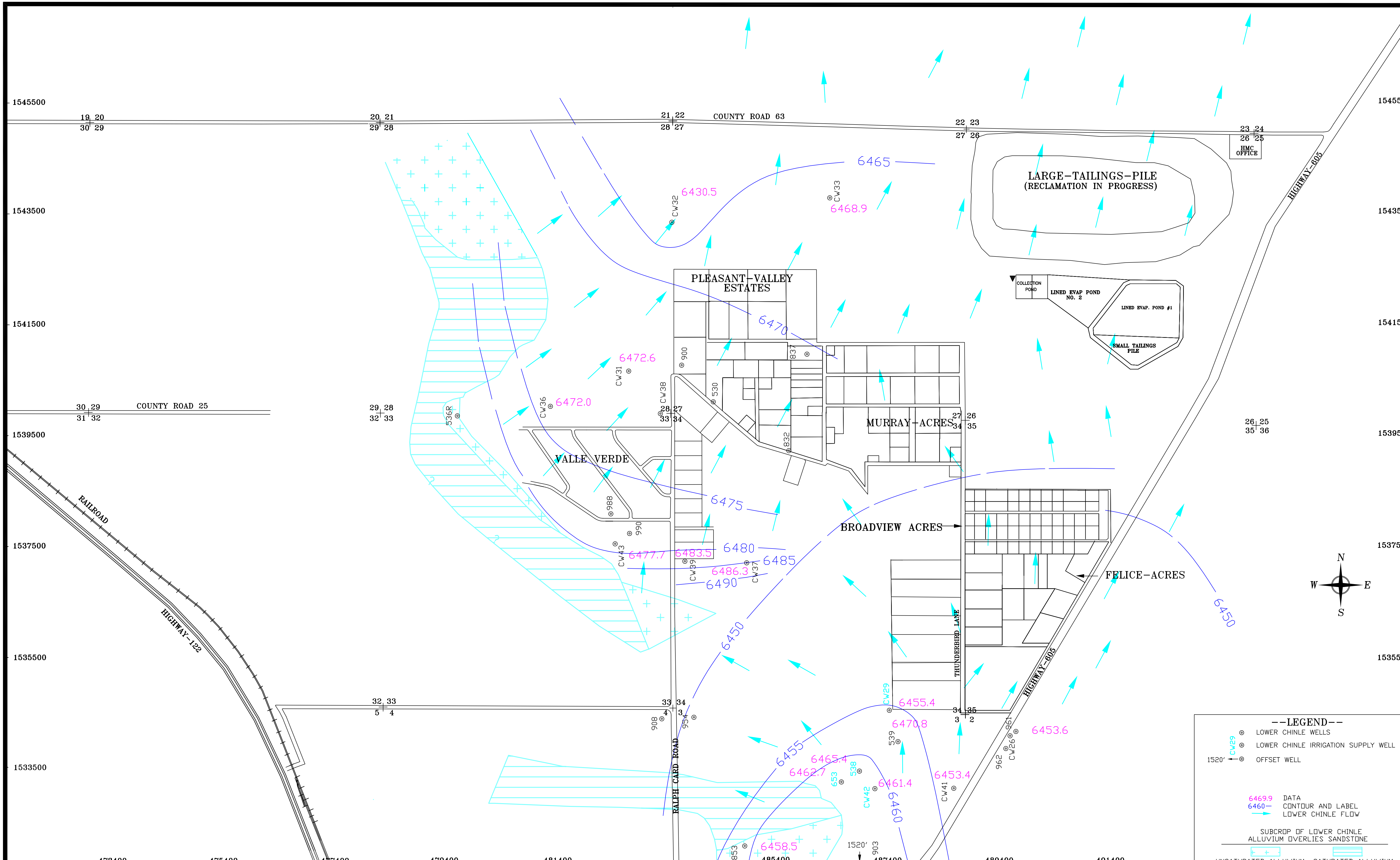
DATE: 10/16/03

HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 2-10. AREAL EXTENT OF THE LOWER CHINLE AQUIFER AND WELL LOCATIONS



SCALE: 1"= 1600"
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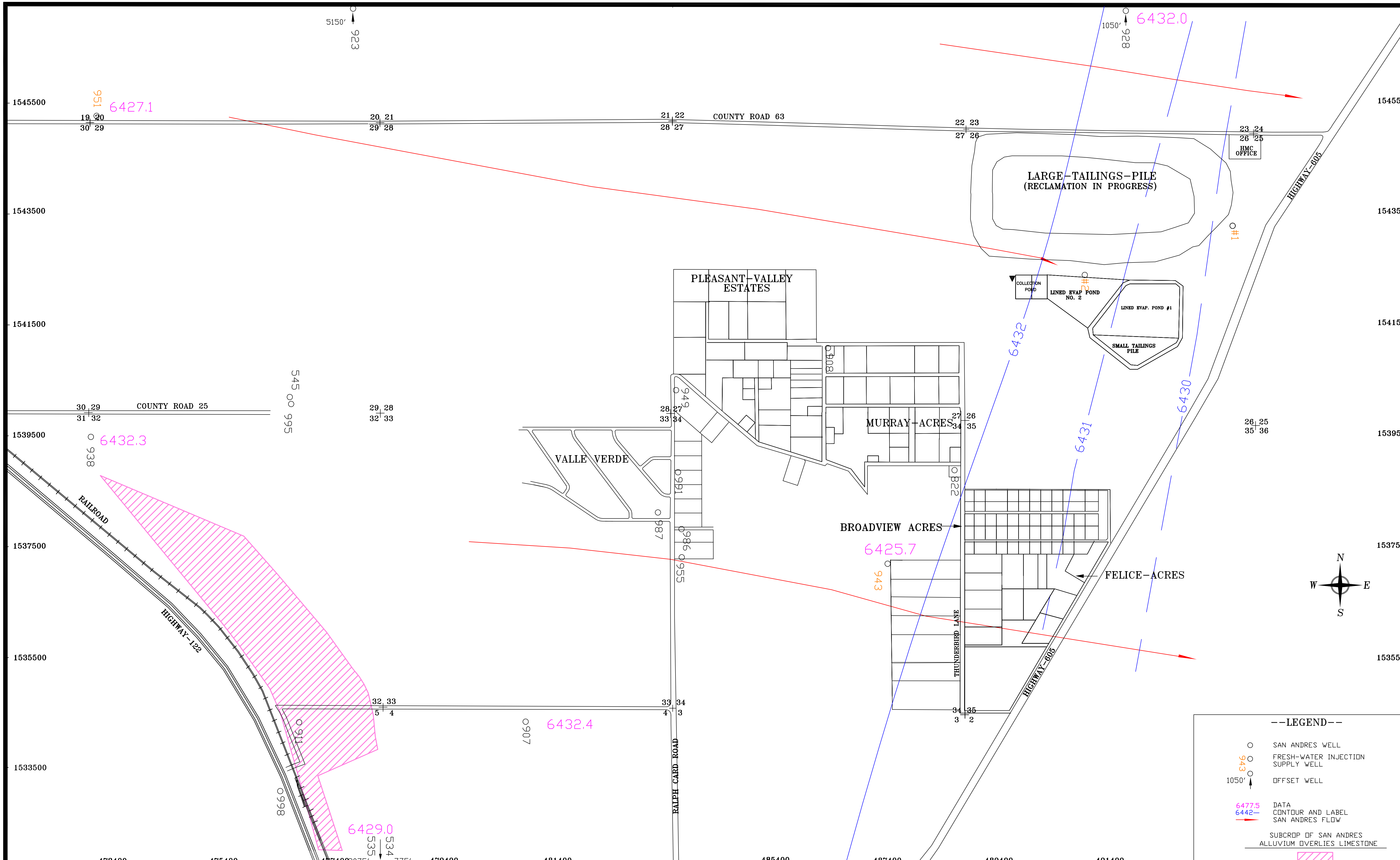
2008-06\1600LOW
03/28/08

HOMESTAKE MILL AND ADJACENT PROPERTIES

GRANTS, NM TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 7.2-1. WATER-LEVEL ELEVATIONS OF THE LOWER CHINLE AQUIFER, FALL 2007, FT-MSL



SCALE: 1"= 1600"

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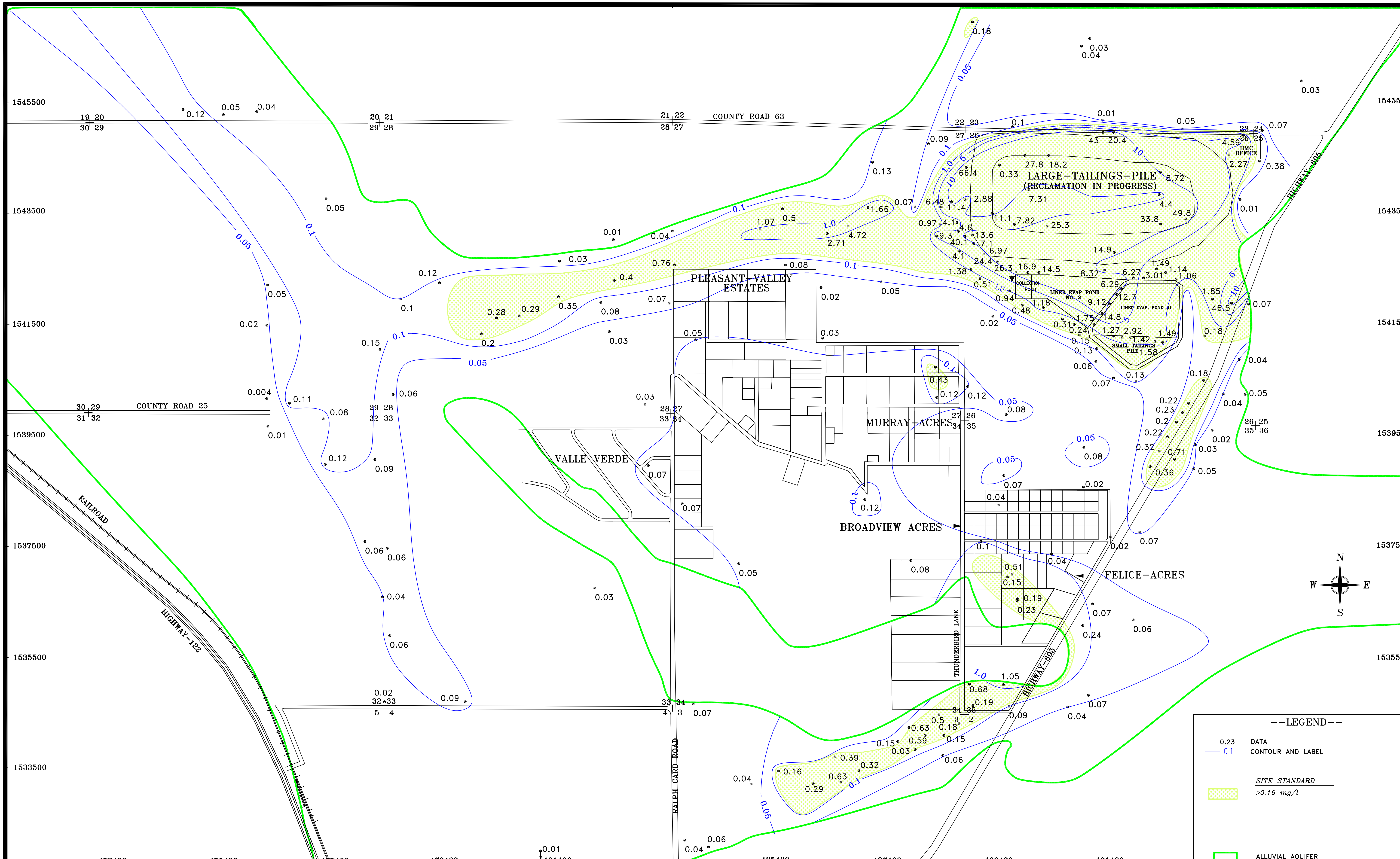
2008-06\1600SAN

DATE: 03/27/08

HOMESTAKE MILL AND ADJACENT PROPERTIES

GRANTS, NM TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 8.0-1. LOCATION OF SAN ANDRES WELLS AND WATER-LEVEL ELEVATION FOR THE SAN ANDRES AQUIFER, 2007, FT-MSL



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DATE: 03/28/08

HOMESTAKE MILL AND ADJACENT PROPERTIES

GRANTS, NM TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 4.3-53. URANIUM CONCENTRATIONS OF THE ALLUVIAL AQUIFER, 2007 mg/l

HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 36
URANIUM CONCENTRATIONS FOR THE ALLUVIAL AQUIFER, FOR 1998 & 2005, MG/L

E:\180899\CLIENT\2006-SEPT\gal98-05-FIG.dwg Nov 07, 2006 - 9:49am

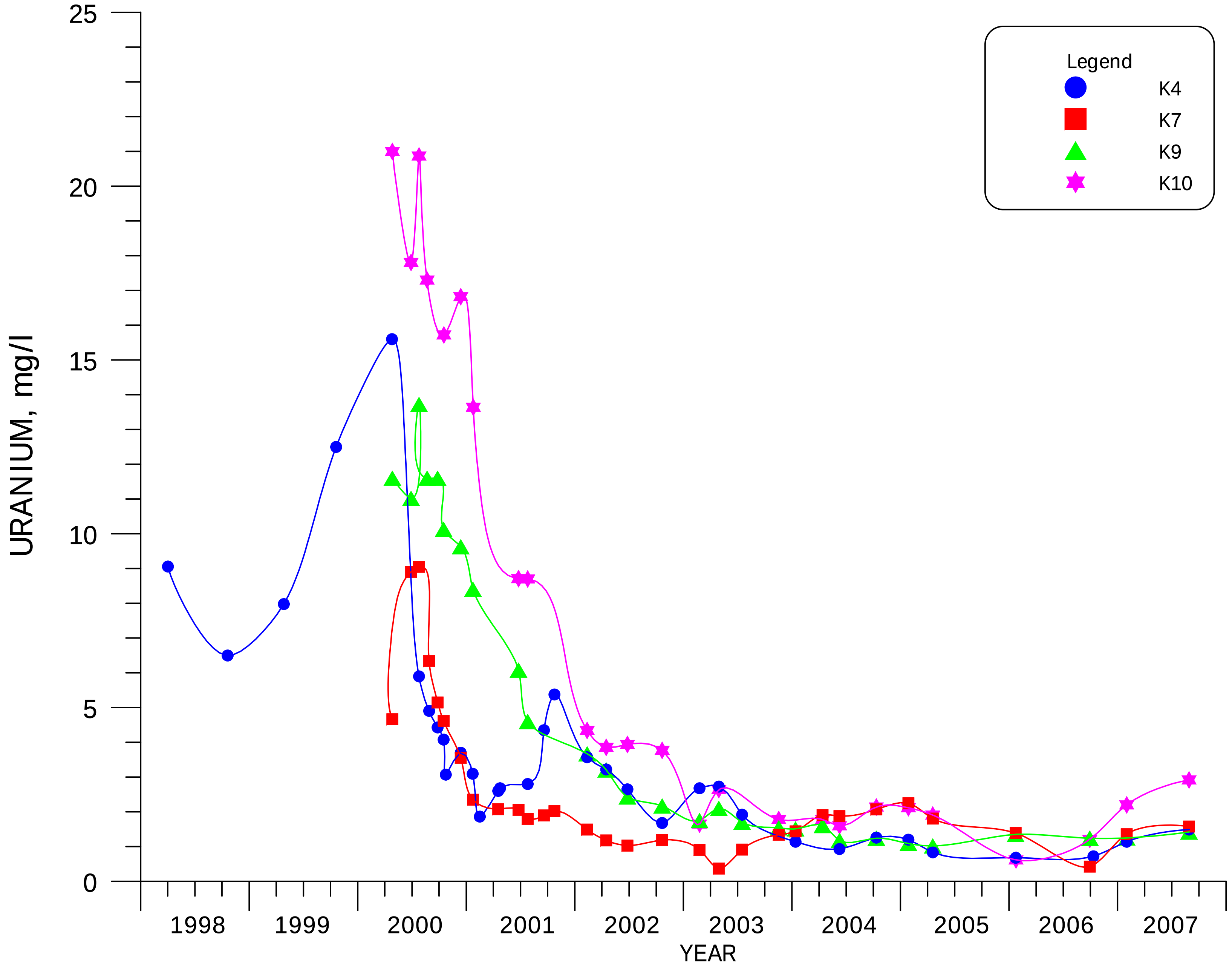


FIGURE 4.3-61. URANIUM CONCENTRATIONS FOR WELLS K4, K7, K9 AND K10.

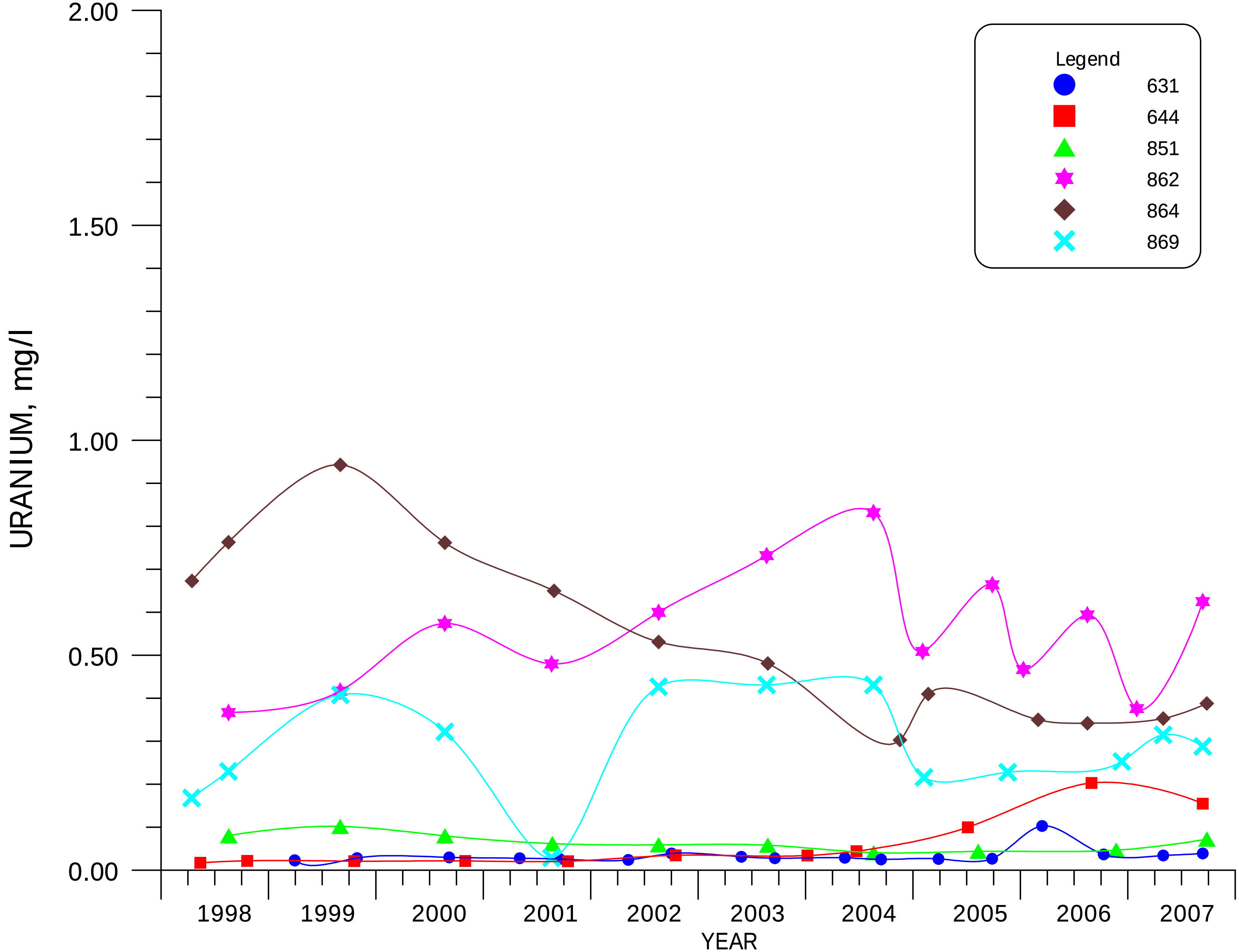
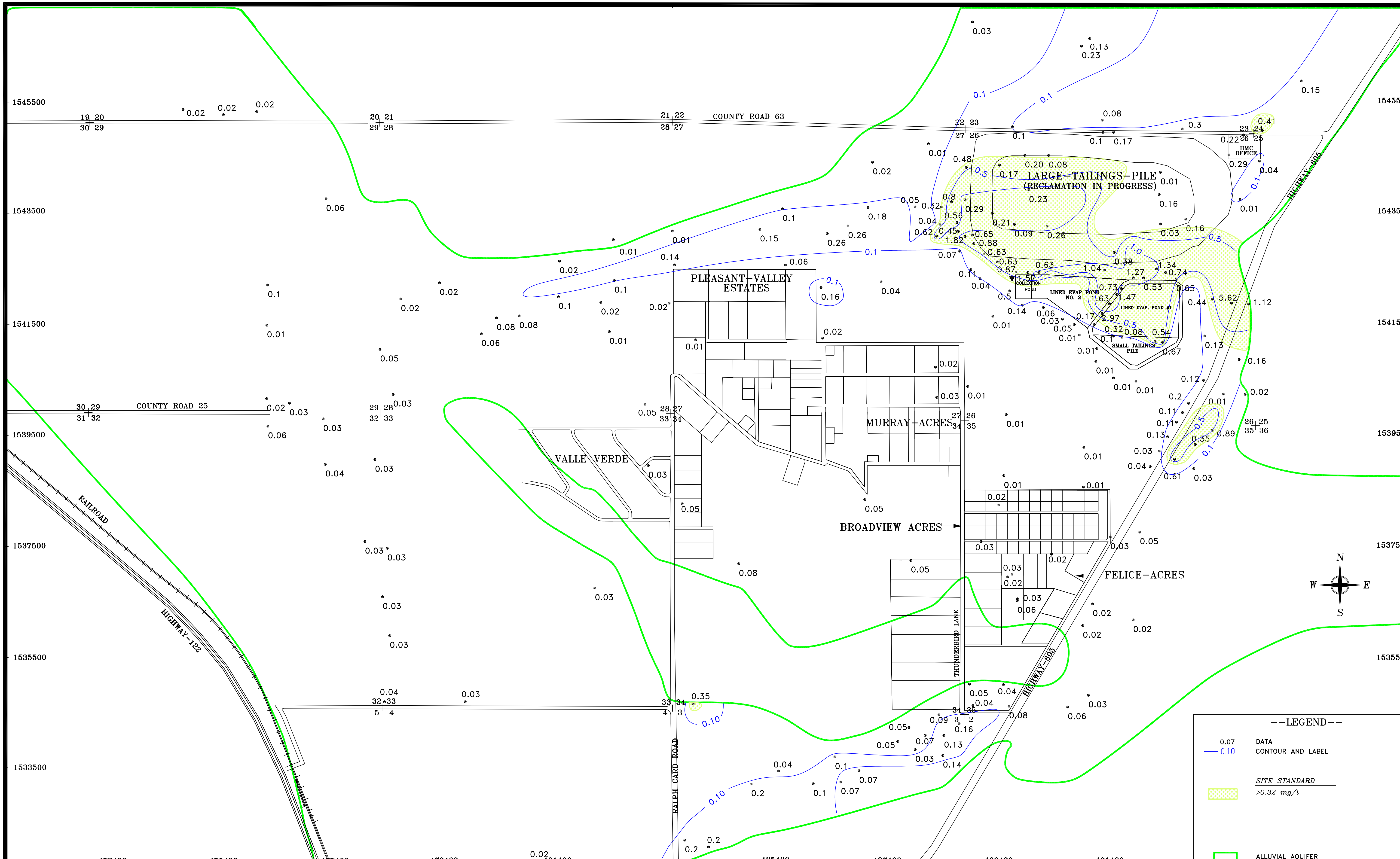


FIGURE 4.3-66. URANIUM CONCENTRATIONS FOR WELLS 631, 644, 851, 862, 864 AND 869.



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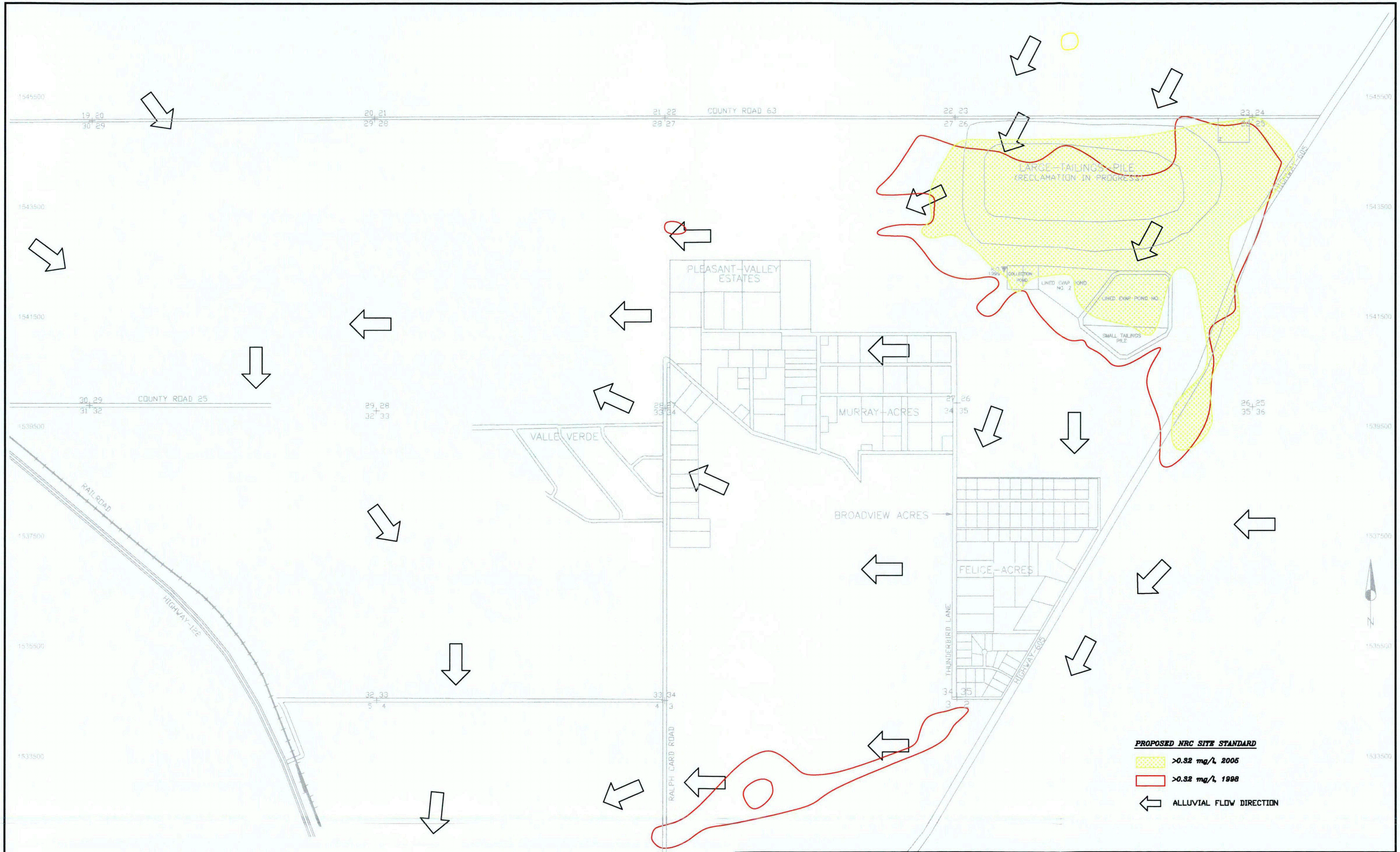
2008-06\1600QAL lgrh
DATE: 03/28/08

HOMESTAKE MILL AND ADJACENT PROPERTIES

GRANTS, NM TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 4.3-70. SELENIUM CONCENTRATIONS OF THE ALLUVIAL AQUIFER, 2007 mg/l



HOMESTAKE MILL AND ADJACENT PROPERTIES
GRANTS NM TOWNSHIP 11&12 N RANGE 10 W

FIGURE 37
SELENIUM CONCENTRATIONS FOR THE ALLUVIAL AQUIFER, FOR 1998 & 2005, MG/L

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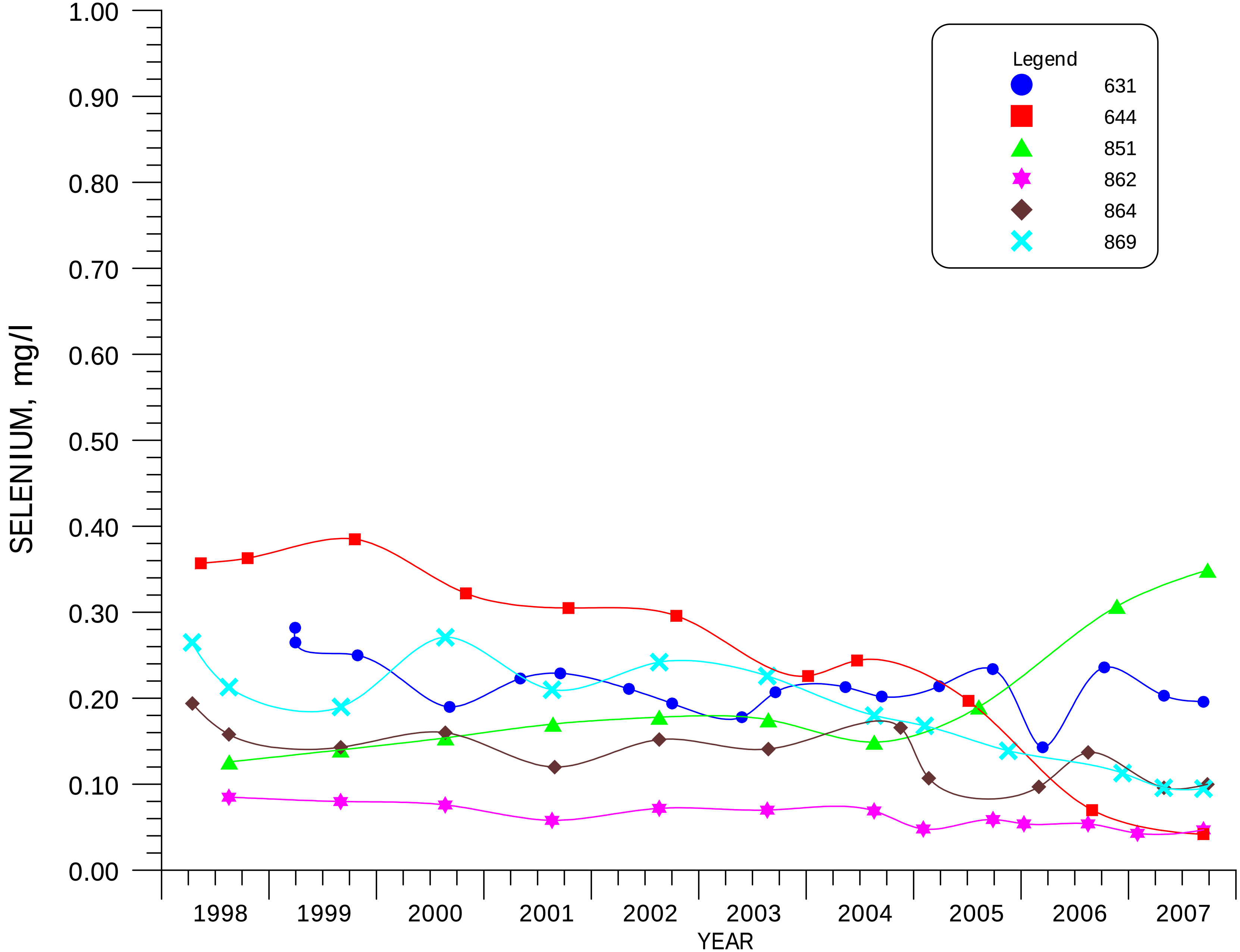


FIGURE 4.3-83. SELENIUM CONCENTRATIONS FOR WELLS 631, 644, 851, 862, 864 AND 869.

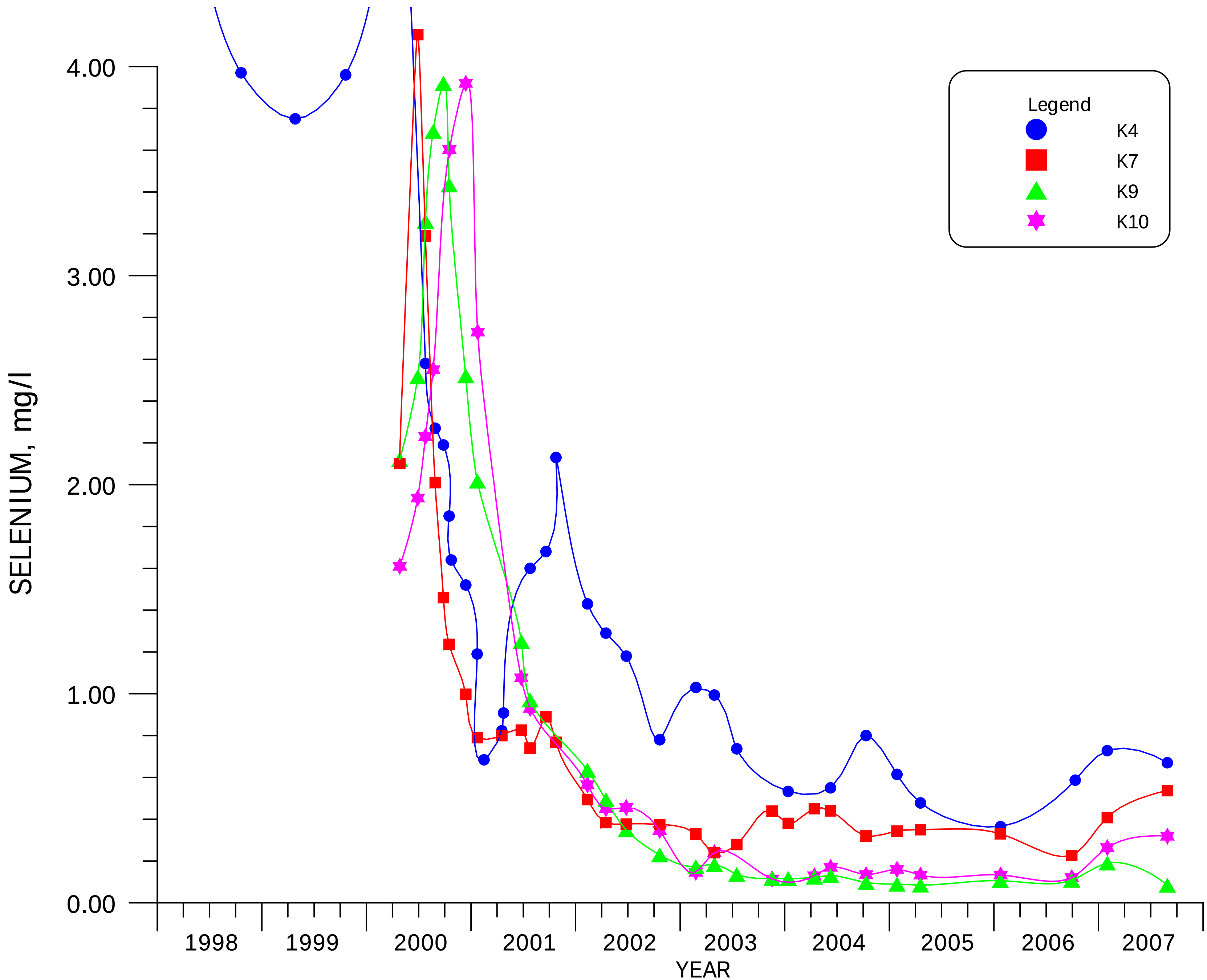
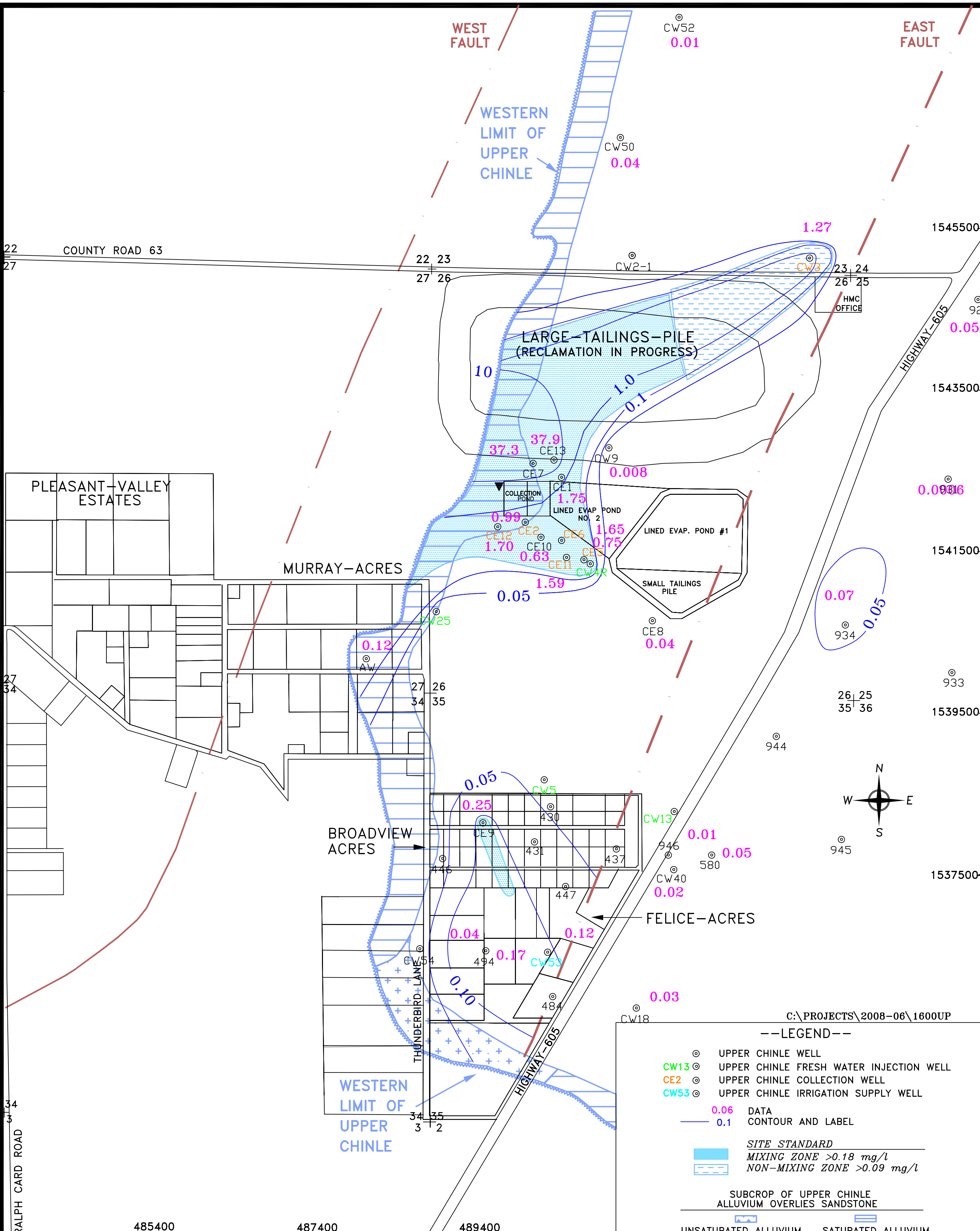


FIGURE 4.3-78. SELENIUM CONCENTRATIONS FOR WELLS K4, K7, K9 AND K10.



HOMESTAKE MILL AND ADJACENT PROPERTIES ~ GRANTS, NM ~ TOWNSHIP-11&12N, RANGE-10W

FIGURE 5.3-11. URANIUM CONCENTRATIONS OF THE UPPER CHINLE AQUIFER, 2007, mg/l

DATE: 03/05/08

SCALE: 1"=1600'

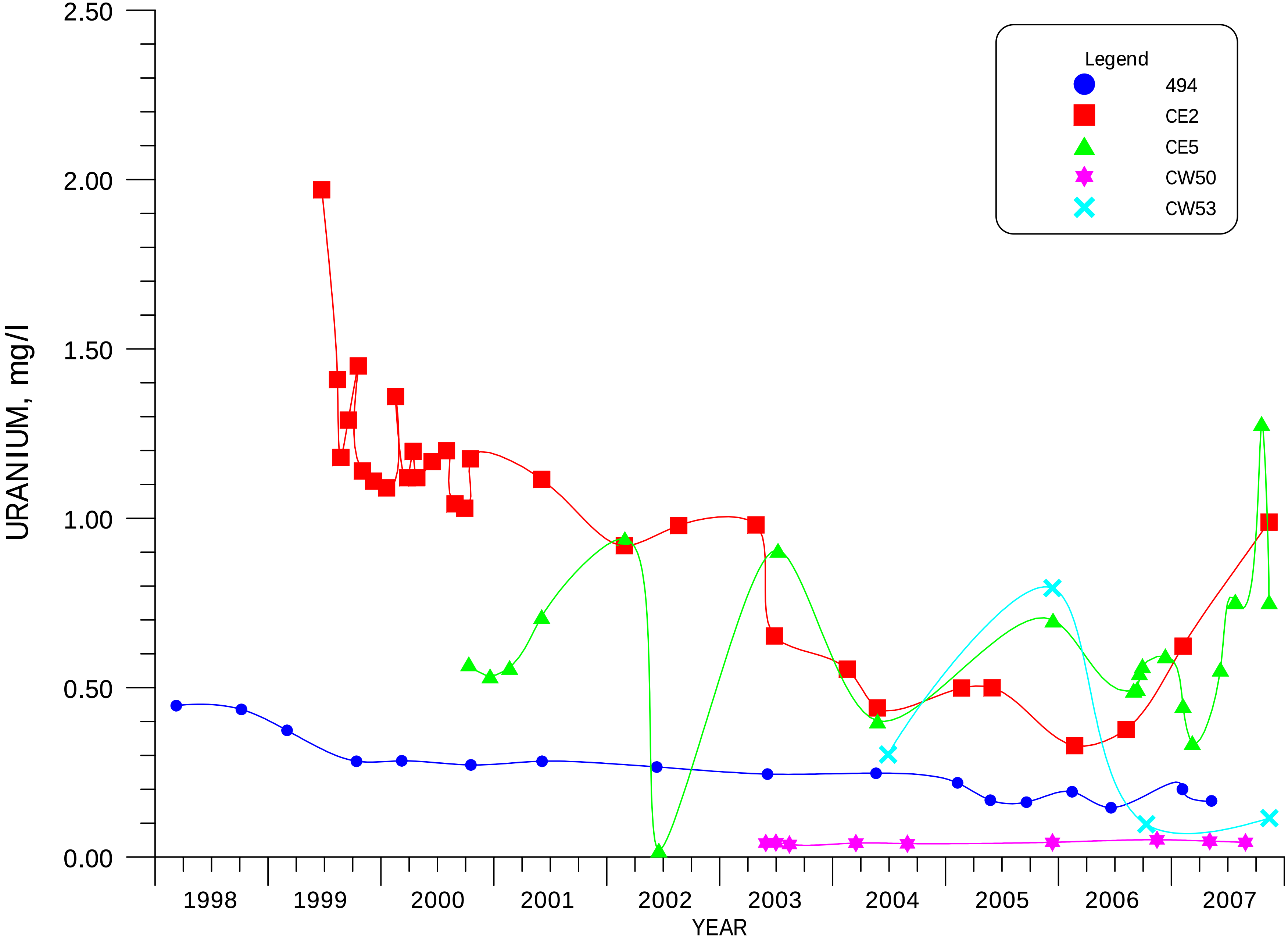


FIGURE 5.3-12. URANIUM CONCENTRATIONS FOR MIXING ZONE WELLS 494, CE2, CE5, CW50 AND CW53.

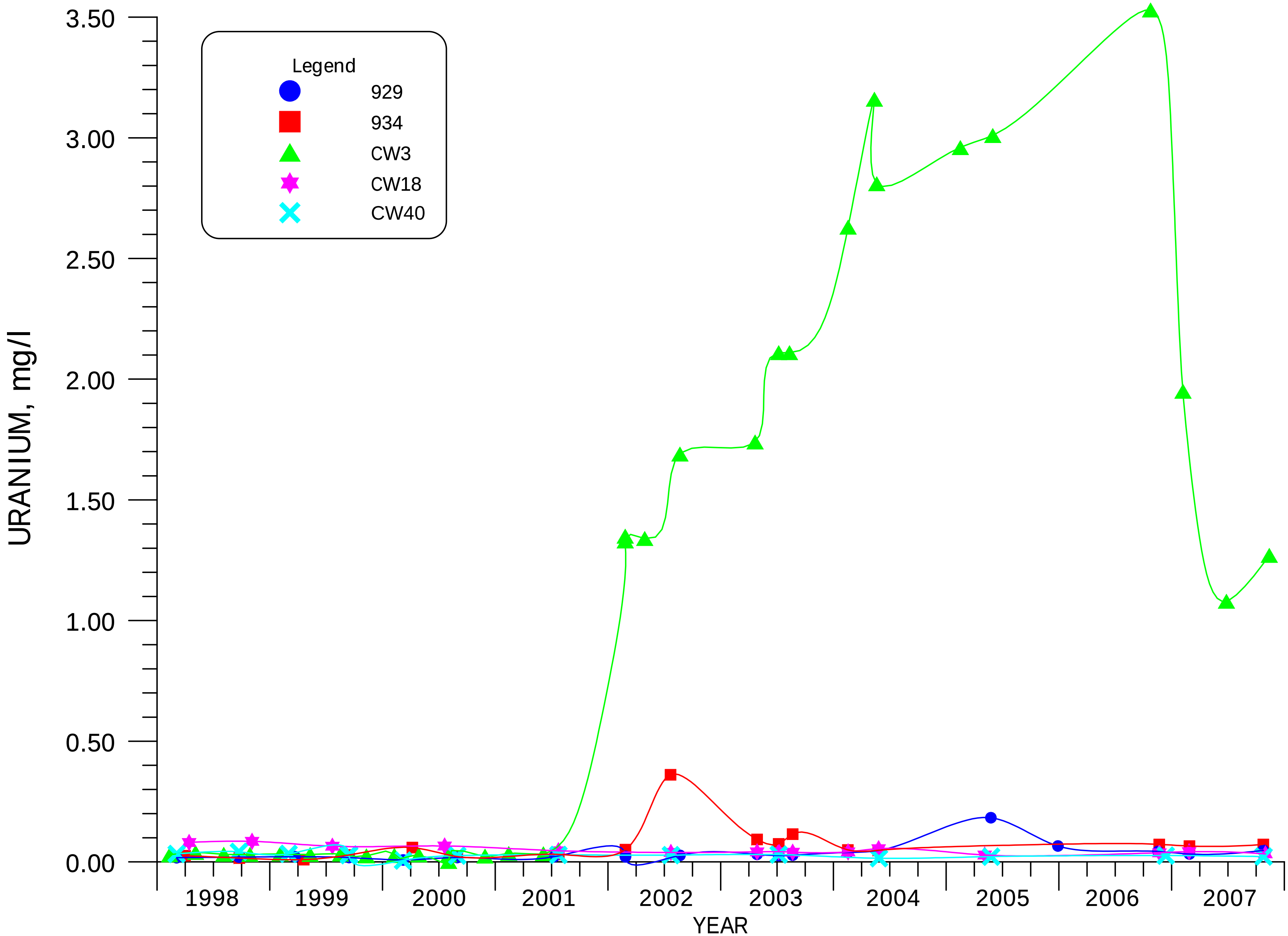
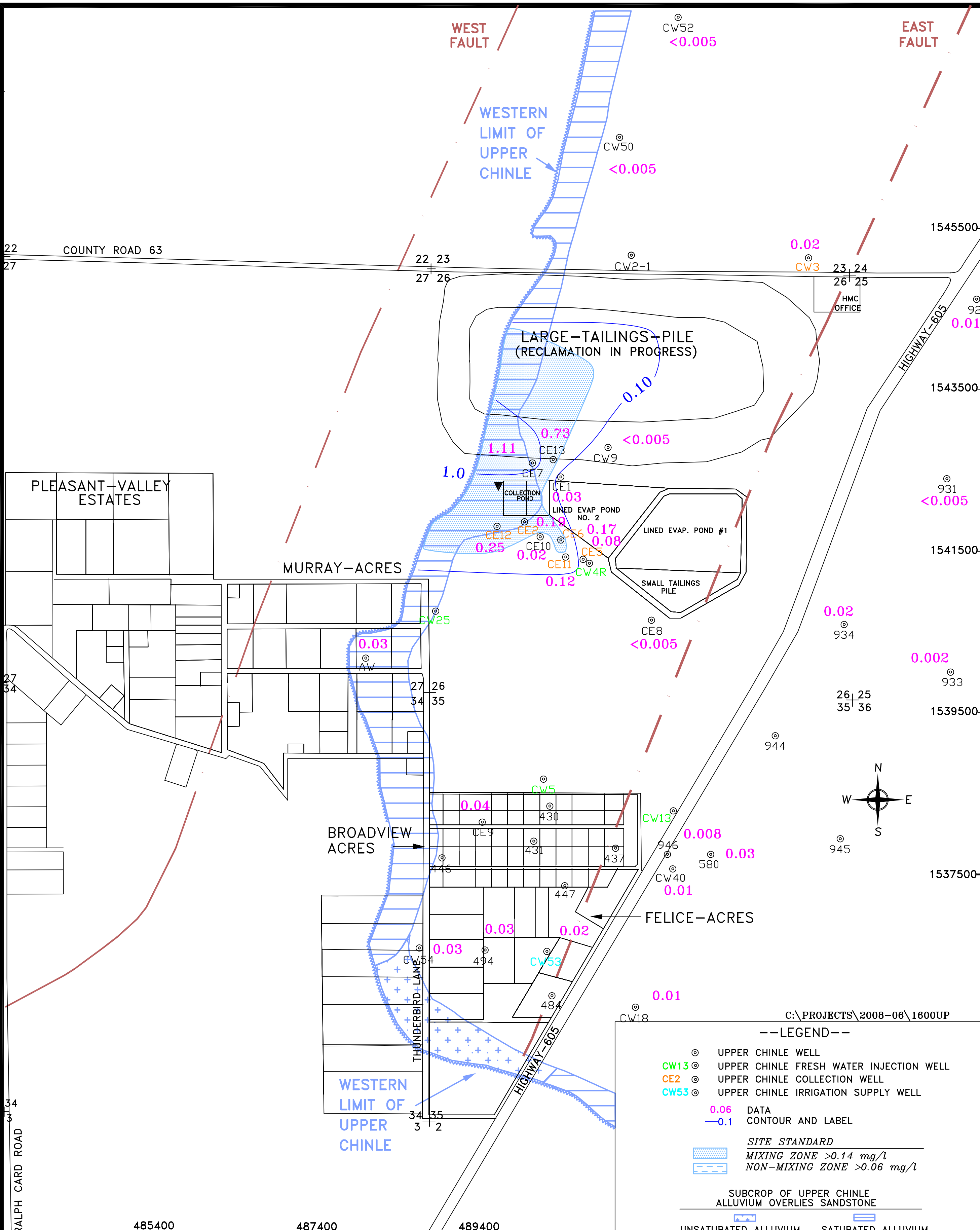


FIGURE 5.3-13. URANIUM CONCENTRATIONS FOR NON-MIXING ZONE WELLS 929, 934, CW3, CW18 AND CW40.



HOMESTAKE MILL AND ADJACENT PROPERTIES ~ GRANTS, NM ~ TOWNSHIP-11&12N, RANGE-10W

FIGURE 5.3-14. SELENIUM CONCENTRATIONS OF THE UPPER CHINLE AQUIFER, 2007, mg/l

DATE: 03/05/08

SCALE: 1"=1600'

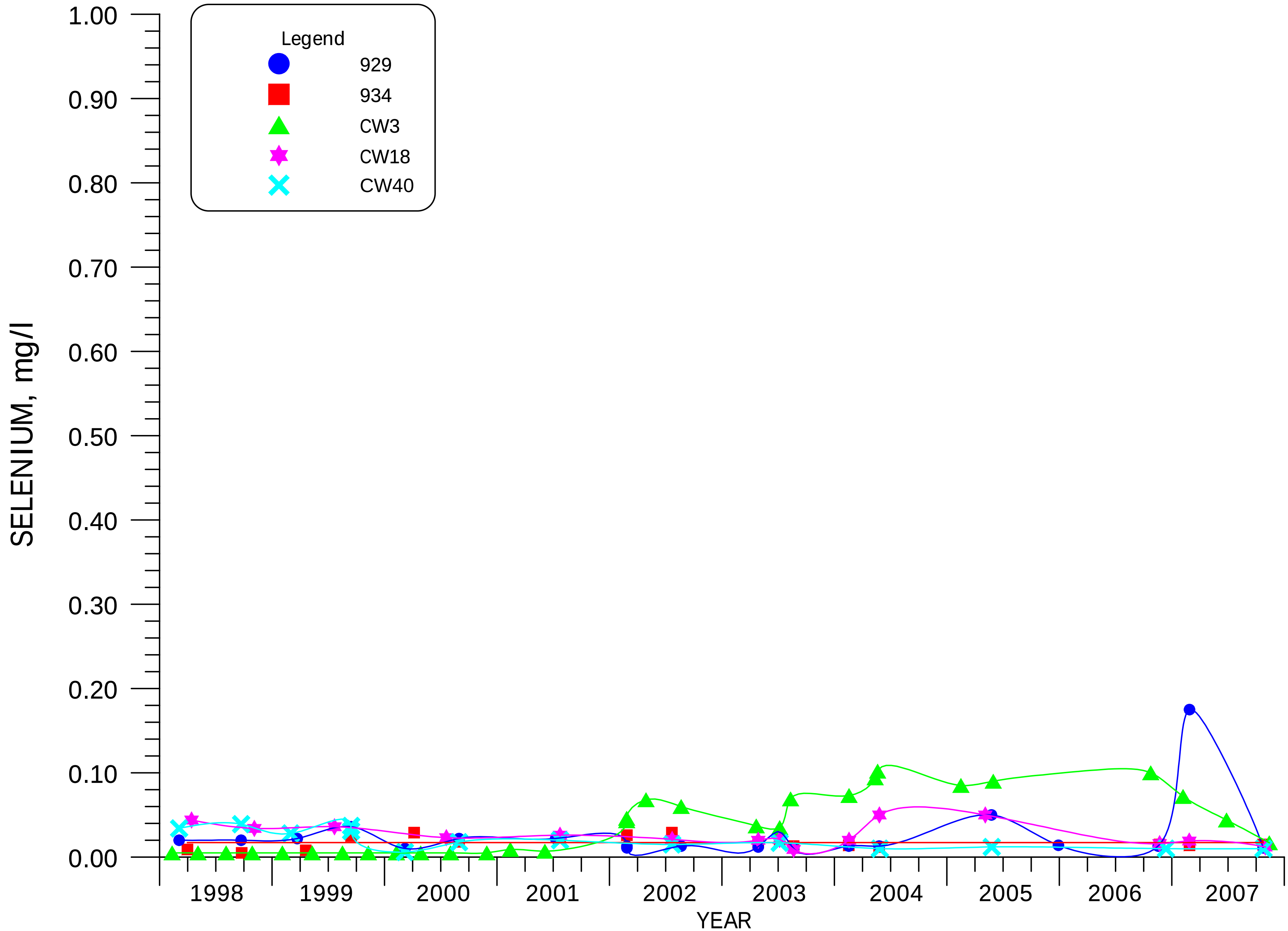
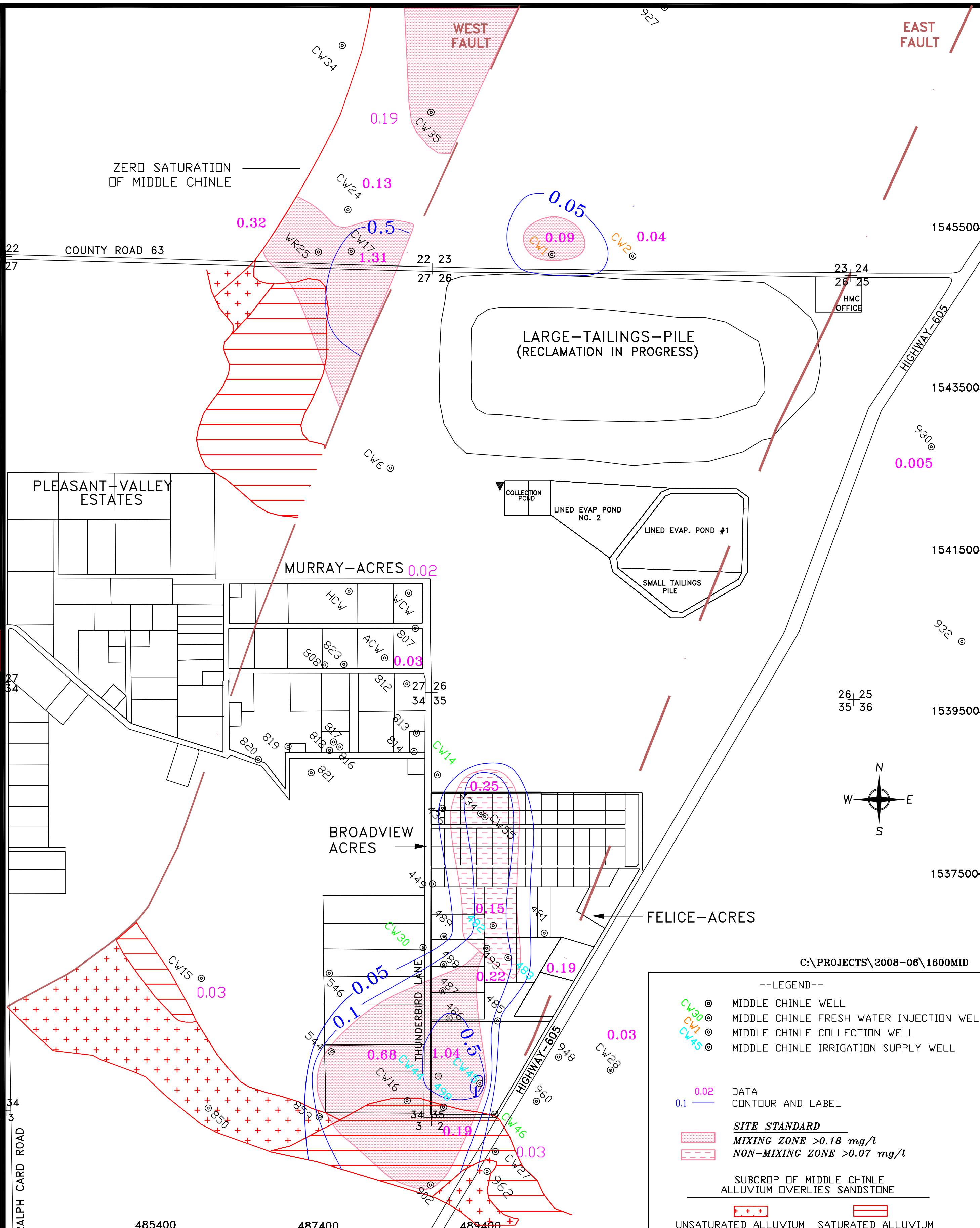


FIGURE 5.3-16. SELENIUM CONCENTRATIONS FOR NON-MIXING ZONE WELLS 929, 934, CW3, CW18 AND CW40.



HOMESTAKE MILL AND ADJACENT PROPERTIES ~ GRANTS, NM ~ TOWNSHIP-11&12N, RANGE-10W

DATE: 03/05/08

FIGURE 6.3-11. URANIUM CONCENTRATIONS OF THE MIDDLE CHINLE AQUIFER, 2007, mg/l

SCALE: 1"=1600'

PAGE: 6.3-18

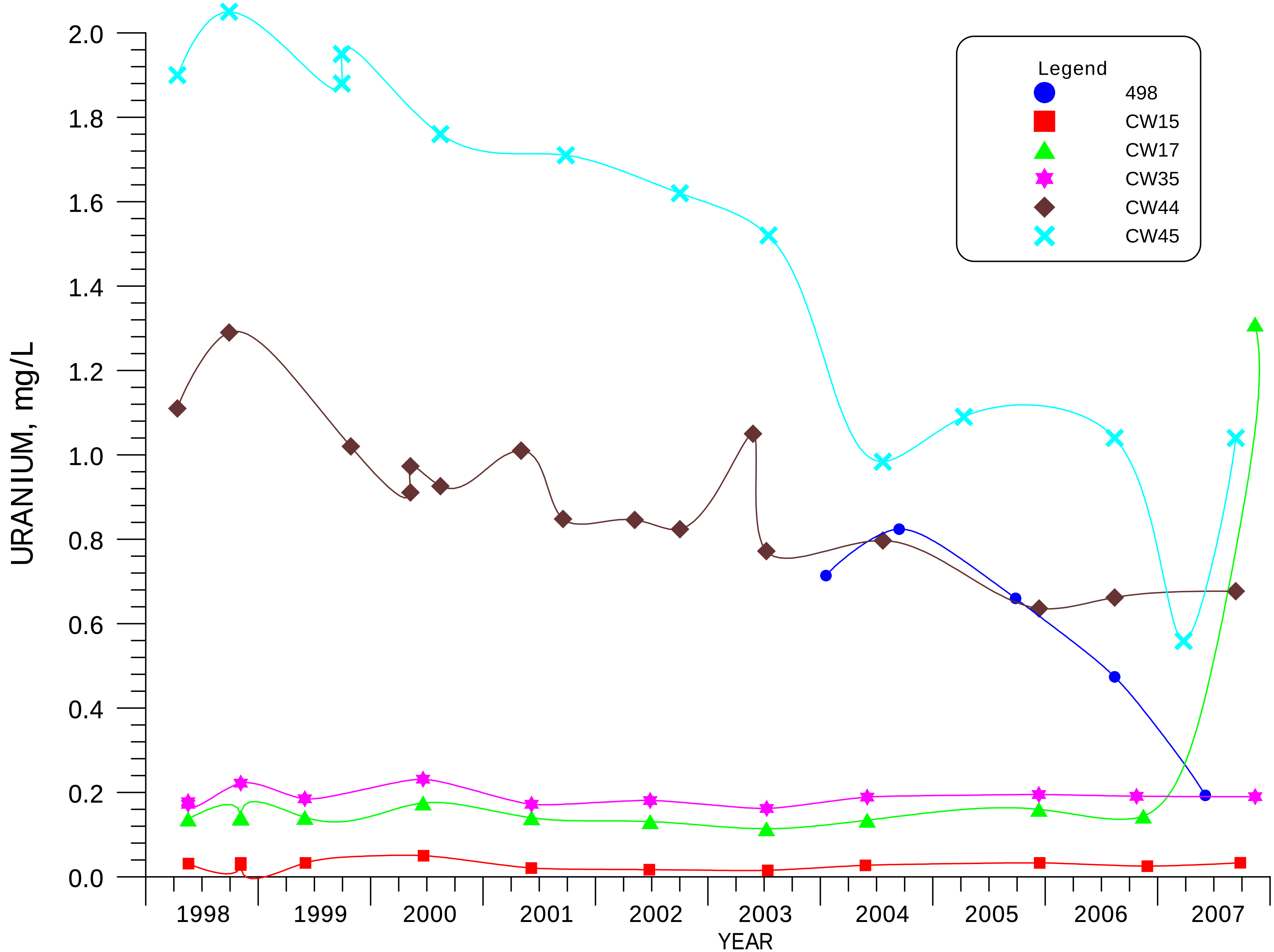


FIGURE 6.3-12. URANIUM CONCENTRATIONS FOR WELLS 498, CW15, CW17, CW35, CW44 AND CW45.

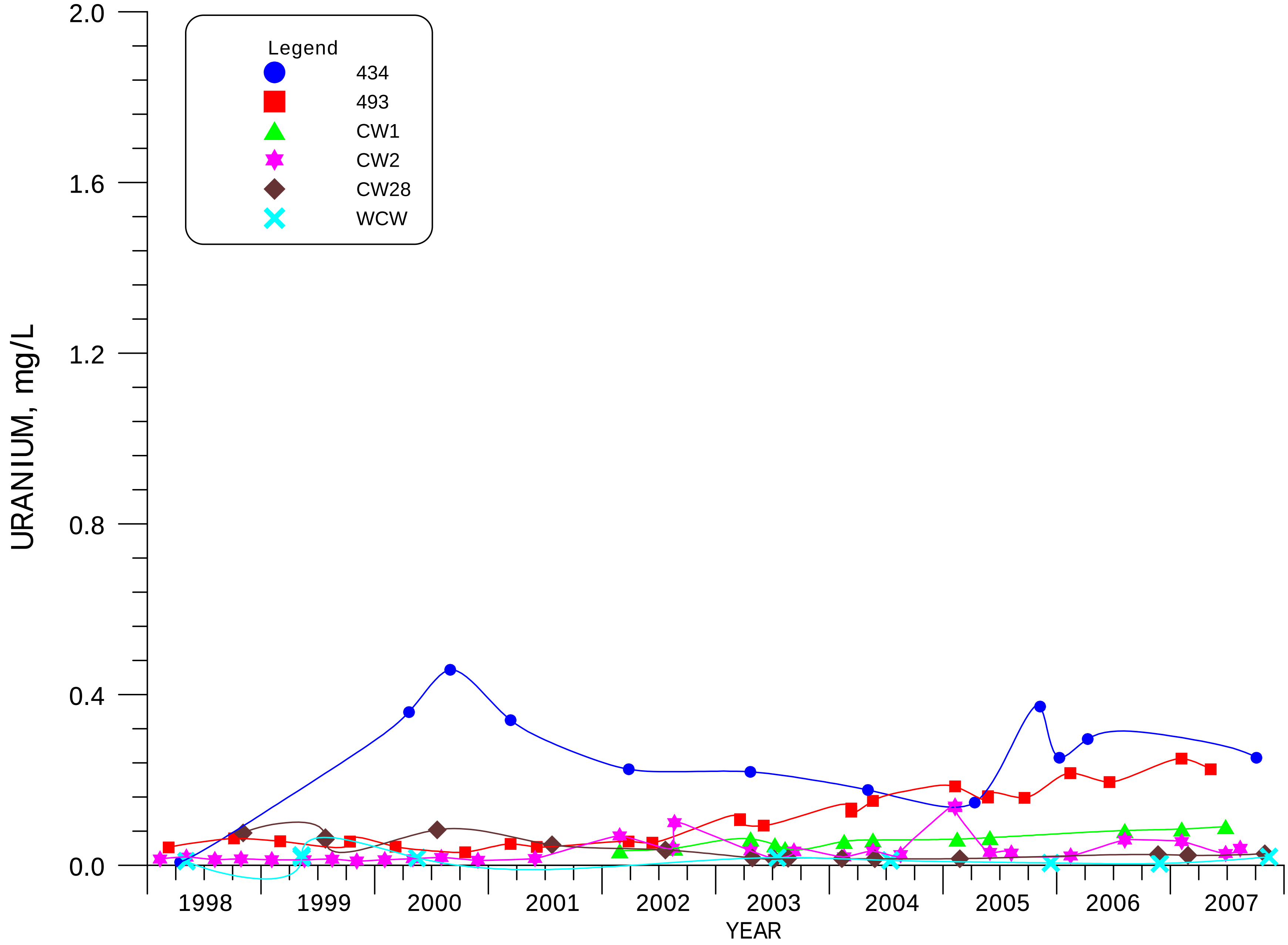
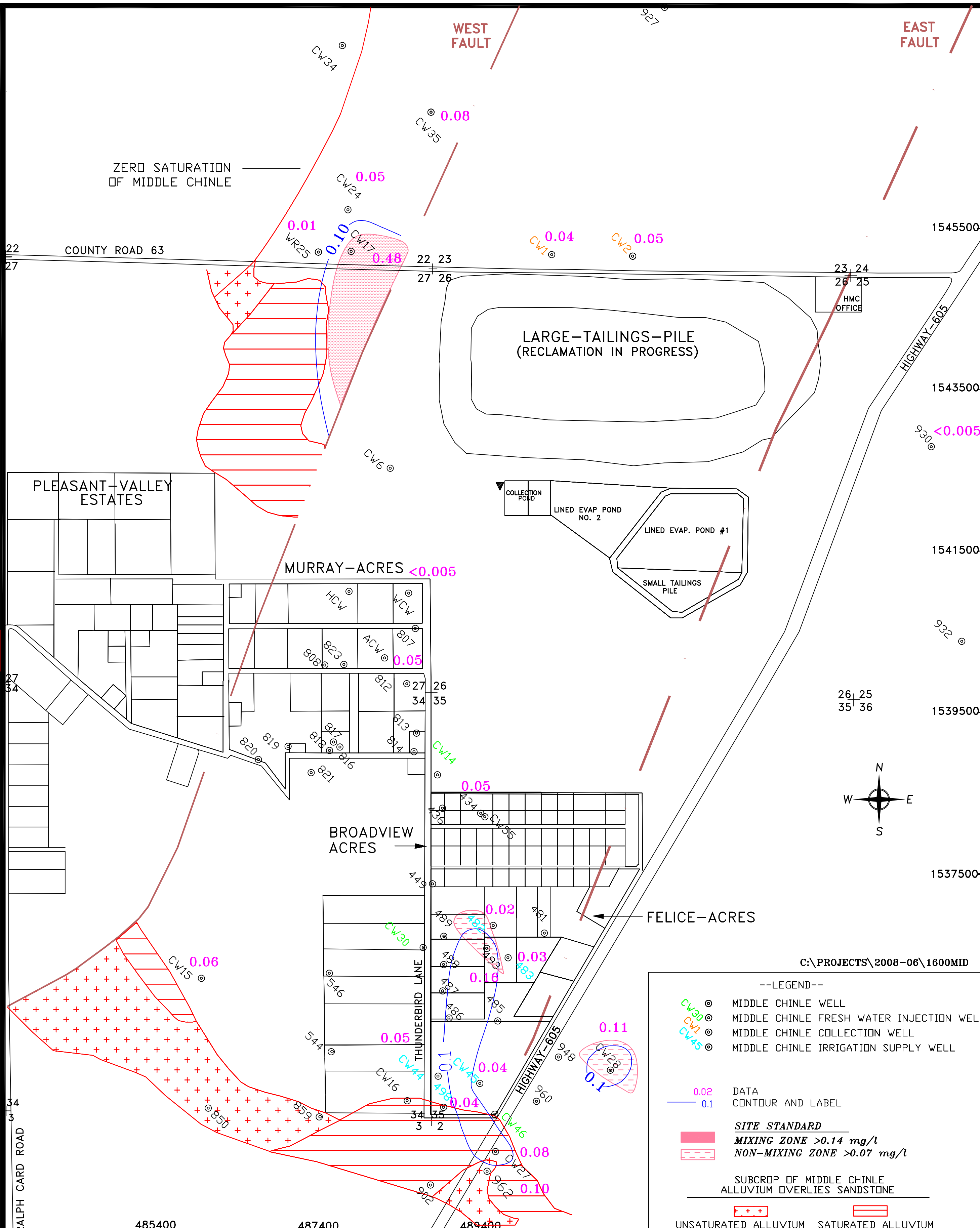


FIGURE 6.3-13. URANIUM CONCENTRATIONS FOR WELLS 434, 493, CW1, CW2, CW28 AND WCW.



HOMESTAKE MILL AND ADJACENT PROPERTIES ~ GRANTS, NM ~ TOWNSHIP–11&12N, RANGE–10W

DATE: 03/05/08

SCALE: 1"=1600'

FIGURE 6.3–14. SELENIUM CONCENTRATIONS OF THE MIDDLE CHINLE AQUIFER, 2007, mg/l

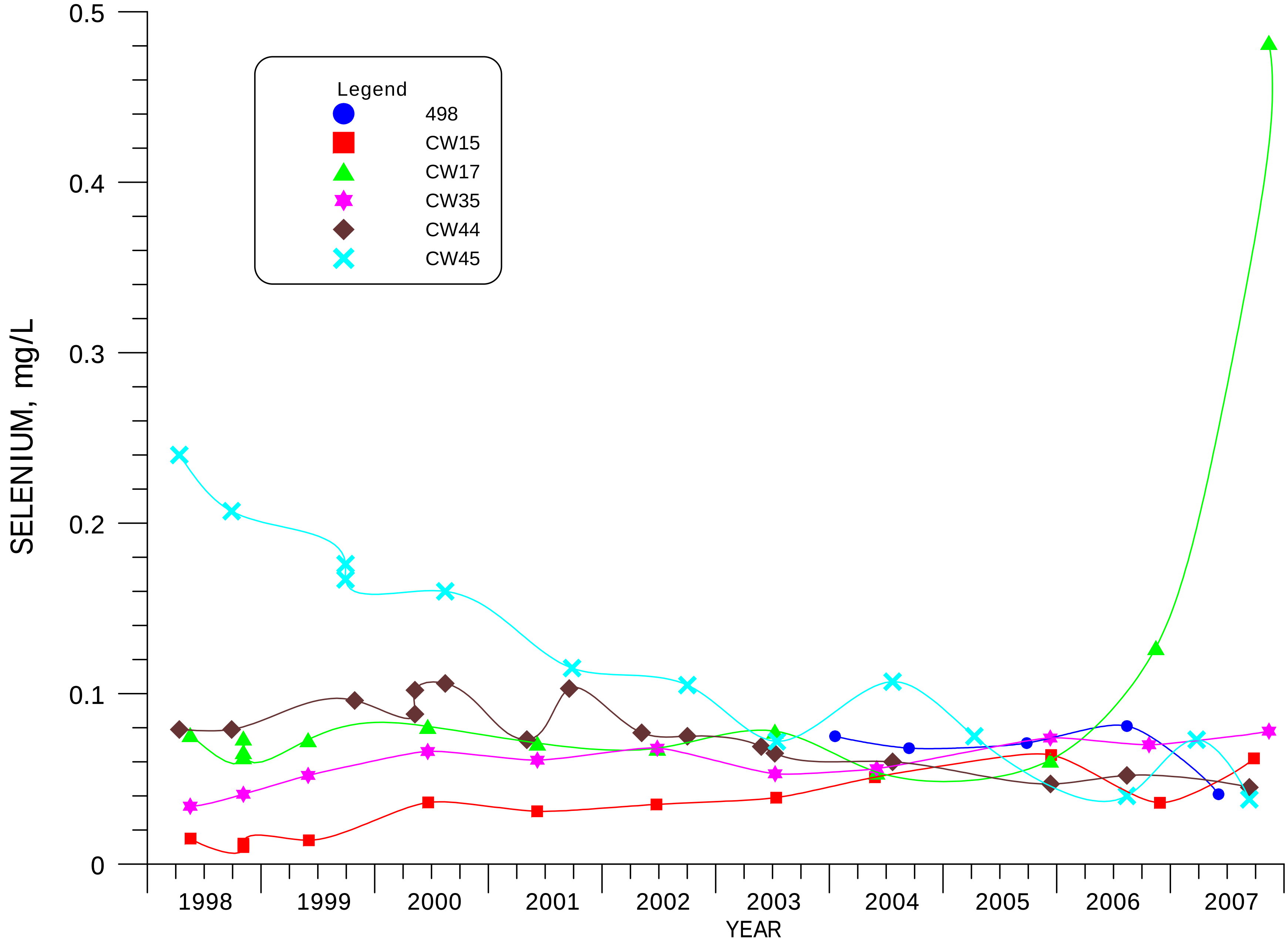


FIGURE 6.3-15. SELENIUM CONCENTRATIONS FOR WELLS 498, CW15, CW17, CW35, CW44 AND CW45.

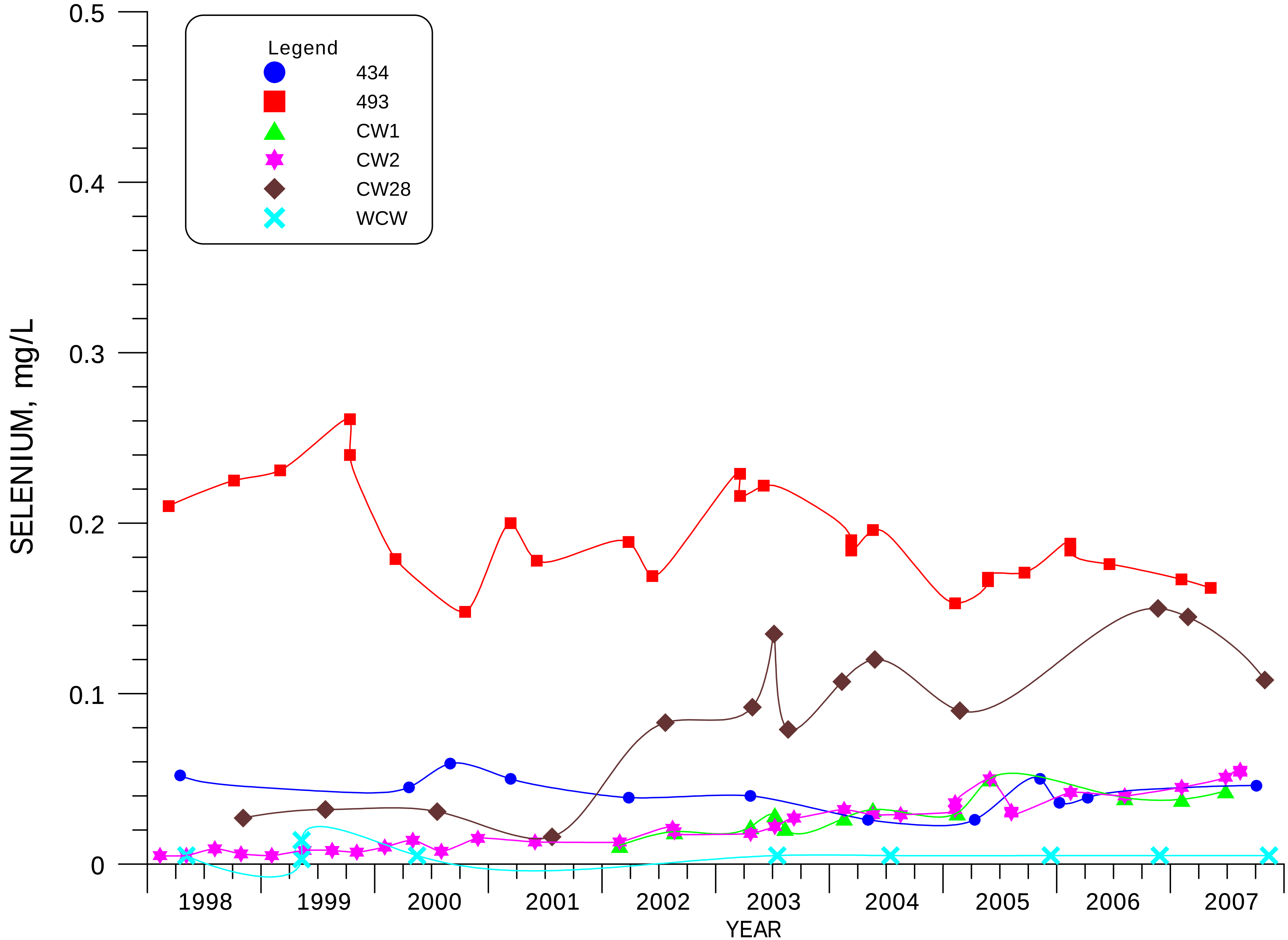
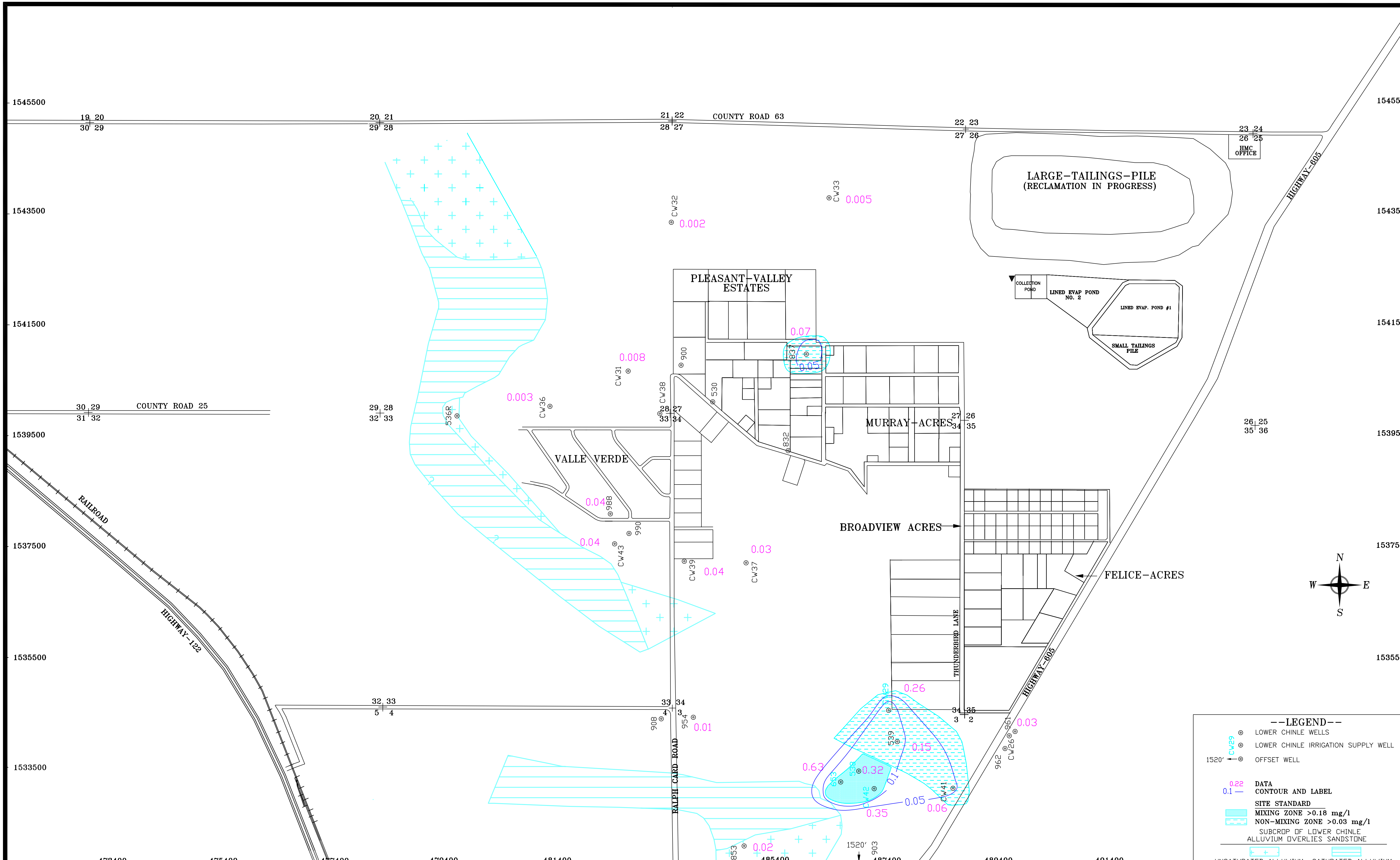


FIGURE 6.3-16. SELENIUM CONCENTRATIONS FOR WELLS 434, 493, CW1, CW2, CW28 AND WCW.



SCALE: 1"= 1600"

C:\PROJECTS\2008-06\1600LOW

03/28/08

HOMESTAKE MILL AND ADJACENT PROPERTIES

GRANTS, NM TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 7.3-8. URANIUM CONCENTRATIONS OF THE LOWER CHINLE AQUIFER, 2007, mg/l

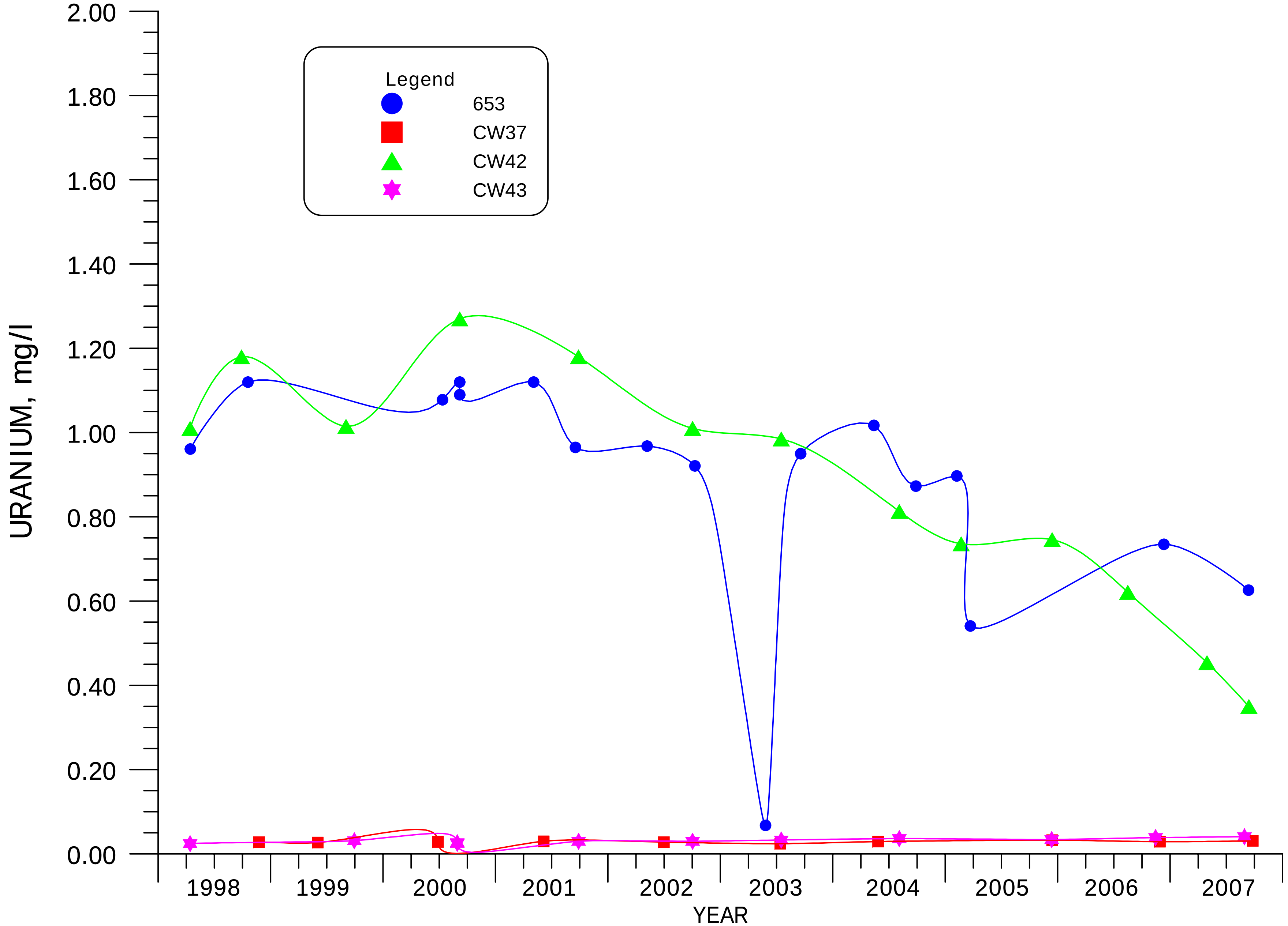


FIGURE 7.3-9. URANIUM CONCENTRATIONS FOR MIXING ZONE WELLS 653, CW37, CW42 AND CW43.

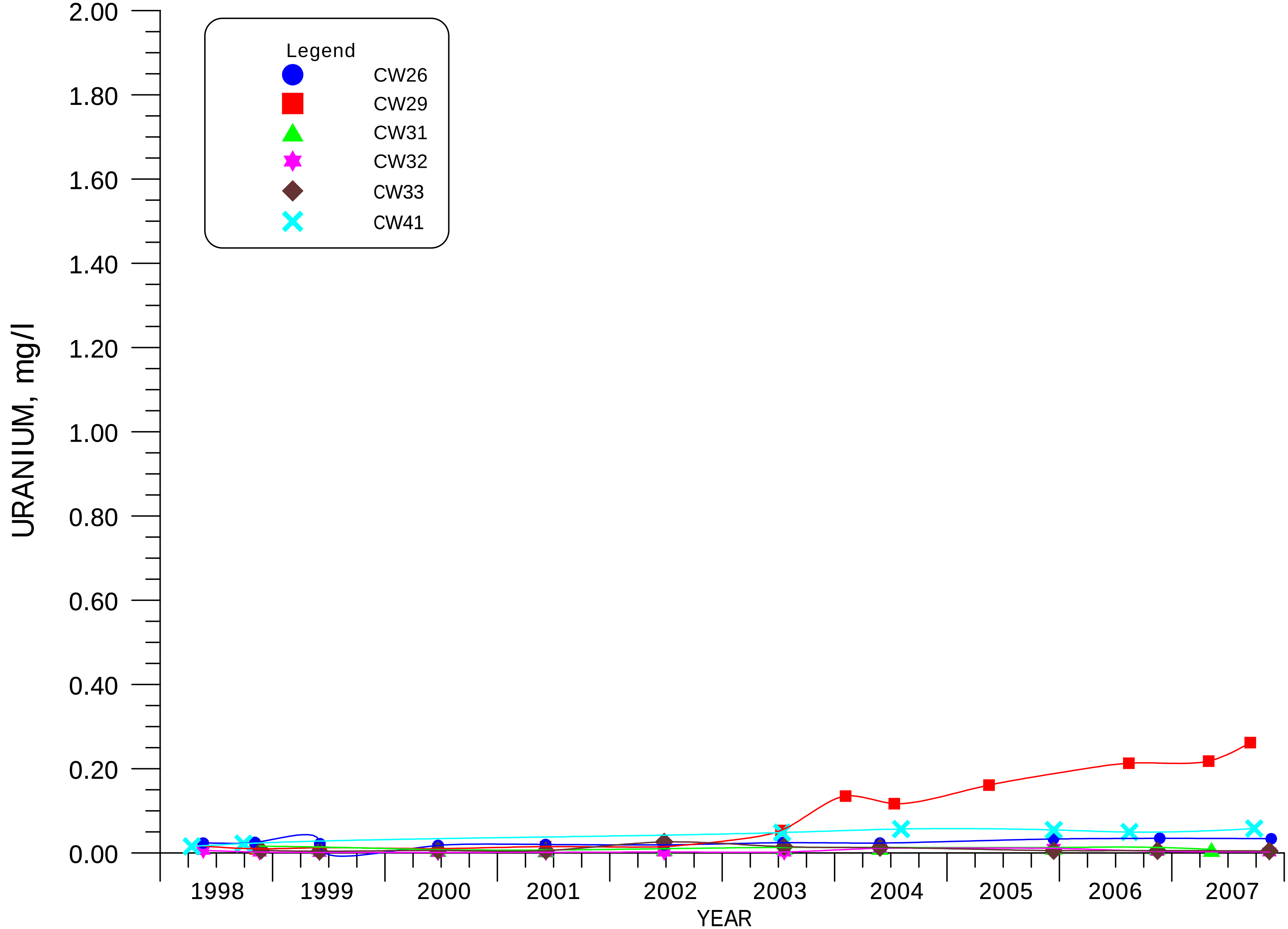
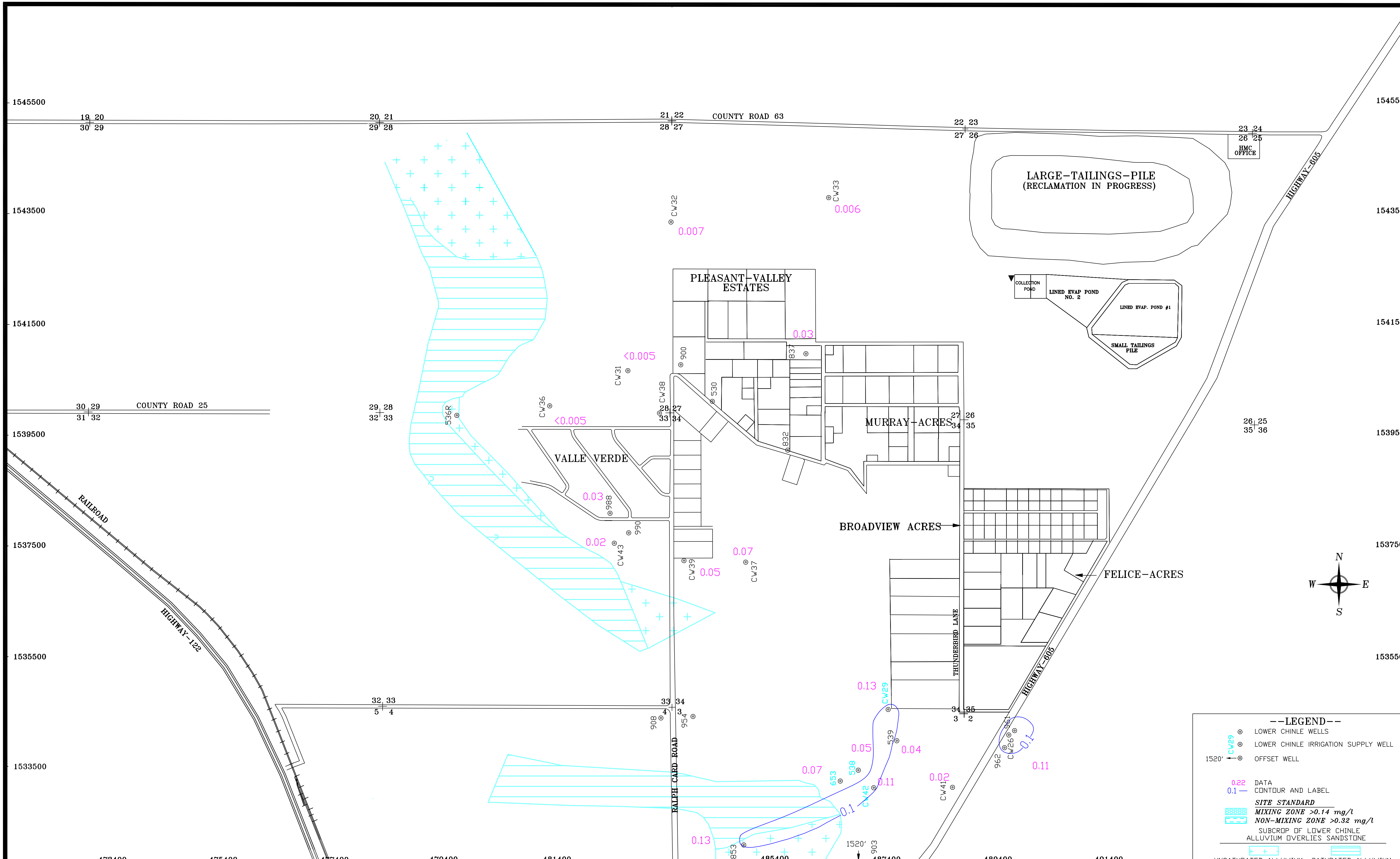


FIGURE 7.3-10. URANIUM CONCENTRATIONS FOR NON-MIXING ZONE WELLS CW26, CW29, CW31, CW32, CW33 AND CW41.



SCALE: 1"= 1600"
C:\PROJECTS\2008-06\1600LOW
03/28/08

HOMESTAKE MILL AND ADJACENT PROPERTIES

GRANTS, NM TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 7.3-11. SELENIUM CONCENTRATIONS OF THE LOWER CHINLE AQUIFER, 2007, mg/l

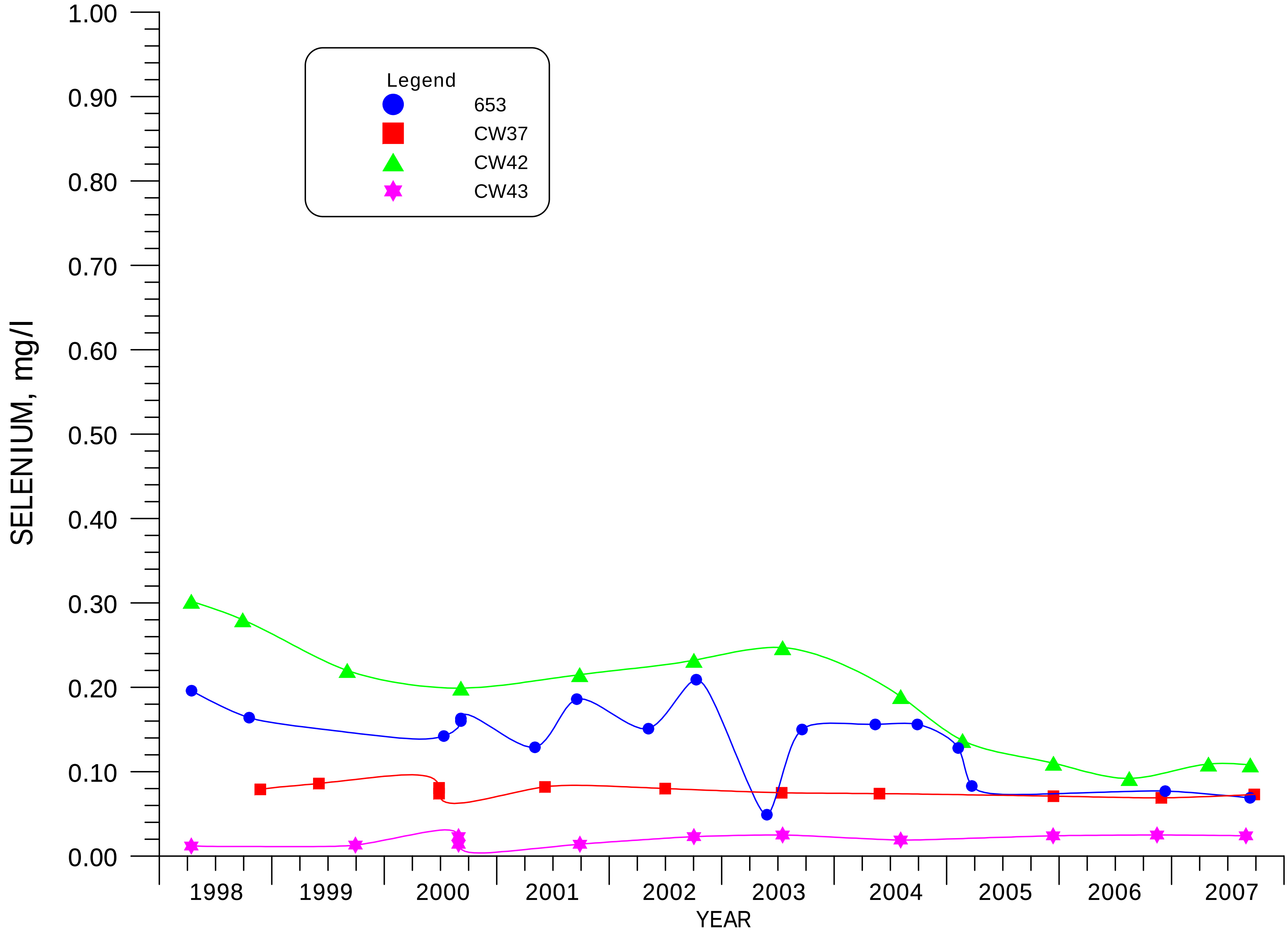


FIGURE 7.3-12. SELENIUM CONCENTRATIONS FOR MIXING ZONE WELLS 653, CW37, CW42 AND CW43.

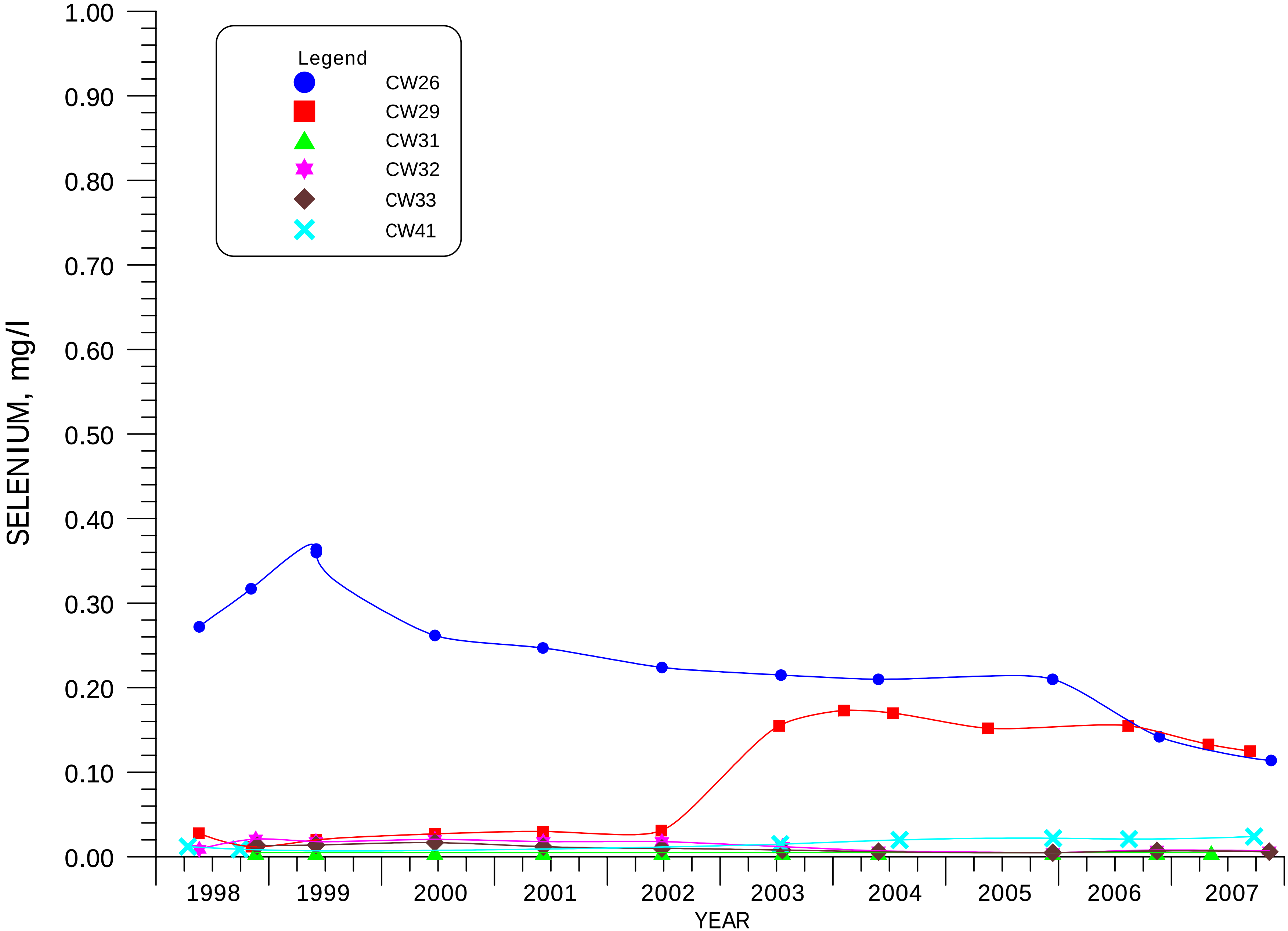
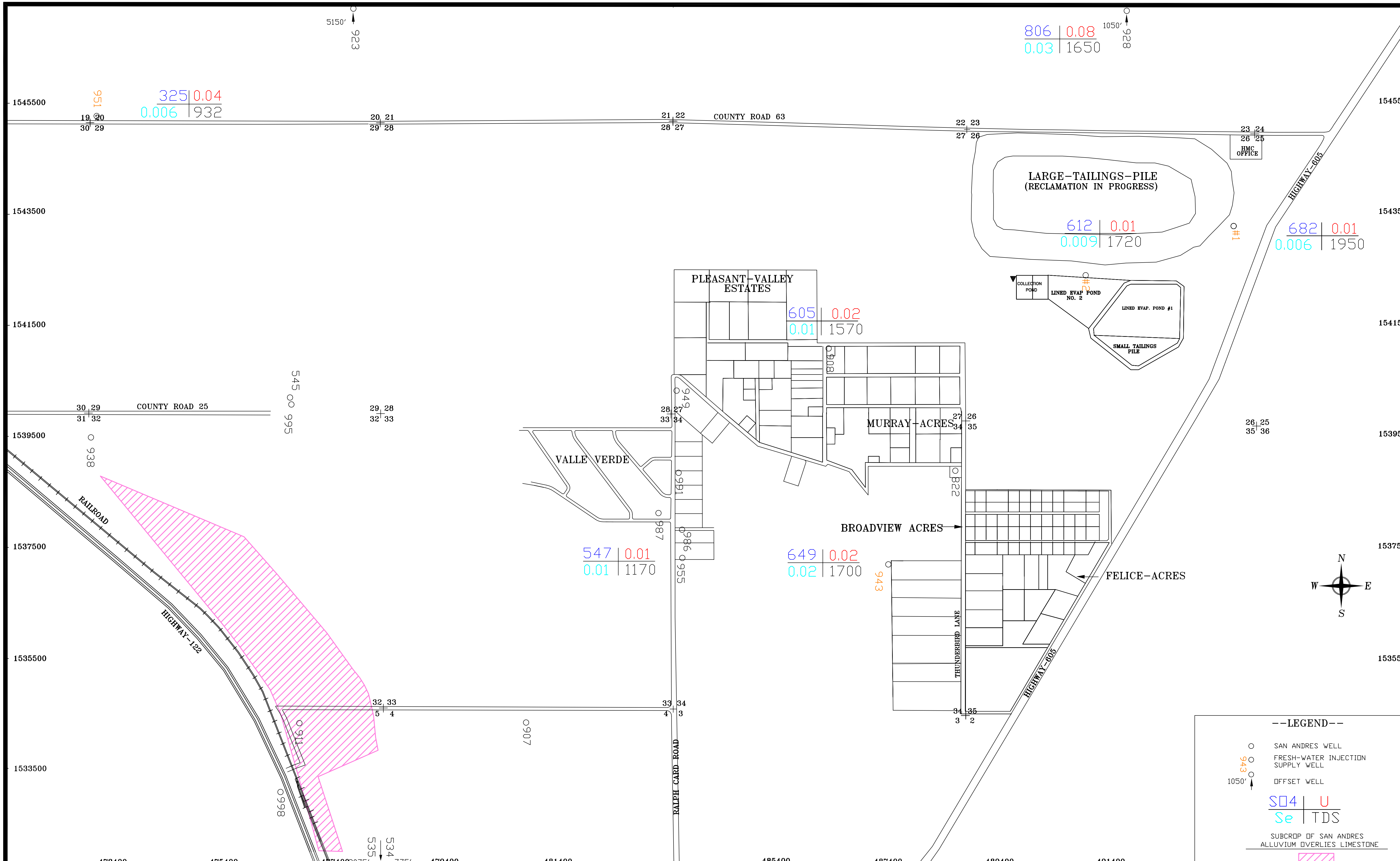


FIGURE 7.3-13. SELENIUM CONCENTRATIONS FOR NON-MIXING ZONE WELLS CW26, CW29, CW31, CW32, CW33 AND CW41.



SCALE: 1"= 1600"

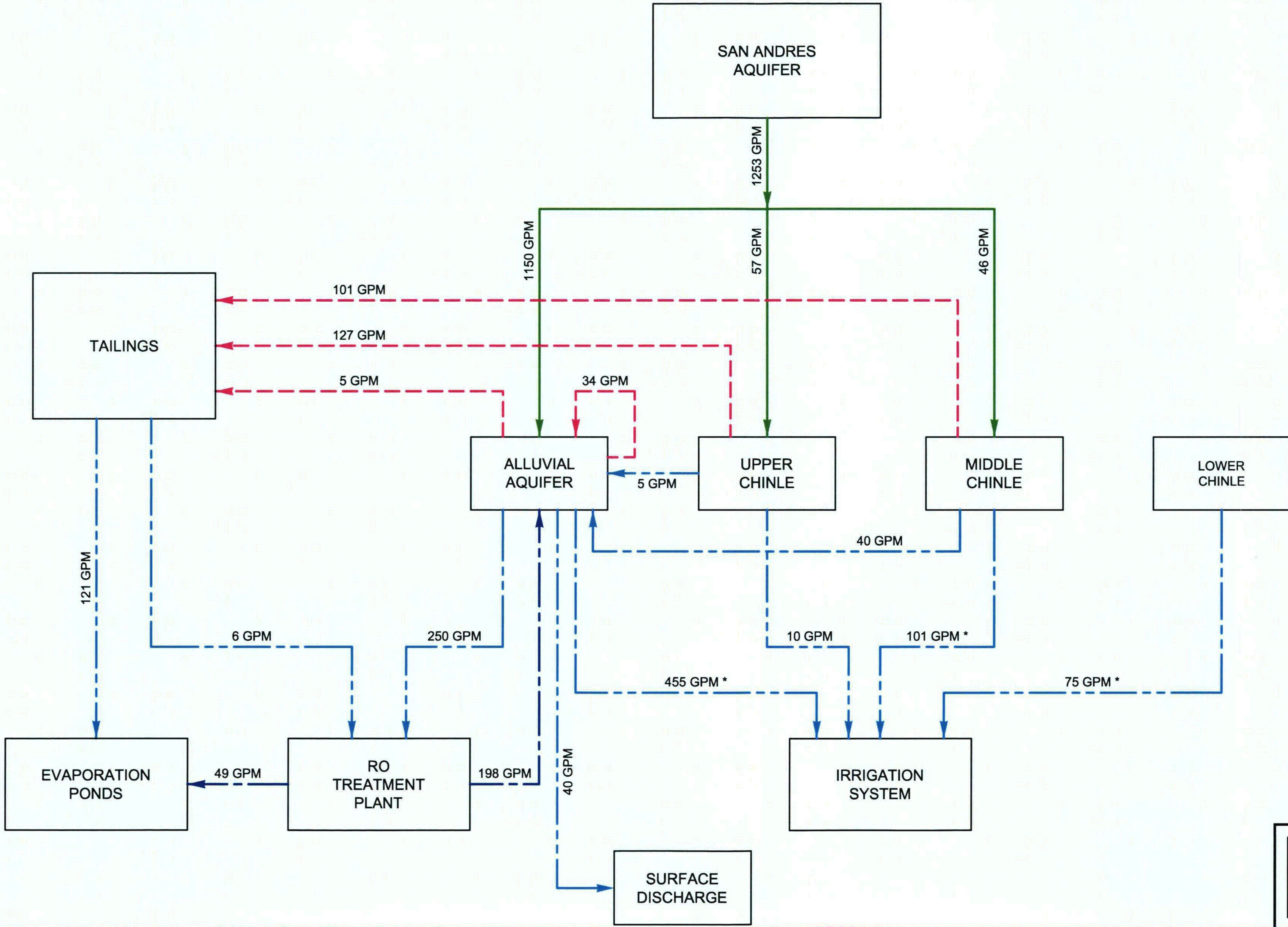
C:\PROJECTS\2008-06\1600SAN

DATE: 03/27/08

HOMESTAKE MILL AND ADJACENT PROPERTIES

GRANTS, NM TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 8.0-2. WATER QUALITY FOR THE SAN ANDRES AQUIFER, 2007, mg/l



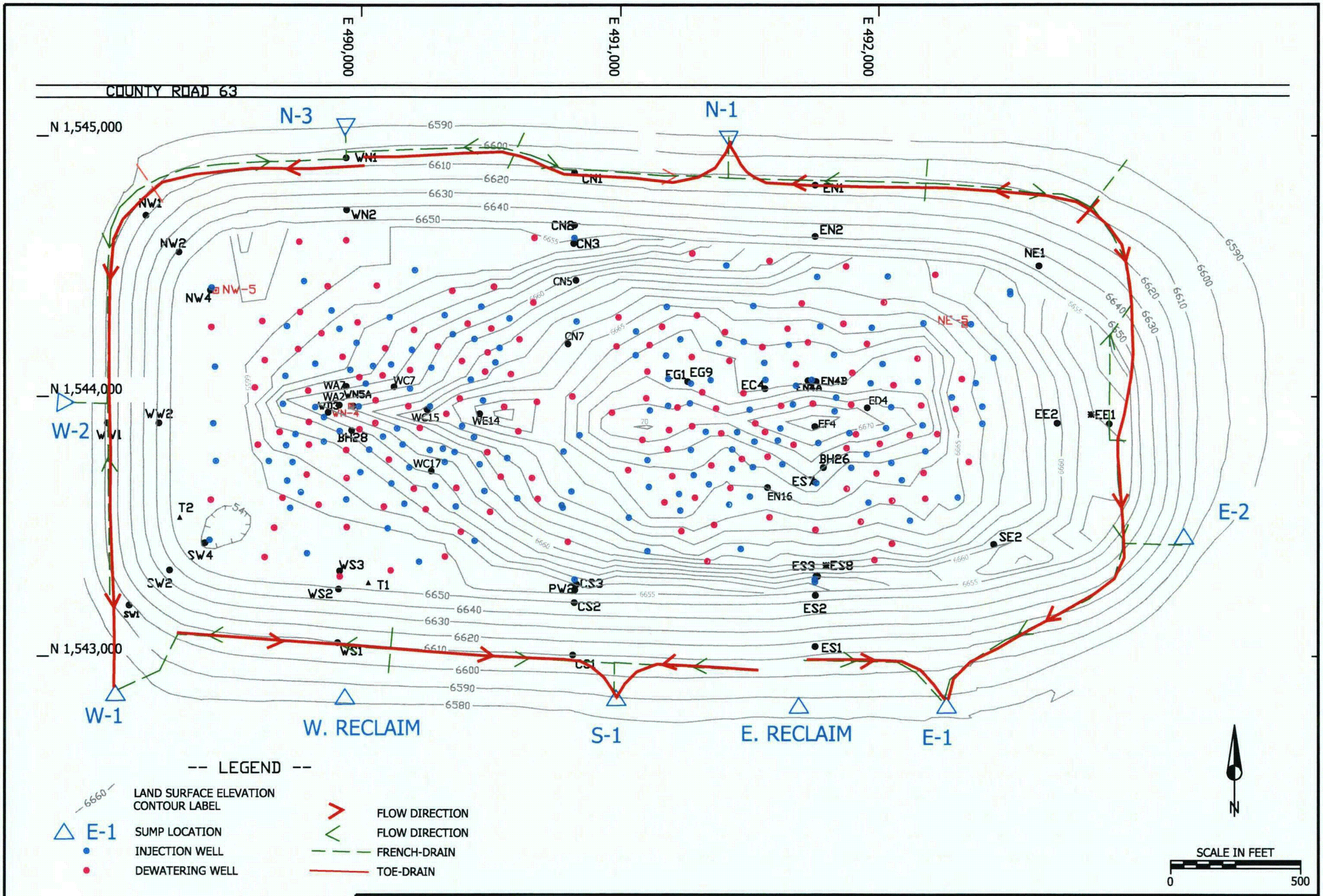
* AVERAGE ANNUALIZED RATES
PUMPING TO IRRIGATION SYSTEM
OCCURS OVER 8 MONTH PERIOD.

FIGURE 28
SUMMARY OF CAP
2005

MFG, Inc.
consulting scientists and engineers

Date: OCTOBER 2006
Project: 180899
File: AQUIFER.dwg

Date: 10/25/2006
Time: 09:39:17.23



HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

Date: 11/17/2004 Filename: E:\180899\CLIENT\2004-NOV\MON2-1-4.dwg

FIGURE 29
LOCATIONS OF TAILINGS DEWATERING WELLS, TOE DRAINS AND SUMPS

SCALE: 1"=1300'
C:\PROJECTS\2008-06
\PLANFIGS lh
DATE: 04/19/08

Figure A. LOCATION OF R.O. COLLECTION WELLS AND PIPING, 2008

HOMESTAKE MILL & ADJACENT PROPERTIES
GRANTS, NM T11&12N, R10W

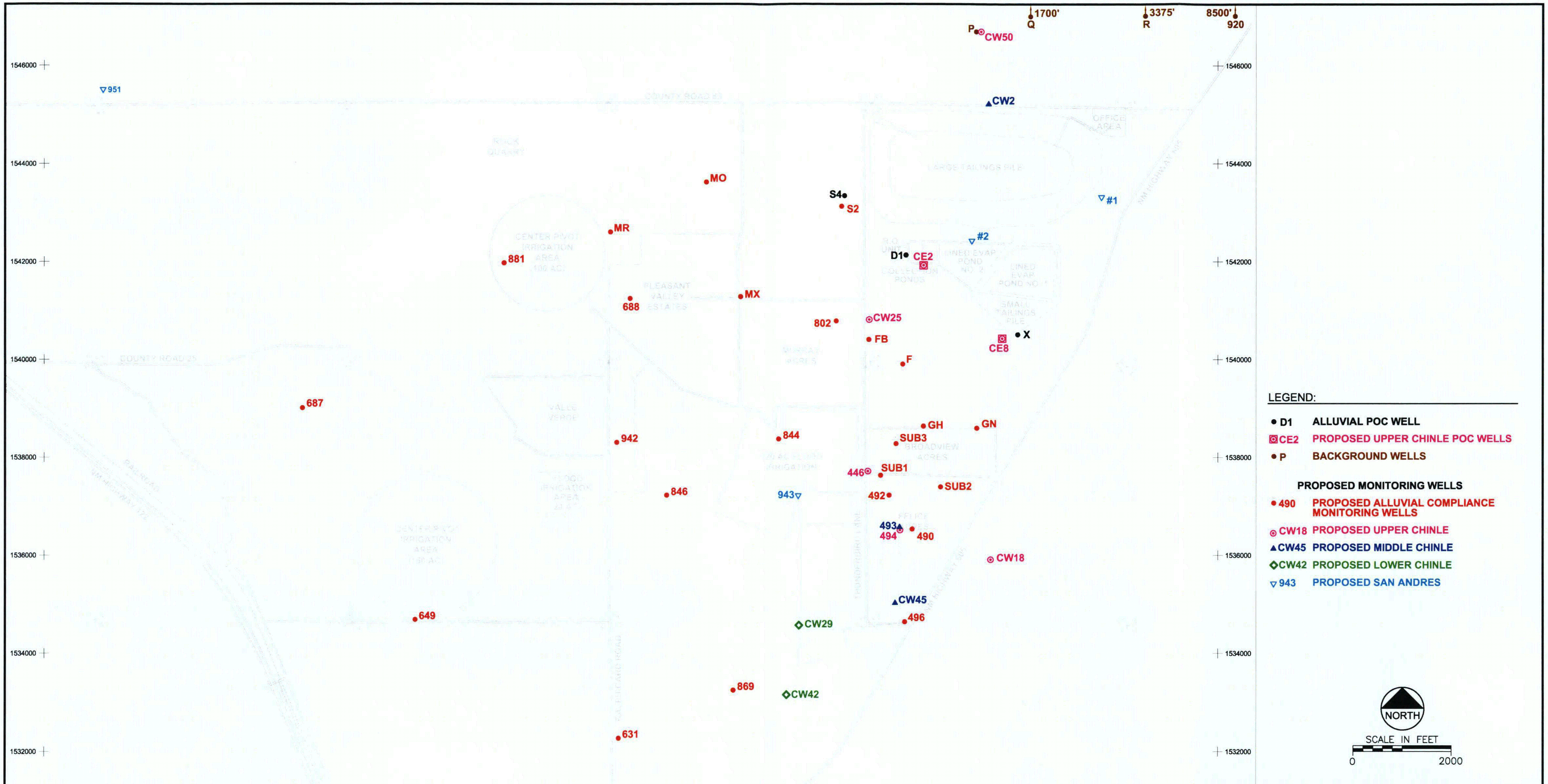
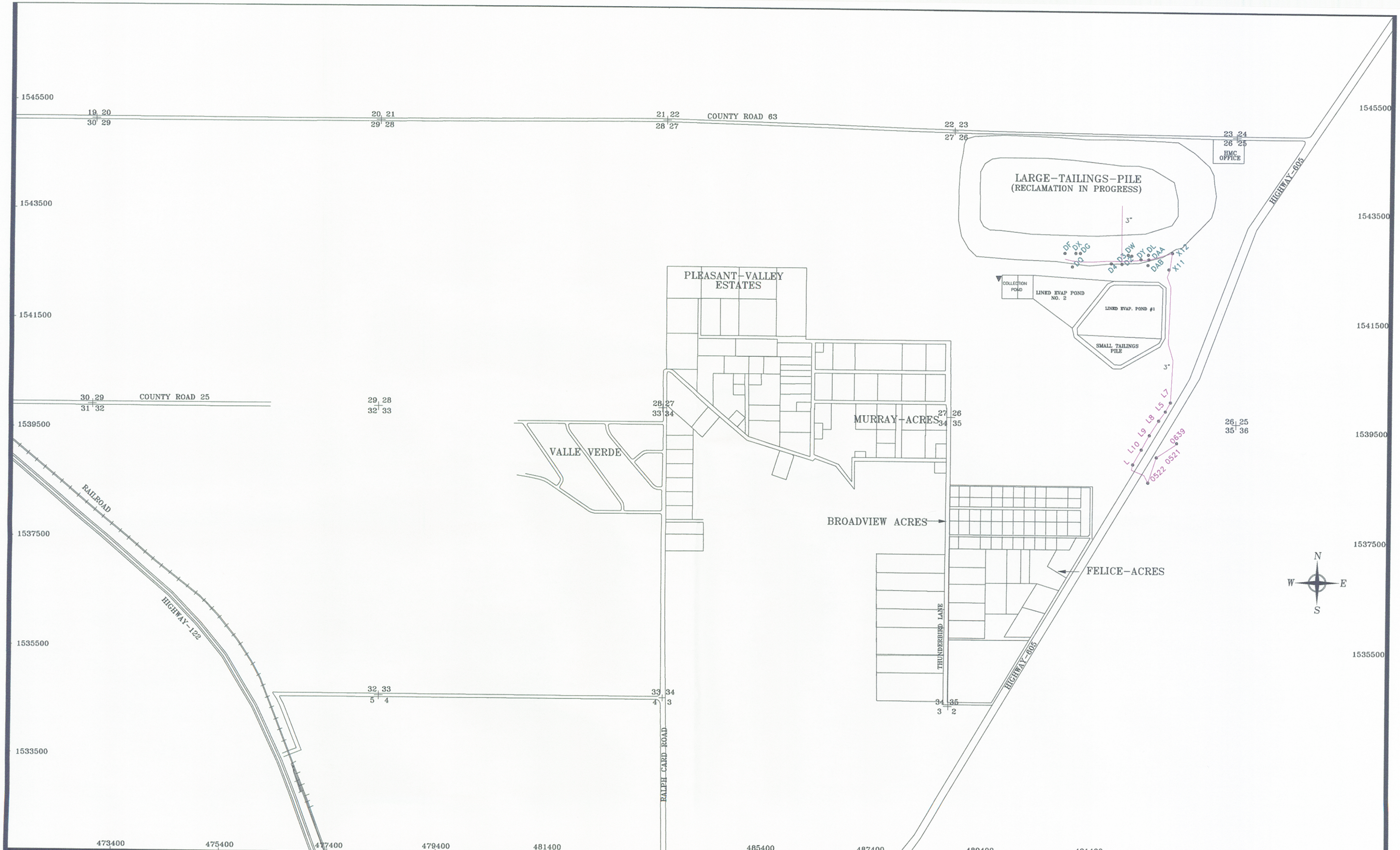


FIGURE 49
PROPOSED MONITORING WELL LOCATIONS

MFG, Inc.
consulting scientists and engineers

Date:	DECEMBER 2006
Project:	180899
File:	WELLS-PROP.dwg

Filename: E:\...\WELLS-PROP.dwg
Date: 12/12/2006
Time: 09:52:04.79



SCALE: 1"=1300'
C:\PROJECTS\2008-06 \PLANFIGS lh
DATE: 04/19/08

Figure C. LOCATION OF COLLECTION FOR REINJECTION WELLS AND PIPING, 2008

HOMESTAKE MILL & ADJACENT PROPERTIES
GRANTS, NM T11&12N, R10W

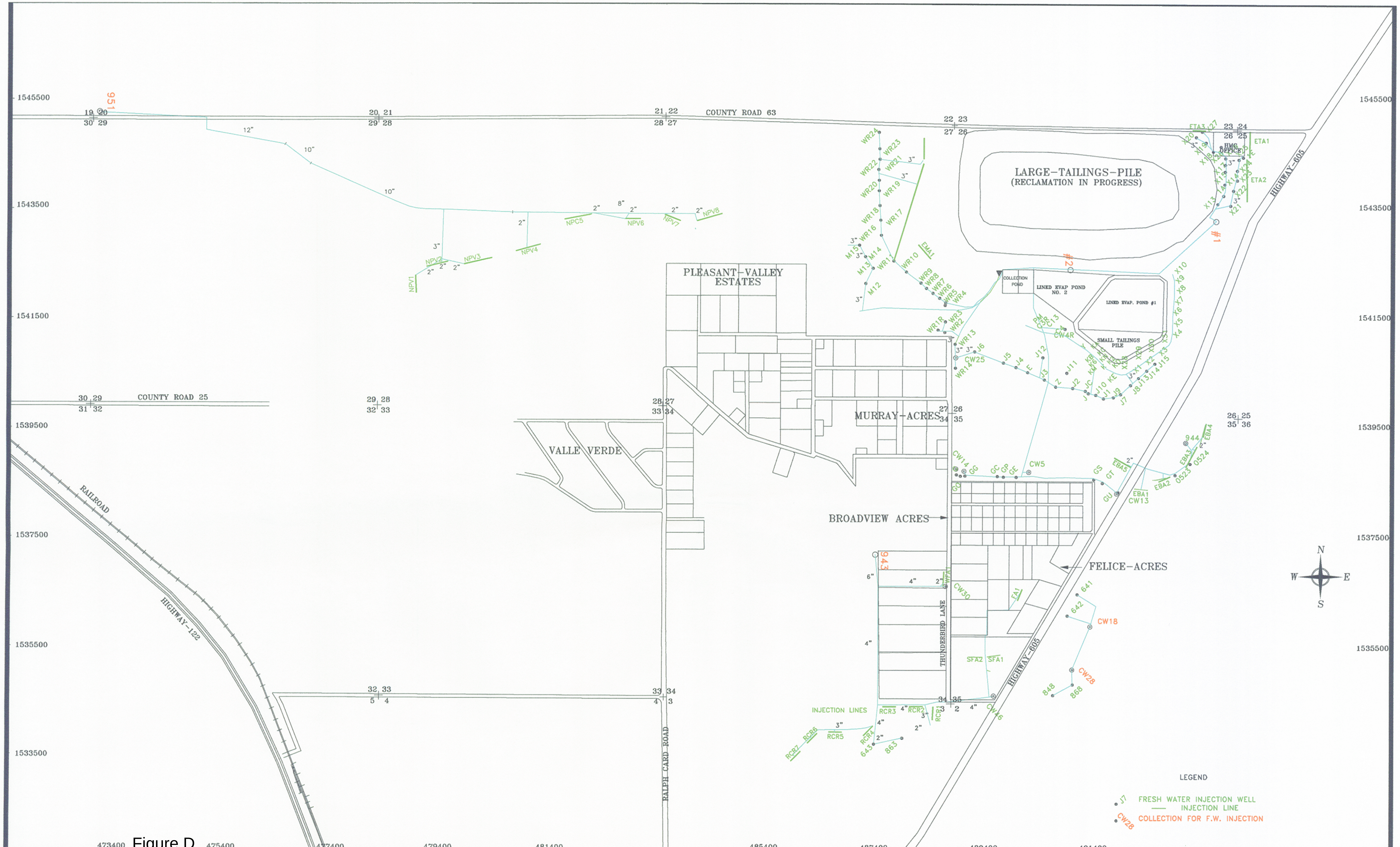


Figure D.

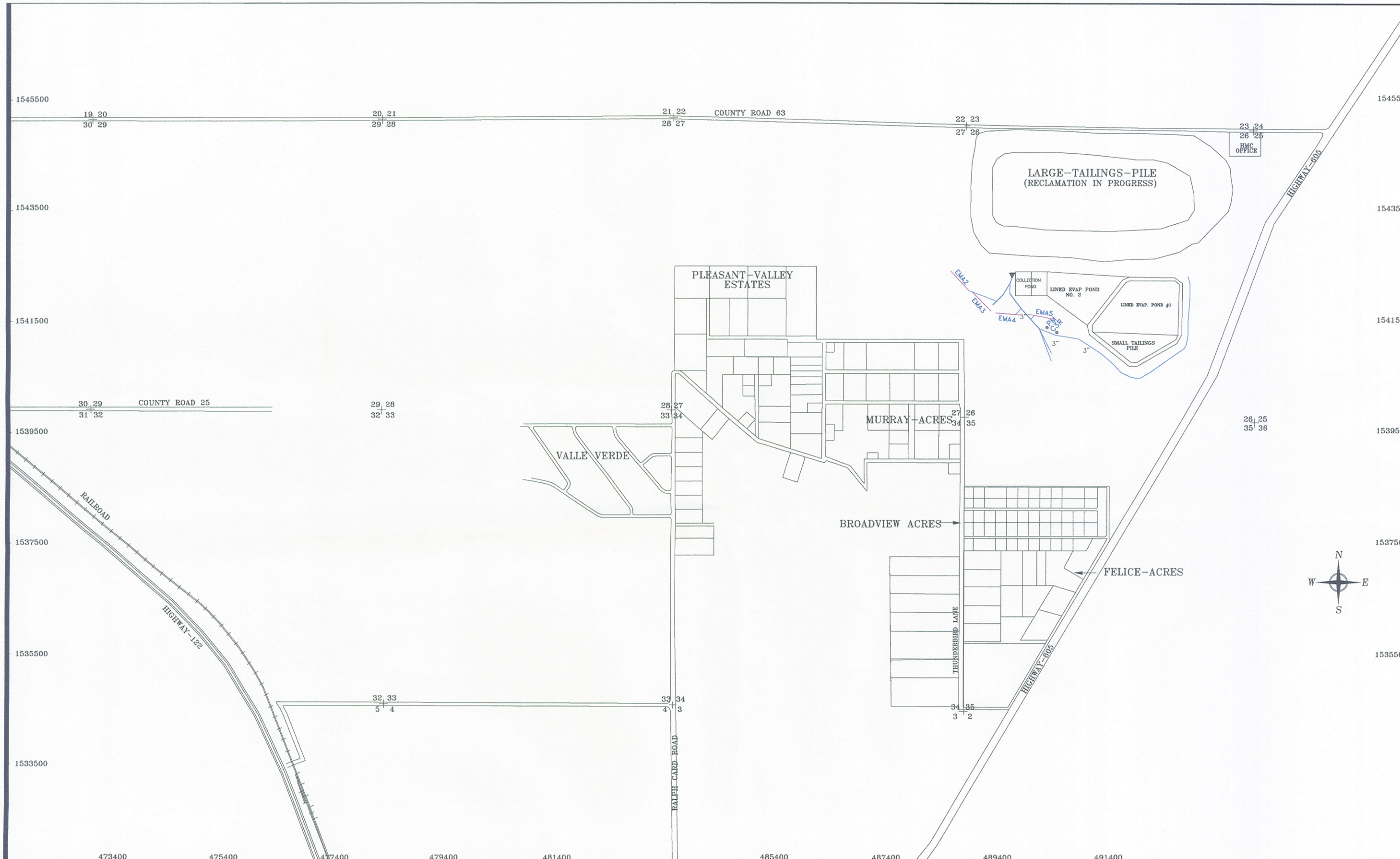
SCALE: 1"=1300'

C:\PROJECTS\2008-06 \PLANFIGS lh

DATE: 04/19/08

LOCATION OF FRESH WATER COLLECTION AND INJECTION WELLS AND PIPING, 2008

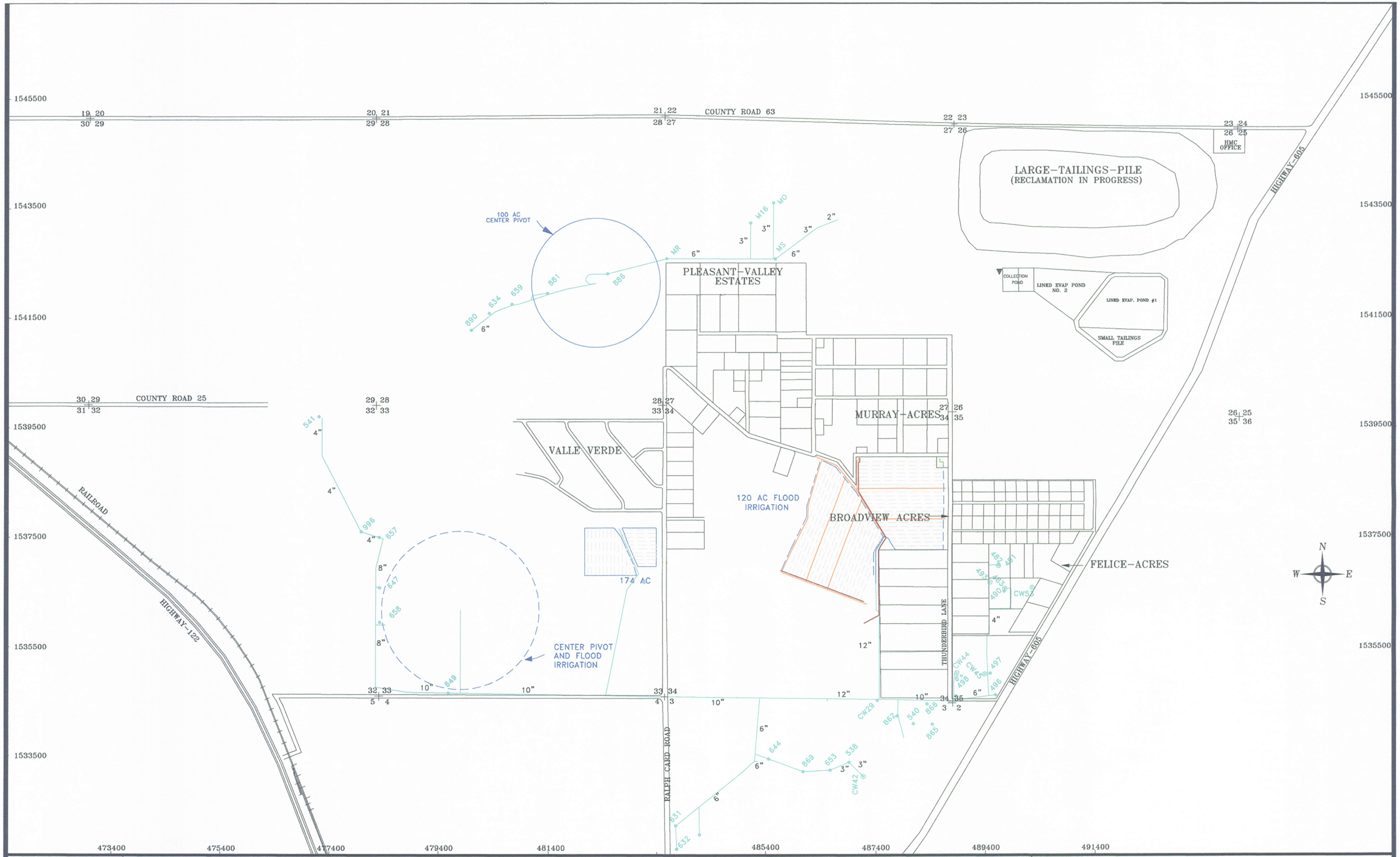
HOMESTAKE MILL & ADJACENT PROPERTIES
GRANTS, NM T11&12N, R10W



SCALE: 1"=1300'
C:\PROJECTS\2008-06 \PLANFIGS lh
DATE: 04/19/08

Figure E. LOCATION OF R.O. PRODUCT INJECTION WELLS AND PIPING, 2007

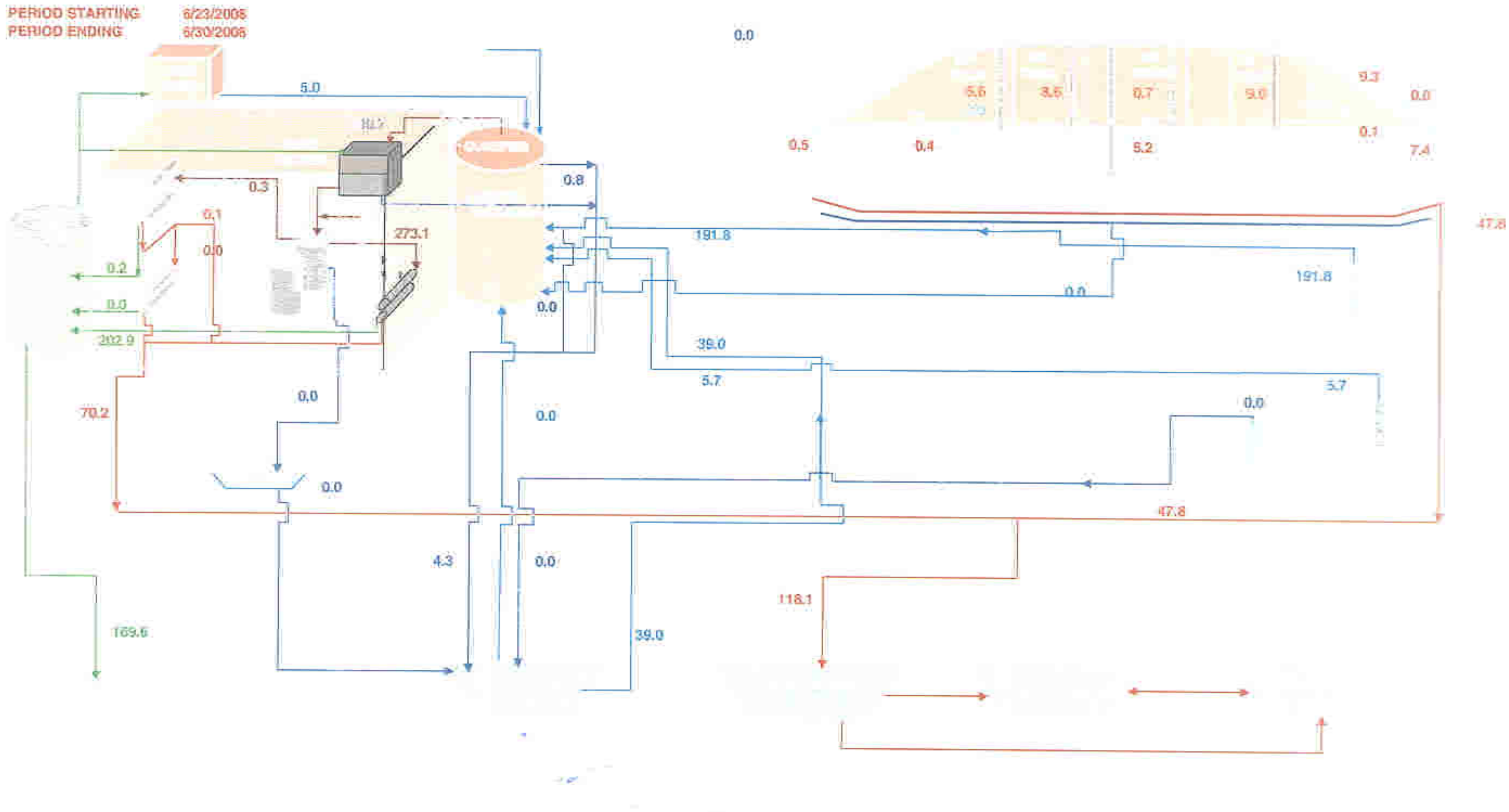
HOMESTAKE MILL & ADJACENT PROPERTIES
GRANTS, NM T11&12N, R10W



SCALE: 1"=1300'
C:\PROJECTS\2008-06 \PLANFIGS lh
DATE: 04/19/08

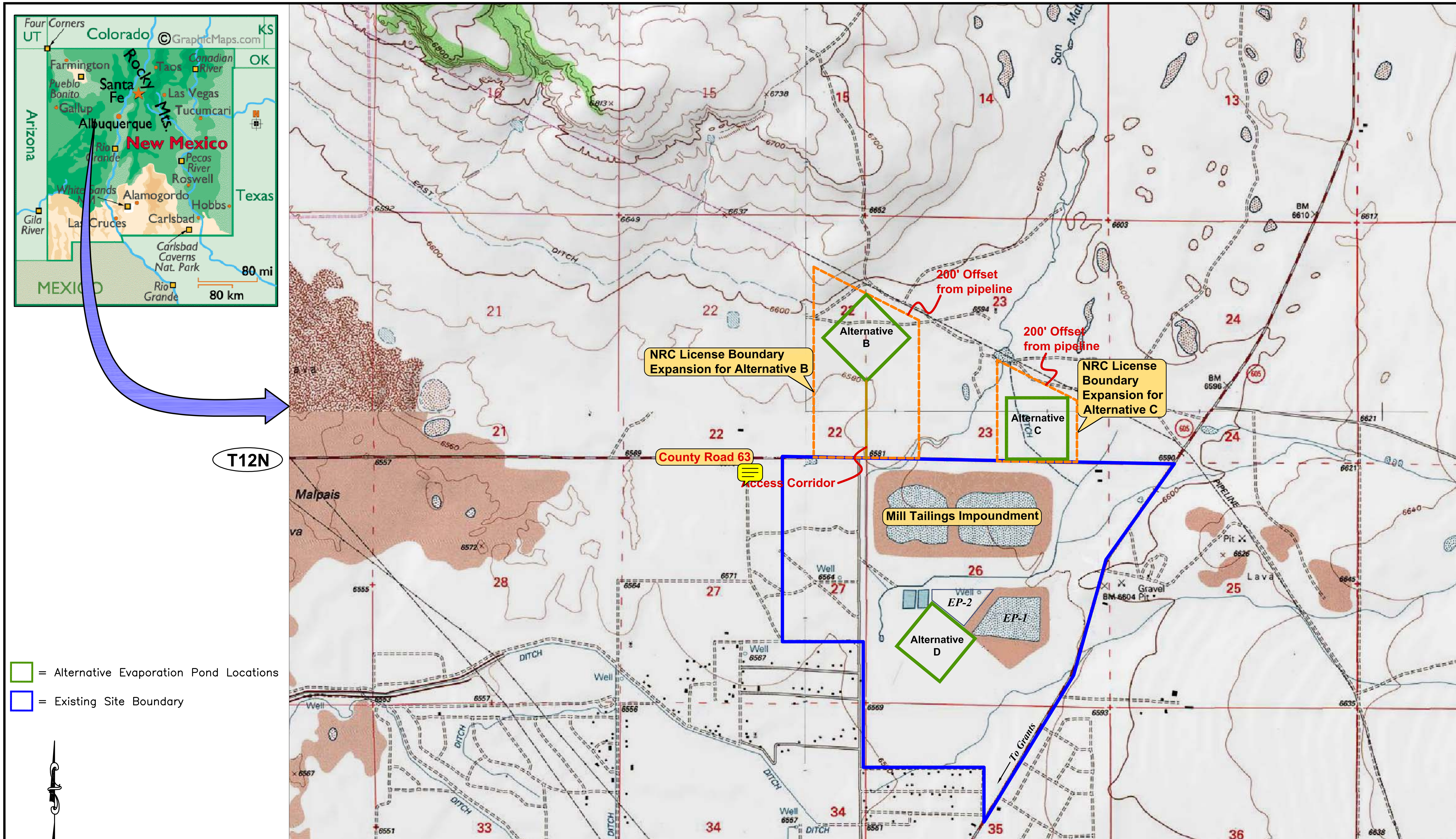
FIGURE 6. LOCATION OF IRRIGATION SYSTEMS AND IRRIGATION SUPPLY WELLS, 2008

HOMESTAKE MILL & ADJACENT PROPERTIES
GRANTS, NM T11&12N, R10W



PERIOD STARTING 6/23/2006
PERIOD ENDING 6/30/2006
0.0
5.0
5.6
3.6
0.7
9.0
9.3
0.0
0.1
7.4
0.5
0.4
5.2
0.8
0.3
0.1
0.0
273.1
191.8
47.8
191.8
0.2
0.0
202.9
0.0
0.0
39.0
5.7
5.7
0.0
0.0
70.2
0.0
0.0
47.8
4.3
0.0
118.1
169.6
39.0

Figure WB.



Source: Map created with TOPO! 2003 National Geographic

R10W

2,000 0 1,000 2,000

SCALE: 1 inch = 2,000 ft

KLEINFELDER

Drawn By: C. Landon	Date: June 2006
Project No.: 16977	Filename: 16977_04_0.dwg
Scale: 1" = 2,000'	Revision: 1

SITE LOCATION MAP
Homestake Grants Project
9km North of Grants of New Mexico
Grants, New Mexico

FIGURE
1A

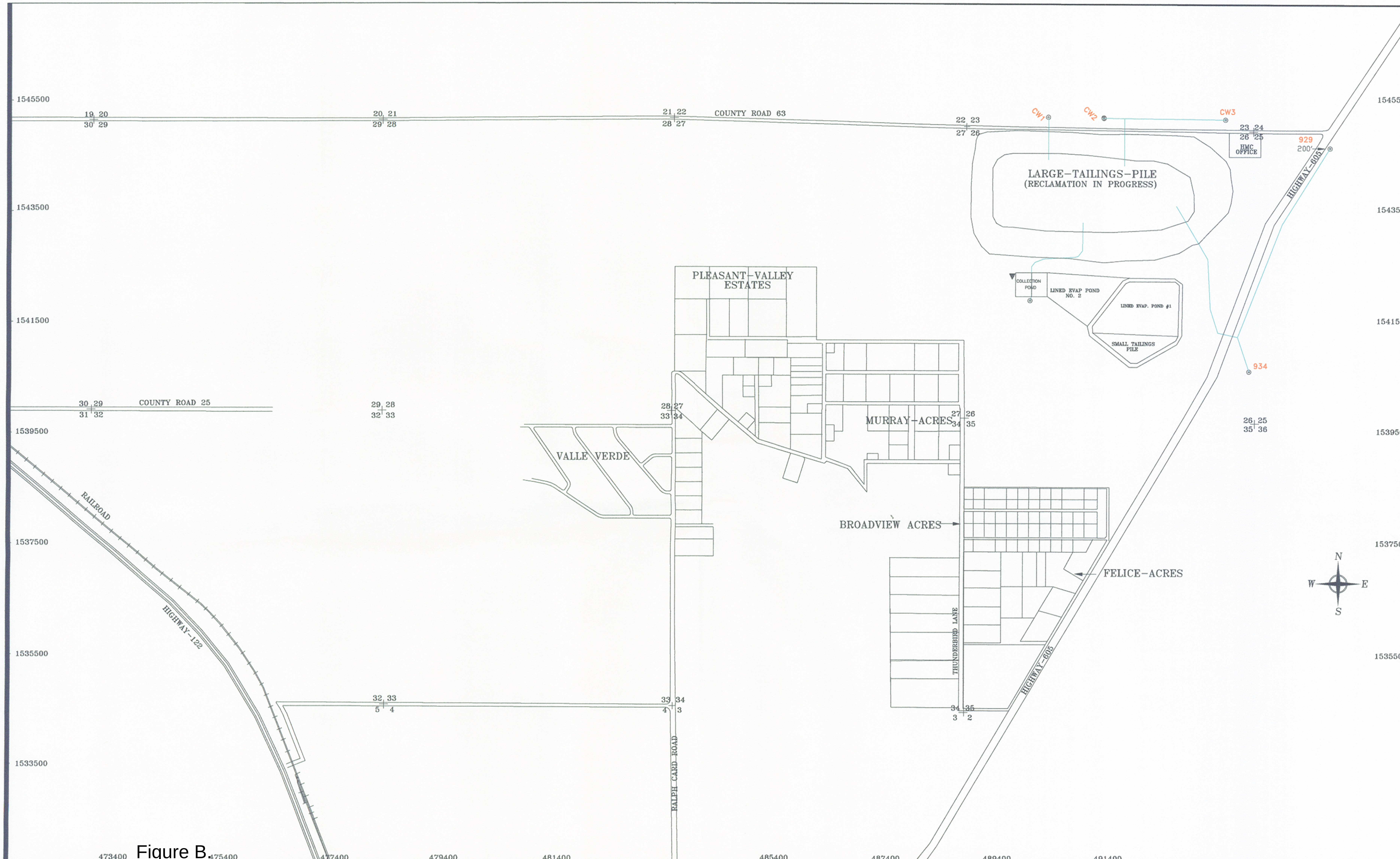
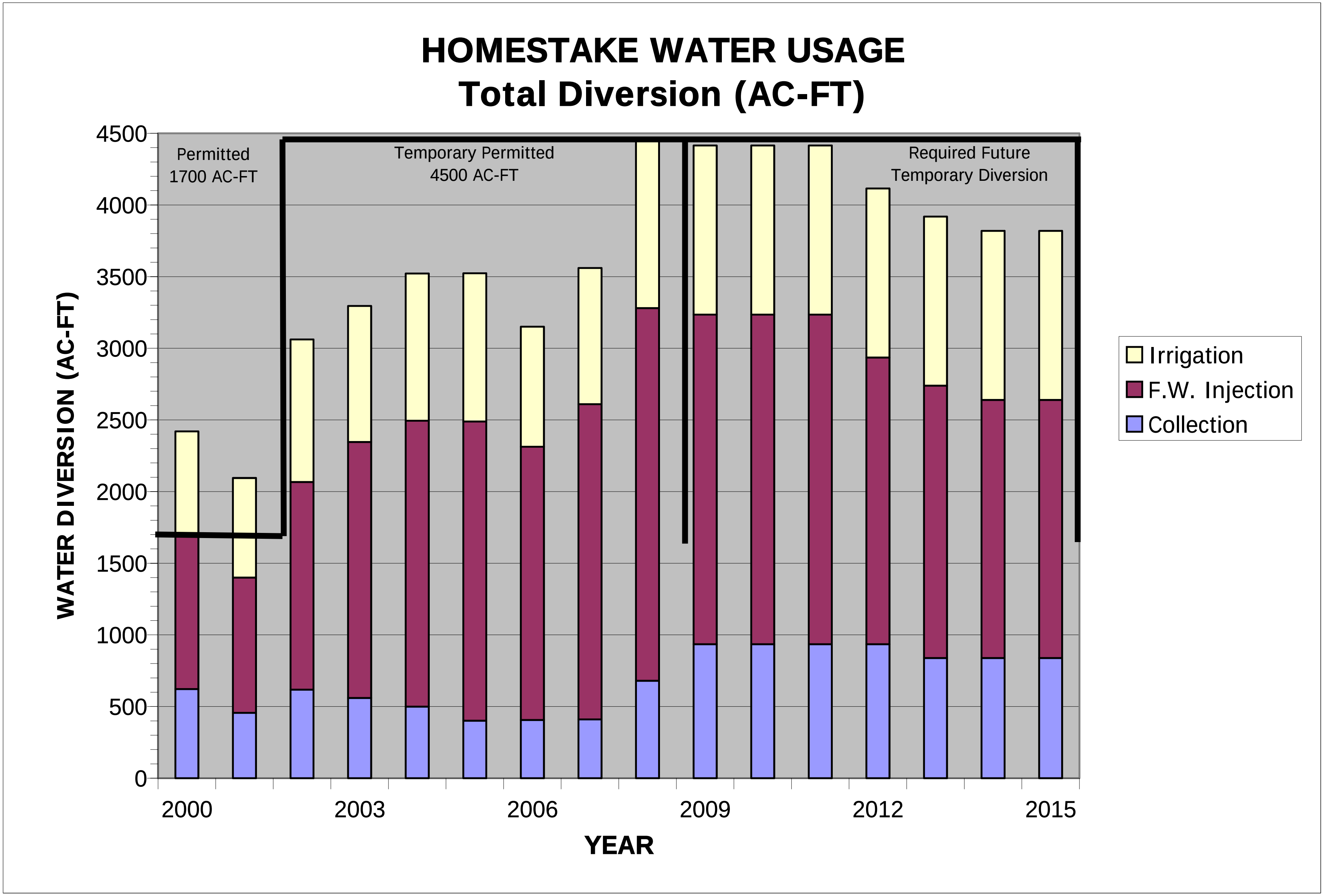


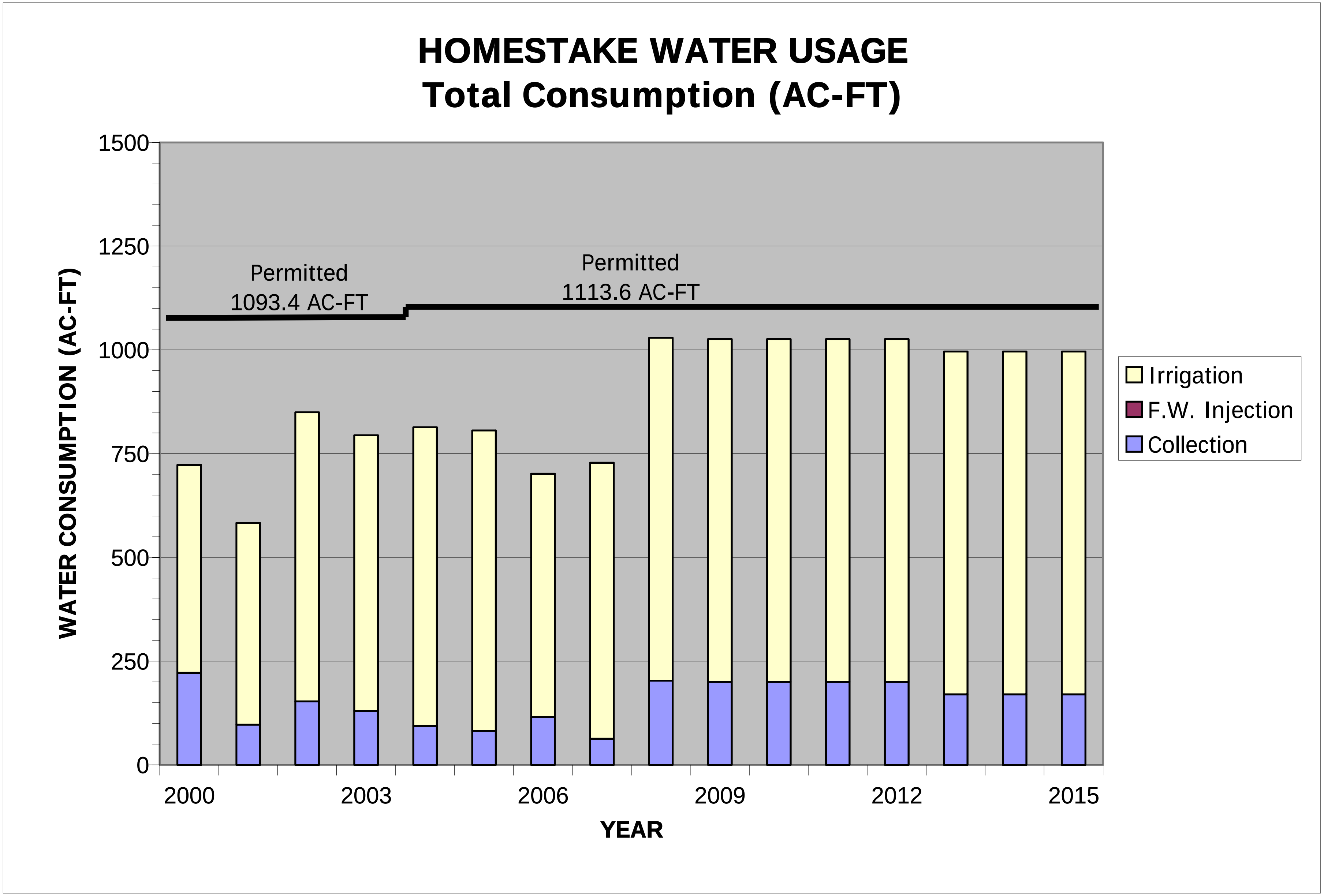
Figure B.

SCALE: 1"=1300' C:\PROJECTS\2008-06 \PLANFIGS lh DATE: 04/19/08	LOCATION OF FRESH WATER COLLECTION AND INJECTION WELLS AND PIPING, 2008	HOMESTAKE MILL & ADJACENT PROPERTIES GRANTS, NM T11&12N, R10W



Date: 11/28/2007

FIGURE 5-1. HISTORICAL AND PLANNED DIVERSION AT THE GRANTS SITE



Date: 11/28/2007

FIGURE 5-2. HISTORICAL AND PLANNED CONSUMPTION AT THE GRANTS SITE

APPENDIX C

COMMENTS

RSE Team Responses to
EPA Comments on the August 2008 Draft RSE Report for the Homestake Mining Company Site
Provided by Sai Appaji, David Reisman, Kathy Yager, and Ron Wilhelm,
with Assistance from Argonne National Laboratory and the US Army Corps of Engineers
(*Revised based on Comments from David Reisman, received on December 15, 2008*)

(Note that Comment #5 is missing and there are two #56. The RSE Team has not changed the numbering.)

Comment Number	Comment and Response	Reviewer
1	The scope and purpose of the Remedial Systems Evaluation (RSE) should be clarified early in the report. The Executive Summary in the Draft RSE Report defines the scope of the RSE as: "It is a broad evaluation that considers the goals of the remedy, site conceptual model, above ground and subsurface performance, and site closure strategy" (page iii, 1st paragraph). The Introduction states: "The purpose of the RSE is to evaluate the performance of the groundwater remediation system to determine if specific cost and/or protectiveness improvements are possible within the required regulatory process for the Site" (page 1, 1st paragraph). Additionally, Section 7.0 Summary (page 32, 2nd paragraph) contains the following statement: "In addition to evaluating the current groundwater remediation system to assist stakeholders in optimizing operations the RSE Team was also tasked with evaluating HMC's efforts to achieve the goals of the ROD." These somewhat different statements throughout the document should be consolidated into one statement of the RSE scope and objective and included in Section 1.1. The introduction should emphasize the independent nature of the analysis, but recognize that EPA, state, and HMC review is part of the process. Any changes made to the RSE report as a result of review comments should be embraced or owned by the independent review team (EQM). Response: Agree. Section 1.1 will be modified to provide a better description of the objectives.	EPA (Argonne and Yager)
2	The conceptual site model (CSM) as presented in the report seems to be strictly a summarization of the CSM developed by HMC over the years. It would be useful if the report contained a critical examination of key CSM assumptions, their technical basis, and any uncertainty that might exist with those assumptions. For example, the spatial location and configuration of water-bearing units and their inter-relationships is presented as a known fact, as are presumed water flow directions both pre-remediation and as they currently exist. Response: Agree. A new CSM (consisting of two parts) will be prepared. CSM-1 (Section 1.5.2) will focus on the hydrogeologic setting and CSM-2 (Section 2.1) will focus on the remedial system components. The RSE does not provide explanations for certain aspects of the contaminant distribution, such as why the plume near	EPA (Argonne)

	Felice Acres is detached from the main plume (Figure 4.3-53), what transport mechanisms caused impacts in the Middle Chinle (Figure 6.3-14) and Lower Chinle (Figure 7.3-8) aquifers. These issues could result in a revised CSM. Response: Agree. Language will be added throughout the Final Report to better describe the mechanisms by which the Chinle Aquifers are contaminated. Note that Figure 4.3-35 does not depict a detachment of the plume but demonstrates where the plume concentration is below the NRC action level (refer to Section 3.3).	
3	Consider alternatives for hydraulic control that may reduce evaporative demands. The current approach of injecting >1,000 gpm of San Andres aquifer water into the alluvial aquifer (for hydraulic control) likely adds a significant amount to the evaporative demand at the site (b/c it is assumed that some injected water is recaptured by the extraction wells and eventually sent to the evaporation ponds). Since one of the limiting factors at the site is evaporation capacity, it may be worthwhile to look at reducing the San Andres injection flow rate and using extraction wells alone (or other capture techniques) rather than injection/hydraulic mounding to achieve capture. The trade off of the two approaches can be evaluated using formal hydraulic and or transport optimization techniques such as MODMAN (see epa.gov/optimization for more information) or through manual approaches using flow and transport modeling without mathematical optimization. This process may "free up" evaporative capacity of the current system. Response: The use of San Andres Aquifer water does not significantly affect the evaporative demands of the site. The primary source of water going to the evaporation ponds (71% or 121 gpm) is the Large Tailings Pile flushing program. The remaining 29% (49 gpm) going to the evaporation ponds comes from the Alluvial Aquifer after RO treatment. This water is primarily re-injected Alluvial Aquifer water and Chinle Aquifers water. This amount is only 4% of the total amount of San Andres Aquifer water being pumped into the Alluvial Aquifer for hydraulic control. It is agreed that independent modeling might assist evaluation of alternative pumping approaches. The effort necessary to conduct independent modeling involves a robust approach involving multiple aquifers including vertical communication between the aquifers. Independent modeling was not a part of this RSE.	EPA (Yager)
4	p. 20, sec. 4.3. Please provide a basis for statements such as "Contaminant mass is being removed and controlled in the subcrop and "mixing zones" in section 4.3.1.3 and "… removal of this water controls potential impacts to the aquifer…" in section 4.3.1.4. The report does not discuss any independent analysis of adequacy of capture. Response: Agree. This section will be revised to provide additional clarification. A thorough capture zone evaluation is necessary using the lines of evidence for capture as proposed in the recent EPA guidance on capture zone assessment (A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems, EPA 600/R-08/003, January 2008). Until this analysis is complete, a determination regarding whether the contaminated groundwater is being	EPA (USACE Becker and Yager)

	captured in each aquifer units cannot be made. Although this analysis is beyond the scope of the RSE, a recommendation describing the importance of understanding capture and the steps involved in conducting this analysis should be included (and highlighted) Response: Agree, however, the data necessary for a detailed independent capture-zone analysis was not available to the RSE Team. *While EQM did not have the data to do capture zone analyses, the reviewers can still comment on whether or not in their professional judgment that the extractions are acquiring or missing water to what extent and make recommendations for improvement. Also, in this response, was the discussed recommendation placed in the document* Response: It is the RSE Team's professional judgment that the current system is working as intended as defined in June 2007 conditions. The RSE Team concludes and states in the report that the current design may not allow HMC to meet its remediation goals	
6	1) Information on the water balance for all aquifers, ponds and waste piles, injection locations, if presented in a clearer format, would be helpful in determining where the water gains and losses occur in this complex system. Tables and flow diagrams would go a long way in understanding where the water is gained, and lost in this complex system. Response: The HMC water balance is continually fluctuating, with daily (and even hourly) changes in how water is moved throughout the system as affected by equipment failures, operating conditions at the RO unit, and the ability to use the spray evaporation system, for example. In fact, the RSE Team is sure that the movement of water in the system was modified on the day of the Site Visit because the rate of spray evaporation was less in the afternoon than in the morning. It is important to recognize that hundreds of injection and extraction points may be used daily by HMC. The RSE Team will prepare a process flow diagram for the remedial system that hopefully provides a clearer description of how water is moved throughout the systems. *I am not sure that I saw anywhere in the documentation that "hundreds of injection and extraction points may be used daily." If this statement was true, this may be an inefficient system by nature of this design. How does Homestake optimize their selection of wells for the best capture scenario?* Response: Information available to the RSE Team indicates that optimization is based on model predicted conditions, field observations and professional judgment. Optimization is based on injection not extraction strategies. HMC uses tailings pile extraction wells, tailings pile perimeter drains, and Alluvial Aquifer extraction wells to extract injected water. Further,	EPA (Wilhelm)

	Alluvial Aquifer injection wells are used to flush the aquifer and to develop a hydraulic barrier to downgradient migration. 2) Mass balance for all the contaminants listed for the Actions Levels. This could follow the outline of the water balance above. Maybe this approach can help to understand the actual mechanisms responsible for the reduction in contaminate concentrations that are described with time. Not much is known about the source term concentrations or form. Might this reduction be due to dilution effect of the added water? Response: Agree, however, the information (e.g., detailed analytical results of all remedial system components) necessary for a detailed mass-balance analysis was not available to the RSE Team. 3) No data or information is given to support the Action Levels being met in the time frame stated (2014, 2017). A sensitivity analysis of the flow, transport model used for these time frames might be in order. Response: The RSE Team is conveying the time frame reported by HMC based on modeling it completed. The RSE Team did not conduct a sensitivity analysis to validate HMC predictions.	
7	The injection system for the pile is passive. There is no information regarding the screened intervals of the injection and extraction points in the pile, nor is there any information regarding the depth of the submersible pumps in the extraction wells, or the average depth to water in the extraction wells when the pumps are in operation. Depending on these details, the pile could either be nearly fully (pumps near surface and water allowed to accumulate to near the top of the extraction wells before the pump is activated) to less than half saturated (pumps near the bottom of the extraction points and water pumped aggressively, keeping water levels in the extraction wells low). If the latter case, there may be a significant amount of contaminated mass within the pile that will not be addressed by the current scheme. In addition, uranium mill tailings are typically fine-grained materials that may exhibit dual porosity behavior under the current injection/extraction scheme. The implication is that there may large zones of the tailings pile that are relatively "untouched" by what is currently being done. It is not clear whether tailings samples were collected and analyzed when the current set of injection/extraction points were installed. If there were, it would be important to know what the likely mass of uranium is in the pile, and to what degree any significant mass removal is taking place. Response: The RSE Team does not view the injection system as passive because contaminants are actively being removed. However, in response to this comment the report will be modified to clarify the description of the Large Tailings Pile flushing and contaminant removal program (Sections 2.2.2, 2.3.1 and 4.1). Other information suggested by the commenter (e.g., analytical data, distribution of slimes, etc.) were not available to the RSE Team. *I don't understand the comment and how an injection system could be passive (by push?). However, the extraction well*	EPA (Argonne)

	designs need to be discussed in more detail in the document, and the screening intervals for capture needed to be clearly detailed. Of the extraction wells, they could be divided into groups—0-10’, 11-20’ etc., so the reader has an understanding of where the water is taken (and not just an aquifer). In the same thought trend, the injections—how deep in the pile, etc. Again, grouping may giver readers a better perspective of the system. It is hard to discuss optimization if the complete system is not detailed in the report. Response: It is agreed that the system is not passive. Well logs for the tailings pile were not available to the RSE Team to conduct the analysis suggested.	
8	Consider horizontal drip lines for delivering water to the tailings pile rather than the vertical injection points currently used. The expectation is that this would result in a more uniform and complete leaching of the pile, if uranium mass removal is a goal for the tailings pile. Response: The RSE Team does not believe that horizontal drip lines will be as effective as vertical wells for the following reasons: 1) drip lines may only affect a few inches of the topmost part of the pile (to pile is over 85 feet thick), 2) the very high evaporation rate (60-90 inches per year) may result in most of the water being lost via evaporation; and 3) the very cold conditions would cause the small delivery tubes to freeze closed for extended periods.	EPA (Argonne)
9	The report contained no discussion of geochemistry, or what potential impacts mixing waters from various sources for injection purposes might have on the mobility of uranium and other contaminants of concern. It is not clear from the report the degree of flexibility the site has in changing the mix of injection water sources, nor is there any discussion as to whether thought has been given to modifying basic water chemistry prior to injection to better control contaminant transport characteristics. Response: Agree, however, the data necessary to conduct an independent geochemical analysis were not available to the RSE Team.	EPA (Argonne)
10	The large tailings pile is shown to have toe drains and french drains (Figure 29). The text does not describe the construction or depth of the toe drains, so it is unclear as to whether they would allow the escape of water injected into the pile. The French drains are not described in the text. Based on Figure 29, the toe drains/French drains are not located at the true perimeter of the pile, nor do they address the interior of the pile. Has there been any consideration given to horizontal drilling along the basement of the pile and installation of drains that transect the pile’s footprint? Response: Detailed construction information was not available. The RSE Team understands that the toe drains are not designed to capture of all water injected into the pile. A system of extraction wells beyond the limits of the Large Tailings Pile is used to manage water that may escape.	EPA (Argonne)

	The RSE Team did not previously consider the use of horizontal wells to collect water from the base of the Large Tailings Pile. However, in response to this comment, the RSE Team believes that the size of the Large Tailings Pile (about 1 mile long by a third mile wide with a depth to groundwater of > 50 feet) makes horizontal wells impractical. *EQM needs to comment on the effectiveness of the extraction wells in capturing the injection water or tailings water. Bottom line: Is this an effective method of capturing contaminated water? Are there other possibilities for capture? (see comment 4 above)* <u>Response</u>: For the date and time of the RSE the integrated system of Tailings Pile wells and drains and Alluvial Aquifer injection and extraction wells is effectively managing the source of contaminants in the Alluvial Aquifer. The Upper Chinle Aquifer remains at risk.	
11	There is a concern that the large tailings pile flushing system may mobilize additional metals through the injection/flushing process and that some of these contaminants may escape the extraction system in the tailing pile and migrate to the underlying alluvial aquifer. Suggest evaluating metals concentrations in the toe and French drains' effluent, and conduct a mass balance for the injection/extraction system in the pile to determine how much water, and consequently how much contamination, is being lost out the bottom to the underlying alluvial aquifer. <u>Response</u>: It is agreed that the flushing program could mobilize any metals present in the pile. The NRC has determined that only uranium, selenium, molybdenum, vanadium, radium, and thorium require remediation. The RSE Team evaluated groundwater quality data available from HMC and NMED and did not identify any other metals present in groundwater at levels requiring further evaluation. The data necessary to conduct an independent mass balance analysis of the Large Tailings Pile were not available to the RSE Team. *Did EQM have any analyses of the targeted metals for toe drain or French drain? If not, why didn't they request the data from Homestake?* <u>Response</u>: The NMED database was reviewed for samples from sumps and drains. Additional data were not requested by the RSE Team.	EPA (Yager)
12	The recommendations appear to be reasonable. However, the report would be greatly improved if a more complete technical basis were provided for each recommendation. For example, the technical basis for recommendation 5 on page iv is not clear. Given that "HMC has not yet eliminated the Large Tailings Pile as a source of contamination" (see item 2, page 32) it would be helpful to discuss the technical basis for understanding the performance of the Large Tailings Pile dewatering and flushing system in depleting this contaminant source. Discussion of the CSM and specifically the conceptual model for	EPA (Argonne)

	contaminant release from the tailings piles and subsequent transport in the subsurface is important in this regard. Such a discussion could provide the reader a basis for understanding if "using more aggressive water or infiltration trenches to increase contact of leaching water with the slime in the Large Tailings Pond" (see recommendation 5 on page iv) is both necessary and sufficient to reduce the source term. In the absence of such discussion of the technical basis, the reader is left to wonder how the observed decrease in contamination concentrations at wells near the Large Tailings Pile should be interpreted. Is it because the contaminant source inventory in the Large Tailings Pile is being depleted effectively by the dewatering/flushing system? Response: Agee. Language will be added through out the Final Report to support the reasons behind the RSE Team's recommendations. What is limiting the rate of contaminant removal? (e.g., is the rate of uranium removal limited by the rate of oxidation of U(IV) to U(VI)? or is it limited by the U (VI) solubility? or is it limited by the injection rate and injection locations of the flushing water?). Response: No information was available to evaluate uranium oxidation state, mineral complex, etc. *What is the limiting rate or limiting factors in capturing the water? Comments on this point are relevant and required of EQM.* Response: Obtaining the data necessary to determine the limiting rate and limiting factors is outside the project SOW.	

13	A small note about the remedial objective of reducing leachate concentrations to 2 mg/l. The real issue is not the concentration of the leachate, but the mass flux exiting the pile via leachate. The problem with the 2 mg/l goal is that as long as the site is actively introducing large volumes of clean water into the pile, the concentration observed in leachate may well not reflect the concentration that would be observed once the injection system is turned off. It is plausible at that point that leachate concentrations could significantly rebound; this would not necessarily represent a system failure from a groundwater protection standpoint if the vertical mass flux remains stable or decreases with the termination of injection points. Response: The RSE Team agrees that mass not concentration is the key. Information available to the RSE Team indicates that HMC's modeling efforts utilizes mass input assumptions. With regard to rebound, the RSE Team is in agreement with the commenter and statements of HMC during the Site Visit indicate that HMC expects some rebound to occur. *Just to agree is not enough. Give us some sort of prediction of what to expect in the future. How does this issue interact with the RAO of 2 mg/l? If the 2 mg/l concentration is made, how long after that period may rebound occur?* Response: The RSE Team did not conduct independent computer modeling to predict rebound. HMC's model predicts rebound may occur for 30 to 40 years after active flushing is terminated. They predicate the rebound will not exceed NRC action levels.	EPA (Argonne)
14	Consider capping the pile with an impermeable layer to eliminate water intake to the pile and allow the pile to dewater using the existing extraction wells within the pile. This would eliminate what we assume is a continuing source of contamination to the underlying alluvial aquifer. Response: Agree. A discussion will be added to Section 4.1.	EPA (Argonne)
15	Consider installing horizontal collection drains via horizontal drilling beneath the pile to improve leachate collection efficiencies and to minimize contaminant movement from the pile into the underlying aquifer. Response: Refer to the response to Comment 10.	EPA (Argonne)

16	Evaluate alternative passive and/or active methods for facilitating evaporation. These should focus on techniques that do not include displacing water droplets to any significant height, unless it can be determined that the residue from droplet evaporation does not pose a significant long-term exposure risk to downwind residents and/or a significant deposition source for downwind surface soils. Response: The report is limited to utilization of increased pond capacity. Calculations will be added to Section 4.3.3 regarding the anticipated new evaporative capacity of the third pond to show its adequacy. In addition, calculations showing the new pond can probably handle the additional flow of discontinuing spray evaporation will be added. *EQM failed to respond to the entire comment and needs to do so re: other possible methods for evaporation or getting rid of excess water. For example, low spray evaporation (compare short vs. long spray columns).* Response: Additional evaporation technologies will be discussed in the report.	EPA (Argonne)
17	General. This Remediation System Evaluation (RSE) report only generally follows the standard outline for RSEs previously conducted for EPA. I appreciate the effort that must have gone into understanding this very complex remediation system, and I suspect there may have been more analyses done regarding alternatives to the current work by HMC than what is apparent in the report. Still, the report itself does not stray much beyond the somewhat confusing description of the remedy and operating strategy. The report does not clearly indicate the RSE looked at the overall approach to the remedy. Based on the RSE report and a necessarily brief look at a few supporting documents, it would seem this is a site with a somewhat questionable and expensive remedial strategy with the potential for completed exposure pathways for residents and ecological receptors. I would have expected additional recommendations for everything from suggested operating conditions for existing treatment components, to alternative treatment equipment or processes, or even entirely different remedial strategies with at least some conceptual description and cost for the recommended changes. Furthermore, an independent critical evaluation of the effectiveness of the remedy is a key aspect of an RSE. Based on my reading the RSE report, there is little discussion of the success of the intricate redistribution of water between aquifers in containing and reducing the footprint of the plume. The RSE expresses few concerns other than making a recommendation for alternative water supplies for one subdivision (Valle Verde) that does not appear to be impacted by contamination and would not seem imminently endangered. The RSE effort needs to include a more thorough analysis of the adequacy of the capture attained by the extraction system under current conditions and perhaps under conditions resulting from other optimization recommendations. Response: Significant effort was made by the RSE Team to thoroughly understand and evaluate this system's ability to achieve its intended objectives. To ensure that the RSE Team's understanding is adequately conveyed, the Final Report will be modified	EPA (USACE Becker)

	through out as necessary. The report does not address the adequacy of the monitoring networks in the various aquifers. There seems to be a very large number of monitoring wells in some aquifers and significantly fewer in others. There would seem to be a very good opportunity for optimization of the program here. Response: Agree. The report will be modified (Section 4.3.7.)	
18	Section 5.6, page 28. Regarding the safe use of contaminated water for animal feed crop irrigation, in a letter to the Bluewater Valley Downstream Alliance in July 2008, the NRC discussed results from HMC monitoring and dose assessments (See Below). The presented results for uranium dose are very low; however, the draft report was not available at the NRC website so that a review of the soil concentrations and model input parameters could be made. The May 2008 ATSDR Health Consultation discusses local concerns about using contaminated water for irrigation, but states that there were no vegetable or soil data available for them to analyze. Apparently, the draft HMC data was not made available to them. ATSDR did point out that uranium transports poorly from soil to plants and recommended that root vegetables be thoroughly rinsed before eating. "With regard to the HMC irrigation system, 10 CFR 40.65 requirements specify that HMC provide NRC periodic effluent monitoring reports. The HMC 2006 Annual Monitoring Report/Performance Review (ADAMS No. ML070940232) provides information on irrigation using onsite supply wells. The report indicates that three irrigation systems were operated in 2006 and that several hay cuttings were produced. Further, the report identifies the supply wells used and the uranium and selenium concentrations in the irrigation water. The report shows that the irrigation water has not exceeded the NRC standard for uranium, or the New Mexico Water Quality Control Commission standard for selenium." "HMC has conducted environmental monitoring for soil and hay for the irrigated plots and has provided NRC a draft report on its evaluation of irrigation with alluvial ground water for 2000 to 2006 (ADAMS No. ML082070083). The report indicates that the uranium and selenium soil concentrations are increasing, but do not exceed acceptable levels. The average selenium concentrations for hay in 2006 ranged from 0.75 to 1.40 milligram per kilogram (mg/kg). The National Research Council has established 2 mg/kg of selenium as the maximum tolerable concentration for cattle feed. HMC will continue to monitor the irrigation project for selenium levels. The average uranium concentration measured in hay from 2000 to 2006 was 0.83 mg/kg with a standard deviation of 0.58 mg/kg. HMC used the guidance in NUREG/CR-5512 to estimate the uranium transfer from hay to beef cattle to people, and has estimated the radiation dose from beef consumption. The radiation dose from ingesting beef fed hay grown on the irrigated plots is estimated to be 0.04 millirem per year (mrem/yr). This is a very small fraction of the NRC public dose limit	EPA (USACE Hearty, Yager, and Argonne)

	of 100 mrem/yr." Include comments in the report recognizing that HMC has evaluated soil and hay concentrations to monitor update and accumulation in soil. Provide an opinion as to whether this approach seems reasonable and recommend potential trigger points where a change may need to be made with the irrigation strategy. Argonne – We have looked at plant uptake in the context of NORM contamination, and I don't believe that it is significant. I have never seen a rad-contaminated site with relatively low-level contamination (such as this site) where biota had to be disposed of in a special way because of plant uptake concerns and bio-concentration effects. Response: The RSE Team is in agreement and Section 5.6 will be modified accordingly. *Why did EQM not request this report from the EPA or HMC to do these calculations?* Response: During the Site Visit the RSE Team asked if any such information was available. We were informed at that time that it was not. Pursuant to this comment the RSE Team obtained a copy of the July 2008 letter from NMED and it contains no more information than included in this comment.	
19	Page 7, Section 1.5.3: The first sentence states 12 COCs were identified by the NRC, but only 10 constituents are listed in Table 2. Response: Agree. The number of constituents should be 10 not 12. The change will be made. Please identify the remaining two COCs. Also, suggest that the most dominant soluble uranium species on site, e.g., uranyl dicarbonate $[UO_2(CO_3)_2]^{2-}$, uranyl tricarbonate $[UO_2(CO_3)_3]^{4-}$, or trihydroxocarbonatodiuranyl $[(UO_2)_2CO_3(OH)_3]^-$, be identified for assessing the remediation systems. EPA USACE Mao Response: While the RSE Team agrees that knowledge about uranium speciation would be very important in understanding the geochemistry of the remedial action, that information was not available to the RSE Team. *Mention uranium speciation issues in the RSE. How does this affect the study?* Response: We do not see that information on uranium speciation affects RSE in any way. However, it does limit an in-depth feasibility study level investigation that may be required.	EPA (USACE Mao)

20	Section 1.5.3.1, page 8. The last two sentences of this section refer to Figures 4.3-78 and 4.3-83 and state that the figures show decreases in uranium concentrations. Please revise "uranium" to "selenium" in these sentences. It appears that Well 851 has shown increased Se concentration in 2006 and 2007 and revise the last sentence accordingly Response: Agree. Corrections will be made.	EPA (USACE Hearty)
21	Page 10, Section 1.5.4: Suggest that the document provide quantitative evaluations of soil contamination due to crop irrigation with contaminated groundwater and bioaccumulation in livestock due to feeding with hay irrigated with contaminated groundwater. Response: Agree, however, no information was available to the RSE Team to provide quantitative evaluations with regard to soil contamination or bioaccumulation of metals associated with the irrigation program.	EPA (USACE Mao)
22	Page 11, Section 2.2.1: Suggest that the document provide detailed discussions of the potential contaminant transport from Chinle Aquifers to San Andres due to continuously groundwater withdraw from San Andres Aquifer. Response: Agree, however, it is more appropriate to include this discussion in Section 1.5.3.5.	EPA (USACE Mao)
23	p. 10, sec. 1.5.4. The information regarding the use of water by residents from the surrounding subdivisions should be more specific regarding which of the 5 aquifers addressed in the RSE they are using as their water source. Please expand on the number of wells in each aquifer and if the areas where the wells are located are within the plume areas. Also summarize the results of the HH and Eco Risk assessments performed by Region 6 (in 1-2 paragraphs). Response: Nine residents in the Valle Verde subdivision currently use wells for potable supply purposes. The RSE Team was not able to specifically determine how many other residents in the Subdivision use wells for non-potable purposes. However, data provided by the ATSDR as a part of its risk evaluation indicates that throughout the Subdivisions individual home owners still use wells for irrigation or stock watering. The Alluvial Aquifer and the three Chinle Aquifers were historically and are currently used for potable and non-potable purposes. Section 1.5.4 will be modified to better address this comment. The Region 6 HH and Eco Risk study is not currently available.	EPA (USACE Lien)

24	p. 11/12, sec. 2.2.2. The text should indicate if the tailings piles were formed entirely at grade or if the base of the units were excavated to some depth below the original ground surface. Response: Agree. Section 1.5.1 will be modified to indicate the piles are at grade. At some point within the RSE the authors should identify optional methods for remediation of the tailings piles, especially capping and the implications on other systems such as the Treatment system, pumping costs and so forth. Response: Agree. Section 4.1 will be modified to address these comments. Why is 6 gpm recovered from the pile flushing process sent to the RO system instead of all 87 gpm going to the evaporation basins? Response: HMC indicates that this is the worst quality water. Also please clarify how it was determined the small tailings pile was not a significant source of contamination to the aquifer. Section 2.3.2. page 14 indicates the "area of highest uranium and selenium contamination south of the Small Tailings Pile" implies the small pile is a source. Response: No information was available to the RSE Team to support NRC's decision that the Small Tailings Pile is not a significant source.	EPA (USACE Lien)
25	Point of Compliance (POC) wells are mentioned on page 12, but not identified by names until page 18. The RSE should call out a figure that shows their locations, but it doesn't, and they were not located during a scan of the available figures. Response: Reference will be added to Figure 49 which is also referenced in Section 2.6.	EPA (Argonne)
26	POC wells are not present in the Middle or Lower Chinle aquifers "because these aquifers do not subcrop beneath the HMC site" (page 18). These units, however, have contaminants above the action levels (Figures 6.3-11, 6.3-14, 7.3-8). The RSE or CSM do not provide possible explanations for this contamination. Response: After further evaluation it was determined that the quoted statement is incorrect. There are no POC wells in the Chinle Aquifers because all Chinle Aquifer wells must achieve the NRC action levels (Section 3.3). Appropriate changes will be made. As previously indicated, a new CSM will be prepared to allow the reader to better understand the mechanisms by which the Chinle	EPA (Argonne)

	Aquifers are contaminated. Additional, language will be added throughout Section 1.5 to convey how the Chinle Aquifers became contaminated.	
27	p. 12, sec. 2.2.2. Even though the NRC does not consider the small tailings pile a source, there does seem to be a spatial relationship between this pile and a ground water U plume. If there would be a reduction to the ground water remedy life-cycle costs and a reduction in human exposure potential resulting from some action at the small pile, options should be discussed. Response: The RSE Team agrees that there is a spatial relationship between the Small Tailing Pile and the plume of contamination in the Alluvial Aquifer. Presently, HMC relies on the groundwater extraction system to address any contaminants that may be coming from the Small Tailings Pile. These efforts are directed toward HMC's current goals for protection of human health and the environment (i.e., NRC action levels). At some future time alternative action levels may be established by NMED or USEPA for the Small Tailings Pile, but it is not possible for the RSE Team to evaluate future conditions.	EPA (USACE Becker)
28	p. 13, sec. 2.2.4. Text here indicates extraction at an average of 15 gpm from the Upper Chinle aquifer, yet elsewhere in the text (e.g., sec. 2.3.1) much higher extraction rates are indicated. This should be clarified. I actually tried to make a mass balance diagram schematically showing where water is extraction and where it goes. The rates for the Upper Chinle were not identified. Response: Agree that 15 gpm is incorrect. The Section will be modified to indicate 75 gpm.	EPA (USACE Becker
29	Section 6.1, page 29. Regarding the use of spray evaporation, the following statement from Section 6.1 appears to recommend or conclude that the spray evaporation system will be discontinued following implementation of EP3. "The RSE Team is concerned about HMC use of spray evaporation to achieve necessary evaporation rates. Considering the issues of spray operations raised by local stakeholders, complete elimination of this practice seems appropriate through construction of a third evaporation pond." Condition 35.D. of Amendment 41 to License SUA-1471 (August 7, 2008) states "Operate evaporation ponds, EP1, EP2 and EP3, and enhanced evaporation systems located in each pond as described in the June 8 and 28, 1990; July 26, August 16, August 19, September 2 and 15, 1994; October 25, 2006, February 7, 2007, July 18, 2007, and March 17, 2008, submittals." There are significant stakeholder concerns that the EP3 area may not be adequate as proposed and if the RSE Team recommendation to eliminate spray evaporation is put in place, the reduction in total evaporation capacity should be reviewed to ensure that it is adequate. Response: Refer to response to Comment #16.	EPA (USACE Hearty)

30	p. 15, sec. 2.5.2. Based on estimated pan evaporation rates for the Grants area, I confirmed the existing evaporation ponds are inadequate to handle even the current flow (I estimated 130-140 gpm average evaporation vs. 170 gpm input). The additional evaporation pond would provider added capacity of 80-90 gpm, though this would still not allow both RO units to run at capacity. Response: Agree. Calculations to evaluate Pond #3 will be added to Sections 4.3.2 and 4.3.3. I question the value of transferring mass from the 170 acre tailings pile to 77 acres of ponds (to ultimately be capped), particularly given that there will be significant mass remaining in the tailings pile. Response: The RSE Team suspects that mass is being transferred from the Tailings Pile to Evaporation Ponds because there may be a future opportunity for recovery and sale. HMC has indicated that it periodically evaluates metals recovery from the ponds.	EPA (USACE Becker
31	p. 15, sec. 2.5.2. The pan evaporation numbers should be included in the report for informational purposes. Have experiments been done at the site, or were numbers estimated? Pan factors used should also be included. Estimates based on NOAA data from Grants and Albuquerque shows a range of annual pan evaporation from 60 – 90 inches per year (unadjusted). Using an adjustment factor of 0.7 indicates a pond capacity of 95 to 143 gpm. More information on the design and performance aspects of the spray systems would also be useful for those reading the analysis. Response: Agree. Please note the response to comments #16 and #30.	
32	p. 15, section 2.5.1. The RSE should more fully address the individual components of the treatment process, and in this case provide a process flow diagram to illustrate the current operations. The discussion should identify major contaminants, function of each individual process in order to set the stage for evaluation of options to consider in later sections of the report. The evaluation should include the evaporation ponds. After the individual components are evaluated, the entire system should be evaluated to assess the interrelationships between components and the extraction/injection system requirements. Response: Agree. A flow diagram of the treatment unit is presented on Figure WB in Appendix B. Sections 2.5.1 and 4.3.2 will be modified appropriately.	EPA (USACE Lien)

33	p. 17, sec. 3.2. Briefly state why no treatment standards apply to the treatment system. What are the current operating goals for the system and how were they determined? Response: Agree. Section 3.2 will be modified to indicate that no treatment standards apply because there is no discharge from the plant to surface water. HMC's goal is to produce the lowest possible TDS water to be used for injection into the Alluvial Aquifer.	EPA (USACE Lien)
34	Section 3.3, Table 2, page 18. Correct the action level entry for uranium in the Lower Chinle Aquifer to 0.03 mg/L. Response: Agree. The correction will be made.	EPA USACE Hearty
35	p. 19, sec. 4.2. The report seems to miss an opportunity here. It would not seem that the effort is really to dewater the tailings. In fact, based on figures in the RSE, there is more water added to the pile than extracted from the wells and toe drains. This would suggest the efforts are forcing water (and also contaminants) into the alluvial aquifer. I do not see the value of the effort when the pile will be capped regardless of the flushing success. There will still be contaminant mass in the slime that is likely little impacted by flushing. Truly dewatering the pile would reduce the mass loading on the aquifer, and would reduce the amount of water being pumped. Globally refer to the "dewatering" system as the "dewatering/flushing" system to provide clarity to readers. Response: The term "dewatering" is not original to the RSE Team. The RSE Team agrees that the objective is not dewatering and thus will use the term "contaminant removal" or "flushing" in place of dewatering. I question the value of transferring mass from the 170 acre tailings pile to 77 acres of ponds (to ultimately be capped), particularly given that there will be significant mass remaining in the tailings pile. Response: Considering that the contaminant removal program has been in operation for about six years and that over 500,000 pounds of contaminants have been removed from the Large Tailings HMC is demonstrating that it is achieving the goal of the ROD. Section 4.2, page 19. Are estimates available for the total amount of uranium in the Large Tailings Pile? If so, they should be provided to clarify the significance of removal of "hundreds of tons of uranium". Response: No information was available to the RSE Team about the amount of uranium remaining in the pile. It is agreed that "hundreds of tons of uranium" have not been removed. Through 2007 a minimum of 137,000 pounds or 68.5 tons of uranium had been removed. Appropriate changes will be made to Section 4.2. *There were 327,000 lbs of other contaminants that are not mentioned, so a table may be good to add to the RSE to inform*	EPA (USACE Becker, Yager, and Argonne

	the reader of the other COCs removed. Also, if you are going to cite the ROD, you better cite the goal that you are discussing. Response: Section 4.1 provides information on the number of pounds of uranium, selenium, molybdenum and sulfated recovered from the Large Tailings Pile. No information is available on other contaminants.	
36	Water levels in pumping wells should not be used in water level mapping because they are not representative of the water level in the adjacent aquifer due to well losses (EPA 600/R-08/003). It is not clear from a comparison of the water-level maps and the extraction system maps whether this practice is taking place. Response: Agree, however, information about how HMC prepares water table and potentiometric maps was not available to the RSE Team.	EPA (Argonne)
37	Details of the groundwater flow model are not given, and it is unclear (page 17) whether the multi-layer model is focused on the alluvial aquifer only, or on both the alluvium and the Chinle units. Given the hydrogeologic complexity and the large number of extraction and injection wells, a useful model of this site would require a significant effort to include proper framework, parameter values, and boundary conditions. Evaluation of the 2005 model is beyond the scope of this review, of course, although it is assumed that the model and the accompanying transport model rely on appropriate input data, including sorption values, and that both have been reviewed technically. It is possible that an optimization model relying on linear programming or similar techniques could be created from the existing flow model so that the proper pump rates at existing wells and possibly additional well locations for hydraulic containment could be determined. Response: No modeling was undertaken by the RSE Team.	EPA (Argonne)
38	p. 21, sec. 4.4.1.1. Please verify the nature of the precipitates. Is this really mineral scale? Is this biofouling? If mineral scale, what is the composition? Is there a well maintenance and rehabilitation program (if the pumps are scaling, the screens probably are, too)? This would be a great opportunity for the RSE to make recommendations to improve system reliability and reduce costs, too. Note that the failure of the pumps is not a matter of the quality of the pumps as implied here. Any pump will fail if allowed to clog with scaling or biofouling. Furthermore, the use of the above-ground piping would seem to be an issue that warrants some analysis – they must have some freezing problems. Average temperatures in Grants in a good part of December and January are below freezing. If this affects the reliability of the system, some suggestions would be appropriate. (buried headers, insulated above-ground piping, etc.). Response: No information was available to the RSE Team to verify the nature of the precipitates. HMC indicated that it is mineral. HMC has a well maintenance and rehabilitation program but its details were not available to the RSE Team.	EPA (USACE Becker

	The RSE Team evaluated methods (e.g., replace submersible pumps with jet pumps) to improve system reliability and reduce cost and found other alternatives to be less reliable and inhibiting the flexibility to modify the well network easily. While HMC could choose to use less costly pumps, their choice is based on site-specific experience. With regard to the piping, the RSE Team (second paragraph of Section 4.4.1.1) finds the current system to be most effective for this program. It allows HMC to easily change wells from extraction to injection, it allows HMC to easily take wells completely off line and it allows HMC to inspect the piping for leaks and to easily repair the lines.	
39	p. 21, sec. 4.4.2. RO plant discussion should include a PFD of the system including all chemical data, pH and so on used in system analysis. High pH is stated in the narrative, is this the most effective, are the membranes designed for this condition? Are there alternatives to the pretreatment step(s), is the step needed, how does it impact the RO performance? The system is running below its stated capacity, could effluent quality or reject quality be varied slightly with little or no impact to the remediation with significant savings in energy and membrane life? Are there alternatives to the chemical feed systems employed, filtration equipment used and etc? Response: Agree. A modified PFD is presented in Appendix B (Figure WB). There is insufficient information available to the RSE Team concerning the quality of water entering the plant to allow for an independent evaluation of treatment alternatives. However, Sections 2.5.1 and 4.3.2 will be modified to the extent possible. *How do you know if the RO system is operating efficiently if you do not know the input water? There were data analyses completed by HMC. Did EQM look at removal efficiency for the metals, and if so, please place in the document.* Response: The RSE Team identify system inefficiencies with regard to pH balancing, potential sand filter clogging, and lack of back-up if full scale operation is achieved. Information on the final discharge TDS was not obtained.	EPA (USACE Lien)

40	Section 6.1, second paragraph on page 29. The basis for saying that: "Without increasing the capacity to handle these waste streams, the closure schedule currently envisioned by HMC (i.e., all actions terminated by 2017) probably cannot be met" should be clarified. Also, the report should address why the closure schedule can be met with increased capacity. Response: The RSE Team will add clarification that HMC projections assume the availability of a third evaporation pond. It is reasonable to conclude that if there is no third pond the termination date calculated by HMC cannot be achieved. The RSE Team did not conduct any independent modeling to verify HMC's predictions.	EPA (Argonne)
41	p. 21, sec. 4.4.1.3. The RSE report could easily assess the impact of the pumping on water levels using transmissivity values for the San Andres from the ground water model or other sources. What are the drawdowns in monitoring wells? Response: Agree. A more in depth discussion of water-level declines in the San Andres will be provided. The RSE Team will provide this material in Section 2.2.1. Section 4.4.1.3 will be eliminated. San Andres Aquifer water levels were reviewed by the RSE Team. These data were evaluated and will be addressed in revised Section 2.2.1.	EPA (USACE Becker
42	p. 23, sec. 4.4.4. The report should note the likelihood of selenium accumulation. Certainly the Kesterson Reservoir case from California would seem to be potentially relevant. Response: Metals accumulation is discussed in Section 4.4.4. Data available to the RSE Team do not suggest that this site is comparable to Kesterson Reservoir.	EPA (USACE Becker
43	p. 23, 24, sec. 4.5. The report cost summary indicates the water treatment system accounts for 80% of the costs. Cost savings should likely be pursued for the extraction/injection systems and the RO plant in particular. Evaluation of the amount of water treated in the RO plant, the need for the flushing system at TP-1, and the costs associated with that effort compared to a cap for the facility should be evaluated. There is a high likelihood significant annual savings could be realized. Response: On average only about 2% (6 gpm) of water from the Large Tailings Pond goes for RO treatment. The rest (250 gpm) is from the Alluvial Aquifer. The RSE Team's understands that the RO unit is used principally to produce very low TDS water, which HMC has determined produces the best geochemical conditions for contaminant removal in the Alluvial Aquifer. The RSE Team agrees that clarification of the purpose of RO needs to be provided. Section 4.3.4 (formerly Section 4.4.4) will be appropriately modified. There are insufficient data on water influent for the RSE Team to evaluate alternative water treatment technologies. Data available to the RSE Team do not directly support a conclusion that placement of a low permeability cap on the Large	EPA (USACE Lien)

	Tailings Pile would be more cost effective than the current system. This conclusion is supported by the fact that the surface area of the top and sides of the Large Tailings Pile is about 183 acres and that the Pile has over 300 injection and extraction wells. However, a ballpark cost ($27.5 - $45.7 million) will be added to the report.	
44	p. 26, sec. 4.9. Apparently suggestions for optimization were made to HMC but the RSE report only provides HMC's responses (that support their current practices). The RSE report is presented to EPA, and the recommendations made for improving reliability and effectiveness are for the EPA RPM. Though the operator or PRP should certainly be offered a chance to comment on the report, the report should be the statement of the technical position and recommendations of the independent review team. The text regarding options should be expanded, regardless of HMC's responses. Response: Section 4.9 was not intended to indicate that the RSE Team made any suggestions for optimization to HMC during the Site Visit. This section is intended only to reflect HMC's experience (if any) with a set of alternative approaches identified during the Site Visit for which the RSE Team requested information. This clarification will be added to the Final Report. p. 27, sec. 5.1. This section is also the place to summarize the independently derived conclusions about the plume capture and remediation. Response: Agree. Section 5.1 will be modified to better address plume capture.	EPA (USACE Becker
45	p. 28, sec. 5.3. What about dust from dried sediment or from the tailings pile? What about radon? Response: Agree. Section 5.3 will be modified to provide more discussion about dry sediment in the collection ponds. With respect to the tailings piles, the Small Tailings Pile has an NRC radiation cap and the Large Tailings Pile has a cap of local "soil." The dust produced by either will be no more than generated by the neighboring undisturbed land. Radon is a radiological parameter monitored by HMC. Information provided during the Site Visit indicated that HMC is achieving adequate radon protection.	EPA (USACE Becker
46	Section 6.5, page 31. NRC has reviewed the adequacy of HMC air monitoring for radionuclides and shown that the effluent release limits are not being exceeded. The recommendation in Section 6.5 to monitor aerosols leaving the site should be better justified. Response: Agree. Language will be added to Sections 5 and 6 to support this recommendation. Also, from a letter from NRC to the NMED in August 2008, the NRC discussed several ongoing issues that are being investigated with HMC that should be discussed in the RSE as appropriate: "In this regard, in the past year NRC has taken action on, and resolved, a number of very important issues raised by NMED including: (1) evaluation of air monitoring at	EPA (USACE Hearty)

	the HMC site and characterization of "white residue" from the spray evaporation system; (2) review and analysis of regional groundwater hydrology to evaluate potential sources of contamination entering the HMC site; (3) working with HMC to develop a work plan to evaluate contamination in Well 986; and (4) an evaluation of the remediation actions for the western and southwestern uranium plumes in the alluvial aquifer downgradient from the tailings pile." Response: The actions referenced in the August 2008 letter from NRC to NMED are not yet completed.	
47	The report includes only a very limited description of the chemistry of the extracted water that requires treatment by reverse osmosis (RO). More characterization data on the water being treated by RO is needed in order to assess whether an alternative treatment process would be economically viable, and advantageous to the project. As assessment should be performed to determine if ion exchange (IE) could be used in place, or in addition to RO. The following water chemistry parameters would be needed to assess IE: pH, sulfate, chloride, nitrate, carbonate, TDS. Assuming that the pH of the water going into the RO unit is above 7.6, it is expected that the uranium is predominantly in the form of UO2(CO3)3 (a tetravalent anion). If present at high enough concentrations, other anions present in the water (i.e., sulfate, chloride, nitrate) would compete for binding sites on the IE resin with the UO2(CO3)3. The relatively high levels of sulfate indicated by data from some of the monitoring wells could interfere with the use of IE for uranium removal. The majority of the flow of water going into the RO system (~250 gpm) is extracted from the Alluvial Aquifer. The 2007 Annual Monitoring Report provides water quality data from Alluvial Aquifer monitoring wells. However, this data indicates that there is a wide variability in the levels of anions (e.g., sulfate ranges from about 300 to over 10,000 ppm). Thus, it does not appear to be possible to use this data to accurately estimate the water quality going into the RO system. Ideally, samples from each of the extraction wells that are used to supply water to the RO system should be collected to obtain the needed data. Also the flow-rate from each of the individual extraction wells would also have to be known. EPA USACe Coyle Response: Agree. No further action necessary.	EPA (USACE Coyle)

48	The report notes that the capacity of the evaporation ponds represents a "bottleneck" which limits the RO through-put, & in-turn limits the volume of high-quality water available for enhancing the progress of aquifer restoration. The flow-rate of the RO reject stream (i.e., brine) is about 49 gpm. One potentially attractive aspect for an alternative such as IE, is that it could result in a substantial reduction of the amount of brine generated. Examples of uranium selective resins include Amberjet 4400 Cl and Amberlite IRA910U Cl. In many applications, the volume of brine generated using IE can be extremely small relative to RO. The volume of brine generated is also dependent on what type of eluant is used to regenerate the resin. For example, the volume of brine resulting from regeneration of the above resins can be reduce by a factor of about 3, if an ammonium nitrate eluant is used, versus a sodium chloride eluant. According to the resin manufacturer, only 5 bed-volumes of brine would be result from regeneration of IE using ammonium nitrate (versus 15 bed-volumes of brine from regeneration of IE using sodium chloride). In either case, the volume of brine produced to regenerate IE would probably be at least an order of magnitude less than that produced using RO. Response: See response to Comment # 47. Recognition of alterative technologies for water treatment will be added to the report without evaluation.	EPA (USACE Coyle)
49	It is noted that there is no information provided regarding whether or not there is any neutralization step downstream from the step where the lime (or NaOH) is added to increase the pH to about 10 S.U. Alternative treatment processes could be impacted by pH. Any assessment of ion exchange (as an alternative to RO), would need to take into consideration the pH of the incoming water, and whether or not a neutralization step would be required. Response: Agree. Sulfuric acid is used to reduce the pH. The text of 2.5.1 will be revised to provide clarification.	
50	Off- gassing of Radon from various sources at the site was not addressed in the report. Recommend that regulatory agencies ensure that radon off gassing from the tailings piles and evaporation ponds are addressed through HMC's ambient air monitoring program. Response: As indicated in Section 5.3, HMC monitors for radon and other radiological parameters.	EPA (Wilhelm)
51	Generally concentrations of uranium should be expressed in both units of mass (to demonstrate compliance with the MCL) and activity (to demonstrate compliance with UMTRCA groundwater standards). Response: Uranium activity data were not available to the RSE Team.	EPA (Walker)

52	The report should state the source of the action level. Response: The RSE Team assumes that this comment concerns the genesis of the values. A combination of water-quality criteria and statistical evaluation of background data were used to generate the action levels. The RSE Team did not evaluate the history of changes of action levels.	EPA (Walker)
53	The report is well written and organized. The information about the complex site conditions are provided in a very easy to understand. Response: Thank you.	EPA (Appaji)
54	The report recommends HMC to build the third evaporation pond as proposed. However, the report does not discuss the sizing of the pond that should be build to accelerate the clean up of ground water at the site. Response: Agree. This information will be added to Section 4.1.	EPA (Appaji)
55	The report recommends discontinuing the spray evaporation pond; however, it does not address any specific technical reason for stopping this practice other than the community concerns. Response: Agree. The recommendation is made due to concerns about the chemical quality of the solids that are transported beyond the limits of the ponds. These practice results in a potential adverse risk to human health and environment. This clarification will be added to the report in Sections 5.0 and 6.0. The report should address whether time required for evaporation would significantly increase without the use of sprayers. Response: Elimination of the sprayers reduces the rate of Alluvial Aquifer flushing which will lengthen the remedial effort if Evaporation Pond #3 in not installed.	EPA (Appaji)
56	The report does not address any potential effects of significant water draw down from the aquifers to nearby building foundations. Response: Agree. The report will be modified to address this issue in Section 4.3.1.1.	EPA (Appaji

56	The EQM team should consider adding a list of alternate technologies available to remove the contaminants in lieu of the current technology used to flush the large tailings pile. Response: The RSE Team considered flushing alternatives that use amended water. There is insufficient information available to the RSE Team to conduct in-depth evaluation of these alternatives.	EPA (Appaji)
58	Figure 5.2-1 is missing. Figure 5.2-1 would have been particularly helpful in reviewing the containment effectiveness for the Upper Chinle. Response: Agree. Figure will be added.	EPA (Argonne)
59	The figures extracted from other documents should be renumbered and properly referenced for use in this report; as currently written it is difficult for the reader to identify the figures referred to throughout the text. Response: To facilitate the reader, the final hard copy report will include tabs in Appendix B.	EPA (Argonne)
60	The large tailings pile is surrounded by what appears to be a broad band of irrigated ground. A large area with a similar appearance is to the southeast. The text does not describe the source of water provided to these zones. Response: There is no extensively irrigated ground in the vicinity of HMC. The only irrigated areas are located south and southwest of the Large Tailings Pile in the area of the Subdivisions. The sources of water are the Alluvial and Chinle Aquifers.	EPA (Argonne)
61	p. 28, sec. 5.4. Is there a recommendation for containing purge water and transport the ponds or the RO plant? Response: Agree. Section 6.3 will be modified.	EPA (USACE Becker

RSE Team Responses to
New Mexico Environment Department Comments
August 2008 Draft RSE Report for the Homestake Mining Company Site

General Comments

The New Mexico Environment Department (NMED) herein submits comments on the draft Remedial System Evaluation (RSE) report. In general, the document provides an adequate evaluation of components of the existing remedial action strategy. However, from discussions with EPA early in the optimization study process, NMED expected that the RSE team would first critically evaluate whether the overall remediation strategy, and then secondly whether individual components of this strategy (e.g., ongoing flushing of tailings, aquifer injection and withdrawal, reverse osmosis [RO], evaporation) are actually working toward achievement of site closure most effectively and efficiently, and only then comment upon the efficacy and efficiency of the existing components.

Specifically, NMED requests that the RSE team first evaluate whether the overall remedial strategy of tailings flushing (to reduce source contamination), pump-and-treat (to contain and reduce ground water contaminant levels in excess of clean-up concentrations), upgradient ground water withdrawals (to reduce ground water flux through the waste source), and evaporative disposal and RO treatment of contaminated ground water is an holistically efficient and effective strategy in the context of both the current hydrologic and contaminant distribution conditions, and the present-day panoply of possible remediation technologies towards the achievement of the goal of site closure. Secondly, NMED recommends that the RSE evaluate each individual component of the current remedial system (e.g., the tailings flushing component, individual plume capture and restoration components, upgradient ground water withdrawal components, and evaporative and RO components) to determine if the component is being deployed in the most effective and efficient manner, and is protective of human health, or else how it might be improved. Finally, NMED would recommend that the RSE team evaluate and comment upon individual mechanical components (e.g., well pumps, reverse osmosis plant operational details). As NMED noted in early discussions preceding the RSE, the overall site remediation strategy has evolved over a period of nearly 30 years to achieve its present configuration. The critical "higher-level" evaluation of the remedial action, as well as any discussion of possible alternatives, is not addressed in this document, and this theme is reflected throughout NMED's comments below.

Response: The RSE Team is in agreement that additional effort is necessary to clarify its findings and recommendations, specifically as related to the overall remedial strategy. However, as pointed out above this system has evolved over 30 years as the result of various HMC and regulatory evaluations and direction. The RSE Team does not have sufficient information to evaluate and critique the historical decision making process. By definition, the RSE process requires a critical evaluation of the currently operated system to achieve protection of human health and the environment. The RSE Team will complete a more in depth evaluation to assure that the Final Report clearly expresses our evaluation of that objective.

NMED also notes that the RSE supports construction of Evaporation Pond #3. However, the report does not indicate that additional evaporative pond capacity could be necessitated by implementation of the RSE team's recommendation to discontinue spray evaporation. The RSE team's evaluation of individual remedial components, such as upgradient withdrawal, tailings flushing, and pump-and-treat components, also would bear upon the RSE team's evaluation of, and recommendations for, evaporative capacity. As the report is currently written, the RSE team evaluation of, and recommendation for, Evaporation Pond #3 construction is both incomplete and discrepant with other recommendations.

Response: The RSE Team will add information to support this recommendation.

NMED considers the "notes" throughout this document to be useful in documenting the boundaries of the RSE, and supports their retention in the final document.

Response: The RSE Team appreciates the commenter's understanding for the purpose of the "notes."

Comment No.	Page	Line(s) on page	Comment
1	Title	NA	The proper reference for the site is the "Homestake Mining Company Superfund Site." Response: Agree. Change will be made.
2	iii	3-4	Another goal of the RSE should include review of the remedy itself and its appropriateness, including a discussion of whether other approaches may be more efficient and effective toward the achievement of site closure. Response: Agree. The RSE Team will provide a "total" remedy evaluation in Section 5.7.
3	iii	13-14	The site contaminants of concern (COCs) include nitrate. Response: Agree. Change will be made.
4	iii	17	The Alluvial aquifer averages 100 feet in thickness (HMC, 2008, "2007 annual monitoring report/performance review for Homestake's Grants project pursuant to NRC license SUA-1471 and discharge plan DP-200"). Response: As indicated in Section 1.5.2.1, the alluvial formation is up to 120 feet thick (averaging 100 feet) but the saturated thickness that constitutes the aquifer is up to 60 feet thick (averaging about 60 feet). Changes will be made to indicate referenced material is average saturated thickness.
5	iii	19	The Upper Chinle varies from a few feet to 40 feet in thickness (HMC, 2003, "Background water quality evaluation of the Chinle aquifers"). Response: Agree. Changes will be made to indicate referenced material is average condition.
6	iii	25-26	The statement, "…the San Andres Aquifer…has not been affected by contaminants," should be qualified. Three wells in the San Andres aquifer are contaminated. Contamination in one well is may be attributable to a poor well completion that is providing a cross-contamination pathway for site-derived contaminants, and contamination in the other two wells may be related to another source. Response: Agree. Changes will be made.

Comment No.	Page	Line(s) on page	Comment
7	iv	1-2	NMED agrees that the Large Tailing Pile dewatering/flushing system is an integral part of the ground water remediation system. Therefore, its efficacy should be evaluated to the same extent as any other portion of the remediation system. Response: Agree. The RSE Team will provide a clearer expression of the effectiveness of tailings flushing.
8	iv	3-5	Contaminant plumes from the site already have migrated beneath the subdivisions; therefore the statement that "[T]he current groundwater remediation effort is focused on preventing migration of contaminated groundwater into the five Subdivisions…" is inaccurate. Homestake's remedial efforts to date include control of further contaminant migration and contaminant concentration mitigation for the existing plumes. Response: Agree. Changes will be made.
9	iv	5-7	NMED notes that site contaminant clean-up standards (i.e., background or "action levels") were changed from a single set of values for 6 COCs that were applied to all impacted aquifers, to a set of aquifer-specific clean-up standards for between 7 to 10 COCs, depending upon the aquifer, in 2006. Therefore, statements about the size of any contaminant plume (defined herein as an area in which COC concentrations exceed the clean-up standard) should be qualified by definition of the timeframe under consideration. Response: Agree. Changes will be made.
10	iv	6	Please change the sentence to read "…mass of contaminants in **the** Alluvial aquifer…" Response: Agree. Changes will be made.
11	iv	7-8	The statement, "[P]rotection of human health will not be achieved until action levels have been meet (*sic*) at the point (*sic*) of compliance established by the NRC," is not correct. Because clean-up levels for most contaminants exceed federal drinking water maximum contaminant levels (MCLs), protection of human health will not be achieved when HMC reaches these action levels. Also please change "meet" to "met," and "point" to "points." Response: Agree. Changes will be made.
12	iv	Bullet 1	Please clarify if construction of Evaporation Pond #3 in the proposed design will provide capacity to manage all waste streams without the use of the spray evaporation component. Response: Agree. Changes will be made.

Comment No.	Page	Line(s) on page	Comment
13	iv	Bullet 5	The statement, "Consider using more aggressive water or infiltration trenches to increase contact of leaching water with the slime in the Large Tailing Pond," appears to support the current practice of flushing the Large Tailings Pile, and implies that the efficacy of this activity relative to eventual achievement of site close-out was evaluated. If this is the case, this should be more clearly stated in the recommendations. Please change "Pond" to "**Pile**." Response: Agree. Changes will be made.
14	x	8	Please remove the "2" preceding "Concentrations." Response: Agree. Changes will be made.
15	1	5-7	As previously stated, another goal of the RSE should include review of the remedy itself and its appropriateness, including a discussion of whether other approaches may be more efficient and effective toward the achievement of site closure. Response: Agree. Changes will be made in Section 5.0.
16	1	14-15	Please note that the Record of Decision ("ROD") for the site only pertains to the potential for human exposure to radon, and does not define ground water contaminant remediation; therefore the reference to the ROD in this section should be modified appropriately. Response: Agree. Clarification of Consent Decree and ROD will be made.
17	1	Bullet 5	Background conditions complicate this issue. Presently, several residents have contaminant levels that exceed MCLs in their wells but are less than background concentrations; therefore, NRC has not identified this as a goal of the remediation, because the background contaminant concentrations are not site-related. Response: Agree. Language will be added to this bullet.
18	4	Bullet 5	As noted on p. iii within the RSE report, the San Andres aquifer has not been determined to have been impacted by site-derived contamination; therefore this reference either should be deleted here or else clarified along with the reference on page iii for consistency. Response: Section 1.5.2 is limited to a description of the aquifer natural characteristics. Section 1.5.3 describes aquifer contamination and will be modified in response to this comment.
19	4	23, 27	Reference to the San "Juan" Alluvial aquifer should be changed to San "**Jose**." Response: Agree. Changes will be made.
20	5	25	Please change "aerial" to "**areal**." Response: Agree. Changes will be made.

Comment No.	Page	Line(s) on page	Comment
21	6	33	Please change "were" to "**where**." Response: Agree. Changes will be made.
22	6	24-28	As noted in previous sections, ground water from the Chinle aquifers flows into the overlying Alluvial aquifer in certain areas, whereas the flow direction is reversed in other areas. NMED recommends that the RSE team evaluate whether operation of the extraction and injection system causes contaminated Alluvial ground water to flow into Chinle aquifers, and therefore whether one possible recommendation would be to abandon this practice in order to restore the ground water in the Chinle aquifers. Response: Agree. Changes will be made.
23	8	7	The sentence should read "Felice Acres have **been** reduced…" Response: Agree. Changes will be made.
24	8	11 and 12	Please change "uranium" to "**selenium**." Response: Agree. Changes will be made.
25	8	23	For clarity, NMED recommends the following revision: "**Operation of this extraction well had caused** a plume of uranium…" Response: Agree. Changes will be made.
26	9	29-32	Please provide more information on contaminant levels. If levels are below MCLs, that should be stated. Response: Agree. More information about contaminant levels will be provided.
27	10	4-5	Please state that HMC financed the waterline extension under a Consent Decree between HMC and EPA. Response: Agree. Changes will be made.
28	10	13	Please change "feed" to "**fed**" or "**used to feed**." Response: Agree. Changes will be made.
29	11	9-11	As previously stated, NMED agrees that the Large Tailing Pile dewatering/flushing system is an integral part of the ground water remediation system. Therefore, its efficacy should be evaluated to the same extent as any other portion of the remediation system. Response: Agree. Changes will be made.
30	12	9-10	For clarity, NMED suggests the following revision: "**The system of wells has the flexibility to allow operation as either injection or extraction as needed**." Response: Agree. Changes will be made.
31	12	26	Figure "A" is not included in this draft report. Response: Agree. Figure will be added to Final Report.

Comment No.	Page	Line(s) on page	Comment
32	12	26-29	It is unclear what the overall effect of extracting 40 gpm from well P2 is. How much does 40 gpm represent against the total amount of water flowing from upgradient through the site from the San Mateo alluvium? Does the strategy of upgradient ground water withdrawal contribute to the overall remediation of ground water to target contaminant levels? Does this strategy as implemented—with single-point upgradient ground water withdrawal of 40 gpm—contribute to the overall effectiveness of the remedial system? Please provide clarification. Response: Agree. Discussed in Section 4.2.1.1.
33	13	25	Figure "B" is not included in this draft report. Response: Agree. Figure will be added to Final Report.
34	13	34	Figures "C, D, E" are not included in this draft report. Response: Agree. Figure will be added to Final Report.
35	14	Section 2.4	Please add a discussion on new MCL for uranium of 0.03 mg/l. Response: The discussion is not appropriate to this Section. The evaluation is limited to action levels that are presently applicable to the Site. Language has been added to the report in Section 3 that NMED and USEPA may apply MCLs as action levels. Please remove "slightly" from the first line of this section. Response: Agree. Change will be made.
36	15	14-15	Please add that the evaporation ponds are also used to manage contaminated water collected at the toe drains (40 gpm). Response: Agree. Changes will be made.
37	15	Section 2.5.2	As previously stated, please clarify if construction of Evaporation Pond 3 in the proposed design will provide capacity to manage all waste streams without the use of the spray evaporation component. Response: Agree. Section 4.3 will be modified. NMED recommends that the RSE team evaluate HMC's handling of solids from the collection and evaporation ponds, specifically whether these solids, left in place during operation, might present a risk for windblown contamination. Additionally, NMED requests that the RSE team evaluate the protectiveness of HMC's strategy of final disposal of solids (i.e., entombment in the tailings pile). Response: Agree. Section 4.3.5 will be modified.
38	15	28	Please insert a period between "Visit" and "Pond." Response: Agree. Changes will be made.
39	16	1-2	Please add that the pond will also have a pump-back system to remove water between the two liners back into the pond. Response: Agree. Changes will be made.

Comment No.	Page	Line(s) on page	Comment
40	17	Section 3.1	Please add that an additional objective is to ensure that the remedy is protective of human health and the environment. Response: The definition of protectiveness of human health and the environment appears to be in a state of flux for this Site. The RSE protocol is limited to evaluation of the remedial system's current state. Future changes cannot be evaluated but the RSE Team will modify the report to indicate that objectives and action levels may change in the future.
41	17	9-10	NMED recommends that the RSE team structure its evaluation of the various components of the remedial system against these objectives. Response: Agree. The RSE Team will make necessary changes to address the ability of the current system to achieve HMC's own objectives.
42	17	17-18	Please add " …**and to collect and treat contaminated water**." Response: While the RSE Team agrees that HMC does this, the objective presented is as stated by the HMC site manager, Al Cox, during the Site Visit.
43	17	19	Please change "mange" to "**manage**." Response: Agree. Changes will be made.
44	17	24	Please change "Pond" to "**Pile**." Response: Agree. Changes will be made.
45	18	Section 3.3	It should be noted that the New Mexico Water Quality Control Commission (WQCC) regulations do not recognize the concept of POC wells. WQCC regulations require that **all** ground water within aquifers that has been contaminated must be restored to target levels. Response: The definition of protectiveness of human health and the environment appears to be in a state of flux for this Site. The RSE is limited to evaluation of its current state. Future changes cannot be evaluated but the RSE Team will acknowledge that objectives and points of compliance action levels may change in the future.
46	18	2	The sentence should read "…agreed to by the NMED **and EPA**." Response: Agree. Changes will be made.
47	19	Section 4.1	As previously indicated, NMED requests the RSE team to evaluate first whether the specific remedial system components provide the most effective means of achieving the remedial objectives. Response: Agree. Changes will be made.
48	19	3	For clarity, NMED suggests changing "systems" to "**components**." Response: Agree. Changes will be made.

Comment No.	Page	Line(s) on page	Comment
49	19	5-6	Please move "below" (line 5) after "recommendations" (line 6) for clarity. Response: Agree. Changes will be made.
50	19	8	Please change "MNED" to "**NMED**." Response: Agree. Changes will be made.
51	20	6-9	The RSE Team indicates that the current extraction and injection system configuration does not capture the west and south uranium plumes. However capture of these contaminant plumes seemingly are important to protecting both the Rio San Jose and San Mateo alluvial systems, as well as underlying aquifers through structural and stratagraphic interconnections, from further degradation. NMED recommends that the RSE team acknowledge that the capture of these plumes should be an important goal of the remedial effort, and discuss whether or how system design and operation can be improved to achieve this hydraulic capture. Response: Agree. Changes will be made.
52	21	4	Please change "affected" to "**effected**." Response: Disagree. Affected (a verb) is appropriate here instead of effected (a noun).
53	21	22	NMED previously had asked the RSE team to examine HMC's strategy and the remedial efficacy in controlling alluvial water flux through the Site, noting that HMC has reported relatively-small quantities of alluvial ground water withdrawals from a single upgradient well (i.e., P2) in recent years. NMED notes that evaluation of this component has not been included within this report, and requests that it be added in the next draft. (i.e., same comment as on page 12, lines 26-29) Response: Agree. Changes will be made.
54	22	1-3	NMED is concerned that the RSE team has not fully evaluated the implications of factors such as upgradient ground water removal and its recommendation to discontinue spray evaporation systems upon the design of proposed Evaporation Pond #3. As indicated in previous conversations with EPA, the design of this pond, installation of which is immediately pending, has ramifications to many of the RSE team's recommendations, and discussion of this design in the context of the RSE team's evaluation and recommendations should be an important part of this report. Response: Agree. Changes will be made as necessary.
55	22	Section 4.4.3	Please add an evaluation of the protectiveness of using the spray evaporation system. Response: Agree. Addressed in Section 5.4.

Comment No.	Page	Line(s) on page	Comment
56	22	38	As previously noted, the determination of background concentrations for COCs has changed since the inception of remediation, as well as the uranium MCL; therefore the description of contaminant concentrations in irrigation water as "low-level" may not now be appropriate. Response: Agree, "low" will be defined.
57	23	Section 4.4.5	As previously stated, NMED recommends that the RSE team evaluate HMC's handling of solids from the collection and evaporation ponds, specifically whether these solids, left in place during operation, might present a risk for windblown contamination. Additionally, NMED requests that the RSE team evaluate the protectiveness of HMC's strategy of final disposal of solids (i.e., entombment in the tailings pile). Response: Agree. Changes will be made as necessary.
58	25	25-27	As previously stated, please add an evaluation of the protectiveness of using the spray evaporation system. Response: Agree. Changes will be made as necessary.
59	26	16-20	NMED recommends that the RSE team critically evaluate whether consideration of the other technologies identified in this section may provide better remedial system optimization for this site. Response: The Final Report will identify other alternatives, where appropriate, but will limit its evaluation to protectiveness. Sufficient data are not available to provide in-depth analysis of the technical feasibility of alternatives.
60	27	2-3	As previously noted, please state that HMC financed the waterline extension under a Consent Decree between HMC and EPA. Response: Agree. Changes will be made.
61	27	4-6	Site-derived contamination in ground water has migrated into the subdivisions; current remediation efforts are, in part, focused on preventing further migration and remediating contaminated ground water that has already migrated. Response: Agree. Changes will be made.

Comment No.	Page	Line(s) on page	Comment
62	27	18-20	As previously stated, the statement "[P]rotection of human health will not be achieved until action levels have been meet (*sic*) at the POC" is not correct because the action levels mostly exceed MCLs. Also, as previously stated, WQCC regulations require that all ground water within aquifers that have been contaminated must be restored to target levels. Please change "meet" to "**met**." Through amendment 40 to HMC's Materials License SUA-1471, the NRC has established 10 ground water protection standards for the alluvial aquifer, and 7 ground water standards for the Upper Chinle aquifer. Response: Agree. Changes will be made where necessary.
63	27	21-22	Please expand upon the note, "[A]ny program established to change groundwater flow through extraction and injection may make some groundwater worse before it gets better." Response: Agree. Changes will be made.
64	27	23	The EPA indicated that it would request the RSE team to evaluate whether existing upstream flood control measures were adequate to protect the site both in the short- and long-term; however, NMED notes that this evaluation has not been included. Response: No information concerning existing upstream flood control measures were obtained. The RSE Team was not aware of NMED's concerns. Additionally, NMED requests that RSE team evaluate the likelihood and potential effects of a possible future rise in the alluvial aquifer water level on contaminant mobilization in the tailings pile. Response: Information available to the RSE Team does not indicate that future changes in the Alluvial Aquifer will mobilize contaminants in the Tailings Pile. Natural groundwater levels in the Alluvial Aquifer are 40 to 50 feet below the bottom of the Pile. -
65	28	Section 5.3	NMED requests the RSE team to complete an evaluation of the air monitoring data to determine if the remedy is protective of human health. Response: Agree. No data are available to the RSE Team to evaluate air monitoring. USEPA-Region 6 will be conducting further evaluation.

Comment No.	Page	Line(s) on page	Comment
66	29	16-17	The tailings piles cannot be completely eliminated "…as a continuing source of groundwater contamination;" rather, HMC's goal is to reduce the contaminant load within the piles in order to reduce the flux of contaminants from these sources. Please evaluate whether HMC's remedial activities adequately addresses this goal. Response: Agree. New Section 5.7 prepared.
67	29	18-20	The recommendation to completely eliminate spray evaporative operations appears to contradict earlier discussion of HMC's need to increase evaporative capacity. NMED recommends that the RSE team comment on the evaporative capacity that is needed to evaporate sufficient water from the Large Tailings Pile dewatering waste stream, the toe drain waste stream and all other waste streams, to facilitate the desired full-capacity operation of the reverse osmosis system (section 4.4.2), and to further optimize ground water extraction operations with respect to the planned size and configuration of proposed Evaporation Pond #3. Response: Agree. Changes will be made where necessary.
68	32	19	Please change "MNED" to "**NMED**." Response: Agree. Changes will be made.
69	32	20-23	NMED recommends that the RSE Team evaluate the efficacy of the current tailings pile flushing operations against the potential for undesirable long-term continued contaminant mobilization into ground water. Response: Agree. New Section 5.7 prepared.

**RSE Team Responses to EPA Comments
on the November 2008 Draft Final RSE Report for the Homestake Mining Company Site
Provided by Robert Ford**

1) Pg. iv: "This system includes injection of water using wells and recovery of water using extraction wells and drains. The purpose of the system is to flush contaminants from the Large Tailings Pile. The Large Tailings Pile is providing source control for the principal contaminants in groundwater."

RGF Comment 1: Recommend changing highlighted text to "is intended to provide". Source control is realized through the reduction of available contaminant mass within source area and prevention of contaminant migration from the source area. The statement should be qualified in the absence of technical review to establish: 1) the extent of mass reduction within source area based on estimates of starting contaminant mass and the amount flushed from the Large Tailings Pile and 2) the extent to which water draining from the Large Tailings Pile is prevented from being transported through the Alluvial and/or Chinle Aquifers beyond the points of compliance.
Response: Agree. Language change will be made.

2) Pg. iv: "The current groundwater remediation effort is focused on preventing further migration of contaminated groundwater into the five Subdivisions where groundwater was historically used for potable and agricultural purposes and source (i.e., Large Tailings Pile) control."

RGF Comment 2: Please clarify the implication of this statement that groundwater pumped from the aquifer(s) underlying the five Subdivisions was used to control contaminant migration from the site. Also, please be specific as to use of groundwater for source control, as pertains to this statement, i.e., flushing of Large Tailings Pile, hydraulic control within or outside of the points of compliance, or some other specific application.
Response: This is a paraphrase of the remedial system objectives as described in the NRC License. In response to the comment a more detailed description will be provided.

3) Pg. 1: "The RSE Team followed the U.S. Army Corps of Engineers RSE Instruction Guide, but made modification, as necessary, to fit the unique and complex nature of the HMC site and regulatory conditions."

RGF Comment 3: Please specifically list what modifications to the RSE process were needed to facilitate review of the operation of the HMC site. The audience for this document needs to be made aware of the specifics factors or conditions at this site that required deviation from the evaluation process delineated in the RSE Instruction Guide, so that they can properly interpret the possible limitations of the findings document in this report.
Response: In response to comment, sentence will end after the word Guide.

4) Pg. 1: "(5) Prevent the consumption of contaminated groundwater by residents of the five Subdivisions adjacent to the site. It must be noted here that natural groundwater quality may not meet criteria considered to be protective of human health."

RGF Comment 4: The inclusion of this statement requires that the source of "natural groundwater" be specifically defined, so that it is clear to what potential source of potable water it refers. Also, include citation of reference material that was reviewed to support this statement. Does this statement apply to groundwater within the Alluvial, Chinle, and or San Andres Aquifers, or some combination thereof? The current statement has broader implications than may be intended. [Note: I am okay with the revision recommended by NMED, so my comment can be disregarded, as needed.]
Response: In agreement with NMED comment and will change accordingly.

5) Pg. 6: "The alluvial formation includes sediments deposited by streams with material ranging in size from clay to sand to gravel and boulders. At some locations, especially in the Rio San Juan part of the formation, basaltic lava flows are present."

RGF Comment 5: Please verify aquifer name and clarify where "basaltic lava flows" occur relative to the dimensions of the compliance and monitoring network for groundwater. Also, please clarify the importance of identification of this subsurface feature relative to groundwater flow or the performance of the remediation effort.
Response: This is an overview description of the make-up of the Alluvial Aquifer. The RSE Team was not provided information to delineate any specific facies in the aquifer.

6) Pg. 6: "However, locally the direction of groundwater flow is controlled by the location of zero aquifer saturation caused by the area of high bedrock elevation and the locations of groundwater extraction and injection systems operating as part of the groundwater remediation system."

RGF Comment 6: Please clarify this statement. Does this mean that high elevations of bedrock within the aquifer confines the direction that groundwater can flow? Note that the unsaturated portion of an unconfined aquifer, such as the Alluvial Aquifer underlying the HMC site, is typically referred to as the vadose zone. Also, please clarify what specific geologic formation confines the direction of groundwater flow.
Response: Yes, high elevation of bedrock within the Alluvial Aquifer confines the direction of groundwater flow in the Alluvial Aquifer. It is stated in the same paragraph that the bedrock is of the Chinle Formation.

7) Pg. 8: "The San Andres Aquifer is a confined limestone aquifer and is the most important regional aquifer. The Aquifer is separated from the Alluvial Aquifer at the Site by up to about 800 feet of low permeability Chinle Formation."

RGF Comment 7: Please include a table that documents the range of measured or calculated transmissivity for each of the aquifer units addressed in this document (Alluvial, Upper Chinle, Middle Chinle, Lower Chinle, San Andes) with reference to the information/data source. Also, please provide reference to document that specifies permeability of the Chinle Shale.
Response: The sentence will clarify that the low permeability material is shale.

Transmissivity data for the Chinle and other geologic units may be found in Table 1-1 of the HMC groundwater modeling report contained in the 2006 Revised CAP. The only transmissivity data in the RSE Report is a figure for the Alluvial Aquifer. It will be removed and no transmissivity values will be presented.

8) Pg. 9: "The presence of elevated concentrations of selenium in local water supply wells in the 1970s triggered the remedial action being undertaken by HMC."

RGF Comment 8: Please specify what aquifer(s) were screened for local water supply wells with elevated selenium and reference document source.
Response: The Alluvial, Upper Chinle, Middle Chinle, and Lower Chinle are used for water supply. All have been affected.

9) Pg. 11: "Both uranium plumes in the Middle Chinle Aquifer are located hydraulically down gradient from where the Middle Chinle Aquifer contacts the Alluvial Aquifer in the subcrop areas. Additionally, the plume beneath Broadview Acres may reflect cross aquifer transfer from the Alluvial Aquifer to the Middle Chinle Aquifer through an inadequately sealed well. From 1997 to 2007, the trend for uranium in both the mixing zone and the Aquifer indicated decreasing concentrations as illustrated in Figure 6.2-12. Samples from wells surrounding the perimeter of these plumes (Figure 6.2-13) indicate the size of the plume is relatively constant and not increasing in size. The exception is a significant increase in uranium at well CW17 located west of the fault and north of County Road 63."

RGF Comment 9: It would be useful to highlight the locations of the suspected "inadequately sealed well" and "well CW17" on Figure 6.2-11 and/or 6.2-13.
Response: No information is available to the RSE to identify a specific well that is inadequately sealed. The statement is made in response to a comment provided by the USEPA on the Draft Report and is supported by understanding of contaminant plume distribution, local well construction practices, and the configuration of the plume in the vicinity of CW17.

10) Pg. 15: "The NRC, through testing conducted for it, determined that the Small Tailings Pile is not a significant source of contaminants for groundwater and therefore it is not being flushed."

RGF Comment 10: Please include reference to report prepared for the NRC that documents this finding.
Response: The RSE Team was not provided with specific historical documents used by NRC to make its decisions. The highlight statement was added to the Draft Final Report as a result of an earlier USEPA comment on the Draft Report, it will be deleted.

11) Pg. 15: "The wells are screened to recover water from the tailings material and from the upper several feet of the underlying Alluvial Aquifer. The Pile is not fully saturated."

RGF Comment 11: Please document the quantity of water within the Large Tailings Pile and depth to water from the surface of the pile. It would also be useful to reference the reviewed document that provides historical trends in water levels within the Large Tailings Pile.
Response: The highlight statement was added to the Draft Final Report as a result of an earlier USEPA comment on the Draft Report, it will be deleted. Information on the water level in the pile including hydrographs is not available to the RSE Team.

12) Pg. 23: "These data demonstrate that HMC has significantly affected the Large Tailings Pile as a continuing source of groundwater contamination. HMC has calculated that about 138,000 pounds of uranium, 4,100 pounds of selenium, 326,000 pounds of molybdenum and 34,000 pounds of sulfate had been removed from the Large Tailings Pile via wells and drains through 2007."

RGF Comment 12: Please document source of estimates of total contaminant mass within the Large Tailings Pile with reference to data source. It must be noted that the underlying assumption of the conceptual model for the Large Tailings Pile is that no further transfer of uranium in tailings solids to tailings water will occur at the cessation of flushing. In short, this translates into unchanging concentration of uranium in tailings water during gravity drainage or active dewatering beyond the planned cessation of flushing. This aspect of the conceptual site model does not appear to have been reviewed as part of this RSE. Please clarify within the review. A statement acknowledging that this technical aspect was not reviewed needs to be incorporated either to discussion of the "modifications" to implementation of the U.S. Army Corps of Engineers RSE Instruction Guide or in qualification of the findings in the Summary (Section 7.0). Also, the text should be revised to remove descriptors of the extent or efficiency of contaminant removal from the Large Tailings Pile given the lack of estimates of total contaminant mass within the pile.
Response: The mass of contaminants recovered from the Large Tailings Pile is contained on Table 2.1-1 of the HMC 2007 Annual Report. The RSE Team believes that recovery of over one half million ponds of contaminants reflect significance, even if the total starting mass is unknown. However, "significantly" will be removed.

As is already noted in the RSE Report, the RSE Team did not conduct any modeling to validate HMC's conclusions.

A discussion of rebound will be added to the Draft Final RSE Report based on HMC modeling contained in the Revised CAP.

13) Pg. 23: "These contaminants have collected and concentrated in the evaporation ponds and are no longer available to leach to the groundwater system from the Large Tailings Pile."

RGF Comment 13: While true that the contaminants that have been transferred to the evaporation ponds will not enter the Alluvial Aquifer via the Large Tailings Pile, this does not necessarily indicate that these contaminants will not leach from the evaporation ponds. If evaluation of current or potential leaching of contaminants from the evaporation pond was evaluated, please refer to documentation of this evaluation within the report. If this aspect was not evaluated, please revise this sentence to remove inference that these contaminants are no longer able to be released into the Alluvial Aquifer.
Response: The highlighted material will be removed. The RSE Report includes a recommendation that HMC investigate and demonstrate the integrity of the evaporation pond as a long-term repository.

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The RSE Team did not conduct human health or ecological risk assessments for the Site. Such evaluations have been completed by the Agency for Toxic Substances and Disease Registry (ATSDR). ~~or are ongoing by USEPA Region~~ 6. ATSDR concluded, among other things, the following:

Comment: Please delete the struck out words in the paragraph above.

Response: Agree, change will be made.

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The human health and ecological risk of irrigation of groundwater containing uranium, selenium and other metals to croplands has been raised by several stakeholders. Information available to the RSE Team indicates that the risk is low; however, the regulating agencies should conduct further evaluation of the situation. ~~USEPA Region 6 will be conducting~~

Comment: Please modify the last sentence in the above paragraph and strike out USEPA Region 6 will be conducting.

Response: Agree, change will be made.

Page 1

The remedial action objectives for groundwater remediation [Operable Unit (OU) #1] are defined in Nuclear Regulatory Commission (NRC) License SUA-1471 and NRC-approved groundwater Corrective Action Plan (CAP), the New Mexico Environment Department (NMED) Discharge Permits DP-200 and DP 745, the 1983 Consent Decree between the USEPA and HMC and the 1989 ROD. The remedial action objectives for decommissioning the mill, surface reclamation, long-term stabilization of the tailings and closure (OU#2) are defined in the NRC License SUA-1471. In general, the objectives of the remedial activities as defined by the ROD are:
(1) Limit radon emissions from the tailings piles
(2) Remediate contamination in soil that resulted from windblown tailings
(3) Remediate groundwater to levels stipulated in the NRC License SUA-1471 and the NMED DP-200
(4) Dewater the large tailings pile to remove this area as a continuing source of groundwater contamination
(5) Prevent the consumption of contaminated groundwater by residents of the five Subdivisions adjacent to the site. It must be noted here that natural groundwater quality may not meet criteria considered to be protective of human health.

Comment: The ROD and Consent Decree do not spell out the remedial objectives as cited above. However, I am not sure exactly where these are spelt out. I have checked both the ROD and Consent Decree and they do not discuss the above remedial objectives. Please verify the source of these statements.

Response: The objectives are contained in the NRC License and the NMED Permit. The reference will be revised.

RSE Team Responses to
New Mexico Environment Department Comments
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Priority change for current revision	Comment No.	Page	Paragraph	Comment	Response
*	1	iii	4	The statement, "…the San Andres Aquifer…**has not been** affected by contaminants," is not accurate. Three San Andres wells have COC's that exceed MCL's. The qualifying statement regarding one of the wells (poor annular seal resulting in cross-contamination) is correct, however, two other wells appear to be impacted from another source, but this is not definitive. NMED suggests the following language – "San Andres Aquifer…**does not appear to be** affected by contaminants,"	Agree, change will be made.
*	2	iii	6	NMED proposes reinsertion of the deleted phrase "…to action levels established by the Nuclear Regulatory Commission (NRC."	Agree, change will be made.
*	3	iv	1	Please revise as follows - "**Flushing of the LTP is intended to**…"	Agree, change will be made.
*	4	iv	2	The statement "Protection of human health will not be achieved until action levels have been met" is incorrect. Background levels, which have been adopted as NRC action levels, exceed MCLs. Therefore, once HMC achieves the action levels, concentrations of COCs will still exceed MCLs which are not protective of human health. NMED suggests deleting this sentence.	Agree, the language will be revised.

Priority change for current revision	Comment No.	Page	Paragraph	Comment	Response
*	5	iv	2	This Section states "Human health and environmental protection will also be established through future implementation of New Mexico and U.S. Environmental Protection Agency remedial criteria". It is unclear what this means as the NRC is the lead agency for cleanup of the site; therefore NMED recommends that this statement be deleted.	Agree. The sentence will be deleted.
*	6	1	1	The purpose of the citation of "[U.S. Environmental Protection Agency (USEPA Region 6)]" in the first sentence is unclear. NMED suggests deleting this citation.	Agree, change will be made.
*	7	1	1	Another equally important goal of the RSE should include a review of the current remedy and its appropriateness, including a discussion of whether other approaches or technologies may be more efficient and/or effective at achieving site closure.	Agree, change will be made.
*	8	1	2	NMED suggests the following revision: "The RSE Team…third party evaluation of site operations **and alternative approaches to meet remediation goals**."	Agree, change will be made.
*	9	1	3	Please revise "DP 745" to DP **725**"	Agree, change will be made.
*	10	1	Bullet 5	Please revise "natural" to "**background**", as natural implies no contribution from man-made sources which may be incorrect.	Agree, change will be made.
*	11	4	4	The first sentence of the paragraph should read "As indicated **in** Section 1.1…" In the last sentence of the paragraph please revise "aquifer" to "**formation**" and "units" to "**aquifers**"	Agree, change will be made. Agree, change will be made.

Priority change for current revision	Comment No.	Page	Paragraph	Comment	Response
*	12	5	CSM	The figure appears to indicate the occurrence of contamination in the Chinle aquifer through wellbore cross-contamination. Although this is probable, this has not been documented. Therefore NMED suggests revising the figure. The figure indicates the occurrence of contamination within the Chinle aquifer at the northeast corner of the block from migration from the overlying non-aquifer Chinle. Although this is probable, this causality has not been documented. Therefore NMED suggests revising the figure. It is unclear whether the CSM depicts areas where the Chinle aquifer discharges to the Alluvial aquifer. NMED suggests adding figures which depict groundwater flow in the Alluvial; upper, middle, lower Chinle; and San Andres aquifers.	The RSE Team supports this interpretation based on all data available for review. Language will be added where needed to indicate a Team opinion. The point referenced is intended to indicate contamination entering at the subcrop. The figure will be revised. The CSM represents current operational conditions.
*	13	6	2	Change "Juan" to "**<u>Jose</u>**" in the next to final sentence.	Agree, change will be made.
*	14	6	4	In the first sentence, please change "…[which] are sources of water to wells" to "…which are **<u>functionally aquifers that are utilized by wells in the area</u>**."	Agree, change will be made.
*	15	7	2	In the second sentence, please insert "**<u>westernmost</u>**" before "faults."	Agee, change will be made.
*	16	7	4	Please insert "**<u>the</u>**" before "western" in the 3rd sentence.	Agree, change will be made.

Priority change for current revision	Comment No.	Page	Paragraph	Comment	Response
*	17	8	2	This Section states that prior to implementation of remediation at the site, groundwater from the Chinle aquifers flowed upward into the overlying Alluvial aquifer in the subcrop areas (indicating confined conditions). Please provide data to support this statement or delete this statement.	Statement is taken from HMC's background studies.
*	18	10	2	Please provide the basis for the statement that "[T]his isolated plume may reflect either cross-aquifer transfer from the Alluvial Aquifer to the Upper Chinle Aquifer through [well CE9] or a neighboring well that was inadequately sealed…" or delete the statement.	Language will be added this is a RSE Team opinion.
*	19	11	1	Please provide the basis for the statement "…the plume beneath Broadview Acres may reflect cross-aquifer transfer from the Alluvial Aquifer to the Middle Chinle Aquifer through an inadequately sealed well," or delete the statement	Language will be added this is a RSE Team opinion.
*	20	11	2	Please provide the basis for the statement "[T]hese plume may be associated with inadequately sealed wells," or delete the statement.	Language will be added this is a RSE Team opinion.
*	21	12	5	The ATSDR Health Consultation report cited has not been finalized; therefore NMED suggests deleting the citation.	The text will be revised to indicate that the conclusions are from the "draft" ATSDR report.
*	22	13	4	The second sentence should read "Withdrawal of water using these collection systems in regulated under **a New Mexico Office of the State Engineer** Temporary Diversion…"	Agree, change will be made.

Priority change for current revision	Comment No.	Page	Paragraph	Comment	Response
	23	16	2	The uranium concentration of <0.44 mg/l is correct, however, it should be stated that this level was established when the NMED standard was 5 mg/l. The uranium standard has since been revised to 0.03 mg/l which will necessitate a change in the concentration allowed to be land applied.	Agree, clarification will be added to Section 4.3.4.
*	24	16	1	It is unclear what the overall effect of extracting 40 gpm from well P2 is. How much does 40 gpm represent against the total amount of water flowing from upgradient through the site from the San Mateo alluvium? Does the strategy of upgradient ground water withdrawal contribute to the overall remediation of ground water to target contaminant levels? Does this strategy as implemented—with single-point upgradient ground water withdrawal of 40 gpm—contribute to the overall effectiveness of the remedial system? Please provide clarification/evaluation.	Well P2 appears to intercept about 67% of the water flowing on the Site from the north. Interception of uncontaminated water to prevent it from becoming contaminated contributes to the overall remediation strategy. Additional clarification will be added to Section 4.2.1.1.
*	25	17	2	This section states water is injected into the Large Tailings Pile (LTP) at a rate of 233 gpm. Section 2.2.2 states 87 gpm is removed from extraction wells and 40 gpm is removed from the toe drain surrounding the LTP. If these extraction rates are correct; 106 gpm of the injected water is not accounted for and may be migrating directly into the alluvial aquifer. Please provide a water balance of all injected and extracted water into and from the LTP and an evaluation of its efficacy.	The RSE Team is in agreement with the calculation provided. The 106 gpm of water is managed by groundwater recovery strategies in the Alluvial Aquifer. Clarification added to Section 4.1.
*	26	19	1	The third sentence should read "Water from the LTP and Alluvial Aquifer with the **lowest** concentrations…"	Agree, change will be made.

Priority change for current revision	Comment No.	Page	Paragraph	Comment	Response
	27	19	1-4	NMED recommends that the RSE team evaluate HMC's handling of solids from the collection and evaporation ponds, specifically whether these solids, left in place during operation, might present a risk for windblown contamination. Additionally, NMED requests that the RSE team evaluate the protectiveness of HMC's strategy of final disposal of solids (i.e., entombment in the tailings pile).	The report identifies the potential risk and recommends HMC conduct further evaluation. There is insufficient information available to the RSE Team to conduct this evaluation. However, the Team has made a recommendation that HMC should conduct additional study.
*	28	22	2	The second sentence should read "the groundwater cleanup levels were established for constituents within a specific aquifer unit utilizing establishment of **<u>upgradient</u>** background conditions." It should be noted that the New Mexico Water Quality Control Commission (WQCC) regulations do not recognize the concept of POC wells. WQCC regulations require that **<u>all</u>** ground water within aquifers that has been contaminated must be restored to target levels.	Agree, change will be made. The RSE Team recognizes this condition.
	29	23	Section 4.0	A recommendation should be provided for each finding/observation	Agree that recommendations should be provided where appropriate.

Priority change for current revision	Comment No.	Page	Paragraph	Comment	Response
	30	23	Section 4.1	NMED requests an evaluation of the long-term ground water protectiveness of flushing the LTP, in comparison to either no action or to the installation of a low-permeability cover and if the concentration of dispersed contaminants within the LTP into the evaporation ponds for eventual entombment provides effective long-term protectiveness of human health and the environment.	A new section called Alternatives (6.0) will be added to the report to include this discussion. Existing Sections 6.0 and 7.0 will be renumbered as 7.0 and 8.0
	31	25	2	NMED requests an evaluation if the total upgradient diversion of 40 gpm is sufficient to "reduce or eliminate the contamination of unaffected water entering the site and if upgradient withdrawal should be conducted at another or an additional location (e.g., upgradient of the western plume) to facilitate ground water restoration.	Refer to response to Comment # 24. The RSE did not include modeling necessary to make the requested evaluation.
*	32	25	2	Please change "Juan" to "Jose" in the second sentence.	Agree, change will be made.
	33	25	4 & 5	Although the removal of contaminant mass may indicate that ground water injection and collection activities in the Upper Chinle aquifer is effective, please provide an evaluation of the current system configurationally and operational efficiency towards achievement of this objective.	The RSE did not include modeling necessary to make the requested evaluation.
	34	26	1	NMED notes that the criteria for water quality suitability for irrigation will be reviewed.	Agree, this note will be added.
*	35	26	2	Please strike "used" from sentence 7.	Agree, change will be made.
	36	27	2	NMED suggests an evaluation to determine if the amount of ground water withdrawal is sufficient to accomplish ground water restoration effectively and efficiently, and if the use of the nearly 75% of withdrawn ground water managed is effective in accomplishing ground water restoration.	The RSE did not include modeling necessary to make the requested evaluation.

Priority change for current revision	Comment No.	Page	Paragraph	Comment	Response
	37	27	3	Does the proposed full-capacity operation of both RO units make sense from the standpoint of optimizing the ground water remedial strategy? How important may the installation of a backup RO system be under the observed conditions of RO system operation, and in consideration of the remedial strategy effectiveness and efficiency?	The RSE Report questions HMC's plans to put the RO unit into full operation from a treatment perspective. The RO unit is used to produce low TDS water to facilitate Alluvial Aquifer flushing. It is an integral part of the system but is not a controlling factor.
	38	27	4	Is the proposed use of nearly 600 gpm of RO output sufficient to accomplish ground water restoration most effectively? NMED suggest the RSE Team evaluate if greater RO capacity could be utilized with more effectiveness and efficiency toward the goal of meeting reclamation goals.	See response to Comment #37. Additional treatment capacity (as well as disposal capacity) may be needed. Additional discussion will be provided in new Section 6.0.
	39	28	1	NMED requests the RSE team to make suggestions about how to address the increased potential for sand filter blockage under the proposed doubling of RO system capacity and whether the increased potential for this blockage outweighs any advantage of the increased RO output towards the effectiveness and efficiency of ground water restoration activities.	The RSE Team has identified sand filter blocking as a concern and agrees to add a recommendation that HMC demonstrate back-up systems to be used to address sand filter

Priority change for current revision	Comment No.	Page	Paragraph	Comment	Response
*	40	28-29	Section 4.3.3	This section makes the argument that the EP-3 has the capacity to handle increased evaporative capacity but fails to include the amount of water from the irrigation system if irrigation were to be discontinued. The section states an increase of 77 gpm of evaporation capacity is gained with the installation of EP-3, however a total of 66-77 gpm is required to handle water from the spray evaporation system and increased amount from the RO Plant. Water from the irrigation system is not accounted for in the evaluation and is estimated at 641 gpm (page 18). Please provide alternative ways to manage the irrigation water and a reference for pan evaporation rates cited.	The RSE Team is in agreement with this comment. New Section 6.0 will provide additional discussion.
*	41	29	3	Please replace "addition" to additional"	Agree, change will be made.
	42	21	22	NMED previously had asked the RSE team to examine HMC's strategy and the remedial efficacy in controlling alluvial water flux through the Site, noting that HMC has reported relatively-small quantities of alluvial ground water withdrawals from a single upgradient well (i.e., P2) in recent years. NMED notes that evaluation of this component has not been included within this report, and requests that it be completed.	See response to Comment #24.
	43	30	1-2	Please provide an opinion with supporting data as to whether the concentration of contaminants flushed from the LTP to the collection ponds for entombment is an effective strategy for the long-term protection of human health and the environment.	New Section 6.0 will provide additional discussion.
	44	30	3	Please provide an opinion with supporting data as to whether the control system that is used for the lime and caustic soda additions is optimal to achieve remedial objectives.	No data available are available to the RSE Team to conduct this analysis.

Priority change for current revision	Comment No.	Page	Paragraph	Comment	Response
	45	32	Section 4.6	NMED requested the RSE team to evaluate the protectiveness of using the spray evaporation system.	Effectiveness is evaluated in Section 5.3.
	46	33	5	NMED requests that the RSE team evaluate whether waste encapsulation on-site provides long-term protectiveness of human health and the environment.	New Section 6.0 will provide additional discussion.
*	47	36	1	Third sentence should be revised to indicate that soils potentially impacted by overspray will be addressed pursuant to Conditions in the NRC license.	Agree, change will be made.
	48	36	6	NMED requests that the RSE team evaluate whether LTP flushing is effective long-term towards "achieving the NRC action levels."	New Section 6.0 will provide additional discussion.
	49	37	1	NMED requests that the RSE team evaluate whether HMC's current remedial strategy to address the west and south alluvial contaminant plumes can be better optimized to achieve the NRC action levels.	New Section 6.0 will provide additional discussion.
	50	37	2	RSE Team evaluation of the effectiveness of RO treated usage is important to remedial optimization, inasmuch as the RO operation is an important component of operational costs as well as evaporative capacity needs.	New Section 6.0 will provide additional discussion.
*	51	38	Section 6.0	A general statement should open the section that states either that the current remedial approach is the most effective one available or identify other approach(s) that may be more effective/efficient. The recommendations listed in the Executive Summary (bullets 1-8, page iv) are not discussed in sufficient detail in this section. Please provide a discussion for each bullet.	New Section 6.0 will provide additional discussion. Agree, changes will be made for consistency.
	52	38	Bullet 2	NMED requests that the RSE team evaluate the effectiveness of any upgradient alluvial ground water withdrawal strategy to achievement of remedial goals	See response to comment #24

Priority change for current revision	Comment No.	Page	Paragraph	Comment	Response
*	53	39	Bullet 3	Statements that the NRC action levels are protective are incorrect. The action levels are based on background concentrations, not on levels protective of human health. Since they are not protective, eliminating extraction of Chinle water until the alluvial aquifer is cleaned to action levels, followed by resumption of Chinle water extraction will not be effective as it will be re-contaminated based on the earlier statement that pumping from the Chinle moved contaminated alluvial water into the Chinle aquifer.	Agree, change will be made.
*	54	39	Bullet 4	Please provide more supporting information for terminating use of land application, such as the creation of contaminated soil and potentially contaminated feed.	Agree, change will be made.
*	55	40	Bullet 1	NRC action levels are not protective of human health, but are based on background concentrations. Therefore, “action levels” should be replaced by “MCLs” in this section.	Agree, change will be made.
	56			The EPA indicated that it would request the RSE team to evaluate whether existing upstream flood control measures were adequate to protect the site both in the short- and long-term; however, no evaluation has been provided.	No data are available to the RSE Team to make the requested evaluation.
	57			The tailings piles cannot be completely eliminated “…as a continuing source of groundwater contamination;” rather, HMC’s goal is to reduce the contaminant load within the piles in order to reduce the flux of contaminants from these sources. Please evaluate whether HMC’s remedial activities adequately addresses this goal.	New Section 6.0 will provide additional discussion.
	58			NMED recommends that the RSE Team evaluate the efficacy of the current tailings pile flushing operations against the potential for undesirable long-term continued contaminant mobilization into ground water.	New Section 6.0 will provide additional discussion.