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Rio Algom

October 22, 2001

CERTIFIED MAIL 7000 1670 0013 4034 8431
RETURN RECIEPT REQUESTED

Melvyn Leach
Chief, Fuel Cycle Licensing Branch
Division of Fuel Cycle Safety and Safeguards
U.S. Nuclear Regulatory Commission
Mail Stop T-8A33
Washington, DC 20555

Subject: **Re: Amendment 1 to Source Material License SUA-1548**
Flare Factor Estimate Change and Justification
License No: SUA-1548 Docket No: 40-8964
Smith Ranch Facility

Dear Mr. Leach:

In response to Amendment 1 to Source Material License SUA-1548, dated September 27, 2001, Rio Algom Mining Corp. is submitting changes to the license application dated November 15, 1999, as amended. These changes include amended language in Sections 6.2.7 and 6.2.8 as well as changes in Appendix 7 for Chapter 6 of Volume I of the License Application. These changes reflect the methodology used by RAMC to estimate the flare factor of its wellfields for the development of the reclamation bond amount. As justification for the flare factor estimate methodology, RAMC has also attached the groundwater modeling report performed by a groundwater consultant. This report will be amended to the license application as Appendix K in Volume V.

The methodology for estimating flare factor, as well as the modeling report, has been reviewed and approved by Wyoming DEQ - Land Quality Division for purposes of bonding. If you have any questions, please call me at (405) 858-4807.

Sincerely,

William Paul Goranson, P.E.
Manager, Radiation Safety, Regulatory Compliance and Licensing

Enclosures

CC: John Lusher, NRC
Marvin Freeman, RAMC (w/o attachment)
Bill Ferdinand, RAMC
John Cash, RAMC
John McCarthy, RAMC

NMSS01 public

Rwd 01/18/02

CHAPTER 6
RECLAMATION PLAN

The objective of the reclamation plan is to return the affected surface and groundwater to conditions such that they are suitable for all uses for which they were suitable prior to mining. The methods to achieve this objective for both the affected groundwater and the surface are described in the following sections.

6.1 Groundwater Restoration

6.1.1. Water Quality Criteria

To achieve the objective stated above, the primary goal of the restoration program is to return the condition and quality of the affected groundwater in a mined area to background (baseline) or better. In the event the primary goal cannot reasonably be achieved, the condition and quality of the affected groundwater will at a minimum be returned to the pre-mining use suitability category (Reference: LQD Rules and Regulations, Chapter XXI, Section 3 (d) (I)).

For the purposes of this application, the use categories are those established by the Wyoming Department of Environmental Quality, Water Quality Division. The final level of water quality attained during restoration is related to criteria based on the pre-mining baseline data from that wellfield, the applicable Use Suitability Category and the available technology and economics. Baseline as defined for this project shall be the mean of the pre-mining baseline data, taking into account the variability between sample results (baseline mean plus or minus tolerance limits, as defined in Section 5.1.2, after outlier removal).

6.1.2 Restoration Criteria

The restoration criteria for the groundwater in a mining unit is based on the mining unit production-injection wellfield as a whole, on a parameter by parameter basis. All parameters are to be returned to as close to baseline as is reasonably achievable. Restoration target values shall be established for all parameters affected by the mining process. The restoration target values for the mining units shall be the mean of the pre-mining values. If during restoration, the average concentration of a parameter in the designated production area wells of a mining unit is not reduced to the target value within a reasonable time, a report describing the restoration method used, predicted results of additional restoration activities, and an evaluation of the impact, if any, that the higher concentration has on the groundwater quality and future use of the water will be prepared and submitted to the applicable regulatory agencies.

6.1.3 Restoration Method

The primary restoration technique is a combination of groundwater sweep, chemical treatment, and clean water injection. Groundwater sweep involves withdrawing water from selected production and injection wells which draws uncontaminated natural groundwater through the leached area displacing the leach solutions. Chemical treatment involves addition of approved water treatment chemicals to waters injected into the wellfield to re-stabilize the host formation. Clean water injection involves the injection of a better quality of "clean" water in selected wells within the production area while pumping other production and/or injection wells which again displaces the leach solutions with the better quality water. The source of the clean water may be from an EDR or RO type unit, water produced from a mining unit that is in a more advanced state of restoration, water being exchanged with a new mining unit, or a combination of these sources. Water withdrawn from the production zone during restoration will first be processed through an ion exchange unit to recover the uranium, then will be treated and reused in the project, treated and discharged under the existing NPDES permit, or routed to a holding pond for future treatment and/or disposal.

It is expected that an average of about six pore volumes of water will have to be displaced to achieve restoration of a mining unit. During restoration of the initial mining units, it is expected that near the midpoint of the process a chemical reductant will be added to approximately one pore volume of clean water injection to accelerate stabilization of trace metals.

Chemical reductants are beneficial because several of the metals, which are solubilized during the leaching process, are known to form stable insoluble compounds, primarily as sulfides. Primary among such metals is uranium, which occurs at the site because of the naturally occurring reduced state of the ore body. The introduction of a chemical reductant into the mine zone at the end of mining phase is designed to expedite the return of the zone to its natural conditions and to return as many of the solubilized metals to their original insoluble state as possible. By effecting this partial restoration directly within the formation (in-situ), the external impact of groundwater restoration is minimized.

The chemical reductant would be added above ground to the clean water stream being injected into selected wells. Based on the historical success reported by other ISL uranium mining companies, the reductant would be a sulfur compound such as gaseous hydrogen sulfide (H_2S) or dilute solutions of sodium hydrosulfide (NaHS) or sodium sulfide (Na_2S). If RAMC should desire to utilize any reductant other than these three sulfur compounds, WDEQ approval will be obtained prior to use. Dissolved metal compounds that are precipitated by such reductants include those of arsenic, molybdenum, selenium, uranium, and vanadium. All of these may be present in concentrations above baseline levels at the conclusion of mining.

The reductant would be introduced during the midst of the restoration process because the introduction of sulfur and sodium increases the total dissolved solids (TDS) level of the injected fluid. once the reducing conditions are re-established, an oxygen free clean water can be injected to effect the final reduction in TDS.

If gaseous hydrogen sulfide is chosen for use, a program for its safe handling would be prepared and submitted to the appropriate agency prior to its use.

6.1.4 Restoration Sampling

When sampling results indicate that restoration has been achieved, the designated production area wells will be sampled and analyzed for the full suite of parameters listed in Table 5-1 as Suite A.

Unless otherwise requested and approved by the applicable regulatory agencies, the production area wells in a mining unit to be sampled for determining restoration and stability shall be wells used for collecting pre-mining baseline data for that unit. If the data confirm restoration is complete this will initiate the stability demonstration period. In the stability demonstration period the full suite assays will be repeated for those same wells at approximately the six month and one year periods. Between these periods the wells will be sampled at six week intervals with the samples analyzed for a short list of key parameters developed for that specific mining unit. The short list of key parameters will be submitted to and approved by WDEQ/LQD in advance of its use. This sampling plan will provide for a minimum of nine samples within a one year period to demonstrate restoration success.

When the sampling data indicate that the mining unit aquifer has been restored and stabilized, a report documenting this will be filed with the appropriate regulatory agencies along with a request for certification of restoration. Plugging of wells and surface reclamation of the mining unit will commence after receipt of restoration certification.

During restoration, sampling of monitor wells for that mining unit will continue at the same frequency and for the same parameters as during mining. However, during stability monitoring the monitor well sampling frequency will be reduced to only once every two months and the sampling will be terminated at the end of the stability demonstration period.

6.1.5 Well Plugging Procedures

Wells no longer needed for operations or restoration and stability demonstration will be plugged in accordance with the guidelines and requirements established by the Wyoming Department of Environmental Quality. The pumps and tubing will be removed from the wells and each well will be filled from total depth to within five feet of the surface with a WDEQ approved abandonment mud or a cement slurry. Typically, a dual plug procedure will be used, whereby a cement plug will be set using a slurry of a weight of no less than 12 lb/gal into the bottom of the well which will extend across and 50 feet above the first overlying aquitard. The remaining portion of the well will be plugged using a bentonite/water slurry with a mud weight of no less than 9.5 lb/gal. A 10-foot top plug of cement slurry will be set 3 feet below the surface to seal the well at the surface, and prevent surface water intrusion into the well. The casing will then be cut off a minimum of two feet below the surface and a cement plug will be placed at the top of the casing. The area will then be backfilled, smoothed to blend with the natural terrain, and reclaimed per the approved surface reclamation plan.

6.2 Surface Reclamation and Decommissioning

6.2.1 Introduction

All lands disturbed by the mining project will be returned to their pre-mining land use of livestock grazing and wildlife habitat unless an alternative use is justified and is approved by the state and the landowner, i.e. the rancher desires to retain roads or buildings. The objectives of the surface reclamation effort is to return the disturbed lands to production capacity of equal to or better than that existing prior to mining. The soils, vegetation and radiological baseline data will be used as a guide in evaluating final reclamation.

An exception to the above will be the reclamation of any surface disturbance created by RAMC on Glenrock Coal Company's reclaimed surfaces within RAMC's permit boundary (T35N, R75W; Sections 13, 18 and 24). Specifically, if disturbed by RAMC, RAMC will reclaim these previously reclaimed areas to coal standards as specified in Glenrock Coal Company's Permit to Mine No. 291.

6.2.2 Surface Disturbance

The primary surface disturbances associated with solution mining are the sites for the recovery plant and evaporation ponds. Surface disturbances also occur during the well drilling program, pipeline installations, road construction. These disturbances, however, involve relatively small areas or have very short-term impacts.

The recovery plant is located within the Bill Smith Mine site (WDEQ Permit No. 304C), therefore plant construction did not create any new disturbance areas. Disturbances associated with the evaporation ponds, ion exchange satellites and field header buildings, will be for the life of those activities and topsoil will be stripped from the areas prior to construction. Disturbance associated with drilling and pipeline installation are limited, and are reclaimed and reseeded as soon as weather conditions permit. Vegetation will normally be reestablished over these areas within two years. Disturbance for access roads is also limited as a network of roads is already in place to most wellfield areas and throughout the project area.

The on-site solid waste landfill site will be closed in a manner that is consistent closure requirements for Construction/Demolition Landfills provided in the WDEQ Solid and Hazardous Waste Rules and Regulations. All current and closed disposal cells located onsite have been or will be closed with six (6)-inch evenly compacted soil cover and a 3 feet of loose soil cover. Any newly constructed solid waste disposal landfill will be closed in a similar manner as the existing landfill.

6.2.3. Topsoil Handling and Replacement

For any construction, soil will be removed and salvaged. The soil disturbances caused by the mining operation will be kept to a minimum especially in areas of steep terrain. No new surface disturbance was required for the recovery plant as the facility is located in the site used for the Bill Smith Mine. Topsoil from the mine site was stockpiled and the piles have been seeded with a cover crop to control erosion. Topsoil from future disturbance areas such as evaporation ponds, will be removed and stockpiled. The stockpiles will be located, shaped, seeded with a cover crop and crimp mulched to minimize loss to erosion. Topsoil signs will also be placed on each topsoil stockpile.

Within the wellfields, topsoil from the A and E horizons , or in areas where the A and E horizons are less than 4 to 6 inches, no less than the top 4 to 6 inches of soil will be removed and stockpiled from new access roads to the headerhouses and from any other roads that will be used during production that are not considered light use roads. The depth of the A and E horizons may be determined using drill pits adjacent to the areas to be stripped. To demonstrate that appropriate care was taken in stripping topsoil, a record of the depth stripped will be maintained at the site and included in the annual report. Topsoil from well header building sites will also be stockpiled as discussed above. If unanticipated high traffic roadways are developed, the topsoil on such roadways would be subject to the same program of removal, stockpiling, seeding and mulching to control erosion. For areas where only limited temporary disturbance occurs, such as for well sites and pipeline construction, the topsoil will be bladed to one side and then re-spread over the area as soon as construction is completed. These areas will be stubble mulched as soon as practical. If topsoil stockpiling or re-topsoiling of an area is completed in the winter or spring, a stubble crop of oats will normally be planted with the final grass seed mix or a long-term cover seed mix planted in the stubble in the fall. The long term cover crop seed mix is discussed in Section 6.2.4. The long-term cover grass mix will be used to protect topsoil stockpiles and/or re-topsoiled areas which are expected to remain in place for longer than one (1) year prior to final seeding. These practices which were tested and proven effective in the pilot programs, provide the needed protection for the topsoil and minimize losses to wind and water erosion. Topsoil is not placed in draws or areas where it will erode into drainages. If necessary, a containment barrier is constructed to ensure the topsoil will not erode into drainages.

Additional measures taken to protect the topsoil in the wellfield areas is to restrict normal traffic to designated roads and keep required traffic in other areas of the wellfield to a minimum. Disturbed areas in a wellfield not needed for normal access are seeded with a cover crop as soon as practical to minimize erosion.

After contouring for final reclamation has been completed, the remaining access roads or hard packed areas will be ripped prior to topsoiling. Topsoil will then be spread evenly over the disturbed areas and will be seeded with a cover crop of oats. Final contouring will blend with the natural terrain and will establish drainage and eliminate depressions that would accumulate water.

6.2.4. Revegetation Practices

During mining operations the topsoil stockpiles, and as much as practical of the disturbed wellfield and pond areas will be seeded with a cover crop to minimize wind and water erosion. After topsoiling for the final reclamation, an area will normally be seeded with oats to establish a stubble crop, then reseeded with grasses the next growing season using the following mix of pure live seed:

	lbs./acre
western wheat grass (Rosana)	3.0
Streambank wheatgrass	3.0
canby bluegrass	1.0
Sheep Fescue(Covar)	2.0
Indian rice grass	2.0
Yellow blossom Sweet Clover	0.5
winterfat	2.0
Lupine (candatus)	1.0
Total	14.5

Note: Quantity to be doubled for broadcast seeding for all species except Streambank wheatgrass and Yellow sweetclover

Alternate Species, if any of the species listed above are not available, are as follows:

prairie junegrass	0.5
green needlegrass	2.0
Blue Flax	1.0
Other Lupines	1.0
scarlet globe mallow	1.0

prairie sandreed	2.0

Reseeding is normally accomplished by broadcasting seeding or drilling with seeding completed before May 1 or after October 15, during the year in which the topsoil is replaced. The area is then harrowed or raked.

Vegetation in larger reclaimed areas is protected from livestock grazing by fencing the livestock out until the newly established plant community is capable of maintaining itself under normal management practices. No major attempt is made to exclude wildlife; type III livestock fencing is used. (see figure 6-1)

Periodic inspections of the newly reclaimed areas is made within the first two growing seasons to check and record the success and progress of the reseeded plant community. Data collected during these inspections are used to determine when the reseeded areas are ready to sustain controlled livestock grazing and for the final evaluation of reclamation success.

Criteria for determining the success of the reclamation efforts include 1) post-mining vegetation cover and production equal to that on an appropriate comparison area, 2) species composition and diversity capable of supporting the planned post-mining use, and 3) a reclaimed vegetation community able to sustain grazing pressure at a rate equal to that of the surrounding native areas. All of the above is achieved for a period of two consecutive years prior to full bond release.

Livestock grazing is critical to full bond release, however, unrestricted grazing at the wrong time could ruin revegetation efforts. Therefore, the determination of when and how domestic livestock grazing will be introduced on the revegetated areas is mutually agreed upon by RAMC, the Land Quality Division, and the landowner or land managing agency. The grazing plan agreed upon will include aspects of controlled grazing practices such as timed grazing, as well as limited and well distributed livestock numbers, so that newly reclaimed areas are not over-utilized. The limited and controlled amount of grazing may occur during the two consecutive years of evaluation prior to full bond release, but are timed so that vegetation production data are not compromised by the grazing. Production estimates on the newly revegetated areas are made using livestock exclosures, which also will assure that grazing practices will not compromise the annual biomass evaluation.

An extended reference area has been established which includes the primary vegetation types to be disturbed. The purpose of this area is to establish a reference area as a source of quantitative data to be used for comparative purposes at the time of final bond release. The location of this site(s) was mutually agreed upon by WDEQ-LQD and RAMC.

6.2.5 Site Decontamination and Decommissioning

When groundwater restoration in the final mining unit is completed, decommissioning of the recovery plant site and the remaining evaporation ponds will be initiated. In decommissioning the recovery plant, the process equipment will be dismantled and sold to another licensed facility, or decontaminated in accordance with "Guidelines for Decontamination of Facilities and Equipment

Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Materials" - September, 198411 published by U.S. NRC. Materials that cannot be decontaminated to an acceptable level will be disposed in an NRC approved facility. After decontamination, materials that will not be reused or that have no resale value, such as building foundations, will be buried on-site.

The plant site will be contoured to blend with the natural terrain, surveyed to ensure gamma radiation levels are within acceptable limits, topsoiled, and reseeded per the approved reclamation plan.

After all liquids in an evaporation pond have evaporated or been disposed in a licensed facility, the precipitated solids and the pond liner will be removed and disposed in a licensed facility. The area will then be contoured to blend with the natural terrain, surveyed to ensure gamma levels are not exceeded, then topsoiled and reseeded per the approved plan.
Gamma surveys are also conducted during the decommissioning of each mining unit. Material identified during the gamma surveys as having contamination levels requiring disposal in a licensed facility will be removed, packaged (if applicable), and shipped to an NRC approved facility for disposal.

6.2.6 Final Contouring

Recontouring of land where surface disturbance has taken place will restore it to a surface configuration that will blend in with the natural terrain and will be consistent with the post mining land use. Since no major changes in the topography will result from the proposed mining operation, a final contour map is not included in the application.

6.2.7 Reclamation Cost Estimate

A detailed reclamation cost estimate has been prepared for all aspects of the project for the period of 1999 to 2000 as part of the proposed bond in June 1999. The attached tables describing the bond calculations represents only the most current version for review within the context of this license/permit application. The bond and detail amounts will be updated by Rio Algom and reviewed by the WDEQ and NRC on an annual basis.

The estimate includes the cost for reclaiming the existing disturbances such as the Bill Smith mine area and pilot ISL Q-Sand and O-Sand facilities, as well as proposed commercial scale facilities. The estimate includes a one-year forward estimate required by WDEQ for forecasted disturbances as well as a five-year forward estimate to cover all potential disturbances within the term of the NRC license. A 15 percent overall contingency has been applied to the total cost estimate, which is in 1997 dollars. The estimate is updated on an annual basis and submitted to the WDEQ in the annual report. The updated estimate is also provided to the NRC for their review. The reclamation cost estimate is summarized in Table 6-1, and is detailed in Appendices 1 through 11. Table 6-1 is taken from the reclamation bond estimate for the 2001-2002 surety estimate. This estimate will be revised annually through the Annual Report to WDEQ/LQD and according to the surety update requirements in License Condition 9.5 of the facilities Source Material License SUA-1548, and the annual update of that surety will substitute for any changes to this application. As a result, changes in surety will not necessitate a change in the Permit or License Application. A list of key details and assumptions used in the reclamation estimate is provided as Table 6-2.

6.2.8 Reclamation Bonding

A reclamation bond will be maintained with the Wyoming Department of Environmental Quality - Land Quality Division, in the amount of the final approved reclamation cost estimate. In 1999, Rio Algom Mining Corp. currently maintains a self-bond in the amount of $8.029 million to cover existing liabilities at the Smith Ranch project. The surety mechanism used for the commercial estimate, which includes the existing liabilities, may either be a parental guaranty or letter of credit. RAMC follows WDEQ and NRC guidelines when securing either the parental guaranty or letter of credit.

6.2.8.1 Estimates for Groundwater Restoration

RAMC performed modeling and evaluation of wellfield restoration plans and cost estimates for the commercial wellfields. That work used both Q-sand pilot restoration information as a calibration of the wellfield model and used that information to conduct both hydrological and geochemical modeling. The methodology, results and conclusions from that modeling were provided to WDEQ/LQD in a report submitted on December 13, 1999. A copy of that report is included as Appendix K of this application. Based on the results of that work, RAMC developed a new methodology for developing the size of the Affected Pore Volume, (Section 7 of Appendix 1 of this Chapter).

Figure 7-1 is derived from Figure 3-16 in "Evaluation and Simulation of Wellfield Restoration at the RAMC Smith Ranch Facility" dated October 29, 1999 (Appendix K). This document was submitted to the Wyoming DEQ - Land Quality Division with a letter dated December 13, 1999 for review. In that document, RAMC proposes a methodology developed through hydraulic and geochemical modeling that uses the geometry of the wellfield to estimate a Flare Factor. In this case, the number of perimeter injection wells are counted, the surface area of the wellfield pattern is measured using a wellfield map, a ratio is developed of the # of perimeter injection wells to the surface area of the wellfield patterns. That ratio is located on the horizontal axis of figure 7-1. From that intercept, a vertical line is projected to intersect the curve. At that intersection, a horizontal line is projected to intercept the vertical axis. The estimated flare factor is derived from that intercept. The curve shown on Figure 7-1 has been validated using modeling for flare factors of 1.5 and higher, but it had not been verified for Flare Factors lower than 1.5. As a result, for bonding purposes only, RAMC will not use a Flare Factor lower than 1.5 for estimating the predicted costs for groundwater restoration.

The proposed groundwater restoration costs in Section 7 of the Appendix to this Chapter, uses the new methodology with the constraints agreed to at the May 11, 2000 meeting between LQD and RAMC.

6.2.8.2 Validation of Groundwater Restoration Estimates

The costs that are related to the restoration of groundwater to meet the primary and secondary goals are primarily dependent upon the volume of water to be treated. The estimates are currently derived using historical data from the Q-Sand Pilot Project and groundwater modeling to develop expected geochemical and hydrological trends to derive a estimated volume of water to be treated.

Although RAMC is confident that the volume estimates are conservative, it is reasonable to acknowledge that model and actual results could differ significantly. As a result of that acknowledgement, upon completion of restoration of the first wellfield, RAMC will compare expected to actual restoration results and adjust treatment volumes if necessary. This comparison will include the appropriateness of continuing the use of Figure 7-1 for estimating flare factor design, the use of pilot studies to predict actual commercial wellfield restoration performance, and the use of conservative constituents for driving restoration modeling. This comparison will be performed on all restoration constituents listed on the restoration tables for the appropriate wellfield. This comparison will be provided in the restoration completion report for the first wellfield.

Table-6-1

WDEQ/NRC RECLAMATION SURETY
SMITH RANCH, CONVERSE COUNTY, WYOMING
RIO ALGOM MINING CORP.

2001-2002 PROPOSED WDEQ/LQD BOND

WORK UNIT		ONE YEAR FORWARD WDEQ/LQD & NRC 2001-2002 BOND AMOUNT
	Ion Exchange Plant[1] (NRC Related Activity)	
1.1	Building	40,116
1.2	Tankage and Vessels	39,913
1.3	Piping	12,924
1.4	Pumps	6,094
1.5	Electrical	9,470
1.6	Foundations	48,588
1.7	Plant Site	2,058
1.8	Access Road	1,054
1.9	SUB-TOTAL	160,217
	Central Processing Plant (NRC Related Activity)	
2.1	Buildings	57,548
2.2	Tankage and Vessels	60,246
2.3	Piping	10,846
2.4	Pumps	10,965
2.5	Electrical	19,682
2.6	Foundations	70,019
	SUB-TOTAL	229,306
	Dryer Area (NRC Related Activity)	
3.1	Buildings	16,222
3.2	Equipment	14,739
3.3	Foundations	16,802
	SUB-TOTAL	47,763
	Existing Facilities	
4.1	Buildings[2] (NRC Related Activity)	95,635
4.2	Structures[3] (NRC Related Activity)	17,963
4.3	Pilot Plant Equipment (NRC Related Activity)	22,620
4.4	Foundations[2] (NRC Related Activity)	139,333
4.5	Site Reclamation[2]	178,287
4.6	O-Sand Pilot (NRC Related Activity)	41,435
4.7	Q-Sand Pilot (NRC Related Activity)	N/A

WORK UNIT		ONE YEAR FORWARD WDEQ/LQD & NRC 2001-2002 BOND AMOUNT
4.8	Mine Water Treatment Ponds	19,878
	SUB-TOTAL	515,151
	Unit Header Site & Wellfields[4] (NRC Related Activity)	
5.1	Buildings	79,463
5.2	Header Piping	140,306
5.3	Secondary Electrical	135,073
5.4	Wells-Totals	540,292
5.5	Monitor Wells-Total	73,515
5.6	Site Reclamation	52,275
	SUB-TOTAL	1,020,924
	Associated Structures	
6.1	#1 Trunkline (5,000 ft ea) (NRC Related Activity)	52,108
6.2	#2 Trunkline (10,000 ft ea) (NRC Related Activity)	104,216
6.3	Radium Settling Ponds (NRC Related Activity)	70,077
6.4a	Plugging & Aband. Disposal Well #1 (NRC Related Activity)	77,735
6.4b	Plugging & Aband. Disposal Well #2 (NRC Related Activity)	77,735
6.5	Sand Mining Area	13,173
6.6	Land Fill	1,500
6.7	Fire Protection System	11,623
	SUB-TOTAL	408,167
	Groundwater Reclamation & RO Units (NRC Related Activity)	
7.1	Restoration	3,605,272
	Health Physics and Radiation Surveys (NRC Related Activity)	
8.1	Monitoring	168,470
	Whole Trucking (Remaining Fractional Units) (NRC Related Activity)	
9.1	Contaminated Trucking	523
9.2	Non-contaminated Trucking	157

WORK UNIT	ONE YEAR FORWARD WDEQ/LQD & NRC 2001-2002 BOND AMOUNT
10.1 Delineation Hole Reclamation	129,953
SUB-TOTAL OF ALL ABOVE	6,285,903
Overhead and Profit at 10%	628,590
Contingency at 15%	942,855
SUB-TOTAL OF ALL ABOVE	7,857,348
Inflation - 10.42% (4/97 CPI-160.2 through 4/01 CPI-176.9)	818,736
TOTAL (in 2001$)	8,676,084
Proposed Bonding	8,676,084

(1) Represents the construction of one (1) satellite during 1997-1998

(2) Incorporates new office annex building.

(3) Incorporates additional surface disturbances (10.46 acres) from commercial construction activities along with new items including fencing, water wells, and fuel storage area.

(4) Represents 1 year forward of 513 patterns to be restored.

TABLE 6-2

LIST OF KEY DETAILS AND ASSUMPTIONS USED IN THE SMITH RANCH BOND ESTIMATE

1. The landfill for non-contaminated materials is the municipal landfill located in Casper, Wyoming. The landfill may be reached by an approximate 80 mile route through Douglas, WY, crossing the Platte River Bridge in Glenrock, WY.
2. The licensed disposal area for contaminated materials is Rio Algom's Quivira tailings facility, Ambrosia Lake, New Mexico, located approximately 800 miles to the south of the Smith Ranch project. This project is licensed by NRC Source Material License SUA-1473, which has been amended to allow the acceptance of byproduct materials from other licensees, including Smith Ranch.
3. All hourly labor costs are "loaded" costs and include a benefits burden.
4. All hourly equipment costs are loaded to include the operator, as well as a benefits burden.

5. References used for equipment rental rates, productivity, wages, etc. are as follows:

Equipment Rental Rates

- Russell Forgey Construction Co. - Casper, WY
  (307) 472-2173, Gail Beloon (out of business)
- Petro Engineering & Construction, Inc. - Casper, WY
  (307) 234-6221, Mark Steinle - Project Manager

CY Transport - Casper, WY

(307) 266-1667 (Out of business)

- Tri-State Trucking Company

Labor Rates

- Previous RAMC correspondence with WDEQ on 304C Annual Reports
- Northwinds of Wyoming, Inc.
  (307) 358-6550, Buck Underwood - President
- Automation Electronics - Casper, WY
  (307) 234-9311, Byron Stamm - President

General (Update references to new edition)

- Richardson's Process Plant Construction Estimating Standards, 1987; Richardson Engineering Service, Inc., San Marcos, California.
- Means Site Work Cost Data, 1987; Construction Consultants and Publishers, Kingston, Maine.

6. Aquifer restoration of the "O" sand pilot will occur with the restoration of the first "O" sand commercial wellfield.

(is this still true?)

7. Building removal costs have all been factored from the actual cost and time involved in dismantlement and removal of a large building located at the 304C open pit mine area in 1988. An average cost of approximately $\$3.50/ft^2$ is derived when 10% for profit and overhead is added to the overall cost of the building reclamation,

then divided by the number of square feet of the building area. For example, the Appendix 1 building reclamation cost would amount to approximately \$3.45 /ft2 if 10% for profit and overhead is added to the \$36,174 total cost (\$39,791), then divided by the 11,550 ft2 of building area. Appendix 2 building costs are \$3.48/ft2 Appendix 3 - \$3.55/ft2, and Appendix 4 - \$3.63/ft2.

8. The basis for calculation of groundwater restoration costs is provided in Table 7.1, 7.2, and 7.3 of Appendix 7.

9. It has been assumed that 90% of all contaminated materials and equipment can be decontaminated to levels acceptable for unrestricted use or disposal. The exceptions to this are the yellowcake dryers, fluid ends of pumps, pond sludges and liners, and 3 inch diameter or smaller piping.

10. Decommissioning volumes for the tanks, vessels and other process equipment are based on actual engineered sizes planned for installation (see individual tables).

11. Wellfield patterns will be drilled approximately one year in advance of their proposed operation. Surface piping and pumps are not installed in the wells until the year of operation. In other words, the one year forward estimate in the Summary Table 61 includes the costs for plugging and abandoning 144 wellfield patterns, but no

costs are included for surface equipment or aquifer restoration.

12. For groundwater restoration, the following liabilities are assumed:

for any year, present liability is the sum of:

- patterns operating
- patterns depleted, awaiting restoration
- patterns in restoration
- patterns in stability

for any year, forward liability for the next year is:

new patterns placed in service during the next year less patterns completing stabilization during the next year

13. The initial IX plant will be located in the existing building adjacent to the central processing plant. The second IX satellite plant, planned for Section 27, will be placed in operation during the five-year forward period.

14. Surface reclamation costs (topsoil replacement and revegetation) are included in Appendix 4, Existing Disturbance, for the initial IX plant (Appendix 1), central processing plant (Appendix 2), and the dryer building (Appendix 3), as these are all existing buildings.

15. The tractor/trailer used for hauling non-contaminated materials is of a flatbed type with an attached crane, with load limit of 47,000#. The tractor/trailer used for hauling contaminated materials will typically be a closed van-type, with a load limit of 40,000#.

16. Increased Disposal Capacity for Restoration Bonding Amount: In a letter dated May 8, 1998 to WDEQ/LQD, RAMC committed to increasing the bonding amount for Permit #633 to reflect the installation of additional disposal capacity required for restoration. This commitment is a response to the first round comments for TFN 3 6/142 dated October 22, 1997. The comment was 0.3(c) regarding the water balance through the plant to include 6,000 gpm of production, the resulting bleed, and the ability to handle 1,000 gpm of restoration flow. The resulting water balance would be approximately 300 gpm of required wastewater disposal capacity. The current disposal well is permitted to accept a maximum average flow of 150 gpm. As RAMC receives approval to inject into Wellfield #3, the plant flow capacity will reach 6,000 gpm. In order to remain within the schedule presented in the mine plan, RAMC is currently evaluating methods of increasing disposal capacity to facilitate the restoration schedule. The additional disposal capacity can be in the form of a second waste disposal well, additional evaporation ponds, land application, discharge through the NPDES permit, or a combination of some or all of these methods. WDEQ requested that RAMC provide additional bonding to cover the costs of the additional disposal capacity. As a

result, the bonding will be increased by $1,000,000 to reflect the requirement to install a second waste disposal well or evaporation ponds to handle the additional water flows resulting from combined production and restoration operations. With the installation of the 2^{nd} Waste Disposal Well at the Smith Ranch Facility, this increase has been eliminated from the surety estimate.

Appendices - SURETY BOND DETAIL

This section presents the support details for the summary totals included in Table 6-1. Within this part, the bond detail is divided into ten (10) sections that encompass the mining activities at the Smith Ranch facility. These 10 divisions match each of the summary sections that are presented in Table 6-1.

These bond division areas include; ion exchange plants, central processing plant, dryer area, existing facilities, header sites and wellfields, associated structures, groundwater reclamation and RO Units, whole trucking, and delineation hole reclamation. The cost basis for these calculations are from contractor quotes. These quotes are presented in "Part III - Cost Basis".

(NRC Related Activity)

Appendix 1
ION EXCHANGE PLANT RECLAMATION COSTS
Cost Summary

ITEM	COSTS ($97)
1.1 Building	**40,116**
1.2 Tankage and Vessels	**39,913**
1.3 Piping	**13,224**
1.4 Pumps	**6,094**
1.5 Electrical	**9,470**
1.6 Foundations	**48,588**
1.7 Plant Site	**2,058**
1.8 Access Road	**1,054**
Total Cost	**160,517**

1.1 Building

Calculation Basis: 70 Ft. x 165 Ft. with 23 Ft. Eave
Floor Area = 11,550 Ft^2
Skin Area = 10,810 Ft^2

A. Washdown Building - 6 Days:
Wash 10,810 Ft^2 @ 1 Gal/Ft^2 = 10,818 Gal
Wash 10,810 Ft^2 @ 450 Ft^2/Man-Day = 24 Man-Days
= 6 Crew-Days

- Labor Crew = 1 - Foreman @ $21.58/Hr
  4 - Laborers @ $13.02/Hr
  $73.66/Hr x 48 Hr =$ 3,536

- Travel = $73.66/Hr x 6 Day x 1 Hr/Day =$ 442

- Eq. Rental = 4 - Pressure Washers @ $ 8.71/ Hr
  $ 34.84/Hr x 48 Hr =$ 1,672

- Materials = Soap @ $1.09/BBL
  10,810 Gal x BBL/42 Gal x $1.09/BBL =$ 281

- Dispose of Fluid @ $0.11/BBL
  10,810 Gal x BBL/42 Gal x $0.11/BBL =$ 28

Sub-total =$ 5,959

B. Dismantle and Load - 15 Days:

11,550 Ft^2 @ 100 Ft^2/Man-Day	= 115.5 Man-Days	
	= 15.0 Crew-Days	

- Labor Crew = 1 - Foreman @ $ 21.58/Hr
  2 - Welders @ $ 19.35/Hr
  2 - Operators @ $ 17.71/Hr
  4 – Laborers @ $ 13.02/Hr
  $147.78/Hr x 120 Hr =$ 17,734

- Travel = $147.78/Hr x 15 Days x 1 Hr/Day =$ 2,217

- Eq. Rental = 2 - 20 Ton Cranes @ $37.39/Hr
  2 - Welders/Torches @ $10.90/Hr
  $96.58/Hr x 120 Hr =$ 11,590

Sub-total =$ 31,541

C. Haul and Dispose - On-Site Land Fill:
Building = 235,000# = 5 Truck Loads** @ 47,000#
- Haul = 5 Trucks x 8 Hrs/Truck x $65.39/Hr = $ 2,616
- Dispose = Cost Included in Section 6.5

** 5 Trucks required to move building in 1988

Building Total ***=$ 40,116***

1.2 Tankage and Vessels

Basis: See Table 1.1

A. Decontaminate - 0 Days: (Assume No Decontamination)

B. Remove and Load - 11 Days:

- Labor Crew = 1 - Foreman @ \$21.58/Hr*
  1 - Operator @ \$17.71/Hr
  2 - Laborers @ \$13.02/Hr
  \$65.33/Hr x 88 Hr =\$ 5,749

- Travel = \$65.33/Hr x 11 Days x 1 Hr/Day =\$ 719

- Eq. Rental = 1 - 20 Ton Crane @ \$37.39/Hr
  \$37.39/Hr x 88 Hr =\$ 3,290

* This foreman will also supervise1.2 C.

Sub-total =\$ 9,758

C. Dismantle, Cut, or Crush - 11 Days:

Cut Steel @ 30 Ft.^{3}/Man-Day @ 631.4 Ft^3 = 21 Man-Day
Crush FRP @ 60 Ft.^{3}/Man-Day @ 240.5 Ft^3 = 4 Man-Day

- Labor Crew =1 - Foreman@ Foreman supervises both 1.2 (B) & (C)
  2 - Welders @ \$19.35/Hr
  2 - Laborers @ \$13.02/Hr
  \$64.74/Hr x 88 Hr =\$ 5,697

- Travel = \$64.74/Hr x 11 Days x 1 Hr/Day =\$ 712

- Eq. Rental = 1 - D8N Dozer @ \$117.71/Hr for 4 Days
  \$117.71 /Hr x 32 Hr =\$ 3,767
  2 - Welders/Torches @ \$ 10.90/Hr
  \$ 21.80/Hr x 88 Hr =\$ 1,918

Sub-total =\$ 12,094

D. Haul and Dispose - Licensed (NRC SUA - #1473) Site:

100% of Contaminated Service = 835.4 Ft.^{3} @ 198,380#
Total = 30.9 Cu.Yd. @ 198,380# = 5 Truck Loads @ 40,000#

- Haul = 5 Truck x 800 Mile x \$3.27/Mile =\$ 13,080
- Dispose = 198,380# = 99.1 tons
  @ \$50/ton disposal cost =\$ 4,955

E. Haul and Dispose - On-Site Land Fill:
100% of Non-Contaminated Service = 36.5 Ft^3 @ 2,320#
Total = 1.4 Cu.Yd. @ 2,230# = 0.05 Truck Loads @ 47,000#

- Haul = 0.05 Trucks x 8 Hrs/Truck x \$65.39/Hr =\$ 26

- Dispose = Cost Included in Section 6.5

Tankage and Vessel Total =***\$39,913***

1.3 Piping

Basis: See Table 1.2

A. Remove, Cut or Crush and Load - 5 Days:
PVC & Poly - 2,800 Ft @ 140 Ft/Man-Day = 20 Man-Day
= 5 Crew-Day
Steel - 1,100 Ft @ 110 Ft/Man-Day = 10 Man-Day
= 5 Crew-Day

- Labor Crew =

1 - Foreman	@ \$ 21.58/Hr		
2 - Welders	@ \$ 19.35/Hr		
1 - Operator	@ \$ 17.71/Hr		
4 - Laborers	@ \$ 13.02/Hr		
	\$130.07/Hr x 40 Hr	=\$ 5,503	

- Travel = \$130.07/Hr x 5 Days x 1 Hr/Day =\$ 650

- Eq. Rental = 1 - 20 Ton Crane @ \$37.39/Hr
2 - Welders/Torches @ \$10.90/Hr
\$59.19/Hr x 40 Hr =\$ 2,368

Sub-total =\$ 8,521

B. Decontaminate - 0 Days: =\$ 0

C. Haul and Dispose - Licensed (NRC SUA #1473) Site:
100% Piping = 886.7 Ft^3 @ 52,080#
Total = 32.8 Cu.Yd. @ 52,080# = 1.3 Truck Load @ 40,000#

- Haul = 1.3 Truck x 800 Mile x \$3.27/Mile =\$ 3,401
- Dispose = 52,080# = 26.04 tons
@ \$50/ton disposal cost =\$ 1,302

Piping Total =***\$ 13,224***

1.4 Pumps

Basis: See Table 1.3

A. Removal and Loading - 6 Days:

21 Pumps @ 2 Pumps/Man-Day = 10.5 Man-Days
= 6.0 Crew-Days

• Labor Crew =	1 - Foreman	@ $21.58/Hr	
	1 - Operator	@ $17.71/Hr	
	2 - Laborers	@ $13.02/Hr	
		$65 .33/Hr x 48 Hrs	=$ 3,136
• Travel = $65.33/Hr x 6 Days x 1 Hr/Day			=$ 392
• Eq. Rental = 1 - 20 Ton Crane @ $37.39/Hr			
		$37.39/Hr x 48 Hrs	=$ 1,795
Sub-total			=$ 5,323

B. Haul and Dispose - Licensed (NRC SUA #1473) Site:

Contaminated Pumps = 77.9 Ft.^{3} @ 5,700#

Total = 2.9 Cu. Yd. @ 5,700# = 0.2 Truck Loads @ 40,000#

• Haul = 0.2 Truck x 800 Mile x $3.27/Mile	=$ 523
• Dispose = 5,700# = 2.85 tons @ $50/ton disposal cost	=$ 143

C. Haul and Dispose - On-Site Land Fill:

Non-Contaminated Motors = 69.9 Ft^3 @ 8,445#

Non-Contaminated Pumps = 2 Ft^3 @ 100#

Total = 71.9 Ft.^{3} @ 8,545# = 0.2 Truck Loads @ 47,000#

• Haul = 0.2 Trucks x 8 Hrs/Truck x $65.39/Hr	=$ 105
• Dispose = Cost Included in Section 6.5	

Pump Total =***$ 6,094***

1.5 Electrical

A. Remove, Cut and Load - 5 Days:

- Labor Crew = 1 - Journeyman Elect. @ \$ 34.88/Hr
  2 - Helpers @ \$ 30.51/Hr
  1 - Welder @ \$ 19.35/Hr
  1 - Operator @ \$ 17.71/Hr
  \$132.96/Hr x 40 Hr = \$ 5,318

- Elec. Travel = \$95.90/Hr x 5 Days x 2 Hr/Day = \$ 959
  \+ \$0.54/Mile x 5 Days x 120 Mile/Day = \$ 324

- Travel = \$37.06/Hr x 5 Days x 1 Hr/Day = \$ 185

- Eq. Rental = 1 - 20 Ton Crane @ \$37.39/Hr
  1 - Truck @ \$12.26/Hr*
  1 - Welder/Torch @ \$10.90/Hr
  \$60.55/Hr x 40 Hr = \$ 2,422

Sub-total = \$ 9,208

B. Haul and Dispose - On-Site Land Fill:

MCC = 11.75 Ft. x 1.25 Ft. x 7.5 Ft. = 110.2 $Ft.^3$ @ 4,550#
Cable = 110.2 $Ft.^3$ x 0.5 = 55.1 $Ft.^3$ @ 18,400# (@ 40% Voids)
Total = 165.1 $Ft.^3$ @ 22,950#
= 6.1 Cu. Yd. @ 22,950# = 0.5 Truck Loads @ 47,000#

- Haul = 0.5 Trucks x 8 Hrs/Truck x \$65.39/Hr = \$ 262
- Dispose = Cost Included in Section 6.5

Electrical Total = ***\$ 9,470***

1.6 Foundation

A. Decontaminate Slab - 3 Days:

11,550 Ft^2 @ 1,000 Ft^3/Man-Day = 11.6 Man-Days
= 3.0 Crew-Days

- Labor Crew = 1 - Foreman @ \$21.58/Hr
4 - Laborers @ \$13.02/Hr
\$73.66/Hr x 24 Hr =\$ 1,768

- Travel = \$73.66/Hr x 3 Days x 1 Hr/Day =\$ 221

- Eq. Rental = Hand Tools @ \$10.90/Hr
(Brooms, Squeegee) \$10.90/Hr x 24 Hr =\$ 262

- 10% HCl = 2 Gal/Ft^2 x 11,550 Ft^2
= 23,100 Gal.

Make-Up from 20° Be HCl Stock @ \$0.55/Gal
Require 288 Gal. Stock per 1,000 Gal. - 10%

23,100 gal x 0.288 x \$0.55/Gal =\$ 3,659

- Dispose of Fluid @ \$0.11/BBL
23,100 Gal x $\frac{\text{BBL}}{\text{42 Gal}}$ x \$0.11/BBL =\$ 61

Sub-total =\$ 5,971

B. Break and Remove 25% of Slab - 10 Days:

11,550 Ft^2 x 0.25 = 2,888 Ft^2
2,888 Ft^2 @ 37.5 Ft^2/Hr = 77 Hrs

- Labor Crew = 1 - Operator @ \$17.71/Hr
17.71/Hr x 77 Hrs =\$ 1,364

- Travel = \$17.71/Hr x 10 Days x 1 Hr/Day =\$ 177

- Eq. Rental = 1 - Pavement Breaker @ \$31.33/Hr
\$31.33/Hr x 77 Hrs =\$ 2,412
1 - Cat 980C Loader @ \$92.64/Hr
\$92.64/Hr x 40 Hrs =\$ 3,706

Sub-total =\$ 7,659

C. Haul and Dispose - Licensed (NRC SUA #1473) Site:

Concrete $= \frac{2,888\ Ft^2 \times 8\ In}{12\ In/Ft} = 1925\ Ft^3$ Set

$= 377,365\#$ @ $196\#\ Ft^3$

$= 3,209\ Ft^3$ Loose (40% voids)

Total = 11.9 Cu.Yd. @ 377,365# = 9.4 Truck Loads @ 40,000#

• Haul = 9.4 Truck x 800 Miles x $3.27/Mile	=$ 24,590
• Dispose = 377,365# = 188.7 tons @ $50/ton disposal cost	=$ 9,435

D. Bury Area w/2 Ft Cover:

• Materials = 856 Cu.Yd. Cover @ $1.09/Cu.Yd.	=$ 933
Foundation Total	=$ 48,588

1.7 Plant Site

Basis: 200 Ft. x 300 Ft. = 60,000 $Ft.^2$ = 1.4 Acres

A. Rip and Contour:

• Basis: See Table 1.4	
• Rip and Contour @ $166.68/Acre	=$ 233

B. Topsoil Placement:

Replace 6 in. Topsoil = 60,000 $Ft.^2$ x 0.5 = 30,000 $Ft.^3$ = 1,111 Cu.Yd.

• Topsoil Placement @ $1.09/Cu.Yd.	=$ 1,211

C. Revegetate:

• Grade and Contour Topsoil	@ $ 87.19/Acre x 1.4 Acre	=$ 122
• Seedbed Prep. (Disc. + Harrow)	@ $ 21.80/Acre x 1.4 Acre	=$ 31
• Mulch (Drill + Seed + Mow)	@ $ 49/Acre x 1.4 Acre	=$ 69
• Drill Seed and Fertilize (Drill + Seed + Fertilizer)	@ $163/Acre x 1.4 Acre	=$ 228
• Revegetation Contingency (All items excluding grading)	@ $233.80/Acre* x 0.7 Acre	=$ 164

*Assume only 50% of acreage requires reseeding

Sub-total	=$ 614
Plant Site Total	=$ 2,058

1.8 Access Road

Basis: Gravel Road = 21 Ft. x 1320 Ft. = 27,720 Ft.^{2} = 0.6 Acres

A. Rip and Contour:

- Basis: See Table 1.4
- Rip and Contour @ $166.68/Acre =$ 233

B. Topsoil Placement:

Replace 6 in. Topsoil = 27,720 Ft.^{2} x 0.5 = 13,860 Ft.^{3} = 513 Cu.Yd

- Topsoil Placement @ $1.09/Cu.Yd. =$ 559

C. Revegetate:

• Grade and Contour	@ $ 87.19/Acre x 0.6 Acre	=$ 52
• Seedbed Prep. (Disc. + Harrow)	@ $ 21.80/Acre x 0.6 Acre	=$ 13
• Mulch (Drill + Seed + Mow)	@ $ 49/Acre x 0.6 Acre	=$ 29
• Drill Seed and Fertilize (Drill + Seed + Fertilizer)	@ $163/Acre x 0.6 Acre	=$ 98
• Revegetation Contingency (All items excluding grading)	@ $233.80/Acre* x 0.3 Acre	=$ 70

Sub-total =$ 262

*Assume only 50% of acreage requires reseeding

Access Road =***$ 1,054***

TABLE 1.4
IX PLANT
SCARIFY (RIP) COMPACTED SURFACE

Equipment = Cat. 140G Motor Grader @ \$65.39/Hr - Complete
Speed = 3.9 mph (2nd gear)
Width = 9 Ft/Pass

$$\text{Productivity} = 3.9\,\frac{\text{Mile}}{\text{Hr}} \times 5280\,\frac{\text{Ft}}{\text{Mile}} \times 9\,\frac{\text{Ft}}{\text{Pass}} \times 0.83\ \text{Eff.}$$

$$= 153{,}822\,\frac{\text{Ft}^2}{\text{Hr}}$$

$$= 3.53\,\frac{\text{Acre}}{\text{Hr}}$$

$$\$/\text{Acre} = \frac{\$65.39}{\text{Hr}} \times \frac{\text{Hr}}{3.53\ \text{Acre}} = \frac{\$18.52}{\text{Acre}}$$

From Above - Ripping @ \$166.68/Acre Allows for 9 Passes

(NRC Related Activity)

APPENDIX 2
CENTRAL PROCESSING PLANT RECLAMATION COSTS

Cost Summary

ITEM	COSTS ($97)
2.1 Building	**57,548**
2.2 Tankage and Vessels	**60,246**
2.3 Piping	**10,846**
2.4 Pumps	**10,965**
2.5 Electrical	**19,682**
2.6 Foundations	**69,719**
Total Cost	**229,006**

2.1 Building

Basis: 100 Ft. x 165 Ft. with 30 Ft. Eave

Floor Area = 16,500 Ft^2

Skin Area = 15,900 Ft^2

A. Washdown Building - 9 days:

Wash 15,900 Ft^2 @ 1 Gal/Ft^2 = 15,900 Gal

Wash 15,900 Ft^2 @ 450 Ft^2/Man-Day = 35 Man-Days

= 9 Crew-Days

- Labor Crew = 1 - Foreman @ $21.58/Hr
  4 - Laborers @ $13.02/Hr
  $73.66/Hr x 72 Hr = $ 5,303

- Travel = $73.66/Hr x 9 Days x 1 Hr/Day = $ 663

- Eq. Rental = 4 - Pressure Washers @ $ 8.71/Hr
  $ 34.84/Hr x 80 Hr = $ 2,787

- Materials = Soap @ $1.09/BBL
  15,900 Gal x BBL/42 Gal x $1.09/BBL = $ 413

- Dispose of Fluid @ $0.11/BBL
  15,900 Gal x BBL/42 Gal x $0.11/BBL = $ 42

Sub-total = $ 9,208

B. Dismantle and Load - 21 Days:

Dismantle and Load	@ 100 Ft^2/Man-Day		
16,500 Ft^2	@ 100 Ft^2/Man-Day = 165 Man-Days	= 168 Man-Days	
		= 21 Crew-Days	

- Labor Crew = 1 - Foreman @ $ 21.58/Hr
  2 - Welders @ $ 19.35/Hr
  2 - Operators @$ 17.71/Hr
  4 - Laborers @$ 13.02/Hr
  $147.78/Hr x 168 Hr = $24,827

- Travel = $147.78 Hrs x 21 Days x 1 Hr/Day = $ 3,103

- Eq. Rental = 2 - 20 Ton Cranes @ $ 37.39/Hr
  2 - Welders/Torches @ $ 10.90/Hr
  $ 96.58/Hr x 168 Hr = $16,225

Sub-total = $44,155

C. Haul and Dispose - On-Site Land Fill:
Building = 376,000# = 8 Truck Loads* @ 47,000#

- Haul = 8 Trucks x 8 Hrs/Truck x $65.39/Hr = $ 4,185
- Dispose = See Appendix 6.5

Building Total = ***$ 57,548***

2.2 Tankage and Vessels

Basis: See Table 2.1

A. Decontaminate - 0 Days: = $ 0

B. Remove and Load - 19 Days:
- Labor Crew = 1 - Foreman @ $ 21.58/Hr
  1 - Operator @ $ 17.71/Hr
  2 - Laborers @ $ 13.02/Hr
  $ 65.33/Hr x 152 Hr = $ 9,930

- Travel = $65.33/Hr x 19 Days x 1 Hr/Day = $ 1,241

- Eq. Rental = 1 - 20 Ton Crane @ $ 37.39/Hr
  $ 37.39/Hr x 152 Hrs = $ 5,683

Sub-total = $ 16,854

C. Dismantle, Cut, or Crush - 19 Days:

Cut Steel @ 30 Ft^3/Man-Day @ 518.5 Ft^3 = 17 Man-Days
Crush FRP @ 60 Ft^3/Man-Day @ 111.4 Ft^3 = 19 Man-Days

- Labor Crew = 1 - Foreman @ $ Foreman Supervises both 2.2(A) & (B)
  1 - Welder @ $ 19.35/Hr
  2 - Laborers @ $ 13.02/Hr
  $ 45.39/Hr x 152 Hrs = $ 6,899

- Travel = $45.39/Hr x 19 Days x 1 Hr/Day = $ 862

- Eq. Rental = 1 - D8N Dozer @ $117.71/Hr
  1 - Welder/Torch @ $ 10.90/Hr
  $128.61/Hr x 152 Hrs = $ 19,549

Sub-total = $ 27,310

D. Haul and Dispose - Licensed (NRC SUA #1473) Site:

100% of Contaminated Service = 1236.7 $Ft.^3$ @ 172,420#
Total = 45.8 Cu.Yd. @ 172,420# = 4.3 Truckloads @ 40,000#

- Haul = 4.3 Trucks x 800 Mile x $3.27/Mile = $ 11,249
- Dispose = 172,420# = 86.2 tons
  @ $50/ton disposal cost = $ 4,310

E. Haul and Dispose - On-Site Land Fill:

100% of Non-Contaminated Service = 393.2 Ft^3 @ 45,010#
Total = 14.6 Cu.Yd. @ 45,010# = 1 Truckloads @ 47,000#

- Haul = 1 Truck x 8 Hrs/Truck x $65.39/Hr = $ 523

- Dispose = See Appendix 6.5

Tankage and Vessel Total = ***$ 60,246***

2.3 Piping

Basis: See Table 2.2

A. Remove, Cut or Crush and Load - 9 days:

PVC and Poly @ 140 Ft/Man-Day @ 5,000 Ft = 36 Man-Days
= 9 Crew-Days

- Labor Crew = 1 - Foreman @ $ 21.58/Hr
  1 - Operator @ $ 17.71/Hr
  4 - Laborers @ $ 13.02/Hr
  $ 91.37/Hr x 72 Hr = $ 6,579

- Travel = $91.37/Hr x 9 Days x 1 Hr/Day = $ 822

- Eq. Rental = 1 - 20 Ton Crane @ $ 37.39/Hr
  $ 37.39/Hr x 72 Hr = $ 2,692

Sub-total = $ 10,093

B. Decontaminate - 0 Days: = $ 0

C. Haul and Dispose - Licensed (NRC SUA #1473) Site:

100% Pipe = 244 Ft.^{3} @ 9,136#
Total = 9 Cu. Yd. @ 9,136# = 0.2 Truckloads @ 40,000#

- Haul = 0.2 Trucks x 800 Mile x $3.27/Mile = $ 523
- Dispose = 9,136# = 4.6 tons
  @ $50/ton disposal cost = $ 230

Piping Total = ***$ 10,846***

2.4 Pumps

Basis: See Table 2.3

A. Removal and Loading - 11 Days:

2 Pumps/Man-Day @ 43 Pumps = 21.5 Man-Days
= 11.0 Crew-Days

- Labor Crew = 1 - Foreman @ $21.58/Hr
  1 - Operator @ $17.71/Hr
  2 - Laborers @ $13.02/Hr
  $65.33/Hr x 88 Hr = $ 5,749
- Travel = $65.33/Hr x 11 Days x 1 Hr/Day = $ 719
- Eq. Rental = 1 - 20 Ton Crane @ $37.39/Hr
  $37.39/Hr x 88 Hr = $ 3,290

Sub-total = $ 9,758

B. Haul and Dispose - Licensed (NRC SUA #1473) Site:

100% Contaminated = 164.3 Ft.^{3} @ 10,612#

Total = 6.1 Cu. Yd. @ 10,612# = 0.3 Truck Load @ 40,000#

• Haul = 0.3 Truck x 800 Mile x $3.27/Mile	=	$ 785
• Dispose = 10,612# = 5.3 tons		
@ $50/ton disposal cost	=	$ 265

C. Haul and Dispose - On-Site Land Fill:

100% Non-Contaminated = 106.5 Ft.^{3} @ 10,723#

Total = 3.9 Cu. Yd. @ 10,723# = 0.3 Truck Load @ 47,000#

• Haul = 0.3 Truck x 8 Hrs/Truck x $65.39/Hr	=	$ 157
• Dispose = See Appendix 6.5		

Pump Total	=	***$ 10,965***

2.5 Electrical

A. Remove, Cut and Load - 10 Days:

• Labor Crew = 1 - Journeyman Elect. @ $ 34.88/Hr		
2 - Helpers @ $ 30.51/Hr		
1 - Welder @ $ 19.35/Hr		
1 - Operator @ $ 17.71/Hr		
$132.96/Hr x 80 Hr	=	$ 10,637
• Elec. Travel = $132.96/Hr x 10 Days x 2 Hr/Day	=	$ 2,659
+ $0.54/Mile x 10 Days x 120 Mile/Day	=	$ 648
• Other Travel = $37.06/Hr x 10 Days x 1 Hr/Day	=	$ 371
• Eq. Rental = 1 - 20 Ton Crane @ $ 37.39/Hr		
1 - Truck @ $ 12.26/Hr		
1 - Welder/Torch @ $ 10.90/Hr		
$ 60.55/Hr x 80 Hr	=	$ 4,844
Sub-total	=	$ 19,159

B. Haul and Dispose - On-Site Land Fill:

MCC#1 = 11.75 Ft. x 1.25 Ft. x 7.5 Ft. = 110.2 Ft.^{3} @ 4,550#

MCC#2 = 11.75 Ft. x 1.25 Ft. x 7.5 Ft. = 110.2 Ft.^{3} @ 4,550#

Cable = 220.4 Ft.^{3} x 0.5* = 110.2 Ft.^{3} @ 36,700#

(555#/Ft.^{3} @ 40% Void = 333#/Ft^2)

Total = 330.6 Ft.^{3} @ 45,800#

= 12.2 Cu. Yd. @ 45,800# = 1 Truck @ 47,000#

• Haul = 1 Truck x 8 Hrs/Truck x $65.39/Hr	=	$ 523
• Dispose = See Appendix 6.5		

* Cable Volume = 1/2 MCC Volume

Electrical Total	=	***$ 19,682***

2.6 Foundation

A. Decontaminate Slab - 5 Days:

16,500 Ft^2 @ 1000 Ft^2/Man-Day = 17 Man-Days

= 5 Crew-Days

- Labor Crew = 1 - Foreman @ \$ 21.58/Hr
  4 - Laborers @ \$ 13.02/Hr
  \$ 73.66/Hr x 40 Hr = \$ 2,646

- Travel = \$73.66/Hr x 5 Days x 1 Hr/Day = \$ 368

- Eq. Rental = Hand Tools @ \$ 10.90/Hr
  (Broom, Squeegee) \$ 10.90/Hr x 40 Hr = \$ 436

- 10% HCl = 2 Gal/Ft^2 x 16,500 Ft^2
  = 33,000 Gal.

make-up from 20° Be HCl Stock @ \$0.508/Gal
Require 288 Gal. Stock per 1,000 Gal. - 10%

33,000 x 0.288 x \$0.55/Gal = \$ 5,227

- Dispose of Fluid @ \$0.11/BBL
  $33{,}000 \text{ Gal} \times \frac{\text{BBL}}{42 \text{ Gal}} \times \$0.11/\text{BBL}$ = \$ 86

Sub-total = \$ 8,763

B. Break and Remove 25% of Slab - 14 Days:

16,500 Ft^2 x 0.25 = 4,125 Ft^2

4,125 Ft^2 @ 37.5 Ft^2/Hr = 110 Hrs

- Labor Crew = 1 - Operator @ \$ 17.71/Hr
  \$ 17.71/Hr x 110 Hrs = \$ 1,948
- Travel = \$17.71/Hr x 14 Days x 1 Hr/Day = \$ 248
- Eq. Rental = 1 - Pavement Breaker @ \$ 31.33/Hr
  \$ 31.33/Hr x 110 Hrs = \$ 3,446
  1- Cat 980C Loader @ \$ 92.64/Hr
  \$ 92.64/Hr x 56 Hrs = \$ 5,188

Sub-total = \$ 10,830

C. <u>Haul and Dispose</u> - Licensed (NRC SUA #1743) Site:

Concrete = 4,125 Ft^2 x $\frac{8 \text{ In.}}{12 \text{ In/Ft}}$ = 2,750 Ft^3 Set

= 539,000# @ 196#/Ft^3

= 4,583 Ft^3 Loose (40% Voids)

Total = 170 Cu.Yd. @ 539,000# = 13.5 Truckloads @ 40,000#

- Haul = 13.5 Truckloads x 800 Miles x \$3.27/Mile = \$ 35,316
- Dispose = 539,000# = 269.5 tons @ \$50/ton disposal cost = \$ 13,475

D. <u>Bury Area with 2 Ft. Cover:</u>

- Material = 1,225 Cu.Yd. Cover @ \$1.09/Cu.Yd. = \$ 1,335

Foundation Total = ***\$69,719***

(NRC Related Activity)

APPENDIX 3
DRYER AREA RECLAMATION COSTS
Cost Summary

ITEM	COSTS ($97)
3.1 Building	**16,222**
3.2 Equipment	**14,739**
3.3 Foundations	**16,802**
Total Cost	**47,763**

3.1 Building

Basis: 100 Ft. x 35 Ft. with 30 Ft. Eave
Floor Area = 3,500 Ft^2
Skin Area = 8,100 Ft^2

A. Washdown Building - 0 Days = $ 0

B. Dismantle and Load - 5 Days:
3500 Ft^2 @ 100 Ft^2/Man-Day = 35 Man-Days
= 5 Crew-Days

- Labor Crew = 1 - Foreman @ $ 21.58/Hr
  2 - Welders @ $ 19.35/Hr
  2 - Operators @ $ 17.71/Hr
  4 - Laborers @ $ 13.02/Hr
  $147.78/Hr x 40 Hr = $ 5,911

- Travel = $147.78/Hr x 5 Days x 1 Hr/Day = $ 739

- Eq. Rental = 2 - 20 Ton Cranes @ $37.39/Hr
  2 - Welder/Torch @ $10.90/Hr
  $96.58/Hr x 40 Hr = $ 3,863

Sub-total = $ 10,513

C. Haul and Dispose - Licensed (NRC SUA - #1473) Site:
Buildings = 71,212#* = 1.8 Truck Loads @ 40,000#
- Haul = 1.8 Trucks x 800 Mile x $3.27/Mile = $ 4,709
- Dispose = 40,000# = 20 tons
  @ $50/ton disposal cost = $ 1,000

*5 Trucks x 47,000#/Truck x $\frac{3500 \text{ Ft}^2}{11550 \text{ Ft}^2}$ = 71,212#

Building Total = ***$ 16,222***

3.2 Equipment

Basis: See Table 3.1

A. Remove and Load - 7 Days:

- Labor Crew = 1 - Foreman @ $21.58/Hr
  1 - Operator @ $17.71/Hr
  4 - Laborers @ $13.02/Hr
  91.37/Hr x 56 Hrs = $ 5,117

- Travel = $91.37/Hr x 7 Days x 1 Hr/Day = $ 640

- Eq. Rental = 1 - 20 Ton Crane @ $37.39/Hr
  $37.39/Hr x 56 Hrs = $ 2,094

Sub-total = $ 7,851

B. Dismantle and Cut - 7 Days:

Cut Steel @ 30 Ft^3/Man-Day @ 198.6 Ft^3 = 7 Man-Days

- Labor Crew = 1 - Foreman @ $ Foreman supervises 3.2(A) & (B)
  1 - Welders @ $19.35/Hr
  $19.35/Hr x 56 Hr = $ 1,084

- Travel = $19.35/Hr x 7 Days x 1 Hr/Day = $ 135

- Eq. Rental = 1 - Welder/Torch @ $10.90/Hr
  $10.90/Hr x 56 Hr = $ 610

Sub-total = $ 1,829

C. Haul and Dispose - Licensed (NRC SUA #1473) Site:

100% of Contaminated = 183.6 $Ft.^3$ @ 53,800#
Total = 6.8 Cu. Yd. @ 53,800# = 1.4 Truck Loads @ 40,000#

- Haul = 1.4 Truck x 800 Mile x $3.27/Mile = $ 3,662
- Dispose = 53,800# = 26.9 tons
  @ $50/ton disposal cost = $ 1,345

D. Haul and Dispose - Land Fill:

100% Non-Contaminated = 15 $Ft.^3$ @ 4,400#
Total = 0.6 Cu. Yd. @ 4,400# = 0.1 Truck Loads @ 47,000#

- Haul = 0.1 Truck x 8 Hrs/Truck x $65.39/Hr = $ 52
- Dispose = See Appendix 6.5

Equipment Total = ***$14,739***

3.3 Foundation

A. Decontaminate Slab - 2 Day:

$3500\ Ft^2$ @ $1000\ Ft^2$/Man-Day Twice = 7 Man-Days
= 2 Crew-Days

- Labor Crew = 1 - Foreman @ \$21.58/Hr
  4 - Laborers @ \$13.02/Hr
  \$73.66/Hr x 16 Hrs = \$ 1,179

- Travel = \$73.66/Hr x 2 Days x 1 Hr/Day = \$ 147

- Eq. Rental = Hand Tools @ \$10.90/Hr
  (Broom, Squeegee) \$10.90/Hr x 16 Hrs = \$ 174

- 10% HCl $= 2\ \frac{Gal}{Ft^2} \times 3500\ Ft^2 \times 2$
  = 14,000 Gal.

Make-Up from 20° Be HCl Stock @ \$0.55/Gal
Require 288 Gal. Stock per 1,000 Gal. - 10%

14,000 x 0.288 x \$0.55/Gal = \$ 2,218

- Dispose of Fluid @ \$0.11/BBL
  $14{,}000\ Gal \times \frac{BBL}{42\ Gal} \times \$0.11/BBL$ = \$ 37

Sub-Total = \$ 3,755

B. Break and Remove 25% of Slab - 3 Day:

$3500\ Ft^2 \times 0.25 = 875\ Ft^2$
$875\ Ft^2$ @ $37.5\ Ft^2/Hr$ = 23 Hrs

- Labor Crew = 1 - Operator @ \$17.71/Hr
  \$17.71/Hr x 23 Hrs = \$ 407

- Travel = \$17.71/Hr x 3 Days x 1Hr/Day = \$ 53

- Eq. Rental = 1 - Pavement Breaker @ \$31.33/Hr
  \$31.33/Hr x 24 Hrs = \$ 752

  1- Cat 980C Loader @ \$92.64/Hr
  \$92.64/Hr x 12 Hr = \$ 1,112

Sub-total = \$ 2,324

C. <u>Haul and Dispose</u> - Licensed (NRC SUA #1743) Site:

Concrete = 875 Ft^2 x $\frac{8\ In}{12\ In/Ft}$ = 583 Ft^3 Set
= 114,268# @ 196#/Ft^3
= 972 Ft^3 Loose (40% Voids)

Total = 36 Cu.Yd. @ 114,268# = 2.9 Truckloads @ 40,000#

- Haul = 2.9 Truck x 800 Mile x \$3.27/Mile = \$ 7,586
- Dispose = 114,268# = 57.1 tons @ \$50/ton disposal cost = \$ 2,855

D. <u>Bury Area with 2 Ft Cover:</u>

- Materials = 259 Cu.Yd. Cover @ \$1.09/Cu.Yd. = \$ 282

Foundation Total = ***\$ 16,802***

(NRC & WDEQ/LQD Related Activity)

APPENDIX 4

EXISTING FACILITIES RECLAMATION COSTS

Cost Summary

ITEM	COSTS ($97)
4.1 Buildings	95,635
4.2 Structures	14,067
4.3 Pilot Plant Equipment	21,266
4.4 Foundation	139,333
4.5 Site Reclamation	105,785
4.6 O-Sand Pilot	41,435
4.7 Q-Sand Pilot	N.A.
4.8Mine Water Trt Ponds	19,878
Total Cost	410,244

4.1 Buildings

Basis: Floor Area = 33,248 Ft^2
Skin Area = 22,828 Ft^2 (13 Ft Eave)

1 @ 200 Ft. x 60 Ft. = 12,000 Ft^2 (Pilot ISL Building)
0 @ 70 Ft. x 48 Ft. - Demolished & Removed Sept. 1991
1 @ 70 Ft. x 68 Ft. = 4,760 Ft^2 (Existing Office Building)
1 @ 48 Ft. x 24 Ft. = 1,152 Ft^2 (Storage Building)
1 @ 24 Ft. x 24 Ft. = 576 Ft^2 (Water Treatment Plant)
1 @ 40 Ft x 120 Ft. = 4,826 Ft^2 (Shop Building)
1 @ Building = 9,934 Ft^2 (New Office Annex Building)

A. Washdown Building - 8 Days
22,828 Ft^2 @ 1 Gal/Ft^2 = 22,828 Gal
22,828 Ft^2 @ 450 Ft^2/Man = 51 Man-Days
= 13 Crew-Days

- Labor Crew = 1 - Foreman @ $ 21.58/Hr
  4 - Laborers @ $ 13.02/Hr
  $ 73.66/Hr x 104 Hr = $ 7,661
- Travel = $73.66/Hr x 13 Days x 1 Hr/Day = $ 958
- Eq. Rental = 4 - Pressure Washers @ $ 8.71/Hr
  $ 34.84/Hr x 104 Hr = $ 3,623
- Materials = Soap @ $1.09/BBL
  22,828 Gal x BBL/42 Gal x $1.09/BBL = $ 592
- Dispose of Fluid @ $0.11/BBL

22,828 Gal x $\frac{BBL}{42\ Gal}$ x \$0.11/BBL	=	\$ 60
Sub-total	=	\$ 12,894

B. Dismantle and Load - 24 Days:

33,248 Ft^2 @ 100 Ft^2/Man-Day = 332 Man-Days
= 42 Crew-Days

• Labor Crew = 1 - Foreman @ \$ 21.58/Hr 2 - Welders @ \$ 19.35/Hr 2 - Operators @ \$ 17.71/Hr 4 - Laborers @ \$ 13.02/Hr \$147.78/Hr x 336 Hrs	=	\$ 49,654
• Travel = \$147.78/Hr x 42 Days x 1 Hr/Day	=	\$ 6,207
• Eq. Rental = 2 - 20 Ton Cranes @ \$37.39/Hr 2- Welder/Torches @ \$10.90/Hr \$96.58/Hr x 336 Hrs	=	\$ 32,450
Sub-total	=	\$ 88,311

C. Haul and Dispose - On-Site Land Fill:

Buildings = 676,800# = 14 Truck Loads* @ 47,000#

• Haul = 14 Trucks x 8 Hrs/Truck x \$65.39/Hr	=	\$ 7,324

• Dispose = See Appendix 6.5

* 5 Trucks x $\frac{18,488\ Ft.^2}{11,550\ Ft.^2}$ = 14 Trucks

Buildings Total	=	***\$ 95,635***

4.2 Structures

A. Plug Shaft - Completed in 1994	=	$	0
B. Plug Venthole			
• Backfill 335 ft. of hole (270 c.y. @ $1.09/yd)	=	$	270
• Backhoe 16 hrs @ $27.25/hr	=	$	436
• Steel plate and rebar	=	$	300
• Cement - 10 c.y. @ $76/c.y. delivered	=	$	760
• 40 man hours @ $13.02/hr	=	$	521
• Dirt cover - 100 c.y. @ $1.09/c.y.	=	$	109
Sub-total	=	$	2,396

C. Mine Water Treatment Ponds
See Section 4.8

D. Evaporation Ponds
Total Area = 200 Ft. x 100 Ft. = 20,000 Ft.^{2} = 0.5 Acres

• Total = 0.5 Acres x $\frac{\$65{,}392^*}{5 \text{ Acres}}$ = $ 6,539

* See Section 6 - part 6.2 for the cost on a 5 acre basis

E. Headframe Removal

• Dismantle - Completed in 1991	=	$	0
• Haul & Dispose - Completed in 1993	=	$	0

F. Fencing (includes delineation posts)

Facility Fence - 5900 ft
Wellfield #1 - 6600 ft
Wellfield #3 - 7500 ft
20000 ft

• Cost to remove fencing = $0.15/ft[1] = $ 3,000

[1] Cost per linear foot based on Third Party Cost Quote dated 6/11/99

G. Water Wells

- Water wells (2) are 5 inch diameter wells with depth of 750 feet.

- Cost Basis - $285/well ($7705 per 27 wells, see "Section 5.4 - Wells") = $ 570

H. Fuel Area

- Size - 15 ft x 25 ft = 375 Ft^2.
  375 Ft^2 @ 37.5 Ft^2/Hr = 10 Hrs

- Labor Crew = 1 - Operators @ $ 17.71/Hr
  $ 17.71/Hr x 10 Hrs = $ 177

- Travel = $17.71/Hr x 2 Days x 1 Hr/Day = $ 35

- Eq. Rental = 1- Pavement Breaker @ $31.33/Hr
  $31.33/Hr x 10 hrs = $ 313

  1- Cat 980C Loader @ 92.64/Hr
  $96.58/Hr x 5 hr = $ 483

Sub-total = $ 1008

Structures Total = ***$ 14,067***

4.3 Pilot Plant Equipment

A. Tanks:

15 Tanks

- Total = 15 Tanks x $\frac{\$55,926^*}{51 \text{ Tanks}}$ = $ 15,095

B. Piping:

1500 Ft. @ 6" Dia. or Less

- Total = 1500 Ft. x $\frac{\$10,616^*}{5,000 \text{ Ft.}}$ = $ 3,185

C. Pumps:

12 Pumps

- Total = 12 Pumps x $\frac{\$10,700^*}{43 \text{ Pumps}}$ = $ 2,986

* Reference Section 2 - parts 2.2, 2.3 & 2.4

Pilot Plant Total = ***$ 21,266***

4.4 Foundation

A. Decontaminate Slab - 5 Days:

33,248 Ft^2 @ 1000 Ft^2/Man-Day = 33.2 Man-Days
= 8.3 Crew-Days

- Labor Crew = 1 - Foreman @ $ 21.58/Hr
  4 - Laborers @ $ 13.02/Hr
  $ 73.66/Hr x 66.4 Hrs = $ 4,891

- Travel = $73.66/Hr x 9 Days x 1 Hr/Day = $ 663

- Eq. Rental = Hand Tools @ $10.90/Hr
  (Brooms, Squeegee) @ $10.90 /Hr x 66.4 Hrs = $ 724

- 10% HCl = 2 Gal/Ft^2 x 33,248 $Ft.^2$
  = 66,496 Gal.

Make-Up from 20° Be HCl Stock @ $0.55/Gal
Require 288 Gal. Stock per 1,000 Gal. - 10%

66,496 x 0.288 x $0.55/Gal = $ 10,532

- Dispose of Fluid @ $0.11/BBL
  66,496 Gal x $\frac{\text{BBL}}{\text{42 Gal}}$ x $0.11 BBL = $ 174

Sub-total = $ 16,984

B. Break and Remove 25% of Slab - 28 Days:

33,248 Ft^2 x 0.25 = 8,312 Ft^2
8,312 Ft^2 @ 37.5 Ft^2/Hr = 221 Hrs

- Labor Crew = 1 - Operator @ $17.71/Hr
  $17.71/Hr x 221 Hrs = $ 3,914

- Travel = $17.71/Hr x 28 Days x 1 Hr/Day = $ 496

- Eq. Rental = 1 - Pavement Breaker @ $31.33/Hr
  $31.33/Hr x 221 Hrs = $ 6,923

  1 - Cat 980C Loader @ $92.64/Hr
  $92.64/Hr x 111 Hrs = $ 10,283

Sub-total = $ 21,616

C. Haul and Dispose - Licensed (NRC SUA #1743) Site:

Concrete = 8,312 Ft^2 x $\frac{8 \text{ In.}}{12 \text{ In/Ft}}$ = 5,541 Ft^3 Set

= 1,086,101# @ 196#/Ft^3

= 9,235 Ft^3 Loose(40% Voids)

Total = 342 Cu.Yd. @ 1,086,101# = 27.1 Truckloads @ 40,000#

• Haul = 27.1 Truckloads x 800 Miles x $3.27/Mile	=	$70,894
• Dispose = 1,086,101# = 543.1 tons @ $50/ton disposal cost	=	$27,155

D. Bury Area with 2 Ft Cover:

• Materials = 2,462 Cu. Yd. Cover @ $1.09/Cu. Yd.	=	$ 2,684
Foundation Total	=	***$139,333***

4.5 Site Reclamation

Basis: 59.53 Acres = 2,593,126 $Ft.^2$

A. Rip & Contour:

• Rip & Contour @ $166.68/Acre x 59.53 Acre	=	$ 9,922

B. Topsoil Placement:

Replace 8 In.* Topsoil = 1,728,750 $Ft.^3$ = 64,028 Cu.Yd.

• Topsoil @ $1.09/Cu. Yd.	=	$69,789

* 8 In. Topsoil Removed in Previous Years

C. Revegetate:

• Grade and Contour @ $87.19/Acre x 59.53 Acre	=	$ 5,190
• Seedbed Prep. (Disc. + Harrow) @ $ 21.80/Acre x 59.53 Acre	=	$ 1,298
• Mulch (Drill + Seed + Mow) @ $ 49/Acre x 59.53 Acre	=	$ 2,917
• Drill Seed and Fertilize (Drill + Seed + Fertilizer)@ $163/Acre x 59.53 Acre	=	$ 9,703
• Revegetation Contingency* @ $234/Acre x 29.77 Acre (All items excluding grading)	=	$ 6,966

* Assume only 50% of acreage requires reseeding

Sub-total	=	$ 26,074
Site Reclamation Total	=	***$105,785***

4.6 O-Sand Pilot

A. Surface Reclamation:
Basis = 6 Patterns

• Total = 6 Patterns x $16,669* / 10 Patterns	=	$ 10,001

* Reference Section 5 - Summary Table Cost Per Pattern

B. Groundwater Restoration:
Basis = 6 Patterns

• Total = 6 Patterns x $5,239* / Pattern	=	$ 31,434

* Reference Appendix #7

Sub-Total	=	$ 41,435

4.7 Q-Sand Pilot

Basis - 6 Patterns

• Building - Removed in 1992	=	$ 0
• Plug & Abandon 10 Wells - Completed in 1992	=	$ 0
• Reclaim Surface = To Be Completed With WF1 Operations	=	$ 0
Sub-total	=	$ 0

4.8 Mine Water Treatment Ponds

A. Burial In-Place
• Settled solids to Pond 3 for Burial In-Place

D8N Dozer - 40 Hrs @ $117.71/Hr	=	$ 4,708

• Backfill and Contour Settling Ponds

D8N Dozer - 120 Hrs @ $117.71/Hr	=	$14,125
Motor Grader - 16 Hrs @ $65.34/Hr	=	1,045
Sub-total	=	$19,878
Mine Water Treatment Total	=	***$19,878***

(NRC & WDEQ/LQD Related Activity)

APPENDIX 5

UNIT HEADER SITE AND ASSOCIATED WELLFIELD RECLAMATION COSTS

Cost Summary

ITEM	Cost ($97) per 10 Patterns	Cost ($97) 374 Patterns 1999-2000
5.1 Buildings	**1,549**	**57,932**
5.2 Header Piping	**2,735**	**102,289**
5.3 Secondary Electrical	**2,633**	**98,474**
5.4 Wells-Total	**10,532**	**393,897**
5.5 Monitor Wells - Total	**1,450**	**54,230**
5.6 Site Reclamation	**1,019**	**37,111**
Total Cost	**19,918**	**743,933**

5.1 Building

Basis: 12 Ft. x 24 Ft. with 10 Ft. Eave
Floor Area = 288 Ft^2
Skin Area = 720 Ft^2

A. Washdown Building - 1 Day:
Wash 720 Ft^2 @ 1 Gal/Ft^2 = 720 Gal
Wash 720 Ft^2 @ 450 Ft^2/Man-Day = 1.6 Man-Days
= 0.8 Crew-Days

- Labor Crew = 1 - Foreman @ $ 21.58/Hr
  2 - Laborers @ $ 13.02/Hr
  $ 47.62/Hr x 8 Hr =$ 381

- Travel = $47.62/Hr x 1 Day x 1 Hr/Day =$ 48

- Eq. Rental = 2 - Pressure Washers @ $ 8.71/Hr
  $ 17.42/Hr x 8 Hr =$ 139

- Materials = Soap @ $1.09/BBL
  720 Gal x BBL/42 Gal x $1.09/BBL =$ 19

- Dispose of Fluid @ $0.11/BBL
  720 Gal x BBL/42 Gal x $0.11/BBL =$ 2

Sub-total =$ 589

B. Dismantle and Load - 1 Day:

Dismantle and Load @ 100 Ft^2/Man-Day

288 Ft^2 @ 100 Ft^2/Man-Day = 2.9 Man-Day

= 1.0 Crew-Day

- Labor Crew = 1 - Foreman @ \$ 21.58/Hr
  1 - Welders @ \$ 19.35/Hr
  2 - Laborers @ \$ 13.02/Hr
  \$66.97/Hr x 8 Hr =\$ 536

- Travel = \$66.97/Hr x 1 Day x 1 Hr/Day =\$ 67
- Eq. Rental = 1 - Backhoe @ \$ 27.25/Hr
  1 - Welder/Torch @ \$ 10.90/Hr
  \$ 38.15/Hr x 8 Hr =\$ 305

Sub-total =\$ 908

C. Haul and Dispose - On-Site Land Fill:

Building = 4,700# = 0.1 Truck Loads* @ 47,000#

- Haul = 0.1 Truck x 8 Hrs/Truck x \$65.39/Hr =\$ 52

- Dispose = See Appendix 6.5

$* \ 5 \text{ Truck} \times \frac{288 \text{ Ft.}^2}{11{,}550 \text{ Ft.}^2} = 0.1 \text{ Trucks}$

Sub-total =\$ 52

Building Total **=\$ 1,549**

5.2 Header Piping

Basis: 2000 Ft. - 1¼" Piping Buried @6 Ft.
Trench = 6 Ft. x 2 Ft. = 45 Cu. Yd./100 Ft.
Excavation = 26 Cu. Yd./Hr (Case 580 Backhoe - 24 in. Bucket)

A. Open Trenches - 5 Days:

$(2000 \text{ Ft.}) \times \left(\frac{45 \text{ Cu. Yd.}}{100 \text{ Ft.}}\right) \times \left(\frac{\text{Hr.}}{26 \text{ Cu. Yd.}}\right) = 35 \text{ Hrs}$

- Eq. Rental = 1 - Backhoe @ \$ 27.25/Hr
  \$ 27.25/Hr x 40 Hr =\$1,090

B. Remove, Cut and Load - 2.5 Days:

Trenches Opened at 400 Ft/Man-Day

Piping = 2000 Ft @ 400 Ft/Man-Day = 5 Man-Days

= 2.5 Crew-Days

- Labor Crew = 1 - Foreman @ \$ 21.58/Hr
  2 - Laborers @ \$ 13.02/Hr
  \$ 47.62/Hr x 20 Hr =\$ 952

- Travel = \$47.62 x 3 Days x 1 Hr/Day =\$ 143

- Eq. Rental = 2 - Chainsaws @ \$2.40/Hr
  \$4.8/Hr x 20 Hrs =\$ 96

Sub-total =\$ 1,191

C. Backfill Trenches - 2 Day:

Backfill @ 2.5 Time Excavation Rate or

Backfill @ 26 $\frac{\text{Cu.Yd.}}{\text{Hr}}$ x 2.5 = 65 Cu.Yd./Hr

(2000 Ft) x (45 $\frac{\text{Cu.Yd.}}{\text{100 Ft}}$) x ($\frac{\text{Hr}}{\text{65 Cu.Yd.}}$) = 13.8 Hrs or 14 hours

- Eq. Rental = 1 - Backhoe@ \$ 27.25/Hr
  \$ 27.25/Hr x 14 Hrs =\$ 382

D. Haul and Dispose - Licensed (NRC SUA #1473) Site:

1 1/4" Poly Pipe = 43 #/100 Ft. = 2,000 Ft. x 0.43#/Ft. = 860#

$$\text{Volume} = \frac{2{,}000 \text{ Ft} \times (43 \text{ \#/100 Ft.})}{62.4 \frac{\#}{\text{Ft.}^3} \times 0.6} = 23 \text{ Ft.}^3$$

Total = 0.9 Cu. Yd. @ 860# = 0.02 Truck Loads @ 40,000#

- Haul = 0.02 Trucks x 800 Mile x \$3.27/Mile =\$ 52
- Dispose = 860# = 0.4 tons
  @ \$50/ton disposal cost =\$ 20

Header Piping Total =***\$2,735***

5.3 Secondary Electrical

Basis: Remove 2,000 ft - #10 AWG, Power Cable
Remove Pole and Motor Starters

A. Remove Tray Cable - 1 Day:

- Labor Crew = 1 - Journeyman @ $ 34.88/Hr
  1 - Helper @ $ 30.51/Hr
  $ 65.39/Hr x 8 Hr =$ 523

- Travel = $65.39/Hr x 1 Day x 2 Hr/Day =$ 131
  + $0.54/Mile x 1 Day x 120 Mile/Day =$ 65

- Eq. Rental = 1 - Truck @ $12.26/Hr
  $12.26/Hr x 8 Hr =$ 98

Sub-total =$ 817

B. Remove Motor Starters - 1 Day:

- Labor Crew = 1 - Journeyman @ $ 34.88/Hr
  1 - Helper @ $ 30.51/Hr
  $ 65.39/Hr x 8 Hr =$ 523

- Travel = $65.39/Hr x 1 Day x 2 Hr/Day =$ 131
  + $0.54/Mile x 1 Day x 120 Mile/Day =$ 65

- Eq. Rental = 1 - Truck @ $12.26/Hr
  $12.26/Hr x 8 Hr =$ 98

Sub-total =$ 817

C. Disconnect Power Cable from Pole - 0.5 Days:

- Labor Crew = 1 - Journeyman @ $ 34.88/Hr
  1 - Helper @ $ 30.51/Hr
  $ 65.39/Hr x 4 Hr =$ 262

- Travel = $65.39/Hr x 0.5 Day x 2 Hr/Day =$ 65
  + $0.54/Mile x 0.5 Day x 120 Mile/Day =$ 32

- Eq. Rental = 1 - Bucket Truck @ $ 37.36/Hr
  1 - Truck @ $ 12.26/Hr
  $ 49.62/Hr x 4 Hr =$ 198

Sub-total =$ 557

D. Remove Pole - 0.5 Day:

- Labor Crew = 1 - Foreman @ \$ 21.58/Hr
  1 - Operator @ \$ 17.71/Hr
  1 - Laborer @ \$ 13.02/Hr
  \$ 52.31/Hr x 4 Hr =\$ 209

- Travel = \$52.31/Hr x 1 Day x 1 Hr/Day =\$ 52

- Eq. Rental = 1 - 20 Ton Crane @ \$ 37.39/Hr
  \$ 37.39/Hr x 4 Hr =\$ 150

Sub-total =\$ 411

E. Haul and Dispose - On-Site Land Fill:

Cable = $\frac{3.14 \times (0.5)^2 \times 2{,}000}{4 \times 144 \times 0.6}$ = 4.5 Ft.^{3} @ 1499#
(555#/Ft.^{3} @ 40% Void)

Motor Starter =
$\frac{10 \times (24in. \times 10in. \times 8in.)}{1728}$ = 11.1 Ft.^{3} @260# (@ 26# Each)

Pole = 1 Ft. Diam. x 35 Ft. = 27.5 Ft.^{3} @ 825# (@ 30#/Ft^3)

Total = 43.1 Ft.^{3} @ 2,585#
= 1.6 Cu. Yd. @ 2,585# = 0.06 Trucks @ 47,000#

- Haul = 0.06 Trucks x 8 Hr/Truck x \$65.39/Hr = \$ 31

- Dispose = See Appendix 6.5

Secondary Electrical Total = ***\$ 2,633***

5.4 Wells

Basis: 27 Wells per 10 Patterns
5 in. Casing, 750 Ft. TD
Pumps and Tubing Set @ 550 Ft.

A. Pull Pumps and Tubing - 2 Days:
10 Pumps @ 5 Pumps/Crew-Day = 2 Days

- Eq. Rental = 1 - Pulling Unit w/2-Man Crew @ \$32.70/Hr
  \$32.70/Hr x 16 Hrs = \$ 523

B. Plug and Abandon - 4.5 Days:

27 Wells @ 6 Wells/Crew-Day = 4.5 Days
10 - Sack Cement/Well
800# - 'Shur-Gel'/Well

- Labor Crew = 1 - Foreman @ $ 21.58/Hr
  1 - Operator @ $ 17.71/Hr
  2 - Laborers @ $ 13.02/Hr
  $ 65.33/Hr x 36 Hrs = $ 2,352

- Travel = $65.33 x 5 Days x 1 Hr/Day = $ 327

- Eq. Rental = 1 - Backhoe @ $ 27.25/Hr
  1 - 6000# Forklift @ $ 13.12/Hr*
  2 - Skid Tanks @ $ 2.40/Hr
  $ 45.17/Hr x 36 Hrs = $ 1,626

* $1927/Month @ 160 Hr/Month x 1.899 (CPI inflator) = $13.12/Hr

- Materials - 270 - Sacks Cement @ $ 5.45/each
  21,600 - # 'Shur Gel' @ $ 16.34/100#
  $ 5,001 = $ 5,001

Sub-total = $ 9,306

C. Haul and Dispose - Licensed (NRC SUA #1473) Site:

Pumps = 10 x 5 In. Dia. x 8 Ft. Long = 10.9 Ft.^{3}
@ 850# (@ 85# Each)

Tubing = $27 \times \frac{550 \text{ Ft} \times 43\#/100 \text{ Ft.}}{62.4 \#/\text{Ft.}^3 \times 0.6}$ = 170.6 Ft.^{3} @ 6386#

Total = 181.5 Ft.^{3} @ 7,236#
= 6.7 Cu. Yd. @ 7,236# = 0.2 Trucks @ 40,000#

- Haul = 0.2 Truck x 800 Mile x $3.27/Mile = $ 523
- Dispose = 7,236# = 3.6 tons
  @ $50/ton disposal cost = $ 180

Wells Total = ***$10,532***

5.5 Monitor Wells

Basis: 3.21 Per 10 Patterns
5 in. Casing, 750 Ft. T.D.
Pumps and Tubing Set @ 550 Ft.

A. Pull Pumps and Tubing - 1 Day:
3.21 Pumps @ 5 Pumps/Crew-Day = 1 Day

- Eq. Rental = 1 - Pulling Unit w/2-Man Crew @ $ 32.70/Hr
$ 32.70/Hr x 8 Hrs = $ 262

B. Plug and Abandon - 0.5 Days:
3.21 Wells @ 6 Wells/Crew-Day = 0.5 Crew-Days
10 Sacks Cement/Well
200# 'Shur-Gel'/Well
- Labor Crew = 1 - Foreman @ $ 21.58/Hr
1 - Operator @ $ 19.35/Hr
2 - Laborers @ $ 13.02/Hr
$ 66.97/Hr x 4 Hrs = $ 268
- Travel = $66.97/Hr x 1 Day x 1 Hr/Day = $ 67
- Eq. Rental = 1 - Backhoe @ $ 27.25/Hr
1 - 6000# Forklift @ $ 13.12/Hr
2 - Skid Tanks @ $ 2.40/Hr
$ 45.17/Hrs x 4 Hrs = $ 181
- Materials - 32 Sacks Cement@ $ 5.45/each
2,568 - # 'Shur Gel' @ $ 16.34/100#
$ 594 = $ 594

Sub-total = $ 1,110

C. Haul and Dispose - Licensed (NRC SUA #1473) Site:
Pumps = 3.21 @ 5 In. Dia. x 8 Ft. Long = 3.5 Ft.^{3} @273#
(83# Each)

Tubing = $3.21 \times \frac{550 \text{ Ft} \times 43\#/100 \text{ Ft.}}{62.4 \#/\text{Ft.}^3 \times 0.6}$ = 20.3 Ft.^{3} @759#

Total = 23.8 Ft.^{3} @ 1032#
= 0.8 Cu. Yd. @ 1032# = 0.03 Truck @ 40,000#

- Haul = 0.03 Truck x 800 Mile x $3.27/Mile = $ 78

Monitor Well Total = ***$ 1,450***

5.6 Site Reclamation

Basis: Revegetate 2.3 Acres (500 Ft. x 200 Ft.)
Replace 10 Cu.Yd. Topsoil (540 $Ft.^2$ x 6 In.) @ Building Pad

A. Topsoil Placement:

• 10 Cu.Yd. @ 1.09/Cu.Yd.		=	$ 11

B. Revegetate:

• Grade and Contour Topsoil	@ $ 87.19/Acre x 2.3 Acres	=	$ 201
• Seedbed Prep. (Disc. + Harrow)	@ $ 21.80/Acre x 2.3 Acres	=	$ 50
• Mulch (Drill + Seed + Mow)	@ $ 49/Acre x 2.3 Acres	=	$ 113
• Drill Seed and Fertilize (Drill + Seed + Fertilizer)	@ $163/Acre x 2.3 Acres	=	$ 375
• Revegetation Contingency* (All items excluding grading)	@ $234/Acre x 1.15 Acres	=	$ 269
Sub-total		=	$ 1,019

* Assume only 50% of acreage requires reseeding

Site Reclamation Total = *$1,030*

(NRC & WDEQ/LQD Related Activity)

APPENDIX 6

ASSOCIATED STRUCTURES RECLAMATION COSTS

Cost Summary

ITEM	COSTS ($97)
6.1 Trunkline #1 (5000 ft)	**52,108**
6.2 Trunkline #2 (10000 ft)	**104,216**
6.3 Radium Settling Ponds	**70,077**
6.4 P/A Disposal Well	**77,735**
6.5 Sand Mining Area	**13,173**
6.6 Land Fill	**1,500**
Total Cost	**318,809**

6.1 Trunkline

Basis: 2 - 16 in. Trunklines Buried @6 Ft.

Length = 5,000 Ft.
Trench = 6 Ft. x 4 Ft. = 89 Cu. Yd./100 Ft
Excavation = 150 Cu. Yd./Hr (Cat. 225 1.25 Cu. Yd. Bucket)

A. Open Trench - 4 Days:

$(5000\ \text{Ft.}) \times \left(\frac{89\ \text{Cu. Yd.}}{100\ \text{Ft.}}\right) \times \left(\frac{\text{Hr.}}{150\ \text{Cu. Yd.}}\right) = 30$ Hrs - Round to 32 Hrs

- Eq. Rental = 1 - Cat. 225 Trackhoe @ $112.26/Hr
  $112.26/Hr x 32 Hr = $ 3,592

B. Remove, Cut and Load - 18 Days:

2 - 5000 Ft Trunklines @ 140 Ft/Man-Day = 71.4 Man-Day
= 18 Crew-Day

- Labor Crew = 1 - Foreman @ $21.58/Hr
  4 - Laborers @ $13.02/Hr
  $73.66/Hrs x 144 Hr = $ 10,607
- Travel = $73.66/Hr x 18 Days x 1 Hr/Day = $ 1,326
- Eq. Rental = 2 - Backhoe @ $27.25/Hr
  2 - Chainsaw @ $ 2.40/Hr
  $59.30/Hr x 144 Hr = $ 8,539

Sub-total = $ 20,472

C. Backfill Trench - 5 Days:

Backfill @ 65 Cu.Yd./Hr Per Backhoe or
Backfill @ 130 Cu.Yd./Hr with 2 Backhoes

$$(5000 \text{ Ft.}) \times \left(\frac{89 \text{ Cu. Yd.}}{100 \text{ Ft.}}\right)\left(\frac{\text{Hr.}}{130 \text{ Cu. Yd.}}\right) = 34 \text{ Hrs}$$

- Eq. Rental = 2 - Backhoes @ $ 27.25/Hr

$ 54.50/Hr x 40 Hrs	=	$ 2,180
D. Decontaminate - 0 Days:	=	$ 0

E. Haul and Dispose - Licensed (NRC SUA #1473) Site:

100% of Pipe = 2 x 5,000 Ft. x 28.27#/Ft = 282,700#

$$= \frac{282{,}700\#}{62.4\#/\text{Ft.}^3 \times 0.6} = 7551 \text{ Ft.}^3$$

Total = 279.7 Cu. Yd. @ 282,700# = 7.1 Truckloads @ 40,000#

• Haul = 7.1 Trucks x 800 Mile x $3.27/Mile	=	$ 18,574
• Dispose = 282,700# = 141.4 tons @ $50/ton disposal cost	=	$ 7,070
F. Haul & Dispose - Land Fill:	=	$ 0

G. Surface Reclamation:

4 Ft. x 5000 Ft. = 20,000 Ft.^{2} = 0.5 Acres

• Grade and Contour @ $ 87.19/Acre x 0.5 Acre	=	$ 43
• Seedbed Prep. (Disc. + Harrow) @ $ 21.80/Acre x 0.5 Acre	=	$ 11
• Mulch (Drill + Seed + Mow) @ $ 49/Acre x 0.5 Acre	=	$ 25
• Drill Seed and Fertilize (Drill + Seed + Fertilizer)@ $163/Acre x 0.5 Acre	=	$ 82
• Revegetation Contingency* @ $234/Acre x 0.25 Acre (All items excluding grading)	=	$ 59

* Assume only 50% of acreage requires reseeding

Sub-total	=	$ 220
Trunkline Total	=	***$52,108***

6.2 Trunkline #2

Cost for 5000 ft line is \$52,108. Truckline #2 is 10,000 ft.
@ \$52,108 x 2 = \$104,216

6.3 Radium Settling Ponds

Basis: 2 Ponds
9 Ft. Deep Below Grade plus 3 Ft. Freeboard Above Grade
Bottom = 180 Ft. x 360 Ft. (Per Pond)
Top = 252 Ft. x 432 Ft. (Per Pond)
Liner = 106,000 Ft^2 x 30 MIL (Per Pond)
Solids = 200 $Ft.^3$/Yr (Both Ponds)

A. Remove Solids and Liner - 8 Days:
Liner = 2 Ponds x 106,000 $Ft.^2$ x 0.03 In/12 = 530 $Ft.^3$
= 33,072# @ 62.4#/Ft^3
= 883 Ft^3 @ 40% Voids

Solids = 200 ft3/yr = 200 $Ft.^3$/Yr Yr #1 - 1998
= 800 $Ft.^3$ In Yr #5 - 2002

Remove @ 55 Gal/Man-Hr or 60 Ft^3/Man-Day

Yr #5 = 1683 Ft^3 @ 60 Ft^3/Man-Day = 28 Man-Days
= 7 Crew-Days

- Labor Crew = 1 - Foreman @ \$21.58/Hr
  4 - Laborers @ \$13.02/Hr
  \$73.66/Hr x 56 Hrs = \$ 4,125

- Travel = \$73.66/Hr x 7 Days x 1 Hr/Day = \$ 516

- Eq. Rental = 2 - Backhoes @ \$27.25/Hr
  \$54.50/Hr x 56 Hr = \$ 3,052

Sub-total = \$ 7,693

B. Backfill Ponds - 27 Days:

Volume @ Grade = 180 Ft x 360 Ft x 9 Ft = 583,200 Ft^3
+ 27 Ft x 180 Ft x 9 Ft = 43,740 Ft^3
+ 27 fT X 360 fT X 9 Ft = 87,480 Ft^3
714,420 Ft^3 (Per Pond)

Total Volume = 714,420 Ft^3/Pond x 2 Ponds = 1,428,840 Ft^3 = 52,920 Cu.Yd.

Backfill @ 250 Cu.Yd./Hr = 212 Hrs

- Eq. Rental = 1 - D8N Dozer @ $117.71/Hr
  1- Grader @ $ 65.39/Hr
  $183.10/Hr x 212 Hr = $ 38,817

C. Replace 6 In. Topsoil:

2 Ponds x 0.5 Ft. x 252 Ft. x 432 Ft. = 108,864 $Ft.^3$ = 4032 Cu. Yd.

- Topsoil = 4032 Cu. Yd x $1.09/Cu. Yd. = $ 4,395

D. Revegetate:

2 Ponds x 252 Ft. x 432 Ft. = 217,728 $Ft.^2$ = 5 Acres

- Grade and Contour @ $ 87.19/Acre x 5 Acre = $ 436
- Seedbed Prep.
  (Disc. + Harrow) @ $ 21.80/Acre x 5 Acre = $ 109
- Mulch (Drill + Seed + Mow) @ $ 49/Acre x 5 Acre = $ 245
- Drill Seed and Fertilize
  (Drill + Seed + Fertilizer)@ $163/Acre x 5 Acre = $ 817
- Revegetation Contingency* @ $234/Acre x 2.5 Acre = $ 585
  (All items excluding grading)

Assume only 50% of acreage requires reseeding

Sub-total	=	$	2,192

E. Haul and Dispose - Licensed (NRC SUA #1473) Site:

Solids = 800 Ft.^{3} @ 154,400# (60% @ 280#/Ft.^{3} + 40% @ 62.4#/Ft.^{3} = 193#/Ft^3)

Liner = 883 Ft.^{3} @ 33,072# (62.4#/Ft.^{3} @ 40% Voids)

Total = 1683 Ft.^{3} @ 187,472#

62.3 Cu. Yd. @ 187,472# = 4.7 Truckloads @ 40,000#

- Haul = 4.7 Trucks x 800 Mile x \$3.27/Mile = \$ 12,295
- Dispose = 187,472# = 93.7 tons @ \$50/ton disposal cost = \$ 4,685

Radium Settling Pond Total = \$ 70,077

6.4 Plugging and Abandoning A Deep Disposal Well

Oilfield Workover Unit, 6 Days @ \$1,634.85/Day	= \$ 9,809
Circulating Pump & Tank, 2 Days @ \$545/Day	= \$ 1,090
Power Swivel, 1 Day @ \$436/Day	= \$ 436
Water Hauling & Water, 3 Days @ \$354/Day	= \$ 1,062
Frac Tank Rental	= \$ 109
Slickline Services, 2 Days @ \$599/Day	= \$ 1,198
2 - 7/8 Inch "R" Nipple	= \$ 1,417
Mud Materials	= \$ 545
2 - 7/8 Inch Tubing Rental, 8610' @ \$0.54/Ft-Day	= \$ 2,325
Rental Tubing Inspection, 278 Jnts @ \$10.90/Jnt	= \$ 3,030
Cement & Services, 3 Squeeze Jobs @ 4374 each	= \$ 13,122
Squeeze Manifold, Retainer, Swivel, Setting Tool @ \$1,820/Squeeze Job	= \$ 5,460
Cement & Services, 2 Stabilizers & Surface Plugs	= \$ 4,711
Welder, Dirtwork & Roustabouts	= \$ 13,624
Trucking	= \$ 2,725
Supervision, 8 Days @ \$545/Day	= \$ 4,360
Miscellaneous, Contingencies, & Sales Tax (10% Above)	= \$ 6,502
Sub-Total	= \$ 71,525
Year 1991 &1992 CPI Escalation	= \$ 6,210
Sub-Total (\$1997)	= \$ 77,735

Plug and Abandoning Disposal Well = \$ 77,735

6.5 Reclamation of Sand Mining Area

10 acres of disturbed area on sand outcrop

Grade and contour @ $ 87.19/acre x 10 Acre	= $ 872
Replace 6 inch topsoil = 217,800 $ft.^3$ = 8,067 Cu.Yd. topsoil = $1.09/Cu.Yd.	= $ 8,793
Seedbed Prep. (Disc. + Harrow) @ $ 21.80/acre x 10 Acre	= $ 218
Mulch (Drill + Seed + Mow) @ $ 49/acre x 10 Acre	= $ 490
Drill Seed and Fertilizer @ $163/acre x 10 Acre	= $ 1,630
Revegetation Contingency* (All items excluding grading) @ $234/acre x 5 Acre	= $ 1,170

Assume only 50% of acreage requires reseeding

Sand Mining Area Total	= ***$ 13,173***

6.6 Land Fill

Basis: Depth = 6 Ft. total with 4 Ft. active strg. plus 2 ft. cover.
Bottom = 30 Ft. x 70 Ft. = 2,100 $Ft.^2$
Top = 54 Ft. x 94 Ft. = 5,076 $Ft.^2$
Grade = 66 Ft. x 106 Ft. = 6,996 $Ft.^2$

4 Ft. Active Strg. Volume = 30 Ft. x 70 Ft. x 4 Ft. = 8,400 $Ft.^3$
+ 12 Ft. x 30 Ft. x 4 Ft = 1,440 $Ft.^3$
+ 12 Ft. x 70 Ft. x 4 Ft. = 3,360 $Ft.^3$
13,200 $Ft.^3$

2 Ft. Cover Volume = 54 Ft. x 94 Ft. x 2 Ft. = 10,152 $Ft.^3$
+ 6 Ft. x 54 Ft. x 2 Ft. = 648 $Ft.^3$
+ 6 Ft. x 94 Ft. x 2 Ft. = 1,128 $Ft.^3$
11,928 $Ft.^3$

Total Volume = 13,200 $Ft.^3$ + 11,928 $Ft.^3$ = 25,120 $Ft.^3$ = 931 Cu.Yd.

A. Open Pit - 1 Day:

Productivity = 167 $\frac{\text{Cu.Yd.}}{\text{Hr}}$ (Cat. 627E Scraper)

(931 Cu. Yd.) x ($\frac{\text{Hr}}{167\ \text{Cu.Yd.}}$) = 5.6 Hrs round to 6 Hrs

- Eq. Rental = 1 - Cat. 627E Scraper @ $121/Hr

$121/Hr x 6 Hrs = $ 726

B. Backfill Non-Contaminated Material - 1 Day:

Basis: See Table 6.1

Yr. 5 Total Volume = 8448 Ft.^{3} = 312.9 Cu.Yd.

Backfill @ 65 Cu.Yd./Hr. = 4.8 Hrs. round to 5 Hrs

- Eq. Rental = 1 - Backhoe @$27.25/Hr

  $27.25/Hr x 8 Hrs = $ 218

C. Backfill to Grade - 2 Days:

Voids = 312.9 Cu.Yd. x 0.4 = 125 Cu.Yd.

Remainder of Active Strg. = 13,200 Ft.^{3} - 8,203 Ft.^{3}

= 5,103 Ft.^{3} = 189 Cu.Yd.

Cover = 11,928 Ft.^{3} = 442 Cu.Yd.

Total = 756 Cu.Yd.

Backfill @ 65 Cu.Yd./Hr = 11.6 Hrs round to 12 Hrs

- Eq. Rental = 1 - Backhoe @ $27.25/Hr

  $27.25/Hr x 12 Hrs = $ 327

D. Surface Reclamation:

Basis: 6996 Ft.^{2} = 0.2 Acre

Replace 6 in. Topsoil = 6996 Ft.^{2} x 0.5 Ft. = 3498 Ft^3 = 130 Cu.Yd.

- Topsoil Placement @ 1.09/Cu.Yd. = $ 142
- Grade and Contour @ $87.19/Acre x 0.2 Acre = $ 17
- Seedbed Prep. (Disc. + Harrow) @ $21.80/Acre x 0.2 Acre = $ 4
- Mulch (Drill + Seed + Mow) @ $49/Acre x 0.2 Acre = $ 10
- Drill Seed & Fertilize @ $163/Acre x 0.2 Acre = $ 33
  - Revegetation Contingency* @ $234/Acre x 0.1 Acre (All items excluding grading) = $ 23

* Assume only 50% of acreage requires reseeding.

Sub-total = $ 229

Land Fill Total = ***$ 1,500***

TABLE 6.1
Non-Contaminated Disposal Volume

SOURCE	UNIT WEIGHT (#)	UNIT VOLUME ($Ft.^3$)	YR. #1 1998 ($Ft.^3$)	YR. #5 2003 ($Ft.^3$)
1. IX Plant:				
A. Building	235,000	801.6*	801.6	1,603.2
B. Tankage & Vessels	2,320	36.5	0	73.0
C. Piping	0	0	0	0
D. Pumps	8,545	71.9	0	43.8
E. Electrical	22,950	165.1	0	30.2
			801.6	2,150.2
2. Central Processing Plant:				
A. Building	376,000	1,282.6*	0	1,282.6
B. Tankage & Vessels	45,010	393.2	0	393.2
C. Piping	0	0	0	0
D. Pumps	10,723	106.5	0	106.5
E. Electrical	45,800	330.6	0	330.6
			0	2,112.9
3. Dryer Area:				
A. Building	0	0	0	0
B. Equipment	4,400	15.0	0	15.0
4. Existing Facilities:				
A. Building	676,800	2,308.6	2,308.6	2,308.6
B. Structures	0	0	0	0
C. Pilot Plant Equip.	16,230	145.3	145.3	145.3
			2,453.9	2,453.9
5. Header Site & Associated Wellfield:				
A. Building	4,700	16.0*	0	742.4
B. Header Piping	0	0	0	0
C. Secondary Elect.	2,585	43.1	0	1,999.8
D. Wells - Total	0	0	0	0
E. Mon. Wells - Total	0	0	0	0
			0	2,742.2
TOTAL			3,255.5	9,474.2

$$\text{*Building Unit Volume} = \frac{\text{Unit Weight}}{62.4 \times 7.83 \times 0.6}$$

(NRC & WDEQ/LQD Related Activity)

SECTION 7

GROUNDWATER RESTORATION COSTS

Cost Summary

ITEM	COSTS ($97)
7.1 Groundwater Restoration	$3,605,272
Total Cost	$3,605,272

7.1 Groundwater Restoration Costs

Basis: Table 7.1, Table 7.2 & Table 7.3, 7.4, 7.5 and 7.6 - Groundwater Restoration Basis

Table 7.1

Affected Pore Volume Estimate

Wellfield	Number of Perimeter Injection Wells	Measured Pattern Area (ft^2)	Perimeter Inj Wells per Unit Area	Number of Patterns	Average Open Interval (ft)	Effective Porosity	Flare Factor from Fig 7-1	Pattern Affected Pore Volume (gal/ pattern)	Wellfield Affected Pore Volume (gallons)
1	170	1115229	1.52E-004	116	18	0.27	1.7	594,146	68,920,890
3	147	1622462	9.06E-005	162	20	0.27	1.5	606,801	98,301,728
3 ext	97	782800	1.24E-004	76	14	0.27	1.5	436,839	33,199,800
4	163	1334798	1.22E-004	128	18	0.27	1.5	568,636	72,785,467
4A	142	1050576	1.35E-004	101	18	0.27	1.5	567,199	57,287,069

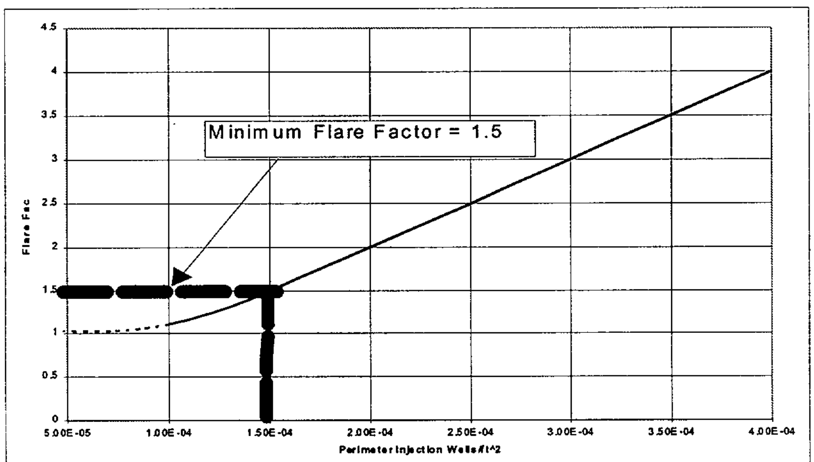

Figure 7-1. Predicted wellfield flare factor for RAMC commercial wellfields, as a function of wellfield scale

Methodology for Flare Factor Determination

Figure 7-1 is derived from Figure 3-16 in *"Evaluation and Simulation of Wellfield Restoration at the RAMC Smith Ranch Facility"* dated October 29, 1999 (provided as Appendix K of this application). This document was submitted to the Wyoming DEQ - Land Quality Division with a letter dated December 13, 1999 for review. In that document, RAMC proposes a methodology developed through hydraulic and geochemical modeling that uses the geometry of the wellfield to estimate a Flare Factor. In this case, the number of perimeter injection wells are counted, the surface area of the wellfield pattern is measured using a wellfield map, a ratio is developed of the # of perimeter injection wells to the surface area of the wellfield patterns. That ratio is located on the horizontal axis of figure 7-1 (above). From that intercept, a vertical line is projected to intersect the curve. At that intersection, a horizontal line is projected to intercept the vertical axis. The estimated flare factor is derived from that intercept.

On May 11, 2000, RAMC met with LQD to discuss the review of the document and RAMC's proposed approach for estimating groundwater restoration costs. RAMC verified that the curve shown on Figure 7-1 had been validated using modeling for flare factors of 1.5 and higher, but it had not been verified for Flare Factors lower than 1.5. RAMC stated that for bonding purposes only, it would not use a Flare Factor lower than 1.5 for estimating the predicted costs for groundwater restoration.

Wellfield 3 ext. represents the 2nd completion within the existing patterns in Wellfield #3. That 2nd completion represents an opening of an upper interval of the patterns in Wellfield #3 which effects 76 patterns and will result in a net increase of 6 patterns.

Table 7.2
SMITH RANCH PROJECT
Mining Unit Groundwater Restoration Costs
Wellfield #1

1 APV = 68,920,890 gallons

RESTORATION COST COMPONENT			Total Gallons Treated	Operating Flow Rate GPM	Total Cost	Number of Days
1. Wellfield Pumping Costs						
a)	Groundwater Sweep (no reinjection) (3 APV)	($0.118/1,000 gal.)	206,762,670	1015	$24,398	141
b)	Chemical Reductant Injection (95% reinjection) (1 APV)	($0.232/1,000 gal.)	68,920,890	1015	$15,990	47
c)	RO/EDR Treatment (75% reinjection) (2 APV)	($0.201/1,000 gal.)	137,841,780	1000	$27,706	96
SUBTOTAL					$68,094	284
2. Chemical Treatment Power Costs						
a)	Reverse Osmosis Unit	$0.10/gpm/day ($0.07/1,000 gal.)	137,841,780	1000	$9,649	
SUBTOTAL					$9,649	
3. Chemicals						
a)	Waste Water Treatment (BaCl2, Resin Elut. Chem)			600	$50,342	284
	BaCl2 @ $9.00/gpm/month, Elution					
	@$400/elution, Waste Water @ 2 mg/L U308	Elution Costs (5.2 Elutions/year * $400/ Elution)			$1,620	
	500 ft3 resin, 2 lb./ft3 loading,					
	Annualized Waste Water Flow; 600 gpm					
	1 elution every 69 days or 5.2 elutions per year					
b)	Chemical Reductant (H2S or alternative)	$1.80/gpm/day ($1.25/1,000 gal.)	68,920,890	1015	$86,151	
c)	RO Chemicals (H2SO4, Antiscalents, Oxygen Scavenger)	$0.57/gpm/day ($0.40/1,000 gal.)	137,841,780	1000	$55,137	
SUBTOTAL					$193,251	
4. Repairs and Maintenance						
a)	Wellfield and Waste Water Treatment	$10,000/mo	9.3	months	$93,227	
b)	RO and process equipment	$5,000/mo	9.3	months	$46,613	
SUBTOTAL					$139,840	
5. Labor						
Supervisor @ $20.00 per hour			9.3	months	$29,833	
4 Operators @ $13.00 per hour			9.3	months	$77,565	
2 Maintenance @ $13.00 per hour			9.3	months	$38,782	
SUBTOTAL					$146,179	
6. Contract Laboratory Analysis						
70 Monitor Wells (140 UCL samples per year @$100)			0.8		$10,876	
Stabilization Samples						
10 Wells	- 3 complete Assays @$350				10,500	
	- 9 abbreviated assays @ $250				22,500	
SUBTOTAL					$43,876	
7. Operating Expenses						
Supplies	@$3,000/mo		9.3		27,968	
Heating	@$5,000/mo		4.7		23,307	
Vehicle Fuel	@$1,000/mo		9.3		9,323	
Office Utilities	@$1,000/mo		9.3		9,323	
SUBTOTAL					$69,920	
TOTAL OPERATING COST TO RESTORE GROUNDWATER AT FULL PRODUCTION (Nominal Mine Unit)					$670,809 (1993$)	
UNIT RESTORATION OPERATING COST				116 Patterns	$5,783 /Pattern	
	1993 -1997 inflation (CPI-U) = 160.6/143.6 =		11.84%		$79,413	
				Total	$750,222 (1997$)	

Table 7.3
SMITH RANCH PROJECT
Mining Unit Groundwater Restoration Costs
Wellfield #3

				Total Gallons Treated	Operating Flow Rate GPM	Total Cost	Number of Days
1 APV =		98301728 gallons					
RESTORATION COST COMPONENT							
1.	Wellfield Pumping Costs						
	a)	Groundwater Sweep (no reinjection) (3 APV)	($0.118/1,000 gal.)	294,905,183	1015	$34,799	202
	b)	Chemical Reductant Injection (95% reinjection) (1 APV)	($0.232/1,000 gal.)	98,301,728	1015	$22,806	67
	c)	RO/EDR Treatment (75% reinjection) (2 APV)	($0.201/1,000 gal.)	196,603,455	1000	$39,517	137
	SUBTOTAL					$97,122	406
2.	Chemical Treatment Power Costs						
	a)	Reverse Osmosis Unit	$1.33/gpm/day ($0.92/1,000 gal.)	196,603,455	1000	$13,762	
	SUBTOTAL					$13,762	
3.	Chemicals						
	a)	Waste Water Treatment (BaCl2, Resin Elut Chem)			600	$71,803	406
		BaCl2 @ $9.00/gpm/month, Elution					
		@$400/elution, Waste Water @ 2 mg/L U3O8	Elution Costs (5.2 Elutions/year * $400/ Elution)			$2,311	
		500 ft3 resin, 2 lb./ft3 loading,					
		Annualized Waste Water Flow; 600 gpm					
		1 elution every 69 days or 5.2 elutions per year					
	b)	Chemical Reductant (H2S or alternative)	$1.80/gpm/day ($1.25/1,000 gal.)	98,301,728	1015	$122,877	
	c)	RO Chemicals (H2SO4, Antiscalents, Oxygen Scavenger)	$0.57/gpm/day ($0.40/1,000 gal.)	196,603,455	1000	$78,641	
	SUBTOTAL					$275,633	
4.	Repairs and Maintenance						
	a)	Wellfield and Waste Water Treatment	$10,000/mo	13.3	months	$132,969	
	b)	RO and process equipment	$5,000/mo	13.3	months	$66,484	
	SUBTOTAL					$199,453	
5.	Labor						
	Supervisor @ $20.00 per hour			13.3	months	$42,550	
	4 Operators @ $13.00 per hour			13.3	months	$110,630	
	2 Maintenance @ $13.00 per hour			13.3	months	$55,315	
	SUBTOTAL					$208,495	
6.	Contract Laboratory Analysis						
	70 Monitor Wells (140 UCL samples per year @$100)			1.1		$15,513	
	Stabilization Samples						
	10 Wells	- 3 complete Assays @$350				10,500	
		- 9 abbreviated assays @ $250				22,500	
	SUBTOTAL					$48,513	
7.	Operating Expenses						
	Supplies	@$3,000/mo		13.3		39,891	
	Heating	@$5,000/mo		6.6		33,242	
	Vehicle Fuel	@$1,000/mo		13.3		13,297	
	Office Utilities	@$1,000/mo		13.3		13,297	
	SUBTOTAL					$99,727	
	TOTAL OPERATING COST TO RESTORE GROUNDWATER AT FULL PRODUCTION (Nominal Mine Unit)					$942,706	(1993$)
	UNIT RESTORATION OPERATING COST			162	Patterns	$5,819 /	Pattern
		1993 -1997 inflation (CPI-U) = 160.6/143.6 =	11.84%			$111,602	
					Total	$1,054,307	(1997$)

Table 7.4
SMITH RANCH PROJECT
Mining Unit Groundwater Restoration Costs
Wellfield #4

1 APV = 72,785,467 gallons		Total	perating		
		Gallons	low Rat	Total	Number of
RESTORATION COST COMPONENT		Treated	GPM	Cost	Days
1. Wellfield Pumping Costs					
a) Groundwater Sweep (no reinjection) (3 APV)	($0.118/1,000 gal.)	218,356,401	1015	$25,766	149
b) Chemical Reductant Injection (95% reinjection) (1 APV)	($0.232/1,000 gal.)	72,785,467	1015	$16,886	50
c) RO/EDR Treatment (75% reinjection) (2 APV)	($0.201/1,000 gal.)	145,570,934	1000	$29,260	101
SUBTOTAL				$71,912	300
2. Chemical Treatment Power Costs					
a) Reverse Osmosis Unit	$1.33/gpm/day ($0.92/1,000 gal.)	145,570,934	1000	$10,190	
SUBTOTAL				$10,190	
3. Chemicals					
a) Waste Water Treatment (BaCl2, Resin Elut. Chem)			600	$53,165	300
BaCl2 @ $9.00/gpm/month, Elution					
@$400/elution, Waste Water @ 2 mg/L U308	Elution Costs (5.2 Elutions/year * $400/ Elution)			$1,711	
500 ft3 resin, 2 lb./ft3 loading,					
Annualized Waste Water Flow; 600 gpm					
1 elution every 69 days or 5.2 elutions per year					
b) Chemical Reductant (H2S or alternative)	$1.80/gpm/day ($1.25/1,000 gal.)	72,785,467	1015	$90,982	
c) RO Chemicals (H2SO4, Antiscalents, Oxygen Scavenger)	$0.57/gpm/day ($0.40/1,000 gal.)	145,570,934	1000	$58,228	
SUBTOTAL				$204,087	
4. Repairs and Maintenance					
a) Wellfield and Waste Water Treatment	$10,000/mo	9.8	months	$98,454	
b) RO and process equipment	$5,000/mo	9.8	months	$49,227	
SUBTOTAL				$147,681	
5. Labor					
Supervisor @ $20.00 per hour		9.8	months	$31,505	
4 Operators @ $13.00 per hour		9.8	months	$81,914	
2 Maintenance @ $13.00 per hour		9.8	months	$40,957	
SUBTOTAL				$154,376	
6. Contract Laboratory Analysis					
70 Monitor Wells (140 UCL samples per year @$100)		0.8		$11,486	
Stabilization Samples					
10 Wells - 3 complete Assays @$350				10,500	
- 9 abbreviated assays @ $250				22,500	
SUBTOTAL				$44,486	
7. Operating Expenses					
Supplies @$3,000/mo		9.8		29,536	
Heating @$5,000/mo		4.9		24,614	
Vehicle Fuel @$1,000/mo		9.8		9,845	
Office Utilities @$1,000/mo		9.8		9,845	
SUBTOTAL				$73,841	
TOTAL OPERATING COST TO RESTORE GROUNDWATER AT FULL PRODUCTION (Nominal Mine Unit)				$706,573 (1993$)	
UNIT RESTORATION OPERATING COST			128 Patterns	$5,520 /Pattern	
1993 -1997 inflation (CPI-U) = 160.6/143.6 =	11.84%			$83,647	
			Total	$790,220 (1997$)	

Table 7.5
SMITH RANCH PROJECT
Mining Unit Groundwater Restoration Costs
Wellfield 4A

1 APV = 57,287,069 gallons

RESTORATION COST COMPONENT		Total Gallons Treated	Operating Flow Rate GPM	Total Cost	Number of Days
1. Wellfield Pumping Costs					
a) Groundwater Sweep (no reinjection) (3 APV)	($0.118/1,000 gal.)	171,861,206	1015	$20,280	118
b) Chemical Reductant Injection (95% reinjection) (1 APV)	($0.232/1,000 gal.)	57,287,069	1015	$13,291	39
c) RO/EDR Treatment (75% reinjection) (2 APV)	($0.201/1,000 gal.)	114,574,138	1000	$23,029	80
SUBTOTAL				$56,600	236
2. Chemical Treatment Power Costs					
a) Reverse Osmosis Unit	$1.33/gpm/day ($0.92/1,000 gal.)	114,574,138	1000	$8,020	
SUBTOTAL				$8,020	
3. Chemicals					
a) Waste Water Treatment (BaCl2, Resin Elut. Chem)			600	$41,845	236
BaCl2 @ $9.00/gpm/month, Elution					
@$400/elution, Waste Water @ 2 mg/L U3O8	Elution Costs (5.2 Elutions/year * $400/ Elution)			$1,347	
500 ft3 resin, 2 lb./ft3 loading,					
Annualized Waste Water Flow; 600 gpm					
1 elution every 69 days or 5.2 elutions per year					
b) Chemical Reductant (H2S or alternative)	$1.80/gpm/day ($1.25/1,000 gal.)	57,287,069	1015	$71,609	
c) RO Chemicals (H2SO4, Antiscalents, Oxygen Scavenger)	$0.57/gpm/day ($0.40/1,000 gal.)	114,574,138	1000	$45,830	
SUBTOTAL				$160,630	
4. Repairs and Maintenance					
a) Wellfield and Waste Water Treatment	$10,000/mo	7.7	months	$77,490	
b) RO and process equipment	$5,000/mo	7.7	months	$38,745	
SUBTOTAL				$116,235	
5. Labor					
Supervisor @ $20.00 per hour		7.7	months	$24,797	
4 Operators @ $13.00 per hour		7.7	months	$64,472	
2 Maintenance @ $13.00 per hour		7.7	months	$32,236	
SUBTOTAL				$121,504	
6. Contract Laboratory Analysis					
70 Monitor Wells (140 UCL samples per year @$100)		0.6		$9,040	
Stabilization Samples					
10 Wells	- 3 complete Assays @$350			10,500	
	- 9 abbreviated assays @ $250			22,500	
SUBTOTAL				$42,040	
7. Operating Expenses					
Supplies	@$3,000/mo	7.7		23,247	
Heating	@$5,000/mo	3.9		19,372	
Vehicle Fuel	@$1,000/mo	7.7		7,749	
Office Utilities	@$1,000/mo	7.7		7,749	
SUBTOTAL				$58,117	
TOTAL OPERATING COST TO RESTORE GROUNDWATER AT FULL PRODUCTION (Nominal Mine Unit)				$563,147	(1993$)
UNIT RESTORATION OPERATING COST			101 Patterns	$5,576	/ Pattern
1993 -1997 Inflation (CPI-U) = 160.6/143.6 =	11.84%			$66,668	
			Total	$629,815	(1997$)

Table 7.6
SMITH RANCH PROJECT
Mining Unit Groundwater Restoration Costs
Wellfield 3 ext

1 APV = 33,199,800 gallons

RESTORATION COST COMPONENT			Total Gallons Treated	Operating Flow Rate GPM	Total Cost	Number of Days
1.	Wellfield Pumping Costs					
a)	Groundwater Sweep (no reinjection) (3 APV)	($0.118/1,000 gal.)	99,599,401	1015	$11,753	68
b)	Chemical Reductant Injection (95% reinjection) (1 APV)	($0.232/1,000 gal.)	33,199,800	1015	$7,702	23
c)	RO/EDR Treatment (75% reinjection) (2 APV)	($0.201/1,000 gal.)	66,399,601	1000	$13,346	46
SUBTOTAL					$32,801	137
2.	Chemical Treatment Power Costs					
a)	Reverse Osmosis Unit	$1.33/gpm/day ($0.92/1,000 gal.)	66,399,601	1000	$4,648	
SUBTOTAL					$4,648	
3.	Chemicals					
a)	Waste Water Treatment (BaCl2, Resin Elut. Chem)			600	$24,250	137
	BaCl2 @ $9.00/gpm/month, Elution					
	@$400/elution, Waste Water @ 2 mg/L U308	Elution Costs (5.2 Elutions/year * $400/ Elution)			$781	
	500 ft3 resin, 2 lb./ft3 loading,					
	Annualized Waste Water Flow; 600 gpm					
	1 elution every 69 days or 5.2 elutions per year					
b)	Chemical Reductant (H2S or alternative)	$1.80/gpm/day ($1.25/1,000 gal.)	33,199,800	1015	$41,500	
c)	RO Chemicals (H2SO4, Antiscalents, Oxygen Scavenger)	$0.57/gpm/day ($0.40/1,000 gal.)	66,399,601	1000	$26,560	
SUBTOTAL					$93,090	
4.	Repairs and Maintenance					
a)	Wellfield and Waste Water Treatment	$10,000/mo	4.5	months	$44,908	
b)	RO and process equipment	$5,000/mo	4.5	months	$22,454	
SUBTOTAL					$67,362	
5.	Labor					
Supervisor @ $20.00 per hour			4.5	months	$14,371	
4 Operators @ $13.00 per hour			4.5	months	$37,364	
2 Maintenance @ $13.00 per hour			4.5	months	$18,682	
SUBTOTAL					$70,416	
6.	Contract Laboratory Analysis					
70 Monitor Wells (140 UCL samples per year @$100)			0.4		$5,239	
Stabilization Samples						
10 Wells	- 3 complete Assays @$350				10,500	
	- 9 abbreviated assays @ $250				22,500	
SUBTOTAL					$38,239	
7.	Operating Expenses					
Supplies	@$3,000/mo		4.5		13,472	
Heating	@$5,000/mo		2.2		11,227	
Vehicle Fuel	@$1,000/mo		4.5		4,491	
Office Utilities	@$1,000/mo		4.5		4,491	
SUBTOTAL					$33,681	
TOTAL OPERATING COST TO RESTORE GROUNDWATER AT FULL PRODUCTION (Nominal Mine Unit)					$340,238 (1997$)	
UNIT RESTORATION OPERATING COST				76 Patterns	$4,477 /Pattern	
	1993 -1997 inflation (CPI-U) = 160.6/143.6 =	11.84%			$40,279	
				Total	$380,517 (1997$)	

Costs Associated with Groundwater Restoration

Using the Affected Pore Volumes developed on Table 7.1, the detail cost for groundwater restoration is provided for each wellfield on Tables 7.2, 7.3, 7.4, and 7.5. The estimated cost for groundwater restoration is shown below on Table 7.6.

TABLE 7.6
Estimated Groundwater Restoration Costs
By Wellfield

Wellfield #	Estimated Cost ($1997)
#1	$750,413
#3	$1,054,307
#4	$790,220
#4A	$629,815
#3ext	$380,517
Total	$3,605,272

(NRC Related Activity)

APPENDIX 8
HEALTH PYSICS COSTS

Cost Summary

ITEM	COSTS ($97)
8.1 Health Physics	**168,470**
Total Cost	**168,470**

Health Physics

Basis: Year #1 - 223 Days:
See Table 8.1

- Labor Crew = 1 - RSO @ $32.70/Hr
  0.5 - RST @ $21.80/Hr
  $43.60/Hr x 1784 Hr = $ 77,782

Basis: Year #5 - 483 Days
See Table 8.1

- Labor Crew = 1 - RSO @ $32.70/Hr
  0.5 - RST @ $22.80/Hr
  $43.60/Hr x 3864 Hr = $168,470

To provide consistency with Rio Algom Mining Corp.'s U.S. Nuclear Regulatory Commission (NRC) surety, Rio Algom has elected at this time to continue to use the five (5) forward bond amount utilized for NRC purposes.

(NRC & WDEQ/LQD Related Activity)

APPENDIX 9
WHOLE TRUCKING COSTS

Cost Summary

ITEM	COSTS ($97)
9.1 Contaminated Trucking	**523**
9.2 Uncontam. Trucking	**157**
Total Cost	**680**

Contaminated Trucking - Year #1

Basis: See Table 9.1

- Haul = 0.2 Trucks x 800 Miles x $3.27/Mile = $ 523

9.2 Non-Contaminated Trucking - Year #1

Basis: See Table 9.2

- Haul = 0.5 Trucks x 8 Hrs/Truck x $65.39/Hr = $ 157

9.3 Contaminated Trucking - Year #5

Basis: See Table 9.3

- Haul = 0.2 Trucks x 800 Miles x $3.27/Mile = $ 523

9.4 Non-contaminated Trucking - Year #5

Basis: See Table 9.4

- Haul = 0.3 Trucks x 8 Hrs/Truck x $65.39/Hr = $ 157

To provide consistency with Rio Algom Mining Corp.'s U.S. Nuclear Regulatory Commission (NRC) surety, Rio Algom has elected at this time to continue to use the five (5) forward bond amount utilized for NRC purposes.

(WDEQ/LQD Related Activity)

APPENDIX 10
DELINEATION DRILLING RECLAMATION COSTS

Cost Summary

ITEM	COSTS ($97)
10.1 Delineation Drilling	**396,808**
Total Cost	**396,808**

<u>Delineation Drilling Costs</u>

Basis:	Delineation Holes drilled in 1998-1999	1,313
	Delineation Holes to be drilled in 1999-2000	1,600
	Total Delineation Holes to be Bond	2,913

Per hole cost for reclamation of delineation is based on bonding estimate for exploration holes under DN 236. (see attached table)

Reclamation costs per hole = $136.22/hole

Cost for plugging and abandonment: 2913 holes x $136.22/hole

Delineation Drilling Costs = ***<u>$396,808</u>***

Table 10.1
Reclamation Cost Estimate for Delineation Holes

1999 Reclamation Bond Estimate			
Well Abandonment and Topsoil Replacement and Re-vegetation			
I.	Assumptions		
	A.	Drill Hole Abandonment	
		of Drill holes	1
		Bentonite chips cost	$12.50
		Personnel - $/hr	$17.50
		Transportation - $/hr	$6.54
		Water truc - $/hr	$10.00
		Holes/day	5
		of Days	0
		of Hours	2
		Drill Hole Abandonment Cost	$80.58
	B.	Survey Crew Cost	
		Hours/hole	0.3
		$/hour	$75.00
		Subtotal	$22.50
		Survey Crew Cost	$22.50
II.	Equipment		
	A.	Abandonment Equipment	N/A
	ABANDONMENT COST		$103.08
Total Cost per Well or Drill Hole			$103.08
III.	Bac fill Topsoil Replacement		
	A.	Assumptions	
	1.	General	
		Affected Area/hole (ft2)	400
		Affected area/hole (acres)	0.01
		Pit area/pit (ft2)	120
		Bac fill depth	9
		Modified Pit Volume	800
		Number of wells and drill holes	1
		Topsoil Replacement Depth (ft)	0.33
		Pit Topsoil Volume (yd3)	1.47
		yd3 bac fill	29.63
		total yd3 bac fill	29.63
		Total yd3 topsoil	1.47
		Total affected area (acres)	0.01
	2.	Equipment with operator	
		Productivity bac hoe w/trailer (yd3/hr)	32.39
		$/hour	$33.24
		Total replacement costs	$31.92
IV.	Reseeding		
	1.	Equipment	
		Drill Seeder w/trailer ($/acre)	$100.00
		Subtotal Equipment Cost	$0.92
	2.	Seed	
		$/acre	$33.00
		Subtotal Seed Cost	$0.30
	Subtotal Re-Seeding Cost		$1.22
V.	Mulching Crimping		
	1.	Equipment	N/A
		Subtotal Equipment Cost	$0.00
	2.	Mulch	N/A
	Subtotal Mulching Crimping Cost		$0.00
Subtotal Reseeding Cost/hole			$1.22
TOTAL			$136.22

APPENDIX 11 - SURETY BOND SUMMARY

This section contains the cost basis that was used in the bond calculations provided within Appendices 1-10. The basis for the bond calculations are from contractor bids to perform the work with the costs then adjusted to constant 1997 dollars as requested by WDEQ/LQD. Provided in the summary table below are the initial bids in the dollars of their day and the adjustment to 1997 dollars. The individual contractor bids follow the summary table.

BID RATES FOR LABOR AND EQUIPMENT

ITEM	HOURLY BID RATE-YEAR ($/HR)	ADJUSTED 1997 DOLLARS ($/HR)
Foreman	19.80 (1993)	21.58
Certified Welder	17.75 (1993)	19.35
Operator	16.25 (1993)	17.71
Laborer	11.95 (1993)	13.02
Journeyman Electrician	32.00 (1993)	34.88
Apprentice Electrician	28.00 (1993)	30.51
20 Ton Crane (**)	34.31 (1993)	37.39
6000# Forklift (**)	12.04 (1993)	13.12
Welding/Torch (**)	10.00 (1993)	10.90
D8N Dozer (*)	108.00 (1993)	117.71
140G Blade (*)	60.00 (1993)	65.34
Pavement Breaker, Fuel/Maint	28.75 (1993)	31.33
980C Loader (*)	85.00 (1993)	92.64
235 Trackhoe (*)	103.00 (1993)	112.25
627 Scraper (*)	111.00 (1993)	120.98
Pulling Unit (*)	30.00 (1993)	32.70
Backhoe (*)	25.00 (1993)	27.25
2000 PSI Spray Washer	8.00 (1993)	8.71
Chainsaw (**)	2.20 (1993)	2.40

Note - (*) includes operator, fuel, and maintenance. Others include fuel and maintenance unless shown otherwise.. (**) bid obtained by telephone. Adjustment to 1997 dollars were made using GNP-IPD inflation rate of 8.99% [1st quarter 1993 (101.8) through 1st quarter 1997 (110.95)].

Estimate of Byproduct Material Disposal Costs

Currently, License Condition 9.5 of Source Material License SUA 1548, authorizes Rio Algom to dispose of byproduct material from the Smith Ranch Facility at the uivira Mining Company tailings pile, New Mexico. uivira Mining Corporation is a wholly owned subsidiary of Rio Algom Mining Corp.

In the 1998 Surety Review, NRC has requested that RAMC consider the disposal costs in the surety estimates. To provide an estimate for byproduct material disposal costs, RAMC will include a cost of $50/ton of material. This cost estimate is based on MC s contract with the Grace Estate, Source Material license SUA-1480, to accept their byproduct material. This cost includes labor, equipment, analysis, and allow for a profit. The estimate is to receive material at MC s site and place the material into the disposal cells. The basis of this cost is to provide funding to place the byproduct material from Smith Ranch into the tailings pile as designated by the license.

The estimated disposal costs are listed below, and the brea down of the tas s are based on the reclamation activities described in Section 6.0 of the amended March 31, 1988 License Application.

Item	ty of Waste (lbs) Section 6.0	ty of Waste (tons)	Disposal Cost (SUA-1473) (1998 dollars)
Ion Exchange Plants			
Tan age and Vessels	396,760	198.38	9,919
Piping	104,160	52.08	2,604
Pumps	11,400	5.7	285
Foundations	754,730	377.37	18,868
Sub Total			31,676
Central Processing Plant			
Tan age and Vessels	172,420	86.21	4,311
Piping	9,136	4.57	229
Pumps	10,612	5.31	266
Foundation	539,000	269.5	13,475
Sub Total			18,281
Dryer Area			
Building	71,212	35.61	1,781
Equipment	53,800	26.90	1,345
Foundations	114,268	57.13	2,857
Sub Total			5,983
Existing Facilities			
Foundations	1,086,101	543.1	27,155

Sub Total			27,155
Item	ty of Waste (lbs) Section 6.0	ty of Waste (tons)	Disposal Cost (SUA-1473) (1998 dollars)
Unit Header Sites Wellfields			
Header Piping	75,852	37.9	1,895
Wells Total	109,015	54.5	2,725
Monitor Wells Total	91,022	45.51	2,276
Sub Total			6,896
Associated Structures			
1 Trun line (5,000 ft. ea.)	282,700	141.4	7,070
2 Trun line (10,000 ft. ea.)	565,400	282.7	14,135
Radium Settling Ponds	187,472	93.74	4,687
Sub Total			25,892
Total Disposal Costs			115,883

Appendix K
Permit to Mine 633
Source Material License SUA-1548

Evaluation and Simulation of Wellfield Restoration at the RAMC Smith Ranch Facility

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EXECUTIVE SUMMARY

This report presents the technical basis and justification necessary to support commercial wellfield restoration cost estimates at the RAMC Smith Ranch ISL facility. This work was initiated in response to a proposed increase in wellfield bonding requirements by the WDEQ/LQD. RAMC has repeatedly objected to the proposed bond increase based on technical, operational, and historical grounds.

RAMC has retained a consultant to assist in providing a technically defensible basis for estimating wellfield restoration costs and associated bonding requirements. To accomplish this objective, site-specific wellfield restoration simulations were conducted. Pore volume requirements were determined for the Q-Sand pilot operation and for the commercial wellfield using the concept of the mixed linear reservoir (MLR) model. The MLR model was supplemented and validated using the equilibrium geochemical mixing model PHREEQC.

Results of the wellfield simulations indicate that pore volume restoration requirements are significantly smaller than originally estimated. It is estimated that RAMC's commercial wellfields can be restored to baseline conditions in less than 4.4 pore volumes. The injection of reducing agents and RO permeate during the latter stages of wellfield restoration is predicted to have a significant effect on reducing the number of pore volumes required to reach restoration objectives.

The affected pore volume for the commercial wellfield was estimated with the aid of a three-dimensional groundwater flow model and advective particle tracking techniques. Results of this modeling suggest that the best estimate of wellfield flare factor is 1.7. This flare factor is slightly higher than RAMC's previous estimate, but substantially smaller than estimates presented by WDEQ/LQD. The resultant affected pore volume for Wellfield 1using a flare factor of 1.7 is 68,920,890 gallons (211.48 acre-ft).

A detailed sensitivity analysis of the wellfield "flare factor" was conducted as part of this work. Results of the sensitivity analyses indicate that the wellfield flare factor is a linear function of the wellfield scale, net production rate, and the ratio of horizontal to vertical hydraulic conductivity of the aquifer. These results can be used to estimate appropriate flare factors for other commercial wellfields at the Smith Ranch facility.

The time required to restore the commercial wellfield to baseline conditions was calculated using the revised pore volume estimates according to the existing restoration plan. Results of this work indicate that the commercial wellfield can be restored to baseline conditions in less than 210 days. Ground water restoration is driven by conservative constituents (e.g. chloride) that do not respond to the effects of chemical additives and possess low baseline concentrations. This conclusion has broader ramifications for ISL restoration in general, since pore volume requirements could be simply determined for any existing wellfield using the MLR model.

A review of the basic methodology used by WDEQ/LQD to estimate affected pore volumes and wellfield restoration costs was evaluated as part of this work. In the opinion of LWC, flare factors developed by WDEQ/LQD have been overestimated due to 1) the small-scale nature of the flow modeling, 2) the methodology employed to estimate the flare factor (plotting of velocity vectors), and 3) inappropriate assumptions used to calculate the vertical flare. In addition, the WDEQ/LQD methodology does not consider all factors necessary to estimate restoration with reasonable accuracy, including the number of pore volumes required to achieve restoration standards, and the affect of reducing agents and RO permeate on restoration timing.

Results of this work can be used to establish reliable estimates of restoration timing and cost for all of RAMCs commercial wellfields. Given these results, wellfield restoration at the Smith Ranch facility can be accomplished well within original time and cost estimates. Based on these findings, there is no technical basis to support an increase in bonding requirements as proposed by WDEQ/LQD.

1.0 INTRODUCTION

This report presents the technical basis and justification necessary to support commercial wellfield restoration cost estimates at the Smith Ranch ISL facility. This work was initiated in response to a proposed increase in bonding requirements by the WDEQ/LQD. The proposed increase in bond amount was based largely upon WDEQ/LQD estimates of the affected aquifer volume derived from limited groundwater flow modeling. RAMC has objected to the proposed bond increase based on technical, operational, and historical grounds.

In April of this year, RAMC retained Lewis Water Consultants (LWC) to provide a technically defensible basis for wellfield restoration cost estimates and associated bonding requirements. The following tasks were completed as part of this work:

- the Q-Sand pilot operation was evaluated and simulated. Pore volume requirements for the pilot operation and the commercial wellfields were developed as part of this task.
- the affected pore volume size was determined for the pilot operation and for the commercial wellfield. A detailed sensitivity analysis of the wellfield "flare factor" was completed as part of this task.
- the restoration of the commercial wellfield to baseline conditions was simulated using RAMC's current restoration plan, field data, and data from the Q-sand pilot. The impact of reducing agents and RO permeate injection on aquifer restoration timing was simulated as part of this task.
- the technical approach adopted by the WDEQ/LQD to estimate affected aquifer pore volumes was evaluated and potential problems were identified.
- recommendations were developed that may allow RAMC to accelerate wellfield restoration and reduce the current bond amount held by the WDEQ/LQD.

This report is organized in five sections. Section 2 describes the Q-Sand pilot simulation and the basic methodology used to develop pore volume requirements for the pilot and the commercial wellfields. Section 3 describes the commercial wellfield simulation, including the methodology used to calculate the affected pore volume and the time required to restore the wellfield to baseline conditions. Section 4 provides a critical evaluation of the methodology used by WDEQ/LQD to estimate wellfield restoration timing. Section 5 provides a summary of findings and conclusions.

2.0 Q-SAND PILOT SIMULATION

In order to predict the time required to restore a commercial wellfield using a pore volume approach, three basic pieces of information are required:

- the number of pore volumes that must be flushed to restore the wellfield to permissible water quality (baseline and/or class-of-use)
- the size of the affected pore volume
- the time required to flush a pore volume (wellfield extraction rate)

The restoration of the Q-sand pilot wellfield in 1985 provided critical information necessary to accurately predict pore volume flushing requirements and the time required to restore a commercial wellfield. The simulation of the Q-sand pilot wellfield restoration is described in the following sections.

2.1 Pore Volume Requirements

Previous estimates of wellfield restoration timing have relied greatly upon estimating the size of the affected pore volume, with little attention devoted to developing accurate pore volume flushing requirements for the commercial wellfields. Water quality data collected during the Q-sand pilot wellfield restoration provides the basis for accurately estimating pore volume flushing requirements for the pilot *and* for the groundwater sweep phase of commercial wellfield restoration.

2.1.1 Mixed Linear Reservoir (MLR) Model

Pore volume flushing requirements for the groundwater sweep phase of wellfield restoration were calculated by applying the general approach of Zheng et al. (1991,1992) using the concept of the mixed linear reservoir (MLR) or batch mixing model of Gelhar and Wilson (1974). The MLR model is based on the simple principle that an affected aquifer can be represented as a fully mixed solution at some average concentration. The concentration of this solute then changes instantaneously in response to changes in inflow, outflow, and solute mass. The average solute concentration within an ISL wellfield is well known due to the composite nature of water quality sampling. In addition, the relatively close proximity of injection and production wells makes the assumption of complete mixing appropriate.

The number of pore volumes (Npv) required to reduce the initial concentration (Ci) to some regulatory standard or final concentration (Cs) based on the MLR model is given by:

$$Npv = -R \ln (Cs/Ci) \qquad (1)$$

where R is the classical retardation factor, a measure of chemical attenuation within the aquifer.

Water quality data collected during the Q-pilot wellfield restoration provides a unique opportunity to directly compute pore volume flushing requirements and the size of the affected pore volume using the MLR model. To accomplish this, pore volume requirements were first computed for chloride, a conservative constituent (R=1). Because the initial concentration (Ci), final concentration (Cs), and retardation factor (R) of chloride are known at the time the pilot restoration was complete, the number of pore volumes flushed during the pilot (Npv) can be calculated directly. Given an initial chloride concentration of 269 mg/l, a final chloride concentration of 11 mg/l, and a retardation factor of 1.0, the number of pore volumes flushed during the pilot restoration was 3.20. This represents a three-fold decrease in pore volume requirements from previous estimates. Figure 2-1 compares observed and modeled chloride flushing curves for the Q-sand pilot restoration. In general, modeled and observed chloride concentrations are in excellent agreement, particularly near the end of the wellfield restoration.

Given the number of pore volumes flushed during the pilot test, retardation factors for other chemical constituents can be back-calculated directly from the MLR model. A knowledge of the site-specific retardation factors allows the concentration of any chemical constituent to be predicted for any set of initial and final conditions using the MLR model. Table 2-1 provides the pore volume requirements and associated retardation factors for key constituents. For some constituents, the initial concentration at the start of the pilot was not known; initial concentrations were estimated for these constituents from observed concentrations in Wellfield 1.

Figure 2-2 compares the relative flushing curves for key constituents. The relative mobility of various chemical constituents can be seen from this graph. Figures 2-3, 2-4, and 2-5 compare modeled and observed pilot flushing curves for uranium, sulfate, and bicarbonate, respectively. In general, modeled and observed concentrations are in excellent agreement, particularly near the end of the pilot restoration. Minor deviations from ideal model behavior are likely due to non-linear, irreversible chemical attenuation within the aquifer not accounted for by the classical retardation factor (linear reversible adsorption).

It is important to note that the pore volume requirements developed from the Q-sand pilot are generally applicable not only for the pilot test area, but for the groundwater sweep portion of RAMC's commercial wellfield restorations. The number of pore volumes required to meet restoration standards is independent of the size of the affected pore volume. Retardation factors should not vary significantly since the commercial wellfields are part of the same aquifer system. Variability in pore volume requirements would exist only if initial wellfield concentrations and baseline target concentrations deviated greatly from those of the Q-sand pilot restoration. Pore volume requirements for chloride developed from the MLR model are

Table 2-1. Retardation Factors at End of Q-sand Pilot Test

Ci = initial concentration (at beginning of restoration)
Cs = concentration at end of pilot test restoration
Npv = number of pore volumes (based on revised affected pore volume)
R = retardation factor from mixed linear reservoir model: R = -Npv/ln(Cs/Ci)

	Ci	Cs	Cs/Ci	ln (Cs/Ci)	Npv	R
mg/L						
Cl	269	11	0.040892	-3.196816	3.20	1.0[a]
U (U_3O_8)	14.4	1.9	0.131944	-2.025374	3.20	1.58
SO_4	450	115	0.255556	-1.364315	3.20	2.34
Ca	273	68	0.249084	-1.389964	3.20	2.30
HCO_3	915	226	0.246995	-1.398389	3.20	2.29
Constituents with estimated Ci values (estimated from Wellfield 1 data)						
Na	80	38	0.475	-0.744	3.20	4.3
K	18	8	0.444	-0.811	3.20	3.9
Mg	90	19	0.211	-1.555	3.20	2.1
B	0.15	0.14[b]	0.933	-0.069	3.20	46.3[b]
Fe	0.05	0.24	4.800	1.569	3.20	na[c]
Mn	0.35	0.06	0.171	-1.764	3.20	1.8
As	0.008	0.008	1.000	0.000	3.20	na[c]
Se	0.08	0.003	0.038	-3.283	3.20	1.0
Ra226 (pCi/L)	4000	477	0.119	-2.127	3.20	1.5

Notes:
a Chloride is assumed to behave conservatively, R = 1
b Final concentration is suspect and results in unreasonably high R
c not applicable - R cannot be calculated from steady or increasing concentrations

more universal in nature (e.g. applicable to all ISL sites), since chloride acts conservatively in essentially all environments.

2.2 Affected Pore Volume Calculation

Another benefit of the MLR model is the ability to calculate the affected pore volume size for the Q-sand pilot directly, without the need for groundwater flow model simulations. Because the number of pore volumes flushed during the pilot restoration is known, and because the total volume of groundwater flushed (extracted) during the test is also known, the affected pore volume (APV) can be computed simply from:

$$APV = TV/Npv \quad (2)$$

where TV is the total volume of groundwater extracted during the pilot restoration. Given a total extracted volume of 2.044×10^7 gallons and 3.20 pore volumes flushed, the affected pore volume size of the Q-sand pilot is 6.387×10^6 gallons. This affected pore volume is appropriate only for the Q-sand pilot restoration, not the commercial wellfields. This is due to significant differences in net production rate, bleed rate (5 % vs. 0.5%), well construction (full vs. partial penetration), and irregular pattern geometry of the Q-sand pilot relative to the commercial wellfields.

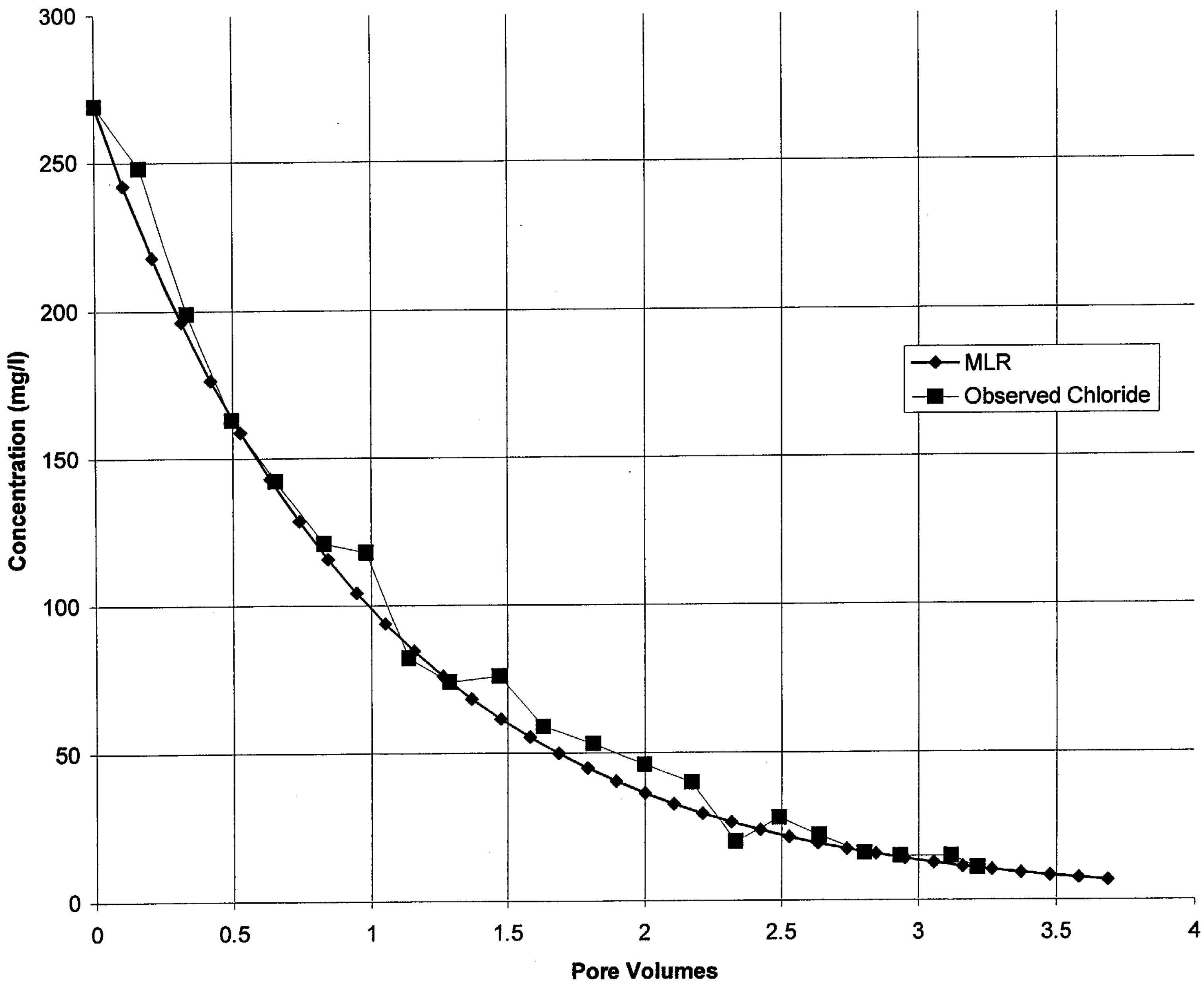
2.3 Verification of MLR Model Using PHREEQC

Results of the Q-sand pilot simulation demonstrate that the MLR model can be used to predict concentration declines during the groundwater sweep phase of wellfield restoration (Phase I). However, the MLR model is not capable of predicting concentration declines due to strongly non-linear chemical reactions including changes in aquifer redox conditions. Significant changes in redox conditions will occur during Phase II and III of RAMC's restoration plan, when reducing agents (H_2S) and RO permeate are injected into the aquifer. A more sophisticated modeling approach is necessary to adequately address these conditions.

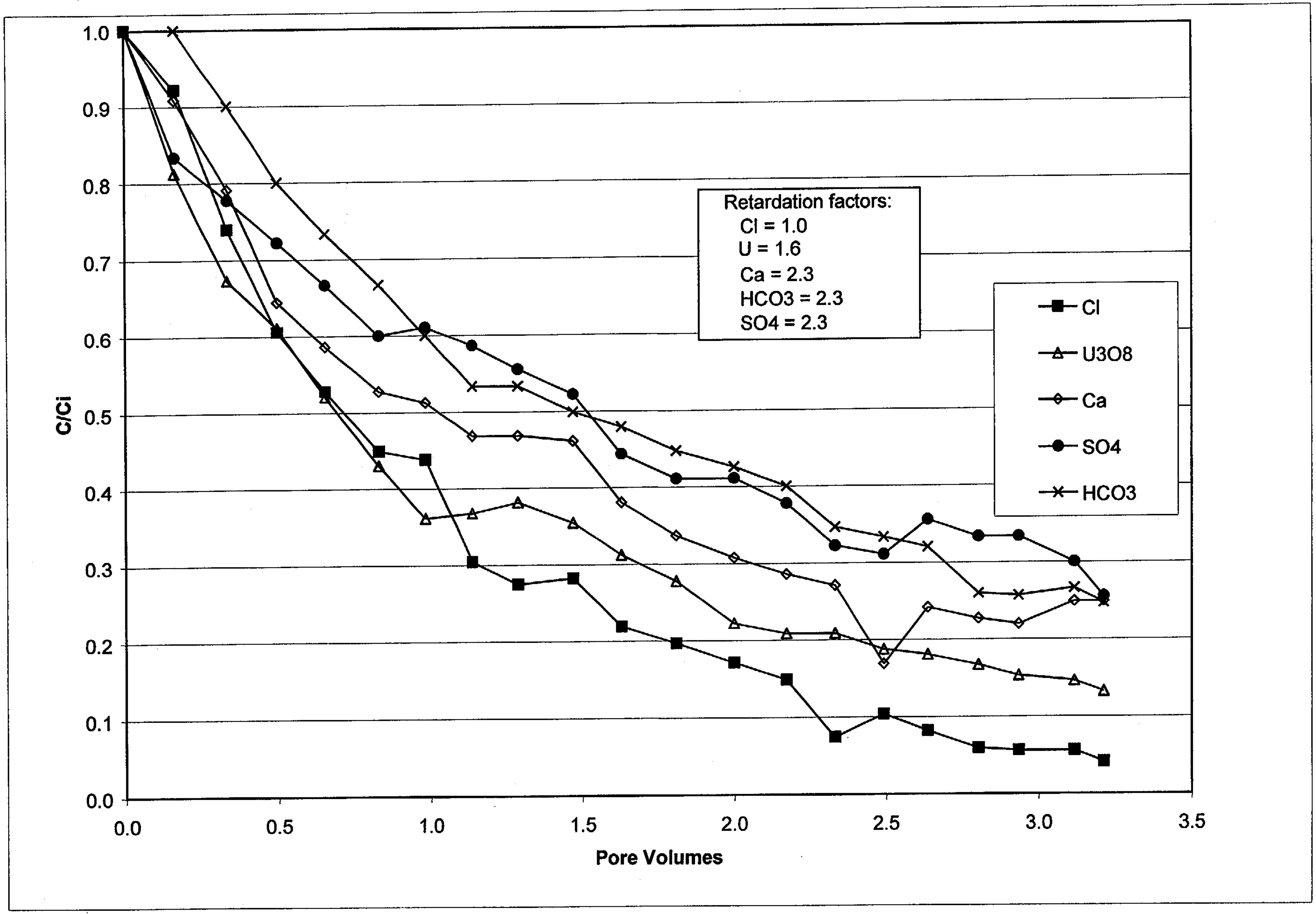
The USGS aqueous geochemical model PHREEQC (Parkhurst, 1995) was selected for the purpose of simulating Phase II and III of wellfield restoration, as discussed in section 3. PHREEQC is an equilibrium geochemical model capable of simulating a wide range of complex aqueous geochemical reactions. Because PHREEQC uses a batch or unit-volume approach, it is ideally suited to the pore volume methodology. Details concerning PHREEQC model development and application are provided in Attachment A.

In theory, the MLR model and PHREEQC should provide essentially identical results when simulating mixing of conservative constituents. To test this hypothesis, PHREEQC was used to simulate chloride flushing during wellfield restoration. This simulation could be considered a validation of the MLR model and PHREEQC for commercial wellfield application.

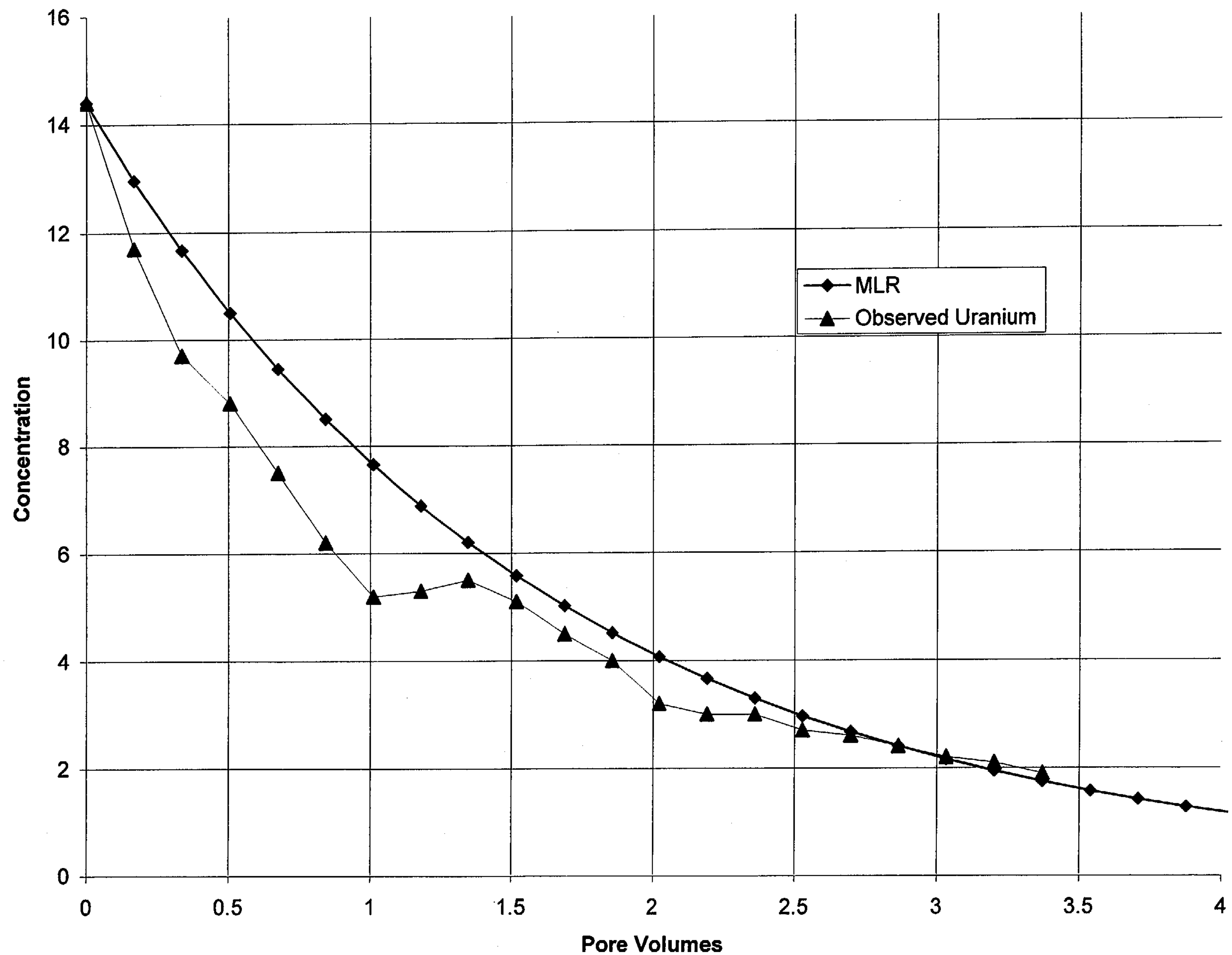
Results of the PHREEQC chloride flushing simulation is provided on Figure 2-6. Results of this simulation illustrate that PHREEQC and the MLR model provide essentially identical results, and that both models simulate measured concentration declines with a high degree of accuracy.



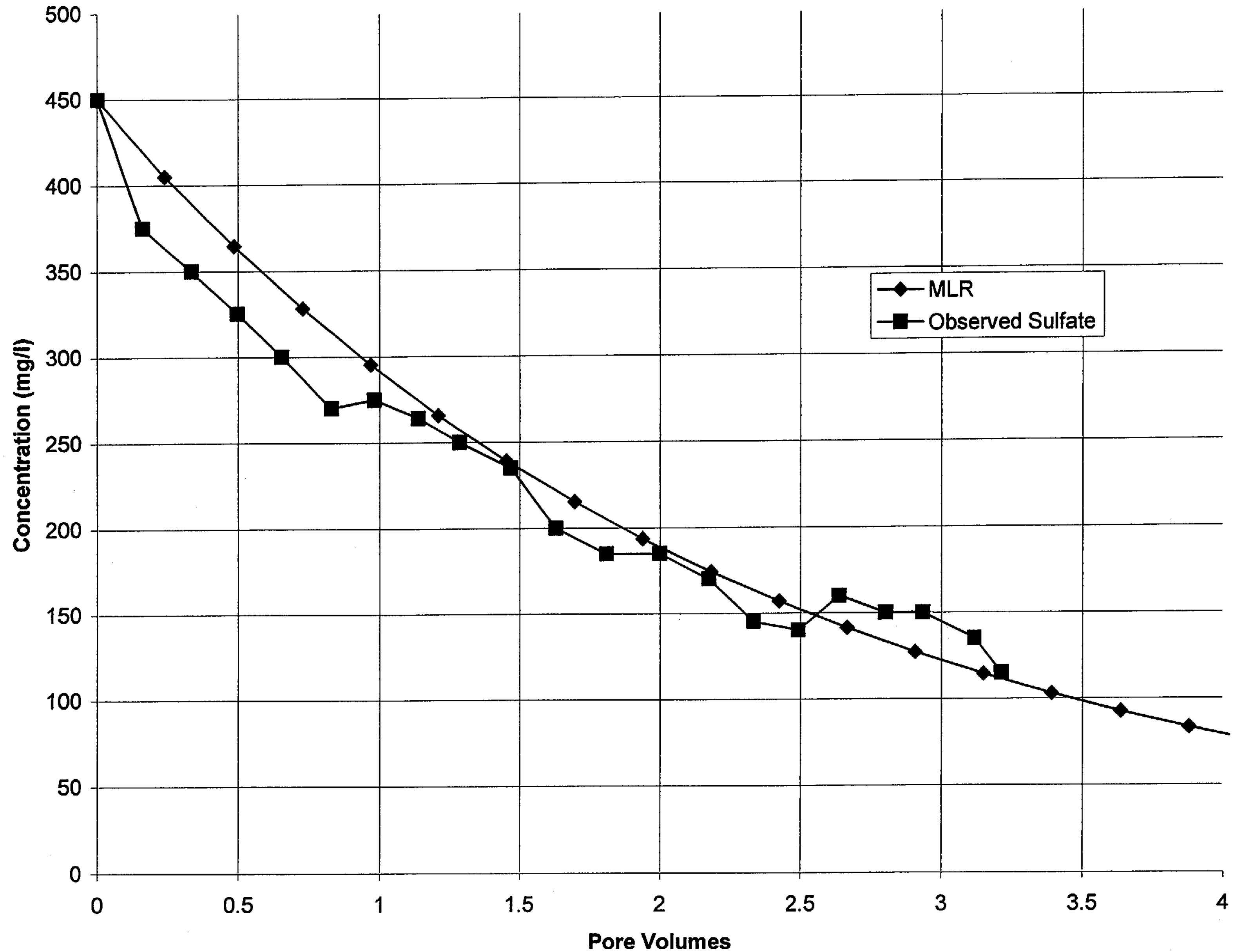
Lewis Water Consultants *Environmental Science/Engineering/Modeling*	**RAMC Smith Ranch Facility** Figure 2-1. Observed vs. simulated chloride flushing curves, Q-Sand Pilot Restoration	Date: **9/14/99** Project: **RAMC Wellfield Evaluation** File: **land.ppt**



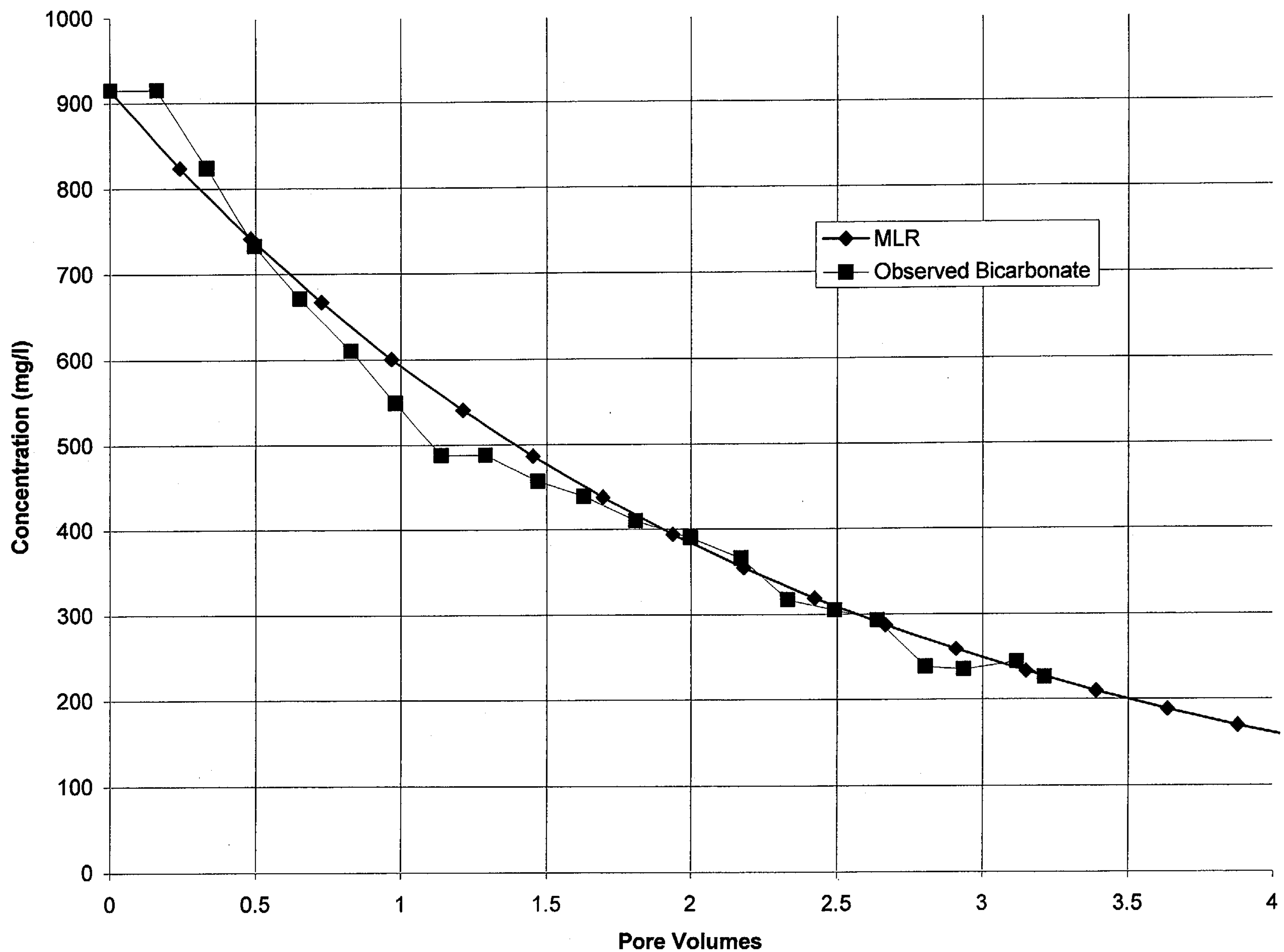
Lewis Water Consultants *Environmental Science/Engineering/Modeling*	**RAMC Smith Ranch Facility** Figure 2-2. Observed Q-Sand pilot flushing curves	Date: **9/14/99** Project: **RAMC Wellfield Evaluation** File: **land.ppt**



Lewis Water Consultants *Environmental Science/Engineering/Modeling*	**RAMC Smith Ranch Facility** Figure 2-3. Observed vs. simulated uranium flushing curves, Q-Sand Pilot Restoration	Date: **9/14/99** Project: **RAMC Wellfield Evaluation** File: **land.ppt**



Lewis Water Consultants *Environmental Science/Engineering/Modeling*	**RAMC Smith Ranch Facility** Figure 2-4. Observed vs. simulated sulfate flushing curves, Q-Sand Pilot Restoration	Date: 9/14/99 Project: RAMC Wellfield Evaluation File: land.ppt



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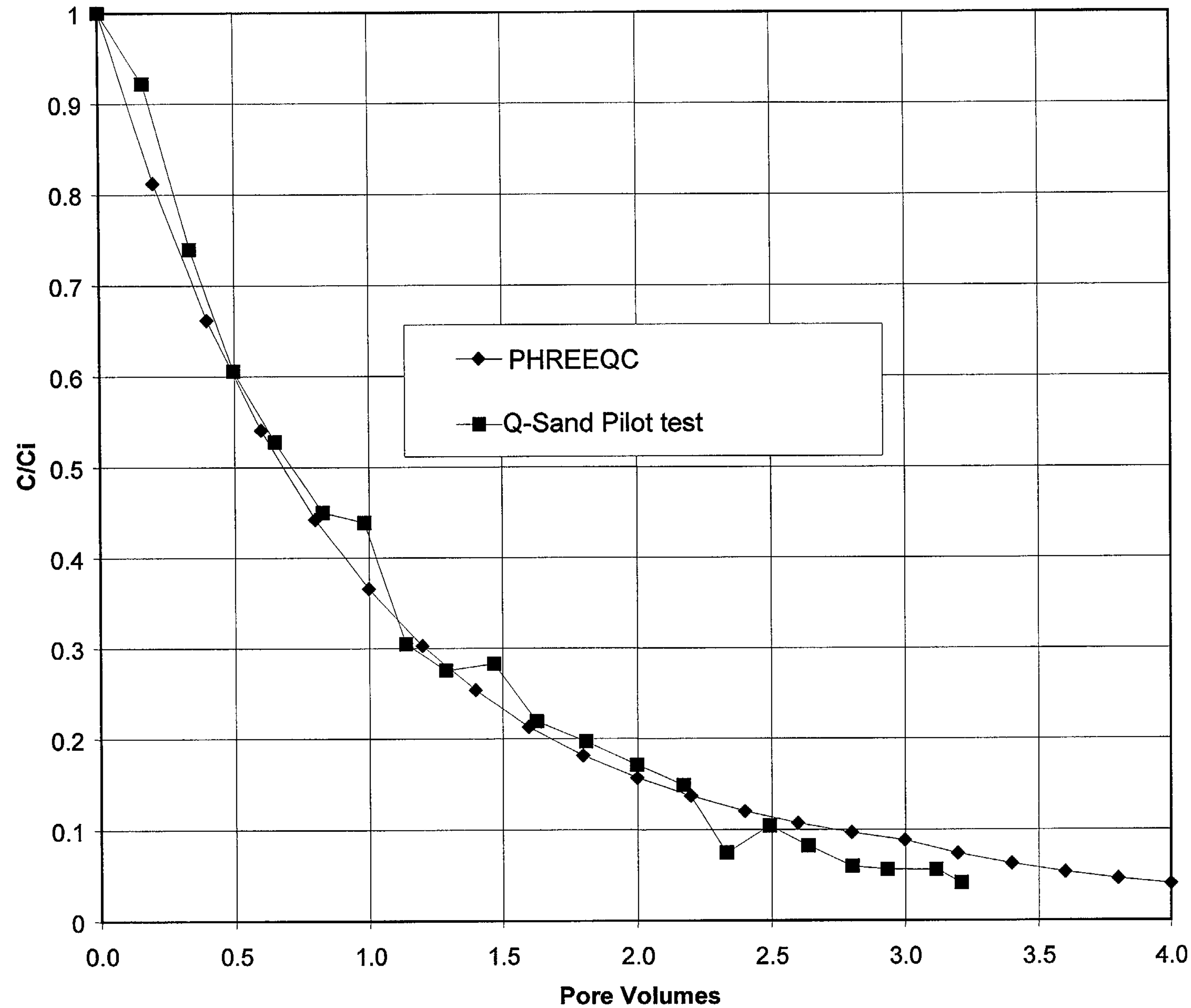
RAMC Smith Ranch Facility

Figure 2-5. Observed vs. simulated bicarbonate flushing curves, Q-Sand Pilot Restoration

Date:	9/14/99
Project:	RAMC Wellfield Evaluation
File:	land.ppt



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RAMC Smith Ranch Facility

Figure 2-6. Comparison of PHREEQC and observed chloride flushing curves

Date: 9/14/99

Project: RAMC Wellfield Evaluation

File: land.ppt

3.0 COMMERCIAL WELLFIELD SIMULATION

The restoration of RAMC's commercial Wellfield 1 was simulated using the basic methodology applied to the Q-sand pilot restoration. Pore volume requirements for the wellfield were developed using the MLR and PHREEQC models. The size of the affected pore volume was then determined using a three-dimensional groundwater flow model (MODFLOW) in conjunction with particle tracking techniques (MODPATH). Sensitivity analyses of the wellfield "flare factor" was performed as part of this work. Finally, the time required to restore the wellfield was computed by incorporating the pore volume requirements, affected pore volume size, and planned wellfield pumping rates.

Commercial wellfield restoration was simulated according to RAMC's current restoration plan. Wellfield restoration is to proceed as follows:

- 3 Pore Volumes native groundwater sweep at 1015 gpm (Phase I)
- 1 Pore Volume treated by Reverse Osmosis (RO) with chemical reductant (H_2S) added at 250 mg/l sulfide, injected with 5% bleed at 1015 gpm (Phase II)
- 2 Pore Volumes treated by RO, permeate injected with 25 % bleed at 1000 gpm (Phase III)

3.1 Pore Volume Requirements

As stated in Section 2.1.1, pore volume requirements developed from the Q-sand pilot simulation are generally applicable to RAMC's commercial wellfields for the groundwater sweep phase of wellfield restoration. However, small differences may exist due to differences between the initial concentration at the start of restoration and baseline or target concentrations at the end of restoration. Because these conditions are slightly different in Wellfield 1 than observed in the Q-sand pilot, pore volume requirements were recomputed for the commercial wellfield using the most current wellfield concentration data.

Pore volume requirements for Phase I of the wellfield restoration (groundwater sweep) were computed using the MLR model. Pore volume requirements for Phase II and III of the restoration were computed using PHREEQC to account for non-linear chemical reactions due to injection of reducing agents and RO permeate. Details concerning the development and application of PHREEQC are provided in Attachment A.

Restoration of Wellfield 1 is expected to proceed in the third quarter of 2000. Initial concentrations in Wellfield 1 at the beginning of restoration were extrapolated from current conditions using recent historical concentration trends. The pH used in the geochemical modeling was the average of the values measured at each production wellhead in May 1999. Starting concentrations of constituents not routinely measured by RAMC were assumed to be equal to the concentrations measured in header house composite samples collected in May 1999. Table 3-1 provides initial concentrations assumed in the restoration simulation.

Figures 3-1 through 3-6 depict the predicted pore volume flushing curves for select key constituents. Table 3-1 provides a summary of concentrations observed at the end of each restoration phase. In addition to these key constituents, concentrations of all constituents monitored by permit requirements were simulated by PHREEQC (Attachment A). Only those constituents having the greatest bearing on restoration timing are presented in the summary figures and tables.

Based on these results, RAMC's commercial wellfields will be restored to class-of-use within 3.4 pore volumes, and should meet baseline conditions for all constituents within 4.4 pore volumes. Figures 3-1 and 3-2 demonstrate the positive affect of reducing agent and RO permeate on redox sensitive elements (e.g. U and Se).

An important result of this analysis is the observation that ground water restoration is driven by conservative constituents (e.g. chloride) that do not respond to the effects of chemical additives and possess low baseline concentrations. This conclusion has broader ramifications for ISL restoration in general, since pore volume requirements can be simply determined for any existing wellfield using the MLR model.

3.2 Affected Pore Volume Calculation

In order to predict wellfield restoration timing, the size of the affected pore volume must be determined. To accomplish this objective, the affected pore volume size of the commercial wellfield was computed using a three-dimensional groundwater flow model in conjunction with particle tracking techniques. A sensitivity analysis of wellfield "flare factor" was also conducted to identify those parameters that most greatly affect pore volume size.

Prior to conducting flow model simulations, the pattern pore volume size of Wellfield 1 was computed. The pattern pore volume size of Wellfield 1 was determined using AutoCAD for area calculations, and SURFER for volumetric cut-and-fill computations. An isopach (thickness) map of the Q-sand aquifer was digitized to compute the total pattern volume of the Q-sand aquifer. An average thickness of the production interval (ore zone) of 18 ft. was used to compute the production zone pore volume. The barren zone thickness was computed to be the difference between the total Q-sand thickness and the production zone thickness. A porosity value of 0.27 was used to be consistent with previous estimates by WDEQ/LQD and RAMC. Results of the pattern volume calculations are provided on Figure 3-7.

3.2.1 Flare Factor and Affected Pore Volume Definition

For purposes of this document, the wellfield flare factor is defined as:

Horizontal Flare Factor = Total Affected Area / Pattern Area (generally >1)
Vertical Flare Factor = Fractional barren zone intrusion (0-1)

Table 3-1. Initial and Predicted Concentrations at End of Restoration Phases

Constituent	Initial Concentration at Start of Restoration	Modeled Concentration after Phase I (GW Sweep)	Modeled Concentration after Phase II (RO + Reductant)	Modeled Concentration after Phase III (RO permeate)
U	15	2.3	<0.168	<0.168
Se	0.092	0.0047	<0.001	<0.001
Cl	210	10	4.9	1.1
SO_4	720	194	91	20
HCO_3	590	159	89	20
Ca	430	116	55	12
Na	41	23	11	2.4
As	0.006	0.001	<0.001	<0.001
B	0.15	0.10	0.048	0.011
Fe	0.05	0.055	<0.01	<0.01
Mn	0.31	0.059	0.028	0.006

Given this definition, a horizontal flare of 1.0 means no lateral extension of mining fluids beyond the pattern boundaries. A horizontal flare of 2.0 means an affected area twice the size of the pattern area. Similarly, a vertical flare of 0.5 means that 50% of the total barren zone thickness is impacted by mining fluids. These definitions are believed to be identical to those currently used WDEQ/LQD and RAMC.

The affected pore volume (APV) is then calculated as:

$$\text{APV} = (\text{PZPV x Horizontal Flare Factor}) + (\text{BZPV x Vertical Flare Factor}) \qquad (3)$$

where PZPV is the production zone pore volume and BZPV is the barren zone pore volume. The PZPV and BZPV for Wellfield 1 are provided on Figure 3-7.

3.2.2 Flare Factor Sensitivity Analyses

Sensitivity analyses of parameters influencing the horizontal flare factor were investigated using the analytical flow and transport model RANDC, a C+ version of the traditional RANDOMWALK particle tracking code (Prickett et al., 1981). RANDC is a full-featured two-dimensional mass transport model using a particle tracking methodology. If dispersion is not included in simulations, RANDC becomes an advective particle tracking code similar to MODPATH, but has the added ability to release particles in a continuous mode and thus create "particle clouds" rather than traditional streamlines. Flare factors are easier to visualize and compute using particle clouds rather than streamlines. Sensitivity analyses of the vertical flare factor were also investigated using a three-dimensional flow model (MODFLOW) in conjunction with conventional particle tracking techniques (MODPATH).

The following parameters were included in the flare factor sensitivity analyses: 1) pattern scale and perimeter injection well density, 2) net production rate, 3) aquifer transmissivity, and 4) ratio of horizontal to vertical hydraulic conductivity.

The following assumptions and aquifer parameters were used in the RANDC sensitivity analyses unless otherwise stated:

- hydraulic conductivity = 33.7 gpd/ft^2 (4.5 ft/day), derived from Q-sand pilot pump test data. This value is representative of the upper range of hydraulic conductivity observed in Wellfield 1.
- effective porosity = 0.27.
- transmissivity = 1000 gpd/ft. This value is deemed representative of the Q-sand aquifer in Wellfield 1 and the Q-sand pilot.
- regional gradient of 0.002. This value is deemed representative of pre-development conditions in the Q-sand.
- storage coefficient = 0.000048. This value is representative of values derived from Q-sand multi-well pump tests.
- three year simulation period.

3.2.2.1 Wellfield Scale and Perimeter Injection Well Density

The scale of the wellfield pattern was identified as having a significant impact on the horizontal flare factor. This conclusion is logical since the horizontal flare is driven by perimeter injection wells, and the number of perimeter injection wells per unit area generally decreases as the scale of the wellfield increases. Thin, elongate wellfields have a higher number of perimeter injection wells per unit area than thick, rectangular wellfields. The logical conclusion would be that horizontal flare should decrease as the scale of the wellfield increases.

A sensitivity analysis of wellfield scale was conducted by simulating three test cases: 1) an ideal single 5-spot pattern, 2) a double pattern rectangle, and 3) a quad-pattern square. Results of these analyses are presented on Figure 3-8. Modeled particle distributions are provided in Attachment B.

Results of this analysis clearly demonstrate that the horizontal flare factor decreases significantly as the size of the wellfield increases. This "scale effect" is quantified on Figure 3-8 in terms of the number of perimeter injection wells per unit pattern area. This result suggests that small-scale modeling of ideal wellfield patterns may not provide a reasonable estimate of commercial wellfield flare factors.

3.2.2.2 Net Production Rate

Another parameter found to have a significant impact on horizontal flare factor is the net pattern production rate. The net production rate is similar to the bleed rate, but provides more information concerning the magnitude of injection and extraction. For example, a 100 gpm pattern would have a larger flare factor than an equivalent 10 gpm pattern, although both may have an identical bleed rate. The net production rate incorporates both the bleed rate and the magnitude of pattern production in a single parameter.

A sensitivity analysis of net production rate (on a per well basis) was conducted by simulating two cases: 1) a 0.08 gpm/well net production rate, and 2) a 0.125 gpm/well net production rate. Results of this analysis are provided on Figure 3-8. Modeled particle distributions are provided in Attachment B.

As expected, results of this analysis demonstrate that the horizontal flare factor decreases significantly as the net production rate decreases. RAMC's commercial wellfields possess very low net production rates (less than 0.08 gpm/well). Alternatively, the Q-sand pilot wellfield possessed a much larger net production rate (greater than 1.2 gpm/well). This result suggests that care must be taken to ensure that modeled "ideal" test patterns possess equivalent net production rates as the commercial wellfields they are intended to simulate.

3.2.2.3 Aquifer Transmissivity (Thickness Variation)

Transmissivity variations were found to have a modest impact on horizontal flare factor. Transmissivity variations in the Q-sand and Wellfield 1 are not substantial; transmissivity typically varies from 500 to 1500 gpd/ft across the large majority of the wellfield, with an average of approximately 1000 gpd/ft. Variations in transmissivity are due almost entirely to changes in aquifer thickness.

A sensitivity analysis of aquifer transmissivity was conducted by simulating two cases: 1) transmissivity of 1500 gpd/ft (+50%), and 2) transmissivity of 500 gpd/ft (-50%). Transmissivity was assumed to vary due to changes in aquifer thickness (hydraulic conductivity was held constant). Modeled particle distributions are provided in Attachment B.

Results of this analysis indicate that a 50 % increase in transmissivity (thickness) results in a 30 % decrease in horizontal flare. Likewise, a 50 % decrease in transmissivity results in only a 5 % increase in pattern flare. These results suggest that wellfield flare factors are not particularly sensitive to aquifer transmissivity variation relative to other parameters tested.

3.2.2.4 Kh/Kv Ratio

The ratio of horizontal to vertical hydraulic conductivity (Kh/Kv) was shown to have a significant impact on both horizontal and vertical flare factors. Although the impact of the

Kh/Kv ratio on the vertical flare could be predicted, the impact on the horizontal flare was somewhat surprising.

The sensitivity analysis of the Kh/Kv ratio required that three-dimensional modeling techniques be employed. MODFLOW (McDonald and Harbaugh, 1988) and MODPATH (Pollock, 1989) were utilized for this purpose. This analysis was conducted as part of the Wellfield 1 flow model simulation described in Section 3.2.3 and Attachment C.

A sensitivity analysis of the Kh/Kv ratio was conducted by simulating three cases: 1) Kh/Kv = 1.0, 2) Kh/Kv = 10, and 3) Kh/Kv = 100. Results of this analysis are presented on Figure 3.9. MODPATH particle traces for these simulations are provided in Attachment C.

Results of this analysis indicate that horizontal and vertical flare factors decrease significantly as the Kh/Kv ratio decreases. Using a Kh/Kv ratio of 100:1, there is essentially no vertical flare and a minimal horizontal flare of 1.7. As discussed in Section 3.2.3 of this report, a Kh/Kv ratio of 100:1 is believed to be representative for RAMC's commercial wellfield(s).

It should be noted that the total simulation time assumed in the sensitivity analyses (and wellfield simulations) does not appear to have a substantial impact on wellfield flare factors. After only months of operation, the wellfields appear to have reached a pseudo- steady state condition with respect to mine fluid expansion and the radius of influence of production/injection wells (assuming flow rates remain constant). This observation suggests that steady-state flow model simulations should provide similar results as those using transient assumptions.

3.2.3 Wellfield Flow Model Simulation and APV Calculation

The affected pore volume of RAMC's commercial Wellfield 1 was computed with the aid of a three-dimensional flow model (MODFLOW) and particle tracking techniques (MODPATH).

The MODFLOW model of Wellfield 1 consists of 154 Rows, 200 Columns, and 3 layers. Elevation maps of the top and bottom of the Q-sand were digitized and imported directly into the MODFLOW simulator (GW Vistas). The production zone was simulated as a separate (middle) layer, and was assigned a uniform thickness of 18 feet. Boundary conditions for the model were assigned as general heads (not constant heads) at sufficient distances from the wellfield to preclude negative boundary effects from injection/production. The model grid and boundary conditions are provided in Attachment C.

Wellfield operations were simulated using all 112 production wells and 212 injection wells. Based on the most recent production data, the wellfield is currently operating near its maximum historical production rate of 1750 gpm with a 5 % bleed (1741 gpm injection). This combined production rate was divided evenly among production and injection wells for the simulation.

The MODFLOW model was calibrated to approximate pre-development conditions based on water levels observed in the Q-sand prior to the multi-well pump tests conducted in February of

1997 (RAMC and Hydro-Engineering, 1997). The calibrated pre-development surface is provided in Attachment C.

The following aquifer properties and assumptions were used in the wellfield simulation:

- Kh = 2.74 ft/day. This value represents the geometric mean of hydraulic conductivity developed from the Q-sand multi-well pump tests.
- Kv = 0.0274 ft/day (calculation discussed below).
- Porosity = 0.27 (for MODPATH simulations).
- Steady-state flow field
- Total particle tracking period of 2.5 years (for MODPATH simulations)

The Kh/Kv ratio has been shown to have a significant impact on horizontal and vertical flare factor. However, no direct measurements of Kv are available. Despite this limitation, the Kv of the Q-sand can be estimated to a reasonable degree by estimating the Kv of individual sublayers in an ideal section. The Kv of a stratified sequence of porous media can be computed as the harmonic mean of individual sublayers (Isaaks and Srivastava, 1989; McDonald and Harbaugh, 1988), or:

$$1 / Kv = 1/n \sum_{i=1}^{n} (1 / Kv_i) \qquad (4)$$

where Kv_i is the vertical permeability of the i sublayer. A representative section of the Q-sand typically contains an interbedded sequence of fluvial sediments consisting of approximately 45 feet of clean sand and 5 feet of interbedded claystone/shale/lignite. If we divide the typical Q-sand section into 10 layers of 5-foot thickness, we would have nine layers of sand (45 feet) and one layer of clay (5 feet). If we allow the Kv of the sand layers to be 2.74 ft/day (equal to Kh), and the Kv of the claystone layer to be 0.0027 ft/day (representing the upper range of values for the R- and P-shale from pump test analysis), the average Kv for the Q-sand computed from equation (4) is 0.027 ft/day. This equates to a Kh/Kv ratio of 100:1, typical of many fluvial depositional environments containing alternating sand/clay layers.

Results of the MODFLOW wellfield simulation were imported into the USGS MODPATH particle tracking model included with the GW Vistas simulator. Ten particles were placed at each injection well location and tracked forward for a period of 2.5 years. MODPATH particle traces for the wellfield simulations are included in Attachment C.

Results of the MODFLOW/MODPATH simulation indicates a flare factor of 1.7 is appropriate for the commercial wellfield (vertical flare factor = 0). This result is slightly higher than RAMC's original estimate, but significantly lower than WDEQ/LQD. The resultant affected pore volume for Wellfield 1 from equation (3) is 68,920,890 gallons.

3.3 Wellfield Restoration Timing

Pore volume requirements presented in section 3.1 can be converted to restoration time requirements given a knowledge of the affected pore volume and planned wellfield production rates. The following time periods apply to each stage of restoration:

- Stage I - 3PVs @ 1015 gpm = 141.5 days
- Stage II - 1 PV @ 1015 gpm = 47.2 days
- Stage III - 2 PVs @ 1000 gpm = 95.7 days
- Total 6 PV restoration period = 284.4 days

Table 3-2 presents restoration time requirements for key constituents to achieve class-of-use and baseline standards. Figures 3-10 through 3-15 show wellfield restoration curves for key constituents, and the time required to reach restoration objectives. Based on these results, the wellfield will be restored to class-of-use within 160 days, and will be restored to baseline conditions for all constituents within 210 days.

3.4 Applicability of Results to Other Wellfields

Pore volume requirements developed for Wellfield 1 are generally applicable to all of RAMC's Smith Ranch commercial wellfields. Small differences may exist due to variations in initial and baseline target concentrations between wellfields.

Results of the flare factor sensitivity analyses indicate that the wellfield flare factor is a linear function of the wellfield scale, net production rate, and the ratio of horizontal to vertical hydraulic conductivity of the aquifer. The Smith Ranch commercial wellfields all possess similar net production and bleed rates (0.08 gpm/well), so this parameter is not a variable. Aquifer test data indicate the hydraulic conductivity of the Ft. Union sands are very similar (e.g. 2 to 5 ft/day average), and the construction of injection and production intervals are also very similar (18 ft. open interval, on the average). This means the production zone transmissivity is very similar for all of the Smith Ranch wellfields. Furthermore, because the wellfields are all located within similar fluvial sequences of the Ft. Union formation, they can be assumed to possess similar Kh/Kv ratios. Given these observations, differences in flare factor between wellfields should be primarily the result of differences in wellfield scale.

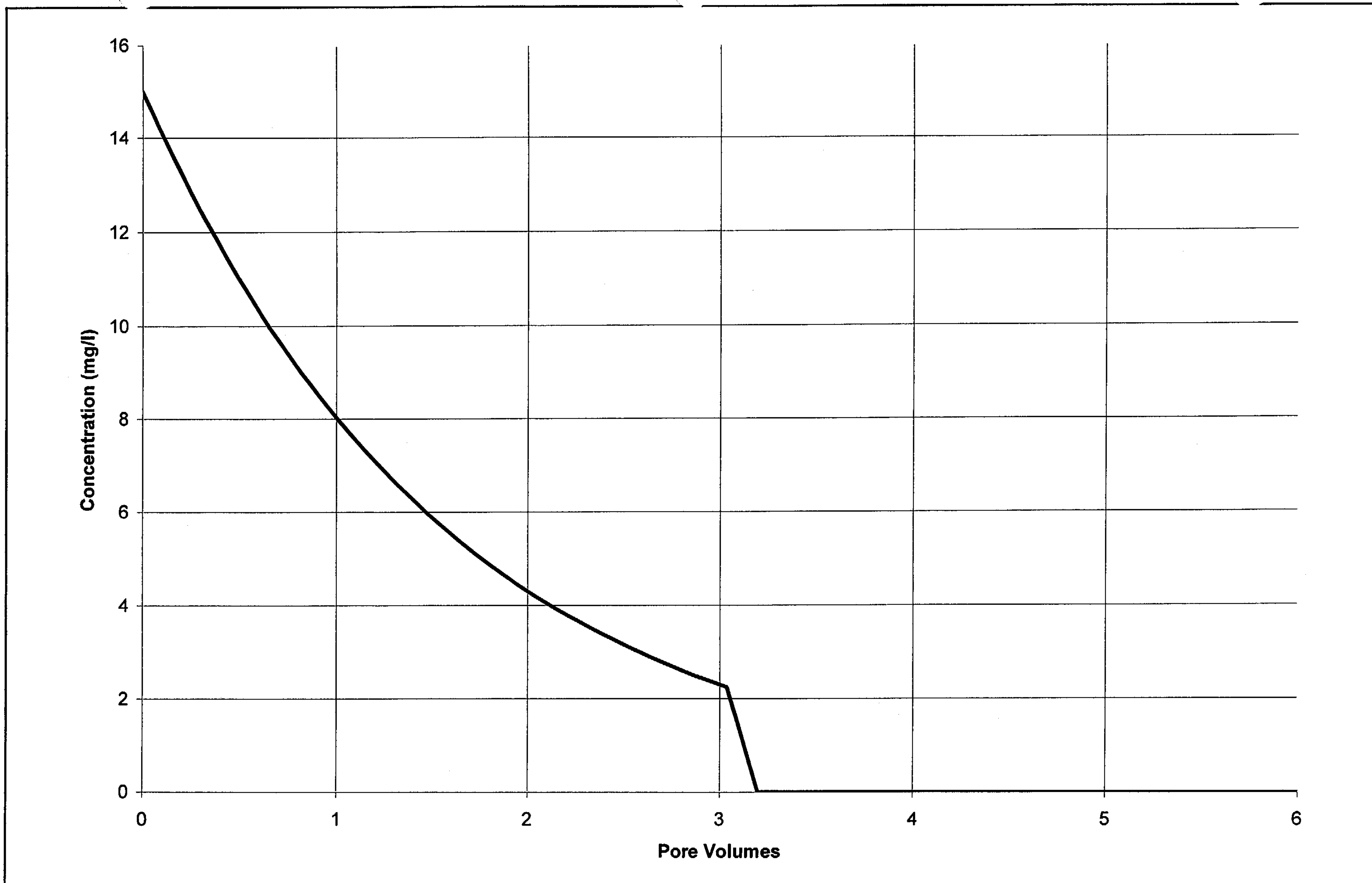
Figure 3-16 provides the predicted flare factor versus wellfield scale (number of perimeter injection wells/ft^2) constructed from results of the sensitivity analyses. Figure 3-16 assumes a net production rate of 0.08 gpm/well and a Kh/Kv ratio of 100:1 (e.g. no vertical flare). These results can be used to estimate appropriate flare factors for remaining commercial wellfields (other than Wellfield 1) at the Smith Ranch facility.

Figure 3-16 assumes that the wellfield flare factor cannot be less than 1.0 (although flare factors less than 1.0 can be shown to exist). Therefore, as a conservative measure, the linear relationship between flare factor and wellfield scale was assumed to be strictly valid only for perimeter injection well densities less than about 1.5e-04 wells/ft^2. It is assumed that the flare factor approaches 1.0 asymptotically at very low injection well densities.

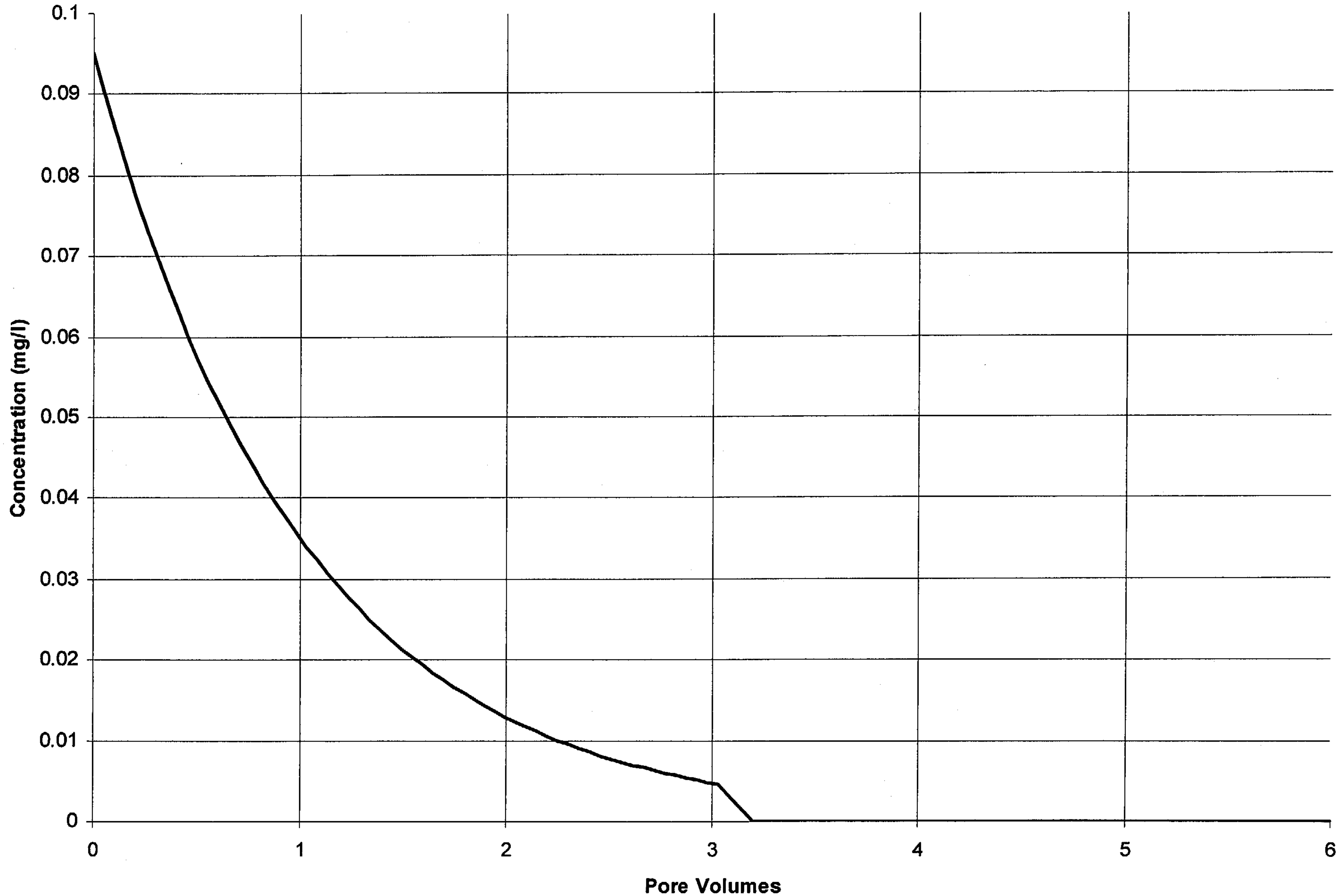
Table 3-2. Predicted Wellfield 1 Restoration Timing

Constituent	Restoration Target (Background)	Number of Pore Volumes to Meet Target	Time Required to Meet Target (Baseline), days	Restoration Target (Class of use[a])	Number of Pore Volumes to Meet Target	Time Required to Meet Target (Class-of-Use),days
U	0.168	3.2	150	5	1.8	86
Se	0.001	3.2	150	0.01	2.3	109
Cl	4.176	4.4	210	250	0	0
SO_4	113.125	3.8	179	250	2.5	117
HCO_3	228.194	2.3	109	na	na	na
Ca	72.617	3.8	179	na	na	na
Na	22.525	3.2	150	na	na	na
As	0.001	3.0	141	0.05	0	0
B	0.100	3.2	150	0.75	0	0
Fe	0.065	0	0	0.3	0	0
Mn	0.022	4.4	210	0.05	3.4	160
Mg	17.364	3.2	150	na	na	na
K	7.269	3.2	150	na	na	na
F	0.322	3.2	150	2.4	na	na
SiO_2	16.975	3.2	150	na	na	na
Zn	0.010	3.2	150	5	0	0

[a] -- standards listed are for Wyoming Class I ground water, although baseline wellfield ground water does not meet this standard due to excessive radium.



Lewis Water Consultants *Environmental Science/Engineering/Modeling*	**RAMC Smith Ranch Facility** Figure 3-1. Simulated uranium flushing curve, commercial wellfield restoration	Date: **9/14/99** Project: **RAMC Wellfield Evaluation** File: **land.ppt**



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RAMC Smith Ranch Facility

Figure 3-2. Simulated selenium flushing curve, commercial wellfield restoration

Date:	9/14/99
Project:	RAMC Wellfield Evaluation
File:	land.ppt

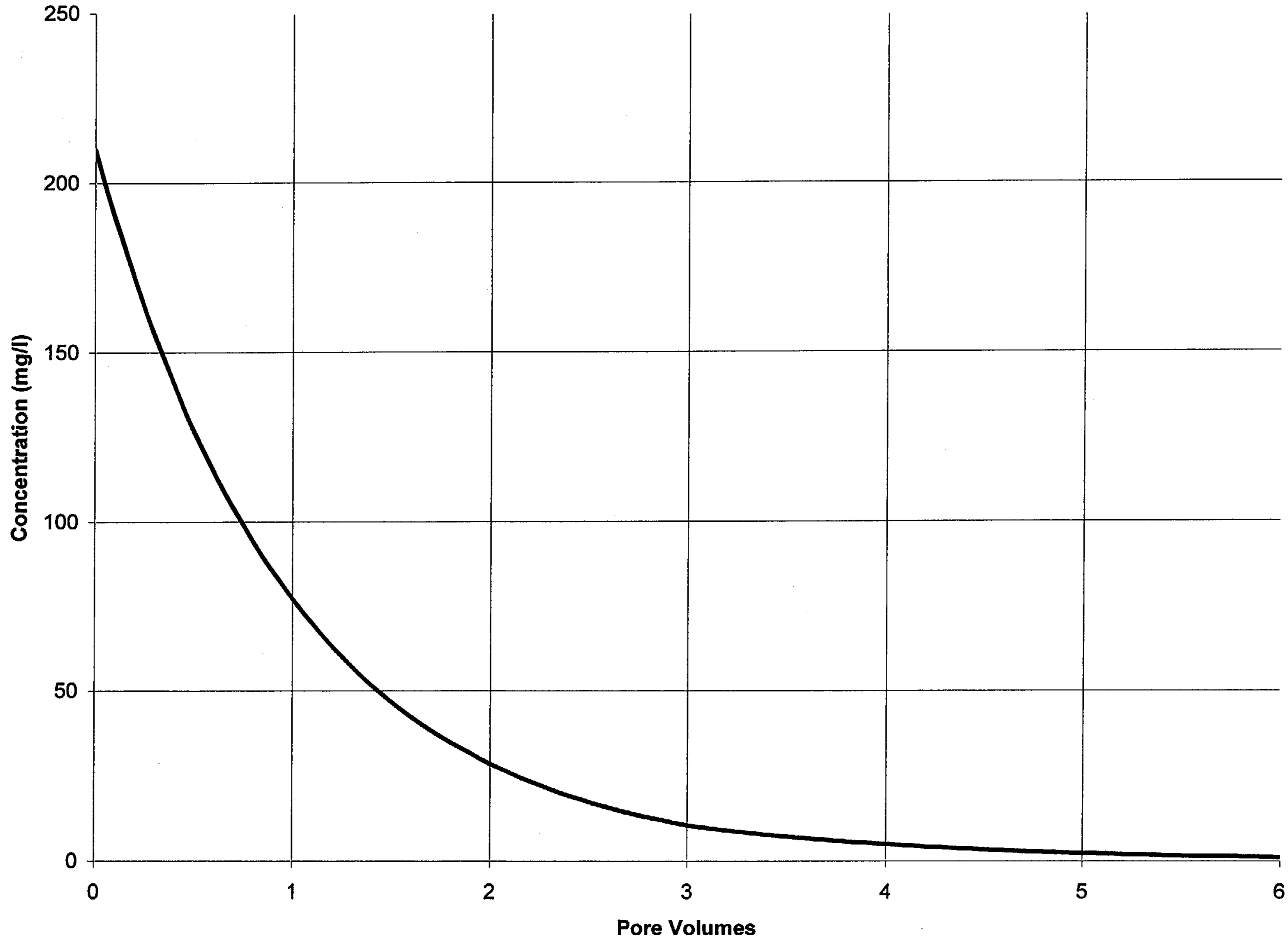

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Figure 3-3. Simulated chloride flushing curve, commercial wellfield restoration

Date:	9/14/99
Project:	RAMC Wellfield Evaluation
File:	land.ppt

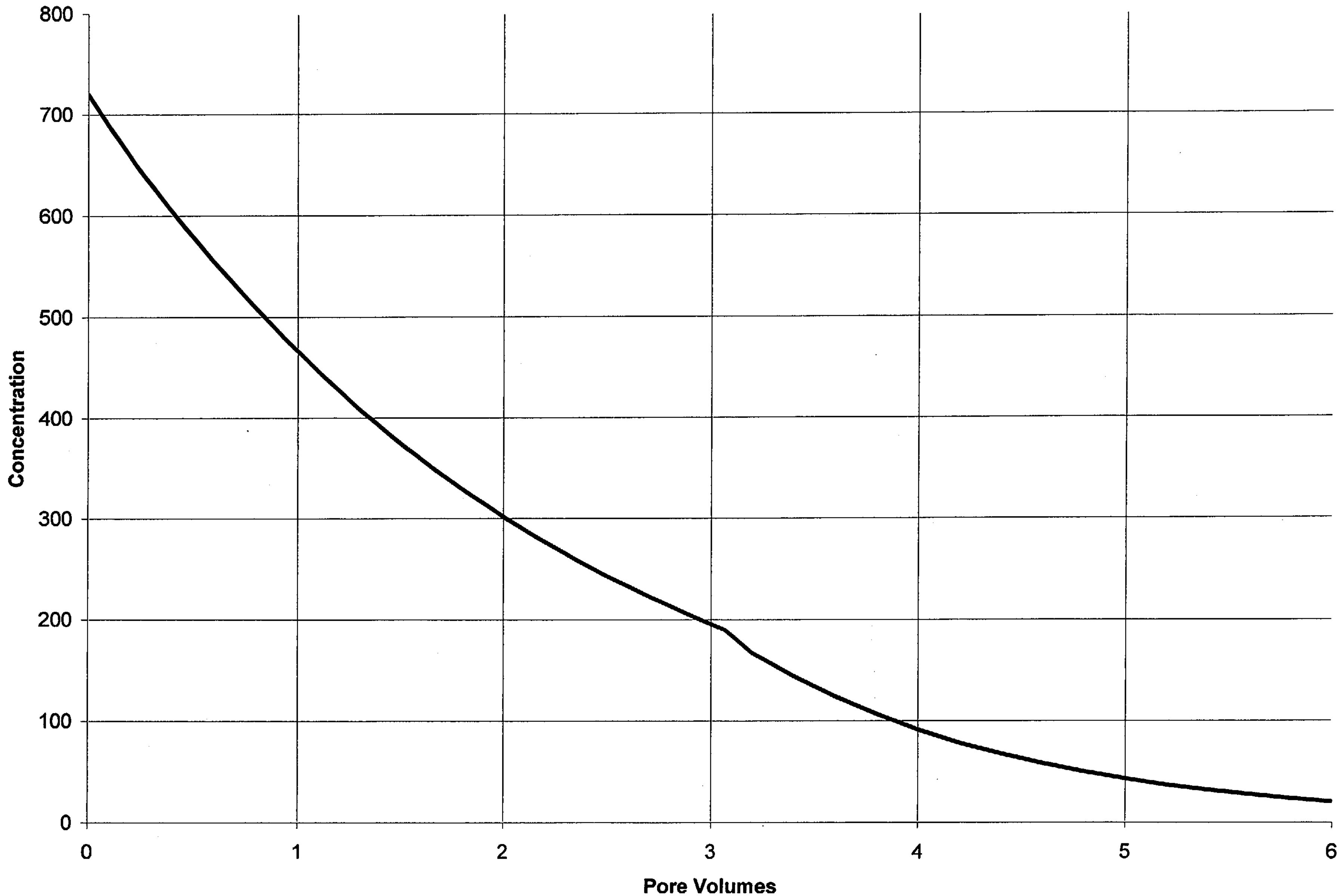

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Figure 3-4. Simulated sulfate flushing curve, commercial wellfield restoration

Date:	9/14/99
Project:	RAMC Wellfield Evaluation
File:	land.ppt

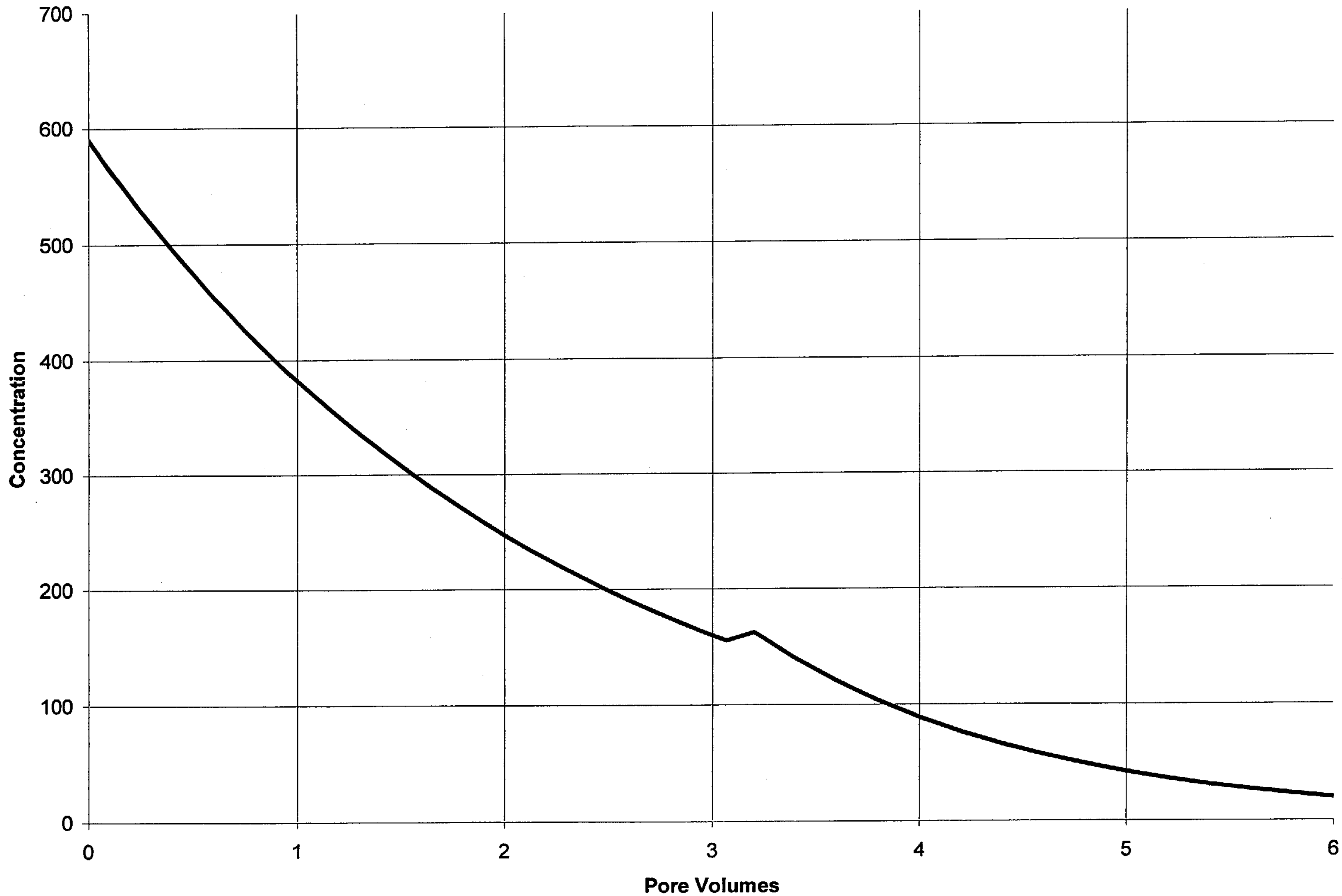

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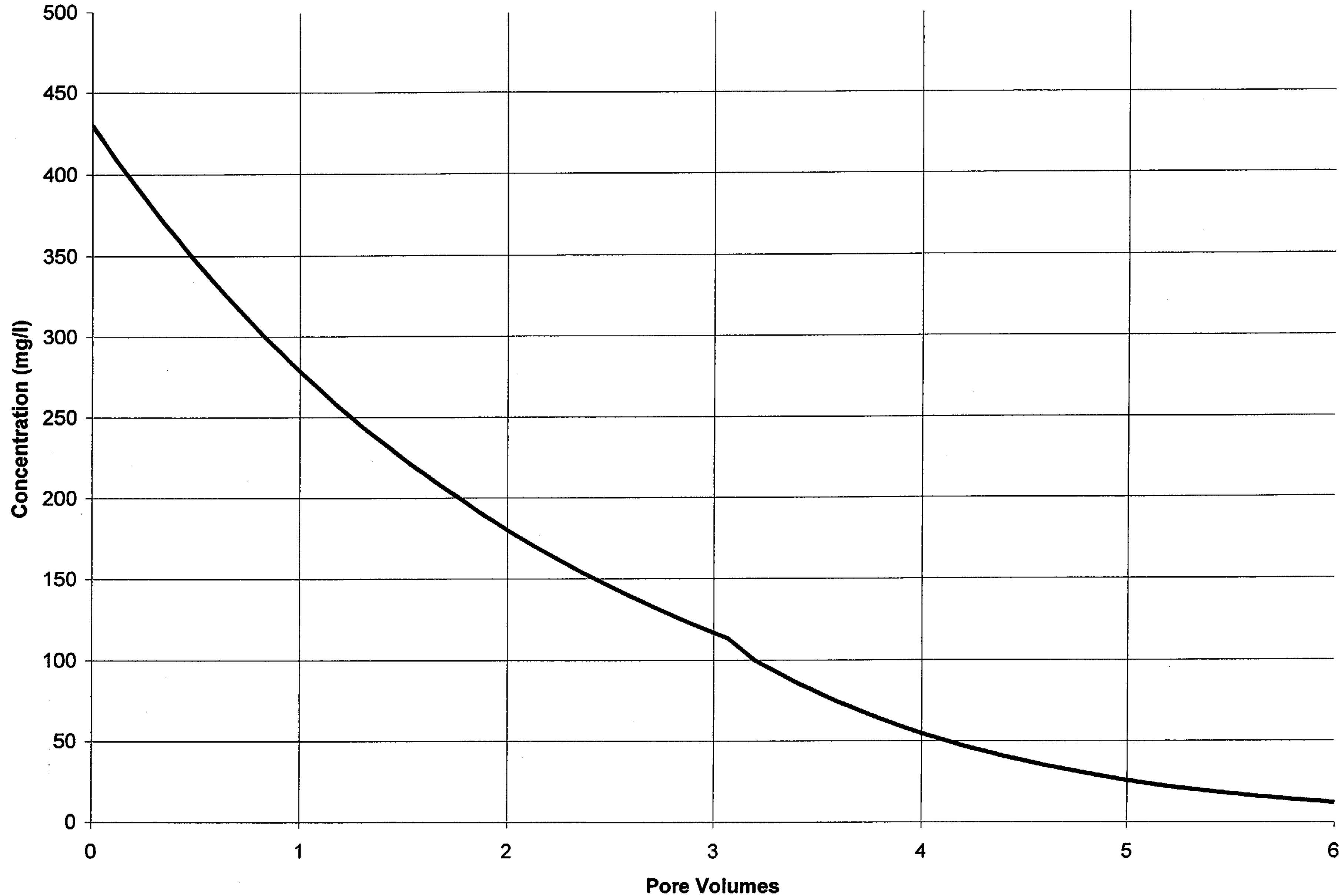
Figure 3-5. Simulated bicarbonate flushing curve, commercial wellfield restoration

Date: 9/14/99

Project: RAMC Wellfield Evaluation

File: land.ppt



Lewis Water Consultants *Environmental Science/Engineering/Modeling*	**RAMC Smith Ranch Facility** Figure 3-6. Simulated calcium flushing curve, commercial wellfield restoration	Date: **9/14/99** Project: **RAMC Wellfield Evaluation** File: **land.ppt**

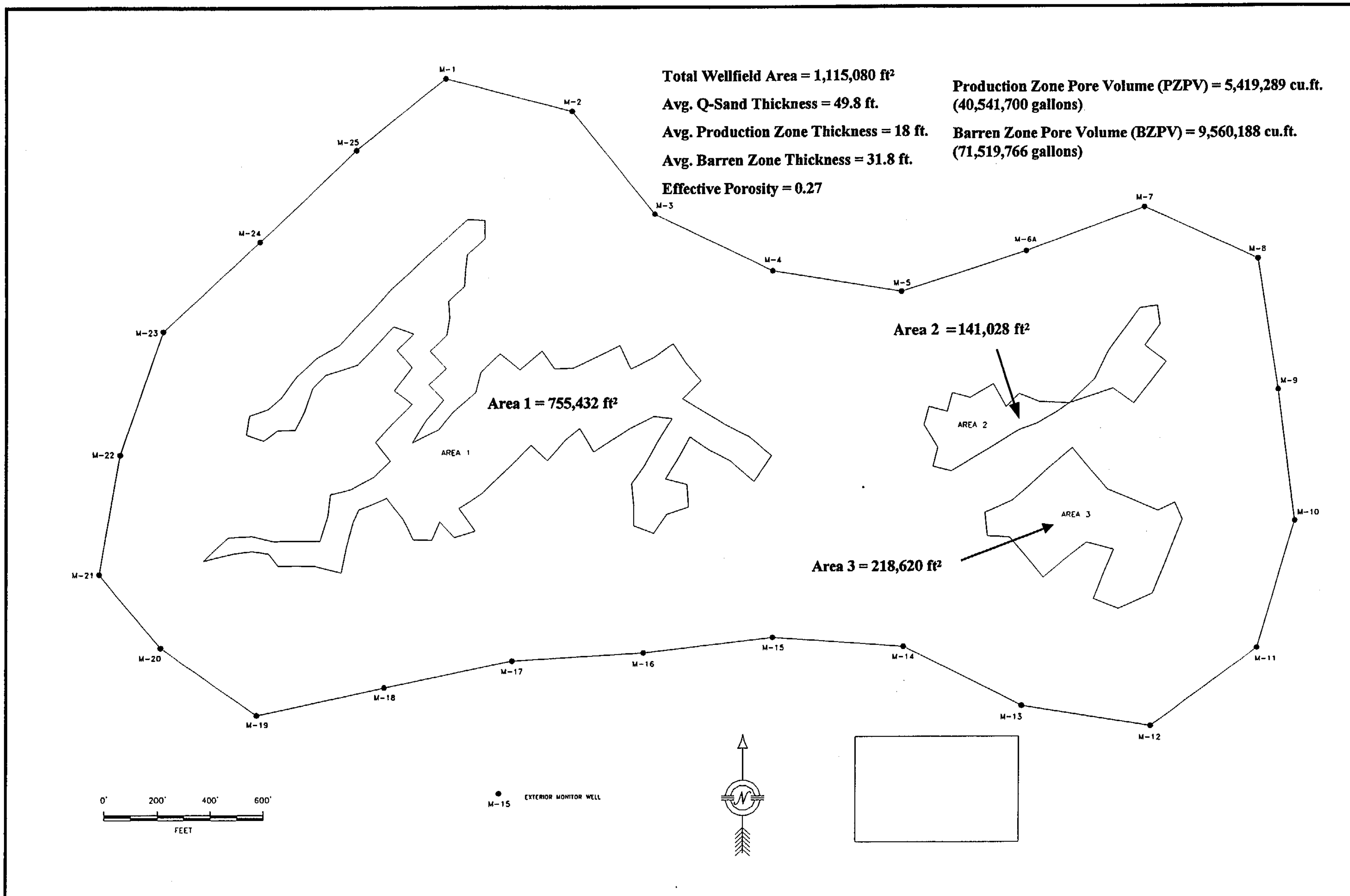


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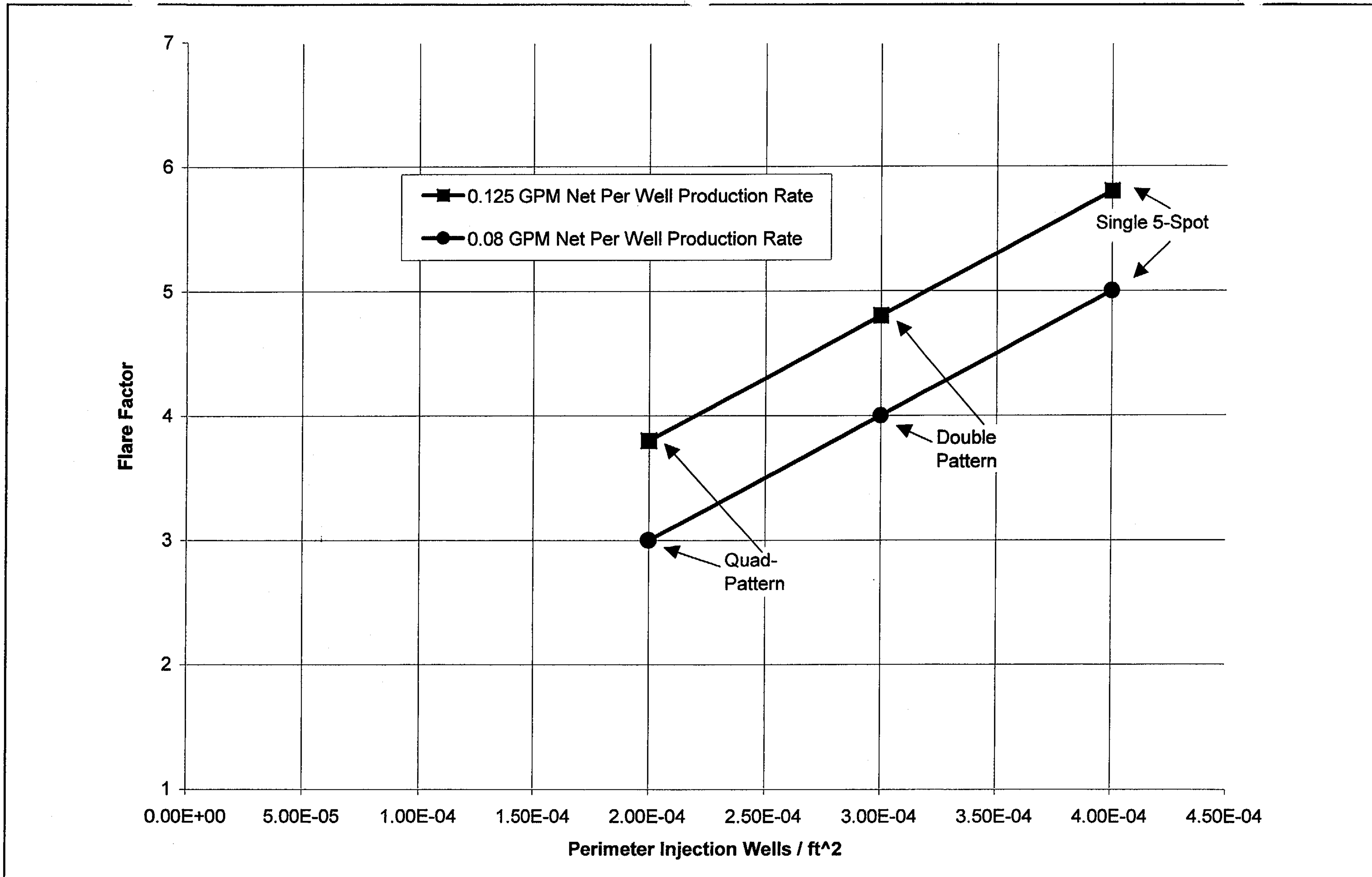
Figure 3-7. Areas and pattern volumes for Wellfield 1

Date:	9/14/99
Project:	RAMC Wellfield Evaluation
File:	land.ppt



Lewis Water Consultants *Environmental Science/Engineering/Modeling*	**RAMC Smith Ranch Facility** Figure 3-8. Flare factor sensitivity analyses, pattern scale and net production rate	Date: **9/14/99** Project: **RAMC Wellfield Evaluation** File: **land.ppt**

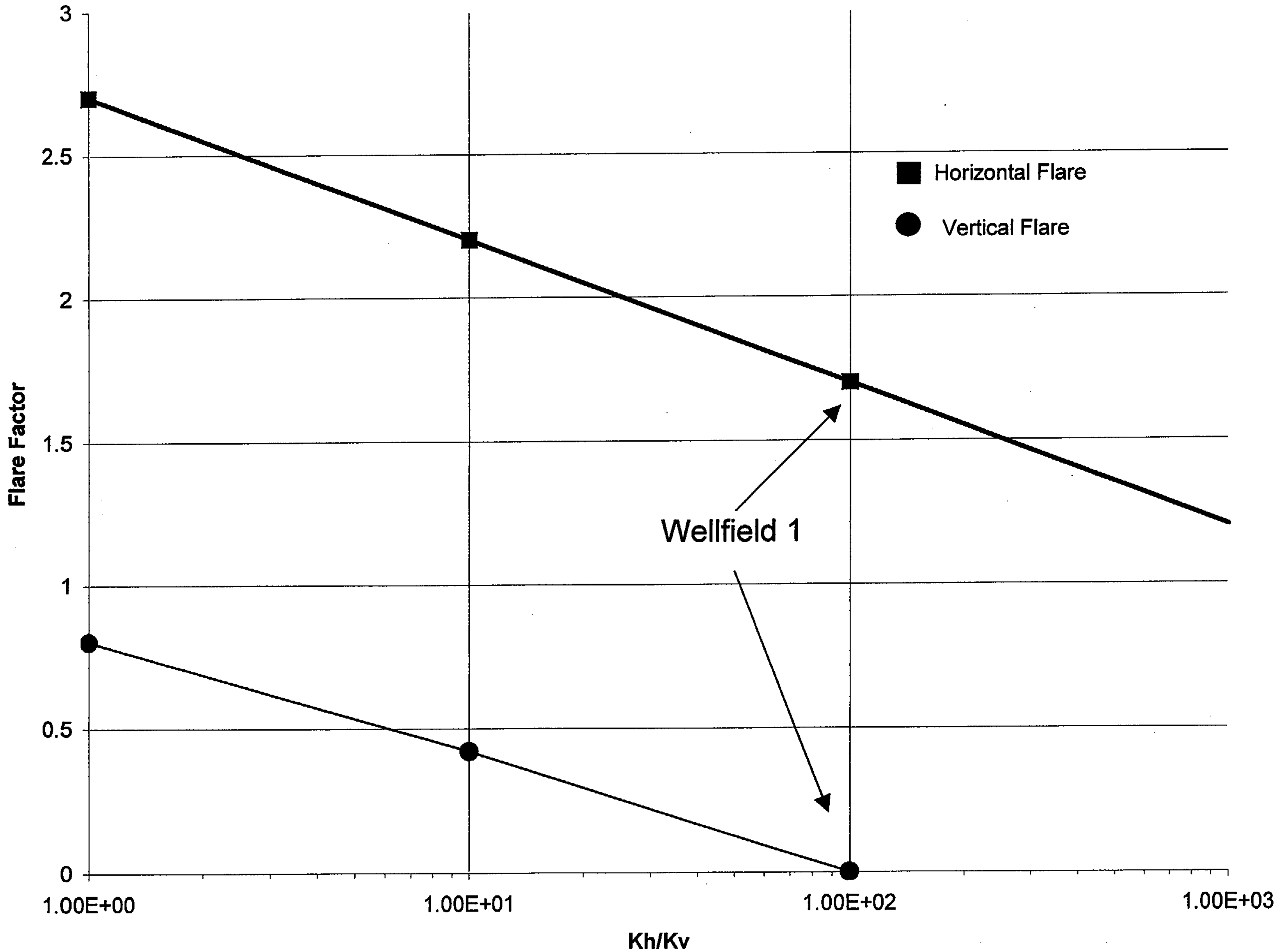


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Figure 3-9. Flare factor sensitivity analyses, Kh/Kv ratio

Date:	9/14/99
Project:	RAMC Wellfield Evaluation
File:	land.ppt

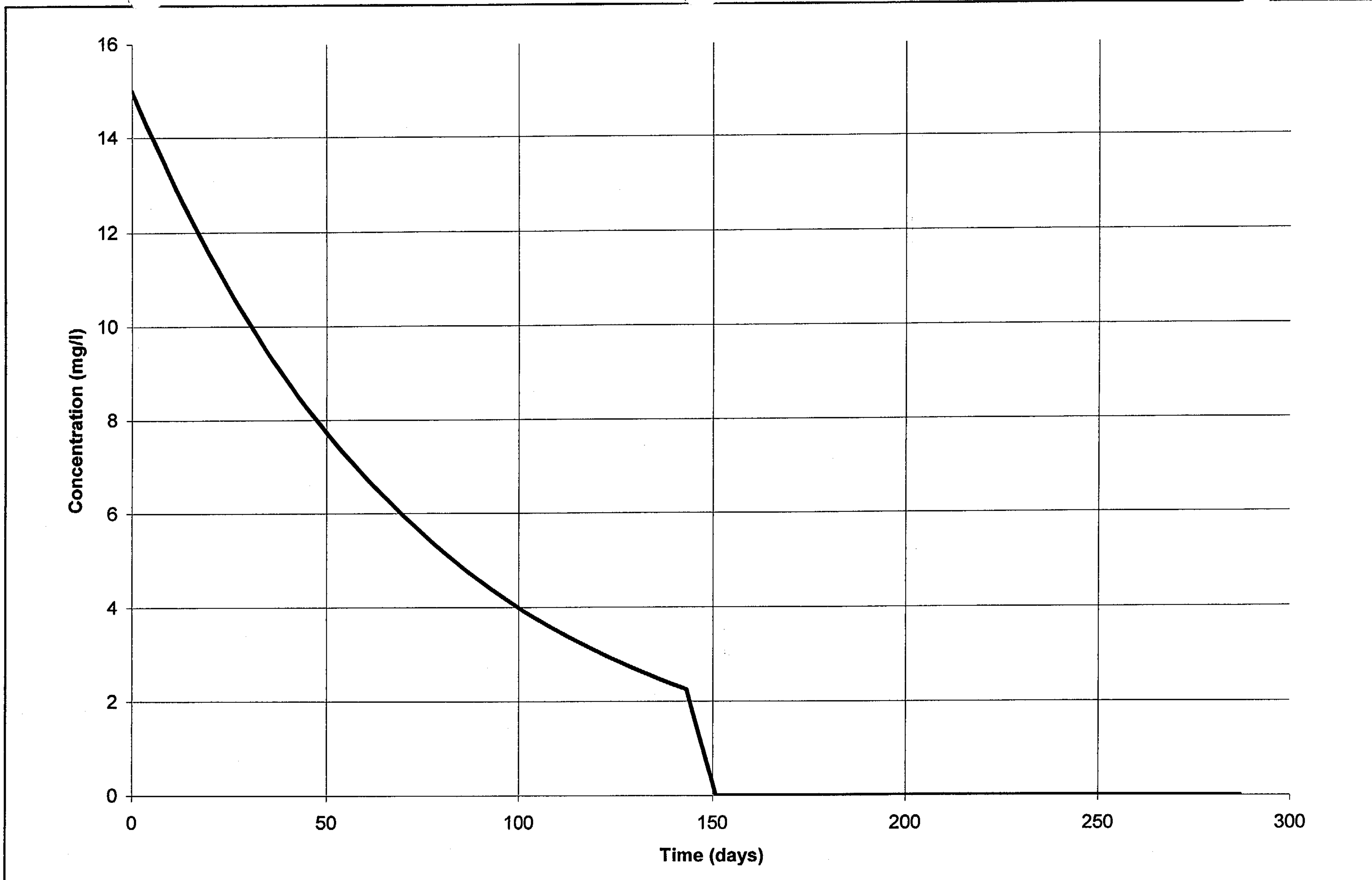

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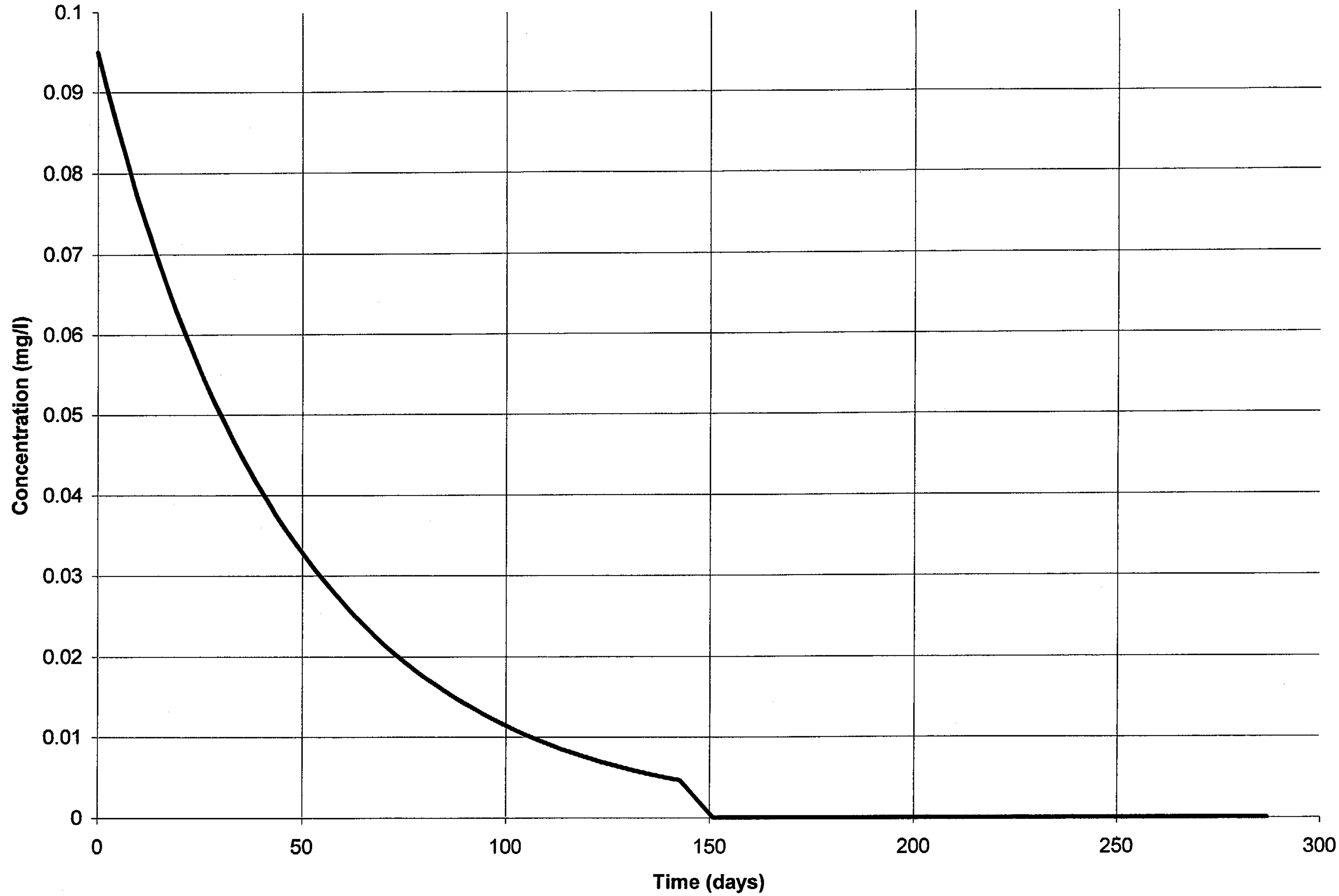
Figure 3-10. Simulated uranium restoration curve, commercial Wellfield 1

Date:	9/14/99
Project:	RAMC Wellfield Evaluation
File:	land.ppt



Lewis Water Consultants *Environmental Science/Engineering/Modeling*	**RAMC Smith Ranch Facility** Figure 3-11. Simulated selenium restoration curve, commercial Wellfield 1	Date: **9/14/99** Project: **RAMC Wellfield Evaluation** File: **land.ppt**

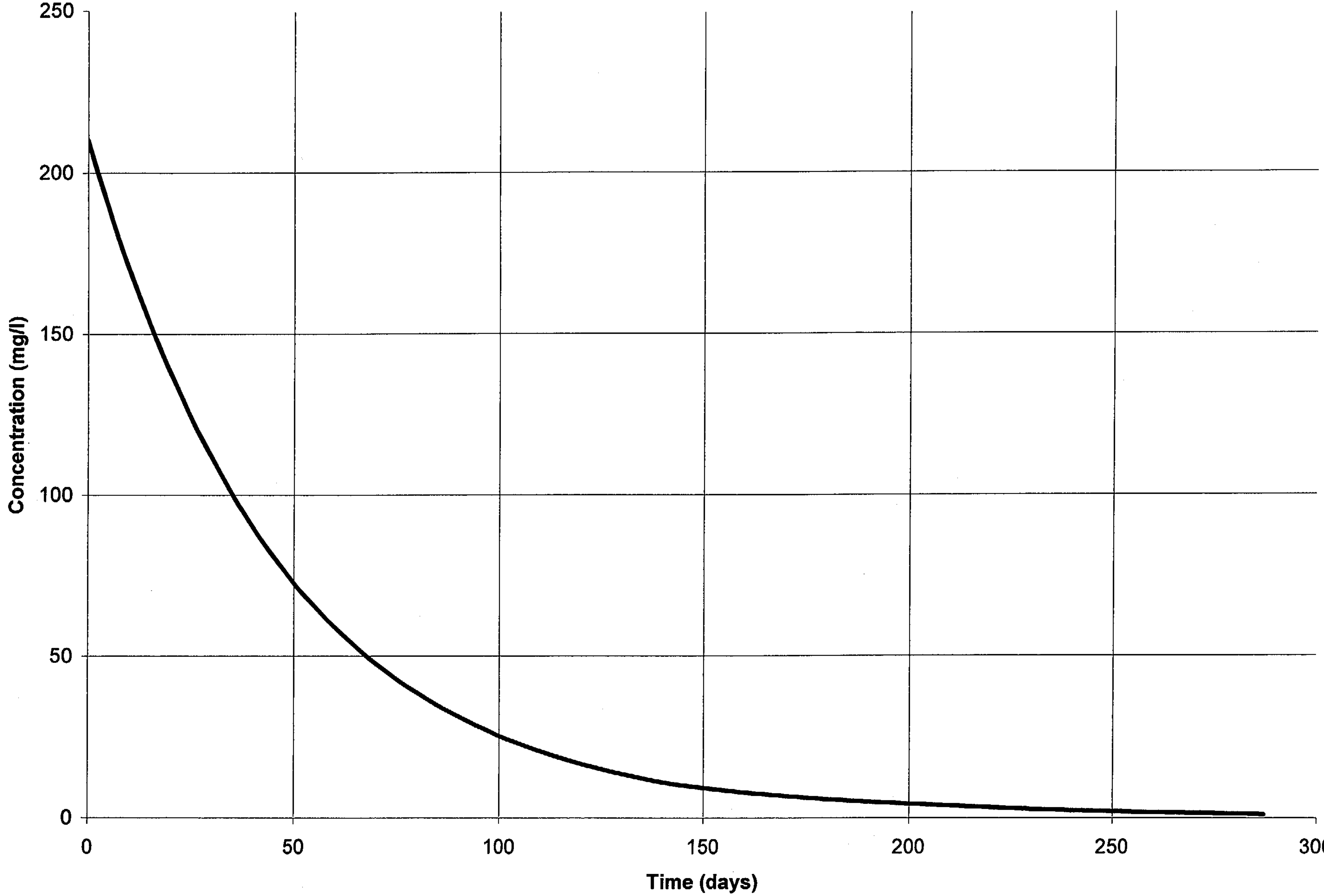


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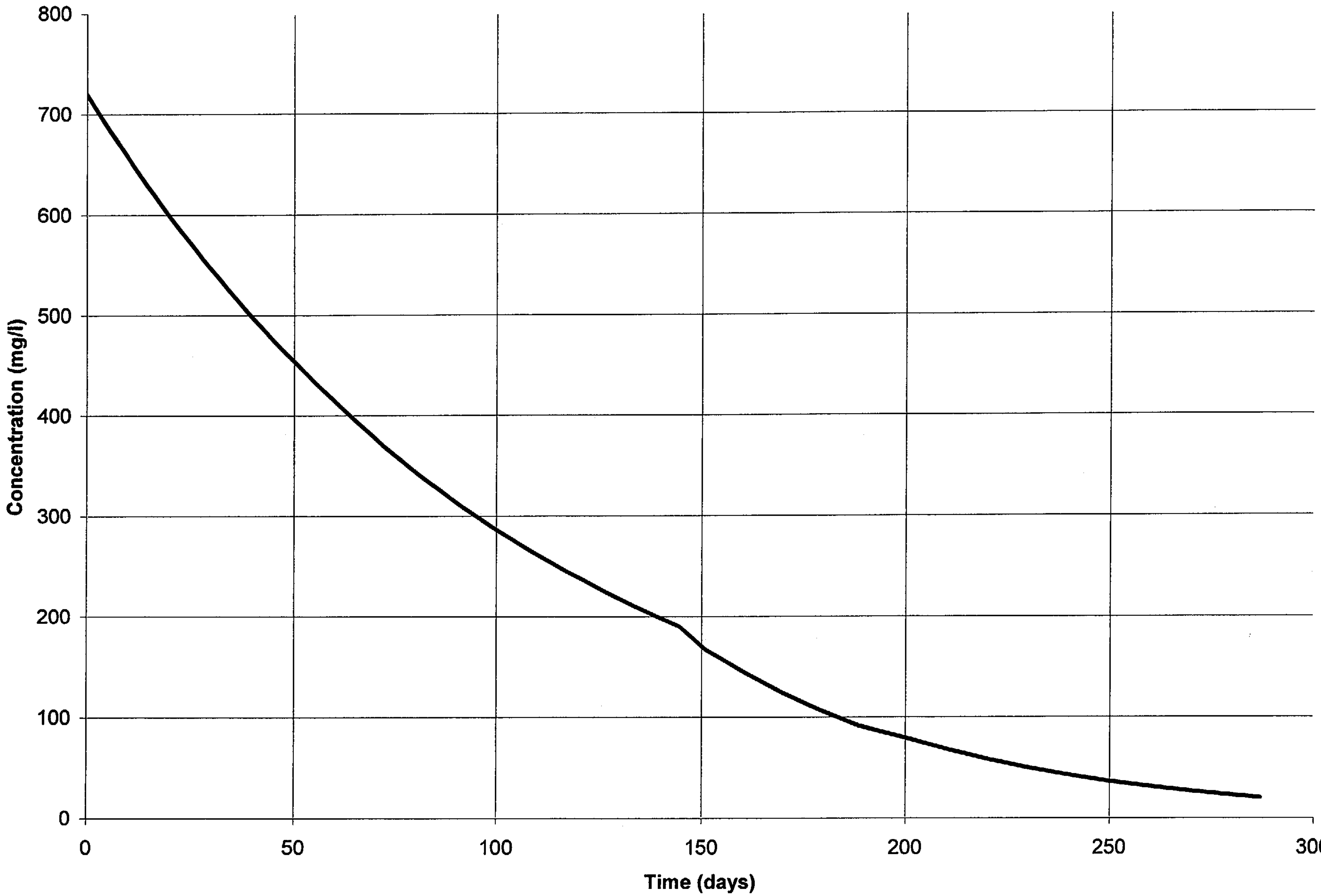
Figure 3-12. Simulated chloride restoration curve, commercial Wellfield 1

Date:	9/14/99
Project:	RAMC Wellfield Evaluation
File:	land.ppt



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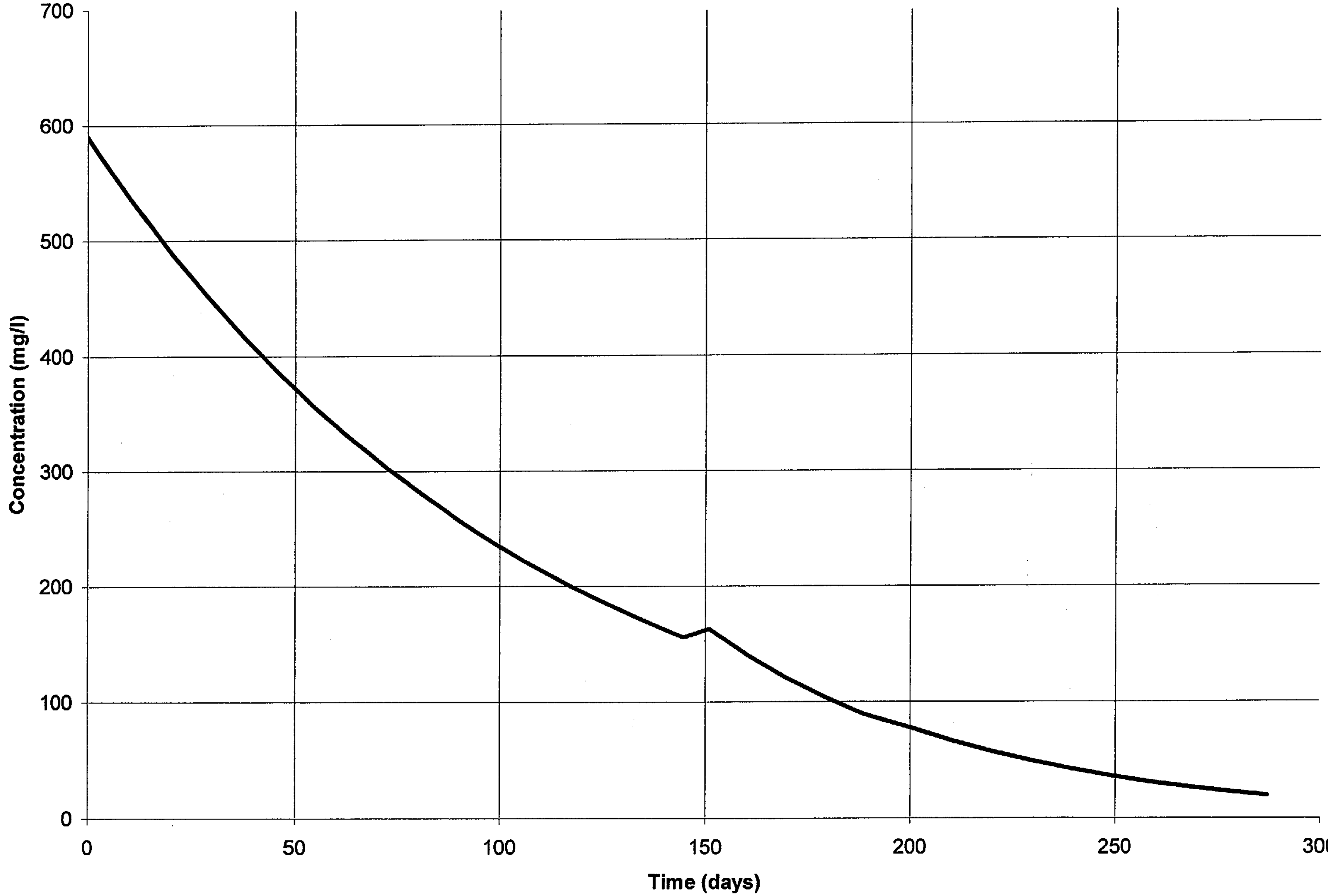
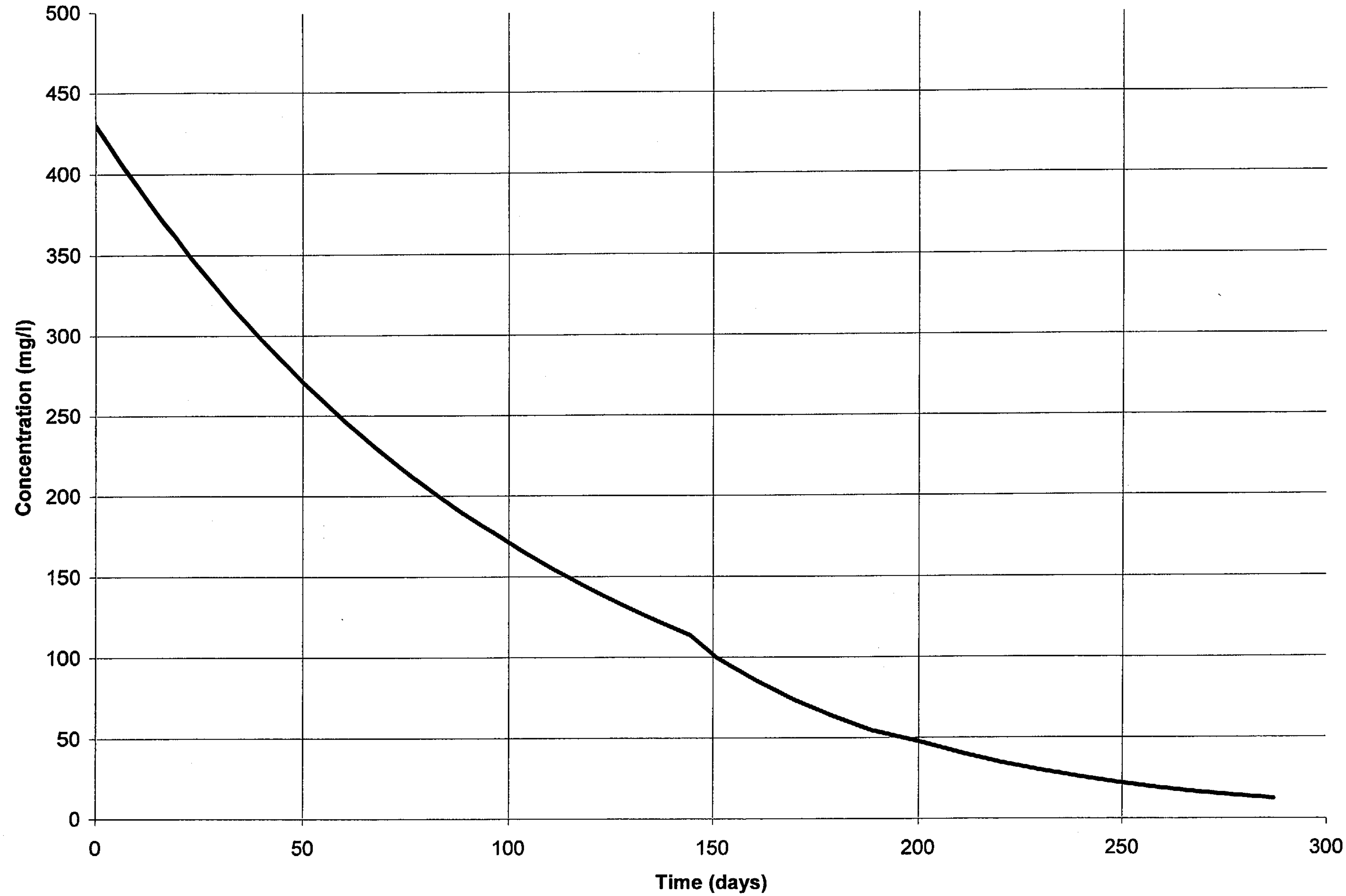
RAMC Smith Ranch Facility

Figure 3-13. Simulated sulfate restoration curve, commercial Wellfield 1

Date:	9/14/99
Project:	RAMC Wellfield Evaluation
File:	land.ppt



Lewis Water Consultants Environmental Science/Engineering/Modeling	**RAMC Smith Ranch Facility** Figure 3-14. Simulated bicarbonate restoration curve, commercial Wellfield 1	Date: 9/14/99 Project: RAMC Wellfield Evaluation File: land.ppt



Lewis Water Consultants *Environmental Science/Engineering/Modeling*	**RAMC Smith Ranch Facility** Figure 3-15. Simulated calcium restoration curve, commercial Wellfield 1	Date: **9/14/99** Project: **RAMC Wellfield Evaluation** File: **land.ppt**

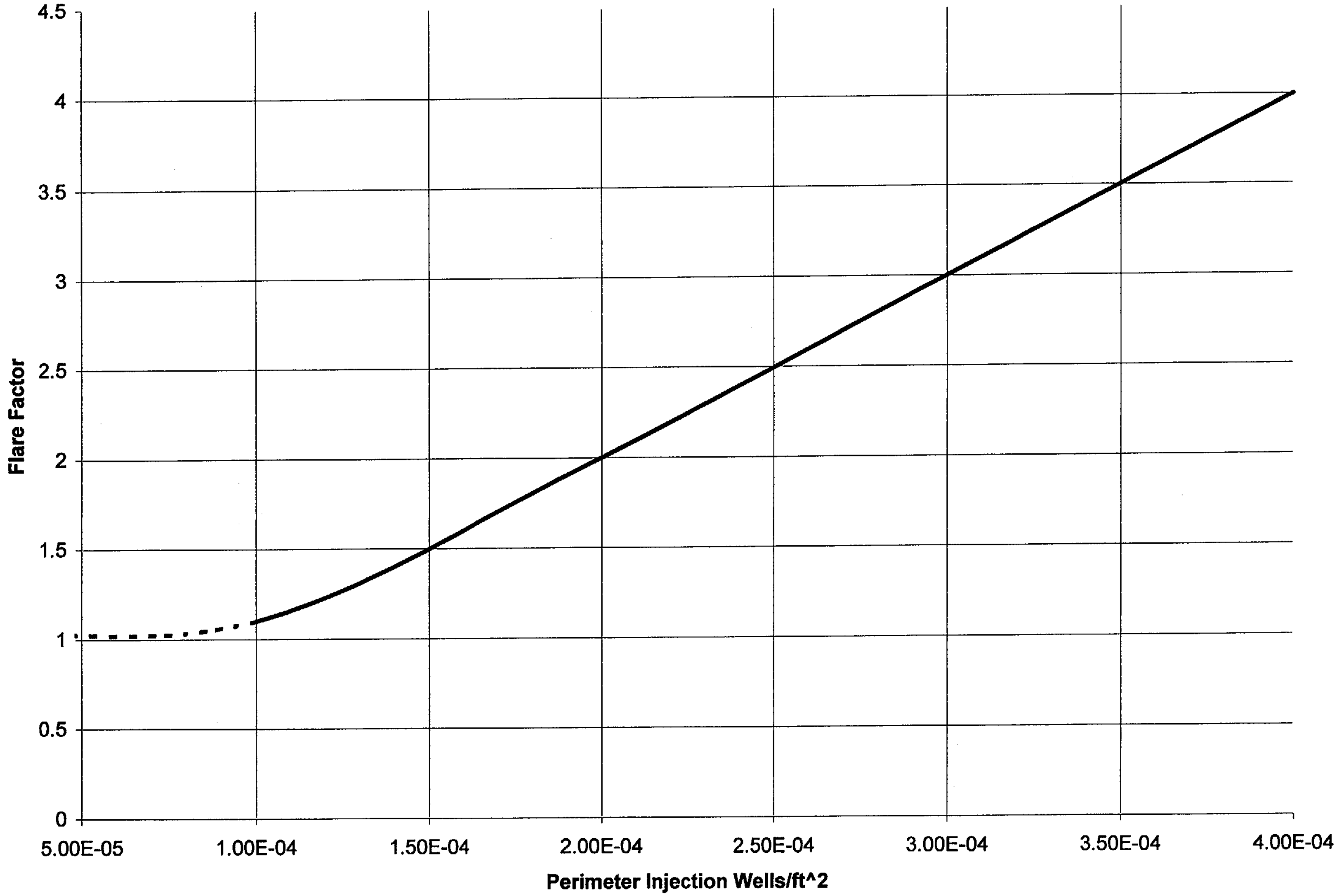


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Figure 3-16. Predicted wellfield flare factor for RAMC commercial wellfields, as a function of wellfield scale

Date:	9/14/99
Project:	RAMC Wellfield Evaluation
File:	land.ppt

4.0 REVIEW OF WDEQ/LQD METHODOLOGY

LWC has reviewed the basic technical approach adopted by the WDEQ/LQD to estimate affected aquifer pore volumes. Correspondence between WDEQ/LQD and RAMC was reviewed, as well as a WDEQ/LQD memorandum concerning pore volume estimates at PRI's Highland facility. Correspondence between WDEQ/LQD and RAMC indicates that LQD has conducted limited modeling of the Smith Ranch wellfield(s), and has used this work to estimate affected pore volumes and bonding requirements for RAMC. Unfortunately, this modeling work has not been made available for review to RAMC or its consultants. Despite this limitation, it is RAMC's understanding that the same basic methodology used to evaluate the Highland facility has been applied to evaluate the Smith Ranch wellfields. Therefore, the following review is believed to be representative of LQD's methodology as applied to the Smith Ranch facility.

The following are significant technical issues and limitations identified during the review of the WDEQ/LQD methodology:

- the WDEQ/LQD has based flare factor estimates upon small-scale flow modeling of ideal pattern geometries and sub-areas of large-scale wellfields. Sensitivity analyses presented in this document clearly demonstrate that wellfield flare decreases substantially with increasing scale. In the opinion of LWC, flare factors developed by WDEQ/LQD are overestimated due (in part) to the small-scale nature of the modeling. In addition, large, rectangular, and continuous wellfields (e.g. Wellfield 3) will have lower flare factors than thin, elongate, and discontinuous wellfields (such as those modeled at PRI), all other factors being equal.

- the WDEQ/LQD methodology is based entirely upon the prediction of the affected pore volume; the number of pore volumes required to restore the wellfield has not been critically evaluated. This report documents that pore volume requirements at the RAMC facility (and probably other facilities) are significantly lower than previously estimated.

- the WDEQ/LQD methodology does not consider the effect of reducing agents and RO permeate in reducing wellfield restoration time (and cost). This report documents the substantial decrease in pore volume requirements observed due to the use of reducing agents and RO injection.

- wellfield flare factors were estimated by LQD by plotting velocity vectors generated from the flow model simulator (Visual MODFLOW). This procedure is subject to significant over-estimation of wellfield flare due to the non-continuous nature of the velocity plots and the professional judgement required to interpret the results. The more accurate and technically defensible methodology involves transient particle tracking using a program such as MODPATH or PATH3D.

- The statement by WDEQ/LQD that "MODPATH is limited to steady-state conditions" (page 8, LQD's June 1996 Highland facility memorandum) is incorrect - more current versions readily incorporate transient pathline analysis. In addition, older versions of MODPATH can be used to conduct transient particle tracing using steady-state results from the groundwater flow model. Constant-discharge, transient flow simulations conducted over extended periods of time (e.g. years) have no technical advantage over steady-state simulations. Psuedo-steady flow is achieved within weeks or months of continuous wellfield operation.

- LQD has presented pore volume requirements for RAMC's Wellfield 1 containing large vertical flare factors (e.g. 1.0). Analyses conducted as part of this document suggest that such large vertical flare factors can only be obtained if the ratio of Kh/Kv is assumed to be near 1:1. Given the depositional environment and observed presence of claystone/lignite in typical Q-sand sections, such a high Kh/Kv ratio cannot be supported. Furthermore, geophysical logs obtained from post-coring pilot operations indicate that mining solutions have not migrated vertically beyond the production interval (conductivity profiles show absence of significant TDS in the barren zone relative to the production interval). Calculations presented in this document suggest a more realistic estimate of the Kh/Kv ratio is 100:1.

5.0 SUMMARY AND CONCLUSIONS

RAMC has completed a detailed evaluation and simulation of commercial wellfield restoration at the Smith Ranch facility. Previous estimates of wellfield restoration conducted by WDEQ/LQD have relied solely on estimates of affected pore volume (flare factor) derived from results of limited, small-scale groundwater flow modeling. RAMC believes that flare factors developed by WDEQ/LQD have been over-estimated due to 1) the small-scale nature of the flow modeling, 2) the methodology employed to estimate the flare factor (plotting of velocity vectors), and 3) inappropriate assumptions used to calculate the vertical flare. Further, the WDEQ/LQD methodology does not consider all factors necessary to estimate wellfield restoration with reasonable accuracy. In contrast, RAMC's evaluation includes a detailed examination of all factors affecting wellfield restoration timing (and cost), including:

- pore volume flushing requirements for RAMCs commercial wellfield(s)
- the affect of reducing agents and RO treatment on wellfield restoration
- the affected pore volume size as computed by full-scale simulation of a commercial wellfield, and
- the sensitivity of the flare factor to wellfield scale (and other parameters)

Results of this work can be used to establish reliable estimates of restoration timing and cost for all of RAMCs commercial wellfields. Given these results, wellfield restoration at the Smith Ranch facility can be accomplished well within original time and cost estimates. Based on these findings, there is no technical basis to support an increase in bonding requirements as proposed by WDEQ/LQD.

6.0 REFERENCES

Isaaks, E. H., and Srivastava, R. M. (1989). An Introduction to Applied Geostatistics, Oxford University Press, New York, 561 pp.

McDonald, M.G., and Harbaugh, A.W. (1988). A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, U.S. Geological Survey Techniques of Water Resources Investigations, Book 6, 586 pp.

Nelson, R.W. (1978). Evaluating the environmental consequences of groundwater contamination, 1: an overview of contaminant arrival distributions and general evaluation requirements, *Water Resources Research*, vol. 14, no. 3, pp. 409-415.

Pollock, D.W. (1989). Documentation of Computer Programs to Compute and Display Pathlines Using Results from the U.S. Geological Survey Modular Three-Dimensional Finite-Difference Ground-Water Model, U.S. Geological Survey Open-File Report 89-381.

Parkhurst, D. L. (1995). User's Guide to PHREEQ - A computer program for speciation, reaction-path, advective-transport, and inverse geochemical calculations. U.S. Geological Survey Water Resources Investigation Report 95-4227.

Prickett, T.A., Naymik, T. G., and Lonnquist, C.G. (1981). A "Random Walk" Solute Transport Model for Selected Groundwater Quality Evaluations, Illinois State Water Survey, Bulletin No. 65, 103pp.

Zheng, C., Bennett, G.D., and Andrews, C.B. (1991). Analysis of ground-water remedial alternatives at a Superfund site, *Groundwater*, vol. 29, no. 6, pp.838-848.

Zheng, C., Bennett, G.D., and Andrews, C.B. (1992). Reply to discussion of "Analysis of ground-water remedial alternatives at a Superfund site", *Groundwater*, vol. 30, no. 3, pp. 440-442.

Attachment A

PHREEQC Model Description and Application

ATTACHMENT A – PHREEQC MODEL DESCRIPTION AND APPLICATION

The equilibrium geochemical code PHREEQC (Parkhurst 1995) was used to simulate ground water quality in Wellfield 1 during future aquifer restoration. This attachment provides supporting documentation and describes the assumptions used in the modeling.

PHREEQC is a widely used code developed and supported by the U.S. Geological Survey. Version 1.6 of the model, released on 1/16/97, was used. PHREEQC calculates the speciation of constituents in solutions, performs mixing of solutions, identifies solid phases that are oversaturated and thus thermodynamically able to precipitate, and removes constituents from solution as solids in the phases specified by the user, among other capabilities. PHREEQC is an equilibrium model and thus may not adequately simulate reactions with slow rates, but is useful for identifying and quantifying reactions likely to control dissolved concentrations of key constituents.

ASSUMPTIONS USED FOR SMITH RANCH SIMULATIONS

The first three pore volumes of ground water restoration using ground water sweep were simulated using the mixed linear reservoir model for U, Cl, SO4, HCO3, Se, Ca, and Mn as described in the report. PHREEQC was used for the fourth through sixth pore volumes for these constituents, and for the entire restoration period for all other constituents.

Injected water (or baseline water for the first three pore volumes) was mixed with the water from the preceding step of the simulation in a 20:80 ratio to provide smooth interim concentrations for graphing. Other mixing ratios were also investigated, but did not significantly affect the model predictions. The permeate from reverse osmosis (RO) water treatment was mixed with extracted water from the preceding step in 70:30 ratio for pore volumes 4 through 6, as specified in the restoration plan, to prevent excessive leaching of aquifer solids by pure permeate. During the fourth pore volume (steps 3.2 through 4.0) H_2S was added to the injection water at a sulfide concentration of 250 mg/L to cause the reduction of uranium and other redox-sensitive species to their more reduced, less soluble forms.

The PHREEQC simulations were run using the thermodynamic database from the equilibrium speciation model WATEQ4F (Ball and Nordstrom, 1991). The WATEQ4F database includes data for U, As, and Se, which are not in the PHREEQC database, and is fully compatible with PHREEQC.

MINERALS SELECTED AS SOLUBILITY CONTROLS

Because it is known from pilot test core studies that uranium minerals will still be present at the beginning of wellfield restoration, uraninite (the assumed predominant uranium mineral in the ore) was specified as present in the system. Pyrite (FeS_2), native selenium, and orpiment (As_2S_3) were allowed to precipitate if supersaturation was reached, thus controlling the dissolved concentrations of Fe, S, Se, and As. While orpiment most commonly forms under hydrothermal conditions, it may form in the aquifer after the addition of a reductant.

Desorption from mineral surfaces, which may occur during aquifer restoration, could not be simulated by PREEQC due to the lack of data on aquifer solids chemistry. PHREEQC therefore predicted conservative behavior for those constituents not constrained by mineral solubility and redox controls. Therefore, the behavior of key constituents during the first three pore volumes (groundwater sweep) were more appropriately simulated by the mixed linear reservoir (MLR) model, which accounted for desorption through the use of the constituent retardation factor.

MODEL RESULTS

The input file generated for simulation of restoration in pore volumes 1 through 3 is included as Appendix A-1, and for pore volumes 4 through 6 is included as Appendix A-2. Tabulated concentrations for the modeled constituents are presented in Table A-1 for constituents not simulated by the MLR model, and in Table A-2 for pore volumes 4-6 (all constituents). Graphs of key constituents are presented in the text of the report.

The sensitivity of PHREEQC predictions to variations in baseline water redox conditions and added sulfide concentration were assessed. Varying the input p_e did not significantly affect the predicted speciation and solubilities. Varying the added sulfide concentration indicated that the concentrations of uranium, selenium, and arsenic could potentially be decreased using a lower sulfide concentration. Bench-scale tests would be required to determine the optimal concentration.

REFERENCES

Ball, J.W. and Nordstrom, D.K., 1991, WATEQ4F--User's manual with revised thermodynamic data base and test cases for calculating speciation of major, trace and redox elements in natural waters: U.S. Geological Survey Open-File Report 90-129, 185 p.

Parkhurst, D. L. (1995). User's Guide to PHREEQ - A computer program for speciation, reaction-path, advective-transport, and inverse geochemical calculations. U.S. Geological Survey Water Resources Investigation Report 95-4227.

APPENDIX A-1. INPUT FILE FOR PHREEQC SIMULATIONS, PORE VOLUMES 1 THROUGH 3

```
#
#SIMULATION FOR PV 1 TO 3 RESTORATION OF WELLFIELD 1 AFTER MINING
#
#
SOLUTION 1 #End of mining  Water Chemistry
        units   mg/l
        pH      6.15
        temp    17
        pe      7
        redox   pe
            density     1.0
        Alkalinity     484   mg/l     as CaCO3
        Ca      430     mg/l
        Mg       90     mg/l
        Na       41     mg/l
        K        18     mg/l
        S(6)    720     mg/l
        S(-2)   0.001   mg/l
        Cl      210     mg/l
        Si      27.2    mg/l
        F       0.16    mg/l
        Fe      0.05    mg/l
        Mn      0.31    mg/l
        B       0.12    mg/l
        Zn      0.05    mg/l
        As      0.006   mg/l
        Se      0.092   mg/l
        U       15      mg/l
END
SOLUTION 2 #Baseline Water Chemistry
        units   mg/l
        pH      7.37
        temp    17
        pe      -0.5   # estimated.
        redox  pe
            density     1.0
        Alkalinity      185.9    mg/l     as CaCO3
        Ca      72.6    mg/l
        Mg      17.4    mg/l
        Na      22.5    mg/l
        K       7.3     mg/l
        S(6)    113.1   mg/l
        S(-2)   0.001   mg/l
        Cl      4.176   mg/l
        Si      17.0    mg/l
        F       0.322   mg/l
        Fe      0.065   mg/l
        Se      0.001   mg/l
        Mn      0.021   mg/l
        B       0.100   mg/l
        Zn      0.01    mg/l
        As      0.001   mg/l
        U       0.065   mg/l
END
#
```

```
#Simulation of the three pore volume sweep
#Mix the post mining water in the aquifer
#with 0.2 PV volumes of the baseline sweep water
#until three pore volumes of the sweep water are mixed.
#Save solution after each mixing stage, and use the
#saved solution in the next mixing stage. Each mixing stage
#includes uraninite as an equilibrium phase and allows
#pyrite and orpiment to precipitate if thermodynamically possible.
#Remaining amount of the solids is saved after
#each mixing stage and used in the next stage
#
MIX 1
        1       0.8
        2       0.2
EQUILIBRIUM_PHASES 1
        Uraninite(C)  0.0     0.4
        Pyrite        0.0     0.0
        Orpiment      0.0     0.0
Save solution 3
Save equilibrium_phases 1
END
MIX 2
        3       0.8
        2       0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 4
End
MIX 3
        4       0.8
        2       0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 5
End
MIX 4
        5       0.8
        2       0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 6
End
MIX 5
        6       0.8
        2       0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 7
End
MIX 6
        7       0.8
        2       0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 8
End
MIX 7
```

```
        8        0.8
        2        0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 9
End
MIX 8
        9        0.8
        2        0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 10
End
MIX 9
        10       0.8
         2       0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 11
End
MIX 10
        11       0.8
         2       0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 12
End
MIX 11
        12       0.8
         2       0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 13
End
MIX 12
        13       0.8
         2       0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 14
End
MIX 13
        14       0.8
         2       0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 15
End
MIX 14
        15       0.8
         2       0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 16
End
MIX 15
        16       0.8
```

```
         2        0.2
USE equilibrium_phases 1
Save equilibrium_phases 1
SAVE solution 17
End
```

Table A-1. PHREEQC results for pore volumes 1 through 3, constituents not simulated using MLR

Pore Volume	Mg	Na	K	Si	As	B	F	Fe	Zn
0.0	90.1	41.1	18.0	27.2	0.0060	0.120	0.160	0.050	0.050
0.2	75.6	37.4	15.9	25.2	0.0050	0.116	0.193	0.053	0.042
0.4	64.0	34.4	14.2	23.6	0.0042	0.113	0.219	0.055	0.036
0.6	54.7	32.0	12.8	22.2	0.0036	0.110	0.239	0.057	0.031
0.8	47.2	30.1	11.7	21.2	0.0031	0.108	0.256	0.059	0.026
1.0	41.2	28.6	10.8	20.4	0.0026	0.107	0.269	0.060	0.023
1.2	36.5	27.4	10.1	19.7	0.0023	0.105	0.280	0.061	0.021
1.4	32.7	26.4	9.6	19.2	0.0021	0.104	0.288	0.062	0.018
1.6	29.6	25.6	9.1	18.8	0.0018	0.103	0.295	0.063	0.017
1.8	27.2	25.0	8.7	18.4	0.0017	0.103	0.300	0.063	0.015
2.0	25.2	24.5	8.5	18.1	0.0015	0.102	0.305	0.064	0.014
2.2	23.7	24.1	8.2	17.9	0.0014	0.102	0.308	0.064	0.013
2.4	22.4	23.8	8.0	17.7	0.0013	0.101	0.311	0.064	0.013
2.6	21.4	23.5	7.9	17.6	0.0013	0.101	0.313	0.064	0.012
2.8	20.6	23.3	7.8	17.5	0.0012	0.101	0.315	0.065	0.012
3.0	20.0	23.2	7.7	17.4	0.0012	0.101	0.317	0.065	0.011

APPENDIX A-2. INPUT FILE FOR PHREEQC SIMULATIONS, PORE VOLUMES 4 THROUGH 6

```
#
# SIMULATION FOR RESTORATION OF THE AQUIFER AFTER MINING
# AND AFTER SWEEPING WITH 3 PORE VOLUMES OF NATIVE (BASELINE)
# GROUND WATER
#
SOLUTION 1 #Chemistry of water at end of 3PV ground water sweep
        units    mg/l
        pH       7.04
        temp     17
        pe       1.8
        redox    pe
            density     1.0
        Alkalinity  159  mg/l     as HCO3
        Ca       116      mg/l
        Mg       19.96    mg/l
        Na       23.17    mg/l
        K        7.68     mg/l
        S(6)     194      mg/l    as SO4
        S(-2)    0.001    mg/l
        Cl       10.4     mg/l
        Si       17.4     mg/l
        F        0.32     mg/l
        Fe       0.065    mg/l
        Mn       0.059    mg/l
        B        0.101    mg/l
        Zn       0.011    mg/l
        As       0.001    mg/l
        Se       0.0047   mg/l
        U        2.29     mg/l
END
#
#Making blend of RO permeate and extracted ground water
#at end of 3PV at 70:30 ratio
#
SOLUTION 2 # RO permeate (assume pure water)
        units    mg/l
        temp     20
        pH       7
        pe       4
MIX 1
        2        0.7
        1        0.3
SAVE Solution 3  #Blend of RO permeate and Starting Solution At 3PV
END
#
#Making reductant solution using solution 3
#
USE solution 3
REACTION 1
      H2S  1.0
      0.0078 moles
SAVE Solution 4 #Solution with 250 mg/L sulfide.
END
#
#Introduce reductant to wellfield after 3.0PV
```

```
#
MIX 2            #Mixture at 3.2 PV of restoration process
     1            0.8   #Starting Solution, water after 3PV sweep
     4            0.2
EQUILIBRIUM_PHASES 1
        Uraninite(C)     0.0      0.4
        Pyrite           0.0      0.0
        Se(s)            0.0      0.0
        Orpiment         0.0      0.0
Save equilibrium_phases 1
Save solution 5      #solution after 3.2PV mixing
END
#
#
#
#Making blend of RO and Water @ end of 3.2PV at 70:30 ratio
MIX 3
        2       0.7
        5       0.3
SAVE Solution 6   #Blend of RO permeate and solution after 3.2PV mixing
END
#Making reductant solution Using Solution 6
USE solution 6
REACTION 1
      H2S  1.0
      0.0078 moles
SAVE Solution 7    #Solution with 250 mg/L S-2.
END
#Introduce reductant in Solution 5
MIX 4            # Mixture at 3.4PV
     5            0.8   #Solution After 3.2PV mixing.
     7            0.2
USE equilibrium_phases 1
Save solution 8
Save equilibrium_phases 1
END
#
#
#Making blend of RO and Water @ end of 3.4PV at 70:30 ratio
MIX 5
        2       0.7
        8       0.3
SAVE Solution 9  #Blend of RO permeate and solution after 3.4PV mixing
END
#Making reductant solution using solution 9
USE solution 9
REACTION 1
      H2S  1.0
      0.0078 moles
SAVE Solution 10  #Solution with 250 mg/L S-2.
END
#Introduce reductant in Solution 8
MIX 6            # Mixture at 3.6PV
     8            0.8   #Solution After 3.4PV mixing.
     10           0.2
USE equilibrium_phases 1
Save solution 11
```

```
Save equilibrium_phases 1
END
#
#
#Making blend of RO and Water @ end of 3.4PV at 70:30 ratio
MIX 7
        2       0.7
        11       0.3
SAVE Solution 12  #Blend of RO permeate and solution after 3.6PV mixing
END
#Making reductant solution Using Solution 12
USE solution 12
REACTION 1
      H2S  1.0
      0.0078 moles
SAVE Solution 13   #Solution with 250 mg/L S-2.
END
#Introduce reductant in Solution 11
MIX 8            # Mixture at 3.8PV
     11            0.8   #Solution After 3.6PV mixing.
     13           0.2
USE equilibrium_phases 1
Save solution 14
Save equilibrium_phases 1
END
#
#
#Making blend of RO and Water @ end of 3.8PV at 70:30 ratio
MIX 9
        2       0.7
        14       0.3
SAVE Solution 15  #Blend of RO permeate and solution after 3.8PV mixing
END
#Making reductant solution Using Solution 15
USE solution 15
REACTION 1
      H2S  1.0
      0.0078 moles
SAVE Solution 16   #Solution with 250 mg/L S-2.
END
#Introduce reductant in Solution 14
MIX 10           # Mixture at 4.0PV
     14           0.8   #Solution After 3.8PV mixing.
     16           0.2
USE equilibrium_phases 1
Save solution 17
Save equilibrium_phases 1
END
#
#
#Last 2.0 PV sweep of RO/Restoration Water - blend
#Making blend of RO and Water @ end of 4.0PV at 70:30 ratio
MIX 11
        2       0.7
        17       0.3
SAVE Solution 18  #Blend of RO permeate and solution after 4.0PV mixing
END
```

```
#
#Introduce Blend into Aquifer Solution 17
#
MIX 12           # Mixture at 4.2PV
     17           0.8   #Solution After 4.0PV mixing.
     18          0.2
USE equilibrium_phases 1
Save solution 19
Save equilibrium_phases 1
END
#
#Making blend of RO and Water @ end of 4.2PV at 70:30 ratio
MIX 13
        2       0.7
        19       0.3
SAVE Solution 20  #Blend of RO permeate and solution after 4.2PV mixing
END
#Introduce Blend into Aquifer Solution 19
MIX 14           # Mixture at 4.4PV
     19           0.8   #Solution After 4.2PV mixing.
     20          0.2
USE equilibrium_phases 1
Save solution 21
Save equilibrium_phases 1
END
#
#
#Making blend of RO and Water @ end of 4.4PV at 70:30 ratio
MIX 15
        2       0.7
        21       0.3
SAVE Solution 22  #Blend of RO permeate and solution after 4.4PV mixing
END
#Introduce Blend into Aquifer Solution 21
MIX 16           # Mixture at 4.6PV
     21           0.8   #Solution After 4.4PV mixing.
     22           0.2
USE equilibrium_phases 1
Save solution 23
Save equilibrium_phases 1
END
#
#
#Making blend of RO and Water @ end of 4.6PV at 70:30 ratio
MIX 17
        2       0.7
        23       0.3
SAVE Solution 24  #Blend of RO permeate and solution after 4.6PV mixing
END
#Introduce Blend into Aquifer Solution 23
MIX 18           # Mixture at 4.8PV
     23           0.8   #Solution After 4.6PV mixing.
     24           0.2
USE equilibrium_phases 1
Save solution 25
Save equilibrium_phases 1
END
```

```
#
#
#Making blend of RO and Water @ end of 4.8PV at 70:30 ratio
MIX 19
        2       0.7
        25       0.3
SAVE Solution 26  #Blend of RO permeate and solution after 4.8PV mixing
END
#Introduce Blend into Aquifer Solution 25
MIX 20          # Mixture at 5.0PV
     25          0.8   #Solution After 4.8PV mixing.
     26          0.2
USE equilibrium_phases 1
Save solution 27
Save equilibrium_phases 1
END
#
#
#Making blend of RO and Water @ end of 5.0PV at 70:30 ratio
MIX 21
        2       0.7
        27      0.3
SAVE Solution 28  #Blend of RO permeate and solution after 5.0PV mixing
END
#Introduce Blend into Aquifer Solution 27
MIX 22           # Mixture at 5.2PV
     27          0.8   #Solution After 5.0PV mixing.
     28          0.2
USE equilibrium_phases 1
Save solution 29
Save equilibrium_phases 1
END
#
#
#Making blend of RO and Water @ end of 5.2PV at 70:30 ratio
MIX 23
        2       0.7
        29      0.3
SAVE Solution 30  #Blend of RO permeate and solution after 5.2PV mixing
END
#Introduce Blend into Aquifer Solution 29
MIX 24          # Mixture at 5.4PV
     29          0.8   #Solution After 5.2PV mixing.
     30          0.2
USE equilibrium_phases 1
Save solution 31
Save equilibrium_phases 1
END
#
#
#Making blend of RO and Water @ end of 5.2PV at 70:30 ratio
MIX 25
        2       0.7
        31      0.3
SAVE Solution 32  #Blend of RO permeate and solution after 5.4PV mixing
END
#Introduce Blend into Aquifer Solution 31
```

```
MIX 26          # Mixture at 5.6PV
     31         0.8   #Solution After 5.4PV mixing.
     32         0.2
USE equilibrium_phases 1
Save solution 33
Save equilibrium_phases 1
END
#
#
#Making blend of RO and Water @ end of 5.2PV at 70:30 ratio
MIX 27
        2       0.7
        33      0.3
SAVE Solution 34  #Blend of RO permeate and solution after 5.6PV mixing
END
#Introduce Blend into Aquifer Solution 33
MIX 28          # Mixture at 5.8PV
     33         0.8   #Solution After 5.6PV mixing.
     34         0.2
USE equilibrium_phases 1
Save solution 35
Save equilibrium_phases 1
END
#
#
#Making blend of RO and Water @ end of 5.2PV at 70:30 ratio
MIX 29
        2       0.7
        35      0.3
SAVE Solution 36  #Blend of RO permeate and solution after 5.8PV mixing
END
#Introduce Blend into Aquifer Solution 35
MIX 30          # Mixture at 6.0PV
     35         0.8   #Solution After 5.8PV mixing.
     36         0.2
USE equilibrium_phases 1
Save solution 37
Save equilibrium_phases 1
END
```

Table A-2. PHREEQC results for pore volumes 4 through 6, wellfield 1 restoration

PVs	HCO3	As	B	Ca	Cl	F	Fe	K	Mg	Mn	Na	S(-2)	SO4	Se	Si	U	Zn
3.0	159.1	1.00E-03	0.1011	116.1	10.40	0.320	0.065	7.68	19.97	0.0591	23.17	0.001	194.1	4.70E-03	17.40	2.2913	0.0110
3.2	162.5	4.09E-12	0.0869	99.8	8.95	0.275	7.68E-13	6.61	17.17	0.0508	19.94	50.0	167.2	1.29E-13	15.00	9.20E-09	0.0095
3.4	139.8	1.46E-12	0.0747	85.8	7.70	0.237	8.23E-13	5.68	14.77	0.0437	17.15	93.0	144.1	8.65E-14	12.86	9.35E-09	0.0081
3.6	120.3	8.61E-13	0.0643	73.8	6.62	0.204	8.48E-13	4.89	12.70	0.0376	14.75	129.9	123.9	6.38E-14	11.06	9.50E-09	0.0070
3.8	103.4	6.17E-13	0.0553	63.5	5.69	0.175	8.59E-13	4.20	10.92	0.0323	12.68	161.9	106.6	4.92E-14	9.50	9.64E-09	0.0060
4.0	88.9	4.90E-13	0.0475	54.6	4.90	0.151	8.61E-13	3.61	9.39	0.0278	10.91	189.2	91.5	3.90E-14	8.17	9.77E-09	0.0052
4.2	76.4	6.38E-13	0.0409	47.0	4.21	0.130	8.75E-13	3.11	8.08	0.0239	9.38	162.6	78.6	3.92E-14	7.03	9.84E-09	0.0045
4.4	65.8	8.28E-13	0.0352	40.4	3.62	0.111	8.87E-13	2.67	6.95	0.0205	8.06	139.9	67.6	3.94E-14	6.49	9.90E-09	0.0038
4.6	56.6	1.07E-12	0.0302	34.7	3.11	0.096	8.97E-13	2.30	5.97	0.0177	6.94	120.3	58.1	3.96E-14	5.21	9.95E-09	0.0033
4.8	48.6	1.37E-12	0.0260	29.9	2.68	0.082	9.07E-13	1.98	5.14	0.0152	5.97	103.5	50.0	3.97E-14	4.48	1.00E-08	0.0028
5.0	41.8	1.76E-12	0.0224	25.7	2.30	0.071	9.16E-13	1.70	4.42	0.0131	5.13	89.0	43.0	3.98E-14	3.85	1.00E-08	0.0024
5.2	36.0	2.25E-12	0.0192	22.1	1.98	0.061	9.26E-13	1.46	3.80	0.0112	4.41	76.5	37.0	3.99E-14	3.32	1.01E-08	0.0021
5.4	30.9	2.86E-12	0.0165	19.0	1.70	0.052	9.36E-13	1.26	3.27	0.0097	3.79	65.8	31.8	3.99E-14	2.85	1.01E-08	0.0018
5.6	26.6	3.64E-12	0.0142	16.3	1.46	0.045	9.47E-13	1.08	2.81	0.0083	3.26	56.6	27.4	4.00E-14	2.45	1.01E-08	0.0015
5.8	22.9	4.62E-12	0.0122	14.1	1.26	0.039	9.60E-13	0.93	2.42	0.0071	2.81	48.7	23.5	4.00E-14	2.11	1.01E-08	0.0013
6.0	19.7	5.85E-12	0.0105	12.1	1.08	0.033	9.76E-13	0.80	2.08	0.0061	2.41	41.8	20.3	4.00E-14	1.82	1.02E-08	0.0011

Attachment B

Flare Factor Sensitivity Results

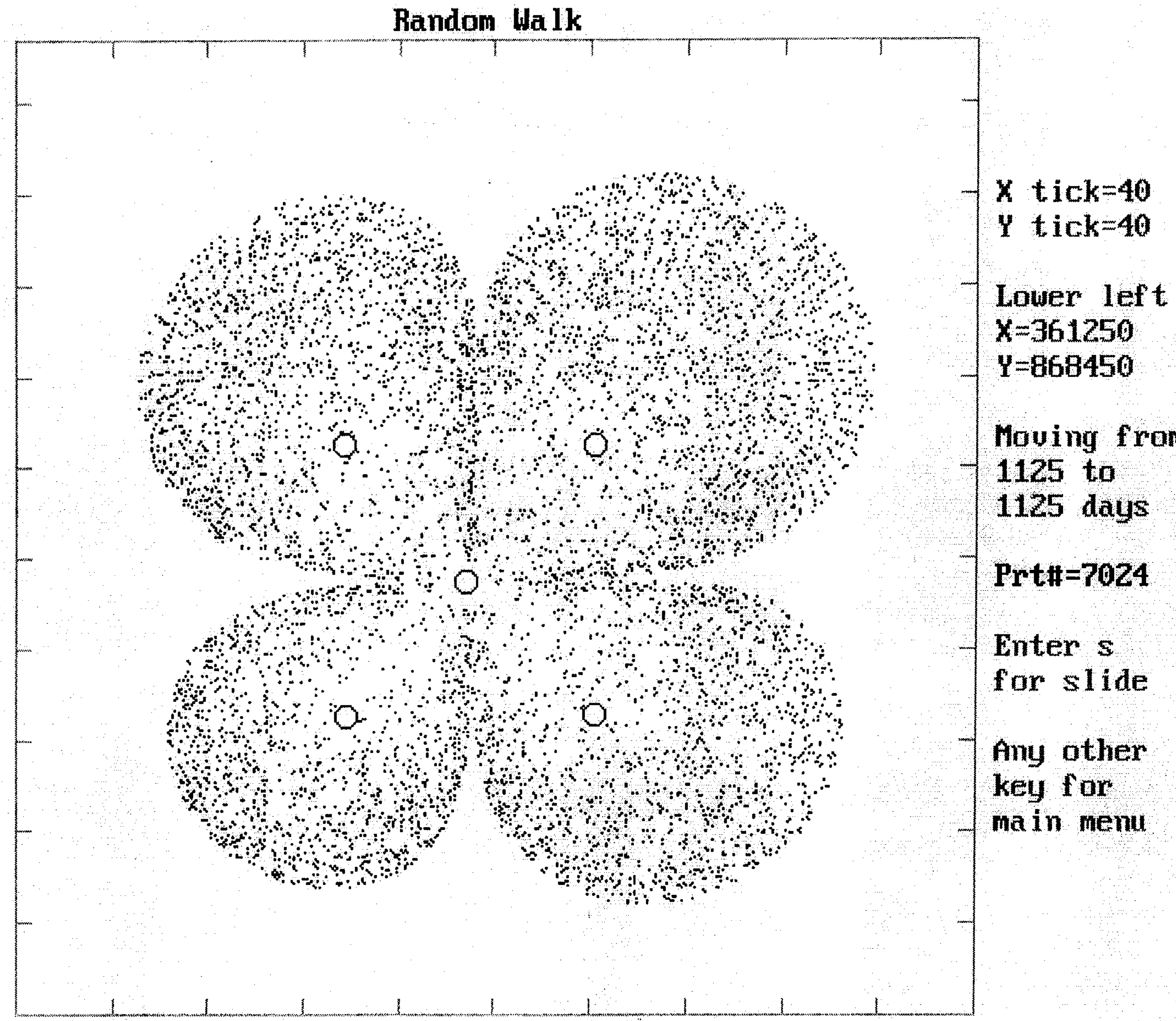

Figure B-1. Single 5-spot pattern advective particle cloud, 0.125 gpm/well net production rate, T=1000 gpd/ft, Flare Factor = 5.8

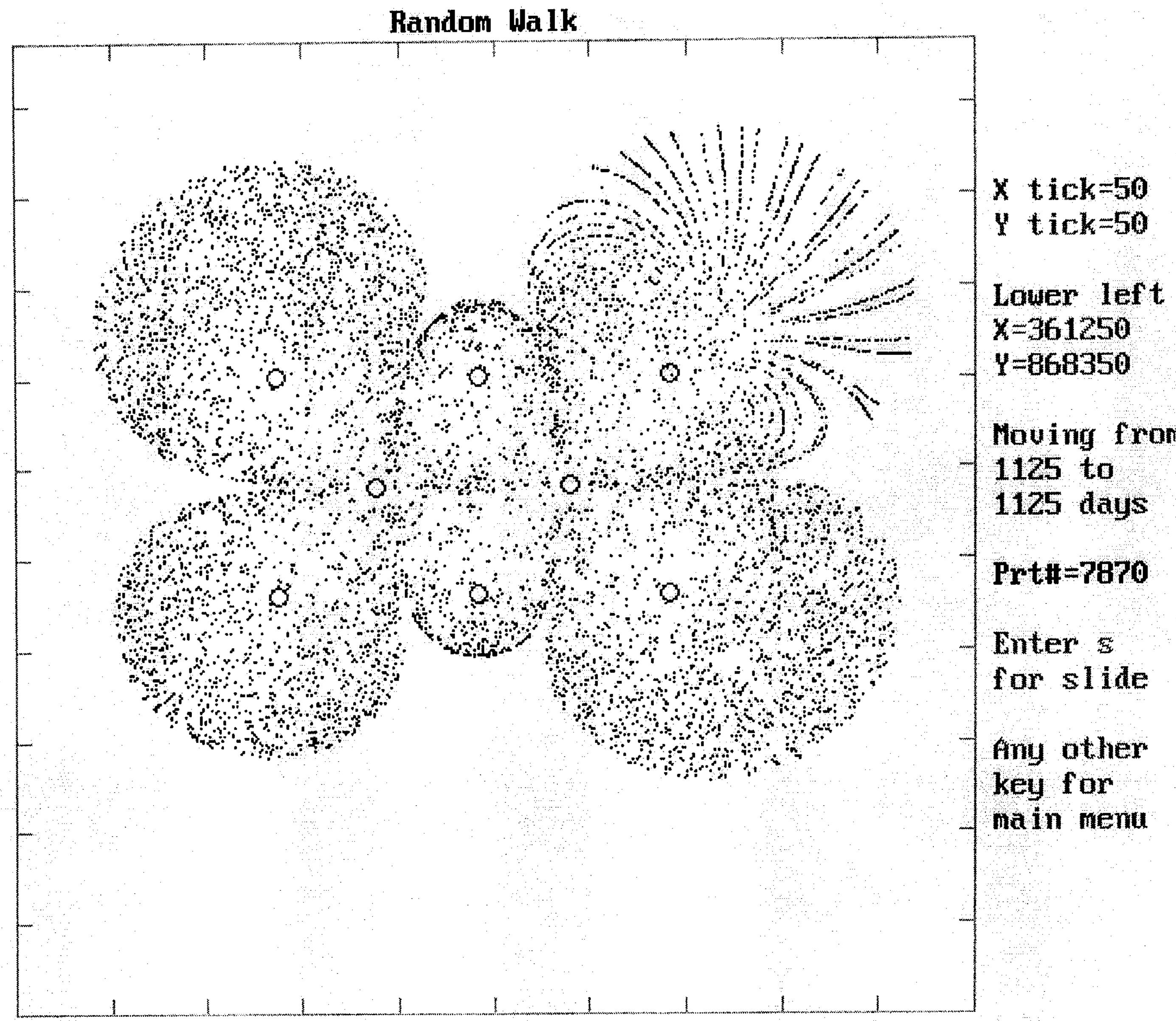

Figure B-2. Double 5-spot pattern advective particle cloud, 0.125 gpm/well net production rate, T=1000 gpd/ft, Flare Factor = 4.8

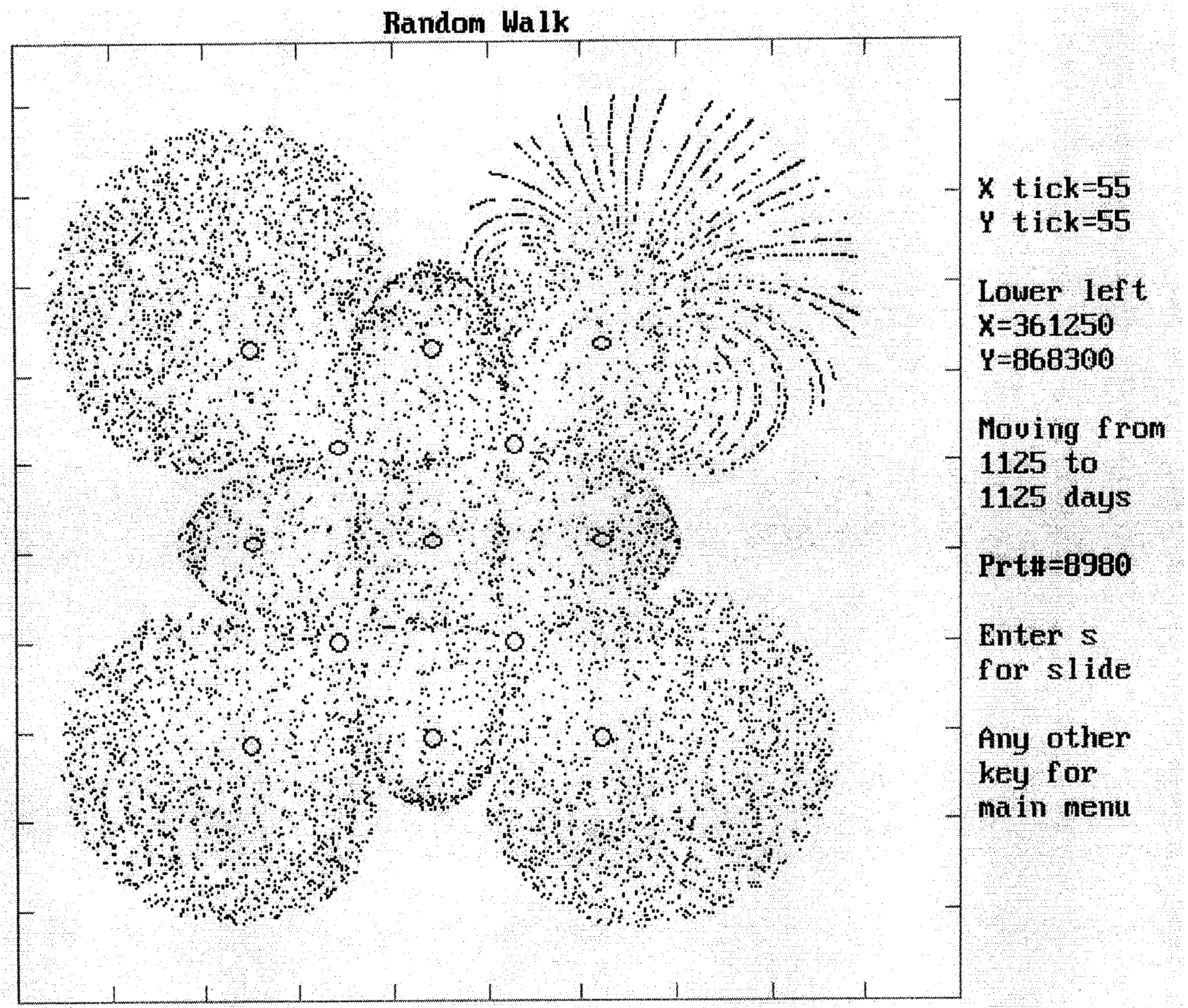

Figure B-3. Quad-square pattern advective particle cloud, 0.125 gpm/well net production rate, T=1000 gpd/ft, Flare Factor = 3.8

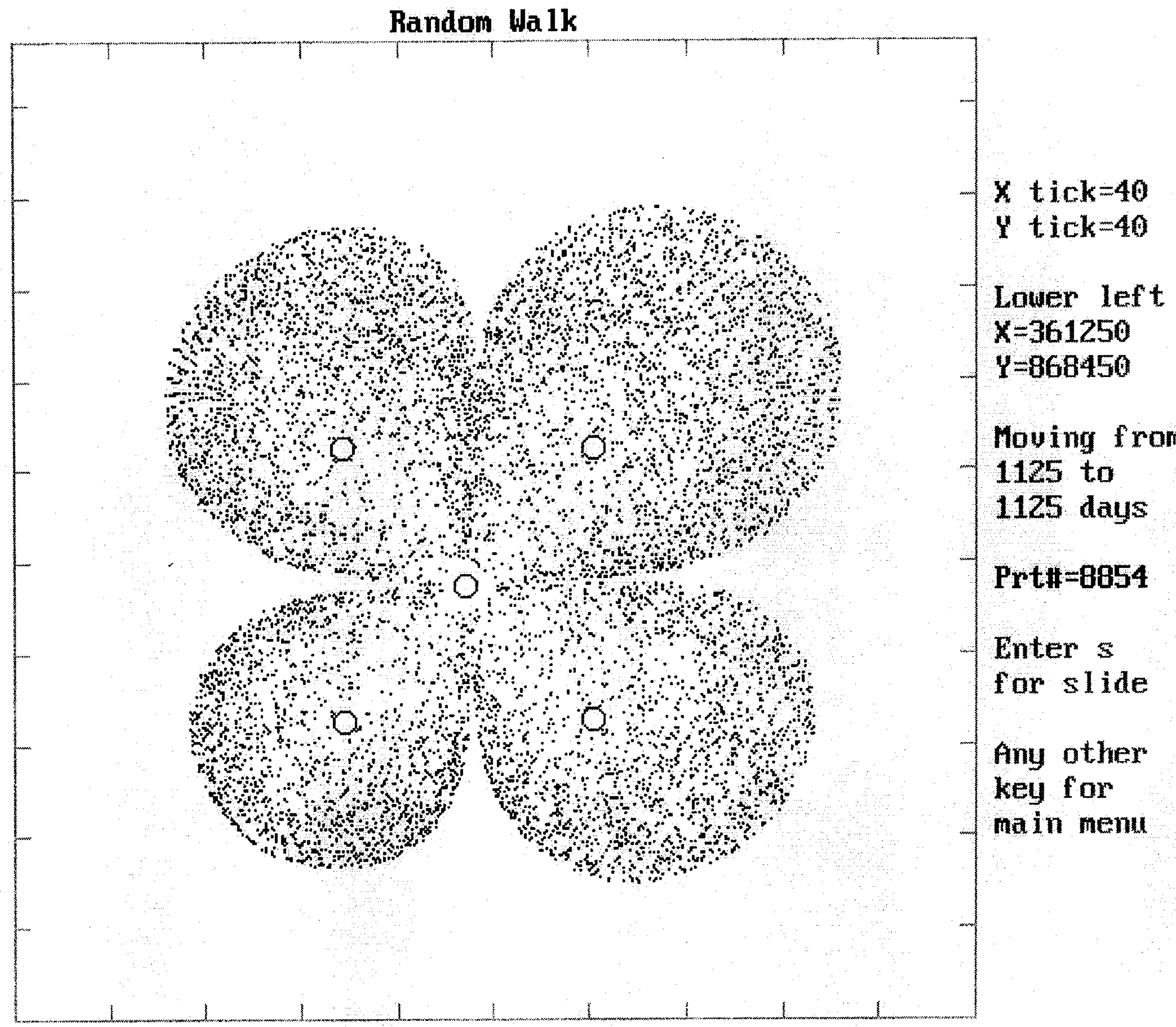

Figure B-4. Single 5-spot pattern advective particle cloud, 0.08 gpm/well net production rate, T=1000 gpd/ft, Flare Factor = 5.0

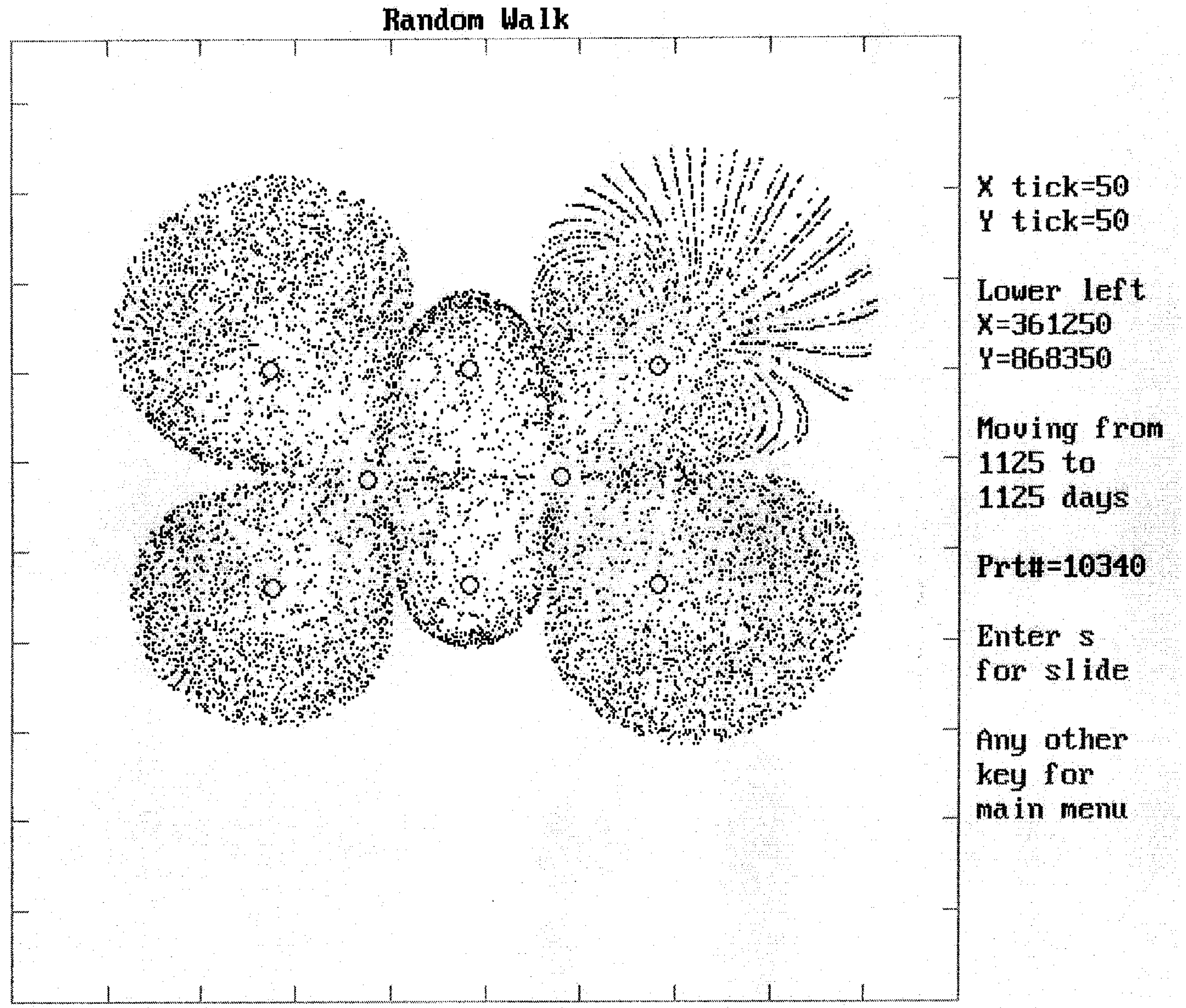

Figure B-5. Double 5-spot pattern advective particle cloud, 0.08 gpm/well net production rate, T=1000 gpd/ft, Flare Factor = 4.0

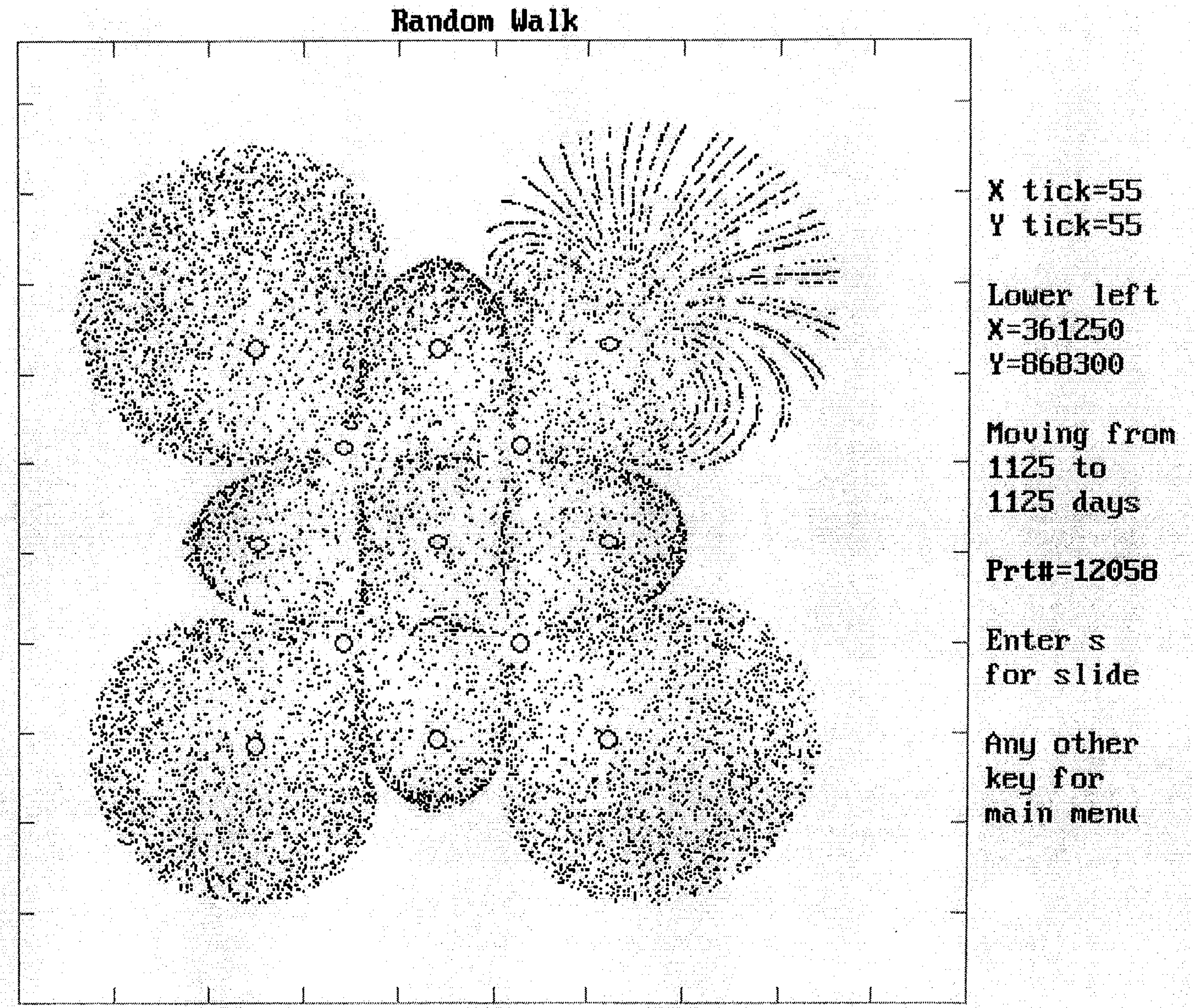

Figure B-6. Quad-square pattern advective particle cloud, 0.08 gpm/well net production rate, T=1000 gpd/ft, Flare Factor = 3.0

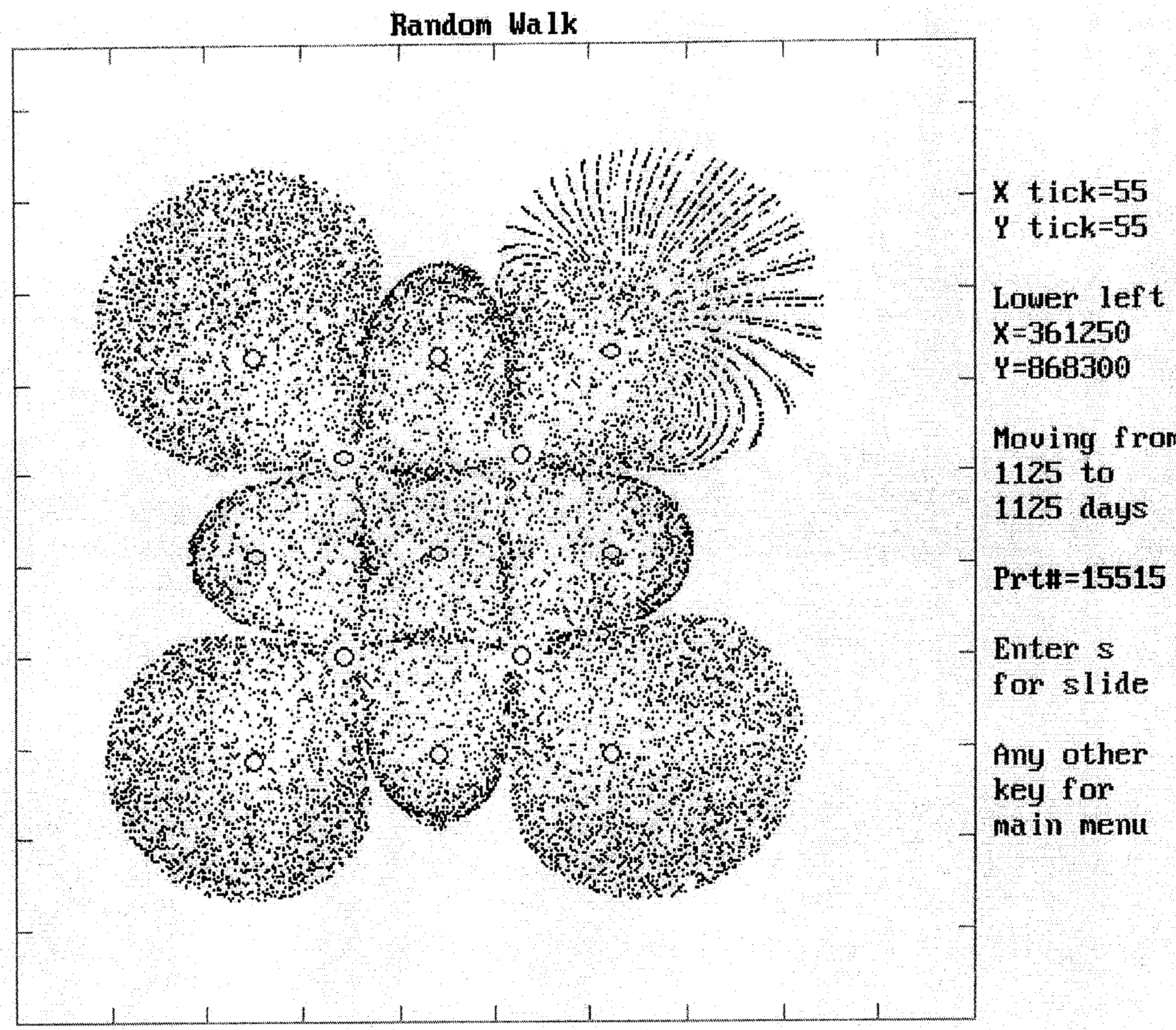

Figure B-7. Quad-square pattern advective particle cloud, 0.08 gpm/well net production rate, T=1500 gpd/ft (+50%), Flare Factor = 2.9

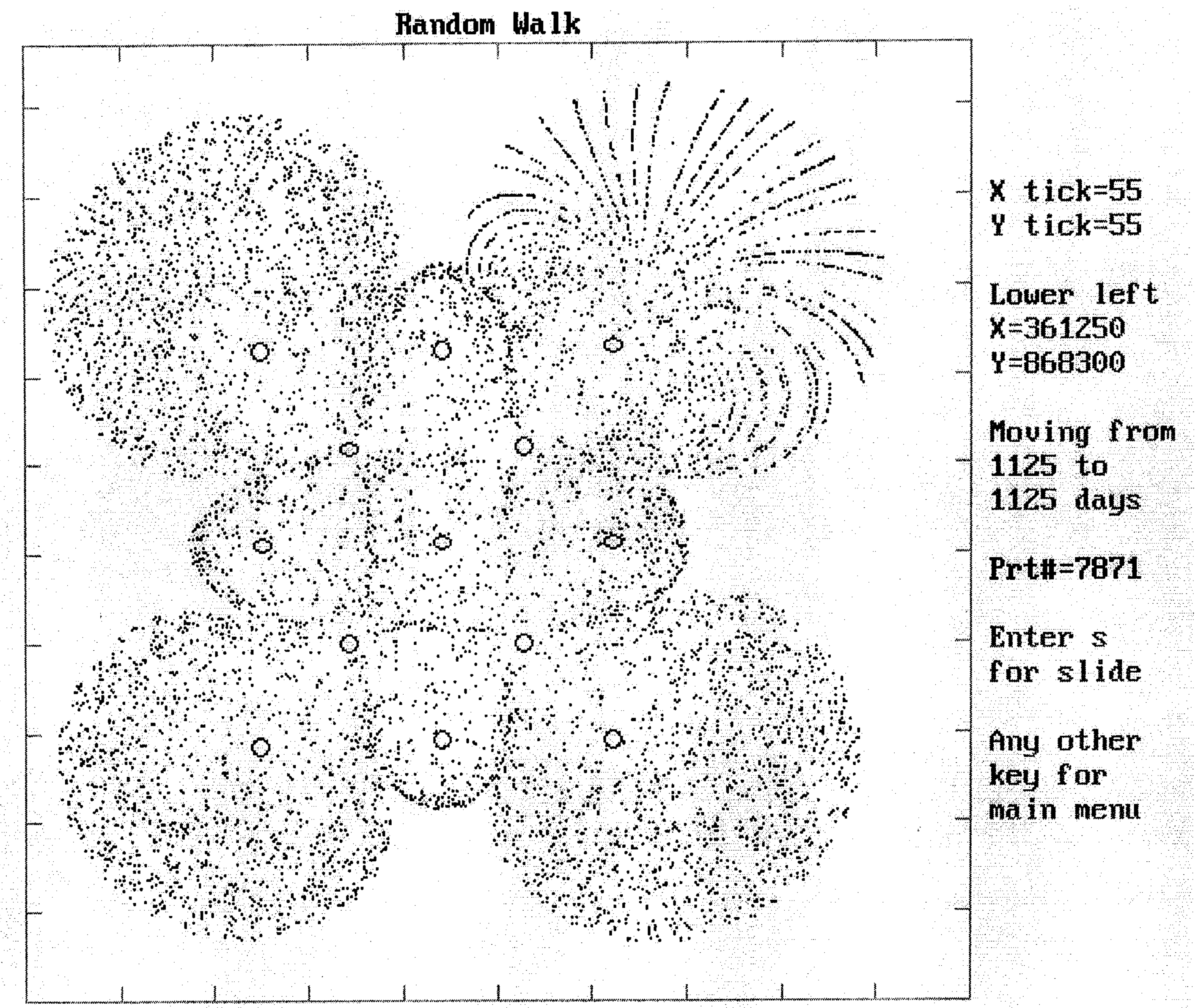

Figure B-8. Quad-square pattern advective particle cloud, 0.08 gpm/well net production rate, T=500 gpd/ft (-50%), Flare Factor = 4.0

Attachment C

Wellfield 1 MODFLOW and MODPATH Information

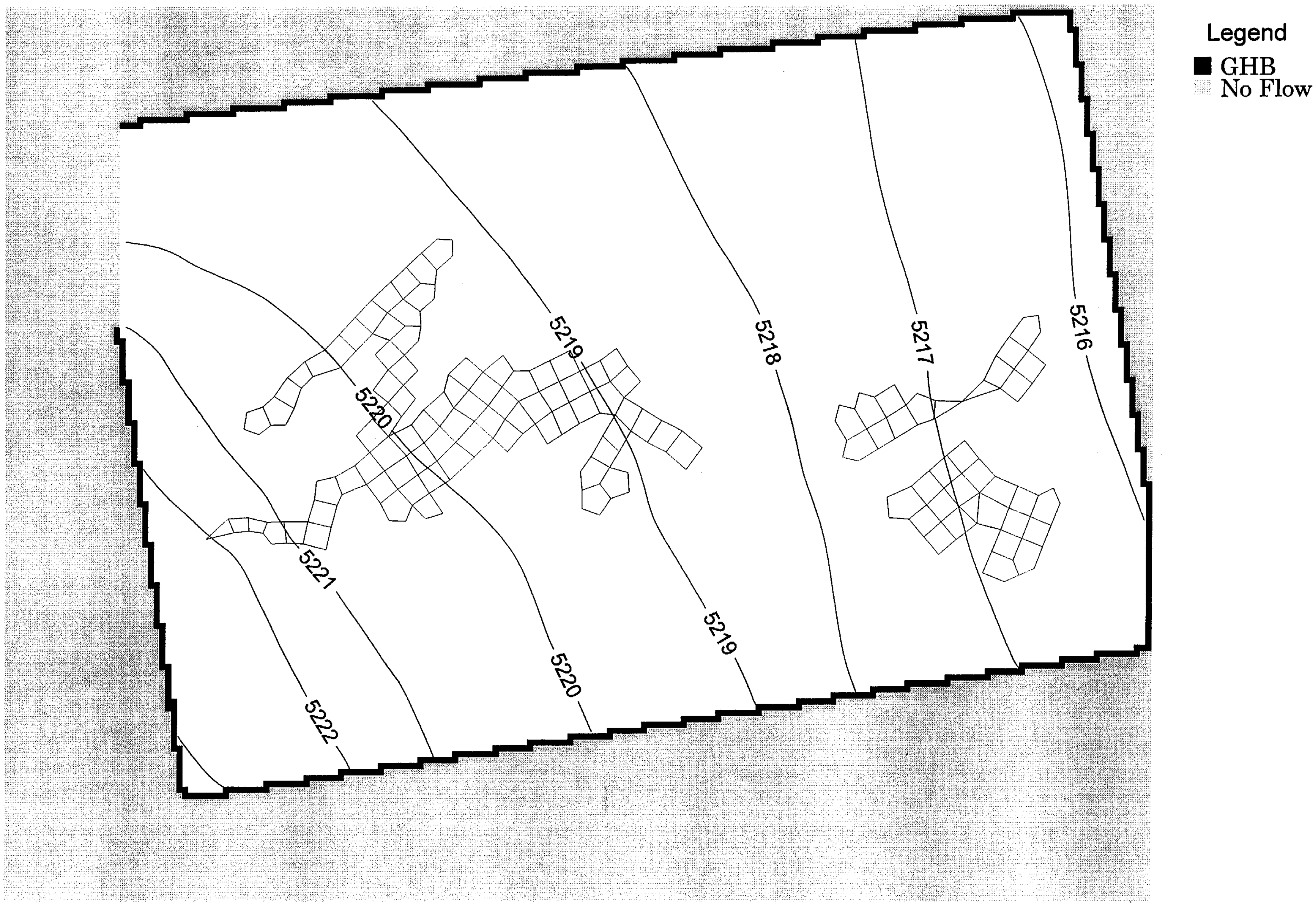

Figure C-1. Wellfield 1 MODFLOW boundary conditions and calibrated potentiometric surface.

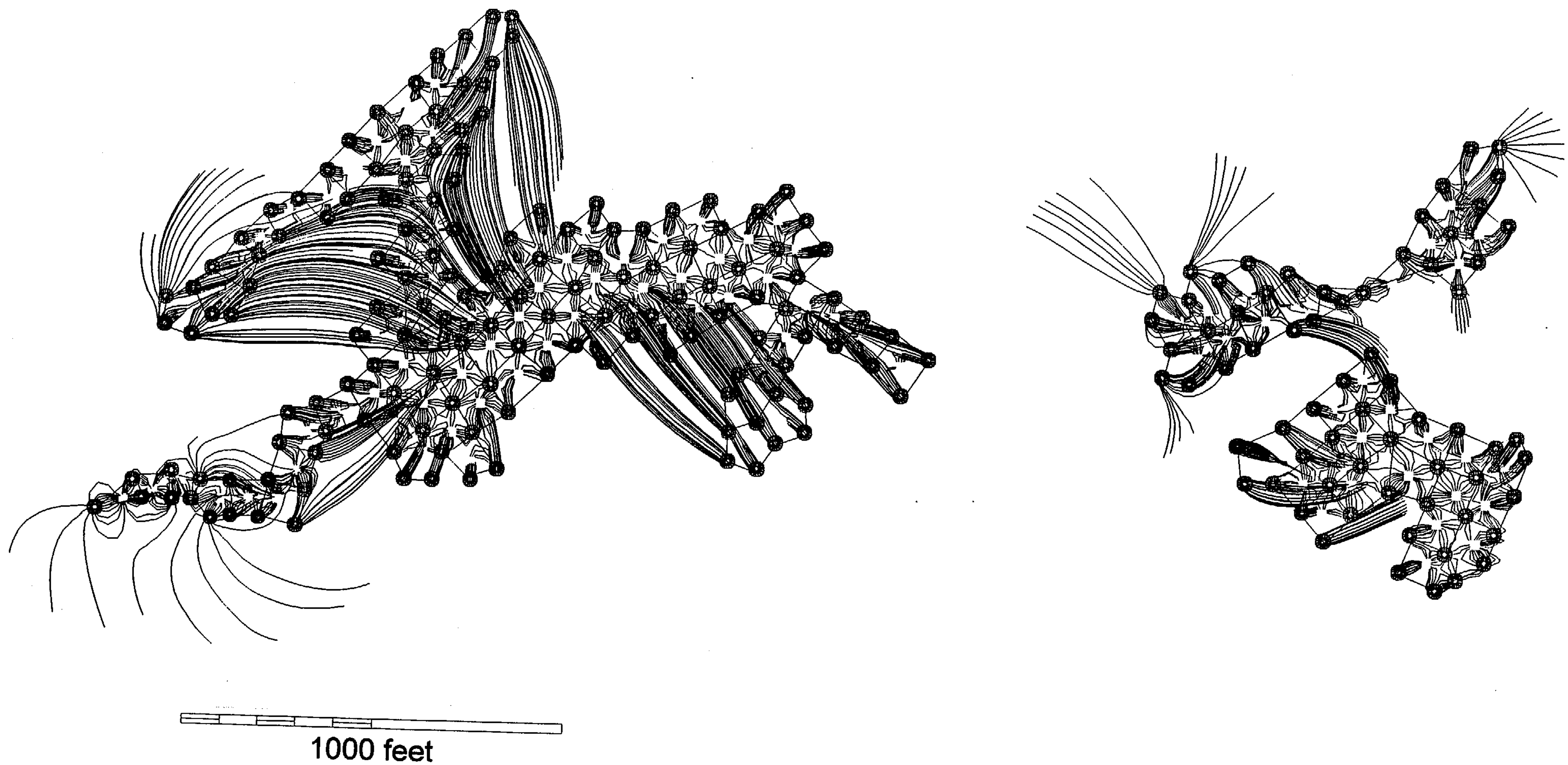

Figure C-2. MODPATH advective particle track after 2.5 year production period, Kh/Kv = 100/1. Flare Factor = 1.7

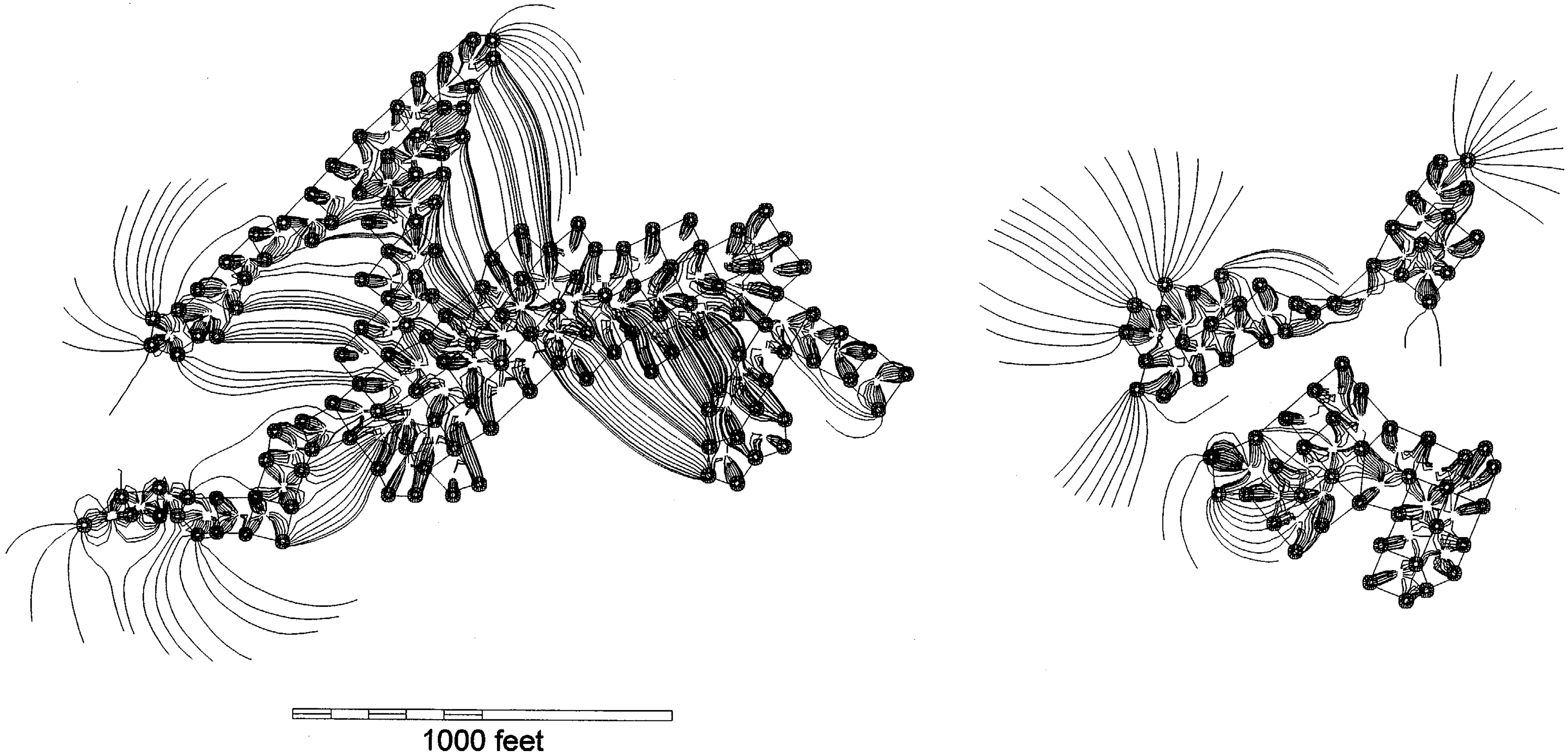

Figure C-3. MODPATH advective particle track after 2.5 year production period, Kh/Kv = 10/1. Flare Factor = 2.2

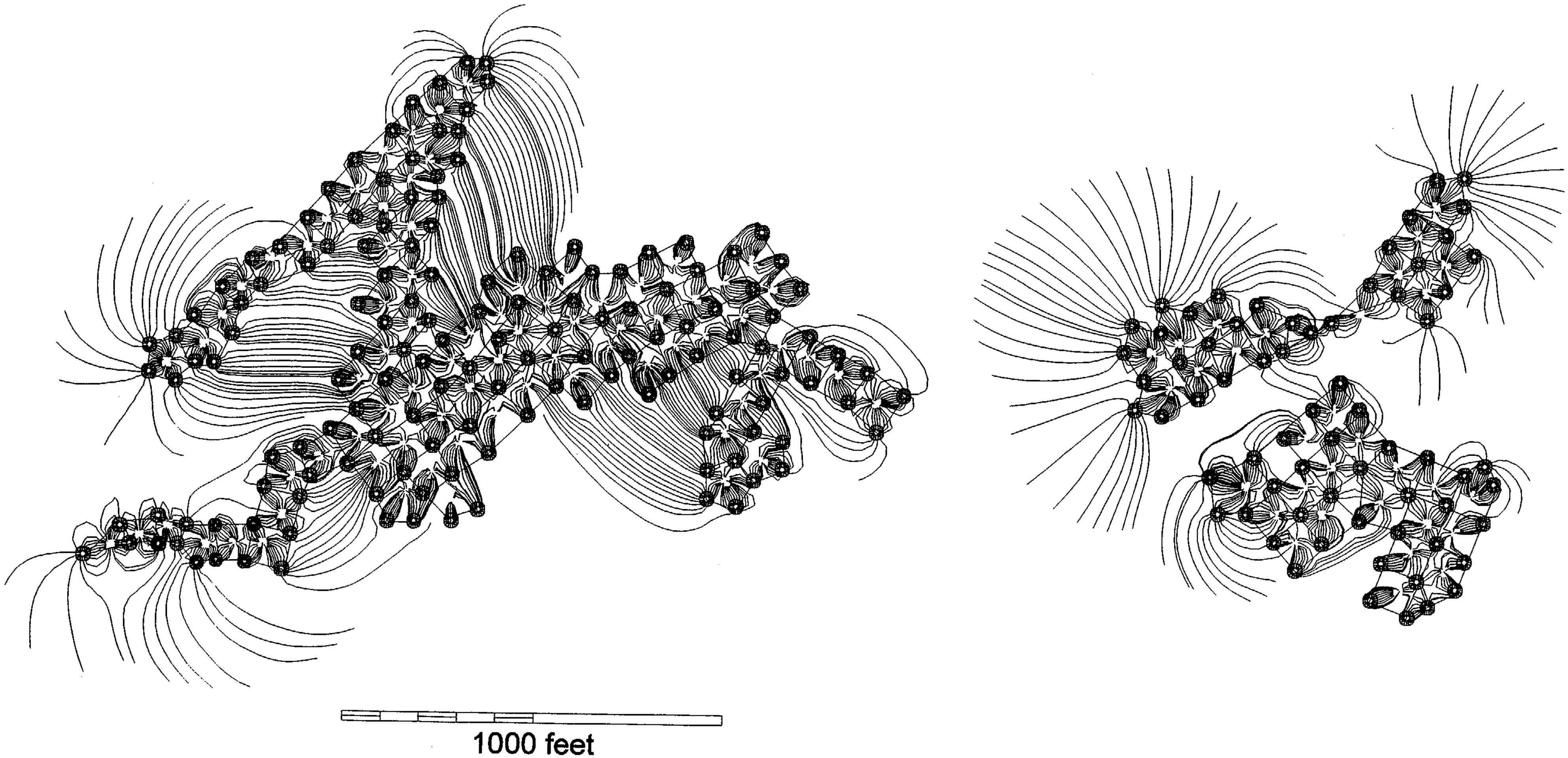

Figure C-4. MODPATH advective particle track after 2.5 year production period, Kh/Kv = 1/1. Flare Factor = 2.7

Cross-Section along Row 64

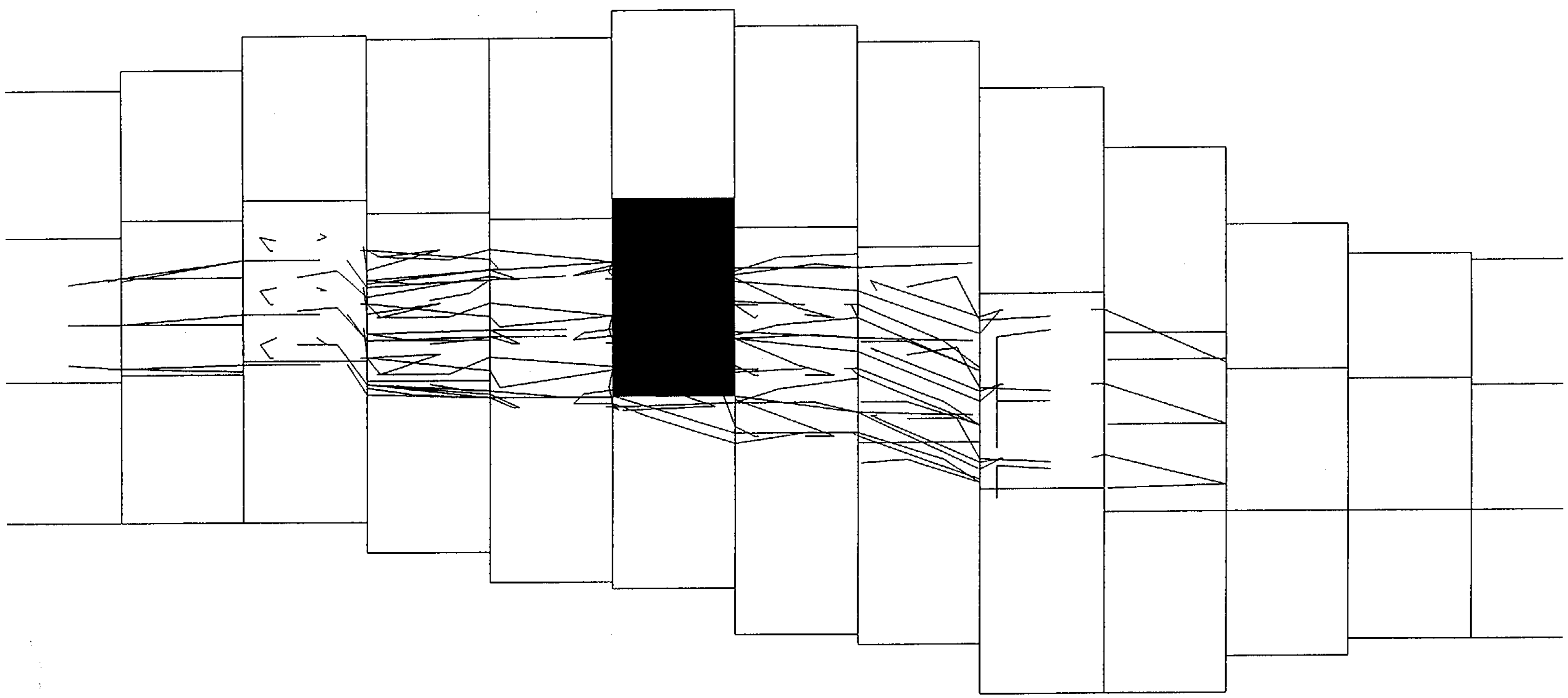

Figure C-5. Typical MODPATH wellfield cross-section showing no vertical flare for Kh/Kv = 100.