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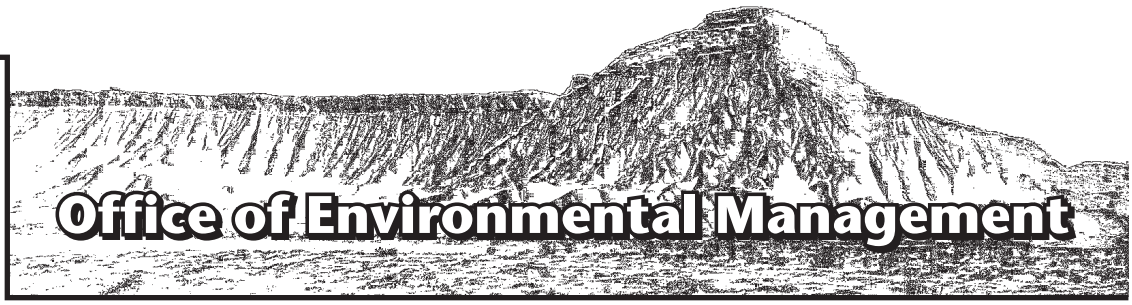
Moab Project

Interim Action Expansion Work Plan for the Moab, Utah, Site

April 2004



U.S. Department of Energy

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Interim Action Expansion Work Plan for the Moab, Utah, Site

DRAFT

April 2004

Work Performed by S.M. Stoller Corporation under DOE Contract No. DEBAC01–02GJ79491
for the U.S. Department of Energy, Grand Junction, Colorado

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Contents

Page

1.0 Introduction 1
2.0 Background 3
3.0 Purpose and Scope 5
4.0 Baseline Monitoring Network 9
4.1 Specific Objectives 9
4.2 Baseline Tasks 10
5.0 Configuration 1 15
6.0 Configuration 2 23
6.1 Specific Objectives 24
6.2 Design for Configuration 2 25
6.3 Configuration 2 Tasks 33
7.0 Project Requirements 39
7.1 Personnel and Equipment 39
7.2 Environmental Compliance 39
7.3 Health and Safety 39
8.0 Sampling and Analysis 41
8.1 Sampling Procedures 41
8.2 Sample Quality Assurance and Control 42
9.0 Routine Reporting 43
10.0 References 45

Figures

Figure 1. Location Map of the Moab Site and Surrounding Area 2
Figure 2. Site Conceptual Model Showing Ground Water Discharge to the Colorado River 3
Figure 3. Location of Interim Action Configurations and Baseline Monitoring Area 7
Figure 4. Baseline Area 11
Figure 5. Cross Section View of Well Screen Intervals and Depths of Existing and Proposed Wells in the Baseline Monitoring Area 12
Figure 6. Effect of Operating Configuration 1 for the Purpose of Mass Removal 15
Figure 7. Configuration Area 1 16
Figure 8. Cross Section View of Well Screen Intervals and Depths of Existing and Proposed Wells in Configuration 1 19
Figure 9. Effect of Operating Configuration 2 Extraction Wells for the Purpose of Mass Removal and Gradient Manipulation to Reverse Ground Water Flow Gradients Near the River 23
Figure 10. Conceptual Model of Hydraulic Barrier by Injection of Clean Water in Configuration 2 24
Figure 11. Location of SEAWAT 2D Cross Section Model 27
Figure 12. Time-Concentration Plot for Three Injection-Depth Scenarios 28
Figure 13. Conceptual Layout of Dual-Purpose Injection and Extraction Wells for Configuration 2 28

Figure 14. Particle Tracking Results Showing Ground Water Flow Directions Associated with Operating Configuration 2 as Extraction Wells 29
Figure 15. Particle Tracking Results Showing Ground Water Flow Directions Associated with Operating Configuration 2 as Clean Water Injection Wells 29
Figure 16. Map View of Computed Mounding (feet) After 30 Days of Continuous Injection Into a Single Well at a Rate of 16 gpm 31
Figure 17. Cross-Sectional View of Computed TDS Concentrations (kg/m^3) After 30 Days of Continuous Injection into a Single Well at a Rate of 16 gpm 32
Figure 18. Map View of Computed Mounding (feet) After 120 Days of Continuous Injection Into a Single Well at a Rate of 4 gpm 32
Figure 19. Cross-Sectional View of Computed TDS Concentrations (kg/m^3) After 120 Days of Continuous Injection into a Single Well at a Rate of 4 gpm 33
Figure 20. Map View of Proposed Location of Dual-Purpose Remediation Wells and Monitor Wells for Configuration 2 34
Figure 21. Cross Section View of Well Screen Intervals and Depths of Proposed Wells in Configuration 2. 36

Tables

Table 1. Proposed Monitor Wells and Piezometers in the Baseline Monitoring Area 10
Table 2. Sampling Frequency Requirements for the Baseline Configuration 13
Table 3. Proposed Monitor Wells for Configuration 1 18
Table 4. Sampling Frequency Requirements for Configuration 1 21
Table 5. SEAWAT 2D Predictions of TDS Concentration Beneath the Backwater Habitat for Selected Injection Scenarios 26
Table 6. Conceptual Design Criteria for Dual-Purpose Remediation Wells for Configuration 2 35
Table 7. Screen Intervals and Locations of Dual-Purpose Remediation Wells for Configuration 2 35
Table 8. Proposed Monitor Wells for Configuration 2 37
Table 9. Sampling Frequency Requirements for Configuration 2 38
Table 10. Regulatory Requirements for Field Activities 39
Table 11. Analytes and Methods for Ground Water and Surface Water Samples 41

1.0 Introduction

The Moab, Utah, Site (Moab site) is a former uranium-ore processing facility located approximately 3 miles northwest of the city of Moab in Grand County, Utah (Figure 1). The plant was constructed in 1956 by the Uranium Reduction Company, which operated the mill until 1962 when the assets were sold to the Atlas Minerals Corporation (Atlas). Operations continued under Atlas until 1984. When the processing operations ceased in 1984, the mill had accumulated an estimated 10.5 million tons of uranium mill tailings in an unlined impoundment in the floodplain of the Colorado River. The tailings pile covers approximately 130 acres, is about 0.5 mile in diameter, averages about 94 feet in height above ground surface, and is located about 750 feet west of the Colorado River. Atlas placed an interim cover over the tailings pile as part of decommissioning activities ongoing between 1988 and 1995. In October 2001, the title of the property and responsibility for remediation of the tailings pile and contaminated ground water beneath the site were transferred to the U.S. Department of Energy (DOE).

Results of a number of investigations, including the most recent one completed by DOE (DOE 2003a), indicate that contaminants have leached from the tailings pile into the ground water. Several site-related contaminants have been identified, but the most pervasive and highest concentration constituent is ammonia. DOE's studies have identified two plumes of ammonia associated with the site—a deep plume beneath the tailings pile and a shallower plume emanating from the toe of the tailings pile to the Colorado River. Ground water from the shallow plume has been demonstrated to discharge to the Colorado River and to have a localized impact on surface water quality. Degradation of surface water quality is of concern because of potential effects on aquatic species in the area—particularly endangered fish.

DOE has initiated an interim action to pump contaminated ground water from the shallow plume to an evaporation pond on top of the tailings pile. The goal of the action is to reduce contaminant mass in the aquifer until a full-scale remediation system can be designed and installed. The interim action has been in place since summer 2003. Each of the 10 extraction wells in the system is equipped to withdraw ground water at rates between 1 and 7 gpm. In its draft environmental impact statement for remediation of the Moab site (DOE 2003b), DOE has proposed to intercept ground water and control discharge of contaminants to the river until concentrations in the alluvial system are reduced to levels that permit unrestricted discharge to the river. The work detailed in this plan for expanding the interim action will help guide the implementation of the final remedial action system for ground water.

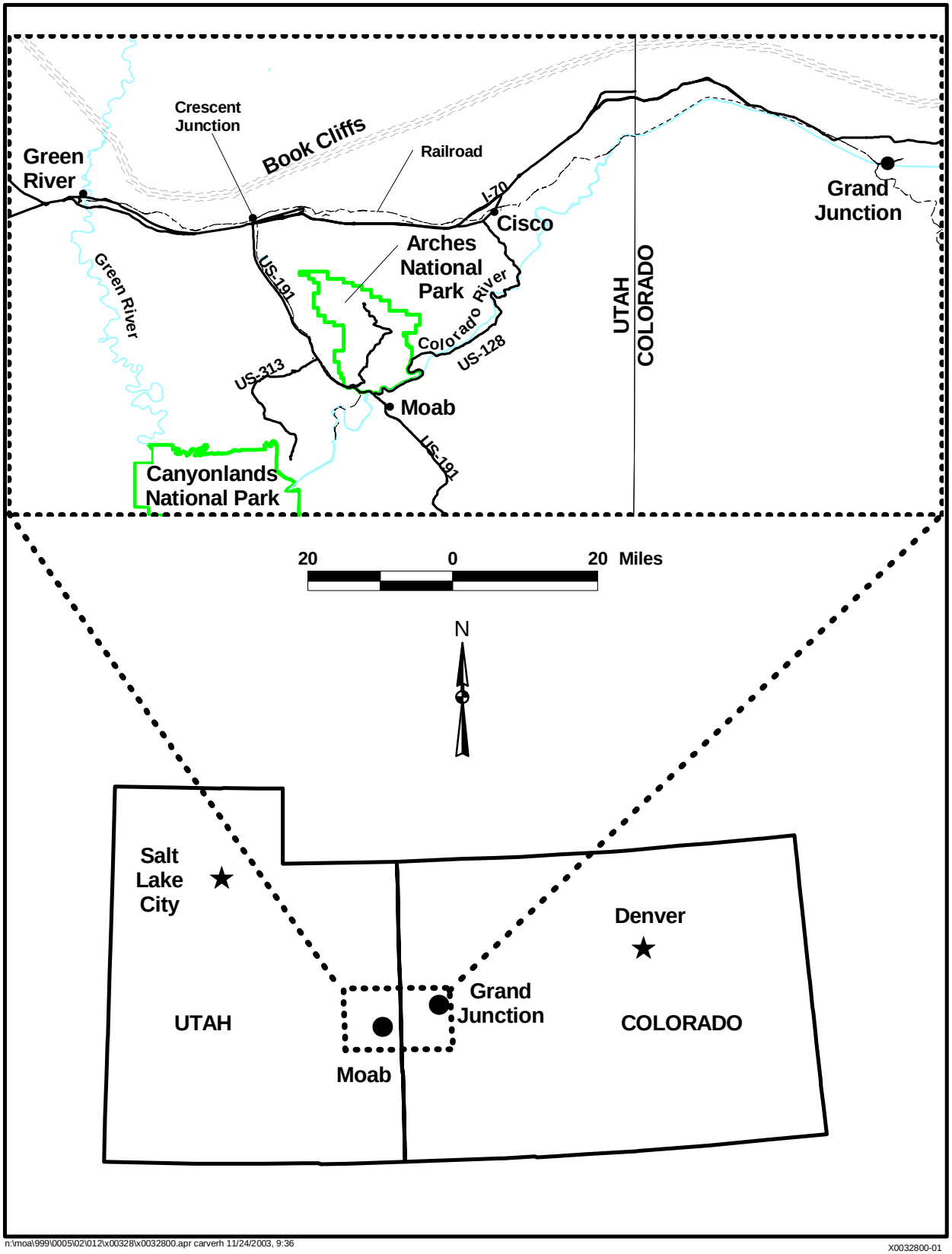

Figure 1. Location Map of the Moab Site and Surrounding Area

2.0 Background

The goal of ground water remediation at the Moab site is focused on improving surface water quality, particularly in areas that are important habitat for endangered fishes. Therefore the most important processes to understand are those that relate to ground water and surface water interactions (hyporheic zone). The activities associated with the interim action expansion are focused on improving the understanding of those interactions and on identifying ways in which the interim action can affect those interactions in a positive way.

A simplistic cross-section showing important features of the conceptual site model in the area where ground water is presumed to discharge to the Colorado River is shown in Figure 2. This figure represents baseline site conditions in the absence of active ground water remediation. Characterization at the site has resulted in the identification of two different water types in the alluvial aquifer based on total dissolved solid (TDS) concentrations (DOE 2003a). The first is a relatively thin layer of fresh to brackish water (TDS < 35,000 mg/L), which overlays a deeper and thicker layer of brine (TDS > 35,000 mg/L). The boundary between the two layers (the "saltwater interface") is relatively sharp and is found at progressively shallower depths in moving from the vicinity of the tailings pile toward the Colorado River. Based on shallow test pit sampling adjacent to the river, in which all ground water samples had concentrations of < 35,000 mg/L TDS, it is assumed that the saltwater interface intersects the river bottom at some distance from the river bank.

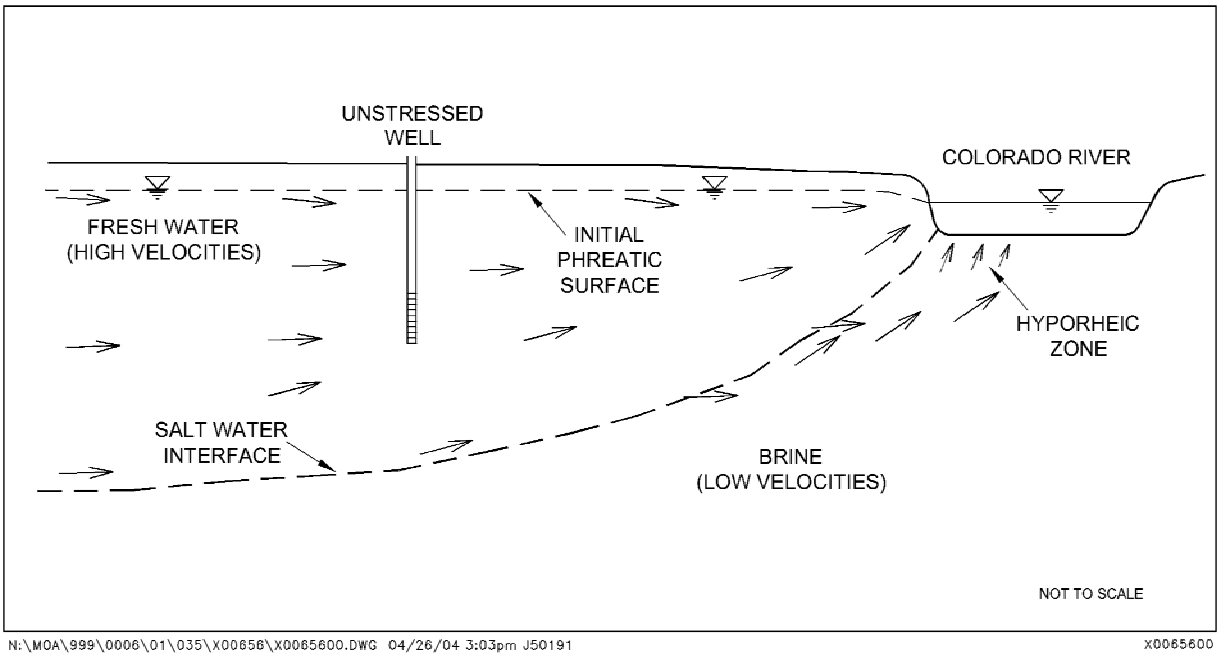

Figure 2. Site Conceptual Model Showing Ground Water Discharge to the Colorado River

The saltwater interface is believed to be an important feature in the alluvial aquifer for a number of reasons. It appears that the highest concentrations of ammonia, the constituent of greatest concern at the site, are associated with the interface (DOE 2003a). Limited sampling across the interface indicates increasing concentrations of ammonia from the top of the water table to the interface, and decreasing concentrations with depth from below the interface. Because of density increases with depth, there is believed to be little flow across the interface at locations away from the river. Therefore the two layers could represent two distinct sources of ammonia contamination that have the potential to discharge to the river. Also due to density differences, any active remediation that results in drawdown of the surface of the freshwater layer could also cause an upconing of the brine layer and a potential shift in the location of the saltwater interface. Pumping of the aquifer could therefore bring the brine closer to the surface and affect vegetation rooted in the ground water and can alter where the brine discharges to the river. One study of vegetation in the Scott M. Matheson Wetlands Preserve across the river from the Moab site attributed mortality of cottonwood trees in the preserve, in part, to increases of natural salinity in the ground water (Bellagamba 1997). It has also been hypothesized that pumping of the aquifer could cause higher concentrations of ammonia to discharge to the river at some locations by shifting the saltwater interface. Therefore, it is important to understand how the alluvial system will likely respond to the application of stresses during remedial action. Activities proposed for the interim action expansion should improve this understanding.

3.0 Purpose and Scope

The main purpose of the interim action is to improve surface water quality in the areas that provide quality habitat to endangered fish species and to reduce contaminant mass in the aquifer until a full-scale remediation system can be designed and installed. Stakeholders have expressed interest in realizing these improvements within a 3- to 5-year period after the start of implementation. The tasks described here for expansion of the interim action will improve the understanding of ground water and surface water interactions and the significance of the saltwater interface in affecting ground water and river water quality. Specifically, the location of the saltwater interface under baseline conditions will be determined and ammonia variation with depth across the interface will be measured.

Implementation and monitoring of two interim action configurations are described and the data collected will be used to demonstrate if and how those configurations affect the location of the saltwater interface and what the resulting consequences are on river water quality, particularly in areas that are suitable for endangered fish habitat. One configuration is that of the existing system (Configuration 1), which utilizes extraction wells alone to intercept contamination and effect mass removal to prevent contaminated ground water discharge to the Colorado River. A second system is proposed (Configuration 2) that consists of dual-purpose wells. These wells would be designed for extraction and mass removal during the evaporation season, and serve as clean water injection wells during the fall and winter months when the evaporation system is not operating. The proposed injection system for Configuration 2 would improve surface water quality by injecting clean water into the shallow alluvial aquifer to contain the ammonia plume by creating a hydraulic barrier of clean water; it would also provide dilution of ammonia concentrations in the ground water before the plume discharges into potential habitat areas.

Baseline monitoring is also described that will be used to evaluate the performance of the two interim action configurations as well as to improve the understanding of the natural variability of the shallow alluvial system, primarily with respect to river stage. Locations of Configuration 1, Configuration 2, and the baseline monitoring area are shown in Figure 3. Other tasks associated with the expanded interim action will evaluate other aspects of system performance such as the determination of sustainable pumping rates, the practical extent to which pumping and injection can be effective, and the effectiveness of mass removal. With this information and a refinement of the conceptual model, the active ground water remediation system and operating requirements can be optimized for longer-term cleanup.

This work plan describes tasks to evaluate the ground water and surface water systems under three conditions: (1) baseline conditions (no remediation system operating), (2) operation of Configuration 1 and 2 extraction wells only, and (3) operation of Configuration 2 clean water injection wells only. Baseline characterization tasks will provide the basis for evaluating the effects of the two active remediation configurations. Much of the information used for the baseline characterization will come from routine ground water and surface water activities described in the Moab surface water and ground water monitoring plan (DOE 2004a). This work plan outlines how those data will be used, but details of the monitoring approach will be referred to the monitoring plan. Tasks associated with the Configuration 1 extraction wells consist of operation of the existing system in accordance with the operations plan (DOE 2004b) and an expansion of the monitoring network to better evaluate and optimize system performance. Extraction of contaminated ground water and injection of clean water associated with

Configuration 2 will be implemented as an expansion of the Configuration 1 remediation system. This work plan forms the basis for design of Configuration 2, outlines tasks involved in installation of additional baseline monitor wells, and provides the necessary information for sampling, analysis, and data evaluation.

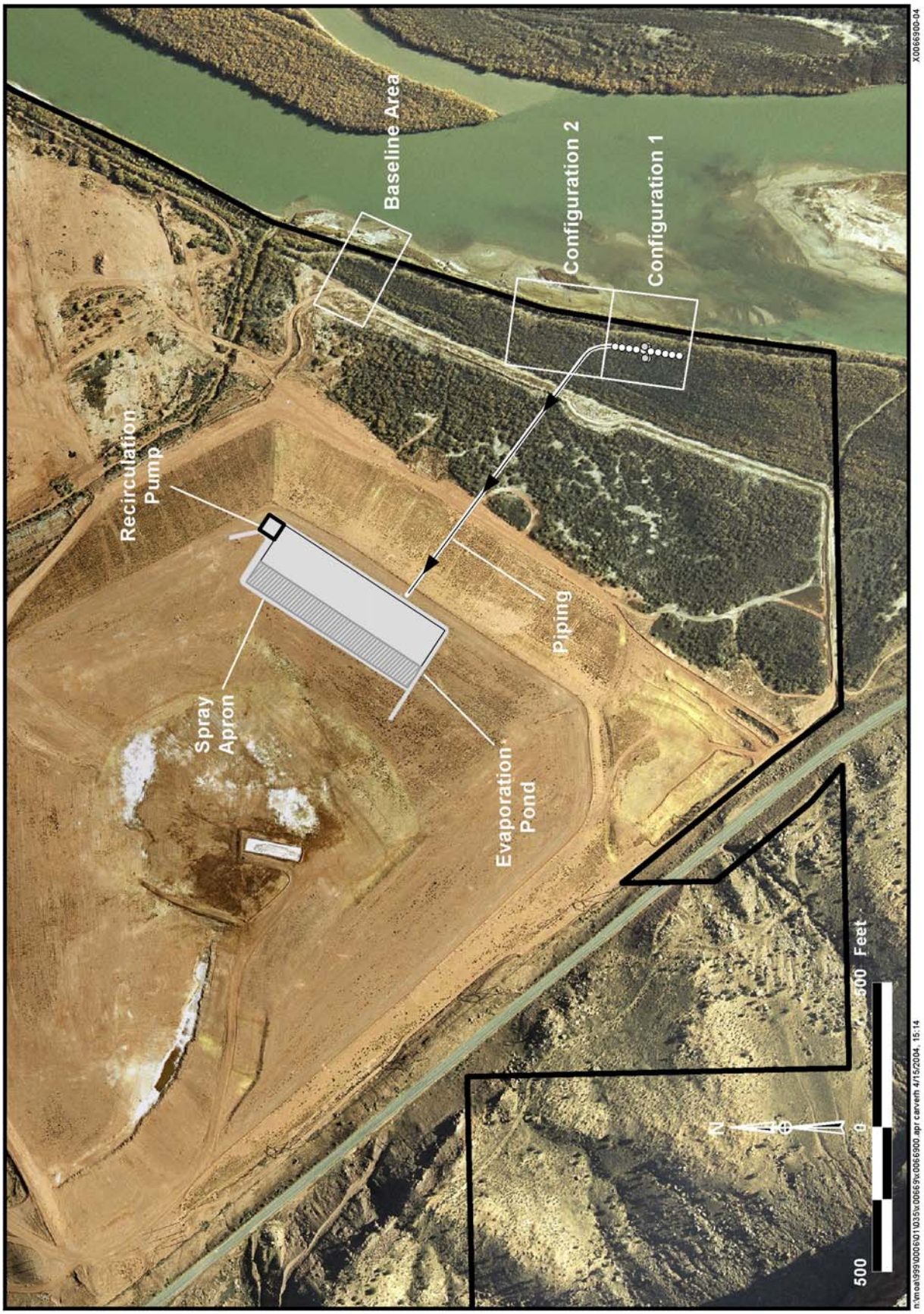

Figure 3. Location of Interim Action Configurations and Baseline Monitoring Area

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4.0 Baseline Monitoring Network

The purpose of baseline characterization is to define conditions prior to remediation startup to be able to evaluate effects of system operation. Sampling will occur to better understand the characteristics and processes in the hyporheic zone shown in Figure 2 (e.g., location of saltwater interface, flow paths and hydraulic gradients, ammonia concentrations, etc.). This section describes sampling and data collection to be conducted for the new dedicated baseline monitoring network. Baseline sampling of Configurations 1 and 2 will also be completed for the purposes of evaluating performance of those systems. Sampling and data collection requirements are described under each of those configurations in Sections 5 and 6.

The baseline area has been established to monitor the ground water chemistry and water level elevation changes that are not under the influence of remediation activities associated with Configurations 1 or 2. The baseline monitoring area is located upstream of Configurations 1 and 2, as shown in Figure 3.

4.1 Specific Objectives

Baseline monitoring will be used to refine the understanding of the unstressed ground water system. In particular, the water quality monitoring network is designed to determine vertical and horizontal distribution of ammonia and TDS concentrations and to determine the significance of the saltwater interface with respect to ammonia distribution. Water level data will be used to define ground water flow paths above and below the saltwater interface and to determine if freshwater or brine serves as the primary source of ammonia contamination in backwater areas. Because the alluvial system is expected to display significant natural variability related to changes in river stage, a baseline system in an unstressed area is necessary to understand this variability in aquifer response characteristics. These data can be used in evaluating the performance of Configurations 1 and 2 to separate natural variation from effects of system operation.

Collocated ground water and surface water data described in the ground water and surface water monitoring plan (DOE 2004a) also will be used to refine the dilution factor for ground water discharge to the river and improve the understanding of interactions between ground water and surface water. Based on this analysis, an appropriate long-term cleanup objective can be developed for ground water where it discharges to the Colorado River (i.e., a refinement of the 3 mg/L target level for ammonia).

Specific questions to be answered with these data are:

- Where are the highest concentrations of ammonia in ground water?
- What area within the aquifer serves as the primary source of discharge to backwater areas?
- What degree of mass reduction in main source areas would be required to meet long-term cleanup objectives where ground water discharges to the river?
- Are highest ammonia concentrations linked to the saltwater interface?
- Does the saltwater interface intersect the river bottom and, if so, where?

4.2 Baseline Tasks

Task 1. Install Monitor Wells

The existing SMI-PW01 well cluster and monitor wells MOA-405 and -409 in combination with new monitor wells to be installed form the baseline monitoring network shown in Figure 4. The existing SMI-PW01 well cluster is located approximately 200 ft from the riverbank and will provide baseline data between the tailings pile and the river. The cluster consists of four wells, the shallowest well is screened from 14 to 19 ft bgs, the middle completion well is screened from 55 to 60 ft bgs, the deepest well is completed from 70 to 75 ft bgs, and the fourth well in the cluster is fully screened from 20 to 60 ft bgs. Based on previous sampling, the saltwater interface lies at a depth between 51 and 56 ft bgs at the SMI-PW01 cluster. Existing monitor wells MOA-405 and -409 are located along the riverbank and are screened from approximately 15 to 20 ft bgs. Samples collected from these wells will provide useful data regarding ground water chemical and water elevation data. Other existing wells, such as the ATP-1 cluster located northwest of the baseline area, contains wells that are screened too deep (the most shallow well in the cluster, ATP-1-S, is screened from 145 to 155 ft bgs) to provide useful data.

Ground water monitor wells BL-1 and BL-2 are proposed to be installed near existing monitor well MOA-405 as shown in Figure 4. These new wells will be screened from 25 to 40 ft bgs and 45 to 55 ft bgs, respectively. Wells screened over these depths will provide useful data regarding the depth of the brine interface and ammonia concentrations discharging to the river at this location. These wells will be constructed using 6-inch diameter casing and screen to allow for the upgrade to an extraction well should the future need arise.

A cross sectional view of the existing and the two new baseline monitor wells BL-1 and BL-2 and their respective screened intervals is shown in Figure 5. A description of the locations and rationale for the proposed new baseline wells is presented in Table 1.

Table 1. Proposed Monitor Wells and Piezometers in the Baseline Monitoring Area

ID	Screen Interval (ft bgs)	Well Type	Location	Purpose
BL-1	25 to 40	6-inch diameter monitor	Within 15 ft of well 405	Monitor saltwater interface elevation, collect chemical data for ground water near the river
BL-2	45 to 55			
BL-3	0.5 to 1	Small diameter piezometer	At the base of the riverbank drop off	Monitor shallow ground water chemistry and vertical gradients east of the riverbank
BL-4	4.5 to 5			
BL-5	0.5 to 1		Half way between the riverbank drop off and shoreline	
BL-6	4.5 to 5			
BL-7	0.5 to 1		Beneath river water near shoreline	
BL-8	4.5 to 5			

Figure 4. Baseline Area

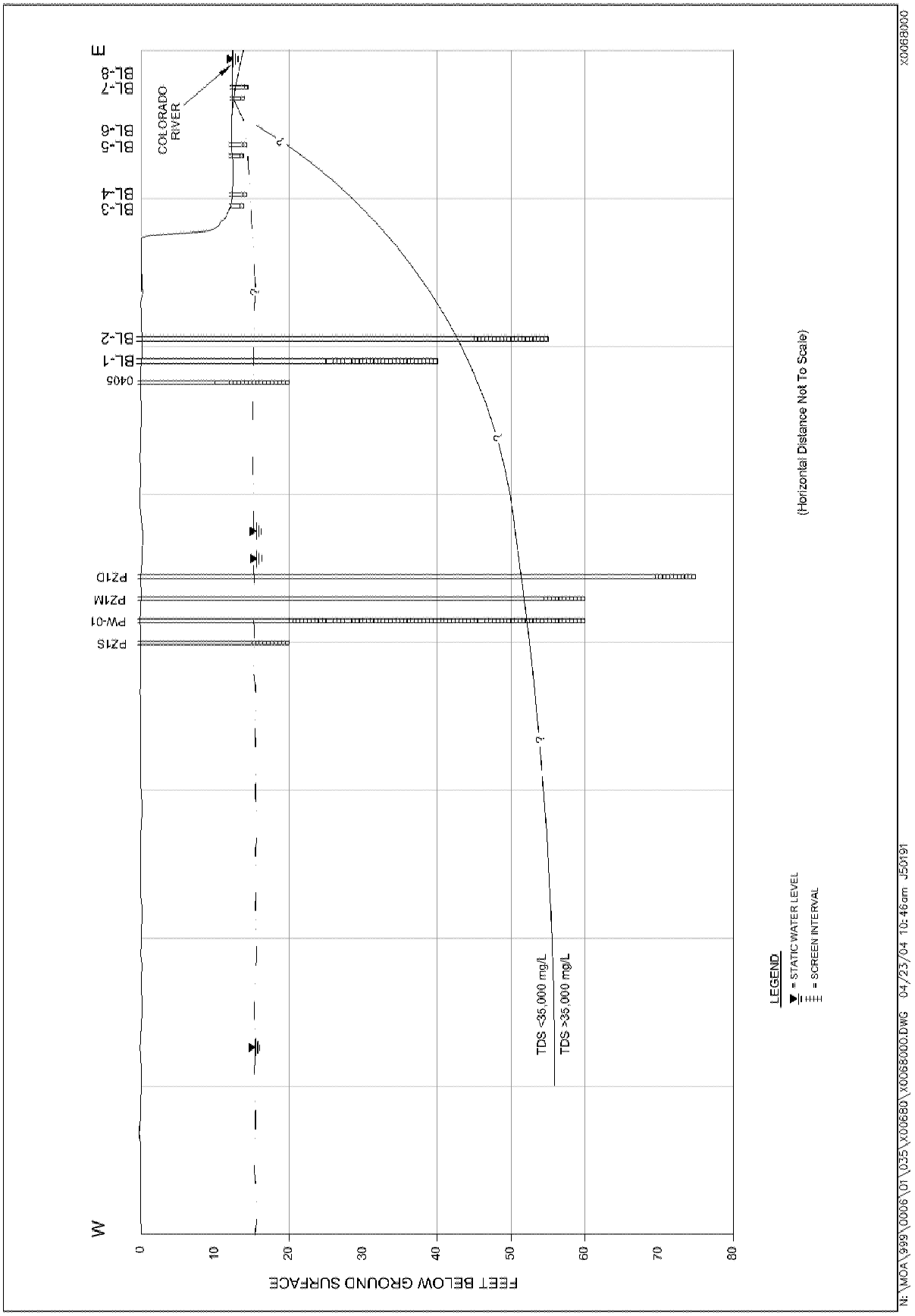

Figure 5. Cross Section View of Well Screen Intervals and Depths of Existing and Proposed Wells in the Baseline Monitoring Area

Task 2. Install Piezometers

Temporary small diameter piezometers that are designed for sampling ground water from specific depth intervals are proposed for installation between the riverbank drop off and the river (shoreline). Samples collected from these piezometers will provide chemical data from the ground water discharging into the river and a method to measure the vertical flow gradient at these locations. A description of the locations and rationale for the proposed small diameter piezometers is presented in Table 1.

Two piezometers will be installed at each of the three areas located between the riverbank drop off and the shoreline as shown in Figure 4. All the small diameter piezometers will be installed in the riverbed in a line beginning at monitor well MOA-405 and extending perpendicular to the shoreline. Two piezometers at each location will allow for the collection of ground water samples from two distinct depths; 0.5 to 1 ft bgs and 4.5 to 5 ft bgs. BL-3 and BL-4 will be installed at the base of the riverbank drop off, while BL-5 and BL-6 will be located half the distance between the riverbank drop off and the river shoreline (the exact distance off the riverbank will be determined in the field due to the changing stage of the river). Piezometers BL-7 and BL-8 will be installed below the river near the shoreline in water that is less than 2 ft deep. Note that the configuration for piezometer locations assumes that the river stage is less than bankfull.

Task 3. Data Collection

Data collected through this sampling will improve the understanding of ground water and surface water interactions and help locate the intersection of the saltwater interface with the riverbed for the natural system. Baseline samples will be collected at the monitor well and piezometer locations for hydrologic and chemical parameters. Measurements will include water levels, field parameters, and laboratory analysis. Sampling the piezometers will progress from on-shore to the off-shore river location. A surface water sample will be collected above the ground water sampling location at the off-shore location. A Troll 8000 unit may be installed in BL-1 to continually monitor the elevation of the saltwater interface. A Mini-Troll to continuously monitor water elevations may be installed in monitor wells MOA-405 and SMI-PW01.

Sampling procedures and analytical requirements for the baseline samples are provided in Section 8. Sampling frequency requirements are summarized in Table 2.

Table 2. Sampling Frequency Requirements for the Baseline Configuration

Location	Field Parameters	Laboratory Analysis	Water Levels
Monitor wells (SMI-PW01, BL-1 and BL-2, and MOA-405	Quarterly	Quarterly	Quarterly
Piezometers (BL-3 through BL-8)	Quarterly	Quarterly	Quarterly
Surface Water	Quarterly	Quarterly	N/A

Task 4. Reporting

A baseline evaluation report, or calculation set, containing the following elements will be prepared.

- Refine conceptual model regarding the relationship between distribution of ammonia concentrations, the location of the saltwater interface, and the source of ground water discharge to the river.
- Describe the natural variability of the system over time and its relationship to river stage.
- Refine the estimate of the dilution factor and describe the concentration relationship of ground water discharge to surface water quality using routine collocated data (DOE 2004a).

5.0 Configuration 1

The primary purpose of operating Configuration 1 is to intercept ammonia in high concentration areas, thereby reducing mass loading to the river. Because the system involves extraction of ground water above the saltwater interface, it is assumed that the main source of ammonia to the backwater areas is located above the interface. Results of baseline monitoring prior to resumption of the existing interim action operation will help test this assumption. The expected result of operating Configuration 1 with the primary purpose of mass removal is shown conceptually in Figure 6.

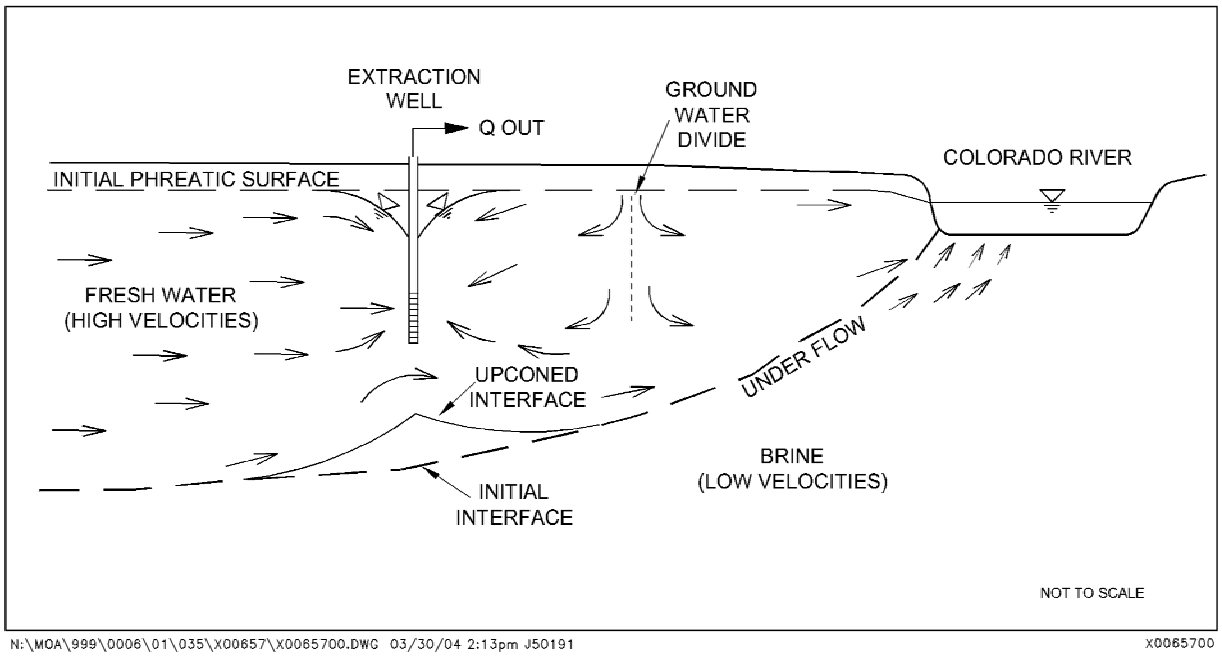

Figure 6. Effect of Operating Configuration 1 or Configuration 2 for the Purpose of Mass Removal

The saltwater interface lies between 30 and 55 ft bgs at the Configuration 1 location. The depth of the interface is inferred from TDS measurements performed on ground water samples collected from two existing Configuration 1 monitor well clusters. Cluster MOA-480/-481/-482 is located to the west, or up gradient of the extraction wells and cluster MOA-483/-484/-485 is located to the east, or down gradient of the extraction wells. The locations of these monitor well clusters are shown in Figure 7. Based on the most recent sampling results from these wells, ground water collected from 29 ft bgs contained TDS concentrations of approximately 27,000 mg/L, and samples collected from 56 ft bgs contained TDS concentrations of approximately 86,000 mg/L. Thus, the saltwater interface (35,000 mg/L TDS) is inferred to be located between 30 and 55-ft bgs.

5.1 Specific Objectives

Configuration 1 monitoring network will be used to determine changes in the distribution of ammonia and TDS concentrations during pumping. It will also be used to determine changes in ground water flow paths above and below the saltwater interface during pumping and the extent of the cone of depression created by the well field. Effects of increased pumping rates on the local ground water system will be evaluated.

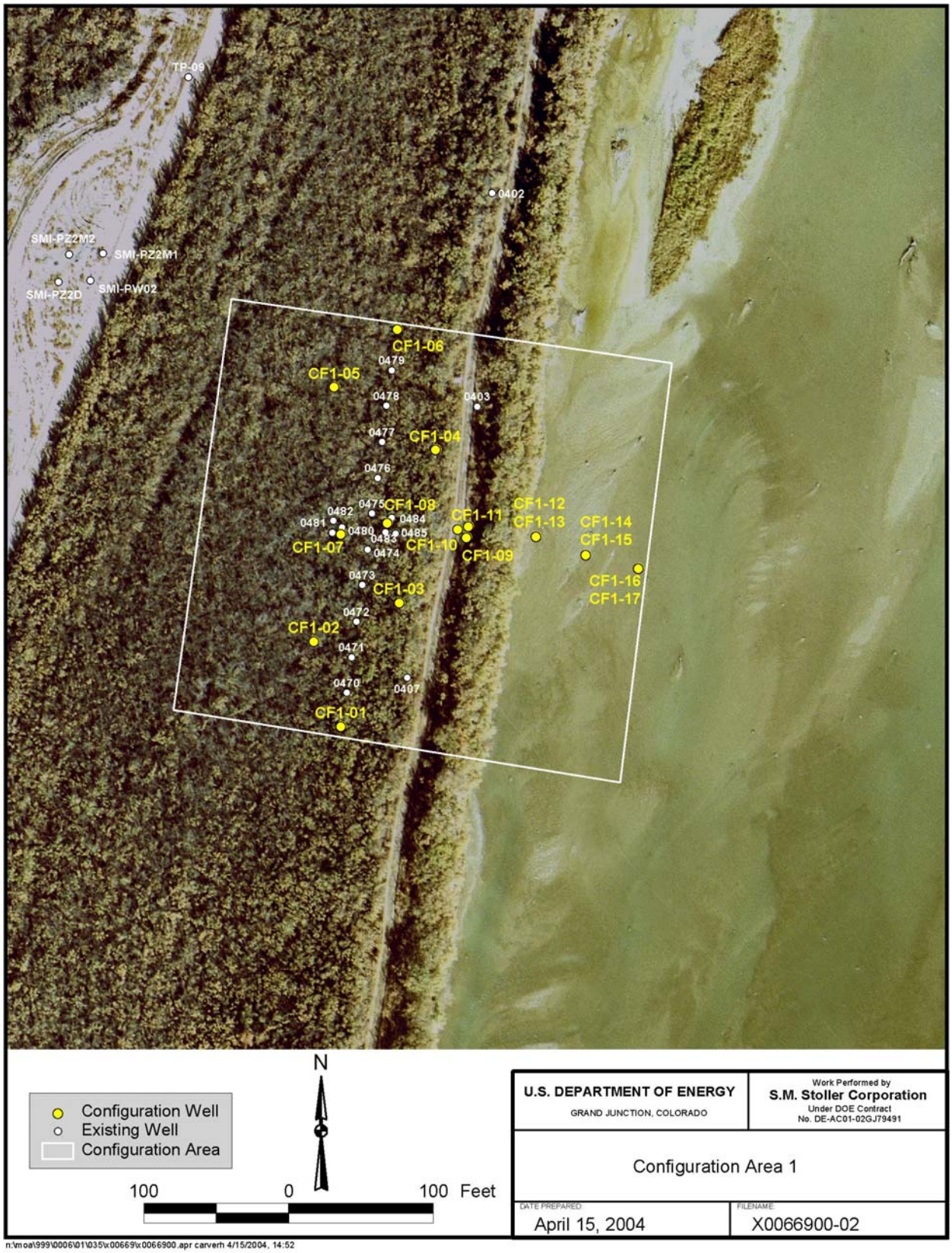

Figure 7. Configuration Area 1

Specific questions to be answered using combined flow path and chemical data are:

- Are existing extraction well locations optimal for:
  - effecting the greatest amount of mass removal?
  - effectively decreasing ammonia loading to backwater areas?
- If baseline sampling shows the saltwater interface is linked to high ammonia concentrations, does pumping affect the location of the saltwater interface?
- If ammonia concentrations are linked to the saltwater interface under baseline conditions, does this linkage still occur under pumping conditions?
- Does the location of the source of ground water discharge to backwater areas during pumping change compared to baseline conditions? Are ammonia and TDS concentrations in the source area higher/lower/unchanged from baseline? If concentrations are higher (implying pumping makes things worse), is this a function of the location of the saltwater interface or some other factor?
- After pumping starts (or stops), how much time is required for the alluvial system to equilibrate?
- Will mass reduction achieved through Configuration 1 have an impact on the ability to achieve long-term cleanup goals (i.e., speed it up, slow it down)? Would pumping from a different location (e.g., depth) be more effective in removing mass and/or achieving long-term cleanup goals?
- Are extraction rates limited by the potential for degradation of surface water? If so, is degradation due to discharge of ammonia to backwaters, discharge of brine to backwaters, upconing of brine to depths of plant uptake, or some other factor?

5.2 Configuration 1 Tasks

Task 1. Install Monitor Wells

Ground water monitor wells and shallow piezometers will be installed to enhance the capabilities to monitor water levels and chemistry of the existing configuration. No additional extraction wells are proposed for this configuration.

Water Level Monitoring Locations

Available performance data (DOE 2004c) indicate the current extraction system generated approximately 0.5-ft of drawdown up to 20-ft from the well field centerline. Furthermore, the cone of depression generated by any single extraction well overlapped with the cone of depression from the adjacent extraction well. Based on these observations, additional monitoring points between the extraction wells or within 20-ft of any existing location are not necessary.

However, except for the existing well cluster previously mentioned, there are no monitoring wells located up gradient of the extraction wells or between the extraction wells and the river. For this reason, six small diameter monitor wells (CF1-1 through CF1-6) are proposed for installation, as shown in Figure 7. The function of these wells is to monitor the draw down in the water level of the shallow alluvial aquifer from the extraction well field. Using this data, a more precise drawdown map can be developed to determine the extent of the cone of depression

generated by the extraction system. Screen intervals and a description of the locations are provided in Table 3. The total depth of each well is 20 ft. A minimum of one-inch diameter PVC casing and a 10-ft screen interval located from 10 to 20 ft bgs are recommended for these wells. One-inch diameter or larger casing allows access for monitoring instrumentation.

Table 3. Proposed Monitor Wells for Configuration 1

ID	Screen Interval (ft bgs)	Well Type	Location	Purpose
CF1-1	10 to 20	1-inch diameter monitor well	30 ft south of extraction well MOA-470	Measure extent of well field cone of depression
CF1-2			30 ft west of centerline	
CF1-3				
CF1-4				
CF1-5				
CF1-6			30 ft north of extraction well MOA-479	
CF1-7	30 to 45	6-inch diameter monitor well (CF1-9 may be 1-inch)	Added to the well 480/481/482 Cluster, 10 ft south of well 480	Monitor elevation of the saltwater interface and collect chemical data
CF1-8	30 to 45		Added to the well 483/484/485 Cluster, as close to the centerline as possible	
CF1-9	10 to 20		Approximately 60 ft east (downgradient) of the well field centerline and 10 ft west of the river bank	Collect chemical and water level data from the shallow zone
CF1-10	25 to 40			Monitor elevation of the saltwater interface and collect chemical data
CF1-11	45 to 55			Collect chemical data from the brine zone
CF1-12	0.5 to 1	Small diameter piezometer	At the base of the riverbank drop off	Monitor shallow ground water chemistry and vertical gradients east of the riverbank
CF1-13	4.5 to 5			
CF1-14	0.5 to 1		Half way between the riverbank drop off and shoreline	
CF1-15	4.5 to 5			
CF1-16	0.5 to 1		Beneath river water near shoreline	
CF1-17	4.5 to 5			

Ground Water Quality Monitoring Locations

Ground water monitor wells are also required to characterize water quality above and below the saltwater interface and to monitor the location of the saltwater interface. These monitor wells (CF1-7 through CF1-11) are designed to be constructed using 6-inch diameter PVC casing and screen to allow for the upgrade to an extraction well should the future need arise. Prepack well screen may be used for some of these wells to determine the site-specific performance. Wells proposed for monitoring water quality and the location of the saltwater interface are also included in Table 3.

Well CF1-7 is proposed to be located adjacent to the existing MOA-480/-481/-482 cluster and is designed to monitor the elevation of the saltwater interface. A well screened between 30-ft and 45-ft in depth is necessary to provide a more complete data set as evident from the cross section shown in Figure 8. As previously mentioned, the interface is inferred to be located at a depth of approximately 30 to 55-ft bgs. CF1-7 screened from 30 to 45-ft bgs is proposed in order to ensure that the interval where the saltwater interface is expected to fluctuate can be monitored.

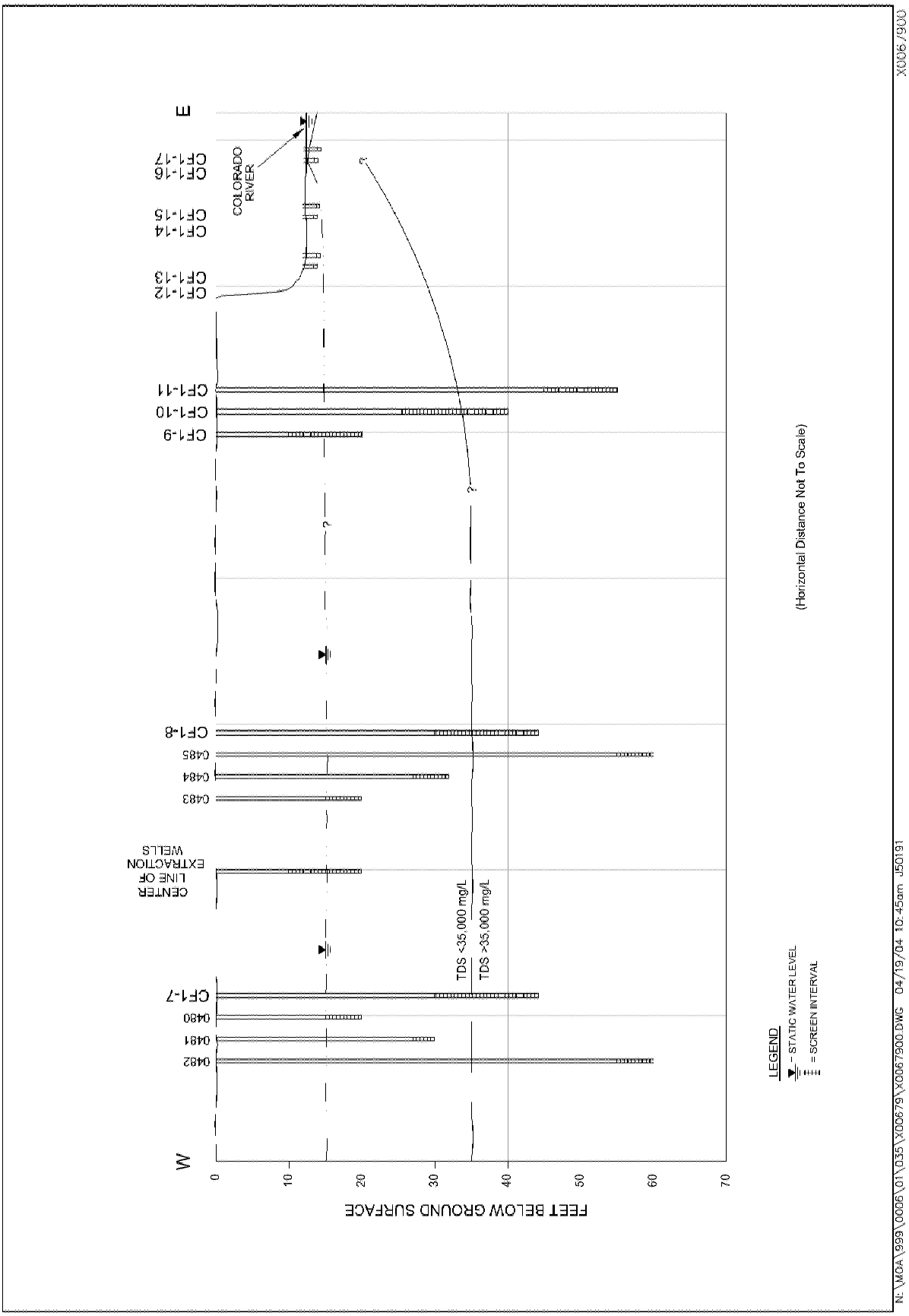

Figure 8. Cross Section View of Well Screen Intervals and Depths of Existing and Proposed Wells in Configuration 1

Well CF1-8 is proposed to be located adjacent to the MOA-483/-484/-485 cluster and would serve the same function as well CF1-7 for the MOA-480/-481/-482 cluster. It will also be installed to a depth of 45 ft bgs and screened from 30 to 45 ft bgs.

A new observation well cluster (CF1-9 through CF1-11) is proposed to be installed approximately 60-ft east of the centerline of the extraction field. This would place the cluster approximately 45-ft downgradient of the MOA-483/-484/-485 cluster and approximately 10-ft west of the riverbank drop off. CF1-9 would be installed at a depth of 20 ft and screened from 10 to 20 ft bgs. CF1-9 may be installed as a 1-inch diameter monitor well as a cost savings. The objective of this well is to monitor the shallow pumping zone and monitor chemical changes. CF1-10 is proposed to be screened from 25 to 40-ft bgs to monitor the interface elevation and chemistry and well CF1-11 is proposed to be screened from 45 to 55-ft bgs to monitor concentrations within the brine.

Task 2. Install Piezometers

Temporary small diameter piezometers that are designed for sampling ground water from specific depth intervals are proposed for installation between the riverbank drop off and the shoreline of the river. Samples collected from these piezometers would provide chemical data from the ground water discharging into the river and provide a method to measure the vertical flow gradient at these locations. Description of the locations and rationale for the proposed small diameter piezometers is presented in Table 3.

Two piezometers are proposed for installation at each of the three areas located between the riverbank drop off and the shoreline as shown in Figure 8. Two piezometers at each location will allow for the collection of ground water samples from two distinct depths (i.e. from 0.5 to 1 ft bgs and from 4.5 to 5 ft bgs). CF1-12 and CF1-13 will be installed at the base of the riverbank drop off. CF1-14 and CF1-15 will be located half the distance between the riverbank drop off and the edge of the river (the exact distance off the riverbank will be determined in the field due to the changing stage of the river). CF1-16 and CF1-17 will be installed below the river near the shoreline in water that is less than 2 ft deep. Again, this configuration assumes the river stage is less than bankfull.

Task 3. Data Collection

Data collected through this sampling will improve the understanding of ground water and surface water interactions and help locate the intersection of the saltwater interface with the riverbed during active remediation. Baseline samples will be collected for hydrologic and chemical parameters at the locations listed in Table 3 before system startup (it is assumed this task would apply prior to 2005 startup period for the newly installed monitoring network; 2004 startup of the extraction system will occur before these new wells are installed). This one-time event will include water levels, field parameters, and laboratory analysis for all monitor wells, extraction wells, and observation wells.

Hydrologic and chemical performance data will also be collected from these locations during routine operation of the system. Sampling the piezometers will progress from on-shore to the off-shore river location. A surface water sample will be collected above the ground water sampling location at the off-shore location.

Troll 8000 units may be installed in monitor wells CF1-13 and -15 to continually monitor the elevation of the saltwater interface. Mini-Trolls may be installed in monitor wells CF1-1, -6, and -10 to continuously monitor water levels.

Sampling procedures and analytical requirements for the baseline characterization and routine operations are provided in Section 8. Sampling frequency requirements are summarized in Table 4.

Table 4. Sampling Frequency Requirements for Configuration 1

Location	Field Parameters	Laboratory Analysis	Water Levels
Monitor wells (CF1-1 through CF1-11)	Quarterly	Quarterly	Quarterly
Piezometers (CF1-12 through CF1-17)	Quarterly	Quarterly	Quarterly
Surface Water	Quarterly	Quarterly	N/A

Sampling procedures, frequency, and analytical requirements for the existing extraction and monitor wells are specified in the operations plan (DOE 2004b). Extraction well flow rates for the Configuration 1 system will initially be operated according to the guidance provided in the operations plan (DOE 2004b). Operating rates may be increased or decreased after examination of the preliminary performance data. The observational approach will be used to establish and adjust operating parameters as necessary to evaluate the specific objectives for this configuration.

Task 4. Reporting

Baseline and operational data collected under Task 3 will be used to evaluate the performance of the system. Chemical and hydrologic effects of system operation on the aquifer will be evaluated. A performance assessment report will be prepared that addresses the specific objectives for this configuration.

End of current text

6.0 Configuration 2

The purpose of Configuration 2 is two fold: (1) remove contaminant mass from the aquifer by extraction and (2) dilution of ammonia concentrations in the backwater habitat by injection of clean water into the aquifer in an area close to the Colorado River. Configuration 2 wells are proposed north of Configuration 1. When functioning as extraction wells, they would remove mass from areas that currently contribute ammonia to the backwater areas as shown in Figure 3. The extraction system would operate similar to the existing Configuration 1 system. The same Configuration 2 extraction wells would also serve as injection wells when the evaporation system is not operating during the fall and winter months.

The expected result of operating Configuration 2 as extraction wells with the primary purpose of mass removal is shown conceptually in Figure 6. Operation of the Configuration 2 system at higher pumping rates than the current Configuration 1 rates would result in a growth of the cone of depression. It is possible that operating an extraction system at high pumping rates could pull the saltwater interface closer to the backwater areas and result in increased ammonia and TDS loading in those areas. It is also possible that an extraction system located closer to the riverbank could result in a reversal of the ground water flow gradients near the west bank of the river and introduce clean river water into the near bank backwater areas and reduce ammonia concentrations by dilution. Dilution would only occur in the shallow ground water because underflow of the pumped zone would continue transporting ammonia toward the riverbed. The expected result of operating Configuration 2 at higher flow rates to manipulate the ground water flow gradients near the river is shown conceptually in Figure 9. Monitoring data collected during operation at higher rates would demonstrate the extent to which the system can affect ground water flow gradients and the position of the saltwater interface.

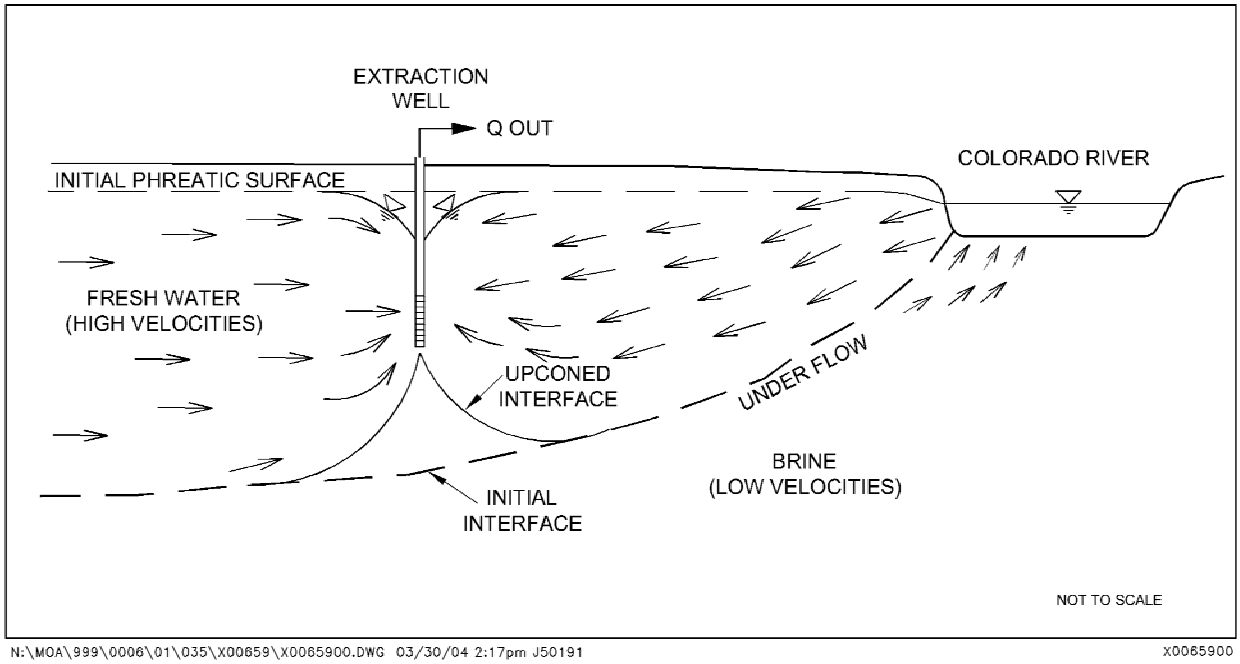

Figure 9. Effect of Operating Configuration 2 Extraction Wells for the Purpose of Mass Removal and Gradient Manipulation to Reverse Ground Water Flow Gradients Near the River

A conceptual depiction of the effect of operating the Configuration 2 system with only clean water injection is shown in Figure 10. Mounding of clean water at the injection well would provide a hydraulic barrier between the ammonia plume and the river. It is possible that if injection were to occur near the Colorado River, advection and dispersion of the clean water would depress the saltwater interface and move the ground water discharge of the ammonia plume farther toward the east and beneath the Colorado River. Clean water discharging to the near shore backwater areas would provide dilution of ammonia concentrations and thereby improve the quality of the surface water.

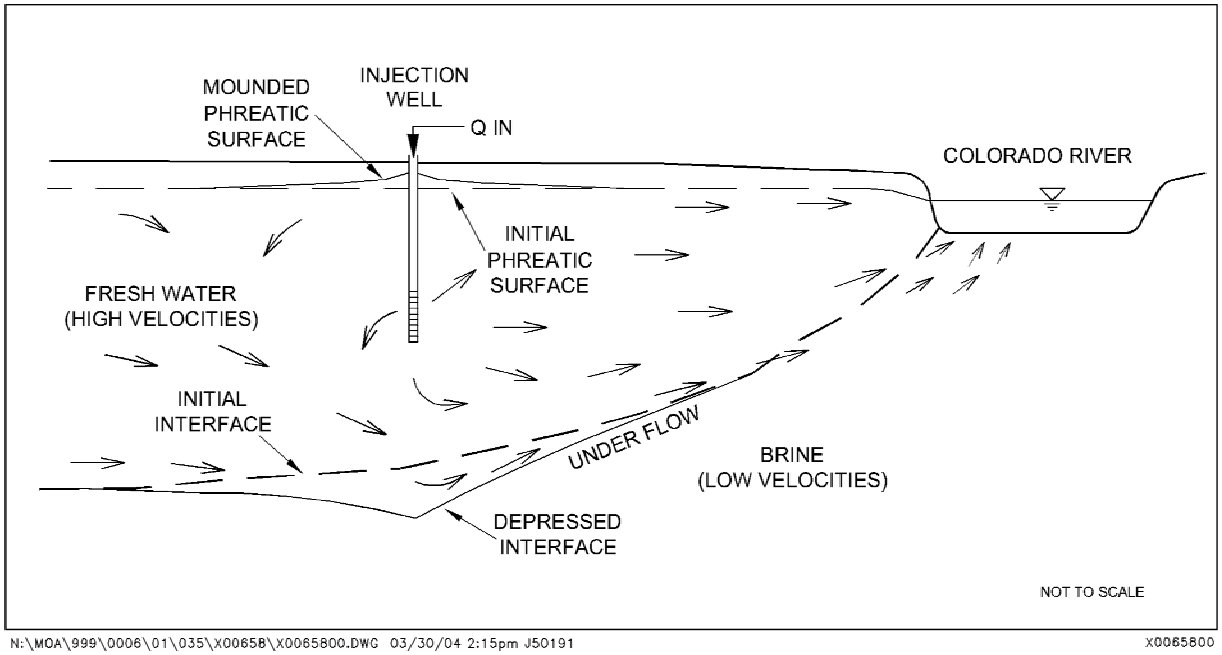

Figure 10. Conceptual Model of Hydraulic Barrier by Injection of Clean Water in Configuration 2

6.1 Specific Objectives

Specific objectives for the extraction wells are the same as those listed in Section 5.1 for Configuration 1. Injection wells associated with the Configuration 2 system are designed to answer several questions:

- What injection rates are required to reduce concentrations of ammonia in backwater areas?
- Is there an optimal injection rate? Is the rate dependent on river stage?
- Will operation of the injection system only during critical times of the year be adequate for protecting backwater areas? Or is it better to inject year-round?
- What is the relationship between the required injection rate and river stage? (If this is known, injection can be adjusted strictly on the basis of river elevations).
- Does the injection system affect the ability of the legacy ammonia plume to naturally flush from ground water?

6.2 Design for Configuration 2

Ground water modeling was performed to develop the conceptual design for Configuration 2. Two ground water models were used: SEAWAT 2.1 (Guo and Langevin 2002) and FEFLOW 5.0 (Diersch 2002). SEAWAT, which is a variable-density, finite-difference flow simulator, was used for two-dimensional (2D) and three-dimensional (3D) simulations of ground water withdrawal and injection and to evaluate the effects those stresses on TDS concentrations and the location of the saltwater interface. The original SEAWAT model developed for the Moab site is described in Appendix D of the Site Observational Work Plan (SOWP) (DOE, 2003).

FEFLOW, which is a variable-density, finite-element simulator, was used as a 3D constant-density model of the freshwater system only. Because the variable-density capability was inactive in the FEFLOW model, the saltwater interface was assumed to behave as a stationary no-flow boundary. The original FEFLOW model developed for the Moab site is described in Chapter 7 of the SOWP (DOE, 2003). The FEFLOW model was used in this study to evaluate the general effects of well spacing, screen depth, and flow rates on ground water streamlines and ammonia concentrations. Both the SEAWAT and FEFLOW modeling studies are described in more detail in the calculation 04−2004−02−05−00 (DOE 2004d).

A variety of well configurations were examined with these simulators, all of which were generally based on the schemes illustrated conceptually in Figure 9 and Figure 10. Outcomes from the modeling indicate that application of fresh water near the bank of the Colorado River would probably reduce ammonia concentrations in the backwater habitat portions of the Colorado River and, consequently, improve the habitat for aquatic species that reside there.

Proximity of the water table to the ground surface is one of the limitations to the amount of habitat improvement that could be realized. The water table is about 3 to 4 meters below ground surface (bgs) near the river's west bank; consequently, mounding from the injection should be limited to about 1 to 2 meters to avoid surface discharge of the ground water.

As with other alluvial systems, the alluvium comprising the aquifer at the Moab site is stratified. As a result, hydraulic conductivities vary with depth. The stratification also means that, at each point in the ground water system, the aquifer exhibits strong anisotropy, with the effective hydraulic conductivity in the vertical direction being perhaps 10 to 100 times smaller than the horizontal hydraulic conductivity. Under such conditions, the ability to drive fresh water deep into the system can be severely impeded. For this reason, use of injection wells placed at strategic depths, rather than an infiltration trench, would probably be the best method to deliver fresh water to desired subsurface locations.

Subject to the constraint of a 3 to 4-m deep vadose zone, the 3D model indicated that the upper flow limit for each injection well is approximately 20 gpm. The actual injection rates that are achievable may be considerably lower than this value given that the efficiency of injection wells is often reduced due to screen clogging, both by suspended solids and dissolved biomass in the injection water. Site-specific testing is recommended to determine the maximum possible injection rate.

Cross-Sectional SEAWAT Simulations of Density-Dependent Flow

The original 2D SEAWAT model was altered slightly to investigate the effects of injection and withdrawal on heads and TDS concentrations beneath the critical habitat area. This facilitated a more robust evaluation of stream-aquifer interactions. The main changes were: (1) the inactive cells beneath the eastern half of the Colorado River were activated resulting in a model that was approximately 500 feet longer than before; and (2) the vertical distribution of aquifer materials was revised to reflect recent drill hole data. A set of trial simulations was also conducted using a refined grid between the injection area and the backwater habitat.

The location of the SEAWAT cross-sectional model is presented in Figure 11 and the model is described in further detail in the calculation 04−2004−02−05−00 (DOE 2004d). Given the constraints of a cross-sectional model, injection is most appropriately simulated using a prescribed-head boundary condition. Using this approach, a series of three simulations were made to mimic the behavior of an injection source (single well) positioned at successively greater depths and about 20 meters from the bank of the Colorado River. The depths of the simulated injection were 2.25 m, 4.5 m, and 9 m below land surface. Results of the flow modeling showed that during injection, the velocities of ground water beneath the backwater habitat area are significantly higher than in the baseline model. This suggests that if injection were to occur near the Colorado River, advection and dispersion would drive the TDS-laden ground water farther to the east beneath the Colorado River. Transport modeling results, presented in Table 5, show that TDS concentrations beneath the backwater habitat area would decline significantly with the passage of time, provided that clean water is injected into the gravelly unit. These data are graphically shown in Figure 12.

Table 5. SEAWAT 2D Predictions of TDS Concentration Beneath the Backwater Habitat for Selected Injection Scenarios

Configuration 2 Scenario	Predicted TDS Concentration (kg/m^3)					
	0 day	30 day	60 day	90 day	180 day	365 day
Baseline	30.3	30.3	30.3	30.3	30.3	30.3
1m Prescribed Head Layer 1	30.3	24.9	17.6	13.8	9.3	7.5
1m Prescribed Head Layer 3	30.3	14.2	6.7	4.4	2.5	1.2
1m Prescribed Head Layer 5	30.3	12.2	5.0	3.0	1.6	1.1

Three-Dimensional FEFLOW Model

Simulations of extraction and clean water injection were performed with the 3D FEFLOW model. Separate simulations were performed for extraction and injection at each of the well locations. The dual-purpose wells are located on a line along the riverbank road just west of the river on approximately 10-meter centers (33-ft) just north of the existing Configuration 1 system. The location of the simulated well field is shown in Figure 13.

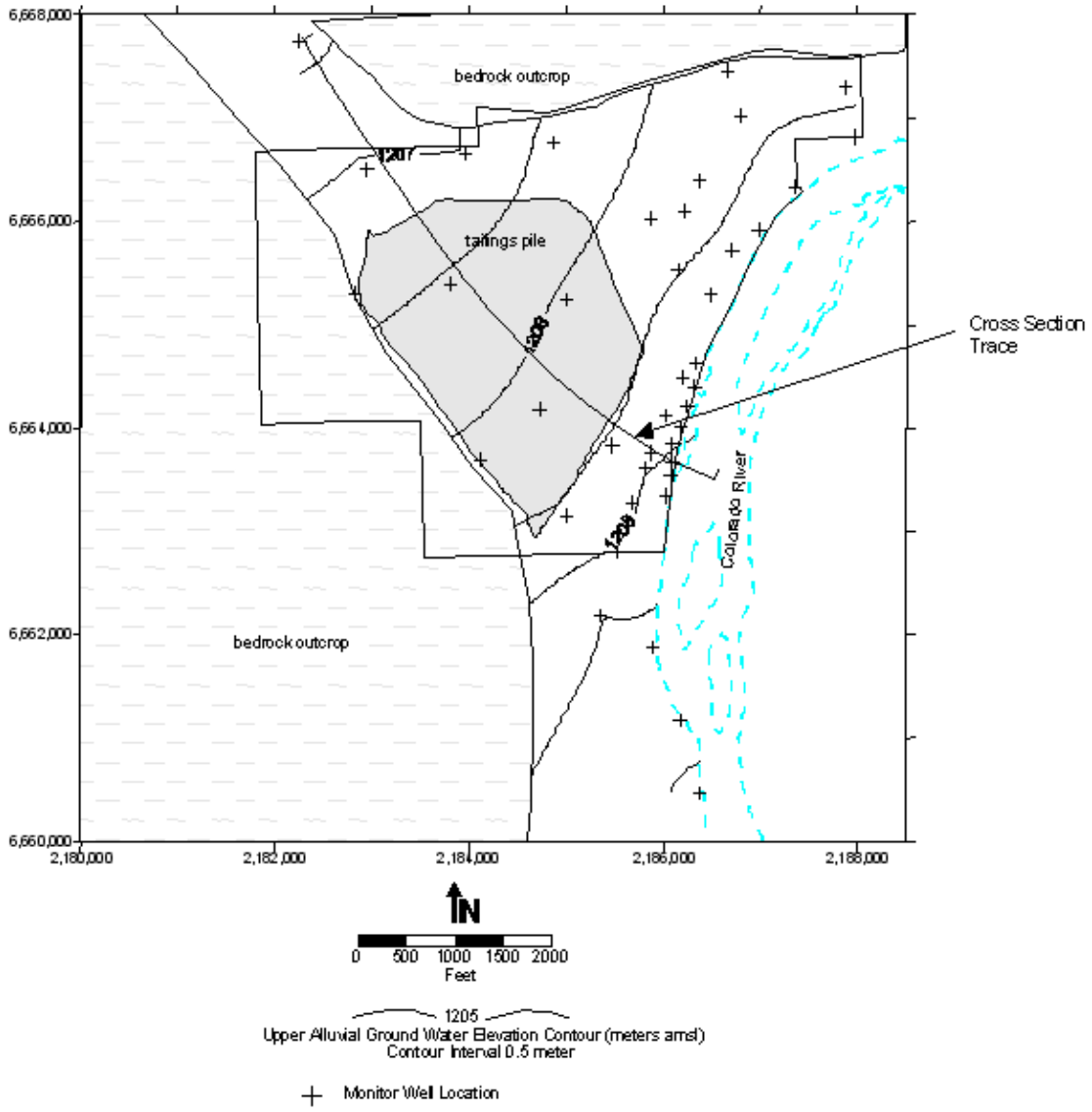

Figure 11. Location of SEAWAT 2D Cross Section Model

The well field was modeled either as extraction wells at a combined rate of 75 gpm or as clean water injection wells at a combined rate of 75 gpm. Model results indicate the extraction wells would cause ground water flow paths to converge in the area of the well field as shown in Figure 14, thus yielding a net reduction in the ammonia mass reaching the Colorado River. Injection of clean water is predicted to decrease ammonia concentrations near the backwater habitat areas. Particle tracking results indicate the mounding would cause the ground water flow paths to diverge around the well field as shown in Figure 15, thus discharging clean water to the backwater areas.

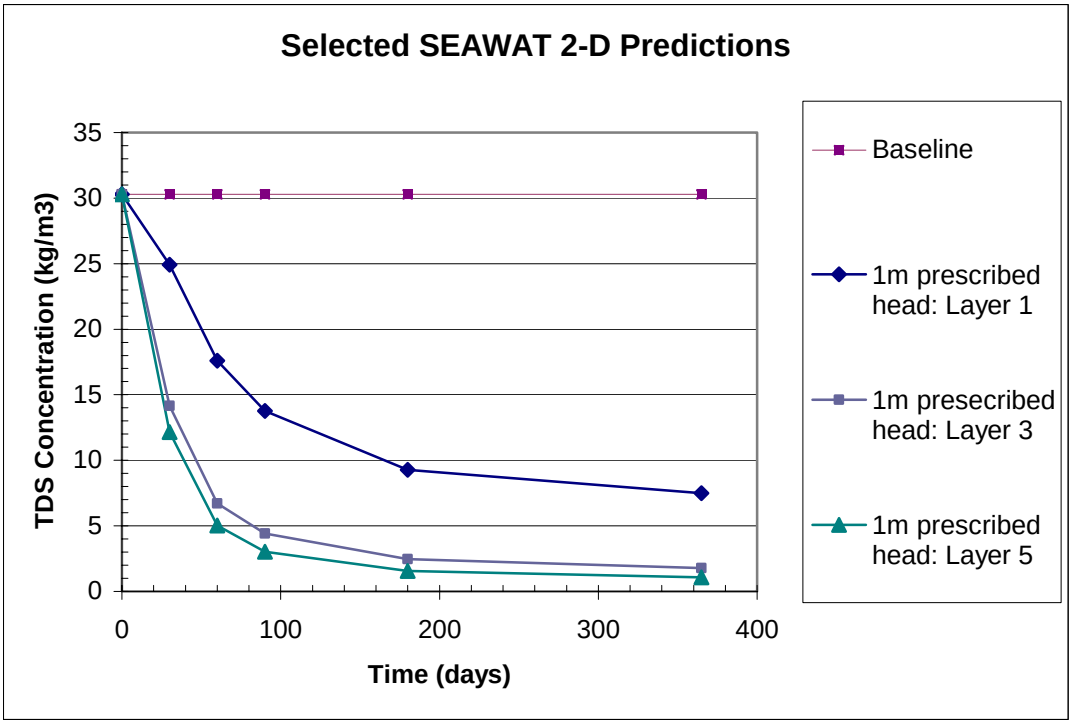

Figure 12. Time-Concentration Plot for Three Injection-Depth Scenarios

Figure 13. Conceptual Layout of Dual-Purpose Injection and Extraction Wells for Configuration 2

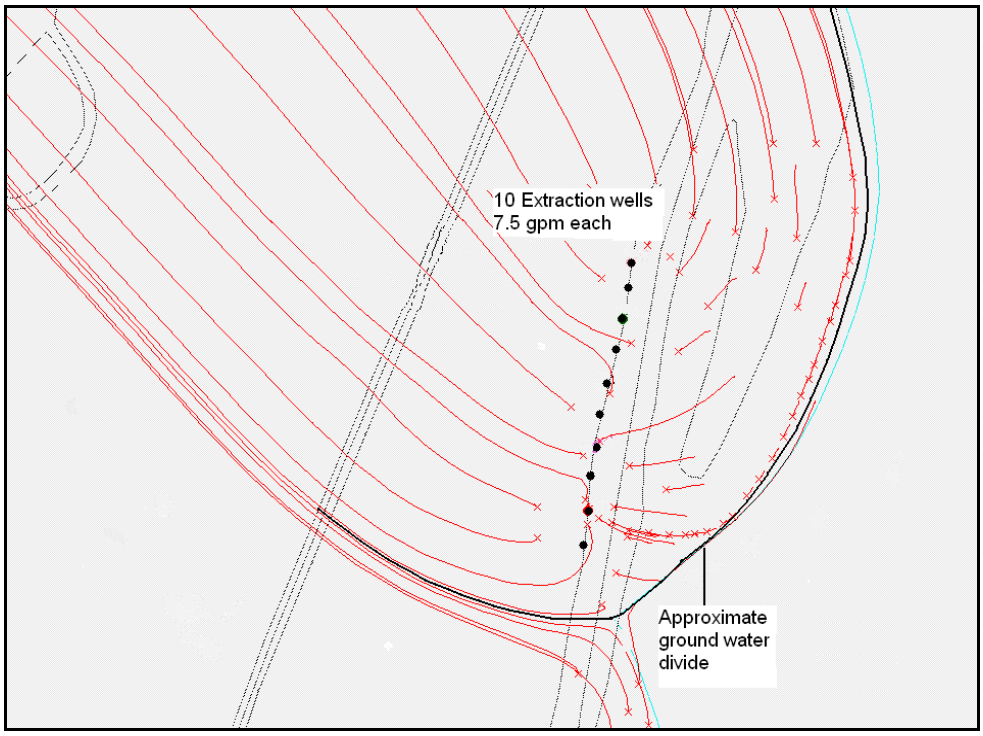

Figure 14. Particle Tracking Results Showing Ground Water Flow Directions Associated with Operating Configuration 2 as Extraction Wells

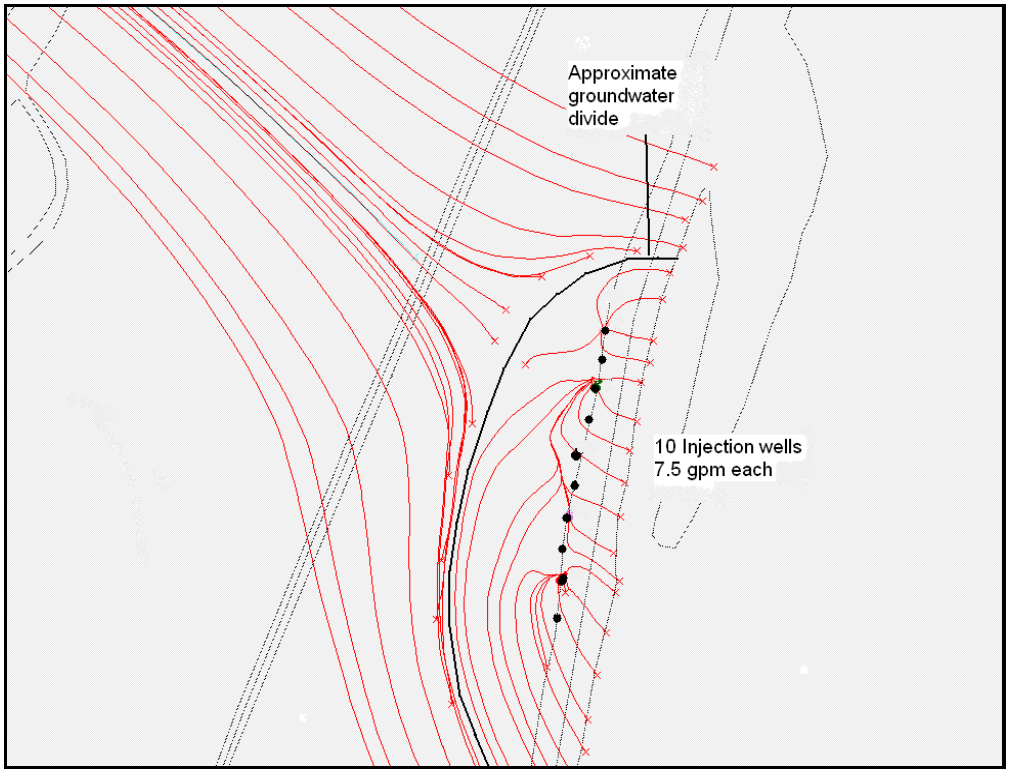

Figure 15. Particle Tracking Results Showing Ground Water Flow Directions Associated with Operating Configuration 2 as Clean Water Injection Wells

SEAWAT 3D Density-Dependent Modeling

Simulations were also performed using a 3D version of the SEAWAT density-dependent model discussed in Appendix D of the SOWP (DOE 2003a). The model used in this case was shorter than the original, extending up gradient to a point below the eastern portion of the tailings. Boundary conditions along the upstream extent of the revised model, in the form of prescribed flows and associated TDS concentrations, were derived from original model results. The SEAWAT model was extended north-to-south by using 13 rows, each of which was 10 m wide. Uniform properties were assigned to the model, taking into account the revised spatial distribution of the upper fine-grained unit adopted for the 2D density dependent modeling. Column spacing in this model was refined in the zone encompassing the west bank of the river so that (1) injection wells could be located more accurately than was the case with the original 2D model, and (2) the spatial distribution of ground water discharge to the river could be better described.

Several test runs were performed with the model to produce steady-state distributions of clean water head and TDS concentrations that approximately conformed to currently observed conditions. To achieve this goal, the total volumetric rate of evapotranspiration from the tamarisk grove was reduced to 60% of the rate adopted in the original 2D model (DOE 2003a). The resulting model produced a saltwater interface surface that intersected the river very close to its west bank and located at a depth of about 45 ft bgs at a distance from the river equivalent to the location of the current extraction well system.

One of the simulations performed with the SEAWAT 3D density dependent model examined the effects of a single well injecting clean water at a continuous rate of 16 gpm. This model run attempted to approximately account for the effects of one of the ten injection wells proposed as a result of the 3D FEFLOW modeling. The injection well in this case was located about 50 ft away from the river's west bank. The screen for the injection well was assumed to lie between 20 and 40 ft bgs.

Results from simulation of a 16 gpm injection rate for a single well indicated that the injection scheme would be effective in diverting contaminated water laterally. In addition, the time needed to create a clean water zone beneath the west bank of the river was limited to about 30 days. This latter result was in accordance with the observation that the 16 gpm of injection produced computed horizontal pore-water velocities that exceeded 2 ft/day in the immediate vicinity of the injection well.

A map view of the degree of water-table mounding that was predicted by the model after 30 days of continuous injection at a rate of 16 gpm is provided in Figure 16. Data presented in this figure suggests that mild amounts of mounding will be observed in the immediate vicinity of the injection well. However, these results are deceiving because the relative model grid block in which the well is placed is too large to accurately reflect head losses associated with radially diverging flow from an injection well. Assessment of mounding due to radially diverging flow is presented in more detail in calculation 04−2004−02−05−00 (DOE 2004d).

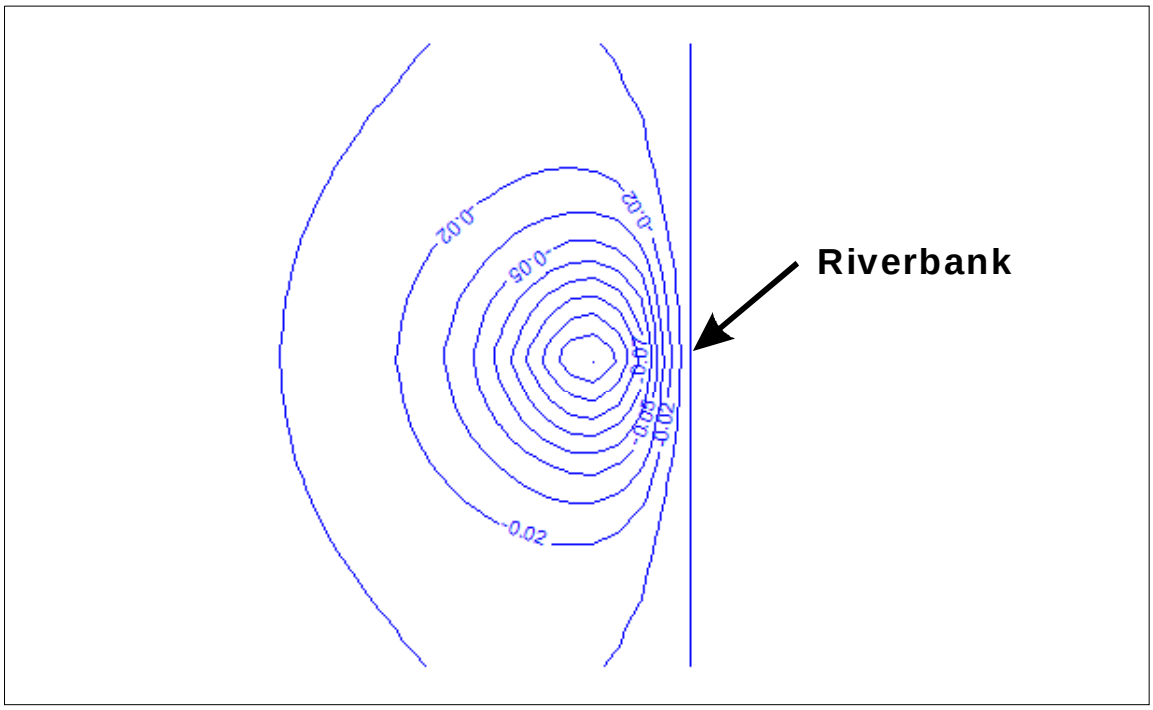

Figure 16. Map View of Computed Mounding (feet) After 30 Days of Continuous Injection Into a Single Well at a Rate of 16 gpm

The data also suggests that mounding from injection will extend north and south of the injection to the no-flow model boundaries, which are located about 215 ft away from the injection well. Consequently the degree of mounding and the ability of injected clean water to move the location of brine discharge to the river farther eastward are larger than would be predicted if the modeling domain were wider. However, these boundary effects are expected to be minor.

A cross-sectional view of predicted TDS concentrations after 30 days of injection at a rate of 16 gpm is shown in Figure 17. The cross section in this case is aligned with a streamline passing directly through the injection well. These results indicate that TDS concentrations at the base of the river near its west bank would be well below the brine threshold (TDS = 35,000 mg/L = 35 kg/m^3), making it possible for contaminant concentrations to be quite diluted in backwater areas.

Given the possibility that the efficiency of each injection well might be reduced due to well screen clogging, an additional model run was made with the 3D density dependent model to evaluate the influence of a single well injecting at a rate of 4 gpm. This latter simulation suggested that it was possible to produce relatively dilute contaminant concentrations in the ground water discharging to backwater areas in the event that design injection rates could not be achieved. However, the time taken to reach such conditions was about 120 days, which was considerably longer than that required using a single well injecting at a rate of 16 gpm. A map view of the water-table mounding levels produced in the model after 120 days of a single-well injection at a rate of 4 gpm is shown in Figure 18. A cross-sectional view of computed TDS levels at this time along the streamline passing through the injection well is shown in Figure 19.

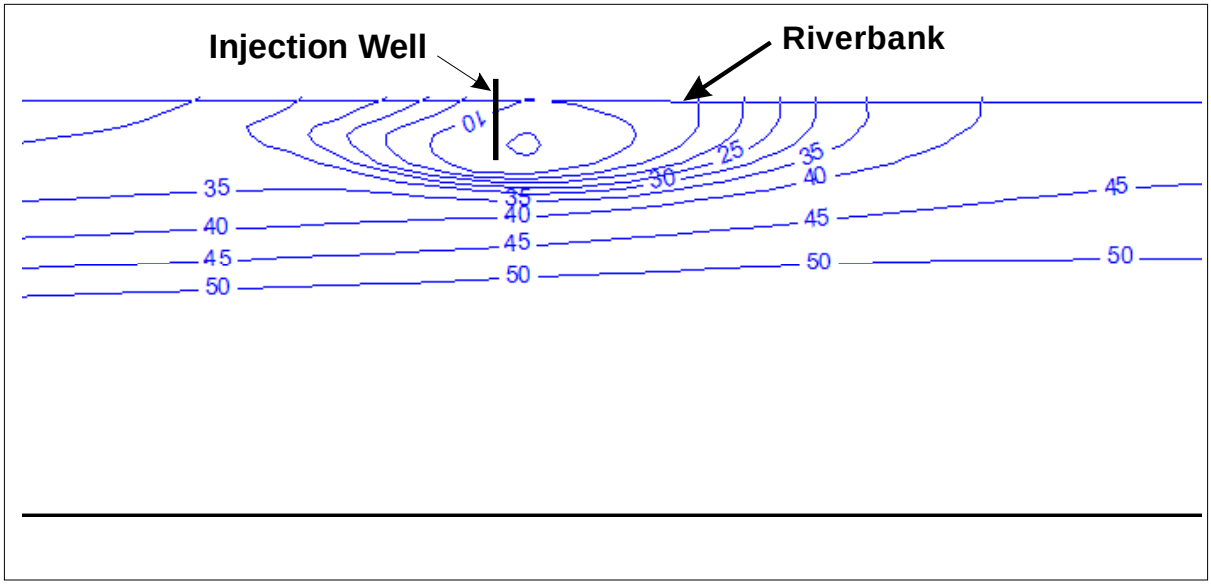

Figure 17. Cross-Sectional View of Computed TDS Concentrations (kg/m^3) After 30 Days of Continuous Injection into a Single Well at a Rate of 16 gpm

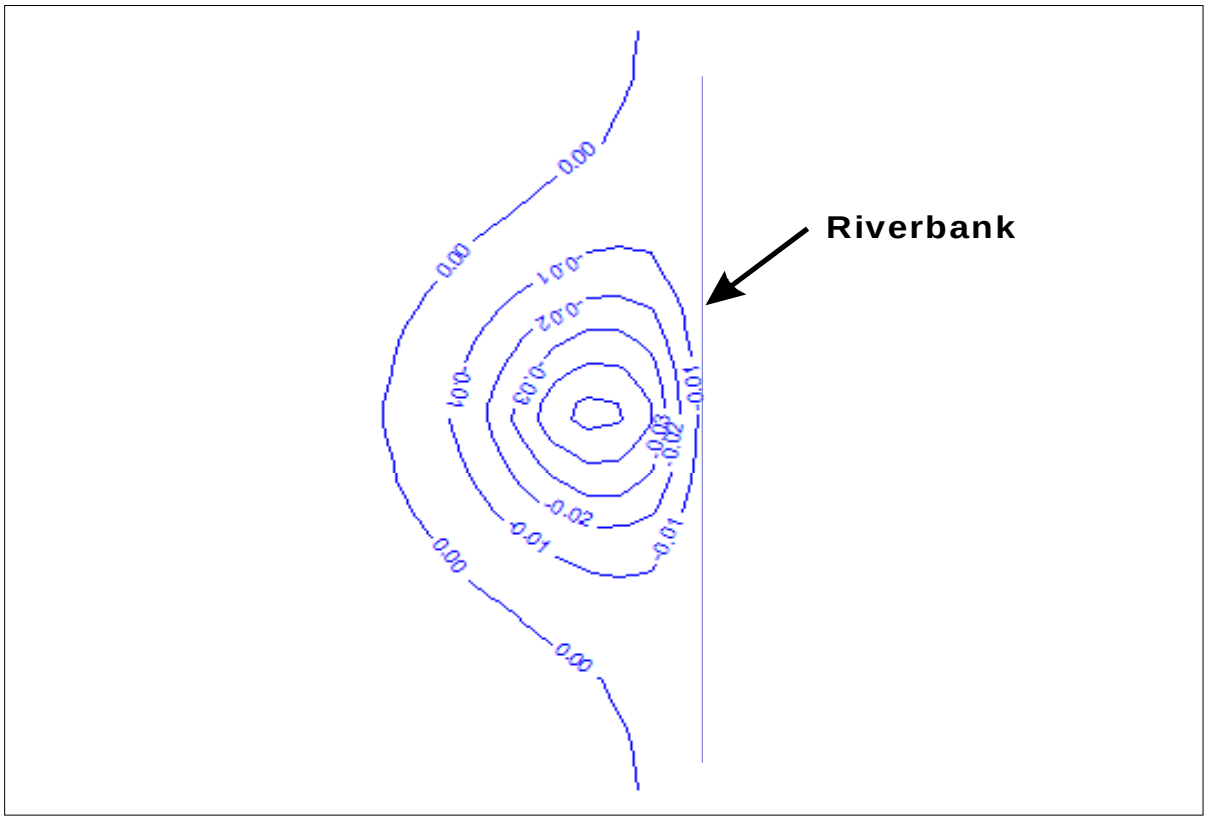

Figure 18. Map View of Computed Mounding (feet) After 120 Days of Continuous Injection Into a Single Well at a Rate of 4 gpm

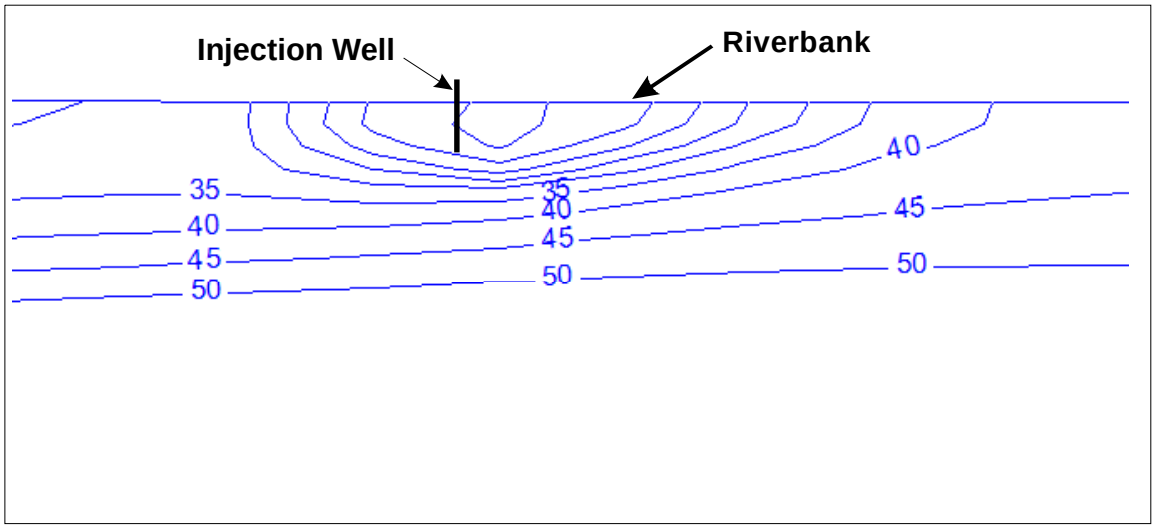

Figure 19. Cross-Sectional View of Computed TDS Concentrations (kg/m^3) After 120 Days of Continuous Injection into a Single Well at a Rate of 4 gpm

6.3 Configuration 2 Tasks

Task 1. Engineering Design

Construction plans and specifications will be prepared based on an engineering design of Configuration 2. The plans and specifications will be of sufficient detail so that the project can be competitively bid out to and constructed by construction contractors. The plans and specifications will provide the necessary detail to construct the system infrastructure and will include any necessary pretreatment requirements, settling basin, piping system, well injection details, extraction well pump details and necessary electrical power connections and controls. Field activities, such as infiltration tests to determine injection rates and area of influence and tests to determine pumping rates will be used in the engineering design to perform the hydraulic analysis and properly size the pumps and piping.

Task 2. Install Injection and Extraction Wells

The configuration and number of injection and extraction wells is based on the modeling previously described. Ten dual-purpose injection and extraction wells are proposed for installation, as shown on Figure 20. Design components proposed for the Configuration 2 wells are summarized in Table 6. Screen intervals and locations are summarized in Table 7.

The depth of the 10 dual-purpose wells will alternate between 30 and 40-ft below ground surface (bgs) as presented in Table 7. For example, the first well in the field will be installed with the top of the screen beginning near the contact between the base of the upper fine-grained unit and the top of the lower gravel unit, which ranges from 15 to 20-ft below ground level. The second well in the field will be installed with the top of the screen in the gravel unit, approximately 25-ft bgs. A 15-ft screen length is recommended for all the wells. The remaining 8 wells in the field will alternate screen depths in this manner.

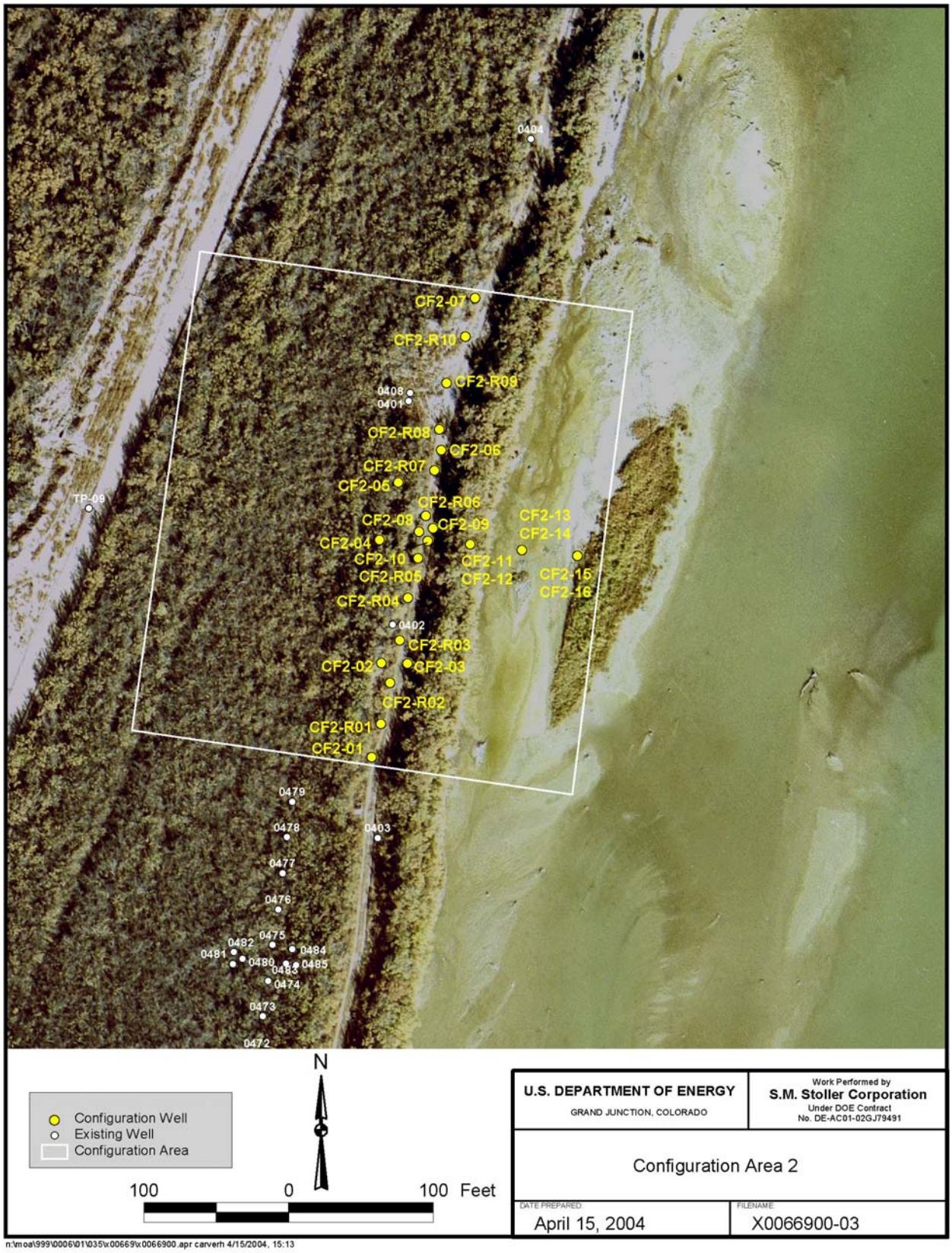

Figure 20. Map View of Proposed Location of Dual-Purpose Remediation Wells and Monitor Wells for Configuration 2

Table 6. Conceptual Design Criteria for Dual-Purpose Remediation Wells for Configuration 2

Design Parameter	Criterion
Well diameter	6-inch
Well screen	Vee-wire
Screen slot size	0.010 – inch
Sand pack	10/20
Screen length	20 ft
Screen material	PVC
Total well depth	30 to 40-ft (bls)
Flow rate	2 – 20 gpm injection 3 – 30 gpm extraction

Table 7. Screen Intervals and Locations of Dual-Purpose Remediation Wells for Configuration 2

ID	Screen Interval (ft bgs)	Well Type	Location	Purpose
CF2-R1	15 to 30	6-inch diameter dual-purpose injection and extraction well	Remediation wells located on 30-ft centers along the riverbank road north of Configuration 1	Ground water extraction and mass removal of ammonia from aquifer or clean water injection, hydraulic barrier, and ammonia dilution in river water
CF2-R2	25 to 40			
CF2-R3	15 to 30			
CF2-R4	25 to 40			
CF2-R5	15 to 30			
CF2-R6	25 to 40			
CF2-R7	15 to 30			
CF2-R8	25 to 40			
CF2-R9	15 to 30			
CF2-R10	25 to 40			

Injection of clean water at a rate between 2 and 20 gpm is recommended. Introduction of clean water into this portion of the aquifer would deflect the flow paths of ground water that would normally discharge at this location, and replace that water with higher quality ground water.

Site characterization data have shown that the ammonia concentrations increase with depth near the Colorado River and attain maximum levels near the saltwater interface. Ground water extraction focused on mass removal is therefore proposed for this horizon. Extraction pumps would be operated at a rate between 3 and 30 gpm each, depending on the available evaporative capacity in the evaporation pond and the conductivity of the aquifer. A cross section view of well screens intervals and depths of existing and proposed wells in Configuration 2 is presented in Figure 21.

Task 3. Install Monitor Wells

A combination of existing and new monitor wells are proposed to assess performance of the system (Figure 20). Small diameter monitor wells, CF2-1 through CF2-8, are proposed to be installed to a depth of 20 ft bgs and completed with a screen from 10 to 20 ft bgs. These wells, designed to monitor the cone of depression generated by the extraction wells or the mounding from the clean water injection, will be constructed using a minimum of 1-inch diameter PVC to allow for monitoring instrumentation. Proposed small diameter monitor well locations for Configuration 2 are presented in Figure 20 and summarized in Table 8.

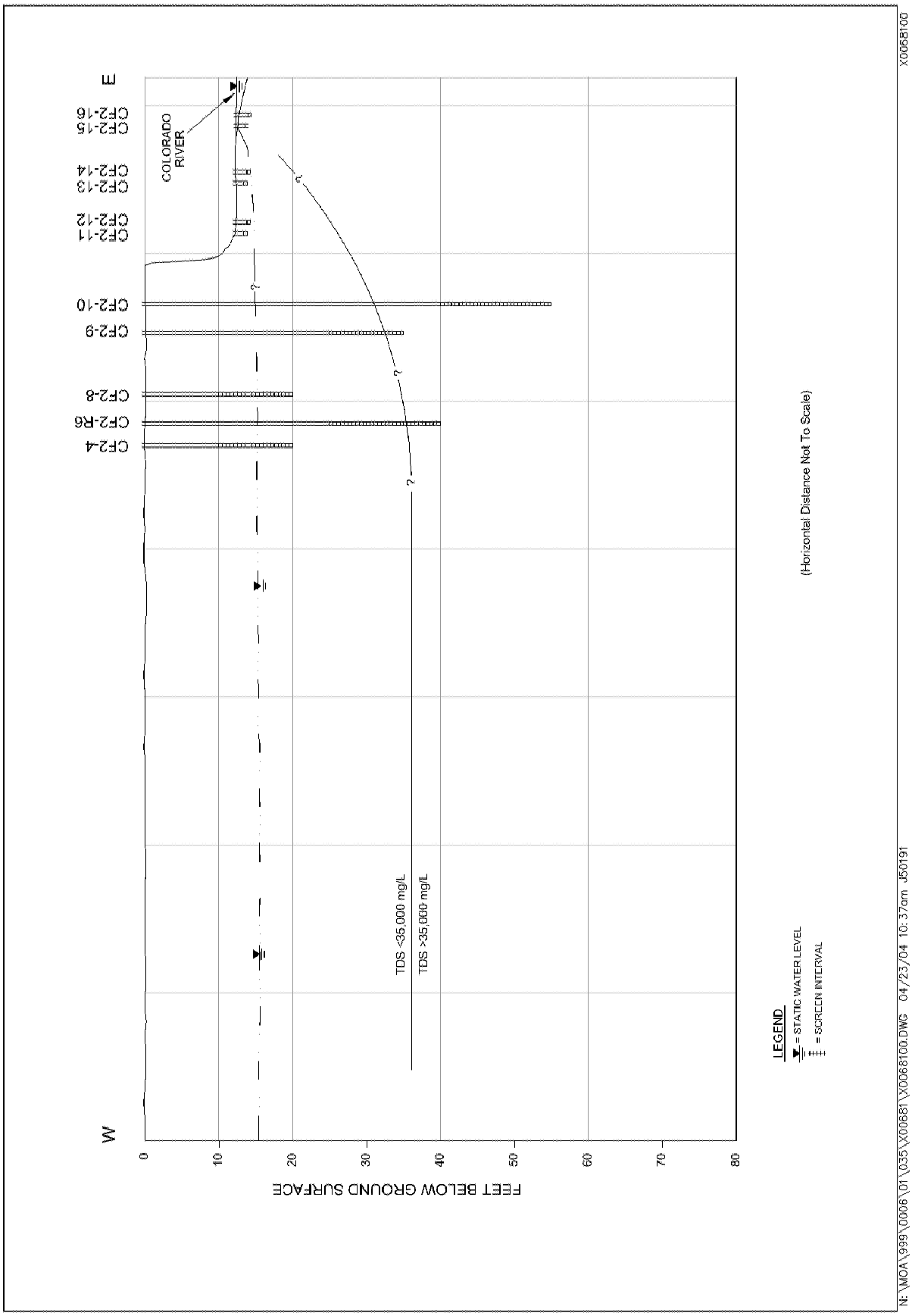

Figure 21. Cross Section View of Well Screen Intervals and Depths of Proposed Wells in Configuration 2.

Table 8. Proposed Monitor Wells for Configuration 2

ID	Screen Interval (ft bgs)	Well Type	Location	Purpose
CF2-1	10 to 20	1-inch diameter monitor well	30 ft south off southern end of well field	Measure extent of well field cone of depression and injection mound
CF2-2			30 ft west of well field	
CF2-3			East side of riverbank road	
CF2-4			30 ft west of well field	
CF2-5				
CF2-6				
CF2-7			30 ft north off northern end of well field	
CF2-8			East side of riverbank road	
CF2-9	25 to 35	6-inch diameter monitor well	10 ft off well 402	Collect chemical/water level data of ground water near river
CF2-10	40 to 55			Monitor elevation of brine interface, chemical data
CF2-11	0.5 to 1	Small diameter piezometer	At the base of the riverbank drop off	Monitor shallow ground water chemistry and vertical gradients east of the riverbank
CF2-12	4.5 to 5			
CF2-13	0.5 to 1		Half way between the riverbank drop off and shoreline	
CF2-14	4.5 to 5			
CF2-15	0.5 to 1		Beneath river water near shoreline	
CF2-16	4.5 to 5			

Monitor wells CF2-9 and CF2-10 are proposed to be installed using 6 inch diameter casing and screen to allow for the upgrade to an extraction well should the future need arise. Monitor well CF2-9 is designed to provide ground water chemical data from the 25 to 35 ft bgs interval. Monitor well CF2-10 is designed to monitor the saltwater interface and provide ground water chemical data from the 40 to 55 ft bgs interval. Locations proposed for the six-inch monitor wells and the small diameter monitor well for Configuration 2 are presented in Figure 20 and summarized in Table 8.

Task 4. Install Piezometers

Temporary small diameter piezometers are proposed to be installed in the riverbed perpendicular to the shoreline to sample shallow ground water immediately beneath the river and to monitor ground water discharge and vertical flow gradients to the river (Figure 20 and Figure 21). It is proposed that 3 sets of nested small diameter piezometers (CF2-11 through CF2-16) will be installed. A description of the locations and rationale for the proposed small diameter piezometers is presented in Table 8. The first nested set of piezometers (CF2-11 and –12) would be installed at the base of the riverbank drop off. The second nest of piezometers (CF2-13 and –14) would be installed approximately half the distance between the first nest and flowing river water. The third set of piezometers (CF2-15 and –16) would be installed below the river near the shoreline in water that is less than 2 ft deep. Again, this configuration assumes the river state is less than bankfull.

Task 5. Data Collection

The monitoring network and procedures to evaluate the performance of Configuration 2 is designed to ascertain ground water flow directions and ammonia concentrations in relationship to the saltwater interface. Concentrations in the Configuration 2 area during pumping or clean water injection would also be compared to the pre-startup concentrations and to the baseline area to evaluate its effectiveness. Monitoring would be conducted using monitor wells and an array of piezometers identical to that used in Configuration 1 and the baseline area; however, because the distance to the riverbank is subject to the transient changes in the edge of the Colorado River, a replication of the monitoring geometry at each site might not be achievable.

Water level data, field parameters, and samples for laboratory analysis will be collected at the monitor wells, piezometers, and remediation wells before the system is started, at startup, and during operation. A Troll 8000 unit may be installed in monitor well CF2-14 to continually monitor the elevation of the saltwater interface.

Ground water sampling at the small diameter piezometer nests will progress from on-shore to off-shore. A surface water sample will be collected from immediately above the ground water sampling location at the off-shore nest. Data collected through this sampling will improve the understanding of ground water and surface water interactions and help determine the areal extent over which injection of clean water is influencing river water quality.

The startup will be performed in a two phased approach; the first phase will consist of operating the system only as extraction wells followed by the second phase which will consist of operating the system as clean water injection wells during the period when the evaporation system is not in operation. The observational approach will be used to establish and adjust operating parameters as necessary to evaluate the specific objectives for this configuration. Sampling and analysis requirements are presented in Section 8. Sampling frequency requirements for operation of Configuration 2 are presented in Table 9.

Table 9. Sampling Frequency Requirements for Configuration 2

Location	Field Parameters	Laboratory Analysis	Water Levels
Remediation wells (CF2-R1 through -R10)	Quarterly	Quarterly	Quarterly
Monitor wells (CF2-1 through -10, MOA-401, -402, and -408)	Quarterly	Quarterly	Quarterly
Piezometers (CF2-11 through -16)	Quarterly	Quarterly	Quarterly
Surface water	Quarterly	Quarterly	N/A

7.0 Project Requirements

7.1 Personnel and Equipment

Sampling will be conducted according to standard sampling protocols and procedures (see Section 8.0). Standard equipment and methods will be employed.

7.2 Environmental Compliance

Additional information (from that given in this section) on environmental compliance, waste management, and emergency response is in the Moab HSP (DOE 2003c). Low volumes of waste water will be generated from sampling activities. Purge water from sampling will be managed by spreading the ground water evenly on the ground surface around the well. Water will not be dispersed onto surface areas that will enable the water to flow into Moab Wash or the Colorado River. Other regulatory requirements are summarized in Table 10.

Table 10. Regulatory Requirements for Field Activities

Task/Activity	Regulation	Requirement
All field activities	NEPA	Categorical Exclusion
Wells greater than 30 ft deep	State water well drillers (UAC Title 655)	• Well construction performed by Utah licensed driller • Permit required
Injection well installation and operation	State UIC program	Permit by rule; notify State with description of proposed well
Wells less than 30 ft deep and shallow piezometers	None	None
Use of clean water for injection	Colorado River water rights	Use existing non-consumptive water right (01-40)

7.3 Health and Safety

Information on health and safety, and emergency response is in the Moab HSP (DOE 2003c). The site-specific HSP has been prepared for the Moab Project in accordance with the requirements of 29 CFR 1910.120. All activities performed in association with well drilling, sampling, and monitoring of ground water and surface water will be performed according to the site-specific health and safety requirements developed for this task (DOE 2003c).

End of current text

8.0 Sampling and Analysis

Water samples will be submitted to a commercial laboratory for analyses of the constituents listed in Table 11. In addition to the chemical constituents listed in Table 11, standard field parameters will also be measured.

Table 11. Analytes and Methods for Ground Water and Surface Water Samples

Analyte	Sample Container	Preservation	EPA Method	Detection Limit	Line Item Code (LIC)
Ammonia- N	125 mL poly	HNO_3, pH < 2	350.3	0.1 mg/L	WCH-A-006
Chloride	500 mL poly	Cool, 4° C	300	0.5 mg/L	WCH-A-011
Sulfate			300	5 mg/L	WCH-A-036
TDS	125 mL poly	Cool, 4° C	160.1	10 mg/L	WCH-A-033
Uranium	500 mL poly	HNO_3, pH < 2	GJO-1	0.1 µg/L	GJO-1
Field parameters include: alkalinity, dissolved oxygen, redox potential, pH, specific conductance, turbidity, temperature					

8.1 Sampling Procedures

Water sampling will be performed in accordance with the *Ground Water and Surface Water Sampling and Analysis Plan for GJO Projects* (DOE 2002b) and the *Grand Junction Office Environmental Procedures Catalog* (GJO 6). Deviations from these procedures will be noted in a field variance log with an explanation and a description of its possible impacts on data quality. The following specific procedures from the Environmental Procedures Catalog will be used for water sampling:

- GT-1(P), “Standard Practice for Field Documentation Processes.”
- GT-2(P), “Standard Practice for Sample Labeling.”
- GT-3(P), “Standard Practice for Chain-of-Sample-Custody and Physical Security of Samples.”
- LQ-2(T), “Standard Test Method for the Measurement of Water Levels in Ground Water Monitoring Wells.”
- LQ-3(P), “Standard Practice for Purging Monitoring Wells.”
- LQ-4(T), “Standard Test Method for the Field Measurement of pH.”
- LQ-5(T), “Standard Test Method for the Field Measurement of Specific Conductance.”
- LQ-6(T), “Standard Test Method for the Field Measurement of the Oxidation-Reduction Potential (Eh).”
- LQ-7(T), “Standard Test Method for the Field Measurement of Alkalinity.”
- LQ-8(T), “Standard Test Method for the Field Measurement of Temperature.”
- LQ-9(T), “Standard Test Method for the Field Measurement of Dissolved Oxygen.”
- LQ-10(P), “Standard Practice for the Use of a Flow Cell for Field Measurements.”
- LQ-24(T), “Standard Test Method for Turbidity in Water.”

- LQ-11(P), “Standard Practice for the Sampling of Liquids.”
- LQ-12(P), “Standard Practice for the Collection, Filtration, and Preservation of Liquid Samples.”
- LQ-19(P), “Standard Practice for the Inspection and Maintenance of Ground water Monitoring Wells.”

8.2 Sample Quality Assurance and Control

The objective of sample quality assurance and control measures is to provide systematic control of the tasks to maximize accuracy, precision, comparability, and completeness. All procedures will be checked for accuracy through internal laboratory quality control checks such as the analysis of blind duplicates, splits, and known standards. Analytical methods to be used for the water samples are summarized in Table 11. Sample preservation will consist of storing the samples in a cooler with ice during field sampling, sample packaging, and shipping.

To maintain evidence of authenticity, the samples collected must be properly identified and easily discernible from other like samples. A label will be attached to the sample container specifying the sample identification number, location, date collected, time collected, and the sampler’s name.

Water samples will be kept under custody from the time of collection to the time of analysis. Chain-of-custody records will be used to list all transfers in the possession of the samples. The chain-of-custody form will show that the sample was in constant custody between collection and analysis. While the samples are in shipment to the analytical laboratory, custody seals will be placed over the cooler opening to ensure that the integrity of the samples have not been compromised. The receiving laboratory must examine the seals on arrival and document that the seals are intact. Upon opening the container, the receiving laboratory will note the condition of the sample container (e.g. broken bottles, leaking bottles, etc.).

All sample shipments will be made in compliance with Department of Transportation regulations (49 CFR 171-179) governing shipment of hazardous materials and substances. These regulations govern the packaging, documentation, and shipping of hazardous material, substances, and waste. Special care will be taken to ensure the integrity of the sample through proper packaging and shipping. To determine the proper identification of a hazardous sample, field personnel will review field measurements data and field notes for relevant information concerning the sample material in a container. This information will include field radiological scans and any other information that might be useful in classifying the sample for shipment. If a sample is known or suspected to contain a specific hazardous material, the sampler will note its presence on the sample label. This information is important to the receiving laboratory to determine the proper handling of the sample prior to its analysis.

9.0 Routine Reporting

After laboratory analysis is complete, results of each sampling event will be reported in a data validation package. This package will include trip reports with all habitat description forms attached. Data collected during these sampling events will subsequently be analyzed to help refine dilution estimates, make habitat availability estimates and potential impacts, assess effectiveness of ground water remediation, and refine long-term remediation objectives, among other uses. Evaluation and interpretation of the data can be reported in calculation sets, annual reports, as supplements to data validation packages, or some other reporting mechanism(s).

End of current text

10.0 References

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