DRAFT FINAL REPORT

OFF-SITE GROUNDWATER FEASIBILITY STUDY

IOWA ARMY AMMUNITION PLANT MIDDLETOWN, IOWA

Prepared for
U.S. Army Corps of Engineers
Omaha District

March 2004

URS

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List of Acronyms and Abbreviations

>	Greater Than
≥	Greater Than or Equal To
<	Less Than
µg	Microgram(s)
%	Percent
AEC	Atomic Energy Commission
AO	American Ordnance
ARAR	Applicable or Relevant and Appropriate Requirement
bgs	Below Ground Surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	Cubic Feet Per Second
COC	Chemical of Concern
COPC	Chemical of Potential Concern
DC	Direct Current
DERP	Defense Environmental Restoration Program
DO	Dissolved Oxygen
DoD	Department of Defense
EBCT	Empty Bed Contact Time
EB	Enhanced Biodegradation
EDB	Enhanced Degradation Barrier
EPA	See USEPA
FFA	Federal Facilities Agreement
FS	Feasibility Study
ft	Foot or Feet
ft^2	Square Feet
ft^3	Cubic Feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
g	Gram(s)
GAC	Granular Activated Carbon

gal	Gallon(s)
gpm	Gallons Per Minute
GRA	General Response Action
HAL	Health Advisory Level
HDPE	High-Density Polyethylene
Hg	Mercury
HGL	HydroGeoLogic, Inc.
HI	Hazard Index
HRC™	Hydrogen Release Compound
IAAAP	Iowa Army Ammunition Plant
IAC	Iowa Administrative Code
JMC	Joint Munitions Command
kg	Kilogram(s)
K_{oc}	Organic Carbon/Water Partition Coefficient
L	Liter(s)
lb	Pound(s)
MCL	Maximum Contaminant Level
mg	Milligram(s)
mL	Milliliter(s)
MNA	Monitored Natural Attenuation
mol	Mole(s)
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
pCi	Picocurie(s)
PM_{10}	Particulate Matter Less Than 10 Microns
POTW	Publicly Owned Treatment Works
ppb	Parts Per Billion
ppm	Parts Per Million
PRB	Permeable Reactive Barrier
PRG	Preliminary Remediation Goal
PRP	Potentially Responsible Party

RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine; a common military explosive
RI	Remedial Investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SWDA	Solid Waste Disposal Act
TBC	To Be Considered
TCE	Trichloroethene
TMV	Toxicity, Mobility, and Volume
URS	URS Group, Inc.
USACE	United States Army Corps of Engineers
USATHAMA	United States Army Toxic and Hazardous Materials Agency
USC	United States Code
USCA	United States Code Annotated
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UV	Ultraviolet
VOC	Volatile Organic Compound
WES	Waterways Experiment Station

This document is the Feasibility Study (FS) report for Off-Site groundwater at the Iowa Army Ammunition Plant (IAAAP) near Middletown, Iowa. The location of IAAAP is shown on **Figure 1-1**.

1.1 AUTHORITY

The IAAAP facility has a Federal Facility Agreement (FFA), dated September 20, 1990 with the United States Environmental Protection Agency (USEPA) Region VII. The FFA requires the monitoring of releases of contaminants into groundwater and surface water, as well as identifying the migration pathways. Groundwater monitoring and environmental investigations at IAAAP, including those for Off-Site groundwater, are being completed under the Department of Defense's (DoD's) Defense Environmental Restoration Program (DERP).

URS Group, Inc. (URS) has been contracted by the United States Army Corps of Engineers (USACE), Omaha District under Contract No. DACA45-96-D-0017, Delivery Order Number 0063, to complete an FS to evaluate remedial alternatives for Off-Site groundwater at IAAAP. The completion of this delivery order includes the preparation of this FS report.

1.2 PURPOSE AND SCOPE

The purpose of this FS is to identify and evaluate alternatives for remedial action for Off-Site groundwater at IAAAP. Using the results of the remedial investigation (RI) (URS 2003), the FS develops remedial action objectives (RAOs), identifies and screens technologies, develops remedial alternatives, and evaluates remedial alternatives in a detailed analysis. The FS is the basis for recommending to the public a technically feasible and cost-effective remedial action that is protective of human health and the environment.

It should be noted that this FS develops and evaluates alternatives to address Off-Site groundwater only. As described in **Section 2**, the surface water within Brush Creek is a source of groundwater contamination in the Off-Site area. It is generally recognized that Brush Creek surface water needs to be addressed to help achieve RAOs for Off-Site groundwater; however, development and evaluation of alternatives to address Brush Creek surface water is outside the scope of this FS and will be completed as a separate project, pursuant to the FFA schedule and dispute resolution of February 2004. Instead, groundwater alternatives are evaluated under two different scenarios, one where surface water is remediated to the same target levels as groundwater and one where no action is taken and levels of contamination in surface water remain the same as currently observed. However, any groundwater action taken prior to addressing Brush Creek surface water would be considered an interim remedial action for groundwater.

For the purposes of discussion, this FS report presents information on Brush Creek, including levels of contaminants detected, flow characteristics, and potential cleanup goals. In addition, some non-source control measures for Brush Creek surface water are conceptually evaluated and provided as **Appendix D**. These could eventually be developed into remedial alternatives and compared to source-control measures, once an investigation is completed for Brush Creek surface water that identifies the actual sources. More information on Brush Creek surface water, as it pertains to the Off-Site Groundwater FS, is provided in the appropriate sections of this report.

1.3 FEASIBILITY STUDY PROCESS

The FS process consists of the following general steps, as taken from USEPA (1988):

- Develop RAOs that specify the contaminants and media of concern, exposure pathways, and preliminary remediation goals (PRGs). PRGs are based on chemical-specific applicable or relevant and appropriate requirements (ARARs), other available information (e.g., reference doses), and site-specific risk-related factors.
- Develop general response actions (GRAs) (e.g., containment, extraction, treatment, disposal) that may be taken to satisfy the RAOs for the site for each medium of concern.
- Identify volumes or areas of media to which GRAs may be applied.
- Identify and screen technologies applicable to each GRA based on technical implementability. Further define GRAs to specify remedial technology types.
- Identify and evaluate technology process options based on effectiveness, implementability, and cost, to select a representative process for each technology type.
- Assemble the selected representative technologies into alternatives representing a range of GRA combinations, as appropriate.
- Where numerous options have been identified, screen alternatives based on the criteria of effectiveness, implementability, and cost, to reduce the number of alternatives to analyze in detail.
- For detailed analysis, evaluate retained alternatives based on nine criteria:
  - Overall protection of human health and the environment
  - Compliance with ARARs
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, and volume (TMV)
  - Short-term effectiveness
  - Implementability
  - Cost
  - State or support agency acceptance
  - Community acceptance

Agency and community acceptance are assessed following comment on the FS report and proposed plan.

1.4 REPORT ORGANIZATION

This report is organized as follows:

Section 1 presents the authority, purpose and scope, FS process, and report organization.

Section 2 presents background information on the IAAAP facility and Off-Site area, taken primarily from the Off-Site Groundwater RI Report (URS 2003).

Section 3 presents the development of RAOs.

Section 4 presents the identification and screening of remedial technologies and process options.

Section 5 presents the development of remedial action alternatives.

Section 6 presents the detailed analysis of remedial action alternatives.

Section 7 presents uncertainties and assumptions of the Off-Site Groundwater FS.

Section 8 describes the remedy selection process and summarizes the preferred remedial alternative for Off-Site groundwater.

Section 9 presents the references used for the FS report.

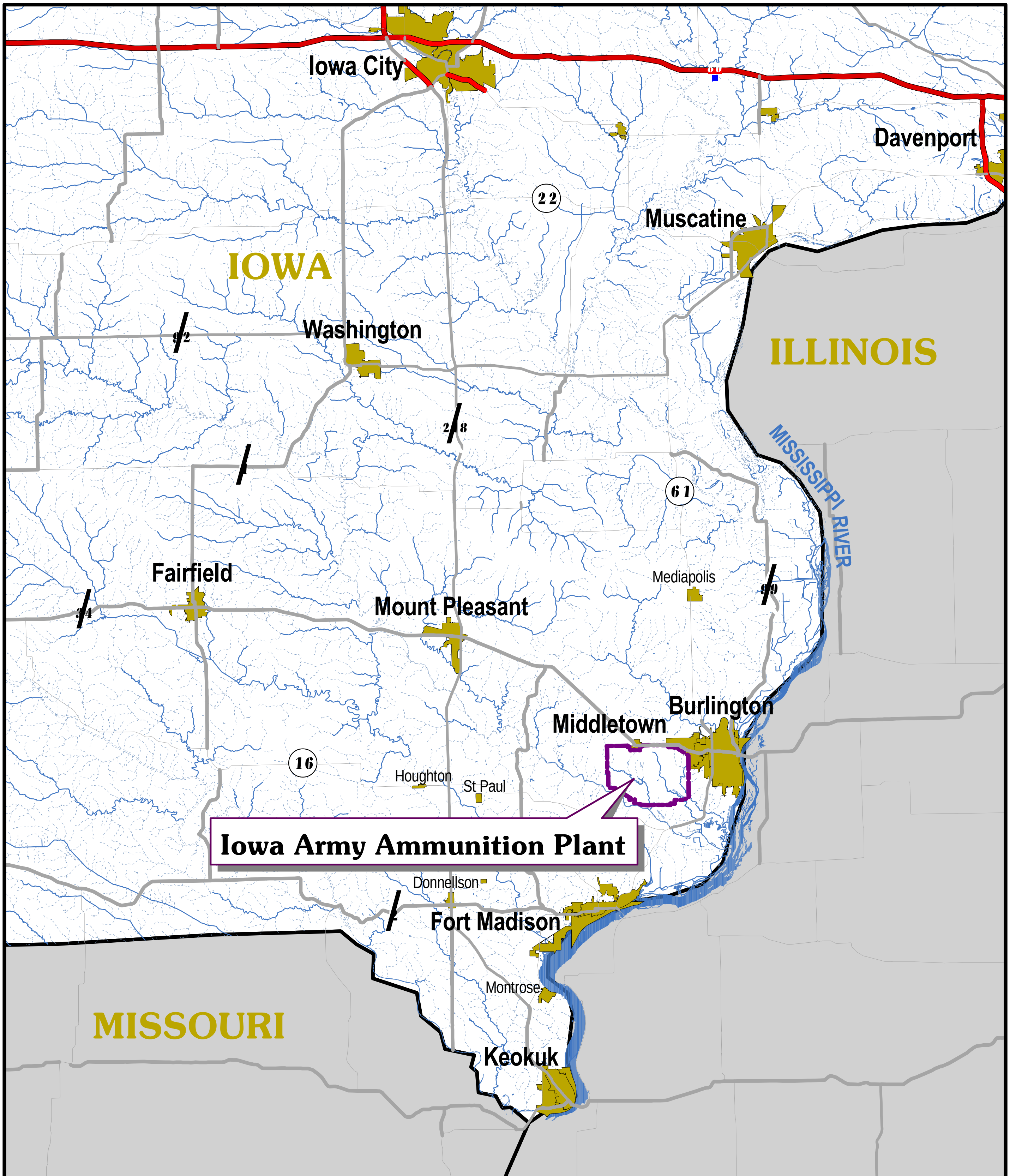
Appendix A presents the conceptual design calculations used to support the FS.

Appendix B summarizes groundwater flow and contaminant fate and transport modeling performed for the screening of process options and development/evaluation of remedial action alternatives.

Appendix C presents the feasibility-level cost estimate for each remedial action alternative developed for Off-Site groundwater.

Appendix D presents conceptual non-source control measures for Brush Creek surface water.

Appendix E presents the analytical results and conclusions of November 2003 Off-Site groundwater and surface water sampling and analysis for total and isotopic uranium.



Datum: North American Datum 1983
Coordinate: Iowa State Plane South (feet)

Z:\IowaAAP\IAAP\Off-Site\off-site_FS.apr [Fig 1-1]

N

0 60000 120000
Feet

0 6 12 18
Miles

URS

FACILITY LOCATION MAP
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DLC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: JMR	DATE: 09/23/03	16169419	1-1

This section presents background information for the Off-Site groundwater study area, including facility/site description and history, previous investigations and reports, the physical site characteristics, chemicals of potential concern (COPCs), nature and extent of contamination, contaminant fate and transport, and human health risk assessment. Information is taken primarily from the Off-Site Groundwater RI report (URS 2003).

2.1 FACILITY DESCRIPTION AND HISTORY

IAAAP is a government-owned, contractor-operated facility under the command of the United States Army Joint Munitions Command (JMC), Rock Island, Illinois. The current operating contractor is American Ordnance (AO). Production of munitions began in 1941, and the facility remains in operation. Production activities at IAAAP currently include loading, assembling, and packaging of munitions, including projectiles, mortar rounds, warheads, demolition charges, anti-tank mines, and anti-personnel mines. The loading, assembling, and packaging operations use explosive materials and lead-based initiating compounds.

IAAAP occupies 19,015 acres adjacent to the town of Middletown in Des Moines County, Iowa (**Figure 2-1**). IAAAP is bordered by U.S. Highway 34 to the north, upland agricultural farms to the east and west, and the Skunk River Valley to the south. Surface topography is characterized by flat-to-gently rolling uplands dissected by entrenched streams and rivers. Approximately one-third of the IAAAP property is occupied by active or formerly active production or storage facilities. Sites include surface impoundments, production lines, landfills, disposal areas, burn areas, demolition areas, and a fire training area. The remaining land at IAAAP is either woodlands or leased for agricultural usage. **Figure 2-1** shows site locations, creeks, and other features of interest.

Wastewater generated at various plant facilities and effluent from wastewater treatment plants are discharged to surface streams under the provisions of a National Pollutant Discharge Elimination System (NPDES) permit. Munitions production at the IAAAP resulted in discharges of wastewater containing explosives and explosives by-products onto soil and into surface water. Explosives contaminants migrated through the soil into the groundwater and also over land into surface water (e.g., Brush Creek). Moderate amounts of volatile organic compound (VOC) contamination in soil and groundwater have also been identified at the facility.

Other potential contributors to contamination at IAAAP include former Atomic Energy Commission (AEC) activities, which, within the Brush Creek watershed, reportedly occurred at Line 1 only (**Figure 2-1**). Contaminants of concern that may have resulted from these activities include various radiological constituents.

2.2 OFF-SITE DESCRIPTION AND HISTORY

The Off-Site area is located southeast of the IAAAP facility and approximately three miles south of Burlington, Iowa on Highway 61 (**Figure 2-2**). The Off-Site area occupies the Brush Creek watershed south of the facility and portions of the Skunk River floodplain (**Figure 2-3**).

Explosives used during production, assembly, burning, or demolition at IAAAP are a potential source for chemical release. Reportedly, untreated wastewater generated by these activities was discharged directly to surface water during the early stages of IAAAP operation. Until implementation of surface water discharge permits and construction of the industrial water treatment plant in the 1970s, surface water concentrations of explosives were reported to have ranged from 18 to 36 parts per million (ppm) at the plant boundary (USATHAMA 1980). Explosives compounds may also have inadvertently been transferred to surface water and sediment via spills, leaking containers, incomplete combustion or detonation, and stormwater runoff. Indirect product discharges to Brush Creek have resulted in the contamination of the surface water and sediment (streambed). Contaminated surface water infiltrates through the soil/sediment to groundwater in the Off-Site area near Highway 61.

In 1993, the presence of explosives above health risk-based levels in Off-Site groundwater was confirmed after an initial round of private drinking water well sampling was completed by the USEPA. IAAAP contracted to connect private residences in the contaminated area to the public water supply. This removal action, completed in the fall of 1994, was designed to eliminate the future exposure to contaminated drinking water. In 2001, IAAAP provided connections to the public water supply for several homeowners who had declined in 1994. Private well locations within the Off-Site groundwater study area, including 1992–2002 results, are shown on **Figure 2-3**.

Since 1999, Off-Site groundwater investigations have included four phases of field sampling activities, one RI, and one groundwater monitoring event. **Table 2-1** summarizes soil, surface water/sediment, and groundwater contamination investigations completed for the Off-Site study area since 1999. Previous investigations and reports include the following:

- 1999 Phases I and II Supplemental Investigation Off-Site Groundwater, Surface Water, and Sediment (Harza 2000a)
- 2000 Phase III Supplemental Off-Site Groundwater Investigation (Harza 2000b)
- 2001 Phase IV Supplemental Off-Site Groundwater Investigation (Harza 2001a)
- 2001–2002 Off-Site Groundwater RI (URS 2003)
- 2002 Groundwater Monitoring (HydroGeoLogic [HGL] 2003)

In addition, to address concerns about possible impacts to Off-Site groundwater resulting from past AEC activities at IAAAP, 28 groundwater samples and 12 surface water samples were collected from the Off-Site area in November 2003 and analyzed for both total and isotopic uranium by the USACE St. Louis District under the Formerly Utilized Sites Remedial Action Program (FUSRAP). Analytical results, including a description of the methodology, are presented in **Appendix E**. The conclusion of these analyses was that isotopic ratios are not consistent with those expected of depleted uranium and that detected uranium was likely naturally occurring. Screening of these results for selection of COPCs is discussed in **Section 2.4**.

2.3 PHYSICAL SITE CHARACTERISTICS

This discussion summarizes physical site characteristics for the IAAAP Off-Site study area, including topography and surface features, geology, hydrogeology, and surface water/groundwater relationships.

2.3.1 Topography and Surface Features

The study area extends southeast of the IAAAP property along a corridor generally parallel to Brush Creek, intersecting Highway 61 (**Figures 2-2** and **2-3**). The study area also occupies portions of the Skunk River/Mississippi River floodplain, bounded to the north by a topographic bluff, or upland, forming the limit of the floodplain. Brush Creek, Spring Creek, and a few small tributaries dissect the upland area and empty onto the Skunk River floodplain. The downstream reach of Brush Creek, which flows south into the Skunk River, has been rerouted from its original course, which was east toward the Mississippi River. Wetlands, ponds, and sloughs occupy the eastern portion of the floodplain, which extends westward to the Highway 61 bridge.

The Skunk River floodplain is primarily agricultural/rural residential land, with some minor commercial activity. The Skunk River/Mississippi River floodplain is relatively broad, extending to the Mississippi River four miles south of the Skunk River.

2.3.2 Geology

The study area includes three different geologic profiles: an upland profile, a transition zone profile, and a lowland profile, as shown on **Figure 2-4**. Section A-A' (**Figure 2-5**) shows the general stratigraphy across the Off-Site groundwater study area in a north-to-south direction, based on data from soil borings completed at the site. The subsurface geology of the upland, transition zone, and lowland profiles is described in the following subsections.

Upland Profile

The subsurface geology of the upland profile, as determined from direct push soil borings, generally consists of:

- Silty clay glacial till from the ground surface to about 82 feet below ground surface (bgs)
- Sand and gravel glacial outwash from about 82 to 88 feet bgs
- Deep glacial till or bedrock units below about 88 feet bgs

Transition Zone Profile

The subsurface geology of the transition zone profile, as determined from monitoring well borings, varies from north to south. The northern edge of the transition zone profile generally consists of:

- Silty clay loess with sand colluvium from the surface to about 15 to 20 feet bgs
- Silty clay alluvium from about 20 to 40 feet bgs

- Fine-grained, gray alluvial sand from about 40 to 60 feet bgs

The southern edge generally consists of:

- Silty clay topsoil from the surface to about 4 feet bgs
- Medium-grained, brown to reddish-brown alluvial sand from about 4 to 60 feet bgs

Below the 60-foot depth across the entire transition zone, the geologic profile consists of:

- Fine-grained, gray alluvial sandy gravel from about 60 to 65 feet bgs
- Silty clay glacial till encountered at about 65 to 80 feet bgs
- Dark gray, poorly graded glacial outwash sands
- Weathered limestone and shale bedrock

Lowland Profile

The subsurface geology of the lowland profile, as determined from direct push borings and monitoring well borings, generally consists of:

- Silty clay topsoil, silty clay loess, and clayey silt alluvium from the surface to about 15 feet bgs
- Medium-grained, brown to reddish-brown alluvial sand from about 15 to 60 feet bgs, grading laterally into fine-grained, gray alluvial sand near the Skunk River
- Fine-grained, alluvial sandy gravel from about 60 to 65 feet bgs
- Clay-rich glacial till encountered from about 65 to 75 or 85 feet bgs
- Dark gray, poorly graded glacial outwash sands from 75 or 85 feet bgs to about 160 feet bgs
- Weathered limestone and shale bedrock underlying the glacial outwash sands

2.3.3 Hydrogeology

Groundwater generally flows through the various profiles from north to south (i.e., from the upland to the lowland) across the study area. Hydrogeologic characteristics are summarized in **Table 2-2.** Water levels, potentiometric surface contours, and groundwater flow directions for the shallow–intermediate alluvial aquifer are illustrated on **Figure 2-6** for both June 2002 (URS 2003) and November 2002 (HGL 2003) conditions. Hydrogeologic characteristics for the individual geologic profiles are described in the following subsections.

Upland Hydrogeologic Characteristics

Generally, readily available groundwater is not encountered in the upland profile, as determined during the RI. This is due to the low permeability of the glacial till units. Groundwater occurrences are limited to localized sand seams within the till.

Transition Zone Hydrogeologic Characteristics

Intermediate sand alluvium comprises the principal aquifer unit. During the RI, groundwater was generally encountered between 18 and 28 feet bgs. The groundwater potentiometric surface was influenced by surface water in Brush Creek. Estimated groundwater flow velocities in the intermediate sand ranged from 7 to 68 feet per year.

Lowland Hydrogeologic Characteristics

Intermediate sand alluvium comprises the principal aquifer unit. During the RI, groundwater was generally encountered between 3 and 25 feet bgs. Brush Creek and Skunk River influence the groundwater potentiometric surface. Brush Creek exhibits both gaining (from IAAAP to Highway 61) and losing (south of Highway 61) stream components. Estimated groundwater flow velocities in the intermediate sand varied by location. Near the intersection of Brush Creek and Highway 61, flow velocities ranged from 210 to 470 feet per year and were influenced by an influx of water from Brush Creek (i.e., losing stream). Flow velocities were lowest near the area of highest RDX concentrations near MW117 (**Figure 2-7**), ranging from 80 to 130 feet per year. South of the Skunk River, flow velocities ranged from 110 to 500 feet per year.

A deep aquifer unit comprised of glacial outwash sands was encountered during the RI at about 80 feet bgs. This deep aquifer is separated from the intermediate alluvial sands by a laterally extensive, 15-to-20-feet-thick glacial till aquitard unit. A slight downward vertical gradient was present between wells screened in the shallow and deep aquifer units at MW117/MW117D. No significant vertical gradient was present at MW509/MW509D, where the glacial till aquitard is absent. Estimated groundwater flow velocities in the deep glacial outwash sands ranged from 7 to 40 feet per year.

2.3.4 Surface Water/Groundwater Relationships

Surface water and groundwater-level data collected in June 2002 and November 2002 indicate that both Brush Creek and Skunk River are in hydraulic contact with the surrounding aquifer. For June 2002, comparison of staff gauge data with groundwater levels in monitoring wells near Brush Creek indicates that Brush Creek is a gaining stream in the upland reaches from the IAAAP facility boundary to just north of Highway 61, changing to a losing stream in the transition zone and upper part of the lowland area. The interpreted June 2002 water table surface contours (**Figure 2-6**) mimic the Skunk River channel, with groundwater levels higher on the north side than the south side. This may be an effect of the Mississippi River regional flow system. More information on how surface water interacts with groundwater in the study area can be found in Section 4.4 of the RI Report (URS 2003).

The interpreted November 2002 water table contours are slightly different from those interpreted for June 2002 (**Figure 2-6**), indicating that groundwater flow patterns may vary, depending on the season or major climatologic events.

2.4 CHEMICALS OF POTENTIAL CONCERN

The selection of risk COPCs during the RI (URS 2003) included evaluating surface water and groundwater data collected during May 2002 RI sampling and sediment data collected during the Supplemental Investigation Off-Site (Harza 2000a) and Ecological Risk Assessment (Harza 2001b). Groundwater and surface water samples were analyzed for explosives, metals (monitoring wells only), and natural attenuation parameters (monitoring wells only). Sediment samples were analyzed for explosives and metals.

RDX was the only compound detected in Off-Site groundwater above its human health risk-based screening level, which is equivalent to the USEPA Health Advisory Level (HAL) of 2 micrograms per liter (µg/L) for lifetime exposure to RDX in drinking water (USEPA 2002). This level is commonly referred to as a “PRG” in the RI and groundwater monitoring reports. Results of the process to select COPCs in groundwater and surface water during the Off-Site Groundwater RI (URS 2003) are summarized as follows:

- No explosives COPCs were identified in sediment, shallow groundwater, or deep groundwater.
- RDX was retained as a COPC in the intermediate groundwater (maximum concentration of 120 µg/L at MW117).
- RDX was retained as a COPC in surface water because it exceeded the groundwater screening values and was interpreted to potentially impact groundwater.
- No metals were retained as COPCs in sediment or groundwater. Based on the metals concentrations in sediment and groundwater, it is not anticipated that metals would be considered COPCs in the surface water.

In addition to the above, based on analytical results of November 2003 radiological analysis (**Appendix E**), total and isotopic uranium were not detected above the maximum contaminant level (MCL) for gross alpha particles of 15 picocuries per liter (pCi/L). Therefore, radiological constituents were not considered for addition as COPCs for Off-Site groundwater or surface water.

2.5 NATURE AND EXTENT OF CONTAMINATION

2.5.1 Groundwater

For the purposes of the FS, the interpreted Off-Site extent of RDX is based on analytical data from groundwater samples collected in May 2002 during the Off-Site Groundwater RI (URS 2003). The interpreted horizontal extent of RDX exceeding its PRG in groundwater is shown on **Figure 2-7.** For reference, groundwater analytical results from November 2002 (HGL 2003) have been added to the table on **Figure 2-7**. Sections B-B’ and C-C’ (**Figures 2-8** and **2-9**) show the vertical extent of RDX-contaminated groundwater exceeding the PRG across the Off-Site study area from north to south and southwest to northeast, respectively, based on May 2002 results. May 2002 Off-Site groundwater sampling results indicated the following:

- The Off-Site RDX groundwater plume originated from Brush Creek in the area near Highway 61 and extended downgradient (south) about 7,800 feet. The average width of the plume was about 4,000 feet. The axis of the plume trended from north to south-southeast. The highest RDX concentrations (up to 120 µg/L) were detected at MW1817 near Highway 61. Concentrations declined to the southeast before dissipating just past the Skunk River.
- Low levels (less than 20 µg/L) of explosives were detected throughout the vertical extent of the aquifer underlying Brush Creek, in the area between Highway 61 and the Skunk River.
- In the lowland area between Brush Creek and the Skunk River, the RDX plume was detected at depths of about 50 to 70 feet bgs. A clean zone extended from the water table to approximately 45 feet bgs.
- RDX was not detected in the deep glacial outwash sands below the glacial till. The glacial till appears to be a natural barrier, retarding the vertical migration of explosives.
- RDX was not detected in the upland geologic units north of the current plume, indicating that the Off-Site groundwater plume did not migrate from the IAAAP facility in groundwater through the glacial till, glacial outwash sands, or bedrock units.

Based on 1992–2002 results, RDX has been detected above its PRG in samples collected from four private wells in the Off-Site area (**Figure 2-3**). One of these has been abandoned (PW5), one is for outside use only (PW8), one has been disconnected (PW9), and one is for open loop heat pump only (PW18). Private wells are typically screened in the upper 30 feet of the aquifer. RDX within the area of highest concentrations and further downgradient portions of the plume is generally located in the bottom 10 to 15 feet of the aquifer (**Figure 2-8**). Most of the private wells where RDX has been detected above its PRG are located adjacent to Brush Creek.

2.5.2 Surface Water

The interpreted extent of RDX in Brush Creek is based on analytical data from surface water samples collected in May 2002 (URS 2003) and November 2002 (HGL 2003), as shown on **Figure 2-10**. Off-Site surface water sampling results indicated the following:

- RDX was detected in all surface water samples collected in Brush Creek.
- RDX contamination was transported via surface water in Brush Creek from the IAAAP facility boundary through the Off-Site area to the Skunk River. The highest Off-Site surface water concentrations were detected near the IAAAP boundary and decline downstream to the southeast, near the Skunk River.
- Surface water samples collected during higher-than-normal flow conditions (e.g., May 2002) showed slightly elevated RDX concentrations (maximum of 22 µg/L) compared to concentrations in samples collected during more normal flow conditions (e.g., November 2002) (maximum of 7.6 µg/L).

2.5.3 Sediment

Explosives have been detected at levels below Region 9 residential soil PRGs (4,400 micrograms per kilogram [µg/kg] for RDX) in the sediments of Brush Creek (Harza 2000a). Sediment samples collected from Brush Creek indicated the following:

- Concentrations of RDX in Brush Creek sediment samples ranged from nondetect to 620 µg/kg.
- Contaminated sediment could potentially impact surface water as a result of mixing and desorption.

2.6 CONTAMINANT FATE AND TRANSPORT

This discussion summarizes contaminant fate and transport for the Off-Site study area, including potential routes of migration, modeling results, and natural attenuation.

2.6.1 Potential Routes of Migration

Explosives compounds used during production, assembly, burning, or demolition at IAAAP are a potential source for chemical release. The potential route of migration begins as a release to surface water at IAAAP, then migrates to Brush Creek, which flows through the Off-Site area. Contaminants infiltrate into the surrounding groundwater in the Off-Site study area near Brush Creek, along losing parts of the stream. Further discussion on exposure rates is provided in **Section 2.7**.

2.6.2 Modeling Results

Results of baseline conditions contaminant fate and transport modeling, performed as part of the Off-Site Groundwater RI (URS 2003), are summarized below. The model-predicted extent of RDX in Off-Site groundwater at various points in time is shown on **Figure 2-11**. RI modeling conservatively assumed a steady-state source of RDX in Brush Creek surface water, generally equivalent to levels observed in May 2002 (i.e., 20 µg/L in upper reaches and 15 µg/L in lower reaches).

- The current RDX plume may be transported downgradient up to 1,000 feet past the current RDX plume extent at concentrations above the PRG of 2 µg/L at a modeled time period of 10 years. The southern end of the plume (south of the Skunk River) will then decline to below PRGs within 30 years, due to the natural processes of dispersion and degradation.
- RDX concentrations in the area of highest concentrations (near MW117) were at their highest predicted values, and concentrations are expected to decline significantly in the next ten years.
- If May 2002 concentrations of RDX in Brush Creek remain unchanged, RDX plume concentrations will reach equilibrium in the aquifer in about 30 years. The extent of the RDX plume at that time would be reduced to primarily the area between Brush Creek and

Skunk River, but concentrations will remain above PRGs indefinitely (just below 20 µg/L near Brush Creek) because of the continuing Brush Creek surface water source.

The groundwater flow and contaminant fate and transport modeling was conservative and potentially overpredicted contaminant fate and transport results by:

- Using Spring 2002 RDX concentrations in surface water and water levels to simulate contaminant fate and transport. The Spring 2002 conditions around Brush Creek showed steeper gradients and more influence from Brush Creek than Fall 2002 flow conditions, likely overestimating the RDX mass coming into the aquifer from Brush Creek and subsequent transport of RDX once it entered the aquifer.
- Using conservative initial RDX input concentrations (i.e., overpredicting the initial mass in the aquifer.
- Using a conservative half-life value (e.g., 10 years) to underestimate degradation rates.

2.6.3 Natural Attenuation

Initial evaluation of natural attenuation data indicate that natural attenuation processes are likely to be occurring in the Off-Site RDX plume within the following geologic units:

- Transition zone geologic profile/intermediate terrace sand alluvium
- Lowland geologic profile/intermediate gray sand alluvium
- Lowland geologic profile/deep glacial outwash

Wells screened within these units generally exhibited reducing conditions, lower dissolved oxygen (DO) concentrations, and evidence of denitrification and iron reduction. More detailed information is provided in Section 8.4 of the RI report (URS 2003).

2.7 RISK ASSESSMENT

2.7.1 Human Health

During the human health risk assessment evaluation, RDX was used as the COPC in intermediate groundwater and surface water. Receptor populations evaluated included current/future construction workers and current/future age-adjusted residents (adults and children). Exposure routes included dermal contact and ingestion. Groundwater was categorized into three distinct zones (i.e., shallow, intermediate, and deep) during the risk assessment. The groundwater was also evaluated using three different concentration scenarios related to the current RDX plume for all receptors, which included:

- Groundwater within the 50-parts per billion (ppb) isoconcentration line
- Groundwater between the 50-ppb and 20-ppb isoconcentration lines
- Groundwater outside the 20-ppb isoconcentration line

A value of 50 ppb was selected to define the higher level areas of the plume, anticipating that this would generally correspond to 10^{-4} cancer risk level, which is the upper limit of the USEPA target risk range. A value of 20 ppb was selected to define the lower level areas of the plume, which is 10 times the HAL for RDX. The human health risk assessment results indicated that:

- RDX concentrations in surface water posed no significant excess human health risk to the construction worker or the age-adjusted resident.
- Intermediate groundwater within the 50-µg/L RDX isoconcentration line indicated a potential for adverse human health effects and/or cancer risks to the age-adjusted resident. The estimated total lifetime excess cancer risk for the age-adjusted resident (2.1×10^{-4}) exceeded the USEPA target risk range of 1×10^{-6} to 1×10^{-4}. The hazard index (HI) was greater than 1 (3.9).
- Intermediate groundwater between the 50-µg/L and 20-µg/L RDX isoconcentration lines indicated that the estimated total lifetime excess cancer risk for the age-adjusted resident (6.1×10^{-5}) was within the USEPA target risk range of 1×10^{-6} to 1×10^{-4}. The HI was above 1 (1.1).
- Intermediate groundwater outside the 20-µg/L RDX isoconcentration line indicated that the estimated total lifetime excess cancer risk for the age-adjusted resident (3.1×10^{-5}) was within the USEPA target risk range of 1×10^{-6} to 1×10^{-4}. The HI was below 1 (0.56).
- Based on the residential scenario, risk-based PRGs for RDX in intermediate groundwater were calculated at 0.61 µg/L, 6.1 µg/L, and 61 µg/L for the target risk levels of 10^{-6}, 10^{-5}, and 10^{-4}, respectively.

2.7.2 Ecological Risk Assessment

No quantitative ecological risk assessment has been performed for the Off-Site study area. No explosives compounds have been detected in surface water or sediment above the ecological risk screening values proposed in the facility-wide ecological risk assessment (Harza 2001b). For RDX, the surface water value is 190 µg/L, and the sediment value is 4,682 µg/kg.

TABLE 2-1
SUMMARY OF PREVIOUS OFF-SITE GROUNDWATER INVESTIGATIONS 1999-2002
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Date	Description	Reference
June to October 1999	Harza Engineering Company, Inc. (Harza) completed the Off-Site Groundwater, Surface Water, and Sediment Investigation (Phases 1 and 2). Groundwater samples were collected from 48 direct push locations (67 samples), one soil boring, and three private well locations. Two surface water samples were collected from Brush Creek. Nine sediment samples were collected, including four from Brush Creek, three from its tributaries, and two from the original Brush Creek channel. Laboratory analysis confirmed the presence of explosives contamination in Off-Site groundwater, Brush Creek surface water, and sediment.	Harza 2000a
May 2000	Harza completed the Off-Site Groundwater Investigation (Phase 3). Groundwater samples were collected from nine direct push locations (18 samples) and one new monitoring well location. A surface water sample was collected from the former quarry lake located adjacent to Brush Creek. Laboratory analysis confirmed the presence of explosives contamination in Off-Site groundwater and the former Quarry Lake.	Harza 2000b
March to April 2001	Harza completed the Off-Site Groundwater Investigation (Phase 4). Groundwater samples were collected from ten direct push locations (15 samples), four new monitoring well locations, and six private well locations. Laboratory analysis confirmed the presence of explosives contamination in Off-Site groundwater.	Harza 2001a
November 2001 to July 2002	URS completed the Off-Site Groundwater Remedial Investigation. Groundwater samples were collected from 20 direct push locations (28 samples), five existing monitoring well locations, 23 new monitoring well locations, and eight private well locations. Eight surface water samples were collected from Brush Creek and surrounding water features. Monitoring well samples were analyzed for explosives, metals, and natural attenuation parameters. All other samples were analyzed for explosives. Laboratory analysis confirmed the presence of explosives contamination in Off-Site groundwater and Brush Creek surface water.	URS 2003
November 2002	HydroGeoLogic completed Off-Site groundwater monitoring in November 2002 as part of facility-wide 2002 groundwater monitoring. Groundwater samples were collected from 28 existing monitoring well locations. Five surface water samples were collected from Brush Creek. Monitoring well samples were analyzed for explosives, metals, and natural attenuation parameters. Surface water samples were analyzed for explosives. Laboratory analysis confirmed the presence of explosives contamination in Off-Site groundwater and Brush Creek surface water.	HydroGeoLogic 2003 (Draft)

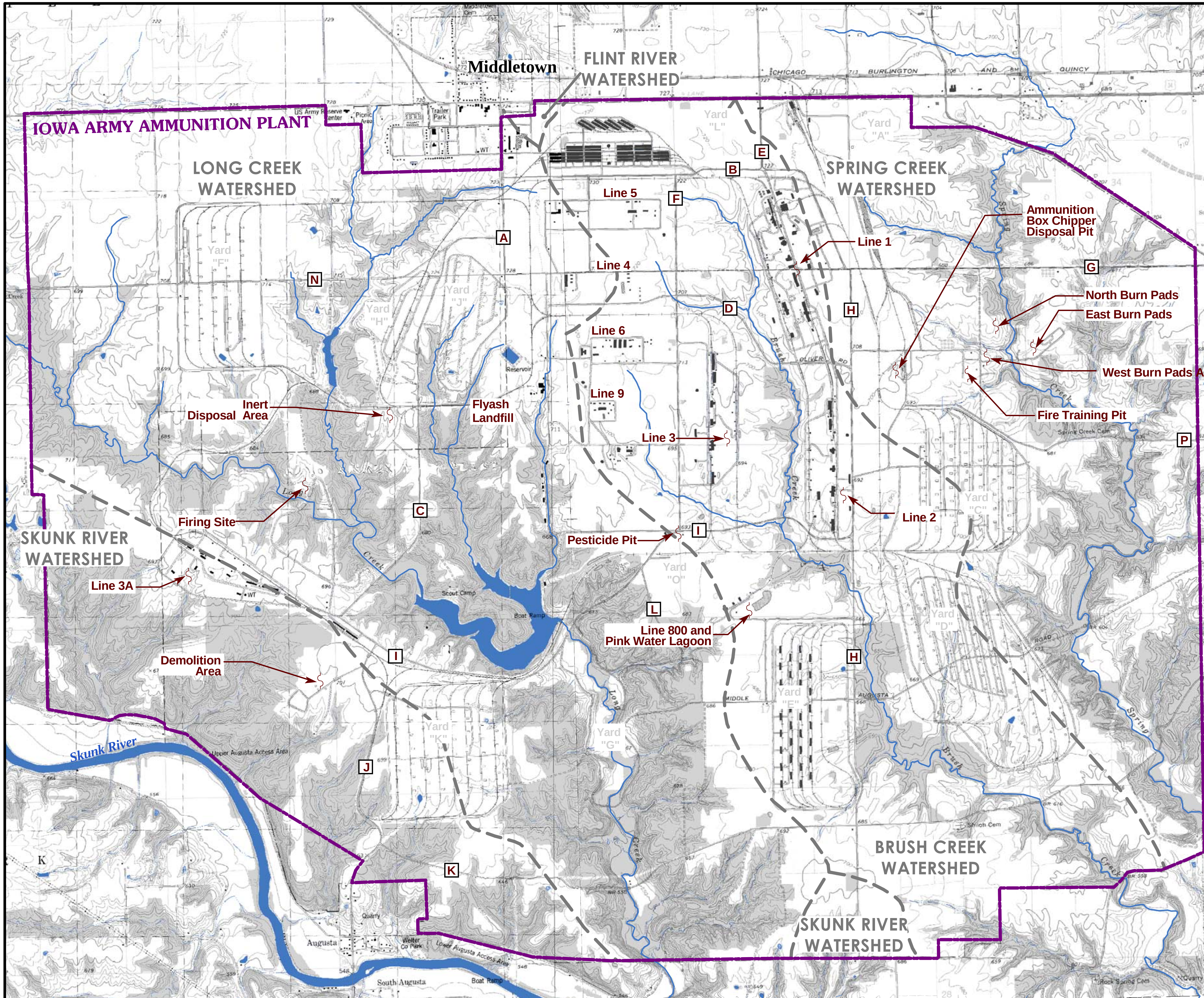
TABLE 2-2
SUMMARY OF HYDROGEOLOGIC CHARACTERISTICS
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Well Identification Number	Geologic Profile	Screened Geologic Unit	Screened Interval Lithology (USCS)	Well TOC Elevation[1] (ft MSL)	Ground Elevation[1] (ft MSL)	Depth to Water June 2002 (ft BTOC)	Water Level Elevation June 2002 (ft MSL)	Depth to Water November 2002 (ft BTOC)	Water Level Elevation November 2002 (ft MSL)	Screened Depth (ft bgs)	Well Depth (ft BTOC)	Till Depth (ft bgs)	Top of Till Elevation (ft MSL)	Hydraulic Conductivity (ft/day)[3]	Horizontal Hydraulic Gradient (ft/ft)[4]	Porosity (%)[5]	Average Linear Groundwater Flow Velocity (ft/year)[6]
Transition Zone Geologic Profile/Shallow Colluvium																	
MW502S	Transition	Shallow Colluvium	SC-CL	554.06	551.6	8.76	545.30	15.87	538.19	6.9-16.9	19.7	NA	NA	0.06	0.01	35	0.63
Transition Zone Geologic Profile/Intermediate Terrace Sand Alluvium																	
MW121	Transition	Intermediate Terrace Sand Alluvium	SP-SM	547.97	548.4	19.46	528.51	23.64	524.33	34-44	43.8	42.0	506.4	5.5	0.0011	30	7.4
MW502	Transition	Intermediate Terrace Sand Alluvium	SP-SM	554.04	551.7	27.36	526.68	29.06	524.98	52.6-62.6	65.4	63.5	488.2	143	0.00035	27	68
MW505	Transition	Intermediate Terrace Sand Alluvium	SP	556.92	554.4	30.77	526.15	32.10	524.82	53-63	66.1	63.0	491.4	151	0.00035	32	60
Lowland Geologic Profile/Intermediate Brown Sand Alluvium																	
MW117S	Lowland	Intermediate Brown Sand Alluvium	SP	551.46	552.0	24.85	526.61	29.12	522.34	28-38	37.6	NA	NA	387	0.00038	32	168
MW117	Lowland	Intermediate Brown Sand Alluvium	SP	551.81	552.0	25.22	526.59	29.17	522.64	51.5-61.5	61.7	61.5	490.5	307	0.00038	33	129
MW123	Lowland	Intermediate Brown Sand Alluvium	SC w/SP-SM	545.96	546.3	18.00	527.96	22.75	523.21	43.2-53.2	53.1	53.5	492.8	208	0.00095	34	212
MW125	Lowland	Intermediate Brown Sand Alluvium	SC-CL	546.35	546.8	18.62	527.73	23.21	523.14	38.5-48.5	48.0	49.0	497.8	363	0.00075	30	331
MW136	Lowland	Intermediate Brown Sand Alluvium	SP	529.42	526.9	4.26	525.16	8.82	520.60	49.8-59.8	62.4	61.5	465.4	213	0.00064	25	199
MW303	Lowland	Intermediate Brown Sand Alluvium	SP	541.81	539.3	15.12	526.69	19.83	521.98	42.5-52.5	55.6	53.5	485.8	217	0.00086	30	227
MW304S	Lowland	Intermediate Brown Sand Alluvium	SP	533.70	531.2	7.92	525.78	13.58	520.12	27.7-37.7	40.1	NA	NA	305	0.00086	27	354
MW304	Lowland	Intermediate Brown Sand Alluvium	SP	534.04	531.4	8.32	525.72	14.00	520.04	57-67	70.8	67.5	463.9	276	0.00086	30	289
MW307	Lowland	Intermediate Brown Sand Alluvium	SP	551.46	551.8	25.38	526.08	28.92	522.54	65-75	73.7	75.0	476.8	233	0.00028	30	80
MW309	Lowland	Intermediate Brown Sand Alluvium	SP	547.24	547.7	20.70	526.54	22.43	524.81	47.9-57.9	58.6	57.5	490.2	348	0.00028	27	132
MW407	Lowland	Intermediate Brown Sand Alluvium	SP	529.97	527.6	4.87	525.10	10.66	519.31	49-59	61.2	59.0	468.6	237	0.00152	32	411
MW408	Lowland	Intermediate Brown Sand Alluvium	SP-SM	527.34	525.2	3.68	523.66	7.32	520.02	54.1-64.1	67.0	64.0	461.2	193	0.00064	35	129
MW409	Lowland	Intermediate Brown Sand Alluvium	SP	545.37	542.8	18.00	527.37	23.16	522.21	48-58	61.3	58.0	484.8	267	0.00144	30	467
MW501	Lowland	Intermediate Brown Sand Alluvium	SP-SM	542.67	540.6	16.56	526.11	20.86	521.81	63.2-73.2	75.7	72.5	468.1	228	0.00038	27	117
MW509	Lowland	Intermediate Brown Sand Alluvium	SP	529.09	526.9	4.47	524.62	10.74	518.35	84.6-94.6	97.6	Absent	Absent	300	0.00067	28	262
MW510	Lowland	Intermediate Brown Sand Alluvium	SP-SM	530.66	528.3	8.16	522.50	12.99	517.67	47-57	59.6	57.0	471.3	207	0.00204	31	498
MW511	Lowland	Intermediate Brown Sand Alluvium	SP	528.50	526.1	4.88	523.62	10.07	518.43	44.5-54.5	57.1	55.0	471.1	204	0.00133	22	449
MW513	Lowland	Intermediate Brown Sand Alluvium	SP	526.47	523.7	5.60	520.87	8.14	518.33	44-54	56.1	55.0	468.7	255	0.00062	23	250
Lowland Geologic Profile/Intermediate Gray Sand Alluvium																	
MW514	Lowland	Intermediate Gray Sand Alluvium	SP	525.28	522.8	4.98	520.30	9.07	516.21	53-63	66.2	63.0	459.8	208	0.00067	28	182
MW515	Lowland	Intermediate Gray Sand Alluvium	SP	524.52	522.3	4.79	519.73	7.07	517.45	50-60	62.4	60.0	462.3	142	0.00071	30	123
MW516	Lowland	Intermediate Gray Sand Alluvium	SP-SM	524.97	522.4	5.68	519.29	7.75	517.22	50-60	61.8	60.0	462.4	157	0.00067	34	113
MW517	Lowland	Intermediate Gray Sand Alluvium	SP	531.15	528.8	9.04	522.11	11.68	519.47	50-60	62.6	60.0	468.8	276	0.00122	26	472
Lowland Geologic Profile/Deep Glacial Outwash																	
MW117D	Lowland	Deep Glacial Outwash	SC-SM	551.81	552.0	25.84	525.97	28.86	522.95	92.8-102.8	103.1	61.5	490.5	18	0.0004	35	7.6
MW509D	Lowland	Deep Glacial Outwash	SP w/GP	529.06	526.8	4.53	524.53	10.78	518.28	145.8-155.8	159.0	Absent	Absent	80	0.0004	29	40

NOTES:

[1]Survey was completed using NAD83 Iowa South Zone (meters)/NAVD88 (meters) coordinate system and was converted to US feet.
[2]All off-site monitoring wells are 2-inch diameter.
[3]Hydraulic conductivity values were estimated from aquifer slug tests completed on each monitoring well.
[4]Horizontal hydraulic gradients were calculated near each well using June 2002 water levels.
[5]Average effective porosity values were estimated from geotechnical soil testing results for each well. If results were not available, an average value of 30% was used.
[6]Average linear groundwater flow velocities were estimated using Darcy's Law: Flow velocity =(hydraulic conductivity)(gradient)/(effective porosity).

% = Percent
bgs = Below Ground Surface
BTOC = Below Top of Casing
ft = Foot or Feet
ft/ft = Feet Per Foot
MSL = Mean Sea Level
USCS = Unified Soil Classification System



LEGEND

- A Road Name
- Plant Property Boundary
- Drainage Basin Boundary
- River/Stream

N

0 3000 6000

Feet

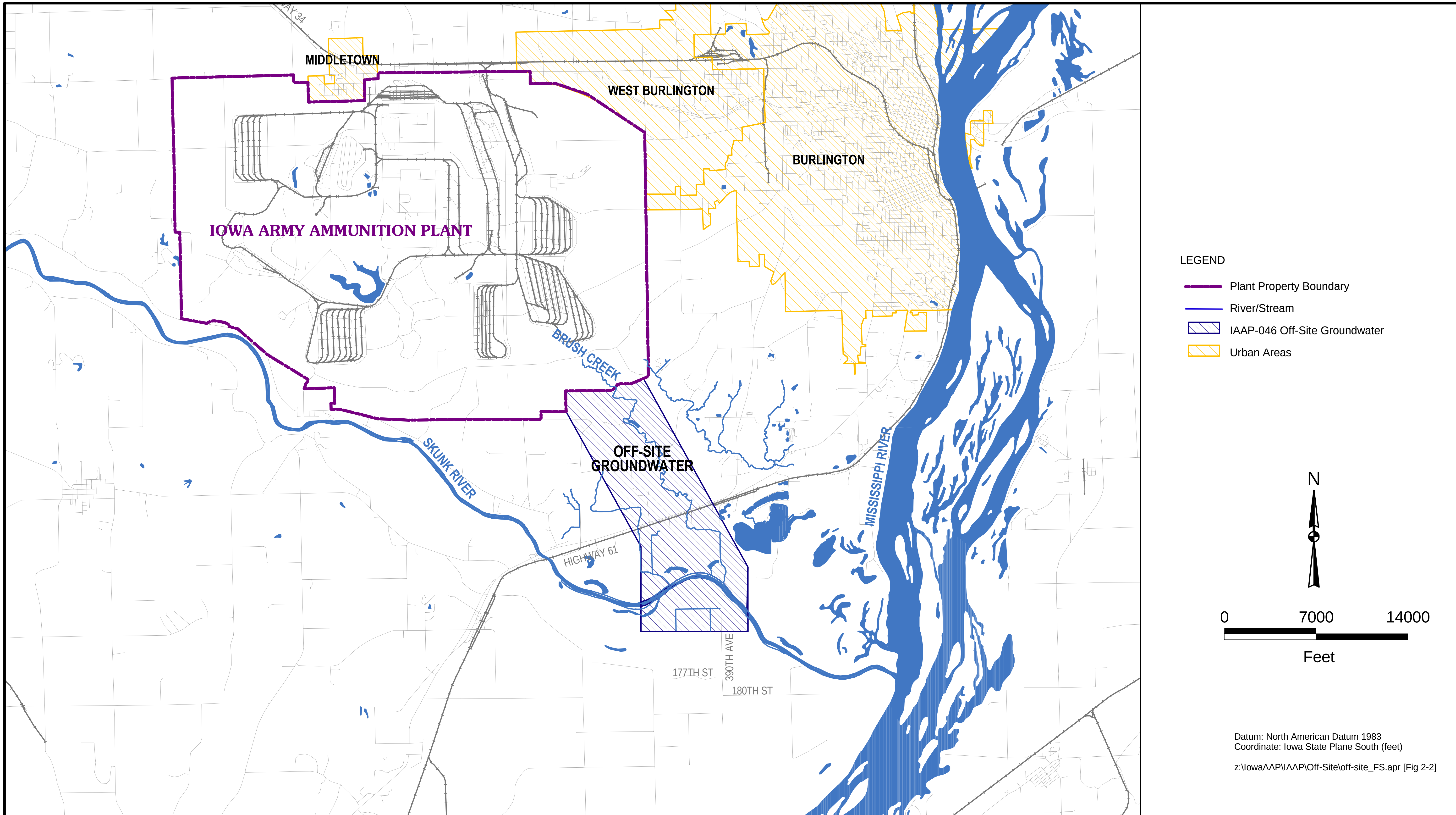
Datum: North American Datum 1983
Coordinate: Iowa State Plane South (feet)

z:\IowaAAP\IAAP\Off-Site\off-site_FS.apr [Fig 2-1]

URS

FACILITY MAP
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

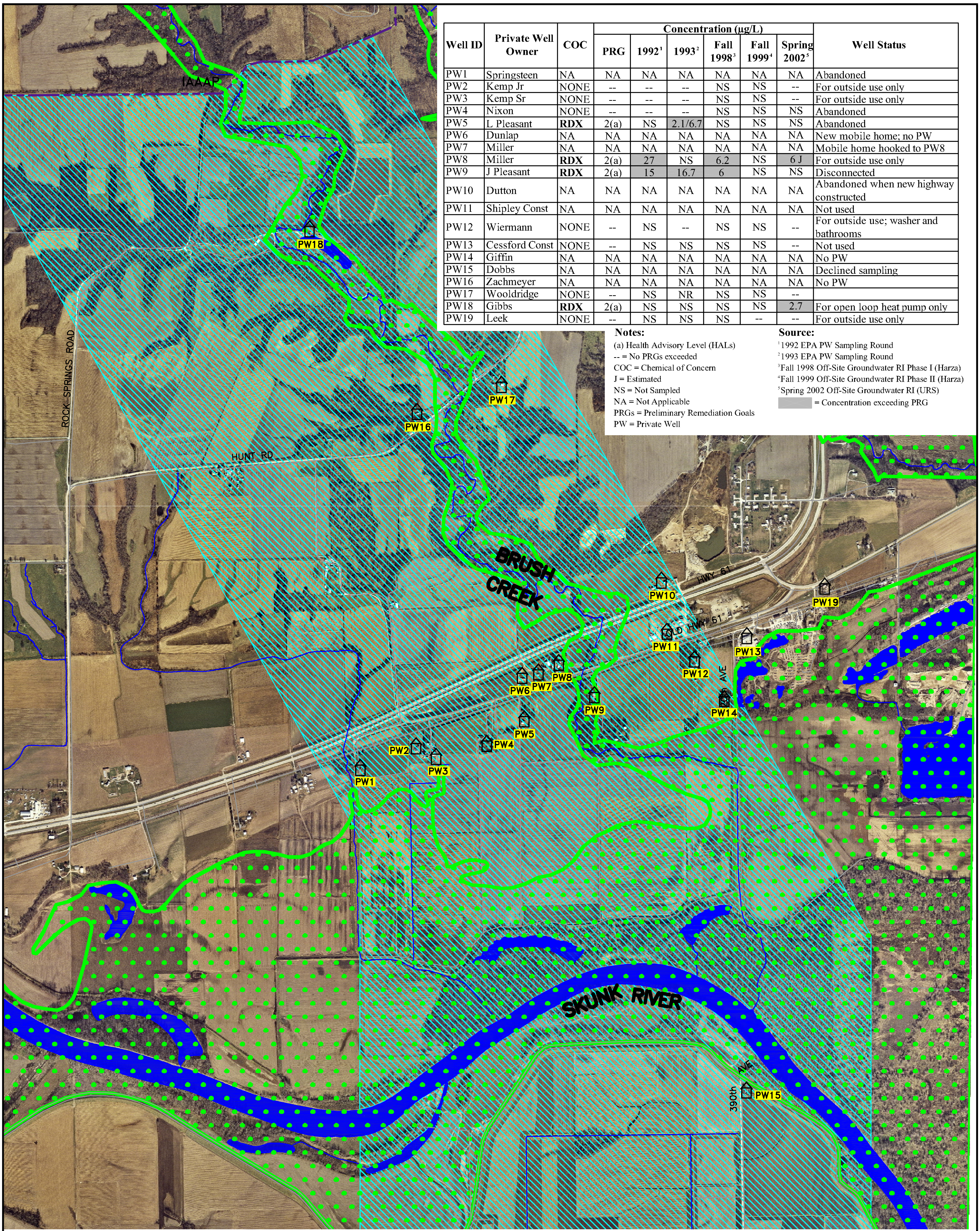
DRN. BY: DLC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: JMR	DATE: 09/23/03	16169419	2-1



URS

INSTALLATION AND OFF-SITE AREA
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DLC	DATE: 09/25/03	PROJECT NO.	FIG. NO.
CHK'D. BY: JMR	DATE: 09/25/03	16169419	2-2



Well ID	Private Well Owner	COC	Concentration (µg/L)						Well Status
			PRG	1992[1]	1993[2]	Fall 1998[3]	Fall 1999[4]	Spring 2002[5]	
PW1	Springsteen	NA	NA	NA	NA	NA	NA	NA	Abandoned
PW2	Kemp Jr	NONE	--	--	--	NS	NS	--	For outside use only
PW3	Kemp Sr	NONE	--	--	--	NS	NS	--	For outside use only
PW4	Nixon	NONE	--	--	--	NS	NS	NS	Abandoned
PW5	L Pleasant	**RDX**	2(a)	NS	2.1/6.7	NS	NS	NS	Abandoned
PW6	Dunlap	NA	NA	NA	NA	NA	NA	NA	New mobile home; no PW
PW7	Miller	NA	NA	NA	NA	NA	NA	NA	Mobile home hooked to PW8
PW8	Miller	**RDX**	2(a)	27	NS	6.2	NS	6 J	For outside use only
PW9	J Pleasant	**RDX**	2(a)	15	16.7	6	NS	NS	Disconnected
PW10	Dutton	NA	NA	NA	NA	NA	NA	NA	Abandoned when new highway constructed
PW11	Shipley Const	NA	NA	NA	NA	NA	NA	NA	Not used
PW12	Wiermann	NONE	--	NS	--	NS	NS	--	For outside use; washer and bathrooms
PW13	Cessford Const	NONE	--	NS	NS	NS	NS	--	Not used
PW14	Giffin	NA	NA	NA	NA	NA	NA	NA	No PW
PW15	Dobbs	NA	NA	NA	NA	NA	NA	NA	Declined sampling
PW16	Zachmeyer	NA	NA	NA	NA	NA	NA	NA	No PW
PW17	Wooldridge	NONE	--	NS	NR	NS	NS	--	
PW18	Gibbs	**RDX**	2(a)	NS	NS	NS	NS	2.7	For open loop heat pump only
PW19	Leek	NONE	--	NS	NS	NS	--	--	For outside use only

Notes:

(a) Health Advisory Level (HALs)
-- = No PRGs exceeded
COC = Chemical of Concern
J = Estimated
NS = Not Sampled
NA = Not Applicable
PRGs = Preliminary Remediation Goals
PW = Private Well

Source:

[1] 1992 EPA PW Sampling Round
[2] 1993 EPA PW Sampling Round
[3] Fall 1998 Off-Site Groundwater RI Phase I (Harza)
[4] Fall 1999 Off-Site Groundwater RI Phase II (Harza)
[5] Spring 2002 Off-Site Groundwater RI (URS)
(shaded) = Concentration exceeding PRG

LEGEND

- IAAAP BOUNDARY
- LEVEE
- PAVED OR GRAVEL ROAD
- RAILROAD TRACKS
- PW1 PRIVATE WELL
- GENERALIZED OR APPROXIMATE BOUNDARY OF OFF-SITE GROUNDWATER INVESTIGATION AREA
- APPROXIMATE 100-YEAR FLOODPLAIN BOUNDARY (FEMA)

N

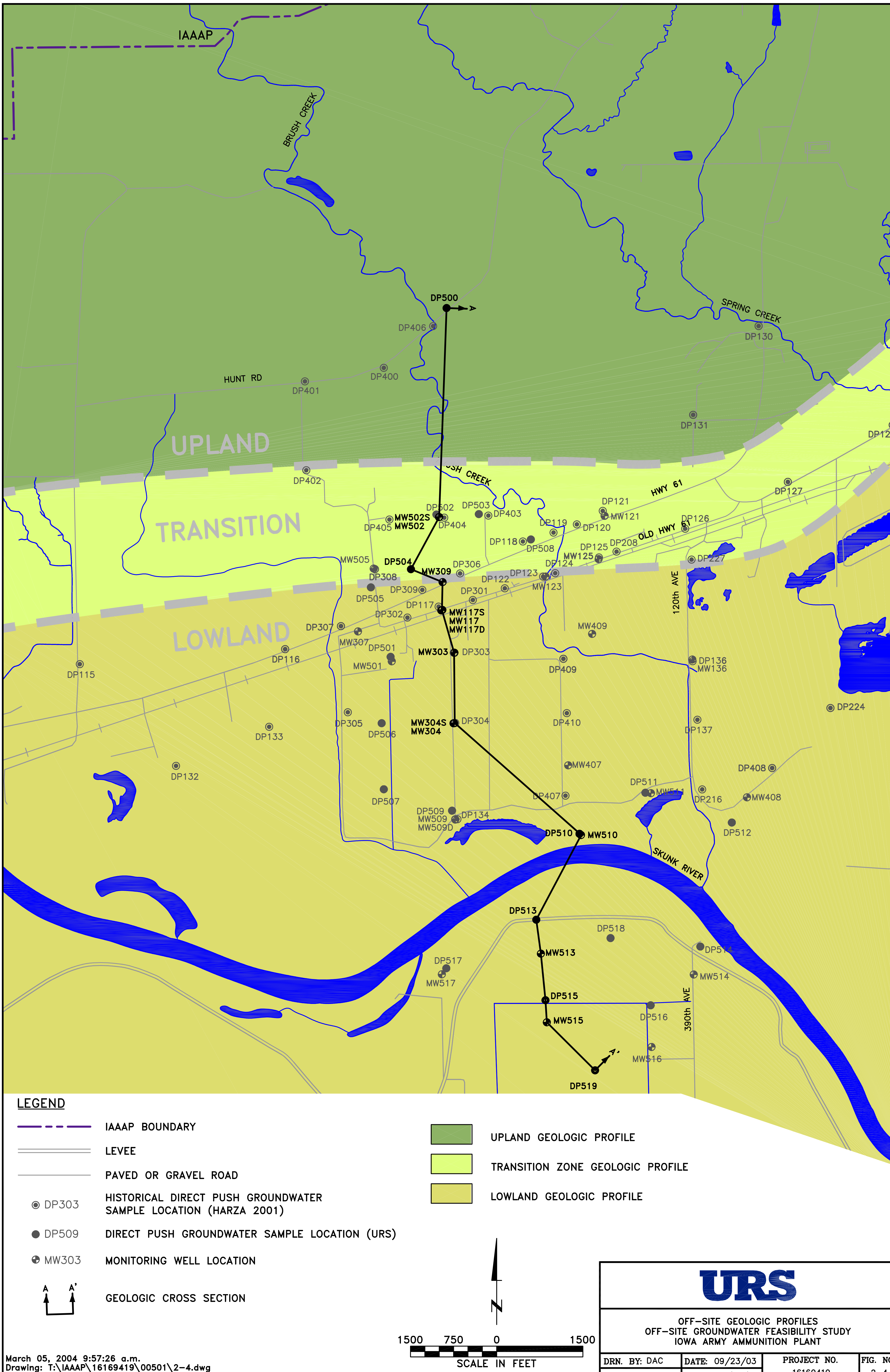
1500 750 0 1500
SCALE IN FEET

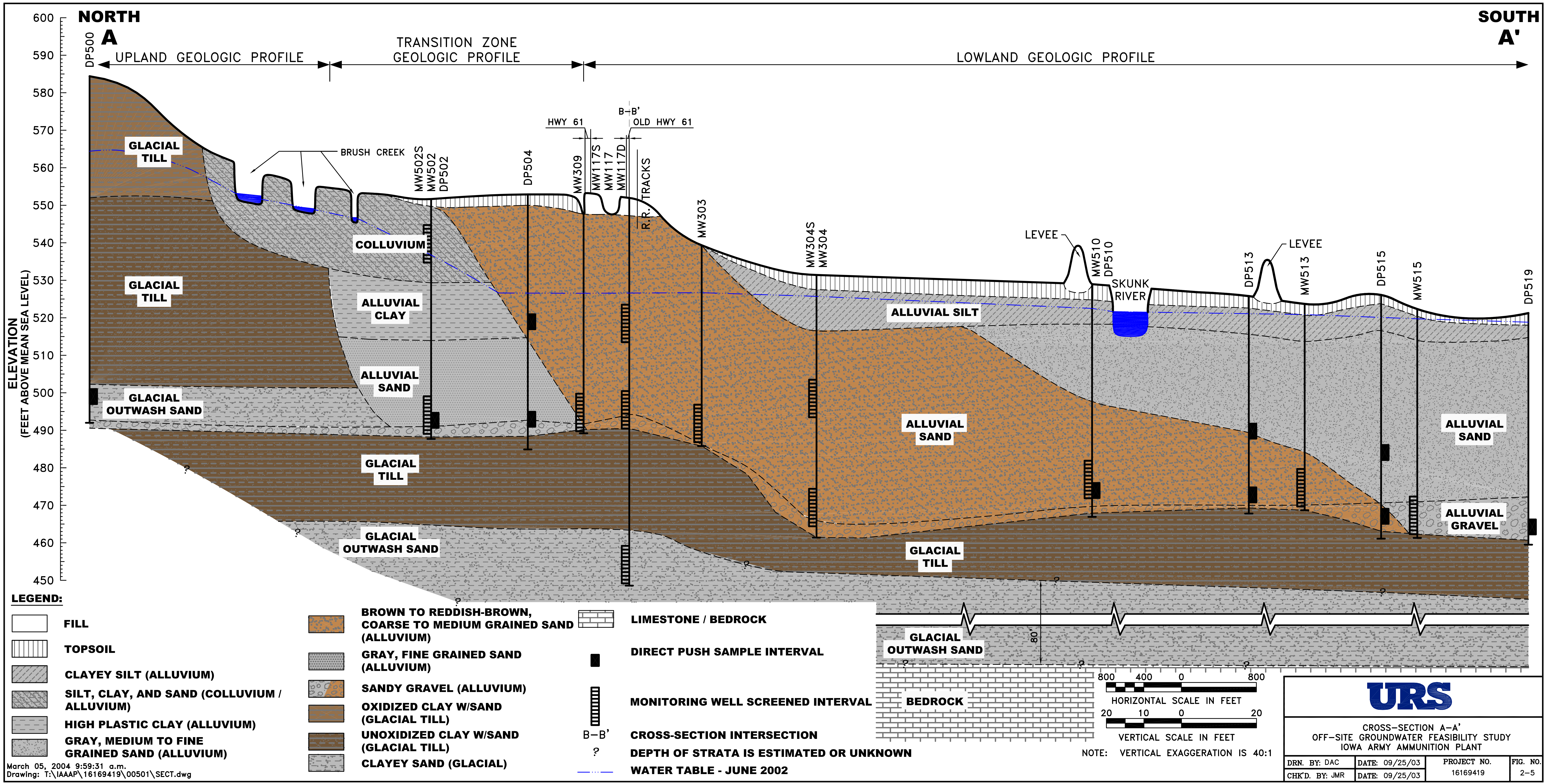
March 05, 2004 9:53:16 a.m.
Drawing: T:\IAAAP\16169419\00501\2-3.dwg

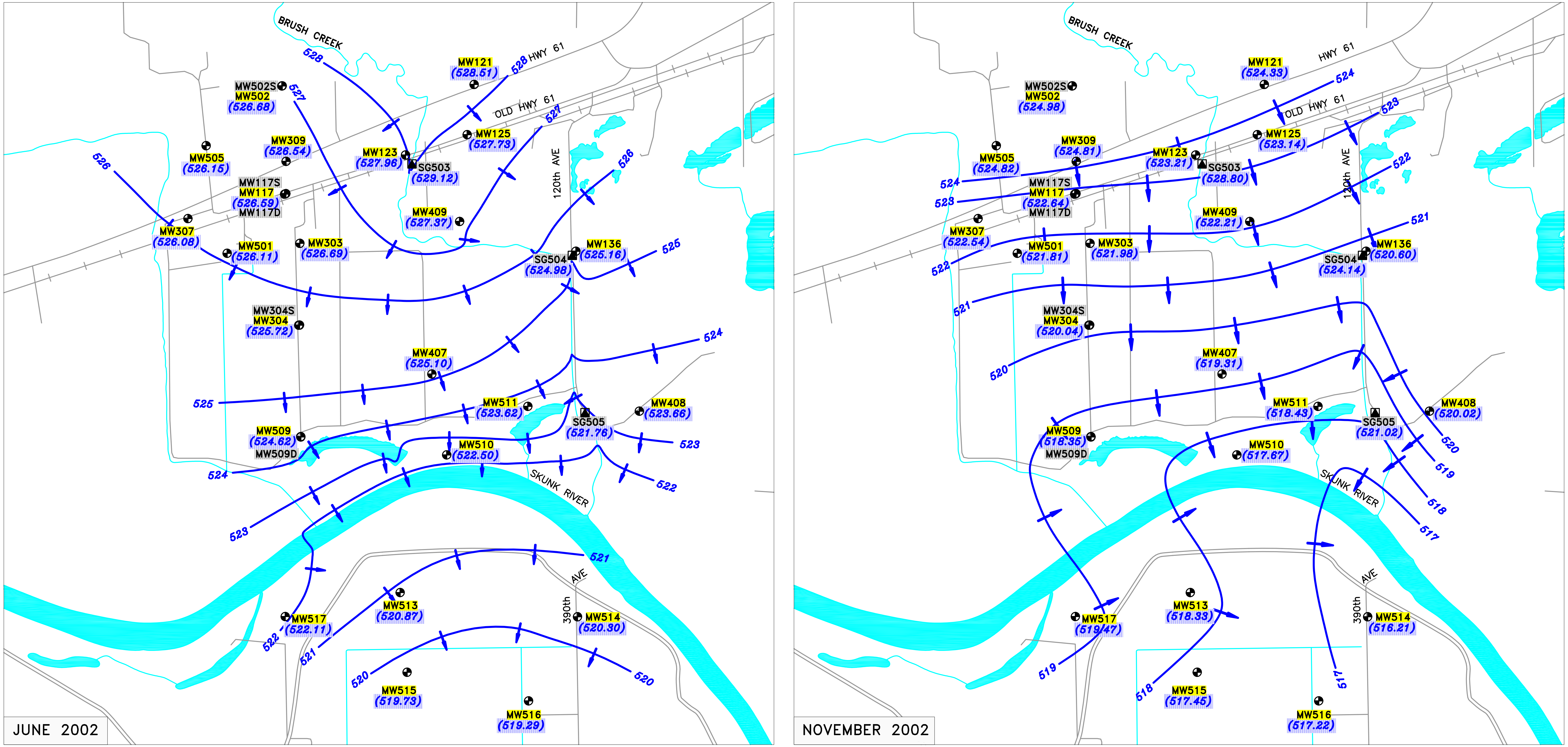
URS

AERIAL PHOTO SITE MAP
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/22/03	PROJECT NO.	FIG. NO.
CHK'D. BY: JMR	DATE: 09/22/03	16169419	2-3


IAAAP
BRUSH CREEK
SPRING CREEK
HUNT RD
UPLAND
TRANSITION
LOWLAND
HWY 61
OLD HWY 61
120th AVE
390th AVE
SKUNK RIVER
DP500
DP406
DP400
DP401
DP402
DP130
DP131
DP128
DP127
DP502
DP503
DP403
DP404
MW502S
MW502
DP405
DP121
MW121
DP126
DP119
DP120
DP118
DP508
DP125
DP208
MW125
DP124
DP227
MW505
DP504
MW309
DP306
DP308
DP123
DP122
MW123
DP309
DP301
DP505
DP117
MW117S
MW117
MW117D
DP302
DP307
MW307
DP501
MW501
MW409
MW303
DP303
DP116
DP115
DP409
DP136
MW136
DP224
DP305
DP506
MW304S
MW304
DP304
DP410
DP137
DP133
DP132
MW407
DP408
DP511
MW511
DP216
MW408
DP407
DP507
DP509
MW509
MW509D
DP134
DP510
MW510
DP512
DP513
DP518
DP517
MW517
MW513
DP514
MW514
DP515
DP516
MW515
MW516
DP519
A
A'
LEGEND
IAAAP BOUNDARY
LEVEE
PAVED OR GRAVEL ROAD
DP303 HISTORICAL DIRECT PUSH GROUNDWATER SAMPLE LOCATION (HARZA 2001)
DP509 DIRECT PUSH GROUNDWATER SAMPLE LOCATION (URS)
MW303 MONITORING WELL LOCATION
GEOLOGIC CROSS SECTION
UPLAND GEOLOGIC PROFILE
TRANSITION ZONE GEOLOGIC PROFILE
LOWLAND GEOLOGIC PROFILE
N
1500 750 0 1500
SCALE IN FEET
March 05, 2004 9:57:26 a.m.
Drawing: T:\IAAAP\16169419\00501\2-4.dwg
URS
OFF-SITE GEOLOGIC PROFILES
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT
DRN. BY: DAC
DATE: 09/23/03
CHK'D. BY: JMR
DATE: 09/23/03
PROJECT NO.
16169419
FIG. NO.
2-4


NORTH
A
SOUTH
A'
DP500
UPLAND GEOLOGIC PROFILE
TRANSITION ZONE GEOLOGIC PROFILE
LOWLAND GEOLOGIC PROFILE
ELEVATION (FEET ABOVE MEAN SEA LEVEL)
600
590
580
570
560
550
540
530
520
510
500
490
480
470
460
450
BRUSH CREEK
HWY 61
B-B'
OLD HWY 61
MW502S
MW502
DP502
DP504
MW309
MW117S
MW117
MW117D
TRACKS
R.R.
MW303
MW304S
MW304
LEVEE
MW510
DP510
SKUNK RIVER
DP513
LEVEE
MW513
DP515
MW515
DP519
GLACIAL TILL
COLLUVIUM
GLACIAL TILL
ALLUVIAL CLAY
ALLUVIAL SAND
GLACIAL OUTWASH SAND
GLACIAL TILL
GLACIAL OUTWASH SAND
ALLUVIAL SILT
ALLUVIAL SAND
GLACIAL TILL
ALLUVIAL SAND
ALLUVIAL GRAVEL
GLACIAL OUTWASH SAND
BEDROCK
80'
?
LEGEND:
FILL
TOPSOIL
CLAYEY SILT (ALLUVIUM)
SILT, CLAY, AND SAND (COLLUVIUM / ALLUVIUM)
HIGH PLASTIC CLAY (ALLUVIUM)
GRAY, MEDIUM TO FINE GRAINED SAND (ALLUVIUM)
BROWN TO REDDISH-BROWN, COARSE TO MEDIUM GRAINED SAND (ALLUVIUM)
GRAY, FINE GRAINED SAND (ALLUVIUM)
SANDY GRAVEL (ALLUVIUM)
OXIDIZED CLAY W/SAND (GLACIAL TILL)
UNOXIDIZED CLAY W/SAND (GLACIAL TILL)
CLAYEY SAND (GLACIAL)
LIMESTONE / BEDROCK
DIRECT PUSH SAMPLE INTERVAL
MONITORING WELL SCREENED INTERVAL
B-B' CROSS-SECTION INTERSECTION
? DEPTH OF STRATA IS ESTIMATED OR UNKNOWN
WATER TABLE - JUNE 2002
800 400 0 800
HORIZONTAL SCALE IN FEET
20 10 0 20
VERTICAL SCALE IN FEET
NOTE: VERTICAL EXAGGERATION IS 40:1
URS
CROSS-SECTION A-A'
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT
DRN. BY: DAC
DATE: 09/25/03
CHK'D. BY: JMR
DATE: 09/25/03
PROJECT NO. 16169419
FIG. NO. 2-5
March 05, 2004 9:59:31 a.m.
Drawing: T:\IAAAP\16169419\00501\SECT.dwg



LEGEND

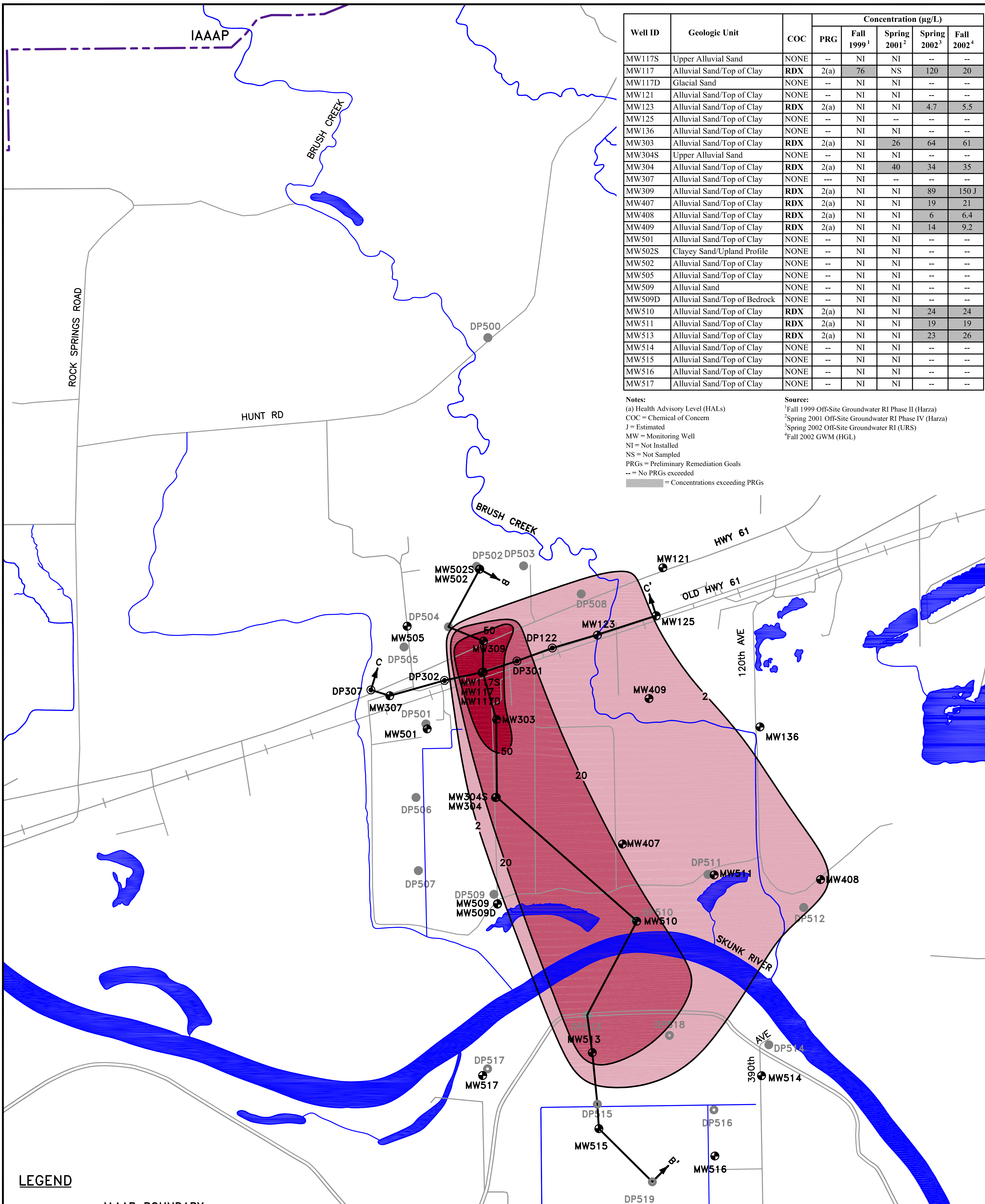
LEVEE	
PAVED OR GRAVEL ROAD	
RAILROAD TRACKS	
MW500	MONITORING WELL LOCATION
SG501	STAFF GAUGE LOCATION
	MONITORING WELLS USED TO CONSTRUCT WATER TABLE MAP
(708.16)	GROUNDWATER/SURFACE WATER ELEVATIONS (FT. ABOVE MEAN SEA LEVEL)
695	WATER TABLE SURFACE CONTOURS (FT. ABOVE MEAN SEA LEVEL)
	INTERPRETED GROUNDWATER FLOW DIRECTIONS

March 05, 2004 10:00:34 a.m.
Drawing: T:\IAAAP\16169419\00501\2-6.dwg

URS

WATER TABLE ELEVATION MAP
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: DRH	DATE: 09/23/03	16169419	2-6



Well ID	Geologic Unit	COC	Concentration (µg/L)				
			PRG	Fall 1999[1]	Spring 2001[2]	Spring 2002[3]	Fall 2002[4]
MW117S	Upper Alluvial Sand	NONE	--	NI	NI	--	--
MW117	Alluvial Sand/Top of Clay	**RDX**	2(a)	76	NS	120	20
MW117D	Glacial Sand	NONE	--	NI	NI	--	--
MW121	Alluvial Sand/Top of Clay	NONE	--	NI	NI	--	--
MW123	Alluvial Sand/Top of Clay	**RDX**	2(a)	NI	NI	4.7	5.5
MW125	Alluvial Sand/Top of Clay	NONE	--	NI	--	--	--
MW136	Alluvial Sand/Top of Clay	NONE	--	NI	NI	--	--
MW303	Alluvial Sand/Top of Clay	**RDX**	2(a)	NI	26	64	61
MW304S	Upper Alluvial Sand	NONE	--	NI	NI	--	--
MW304	Alluvial Sand/Top of Clay	**RDX**	2(a)	NI	40	34	35
MW307	Alluvial Sand/Top of Clay	NONE	---	NI	--	--	--
MW309	Alluvial Sand/Top of Clay	**RDX**	2(a)	NI	NI	89	150 J
MW407	Alluvial Sand/Top of Clay	**RDX**	2(a)	NI	NI	19	21
MW408	Alluvial Sand/Top of Clay	**RDX**	2(a)	NI	NI	6	6.4
MW409	Alluvial Sand/Top of Clay	**RDX**	2(a)	NI	NI	14	9.2
MW501	Alluvial Sand/Top of Clay	NONE	--	NI	NI	--	--
MW502S	Clayey Sand/Upland Profile	NONE	--	NI	NI	--	--
MW502	Alluvial Sand/Top of Clay	NONE	--	NI	NI	--	--
MW505	Alluvial Sand/Top of Clay	NONE	--	NI	NI	--	--
MW509	Alluvial Sand	NONE	--	NI	NI	--	--
MW509D	Alluvial Sand/Top of Bedrock	NONE	--	NI	NI	--	--
MW510	Alluvial Sand/Top of Clay	**RDX**	2(a)	NI	NI	24	24
MW511	Alluvial Sand/Top of Clay	**RDX**	2(a)	NI	NI	19	19
MW513	Alluvial Sand/Top of Clay	**RDX**	2(a)	NI	NI	23	26
MW514	Alluvial Sand/Top of Clay	NONE	--	NI	NI	--	--
MW515	Alluvial Sand/Top of Clay	NONE	--	NI	NI	--	--
MW516	Alluvial Sand/Top of Clay	NONE	--	NI	NI	--	--
MW517	Alluvial Sand/Top of Clay	NONE	--	NI	NI	--	--

Notes:
(a) Health Advisory Level (HALs)
COC = Chemical of Concern
J = Estimated
MW = Monitoring Well
NI = Not Installed
NS = Not Sampled
PRGs = Preliminary Remediation Goals
-- = No PRGs exceeded
[shaded] = Concentrations exceeding PRGs

Source:
[1]Fall 1999 Off-Site Groundwater RI Phase II (Harza)
[2]Spring 2001 Off-Site Groundwater RI Phase IV (Harza)
[3]Spring 2002 Off-Site Groundwater RI (URS)
[4]Fall 2002 GWM (HGL)

LEGEND

IAAAP BOUNDARY
LEVEE
PAVED OR GRAVEL ROAD
RAILROAD TRACKS
MW500 MONITORING WELL GROUNDWATER SAMPLE LOCATION
DP509 NOVEMBER 2001 DIRECT PUSH GROUNDWATER SAMPLE LOCATION (URS)
DP509 JANUARY 2002 DIRECT PUSH GROUNDWATER SAMPLE LOCATION (URS)
2 RDX CONCENTRATIONS > 2µg/L AT BASE OF AQUIFER – MAY 2002
B B' CROSS SECTION B–B'
C C' CROSS SECTION C–C'

N

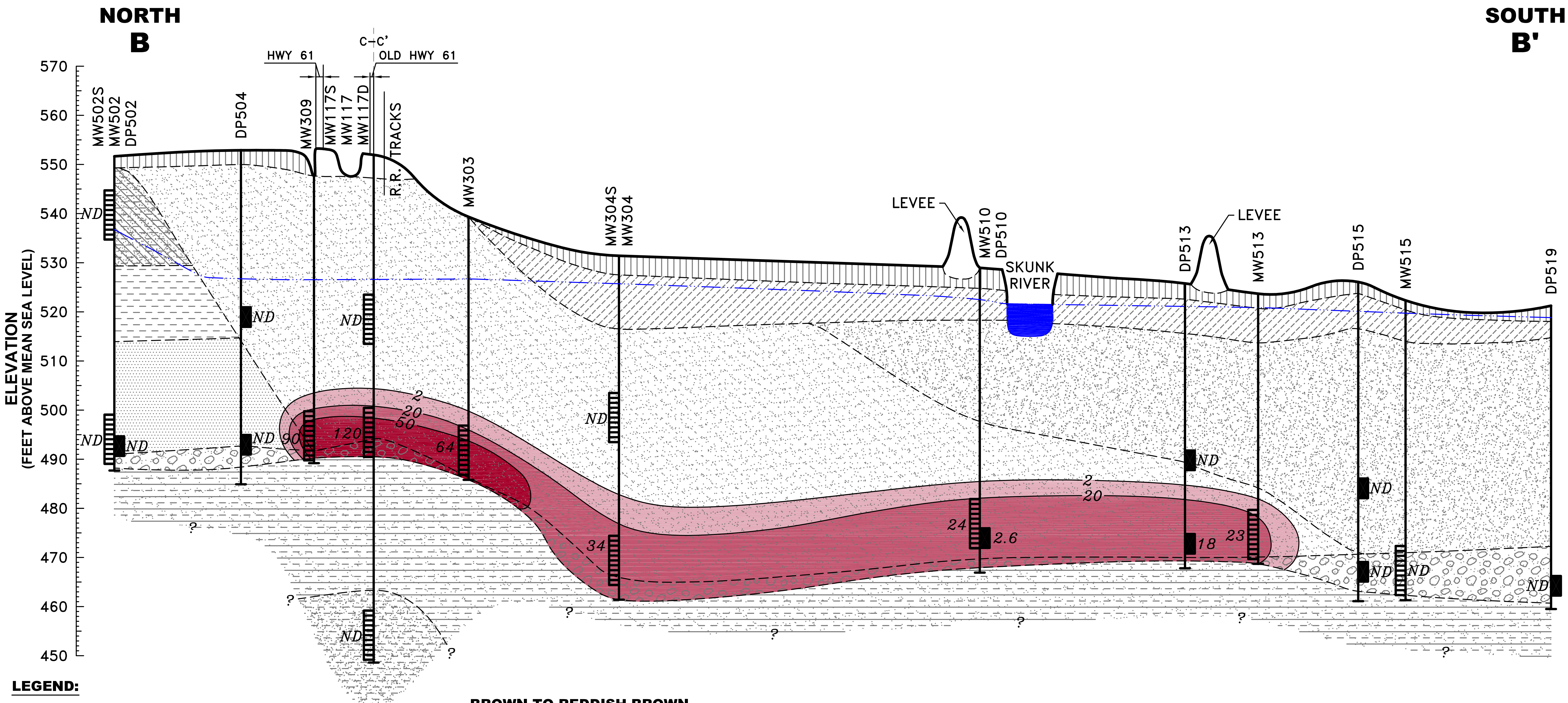
1500 750 0 1500
SCALE IN FEET

March 05, 2004 10:01:13 a.m.
Drawing: T:\IAAAP\16169419\00501\2-7.dwg

URS

HORIZONTAL EXTENT OF RDX EXCEEDING PRGs IN GROUNDWATER
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAV	DATE: 09/26/03	PROJECT NO. 16169419	FIG. NO. 2-7
CHK'D. BY: JMR	DATE: 09/26/03		



LEGEND:

FILL	BROWN TO REDDISH-BROWN, COARSE TO MEDIUM GRAINED SAND (ALLUVIUM)
TOPSOIL	GRAY, FINE GRAINED SAND (ALLUVIUM)
CLAYEY SILT (ALLUVIUM)	SANDY GRAVEL (ALLUVIUM)
SILT, CLAY, AND SAND (COLLUVIUM / ALLUVIUM)	CLAY W/SAND (GLACIAL TILL)
SILT (ALLUVIUM)	CLAYEY SAND (GLACIAL)
HIGH PLASTIC CLAY (ALLUVIUM)	C–C' CROSS-SECTION INTERSECTION
GRAY, MEDIUM TO FINE GRAINED SAND (ALLUVIUM)	? DEPTH OF STRATA IS ESTIMATED OR UNKNOWN
	WATER TABLE - JUNE 2002
	2 EXTENT OF RDX > 2 μg/L - MAY 2002

97 DIRECT PUSH SAMPLE INTERVAL WITH RDX CONCENTRATIONS (IN μg/L)

76 MONITORING WELL SCREENED INTERVAL WITH RDX CONCENTRATIONS (IN μg/L)

800 400 0 800
HORIZONTAL SCALE IN FEET

20 10 0 20
VERTICAL SCALE IN FEET

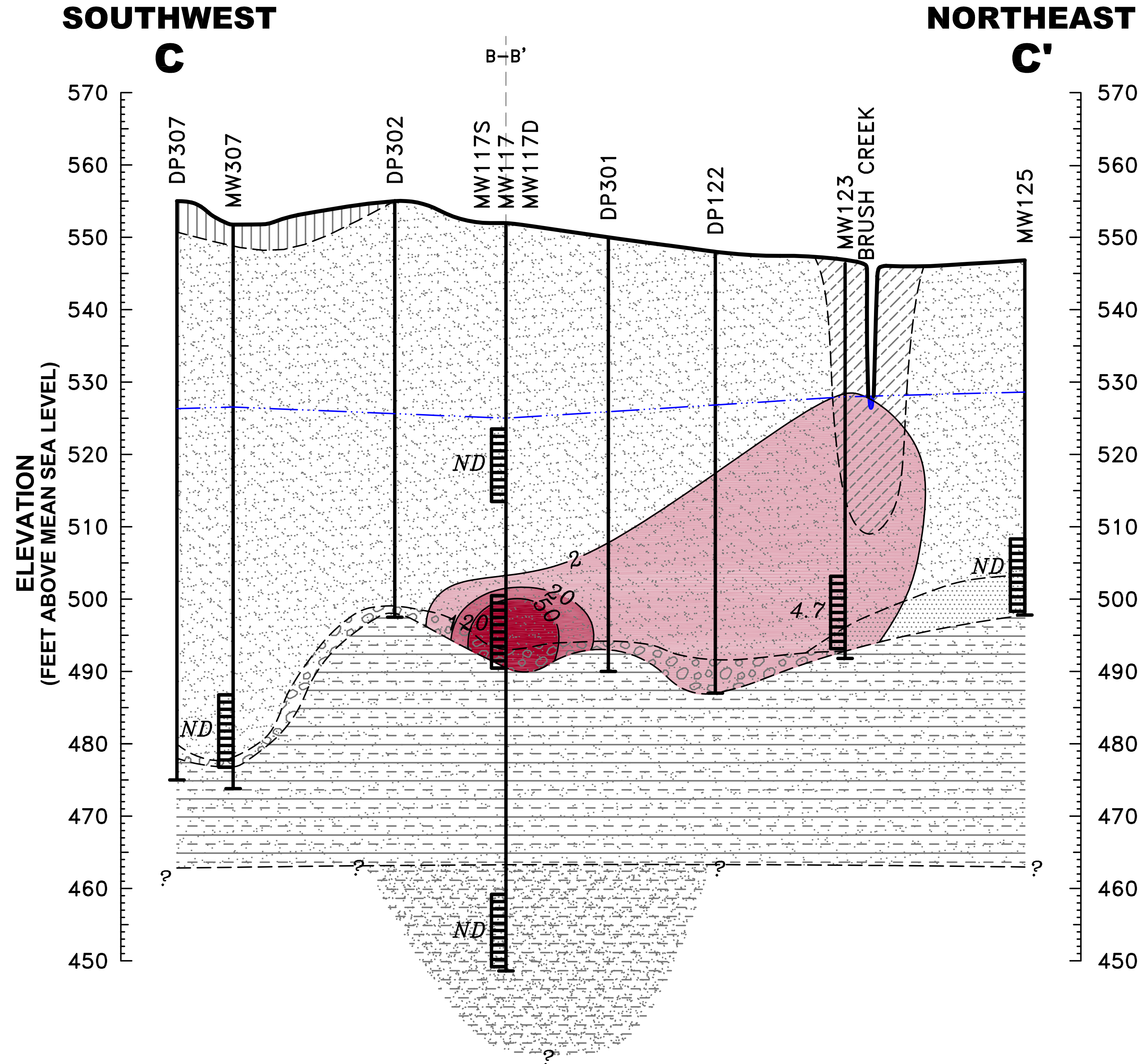
NOTE: VERTICAL EXAGGERATION IS 40:1

URS

RDX CONCENTRATIONS ALONG CROSS-SECTION B-B'
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/25/03	PROJECT NO.	FIG. NO.
CHK'D. BY: DRH	DATE: 09/25/03	16169419	2-8

March 05, 2004 9:58:53 a.m.
Drawing: T:\IAAAP\16169419\00501\SECT.dwg



LEGEND:

- FILL
- TOPSOIL
- SILTY CLAY (ALLUVIUM)
- GRAY, MEDIUM TO FINE GRAINED SAND (ALLUVIUM)
- BROWN TO REDDISH-BROWN, COARSE TO MEDIUM GRAINED SAND (ALLUVIUM)
- GRAY, FINE GRAINED SAND (ALLUVIUM)
- SANDY GRAVEL (ALLUVIUM)
- CLAY W/SAND (GLACIAL TILL)
- CLAYEY SAND (GLACIAL OUTWASH)
- B–B' CROSS-SECTION INTERSECTION
- ? DEPTH OF STRATA IS ESTIMATED OR UNKNOWN
- WATER TABLE - JUNE 2002
- 76 MONITORING WELL SCREENED INTERVAL WITH RDX CONCENTRATIONS (IN μg/L)
- 2 EXTENT OF RDX > 2 μg/L - MAY 2002

800 400 0 800
HORIZONTAL SCALE IN FEET

20 10 0 20
VERTICAL SCALE IN FEET

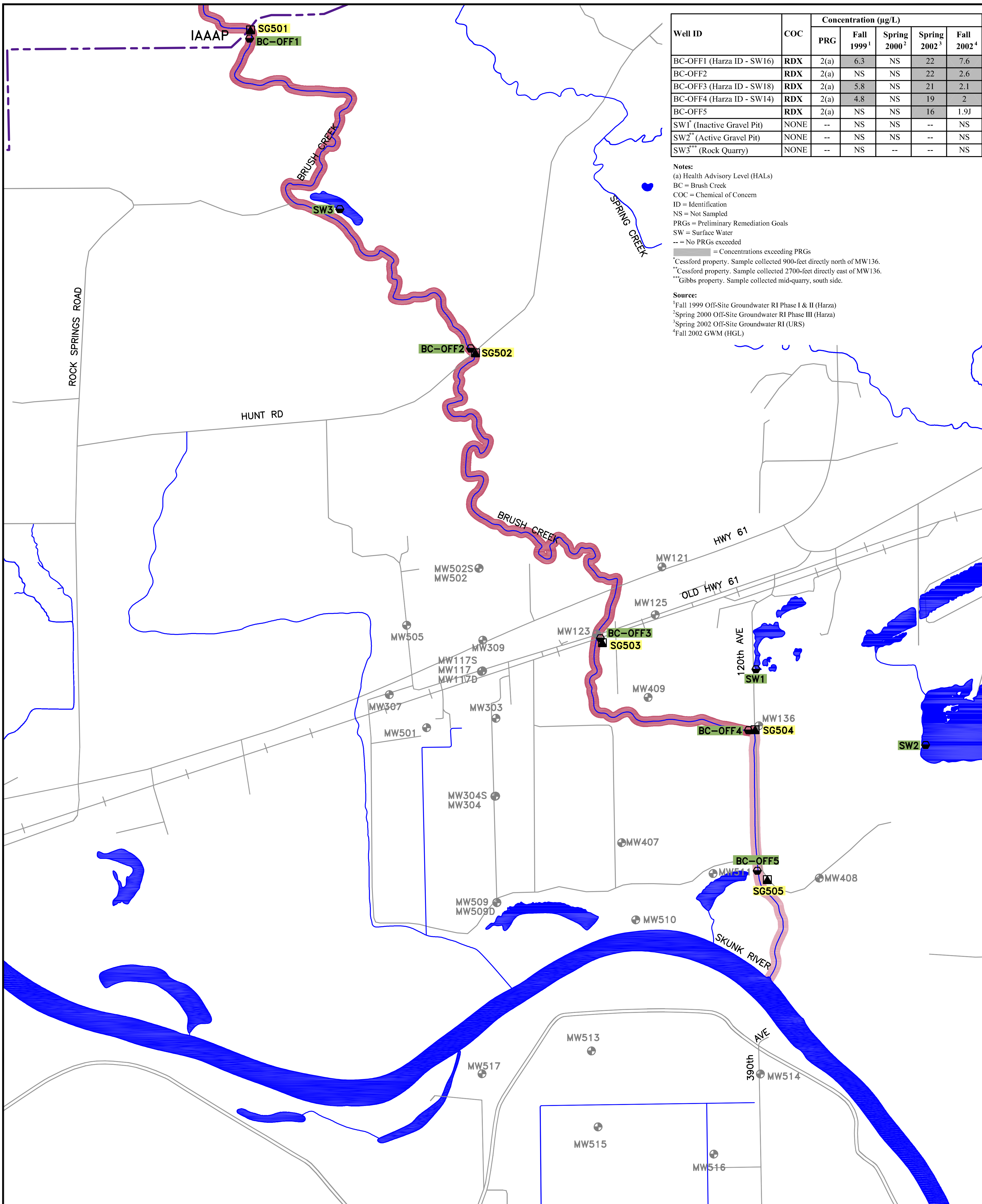
NOTE: VERTICAL EXAGGERATION IS 40:1

March 05, 2004 9:58:32 a.m.
Drawing: T:\IAAAP\16169419\00501\SECT.dwg

URS

RDX CONCENTRATIONS ALONG CROSS-SECTION C–C'
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/25/03	PROJECT NO.	FIG. NO.
CHK'D. BY: DRH	DATE: 09/25/03	16169419	2-9



Well ID	COC	Concentration (µg/L)				
		PRG	Fall 1999[1]	Spring 2000[2]	Spring 2002[3]	Fall 2002[4]
BC-OFF1 (Harza ID - SW16)	**RDX**	2(a)	6.3	NS	22	7.6
BC-OFF2	**RDX**	2(a)	NS	NS	22	2.6
BC-OFF3 (Harza ID - SW18)	**RDX**	2(a)	5.8	NS	21	2.1
BC-OFF4 (Harza ID - SW14)	**RDX**	2(a)	4.8	NS	19	2
BC-OFF5	**RDX**	2(a)	NS	NS	16	1.9J
SW1* (Inactive Gravel Pit)	NONE	--	NS	NS	--	NS
SW2** (Active Gravel Pit)	NONE	--	NS	NS	--	NS
SW3*** (Rock Quarry)	NONE	--	NS	--	--	NS

Notes:
(a) Health Advisory Level (HALs)
BC = Brush Creek
COC = Chemical of Concern
ID = Identification
NS = Not Sampled
PRGs = Preliminary Remediation Goals
SW = Surface Water
-- = No PRGs exceeded
[shaded] = Concentrations exceeding PRGs
*Cessford property. Sample collected 900-feet directly north of MW136.
**Cessford property. Sample collected 2700-feet directly east of MW136.
***Gibbs property. Sample collected mid-quarry, south side.

Source:
[1]Fall 1999 Off-Site Groundwater RI Phase I & II (Harza)
[2]Spring 2000 Off-Site Groundwater RI Phase III (Harza)
[3]Spring 2002 Off-Site Groundwater RI (URS)
[4]Fall 2002 GWM (HGL)

LEGEND

- IAAAP BOUNDARY
- LEVEE
- PAVED OR GRAVEL ROAD
- RAILROAD TRACKS
- MW303 — MONITORING WELL LOCATION
- SG501 — STAFF GAUGE LOCATION
- BC-OFF1 — SURFACE WATER SAMPLE LOCATION
- 2 — RDX CONCENTRATIONS > 2µg/L IN SURFACE WATER – MAY 2002
- 20 — RDX CONCENTRATIONS > 20µg/L IN SURFACE WATER – MAY 2002

N

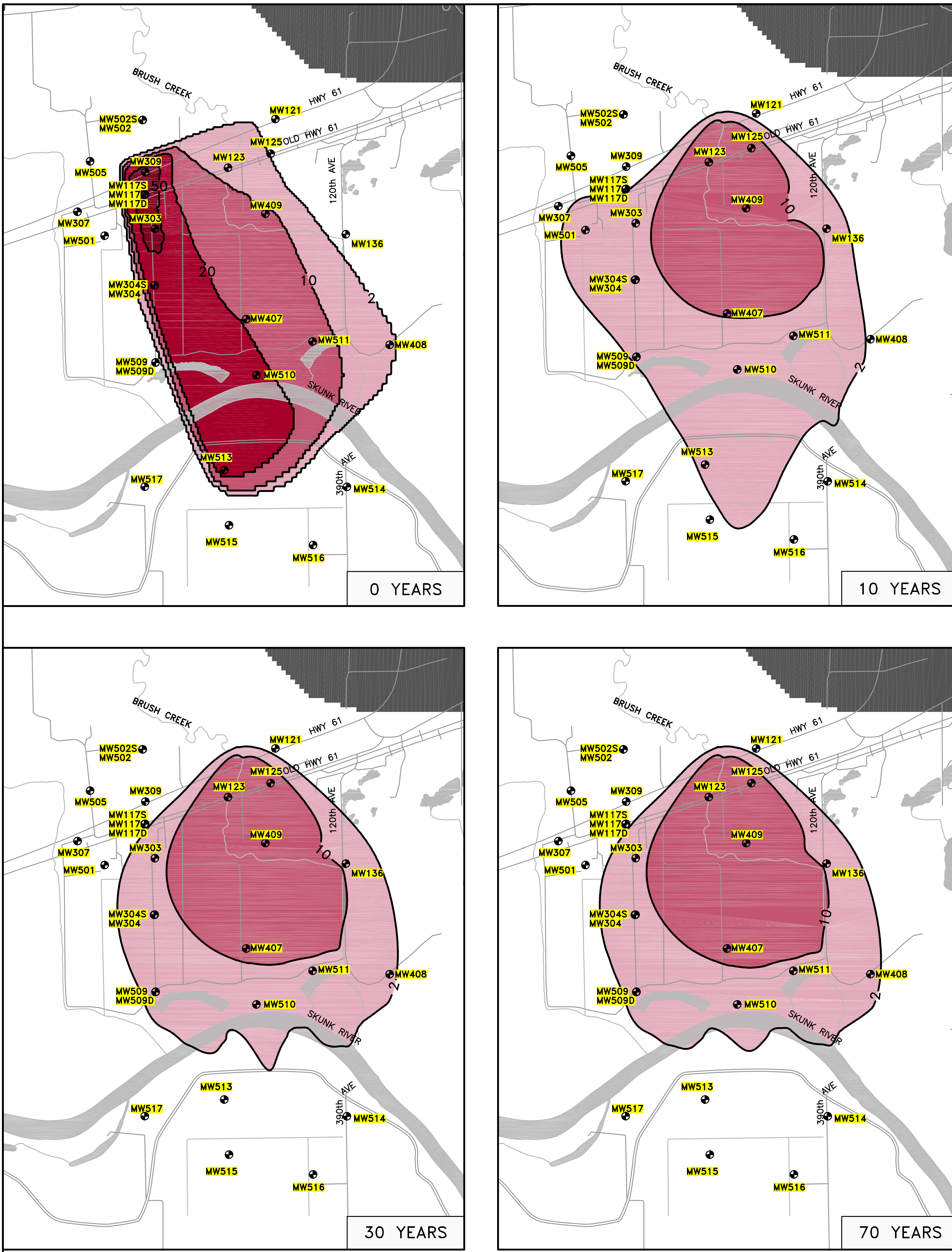
1500 750 0 1500
SCALE IN FEET

February 20, 2004 1:32:55 p.m.
Drawing: T:\IAAAP\16169419\00501\2-10.dwg

URS

EXTENT OF RDX EXCEEDING PRGs IN SURFACE WATER
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 08/19/02	PROJECT NO. 16169419	FIG. NO. 2-10
CHK'D. BY: TLT	DATE:		



LEGEND

LEVEE

PAVED OR GRAVEL ROAD

RAILROAD TRACKS

MW500 MONITORING WELL LOCATION

2 HORIZONTAL EXTENT OF RDX >2μg/L

INACTIVE FLOW BOUNDARY

NOTES

CONTAMINANT PLUMES SHOWN ARE FROM MODEL LAYER 3 (INTERMEDIATE SAND ALLUVIUM) BECAUSE THE GREATEST EXTENT OF RDX IS IN LAYER 3.

0 YEARS = MAY 2002 INPUT

N

2000 1000 0 2000

SCALE IN FEET

September 23, 2003 1:50:34 p.m.
Drawing: T:\IAAAP\16169419\00501\2-11.dwg

URS

MODEL-PREDICTED RDX CONCENTRATIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: JJS	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: DRH	DATE: 02/18/04	16169419	2-11

This section presents the development of RAOs for Off-Site groundwater, including identification of contaminants, media of concern, and exposure pathways; evaluation of ARARs; and determination of PRGs.

3.1 CONTAMINANTS, MEDIA OF CONCERN, AND EXPOSURE PATHWAYS

The primary contaminant and medium of concern is RDX in groundwater. A secondary contaminant and medium of concern is RDX in surface water within Brush Creek, identified as a potential source of groundwater contamination. However, alternatives are not developed in this FS to address Brush Creek surface water. Instead, Brush Creek will be addressed as a separate project. The exposure pathway of concern identified during the human health risk assessment (**Section 2.7**) was residential exposure to RDX-contaminated groundwater from drinking water wells screened in the shallow–intermediate aquifer.

3.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Remedial actions under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) must attain cleanup standards that assure protection of human health and the environment, are cost-effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable (USEPA 1988). In addition, Section 121(d) of CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that any hazardous substance or pollutant remaining on site meet certain regulatory standards that have been identified as ARARs. Subpart E, Section 300.400(g), “Identification of applicable or relevant and appropriate requirements,” of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] Part 300) describes the process to establish the ARARs. ARARs include standards, requirements, criteria, or limitations established under any federal environmental law or any more stringent standards, requirements, criteria, or limitations promulgated in accordance with a state environmental statute. According to the NCP, “promulgated” means that the standards are of general applicability and are legally enforceable.

A requirement may be either applicable or relevant and appropriate to remedial activities at a site, but not necessarily both. Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a site. A remedial action must satisfy all the jurisdictional prerequisites of a requirement for the requirement to be applicable.

If a regulation is not applicable, it may still be relevant and appropriate. The basic considerations are whether the requirement: (1) regulates or addresses problems or situations sufficiently similar to those encountered at the subject site (i.e., relevance); and (2) is appropriate to the circumstances of the release or threatened release, such that its use is well suited to the particular site. Determining whether a requirement is relevant and appropriate is site-specific and based on professional judgment. When determining relevance and appropriateness, various site-specific factors are considered and compared to statutory or regulatory requirements. The site-specific factors include the characteristics of the remedial action, the hazardous substances present at the site, and the physical circumstances of the site and of the release.

ARARs are classified in three categories, as follows:

- Chemical-specific ARARs are health- or risk-based concentration limits or discharge limitations in environmental media (i.e., air, soil, or water) for specific hazardous chemicals. These requirements may be used to set cleanup levels for the chemicals of concern in the designated media or to set a safe level of discharge (e.g., air emission or wastewater discharge, taking into account water quality standards) where a discharge occurs as part of the remedial action.
- Location-specific ARARs are restrictions placed on the types of activities that may occur in particular locations. The location of a site may be an important characteristic in determining its impact on human health and the environment. Location-specific ARARs include federal requirements for wetlands protection and floodplain restrictions on management of hazardous waste.
- Action-specific ARARs generally set performance, design, or other similar operational controls or restrictions on particular activities related to management of hazardous substances or pollutants. These requirements address specific activities that are used to accomplish a remedy. Action-specific requirements do not in themselves determine the remedial action; rather, they indicate how a selected remedial action alternative must be designed, operated, or managed.

In addition to ARARs, "to be considered" (TBC) guidances are nonpromulgated advisories, proposed rules, criteria, or guidance documents issued by federal or state governments that do not have the status of potential ARARs. These advisories and guidances are to be considered when determining protective cleanup levels where no ARAR exists or where ARARs are not sufficiently protective of human health and the environment.

Potential chemical-specific, location-specific, and action-specific ARARs for the Off-Site Groundwater FS are described and evaluated in **Tables 3-1**, **3-2**, and **3-3**. Based on chemicals present, potential locations of actions, and potential actions, the following are considered to be key ARARs/TBCs for Off-Site groundwater remedial alternatives:

Federal

- Drinking Water Standards and Health Advisories, USEPA 2002
  - Lifetime Health Advisory Levels (HALs)
- Clean Water Act, as amended, 33 USC Section 1251-1387
  - 40 CFR Part 125, Criteria and Standards for the National Pollutant Discharge Elimination System (NPDES)
  - 40 CFR Part 131, Water Quality Standards
  - 40 CFR Part 136, Guidelines Establishing Test Procedures for the Analysis of Pollutants

- Solid Waste Disposal Act (SWDA), as amended, 42 USCA Section 6901-6992K
  - 40 CFR Part 260, Hazardous Waste Management Systems-General (Subtitle C)
  - 40 CFR Part 261, Identification and Listing of Hazardous Wastes (Subtitle C)
  - 40 CFR Part. 262, Standards Applicable to Generators of Hazardous Waste
  - 40 CFR Part. 263, Standards Applicable to Transporters of Hazardous Waste
- Occupational Safety and Health Act, 29 USC 15
  - 29 CFR Part 1910, Occupational Safety and Health Standards
  - 29 CFR Part. 1910.120, Hazardous Waste Operations and Emergency Response
  - 29 CFR Part 1926, Safety and Health Regulations for Construction
- Hazardous Materials Transportation Act, 49 CFR Parts 101, 106-107, 172-173, 178-180, 171, 173-177
  - 49 CFR Parts 107 and 171-177
- Endangered Species Act, 16 USC Section 1531 et seq.
  - 50 CFR Part 17, Endangered and Threatened Wildlife and Plants
  - 50 CFR Part 402, Interagency Cooperation--Endangered Species Act of 1973, as amended
- Bald and Golden Eagle Protection Act, 16 USC Section 668 et seq.
  - 16 United States Code (USC) 668 et seq.
- Migratory Bird Treaty Act of 1972, 16 USC Section 703
  - 16 USC Section 703
- National Archaeological and Historic Preservation Act of 1974, 16 USC Section 469
  - 16 USC Section 469
  - 36 CFR Part 65
- Floodplain Management, Executive Order 11988
  - 40 CFR Part 6.302
- Protection of Wetlands, Executive Order 11990
  - Executive Order 12608 (amended),
  - 40 CFR Part 6.302

State

- Effluent and Pretreatment Standards, 567 IAC, Title IV, Chapter 62
  - 567 Iowa Administrative Code (IAC) 62.1(455B)(1)
- Water Quality Standards, 567 IAC, Title IV, Chapter 61

  - 567 IAC 61.2(455B)(2)
  - 567 IAC 61.3(455B)
- Nonpublic Water Supply Wells, 567 IAC, Division B, Chapter 49
  - 567 IAC 49(455b)
- Criteria and Conditions for Authorizing Withdrawal, Diversion, and Storage of Water, 567 IAC, Division C, Chapter 52
  - 567 IAC 52(455b)
- Wastewater Treatment and Disposal, 567 IAC, Title IV
  - 567 IAC 61(455b), Establishment of Water Quality Standards
  - 567 IAC 62(455b), Effluent and Pretreatment Standards
  - 567 IAC 63(455b), 567 IAC 64(455b), Wastewater Disposal Systems
  - 567 IAC 69(455b), On-Site Wastewater Treatment and Disposal Systems
- Flood Plain or Floodway Development, 567 IAC, Title V, Chapter 71
  - 567 IAC 71(455b)
- Solid Waste Comprehensive Planning Requirements, 567 IAC, Title VIII, Chapter 101
  - 567 IAC 101(455b, 455d), Iowa Solid Waste Management and Disposal General Requirements
- Rules for Determining Cleanup Actions and Responsible Parties, 567 IAC, Title IX, Chapter 133
  - 567 IAC 133(455b, 455e)
- Hazardous Waste, 567 IAC, Title XI, Chapter 141
  - 567 IAC 141(455b)
- Endangered Plants and Wildlife, 571 IAC, Chapter 77
  - 571 IAC 77(481b)

3.3 PRELIMINARY REMEDIATION GOALS

PRGs are recommended maximum concentrations of individual chemicals for specific media and land use combinations. PRGs provide long-term targets to use during development, evaluation, and selection of remedial action alternatives. PRGs are generally incorporated into RAOs and developed from two sources: (1) concentrations based on chemical-specific ARARs, and (2) concentrations based on risk assessment. Risk-based PRGs are concentration limits that are calculated using carcinogenic and noncarcinogenic toxicity values under specific exposure conditions. PRGs are typically refined into final remediation goals at the conclusion of the remedy selection process, which follows the FS.

For Off-Site groundwater, two sets of PRGs have been identified:

- In the absence of an MCL, the lifetime HAL for RDX in drinking water. Per USEPA (2001), the lifetime HAL is the concentration of a chemical in drinking water that is not expected to cause any adverse noncarcinogenic effects for a lifetime of exposure, adjusted for possible carcinogenicity for Class C carcinogens, which includes RDX.
- Risk-based PRGs for RDX calculated during the human health risk assessment (**Section 2.7**) completed as part of the Off-Site Groundwater RI (URS 2003). These PRGs were calculated using the USEPA target risk levels of 10^{-6}, 10^{-5}, and 10^{-4}.

The potential range of values for the RDX PRG, based on the preceding criteria, is listed below:

Contaminant	Medium of Concern	USEPA Lifetime HAL (µg/L)	Calculated Risk-Based PRG (µg/L)		
			10^{-6}	10^{-5}	10^{-4}
RDX	Groundwater	2	0.61	6.1	61

For Off-Site groundwater, the lifetime HAL will be incorporated into RAOs. The selection of the lifetime HAL is consistent with the general hierarchy used at the IAAAP facility to establish PRGs, which first considers whether there is an MCL, then a HAL, then a USEPA Region 9 PRG, and then using a site-specific, risk-based PRG. The final remediation goal for Off-Site groundwater will be determined during the remedy selection process (**Section 8**), incorporating any new information that may be available at that time.

3.4 REMEDIAL ACTION OBJECTIVE

Based on the above considerations, the following RAO is proposed for IAAAP Off-Site groundwater:

- Prevent residential human exposure to RDX above its lifetime HAL of 2 µg/L in Off-Site groundwater.

TABLE 3-1
POTENTIAL CHEMICAL-SPECIFIC ARARs
OFF-SITE GROUNDWATER FEASIBILITY STUDY

CITATION	DESCRIPTION	COMMENT
FEDERAL		
Safety of Public Water Systems (Safe Drinking Water Act), 42 USC Section 300		
40 CFR Part 141 **National Primary Drinking Water Regulations and National Revised Primary Drinking Water Regulations**	Establishes MCLs, which are health-based standards for specific contaminants.	Not an ARAR. No MCL exists for contaminant of concern (RDX).
40 CFR Part 142 **National Primary Drinking Water Regulations Implementation**	Establishes procedures for granting variances from MCL requirements. Specifies best technologies for treatment of various pollutants.	Applicable if treated water is to be used as a source of drinking water.
40 CFR Part 143 **National Secondary Drinking Water Regulations**	Establishes secondary MCLs, which are guidelines for public drinking water systems to protect the aesthetic quality of the water. Secondary MCLs are not federally enforceable.	TBC for specified constituents if treated water is to be used as a source of drinking water.
"2002 Edition of the Drinking Water Standards and Health Advisories," EPA Office of Water, Summer 2002		
Lifetime Health Advisory Levels (HALs)	Lifetime HALs provide the most currently available information on concentrations of drinking water contaminants at which adverse noncarcinogenic effects are anticipated to occur as a result of lifetime exposure.	TBC for helping to establish cleanup goals for certain contaminants that do not have MCLs (e.g., RDX).
"USEPA Region 9 Preliminary Remediation Goals", October 1, 2002		
Region 9 Preliminary Remediation Goals (PRGs)	Region 9 PRGs are non-enforceable chemical concentration levels used to screen pollutants in environmental media.	TBC for helping to establish cleanup goals for certain contaminants that do not have MCLs or HALs.
Water Pollution Control Act (Clean Water Act), as amended, 33 USC Section 1251-1387		
40 CFR Part 125 **Criteria and Standards for the National Pollutant Discharge Elimination System (NPDES)**	Establishes procedures for determination of effluent limitations for discharges of pollutants to navigable waters.	Applicable if treated groundwater is discharged to a water of the United States.
40 CFR Part 129 **Toxic Pollutant Effluent Standards**	Establishes effluent standards or prohibitions for certain toxic pollutants (as designated at 40 CFR 401).	Not an ARAR. Applicable only where remedial action would result in effluent containing the listed toxic pollutants, which have not been detected in the IAAAP Off-Site area.
40 CFR Part 131 **Water Quality Standards**	Requires states to establish AWQC for surface water based on use classifications and the criteria stated under Section 304(a) of the CWA.	Applicable if treated groundwater is discharged to a water of the United States.
40 CFR Part 136 **Guidelines Establishing Test Procedures for the Analysis of Pollutants**	Specific analytical procedures for NPDES applications and reports.	Applicable if treated groundwater is discharged to a water of the United States.

TABLE 3-1
POTENTIAL CHEMICAL-SPECIFIC ARARs
OFF-SITE GROUNDWATER FEASIBILITY STUDY

CITATION	DESCRIPTION	COMMENT
FEDERAL		
40 CFR Part 401 **General Provisions for Effluent Guidelines and Standards**	Defines the list of toxic pollutants for purposes of Section 307(a)(1) of the CWA. Effluent standards for some pollutants found on this list are found at 40 CFR 129.4.	Not an ARAR. Applicable only where remedial action would result in effluent containing the listed toxic pollutants, which have not been detected in the IAAAP Off-Site area.
40 CFR Part 403 **General Pretreatment Regulations for Existing and New Sources of Pollution**	Applies to discharges of pollutants to POTWs. Requires that such pollutants not interfere with operation of the POTW or pass through the POTW at concentrations which cause a violation of the POTW's NPDES permit.	Not an ARAR. There are no plans to discharge untreated or treated water to a POTW.
STATE		
Water Supplies, 567 IAC, Division B, Chapter 41		
567 IAC 41.3(455B)(1)(b) **567 IAC 41.3(455B)(5)(a) and (b)** **567 IAC 41.3(455B)(6)(a)**	Establishes MCLs for specific contaminants that are applicable for drinking water supplied by community water systems and for nontransient, noncommunity drinking water systems.	Not an ARAR. No MCL exists for contaminant of concern (RDX).
Effluent and Pretreatment Standards, 567 IAC, Title IV, Chapter 62		
567 IAC 62.1(455B)(1)	Establishes NPDES permit conditions for point source discharge of pollutants into navigable waters.	Applicable if treated groundwater is discharged to a water of the United States.
Water Quality Standards, 567 IAC, Title IV, Chapter 61		
567 IAC 61.2(455B)(2) **567 IAC 61.3(455B)**	Establishes an antidegredation policy for surface waters of the State of Iowa, including requirements to maintain certain flows and water quality criteria.	Applicable if treated groundwater is discharged to a water of the United States.

NOTES:
ARAR = Applicable or Relevant And Appropriate
AWQC = Ambient Water Quality Criteria
CFR = Code of Federal Regulations
CWA = Clean Water Act
IAC = Iowa Administrative Code
MCL = Maximum Contaminant Level
NPDES = National Pollutant Discharge Elimination System
POTW = Publicly Owned Treatment Works
RDX = A common military explosive (cyclonite)
TBC = To Be Considered
USC = United States Code
USEPA (EPA) = United States Environmental Protection Agency

TABLE 3-2
POTENTIAL LOCATION-SPECIFIC ARARs
OFF-SITE GROUNDWATER FEASIBILITY STUDY

CITATION	DESCRIPTION	COMMENTS
FEDERAL		
Endangered Species Act, 16 USC Section 1531 et seq.		
50 CFR Part 17 **Endangered and Threatened Wildlife and Plants** **50 CFR Part 402** **Interagency Cooperation--Endangered Species Act of 1973, as amended**	Protects endangered species and the critical habitats upon which endangered species depend.	Applicable. Activities within the habitat of the Indiana bat and the bald eagle require Section 7 ESA consultation with USFWS. Currently, an endangered species management plan for the Indiana Bat, Bald Eagle, or Orangethroat Darter does not exist for the Off-Site area.
Bald and Golden Eagle Protection Act, 16 USC Section 668 et seq.		
16 USC 668 et seq.	Prohibits the taking, possession, and transportation or any bald or golden eagle, dead or alive, or any part, nest or egg.	Applicable. The bald eagle winters along large rivers such as the Skunk and Mississippi, which are in the vicinity of the IAAAP Off-Site area.
Game, Fur-Bearing Animals, and Fish (Fish and Wildlife Coordination Act), 16 USC Section 661 et seq.		
16 USC Section 661 et seq. **40 CFR Part 6.302** **Wetlands, Floodplains, Important Farmlands, Coastal zones, Wild and Scenic Rivers, Fish and Wildlife, and Endangered Species**	Provides for protection of fish or wildlife if proposed action involves diversion, channeling, or other activity that modifies a stream or river.	Applicable if remedial activities modify Brush Creek.
Migratory Bird Treaty Act of 1972, 16 USC Section 703		
16 USC Section 703	Protects native migratory bird species from unregulated "take." Poisoning due to exposure at hazardous waste sites can be included under this Act.	Applicable. The IAAAP Off-Site area is near the Mississippi River, a major flyway for migratory birds.
United States Wilderness Preservation System Act, 16 USC Section 1131 et seq.		
16 USC Section 1131 et seq. **50 CFR Part 35**	Federally owned area designated as wilderness area must be administered in such a manner that will leave it unimpaired as wilderness and to preserve its wilderness.	Not an ARAR. No federally owned wilderness area is located in the vicinity of the IAAAP Off-Site area.
National Wildlife Refuge System Administration Act, 16 USC Section 668dd		
50 CFR Parts 25-27	Limits actions allowed in areas designated as part of the National Wildlife Refuge System.	Not an ARAR. No national wildlife refuge is located in the vicinity of the IAAAP Off-Site area.
National Archaeological and Historic Preservation Act of 1974, 16 USC Section 469		
16 USC Section 469 **36 CFR Part 65**	Must recover and preserve artifacts in area where alteration of terrain threatens significant scientific, prehistoric, historical, or archaeological data.	Applicable if historic ruins or objects are found during remedial activities.
National Historic Preservation Act of 1966, 16 USC Section 470 et seq.		
36 CFR Part 800 **40 CFR Part 6.301**	Must preserve property in or eligible for National Register of Historic Places; actions should minimize harm to National Historic Landmarks.	Not an ARAR. No historical place or landmark has been identified at the IAAAP Off-Site area.

TABLE 3-2
POTENTIAL LOCATION-SPECIFIC ARARs
OFF-SITE GROUNDWATER FEASIBILITY STUDY

CITATION	DESCRIPTION	COMMENTS
	FEDERAL	
The Antiquities Act of 1906, 16 USC Section 433		
43 CFR Part 3	Provides for protection of historic and prehistoric ruins and objects on federal lands.	Not an ARAR. The Off-Site area is not located on federal lands.
Native American Graves Protection and Repatriation Act, 25 USC Section 3001		
Public Law 101-601	Requires that if Native American remains or cultural items are found on federal lands, the appropriate tribe must be notified, and all activity in the area of discovery must cease for at least 30 days.	Not an ARAR. The Off-Site area is not located on federal lands.
Farmland Protection Policy Act, 7 USC Section 4201 et seq.		
7 CFR Part 658	Protection of significant and important agricultural lands from irreversible conversion.	Not an ARAR. No significant or important agricultural land will be irreversibly impacted by remedial action at the IAAAP Off-Site area.
Coastal Zone Management Act, 16 USC Section 1451 to 1465		
16 USC Section 1451 to 1465	Activities affecting the coastal zone, including lands therein and thereunder, and adjacent shore lands must be conducted in a manner consistent with approved state management programs.	Not an ARAR. No coastal zone is present at IAAAP.
Coastal Barrier Resources Act, 16 USC Section 3501 et seq.		
16 USC Section 3501 et seq.	Prohibits any new federal expenditures that can promote development within the coastal barrier resource system.	Not an ARAR. No coastal area is present at IAAAP.
The Wild and Scenic Rivers Act, 16 USC Section 1271 et seq.		
40 CFR Part 6.302(e) **36 CFR Part 297**	Limits actions that will have direct adverse effect on scenic river as specified in Section 1276(a).	Not an ARAR. No designated scenic or wild rivers are located at the IAAAP Off-Site area.
Floodplain Management, Executive Order 11988		
40 CFR Part 6.302	Limits activities in a floodplain, which is defined as "the lowland and relatively flat areas adjoining inland and coastal waters including at a minimum that area subject to a 1 percent or greater chance of flooding in any given year" (the 100-year floodplain).	Applicable for remedial activities in the lowland area of the IAAAP Off-Site area.
Standards for Owners and Operators of Solid Waste Treatment, Storage and Disposal Facilities, 40 CFR Part 265		
40 CFR 264.18	RCRA treatment, storage, or disposal facility must be designed, constructed, operated, and maintained to avoid faults, floodplains and salt domes.	Not ARAR. Remedial activities will not involve construction of TSD facility within or near the regulated features.

TABLE 3-2
POTENTIAL LOCATION-SPECIFIC ARARs
OFF-SITE GROUNDWATER FEASIBILITY STUDY

CITATION	DESCRIPTION	COMMENTS
FEDERAL		
Protection of Wetlands, Executive Order 11990		
Executive Order 12608 (amended) **40 CFR Part 6.302**	Addresses possible impacts of construction of facilities or management of property in wetlands; must avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.	Applicable. Wetland areas occur within the IAAAP Off-Site area.
Safety of Public Water Systems (Safe Drinking Water Act), 42 USC Section 300 et seq.		
40 CFR Part 146 **Underground Injection Control Program: Criteria and Standards**	Sets criteria for underground injection wells, including those used to inject treated wastes from RCRA or CERCLA cleanup actions. These regulations address how close injection wells may be placed to underground sources of drinking water.	Not an ARAR. Treated wastes will not be injected as part of remedial activities.
40 CFR Part 149 **Sole Source Aquifers**	Includes regulations for defining sole or principal drinking water source aquifers.	Not an ARAR. No sole source aquifer is located in the IAAAP Off-Site area.
Public Law 104-182 **Wellhead Protection Program**	1986 SDWA amendments direct states to implement programs to protect wells and recharge areas for drinking water wells.	Not an ARAR. No wellhead protection area is located in the IAAAP Off-Site area.
Water Pollution Prevention and Control Act, as amended, 33 USC Section 1251 et seq.		
40 CFR Part 230 **33 CFR Parts 320-330**	Prohibits discharge of dredged or fill material into wetlands (as defined in U.S. Army Corps of Engineers regulations) without a permit.	Not an ARAR. No dredging or fill material will be generated as part of remedial activities.
STATE		
Use, Maintenance, Removal, Inspections, and Safety of Dams, 567 IAC, Title V, Section 73		
567 IAC 73(455b, 481a)	Establishes rules on the use, maintenance, removal, inspection, and safety of dams.	Not an ARAR. Damming will not be part of remedial activities.
Criteria for Siting Hazardous Waste Management Facilities, 567 IAC, Title XI, Chapter 151		
567 IAC 151.3(2) and Table 1	These rules establish criteria for evaluating sites for hazardous waste disposal.	Not an ARAR. A hazardous waste disposal facility will not be constructed as part of the remedial activities.
Endangered Plants and Wildlife, 571 IAC, Chapter 77		
571 IAC 77(481b)	Protects endangered species and the critical habitats upon which endangered species depend.	Applicable.

NOTES:

ARAR = Applicable or Relevant And Appropriate
CFR = Code of Federal Regulations
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
IAAAP = Iowa Army Ammunition Plant
IAC = Iowa Administrative Code
RCRA = Resource Conservation and Recovery Act
SDWA = Safe Drinking Water Act
USC = United States Code
USFWS = United States Fish and Wildlife Service

TABLE 3-3
POTENTIAL ACTION-SPECIFIC ARARs
OFF-SITE GROUNDWATER FEASIBILITY STUDY

CITATION	DESCRIPTION	COMMENTS
FEDERAL		
Solid Waste Disposal Act (SWDA), as amended, 42 USCA Section 6901-6992K		
40 CFR Part 257 **Criteria for Classification of Solid Waste Disposal Facilities and Practices (Subtitle D)**	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health. Prohibits open dumps.	Not an ARAR. Remedial action would not involve land disposal of derived wastes.
40 CFR Part 258 **Criteria for Municipal Waste Landfills (Subtitle D)**	Sets forth minimum criteria for municipal solid waste landfills, including design, operation, monitoring, corrective action, closure, and post-closure care requirements.	Not an ARAR. Remedial action will not involve design and operation of a non-hazardous solid waste landfill.
40 CFR Part 260 **Hazardous Waste Management Systems-General (Subtitle C)**	Provides definitions, general standards, and information applicable to 40 CFR Parts 260-265, 268.	Applicable if remedial action involves hazardous waste management.
40 CFR Part 261 **Identification and Listing of Hazardous Wastes (Subtitle C)**	Defines those solid wastes which are subject to regulations as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271.	Applicable for proper identification of remedial action generated waste.
40 CFR Part. 262 **Standards Applicable to Generators of Hazardous Waste**	Establishes standards for generators of hazardous waste.	Applicable if remedial action generates hazardous waste.
40 CFR Part. 263 **Standards Applicable to Transporters of Hazardous Waste**	Establishes standards which apply to transporting hazardous waste within the U.S. if the transportation requires a manifest under 40 CFR Part 262.	Applicable for remedial activities that will involve off-site transportation of hazardous waste.
40 CFR Part. 268 **Land Disposal Restrictions**	Identifies hazardous wastes restricted from land disposal and treatment standards for restricted wastes and waste treatment residuals.	Applicable if remedial action involves land disposal of hazardous waste.
Water Pollution Prevention and Control Act (Clean Water Act), 33 USC 1251-1387		
40 CFR Part. 122 **EPA Administered Programs : The National Pollutant Discharge Elimination System**	Requires control of excavated soils to prevent runoff and high sedimentation into surface water bodies. Erosion control measures should be implemented to reduce run-on and run-off that would cause migration of contaminants.	Applicable if remedial action involves excavation and/or stockpiling of contaminated soil.
40 CFR Part. 125 **Criteria and Standards for the National Pollutant Discharge Elimination System (NPDES)**	Regulates discharge of treated water or point sources to surface waters.	Applicable if remedial action discharges treated water to stream.
40 CFR Part. 403 **General Pretreatment Regulations for Existing and New Sources of Pollution**	Discharge of water to POTW requirements.	Not an ARAR. There are no plans to discharge water to a POTW.

TABLE 3-3
POTENTIAL ACTION-SPECIFIC ARARs
OFF-SITE GROUNDWATER FEASIBILITY STUDY

CITATION	DESCRIPTION	COMMENTS
FEDERAL		
Occupational Safety and Health Act, 29 USC 15		
29 CFR Part 1910 **Occupational Safety and Health Standards**	Regulates occupational health and safety. Requires proper precautions, equipment, and training before certain tasks are completed.	Certain portions of 29 CFR 1910 are applicable to remedial activities conducted at the IAAAP Off-Site area. The applicability of specific subsections would be determined as part of the Health and Safety Plan (29 CFR 1910.120)
29 CFR Part. 1910.120 **Hazardous Waste Operations and Emergency Response**	Remediation efforts must be conducted in accordance with health and safety regulations. Requires a Health and Safety Plan for remedial actions that involve potential contact with contaminated environmental media to protect workers health and prepare for any foreseeable emergencies.	Applicable to intrusive remedial activities.
29 CFR Part 1926 **Safety and Health Regulations for Construction**	Regulates construction health and safety.	Applicable to construction activities.
Hazardous Materials Transportation Act, 49 CFR Parts 101, 106-107, 172-173, 178-180, 171, 173-177		
49 CFR Parts 107 and 171-177	Establishes standards applicable to transporters of hazardous materials.	Applicable if remedial action involves transport of hazardous materials.
Air Pollution Prevention and Control (Clean Air Act), 42 USC 7401-7671q		
40 CFR Part. 50 **National Primary and Secondary Ambient Air Quality Standards**	Establishes monitoring requirements for sulfur oxides, particulate matter, carbon monoxide, ozone, nitrogen dioxide and lead during excavation.	May be applicable if remedial action involves excavation.
40 CFR Part 61 **National Emission Standards for Hazardous Air Pollutants**	Establishes substances considered to be hazardous air pollutants and emissions standards for those substances.	Not an ARAR. Applicable only where remedial action would result in emissions containing the listed toxic pollutants, which have not been detected in the IAAAP Off-Site area.
STATE		
Air Quality, 567 IAC, Title II		
567 IAC 23.3 (455B) **Emission Standards**	Establishes monitoring requirements for emission of particulates or dust from any process.	Applicable if remedial action involves excavation or other activity that may create dust.
567 IAC 28 (455B) **Ambient Air Quality Standards**	Establishes monitoring requirements for PM_{10} and lead during excavation.	Applicable if remedial action involves excavation or other activity that may create dust.
Nonpublic Water Supply Wells, 567 IAC, Division B, Chapter 49		
567 IAC 49(455b)	Establishes uniform minimum standards and methods for well construction and reconstruction for nonpublic water supply wells.	TBC for well construction and proximity to other water wells and sources.
Criteria and Conditions for Authorizing Withdrawal, Diversion, and Storage of Water, 567 IAC, Division C, Chapter 52		
567 IAC 52(455b)	Establishes criteria for issuance of water permits, permit conditions, and conditions for modification, cancellation, or suspension of permits. Includes special criteria for particular types of water sources such as streams and groundwater.	May be applicable if remedial action involves installation of water extraction wells.

TABLE 3-3
POTENTIAL ACTION-SPECIFIC ARARs
OFF-SITE GROUNDWATER FEASIBILITY STUDY

CITATION	DESCRIPTION	COMMENTS
STATE		
Wastewater Treatment and Disposal, 567 IAC, Title IV		
567 IAC 61(455b) **Establishment of Water Quality Standards**	Sets standards for the point or nonpoint source pollution of state waters.	Applicable if remedial action discharges treated water to waters of the state.
567 IAC 62(455b) **Effluent and Pretreatment Standards**	Sets standards for the treatment of water prior to discharge to either waters of the state or a POTW.	Applicable if remedial action discharges treated water to waters of the state.
567 IAC 63(455b), 567 IAC 64(455b) **Wastewater Disposal Systems**	Sets construction, operation, discharge, monitoring, analytical and reporting requirements for the operation of wastewater disposal systems.	Applicable if remedial action involves construction of a groundwater treatment system.
567 IAC 69(455b) **On-Site Wastewater Treatment and Disposal Systems**	Establishes rules for on-site wastewater treatment and disposal systems, including discharge restrictions and minimum distances.	Applicable if a remedial action includes an ex-situ treatment system such as granular activated carbon.
Flood Plain or Floodway Development, 567 IAC, Title V, Chapter 71		
567 IAC 71(455b)	Establishes statutory requirements for approval of development in a flood plain or floodway.	Applicable if a remedial action includes development in the Brush Creek or Skunk River flood plain or floodway
Use, Maintenance, Removal, Inspections, and Safety of Dams, 567 IAC, Title V, Section 73		
567 IAC 73(455b, 481a)	Establishes rules on the use, maintenance, removal, inspection, and safety of dams.	Not an ARAR. Damming will not be part of remedial activities.
Solid Waste Comprehensive Planning Requirements, 567 IAC, Title VIII, Chapter 101		
567 IAC 101(455b, 455d) **Iowa Solid Waste Management and Disposal General Requirements**	Defines requirements for disposal of solid wastes.	Applicable if remedial action produces solid wastes.
Rules for Determining Cleanup Actions and Responsible Parties, 567 IAC, Title IX, Chapter 133		
567 IAC 133(455b, 455e)	These rules establish the procedures and criteria the Department will use to determine the parties responsible and cleanup actions necessary to meet the goals of the State pertaining to the protection of groundwater. These rules pertain to the cleanup of groundwater, soils, and surface water where groundwater may be impacted.	Relevant and appropriate. The IAAAP Off-Site area is being remediated under CERCLA and the responsible parties have already been determined.
Iowa Land Recycling Program and Response Action Standards, 567 IAC, Title IX, Chapter 137		
567 IAC 137	Entry into the Iowa "land recycling" program.	Not an ARAR.
Hazardous Waste, 567 IAC, Title XI, Chapter 141		
567 IAC 141(455b)	Defines criteria for characterization and listing of RCRA hazardous waste.	Applicable for proper identification of remedial action-generated

NOTES:

ARAR = Applicable or Relevant And Appropriate
CFR = Code of Federal Regulations
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
EPA = United States Environmental Protection Agency
IAAAP = Iowa Army Ammunition Plant
IAC = Iowa Administrative Code
NPDES = National Pollutant Discharge Elimination System
PM_{10} = Particulate Matter Less Than 10 Microns
POTW = Publicly Owned Treatment Works
RCRA = Resource Conservation and Recovery Act
TBC = To Be Considered
USC = United States Code
USCA = United States Code Amended

This section presents the identification and screening of remedial technologies for Off-Site groundwater including GRAs, volumes or areas of media of concern, characteristics that may affect design or operation of remedial action, and identification and screening of remedial technologies and process options. At the end of this process, representative process options are selected for each GRA for assembly into alternatives.

4.1 GENERAL RESPONSE ACTIONS

GRAs are broad classes of medium-specific actions intended to satisfy the RAOs. The medium of concern is groundwater of intermediate depth contaminated with RDX above the PRG. The following GRAs are potentially applicable to groundwater in the Off-Site study area:

- No Action: Leave the site "as is," with no provision for monitoring or control. Typically used for a baseline to compare to other GRAs.
- Institutional Controls: Impose legal or administrative measures to reduce or eliminate the potential for exposure to contaminants.
- Engineering Controls: Physically restrict public access; maintain and/or monitor the area.
- Containment: Physically restrict the mobility of contaminants left in place.
- Removal: Extract contaminated groundwater for ex-situ treatment and/or disposal or to reduce the volume of contaminants.
- In-Situ Treatment: Use treatment processes to reduce TMV of the contaminated groundwater in place, including natural attenuation.
- Ex-Situ Treatment: Use treatment processes to reduce TMV of the contaminated groundwater after removal.
- Disposal: Relocate treated or untreated groundwater in a manner that reduces potential interaction with the public or the environment.

These response actions may be implemented alone or in combination.

4.2 VOLUMES OR AREAS OF MEDIA OF CONCERN

The GRAs will be applied to different areas and volumes of concern based on the RAOs. The medium of concern is groundwater contaminated above PRGs. Two areas of the groundwater plume have been identified for discussion based on their respective contaminant levels. The high level area of the plume will be defined by RDX concentrations at or above 50 µg/L, which is considered generally equivalent to the 10^{-4} cancer risk level. The entire area of the plume (high level plus low level areas) will be defined by RDX concentrations above the groundwater PRG of 2 µg/L. These areas are shown on **Figure 4-1**. The following summarizes the areas and volumes of the affected medium:

Location	RDX Concentration (µg/L)	Surface Area (ft^2)	Approximate Depth Interval (ft)	Average Thickness (ft)	Total Volume (ft^3)	Average Porosity (%)	Groundwater Volume (gal)
High Level Area	≥ 50	$1.2x10^6$	52 to 60	8	$9.8x10^6$	30	$2.2x10^7$
Entire Plume	≥ 2	$3.0x10^7$	45 to 60	15	$4.6x10^8$	30	$1.02x10^9$

Total contaminant (RDX) mass as of May 2002 was conservatively estimated by the model to range from 800 to 900 pounds (see **Appendix B**).

4.3 CHARACTERISTICS THAT MAY AFFECT DESIGN OR OPERATION OF REMEDIAL ACTION

The following remedial design and operational issues should be considered during the development and evaluation of alternatives.

4.3.1 Site Characteristics

- The water table surface is generally encountered between 3 and 25 feet bgs in the shallow–intermediate aquifer.
- Estimated groundwater flow velocities in the lowland profile intermediate sand are relatively high (80 to 470 feet per year) and variable (**Section 2.3.3**).
- Groundwater flow patterns vary, depending on the season. In the high level area, there appeared to be more of a southwesterly flow component measured in June 2002 and more of a southerly flow component measured in November 2002.
- The RDX plume is located primarily at the base of the shallow–intermediate aquifer at depths of 45 to 60 feet bgs.
- The glacial till that underlies the intermediate alluvial sand appears to act as a natural barrier (aquitard), retarding the vertical migration of explosives to the deep aquifer.
- Brush Creek is the main source of contaminant loading to the shallow–intermediate aquifer. The estimated base flow in Brush Creek is about 2 cubic feet per second (cfs), based on cross-section dimensions and velocity measurements made in April 2003.
- Six known private drinking water wells exist within the Off-Site groundwater contaminant plume area (**Figure 4-1**). All but one resident have accepted connection to the regional public water supply system.
- Most of the area of the RDX plume is within the 100-year floodplain of the Skunk River (**Figure 4-1**).

4.3.2 Contaminant Characteristics

- Explosives have high relative solubility (4.57 milligrams per liter [mg/L] for RDX) (Townsend and Myers 1996). High relative solubility can result in dissolved phase groundwater contamination at levels that exceed regulatory threshold standards.
- Explosives contamination tends to sink in groundwater due to relatively high molecular weight (222.2 grams per mole [g/mol] for RDX).
- RDX has relatively low adsorption potential, indicating a preference to remain in the dissolved phase. Organic carbon/water partition coefficient (K_{oc}) for RDX is 7.8 milliliters per gram (mL/g) to 269 mL/g (Townsend and Myers 1996). Adsorption to soils is not expected to significantly retard the movement of the explosives through groundwater, especially in the saturated intermediate sand, which has relatively low organic carbon content (0.05 to 1.8 percent by weight).
- Explosives generally have low volatility (low Henry's Law constants and vapor pressures), indicating that volatilization will not be an important fate process. The low volatility of explosives precludes the use of air stripping and other groundwater treatment technologies that rely on volatilization of contaminants.
- Where site conditions are favorable (e.g., anaerobic conditions), explosives are biodegradable. Half-life values range from 0.1 years to 8.9 years (Townsend and Myers 1996, URS 2001). For baseline groundwater contaminant fate and transport modeling, a conservative half-life value of 10 years was used.

4.3.3 Model-Predicted Fate and Transport

- If May 2002 concentrations of RDX in Brush Creek remain unchanged (i.e., steady-state source), RDX plume concentrations will reach equilibrium in the aquifer in about 30 years. The extent of the RDX plume at that time would be reduced to primarily the area between Brush Creek and Skunk River, but concentrations will remain above 2 µg/L indefinitely (just below 20 µg/L near Brush Creek) because of the continuing Brush Creek surface water source.
- Sensitivity runs during modeling to support the FS indicate that, in general, concentrations of RDX in groundwater will remain above 2 µg/L unless concentrations in surface water are reduced to below that level.
- Although the baseline model predicts RDX concentrations in the high level area will decline significantly during the next ten years, actual monitoring data are limited. Therefore, there is some uncertainty about how soon the levels in this area would be reduced to 50 µg/L.

4.4 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

Several remedial technologies and technology process options were identified for the various GRAs. The term "remedial technology" refers to a category of technology capable of achieving its GRA. The term "process option" refers to a specific process within the remedial technology category. For example, "hydraulic controls" is a remedial technology under the containment response action, and "injection wells" is a process option under the hydraulic controls remedial technology. The following describes the process of initial screening of technologies and evaluation of process options.

4.4.1 Initial Screening of Technologies and Process Options

Candidate remedial technologies and process options were assembled based on experience at similar sites and following a review of applicable USEPA documents, pertinent textbooks and published articles, and remediation vendor information. The candidate remedial technologies and process options were reviewed for applicability to IAAAP Off-Site groundwater, to screen out technologies or process options that are not technically feasible or not applicable to existing site conditions (**Table 4-1**). The evaluation of applicability takes into consideration the practical nature of implementation, given the physical site conditions (e.g., location, configuration, topography) and the waste or contaminant characteristics (e.g., contaminant types and extent). Remedial technologies and process options that are considered to be potentially applicable, based on this initial screening, are listed in **Table 4-1**.

4.4.2 Evaluation of Process Options

The potentially applicable process options (**Table 4-1**) were further evaluated and screened (**Table 4-2**) to narrow the field to a single (if possible) representative process option for each technology to facilitate the assembly of remedial alternatives. The criteria for screening of process options consisted of effectiveness, implementability, and cost, as described below.

Effectiveness

The evaluation of a process option's effectiveness focused on three primary considerations:

- Ability to handle the estimated areas or volumes of contaminated media and to meet remediation goals
- Potential effects on human health and the environment during implementation
- Reliability and proven performance with respect to site conditions and contaminants

Implementability

The evaluation of implementability included consideration of the technical and administrative feasibility of a process option. Implementability was characterized as readily implemented, moderately difficult, or difficult to implement relative to other process options under consideration, based on experience. The following factors were considered as part of the implementability evaluation:

- Ability to obtain necessary permits
- Availability and capacity of treatment, storage, and disposal facilities
- Availability of equipment and skilled workers needed to implement the process option

Cost

The cost evaluation was limited to a qualitative cost comparison that considered the capital cost and the operation and maintenance (O&M) costs of a particular process option. Costs were characterized as low, medium, or high in comparison to other process options within a technology category, based on experience and engineering judgment.

Summary of Screening Results

The evaluation and screening of process options is presented in **Table 4-2**. The process options with more favorable effectiveness, implementability, and lower relative costs were retained as the representative process options. Comments regarding effectiveness, implementability, and relative cost are also provided in **Table 4-2**. Process options are identified as being retained or not retained, and screening comments are provided to justify exclusion of certain process options. Several process options cannot be used alone as a remedial technology for the site conditions but have been retained for use with another technology. The following technologies and process options were retained for potential assembly into remedial alternatives:

General Response Action	Representative Process Option
No Action	No Action
Institutional Controls	Zoning Local Permits Groundwater Use Restrictions Easements Deed Notices Advisories Health and Safety Program
Engineering Controls	Groundwater Monitoring Alternate Water Supply At-Well Treatment
Containment/Removal	Vertical Wells
In-Situ Treatment	Monitored Natural Attenuation Chemical Oxidation Enhanced Biodegradation
Ex-Situ Treatment	Adsorption
Disposal	Surface Water Discharge

These process options are assembled into remedial action alternatives in **Section 5**.

TABLE 4-1
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Response Action	Technology	Process Option	Description	Potentially Applicable?
No Action	None	None	Do nothing to achieve remedial action objectives.	Yes
Institutional Controls	Governmental Controls	Zoning	Zoning authority exercised by local governments to specify land use for certain areas.	Yes
		Local Permits	Special permits outlining specific requirements before an activity can be authorized.	Yes
		Groundwater Use Restrictions	Place restrictions to control future groundwater use.	Yes
		Property Condemnation	When a local government, exercising eminent domain, condemns a property in order to take over title.	No
	Proprietary Controls	Easements	A property right conveyed by a landowner to another party which gives the second party rights with regard to the first party's land. An "affirmative" easement allows the holder to enter upon or use another's property for a particular purpose. A "negative" easement imposes limits on how the landowner can use his or her own property.	Yes
		Covenants	A promise by one landowner to another made in connection with the conveyance of property. Generally, a covenant is a promise by the holder of a possessory interest in property to use or refrain from using the property in a certain manner. Covenants are similar to easements but have been traditionally subject to somewhat different formal requirements.	No
		Equitable Servitude	A real estate interest, similar to a covenant, that arose when courts of equity enforced agreements that did not meet all of the formal requirements for a covenant.	No
		Reversionary Interest	A real estate interest created when a landowner deeds property to another, but the deed specifies that the property will revert to the original owner under specified conditions.	No
		Conservation Easements	Statutes adopted by some states that establish easements to conserve and protect property and natural resources.	No
	Enforcement Tools	Administrative Orders	A legal agreement signed by the USEPA and the PRPs, through which the PRP agrees to pay for or take the required corrective or cleanup actions, or refrain from an activity. It describes the action to be taken, may be subject to a comment period, applies to civil actions, and can be enforced in a court.	No
		Consent Decree	A legal document, approved by a judge, that formalizes an agreement reached between the USEPA and PRPs through which PRPs will conduct all or part of a cleanup action at a Superfund site, cease or correct actions or processes that are polluting the environment, or otherwise comply with the USEPA initiated regulatory enforcement action.	No
	Informational Devices	Deed Notices	Commonly refers to a non-enforceable, purely informational document filed in public land records that alerts anyone researching the records to important information about that property.	Yes
		State Registries of Hazardous Waste Sites	Registries established by state legislatures that contain information about properties. Types of registries include a list of hazardous waste sites in the state; annual reports submitted to the state legislature summarizing the status of each site on the registry; and notice with the deed for sites on the registry that the site is contaminated.	No

TABLE 4-1
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Response Action	Technology	Process Option	Description	Potentially Applicable?
Institutional Controls (cont'd)	Informational Devices (cont'd)	Advisories	Warnings, usually issued by public health agencies, either at the federal, state, or local level, that provide notice to potential users of land, surface water, or groundwater of some existing or impending risk associated with their use.	Yes
	Construction Management	Health and Safety Program	Require health and safety program during activities to protect workers.	Yes
Engineering Controls	Site Controls	Fencing	Install fencing to prevent unauthorized access to areas of contamination where exposure could occur.	No
	Residential Water Use Controls	Alternate Water Supply	Provide alternate drinking water source (i.e., bottled water, hookup to municipal water system) to residents on affected properties.	Yes
		At-Well Treatment	Add individual treatment system (GAC) to existing water wells on affected properties to provide residents with clean drinking water.	Yes
	Site Monitoring	Groundwater Monitoring	Periodically sample monitoring wells to evaluate contaminant plume migration.	Yes
Containment	Vertical Barriers	Slurry Wall	Excavate a trench and backfill with low permeable soil-bentonite mixture to make a barrier to groundwater flow.	Yes
		Grout Curtain	Pressure-inject grout into overlapping boreholes to make a barrier to groundwater flow.	Yes
		Deep Soil-Mixed Wall	Auger holes with deep soil mixing rig while injecting bentonite and water slurry to make a barrier to groundwater flow.	Yes
		Sheet Pile Wall	Drive sheet piling to make a barrier to groundwater flow.	No
		Vibrating Beam Wall	Use vibratory force to advance steel beam into ground. Inject cement or bentonite slurry when beam is withdrawn to make a barrier to groundwater flow.	Yes
		Biofilm Wall	Inject biofilm-forming solution into overlapping boreholes to make a barrier to groundwater flow.	Yes
		Interceptor Trench	Excavate a trench and install drain to create a barrier to groundwater flow.	Yes
	Hydraulic Controls	Vertical Wells	Install vertical pumping wells to alter the hydraulic gradient.	Yes
		Directional Wells	Install non-vertical pumping wells to alter the hydraulic gradient.	Yes
		Injection Wells	Inject water to alter the hydraulic gradient.	Yes
Removal	Groundwater Extraction	Interceptor Trench	Excavate a trench and install drain to collect groundwater for extraction.	Yes
		Vertical Wells	Install vertical pumping wells to extract and collect groundwater.	Yes
		Directional Wells	Install non-vertical extraction wells to allow access to contaminated areas that are not accessible using vertical wells to extract and collect groundwater.	Yes
		Hydraulic/ Pneumatic Fracturing	Pressure-inject water or air into subsurface to form cracks in low permeability soils. Fill cracks with porous media to improve permeability and increase extraction/infiltration efficiency.	No
In-Situ Treatment	Intrinsic Remediation	Monitored Natural Attenuation	Allow naturally-occurring processes (e.g., dispersion, volatilization, biodegradation, adsorption, and chemical reactions) to reduce contaminant levels.	Yes

TABLE 4-1
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Response Action	Technology	Process Option	Description	Potentially Applicable?
In-Situ Treatment (cont'd)	Physical/Chemical	Air Sparging	Inject air into saturated zone to remove VOCs from groundwater into soil vapor by volatilization.	No
		Carbon Dioxide Vacuum Stripping	Vacuum is applied to a well screened in the saturated zone to induce volatilization of VOCs in groundwater. Carbon dioxide is injected as the stripping agent.	No
		Hot Water/Steam Flushing/Stripping	Force hot water or steam into aquifer through injection wells to volatilize organic contaminants. Vapor extraction and treatment system needed to remove soil vapors.	No
		Permeable Reactive Barrier	Install a permeable wall by trenching or injection containing substrates (e.g., zero-valent iron, limestone, activated carbon, wood mulch, biological nutrients, oxygen or hydrogen releasing compounds) to increase degradation rates of organic contaminants as groundwater passes through treatment zone.	Yes
		Electro-osmosis	Use DC electrodes to drive contaminated groundwater from clay soil through a treatment zone for degradation. Liquid flow direction can be reversed by reversing polarities.	No
		LASAGNA process	Combination of treatment components that permits in-situ treatment of contaminants by creating higher permeability in soil environments. Used in concert with electrokinetics.	No
		Chemical Oxidation	Oxidizing agents (e.g., ozone, peroxide, permanganate) are delivered to the contaminated media where contaminants (e.g., chlorinated solvents, petroleum hydrocarbons, pesticides) are completely oxidized into CO_2 or converted into innocuous compounds commonly found in nature.	Yes
		Chemical Flooding	Uses surfactants or alcohols to displace non-aqueous phase liquids and/or enhance their solubility so that they can be treated in situ or extracted more easily.	No
		Groundwater Circulation Wells	A three dimensional circulating pattern is created by removing water through one screened section and reintroducing it into the aquifer through another screened section. Flow through the well can be up or down.	No
		VER process	A high vacuum (20-28 in Hg) drawn through a well installed below the water table can strip volatile contaminants in groundwater and saturated and unsaturated soils from the aqueous phase to the vapor phase. Typically used in combination with groundwater extraction.	No
		In-Well Aeration	Process of injecting gas, usually air, into a well resulting in an airlift pump effect. The air stream may also serve to strip volatiles and provide oxygen for biodegradation.	No
		Illuminated Membranes	Contaminated groundwater is circulated through a cleanup module containing special inorganic membranes illuminated by near-UV light. The membranes both filter the water and destroy TCE molecules through a photocatalytic reaction on the surface.	No
	Biological	Enhanced Biodegradation	Process of injecting groundwater with substrates to stimulate the rapid conversion of contamination organics to innocuous end products by altering the subsurface environment and/or by providing a food source for contaminant degrading microorganisms.	Yes
		Bio-Augmentation	Improve naturally occurring biological degradation of organic contaminants in the subsurface by the addition of specific bacteria and microorganisms	Yes

TABLE 4-1
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Response Action	Technology	Process Option	Description	Potentially Applicable?
In-Situ Treatment (cont'd)	Biological (cont'd)	Cometabolic Treatment	Cometabolism involves the injection of a dilute solution of nutrients such as methane and oxygen into the contaminated groundwater or soil. The microbes which metabolize these nutrients produce enzymes that react with the organic contaminant and degrade it to harmless minerals.	Yes
		Phytoremediation	Use plants to remove, transfer, stabilize, and destroy contaminants in groundwater, surface water, or soil.	Yes
Ex-Situ Treatment	Physical/Chemical	Air Stripping	Pass contaminated water through a shallow tray or packed column aeration system to transfer VOCs from water to vapor phase. Vapor may require further treatment.	No
		Steam Stripping	Pass contaminated water through a packed column and use countercurrent steam to transfer VOCs from water to vapor phase. Vapor may require further treatment.	No
		Mechanical Aeration	Pass contaminated water through an in situ mechanical device (e.g., constructed waterfall) to transfer contaminants from water to vapor phase.	No
		Adsorption	Pass contaminated water through a column or columns) of natural or synthetic adsorbents so that contaminants can adsorb to the surface.	Yes
		Coagulation/ Flocculation	Add coagulant/flocculent (e.g., alum) and agitate to agglomerate particles.	No
		Sedimentation	Remove solid particles (e.g., floc) that can settle from extracted groundwater using force of gravity.	No
		Distillation	Apply heat to contaminated groundwater to vaporize most volatile fraction, and remove heat from vaporized portion to condense contaminants.	No
		Filtration	Remove solid particles not able to settle from extracted groundwater by passing through media using gravity or a pressure differential.	No
		Precipitation	Add precipitating agent (e.g., lime, sodium hydroxide) to extracted water to form metal hydroxides, carbonates, or sulfides.	No
		Sprinkler Irrigation	Pressurized distribution of contaminated water through a standard sprinkler irrigation system to transfer volatile contamination directly to the atmosphere.	No
		Reverse Osmosis	Separates a solute from a solution (e.g., salt water) by forcing the solvent through a membrane using externally applied pressure to oppose the normal osmotic pressure of the solution. The term reverse osmosis is generally applied to describe the process in which solute molecules are approximately the same size as the solvent molecules.	No
		UV Photolysis	Pass contaminated water through a reactor vessel where it is exposed to UV light to photodegrade the contaminants.	Yes
		Chemical Oxidation	Oxidizing agents (e.g., ozone, peroxide, permanganate) chemically convert hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert.	Yes
		UV- Enhanced Oxidation	Oxidize COCs in contaminated water in a reactor using ultraviolet light and oxidizing agents (e.g., ozone, peroxide).	Yes

TABLE 4-1
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Response Action	Technology	Process Option	Description	Potentially Applicable?
Ex-Situ Treatment (cont'd)	Physical/Chemical (cont'd)	Ion Exchange	Pass contaminated water through a resin bed where ions are exchanged between the resin and the water.	Yes
		Sequestering	Add sequestering agents to extracted water to keep dissolved iron and scale-forming inorganics in solution.	Yes
	Biological	Aerobic Bioreactor	Use attached growth or suspended growth biological processes to degrade organics in water.	Yes
		Anaerobic Digestion	Use oxygen deficient process to degrade organics in water.	Yes
		Constructed Wetland	Uses natural geochemical and biological processes inherent in an artificial wetland ecosystem to accumulate contaminants from influent waters. Could be implemented in situ by diversion of a stream channel.	Yes
Disposal	Discharge	Groundwater Re-Injection	Treated groundwater is re-introduced into the aquifer by injection.	Yes
		Evaporation/ Infiltration Pond	Discharge treated water to pond for evaporation and infiltration.	Yes
		POTW Discharge	Discharge contaminated or treated water into sanitary sewer for treatment at POTW.	Yes
		Surface Water Discharge	Discharge treated water to surface water.	Yes
		Beneficial Re-Use	Pressurized distribution of contaminated or treated water to an IAAAP facility for industrial use.	Yes

NOTES:

COC = Chemical of Concern
DC = Direct Current
GAC = Granular Activated Carbon
Hg = Mercury
IAAAP = Iowa Army Ammunition Plant
POTW = Publicly Owned Treatment Works
PRP = Potentially Responsible Party
TCE = Trichloroethene
USEPA = United States Environmental Protection Agency
UV = Ultraviolet
VOC = Volatile Organic Compound

TABLE 4-2
EVALUATION OF POTENTIALLY APPLICABLE TECHNOLOGIES AND PROCESS OPTIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Response Action	Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
No Action	None	None	Do nothing to achieve remedial action objectives.	The current site status would remain unchanged. May achieve remedial objectives after long period of time due to natural processes.	No action required.	No capital. No O&M.	Retained. Required for comparison with other alternatives.
Institutional Controls	Government Controls	Zoning	Zoning authority exercised by local governments to specify land use for certain areas.	Limits potential exposures through legal restrictions on land use.	Survey and legal assistance required. Requires a single governmental entity with the ability to enforce.	Low capital. No O&M.	Retained.
		Local Permits	Special permits outlining specific requirements before an activity can be authorized.	Effective for satisfying specific ARARs (e.g., surface water discharge requirements).	Readily implemented. Requires regulatory approval and periodic monitoring for compliance.	Low capital. Low O&M.	Retained.
		Groundwater Use Restrictions	Place restrictions to control future groundwater use.	Limits potential exposures through legal restrictions on groundwater use.	Survey and legal assistance required. Restricts future land use. Requires a single governmental entity with the ability to enforce.	Low capital. No O&M.	Retained.
	Proprietary Controls	Easements	A property right conveyed by a landowner to another party which gives the second party rights with regard to the first party's land. An "affirmative" easement allows the holder to enter upon or use another's property for a particular purpose. A "negative" easement imposes limits on how the landowner can use his or her own property.	Allows access to specified areas of private property.	Survey and legal assistance required.	Low capital. No O&M.	Retained.
	Informational Devices	Deed Notice	Commonly refers to a non-enforceable, purely informational document filed in public land records that alerts anyone researching the records to important information about that property.	Effective for providing important information concerning the property to the public.	Legal assistance required.	Low capital. No O&M.	Retained.
		Advisories	Warnings, usually issued by public health agencies, either at the federal, state, or local level, that provide notice to potential users of land, surface water, or groundwater of some existing or impending risk associated with their use.	Effective for providing important information concerning the property to the public.	Legal assistance required.	Low capital. No O&M.	Retained.

TABLE 4-2
EVALUATION OF POTENTIALLY APPLICABLE TECHNOLOGIES AND PROCESS OPTIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Response Action	Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
Institutional Controls (cont'd)	Construction Management	Health and Safety Program	Require health and safety program during activities to protect workers.	Helps to prevent exposures or high stress levels to workers and monitors to ensure conditions are as expected.	Readily implemented. Requires administration of projects.	Low capital. Low O&M.	Retained.
Engineering Controls	Residential Water Use Controls	Alternate Water Supply	Provide alternate drinking water source (i.e., bottled water, hookup to municipal water system) to residents on affected properties.	Effective for preventing further ingestion of or exposure to contaminated groundwater.	Readily implemented. Commercially available. Requires voluntary cooperation of residents.	Low to medium capital. Medium O&M.	Retained.
		At-Well Treatment	Add individual treatment system (GAC) to existing water wells on effected properties to provide residents with clean drinking water.	Effective for preventing further ingestion of or exposure to contaminated groundwater.	Readily implemented. Commercially available. Requires voluntary cooperation of residents.	Low capital. Medium O&M.	Retained for residents who cannot be connected to municipal water.
	Site Monitoring	Groundwater Monitoring	Periodically sample monitoring wells to evaluate contaminant plume migration or attenuation.	Useful to document site conditions, and to evaluate potential migration and changes in concentrations with time.	Technical staff and laboratory required to monitor plume. Readily available.	Low capital. Medium O&M.	Retained.
Containment	Vertical Barriers	Slurry Wall	Excavate a trench and backfill with low permeable soil-bentonite mixture to make a barrier to groundwater flow.	Effective for preventing further migration of contaminated groundwater.	Difficult to implement. Requires trenching through saturated contaminant zone sands. Commercially available through specialty contractors.	High capital. No O&M.	Not retained. Process would not be cost-effective or practical, given soil type and depth of contamination.
		Grout Curtain	Pressure-inject grout into overlapping boreholes to make a barrier to groundwater flow.	Effective for preventing further migration of contaminated groundwater.	Moderately difficult to implement. Commercially available through specialty contractors.	Medium capital. No O&M.	Not retained. Process would not be practical.
		Deep Soil-Mixed Wall	Auger holes with deep soil mixing rig while injecting bentonite and water slurry to make a barrier to groundwater flow.	Effective for preventing further migration of contaminated groundwater.	Difficult to implement. Commercially available through specialty contractors.	High capital. No O&M.	Not retained. Process would not be cost-effective or practical given soil type and depth of contamination.
		Vibrating Beam Wall	Use vibratory force to advance steel beam into ground. Inject cement or bentonite slurry when beam is withdrawn to make a barrier to groundwater flow.	Effective for preventing further migration of contaminated groundwater.	Difficult to implement. Commercially available through specialty contractors.	High capital. No O&M.	Not retained. Process would not be cost-effective or practical given soil type and depth of contamination.
		Biofilm Wall	Inject biofilm-forming solution into overlapping boreholes to make a barrier to groundwater flow.	Effective for preventing further migration of contaminated groundwater.	Moderately difficult to implement. Commercially available through specialty contractors.	Medium capital. No O&M.	Not retained. Process would not be practical.

TABLE 4-2
EVALUATION OF POTENTIALLY APPLICABLE TECHNOLOGIES AND PROCESS OPTIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Response Action	Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
Containment (cont'd)	Vertical Barriers (cont'd)	Interceptor Trench	Excavate a trench and install drain to create a barrier to groundwater flow.	Effective to intercept and collect groundwater driven by hydraulic gradient.	Difficult to implement. Requires trenching through saturated contaminant zone sands. Commercially available through specialty contractors.	High capital. Medium O&M.	Not retained. Process would not be cost-effective or practical, given soil type and depth of contamination.
	Hydraulic Controls	Vertical Wells	Install vertical pumping wells to alter the hydraulic gradient.	Can change localized direction of groundwater flow if sufficient quantity of water is removed.	Easily implemented. Requires permanent facility to house pump controls, collection tanks, etc. Commercially available.	Medium capital. Medium O&M.	Retained.
		Directional Wells	Install non-vertical pumping wells to alter the hydraulic gradient.	Can change localized direction of groundwater flow if sufficient quantity of water is removed. May minimize the number of extraction wells required.	Moderately difficult to maintain target alignment. Requires permanent facility to house pump controls, collection tanks, etc. Commercially available.	Medium capital. Medium O&M.	Not retained. Process would not be practical, given aquifer and plume characteristics.
		Injection Wells	Inject water to alter the hydraulic gradient.	Can change localized direction of groundwater flow if sufficient quantity of water is injected.	Moderately difficult to implement. Requires permanent facility to house pump controls, etc. Commercially available.	Medium capital. High O&M.	Not retained. Process would not be practical, given aquifer and plume characteristics.
Removal	Groundwater Extraction	Interceptor Trench	Excavate a trench and install drain to collect groundwater for extraction.	Effective to intercept and collect contaminated groundwater driven by hydraulic gradient.	Difficult to implement. Requires trenching through saturated contaminant zone sands. Requires permanent facility to house pump controls, collection tanks, etc. Commercially available.	Medium capital. Medium O&M.	Not retained. Process would not be cost-effective or practical, given soil type and depth of contamination.
		Vertical Wells	Install vertical pumping wells to extract and collect contaminated groundwater.	Effective to remove contaminated groundwater in high permeability soils.	Readily implemented. Requires permanent facility to house pump controls, collection tanks, etc. Commercially available.	Medium capital. Medium O&M.	Retained.
		Directional Wells	Install non-vertical extraction wells to allow access to contaminated areas that are not accessible using vertical wells to extract and collect groundwater.	Effective to remove contaminated groundwater in high permeability soils. May minimize the number of extraction wells required to remediate a site.	Moderately difficult to maintain target alignment. Requires permanent facility to house pump controls, collection tanks, etc. Commercially available.	Medium capital. Medium O&M.	Not retained. Process would not be required given aquifer characteristics relative ease of vertical well installation.

TABLE 4-2
EVALUATION OF POTENTIALLY APPLICABLE TECHNOLOGIES AND PROCESS OPTIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Response Action	Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
In-Situ Treatment	Intrinsic Remediation	Monitored Natural Attenuation	Allow naturally-occurring processes (e.g., dispersion, volatilization, biodegradation, adsorption, and chemical reactions) to reduce contaminant levels.	Existing conditions appear to support limited natural attenuation.	Technical staff and laboratory required to monitor for effectiveness. Readily available.	Low capital. Medium O&M.	Retained.
	Physical/Chemical	Permeable Reactive Barrier	Install a permeable wall by trenching or injection containing substrates (e.g., zero-valent iron, limestone, activated carbon, wood mulch, biological nutrients, oxygen or hydrogen releasing compounds) to increase degradation rates of organic contaminants as groundwater passes through treatment zone.	Proven to degrade explosive contaminants in a reductive environment while allowing groundwater to pass through.	Moderately difficult to implement. Requires treatability testing. Certain substrates require royalty fees. Commercially available. Wall would need to be continuous except for substrates that use diffusion (e.g., hydrogen release compound).	Medium to high capital. Low O&M.	Not retained. Compared to other methods, a continuous barrier would not be cost-effective and would be difficult to implement, given the required depth (about 60 feet) and aquifer material (sand).
		Chemical Oxidation	Oxidizing agents (e.g., ozone, peroxide, permanganate) are delivered to the contaminated media where contaminants (e.g., chlorinated solvents, petroleum hydrocarbons, pesticides) are completely oxidized into CO_2 or converted into innocuous compounds commonly found in nature.	Proven to degrade or destroy some organic contaminants. Recent case studies have shown some success for explosives.	Readily implemented. Pilot or bench test is required. Permit may be required. Commercially available. Handling of agents requires special precautions.	Medium capital. Low O&M.	Retained as a possible in-situ degradation amendment.
	Biological	Enhanced Biodegradation	Process of injecting groundwater with substrates to stimulate the rapid conversion of contamination organics to innocuous end products by altering the subsurface environment and/or by providing a food source for contaminant degrading microorganisms.	Can be used to create a reducing environment to stimulate the degradation of explosive contaminants. Can be injected directly into the source area or as a permeable barrier.	Readily implemented. Requires treatability testing. May require periodic substrate re-injection events. Commercially available through specialty contractors.	Medium capital. Low O&M.	Retained in the form of a non-continuous barrier utilizing diffusive substrates to induce reductive conditions.
		Bio-Augmentation	Improve naturally occurring biological degradation of organic contaminants in the subsurface by the addition of specific bacteria and microorganisms	Addition of microorganisms may stimulate degradation of explosive contaminants under reducing conditions.	Readily implemented. Requires treatability testing. Commercially available through specialty contractors.	Medium capital. Low O&M.	Not retained. Process not proven to stimulate the degradation of explosive contaminants.
		Cometabolic Treatment	Cometabolism involves the injection of a dilute solution of nutrients such as methane and oxygen into the contaminated groundwater or soil. The microbes which metabolize these nutrients produce enzymes that react with the organic contaminant and degrade it to harmless minerals.	Can initiate the oxidation of a variety of carbon compounds.	Readily implemented. Requires treatability testing. Commercially available through specialty contractors.	Medium capital. Low O&M.	Not retained. Process not proven to stimulate the degradation of explosive contaminants.

TABLE 4-2
EVALUATION OF POTENTIALLY APPLICABLE TECHNOLOGIES AND PROCESS OPTIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY

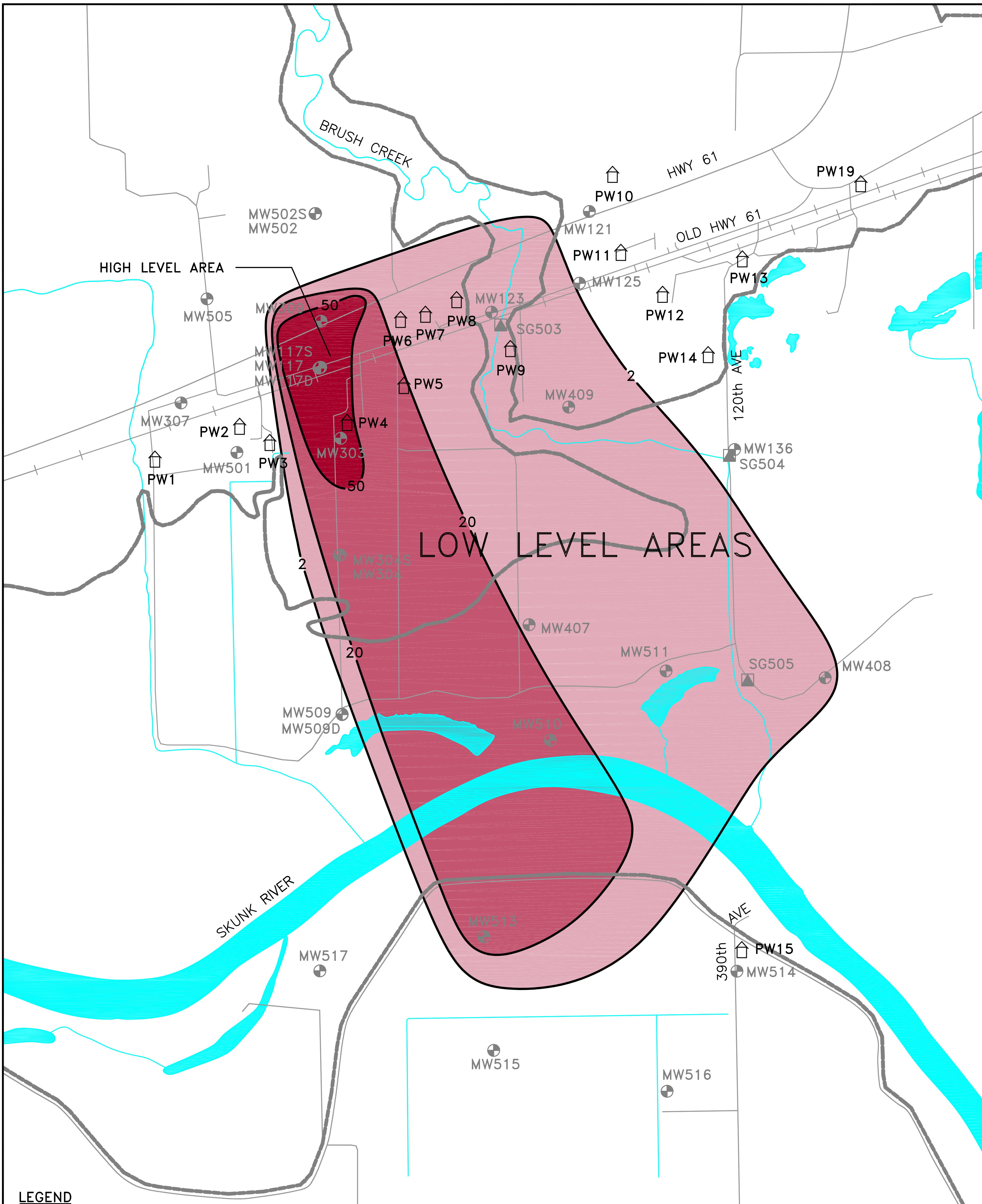
Response Action	Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
In-Situ Treatment (cont'd)	Biological (cont'd)	Phytoremediation	Use plants to remove, transfer, stabilize, and destroy contaminants in shallow groundwater, surface water, or soil.	Proven to destroy or stabilize contaminants through processes such as phytodegradation, rhizodegradation, and phytostabilization.	Readily implemented. Treatability studies have been performed at IAAAP. Commercially available.	Medium capital. Low O&M.	Not retained. Process would not be practical given depth of contamination.
Ex-Situ Treatment	Physical/Chemical	Adsorption	Pass contaminated water through a column or columns) of natural or synthetic adsorbents so that contaminants can adsorb to the surface.	Certain adsorbents (e.g., granular activated carbon) are proven effective to remove explosive contaminants from groundwater.	Readily implemented. Adsorbent media must be replaced/recharged at regular intervals. Commercially available.	Medium capital. High O&M.	Retained.
		UV Photolysis	Pass contaminated water through a reactor vessel where it is exposed to ultra violet light to photo degrade the contaminants.	Explosive contaminants are susceptible to destruction by UV photolysis. The aqueous stream being treated must provide for good transmission of UV light.	Readily implemented. Pilot or bench test may be required. May require pretreatment. Commercially available.	High capital. High O&M.	Not retained. Process would not be cost-effective or practical given the expected high influent flow rate.
		Chemical Oxidation	Oxidizing agents (e.g., ozone, peroxide, permanganate) chemically convert hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert.	Proven to degrade or destroy some organic contaminants.	Readily implemented. Pilot or bench test is required. May require further treatment. Commercially available. Handling of agents requires special precautions.	Medium to High capital. High O&M.	Not retained. Process would not be cost-effective or practical given the expected high influent flow rate.
		UV- Enhanced Oxidation	Oxidize contaminants in water in a reactor using ultraviolet light and oxidizing agents (e.g., ozone, peroxide).	Explosive contaminants are susceptible to destruction by UV/oxidation. The aqueous stream being treated must provide for good transmission of UV light.	Readily implemented. Pilot or bench test may be required. May require pretreatment. Commercially available.	High capital. High O&M.	Not retained. Process would not be cost-effective or practical given the expected high influent flow rate.
		Ion Exchange	Pass contaminated water through a resin bed where ions are exchanged between the resin and the water.	Can be effective for degradation of certain organic contaminants.	Readily implemented. Pilot or bench test required. May require pretreatment. Commercially available.	Medium capital. High O&M.	Not retained. Process is not proven for explosives.
		Sequestering	Add sequestering agents to extracted water to keep dissolved iron and scale-forming inorganics in solution.	Effective for preventing formation of scale on treatment system equipment.	Readily implemented. Commercially available.	Medium capital. Medium O&M	Not retained. Process not required for retained process options.
	Biological	Aerobic Bioreactor	Use attached growth or suspended growth biological processes to degrade organics in water.	Can be effective for degradation of certain organic contaminants.	Readily implemented. Pilot or bench test required. Commercially available.	Medium capital. Medium O&M	Not retained. Process is not proven for explosives.

TABLE 4-2
EVALUATION OF POTENTIALLY APPLICABLE TECHNOLOGIES AND PROCESS OPTIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Response Action	Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
Ex-Situ Treatment (cont'd)	Biological (cont'd)	Anaerobic Digestion	Use oxygen deficient process to degrade organics in water.	Degrades explosives to less toxic compounds.	Readily implemented. Bench and/or pilot test required. May require pretreatment. Commercially available.	Medium capital. Medium O&M.	Not retained. Process would not be cost-effective or practical given the expected high influent flow rate.
		Constructed Wetland	Uses natural geochemical and biological processes inherent in an artificial wetland ecosystem to accumulate contaminants from influent waters.	Removes contaminants from water using natural geochemical and biological processes inherent in a wetland ecosystem. Only available during the summer months.	Moderately difficult to implement. Treatability studies have been performed at IAAAP. Process would occupy a relatively large area.	Medium capital. Low O&M.	Not retained. Process would not be practical given limitations of seasonal operation.
Disposal	Discharge	Groundwater Re-Injection	Treated groundwater is re-introduced into the aquifer by injection.	Effective if groundwater is treated to meet or exceed groundwater PRGs.	Moderately difficult to implement and permit may be required.	High capital. Medium O&M.	Not retained. Process would not be cost-effective or practical relative to surface water discharge.
		Evaporation/ Infiltration Pond	Discharge treated water to pond for evaporation and infiltration.	Effective if groundwater is treated to required effluent limits and will not migrate to the subsurface at levels above the groundwater PRGs.	Readily implemented. Permit may be required.	Medium capital. Low O&M.	Not retained. Process would not be cost-effective or practical relative to surface water discharge.
		POTW Discharge	Discharge contaminated or treated water into sanitary sewer for treatment at POTW.	Effective if groundwater is treated to required effluent limits.	Readily implemented. Permit may be required.	Medium to high capital. Medium O&M.	Not retained. Process would not be cost-effective or practical given the distance to the nearest POTW discharge access point.
		Surface Water Discharge	Discharge treated water to surface water.	Effective if groundwater is treated to required effluent limits and will not migrate to the subsurface at levels above the groundwater PRGs.	Readily implemented. Must meet substantive requirements of NPDES permit.	Low capital. Low O&M.	Retained.
		Beneficial Re-Use	Pressurized distribution of contaminated or treated water to an IAAAP facility for industrial use.	Effective for disposal of treated or contaminated groundwater. Water may receive further treatment during and/or after industrial re-use processes.	Moderately difficult to implement. Substantial amount of piping required to transfer groundwater to IAAAP facility.	High capital. Medium O&M.	Not retained. Process would not be cost-effective or practical given the distance to the IAAAP facility.

NOTES:

ARAR = Applicable or Relevant and Appropriate Requirement
GAC = Granular Activated Carbon
IAAAP = Iowa Army Ammunition Plant
NPDES = National Pollutant Discharge Elimination System
O&M = Operation and Maintenance
POTW = Publicly Owned Treatment Works
UV = Ultraviolet



LEGEND

LEVEE

PAVED OR GRAVEL ROAD

RAILROAD TRACKS

MONITORING WELL LOCATION

SG501 STAFF GAUGE LOCATION

PW1 PRIVATE WELL

2 RDX CONCENTRATIONS > 2μg/L AT BASE OF AQUIFER – MAY 2002

APPROXIMATE 100–YEAR FLOODPLAIN BOUNDARY (FEMA)

N

1000 500 0 1000

SCALE IN FEET

URS

SITE CHARACTERISTICS MAP
OFF–SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: JMR	DATE: 09/23/03	16169419	4–1

March 05, 2004 10:02:38 a.m.
Drawing: T:\IAAAP\16169419\00501\4–1–hatch.dwg

This section presents the assembly and detailed description of remedial action alternatives. Because a manageable list of alternatives was developed, intermediate screening of alternatives was not necessary. Calculations and information to support the conceptual design of remedial alternatives are presented in **Appendix A.**

5.1 ASSEMBLY OF REMEDIAL ACTION ALTERNATIVES

Remedial action alternatives were assembled from combinations of process options and technologies that survived the screening process, to provide a range from no action to active treatments that will reduce TMV of contaminants at the site. Alternatives address both the high level and low level areas of the groundwater contaminant plume. The alternative assembly process for Off-Site groundwater is summarized in **Table 5-1**. Assembled alternatives are listed below:

- Alternative 1 – No Action
- Alternative 2 – Monitored Natural Attenuation (MNA)
- Alternative 3 – Focused Extraction/MNA
- Alternative 4 – Enhanced Degradation Barrier (EDB)/MNA
- Alternative 5 – Total Groundwater Restoration

As summarized in **Table 5-1**, besides common institutional and engineering controls described below, Alternative 2 uses MNA to remediate the entire plume; Alternative 3 combines vertical wells removal, adsorption ex-situ treatment, and surface water discharge for the high level area and MNA for the entire plume; Alternative 4 combines chemical oxidation or enhanced biodegradation in-situ treatment for the high level area and MNA for the entire plume; and Alternative 5 combines vertical wells removal, adsorption ex-situ treatment, and surface water discharge for the entire plume. None of the alternatives would meet RAOs, however, unless Brush Creek surface water is addressed.

5.2 DESCRIPTION OF ALTERNATIVES

The following provides a detailed description of each remedial alternative assembled for Off-Site groundwater. Estimated project durations are based on fate and transport modeling conducted under the assumption that surface water contamination in Brush Creek will be reduced to the groundwater PRG before or simultaneous to implementation of any groundwater remedial action. Results of groundwater modeling to support evaluation and development of remedial alternatives are presented in **Appendix B**.

Alternatives 2, 3, 4, and 5 share common institutional and engineering controls. These include:

- Deed notices, to be filed in public land records, alert anyone researching the affected properties' records to the potential health risk from ingesting contaminated water from the properties' wells.

- Locally issued advisories provide notice to private well owners/users of the potential health risk from ingesting contaminated well water.
- A health and safety program protects workers during remedial activities, including initial construction, O&M, and groundwater and treatment system monitoring.
- Residents of affected properties would be connected to municipal water or, if they cannot be connected, would be provided with at-well treatment systems to remove RDX from drinking water by granular activated carbon (GAC) adsorption. Treatment systems would include an appropriately sized carbon vessel, associated piping and metering, and appropriately sized shelter. Treated water would periodically be sampled for RDX concentrations to confirm system effectiveness.

Potential governmental controls (such as zoning and groundwater use restrictions) to prevent new water supply wells from being installed in contaminated areas for domestic use will be further investigated by the U.S. Army. The details of the controls, if implemented, will be described in detail during remedial design.

5.2.1 Alternative 1 – No Action

Alternative 1 assumes that no remedial action would be implemented. This alternative is required by the NCP (40 CFR Part 300) and serves as a baseline against which other alternatives are compared.

Under no action, existing site conditions remain unchanged, and the human health risks are those identified by the baseline risk assessment. RDX would remain above its lifetime HAL.

5.2.2 Alternative 2 – Monitored Natural Attenuation

Alternative 2 consists of MNA to allow natural destructive and nondestructive subsurface attenuation mechanisms to reduce the mass of contamination in Off-Site groundwater.

MNA includes groundwater sampling at 35 monitoring wells for analysis of explosives and natural attenuation parameters, reporting monitoring results, and completing five-year reviews. Five-year reviews would include recalibration of the fate and transport model using the latest site data. The sampling plan would periodically be adjusted to account for changing site conditions. An estimated seven new monitoring wells would be installed to better define the horizontal extent and monitor future migration of the explosives plume. The actual number and location of monitoring wells would be established in the future to meet defined monitoring objectives. The estimated duration for this alternative is 40 to 45 years, based on modeling results and assuming Brush Creek surface water is addressed. Locations of new and existing monitoring wells to be sampled as part of MNA are shown on **Figure 5-1**.

5.2.3 Alternative 3 – Focused Extraction/Monitored Natural Attenuation

Alternative 3 includes installing three groundwater extraction wells in the high level area to remove RDX-contaminated groundwater for collection, treatment, and discharge to surface water. Locations and pumping rates of the extraction wells were estimated based on the results of site-specific groundwater modeling (**Appendix B**). The three extraction wells would be located on the western edge of the high level area, arranged in a mostly north-to-south line and spaced about 700 feet apart, to capture the seasonal southwesterly flow of groundwater (**Figure 5-2**). Each well would remove groundwater at a rate of 150 gallons per minute (gpm). The downgradient well would be placed near the southern edge of the area to cut off southward migration.

Extracted groundwater would be collected and treated by GAC adsorption at a rate of 450 gpm. The conceptual design, as developed through consultation with various GAC system vendors and from design experience with similar systems, consists of a 1,000-gallon collection/surge tank, 450-gpm transfer pump, and two 20,000-pound-capacity GAC adsorption vessels, arranged in series as shown on **Figure 5-3**. Running the system in series would allow the first vessel in sequence, known as the "lead bed," to adsorb most of the contamination before it reaches the second vessel, or "lag bed." When carbon in the lead bed has reached its adsorption capacity, it would be replaced. Flow through the vessels would be reversed causing the former lag bed to become the new lead bed and vice versa. This method of operation increases contaminant removal efficiency and reduces downtime during carbon change-out activities. Carbon replacement is expected to be required on a semiannual basis (20,000 pounds per change-out), based on a flow rate of 450 gpm and an RDX concentration of 150 µg/L.

The GAC vessels would be backwashed periodically to remove accumulated solids and extend the life of the carbon. The backwash system would consist of two 7,400-gallon, flat-bottom effluent collection/backwash supply tanks and two 7,400-gallon, conical-bottom backwash/ sludge collection tanks, with associated piping and pumps (**Figure 5-3**). The treatment system would be housed in an appropriately sized steel building. The wells and treatment building, as shown on **Figure 5-2**, are outside the 100-year floodplain. Because this is private property, easements for the wells, pipelines, and treatment plant building would be required. A pre-design investigation consisting of further delineation of the high level area, aquifer pumping tests, and the GAC treatability study would be completed to obtain the data necessary for remedial design.

The nearby unnamed tributary of the Skunk River would be the effluent discharge point (**Figure 5-2**). A surface water discharge permit would be required (discharge criteria of 2 µg/L for RDX). The discharge point is located within the 100-year floodplain. If flood conditions cause the discharge outlet pipe to become submerged, the treatment system would be temporarily shut down.

Alternative 3 also relies on MNA, as described for Alternative 2, to reduce the contaminant mass of the Off-Site groundwater plume that is not affected by focused extraction.

Modeling estimates put the time to reduce concentrations below 50 µg/L RDX at less than five years. After confirming that permanent reduction of contaminant mass in the high level area has been achieved, the extraction and treatment system would be shut down and dismantled. MNA would continue to degrade the remaining groundwater contamination for 35 to 40 years. The total estimated duration for this alternative is 40 to 45 years, assuming Brush Creek surface water is addressed.

5.2.4 Alternative 4 – Enhanced Degradation Barrier/Monitored Natural Attenuation

Alternative 4 includes installing a series of EDBs to create passive treatment zones that intercept and either anaerobically degrade or chemically oxidize RDX in groundwater in the high level area. Site-specific groundwater modeling (**Appendix B)** and vendor consultation were used as the basis for conceptual design of the barrier system.

The EDB system consists of three permeable barriers placed perpendicular to the groundwater flow, each positioned to intercept one-third of the high level area of the plume as it migrates south toward the Skunk River (**Figures 5-4** and **5-5**). Each barrier consists of two offset rows of injection points with 10 feet between each row and 10 feet between each point within a row (**Figure 5-4**). The length of each barrier would be 1,200 feet (240 points each, 720 points total). Each barrier would extend vertically from about 50 to 60 feet bgs (**Figure 5-5**).

A field-scale test would be completed before full-scale implementation to determine the most effective substrate and optimal barrier layout. Potential biodegradation substrates (e.g., acetate, molasses, emulsified vegetable oil, Hydrogen Release Compound [HRC™]) or chemical oxidation agents (e.g., Fenton's reagent, ozone, permanganate) would be injected into the subsurface within the high level area, directly upgradient from existing monitoring wells. Each well would be sampled monthly for field parameters, RDX concentrations, and geochemical parameters. Sampling would continue for an estimated six to nine months or until degradation and geochemical trends are identified. The substrate that proves most effective at inducing and maintaining degrading conditions in the subsurface would be selected for full-scale implementation. For chemical oxidation agents, special attention would be given to geochemical impacts (e.g., change in pH, temperature) and how quickly the aquifer can recover to its natural anaerobic state. Special safety precautions would also be required for handling chemical oxidants.

Following the EDB system installation, groundwater samples would be collected from newly installed performance monitoring wells located immediately downgradient from each of the barriers (**Figure 5-4**). Samples would be analyzed for field parameters, RDX concentrations, and geochemical parameters to monitor EDB system effectiveness. Sampling would continue until biodegradation and geochemical trends and substrate reapplication frequency have been determined (estimated time of two years). Substrate reapplication frequency is assumed to be every two years.

Alternative 4 also relies on MNA, as described for Alternative 2, to reduce the contaminant mass of the Off-Site groundwater plume that is not affected by the EDB system.

Modeling estimates put the time to reduce concentrations below 50 µg/L RDX at less than five years. After confirmation that permanent reduction of contaminant mass in the high level area has been achieved, substrate reapplications would be discontinued, and MNA would continue to degrade the remaining groundwater contamination for 35 to 40 years. The total estimated duration for this alternative is 40 to 45 years, assuming Brush Creek surface water is addressed.

5.2.5 Alternative 5 – Total Groundwater Restoration

Alternative 5 includes installing 13 groundwater extraction wells to remove all explosives-contaminated groundwater at levels above the groundwater PRG for collection, treatment, and discharge to surface water. Individual extraction well locations and pumping rates were estimated based on the results of fate and transport modeling (**Appendix B**). As shown on **Figure 5-6**, four wells would be located along the western edge of the plume (EW-1 to EW-4), six in a line running east to west just north of the northern Skunk River levee (EW-5 to EW-10), and three located just south of the Skunk River's southern levee (EW-11 to EW-13). EW-1 through EW-10 would each remove groundwater at an estimated rate of 150 gpm. EW-11 through EW-13 would each remove groundwater at an estimated rate of 200 gpm. The total combined pumping rate would be 2,100 gpm across the site.

Extracted groundwater would be collected and then treated by GAC adsorption. Because of the difficulty of piping extracted groundwater from the southernmost wells northward across the Skunk River for treatment, two separate treatment systems are assumed: a northern system to treat 1,500 gpm, and a southern system to treat 600 gpm. The conceptual design of the systems was developed through consultation with various GAC system vendors and from design experience with similar systems. The northern system would consist of a 5,000-gallon collection/surge tank, three 500-gpm transfer pumps, and six 20,000-pound-capacity GAC adsorption vessels arranged as three series of two vessels each. The southern system would consist of a 2,000-gallon collection/surge tank, a 600-gpm transfer pump, and two 10,000-pound-capacity GAC adsorption vessels arranged in series. Conceptual layouts of the treatment systems are shown on **Figures 5-7** and **5-8**. Carbon replacement is expected to be required annually for the northern treatment system (60,000 pounds per change-out), based on a flow rate of 1,500 gpm and an average RDX concentration of 50 µg/L, and every one and one-half years for the southern treatment system (10,000 pounds per change-out), based on a total flow rate of 600 gpm and an average RDX concentration of 20 µg/L.

The GAC vessels would be backwashed periodically to remove accumulated solids and extend the life of the carbon. The northern backwash system would consist of two 7,400-gallon, flat-bottom effluent collection/backwash supply tanks, two 7,400-gallon, conical-bottom backwash/sludge collection tanks, and associated pumps (**Figure 5-7**). The southern backwash system would consist of two 6,000-gallon, flat-bottom effluent collection/backwash supply tanks, one 11,500-gallon, conical-bottom backwash/sludge collection tank, and associated pumps (**Figure 5-8**). Both treatment systems would be housed in appropriately sized steel buildings. The wells and treatment building, as shown on **Figure 5-6**, are outside the 100-year floodplain. Because this is private property, easements for the wells, pipelines, and treatment plant building would be required. A pre-design investigation consisting of aquifer pumping tests and the GAC treatability study would be completed to obtain the data necessary for remedial design.

For the northern system, the nearby unnamed tributary of the Skunk River would be the effluent discharge point (**Figure 5-6**). For the southern system, treated effluent would be discharged directly to the Skunk River. A surface water discharge permit would be required for each system (discharge criteria of 2 µg/L for RDX). Both discharge points are located within the 100-year floodplain. If flood conditions cause either discharge outlet pipe to become submerged, the treatment system would be temporarily shut down.

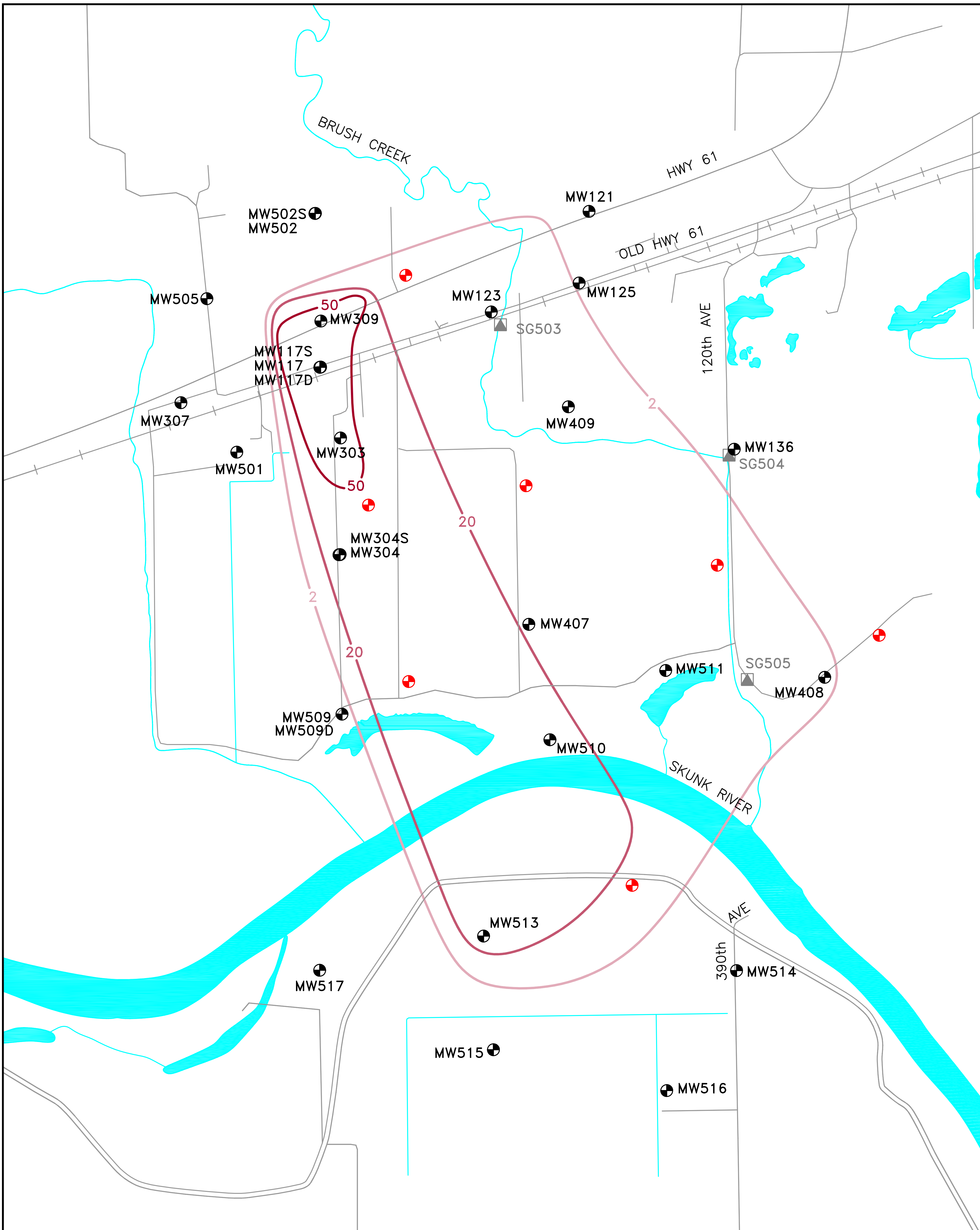
Alternative 5 would consist of the same quantity and duration of groundwater sampling as for MNA under Alternatives 2, 3, and 4. Locations of new and existing monitoring wells to be sampled as part of groundwater monitoring are the same as for Alternative 2, as shown on **Figure 5-1**. The total estimated duration for this alternative is 30 to 35 years, based on modeling results, assuming Brush Creek surface water is addressed.

TABLE 5-1
ASSEMBLY OF REMEDIAL ACTION ALTERNATIVES
OFF-SITE GROUNDWATER FEASIBILITY STUDY

General Response Action	Remedial Technology/ Process Option	Area, Location, or Media	Alternative 1 No Action	Alternative 2 MNA	Alternative 3 Focused Extraction/MNA	Alternative 4 EDB/MNA	Alternative 5 Total Groundwater Restoration
No Action	None	Entire Plume (>2 µg/L)	✓				
Institutional Controls	Deed Notices	Entire Plume (>2 µg/L)		✓	✓	✓	✓
	Advisories	Entire Plume (>2 µg/L)		✓	✓	✓	✓
	Health and Safety Program	Entire Plume (>2 µg/L)		✓	✓	✓	✓
Engineering Controls	Groundwater Monitoring	Entire Plume (>2 µg/L)		✓	✓	✓	✓
	At-Well GAC Treatment	Affected Private Well		✓	✓	✓	✓
Containment/ Removal	Vertical Wells	High Level (>50 µg/L)			✓		
		Entire Plume (>2 µg/L)					✓
In-Situ Treatment	MNA	Entire Plume (>2 µg/L)		✓	✓	✓	
	Chemical Oxidation	High Level (>50 µg/L)				✓	
	EB	High Level (>50 µg/L)				✓	
Ex-Situ Treatment	Adsorption	Extracted Groundwater			✓		✓
Disposal	Surface Water Discharge	Tributary of the Skunk River			✓		✓
		Skunk River					✓
Alternative Carried Forward for Detailed Analysis?			Yes	Yes	Yes	Yes	Yes
Discussion			Retained for comparison purposes.		Carbon adsorption is considered to be the most effective, consistent, and predictable adsorption media and will be assumed for detailed analysis.	Biodegradation-enhancing substrates or chemical oxidizing agents would be injected into the subsurface to create barriers to contaminant migration. Substrates would be selected using treatability tests before full scale implementation. HRC™ is assumed for detailed analysis.	Retained for comparison purposes.

NOTES:

> = Greater Than
µg/L = Micrograms Per Liter
EB = Enhanced Biodegradation
EDB = Enhanced Degradation Barrier
GAC = Granular Activated Carbon
HRC™ = Hydrogen Release Compound
MNA = Monitored Natural Attenuation



LEGEND

LEVEE

PAVED OR GRAVEL ROAD

RAILROAD TRACKS

MW515 EXISTING MONITORING WELL

PROPOSED MONITORING WELL

SG501 STAFF GAUGE

2 RDX CONCENTRATIONS > 2μg/L AT BASE OF AQUIFER – MAY 2002

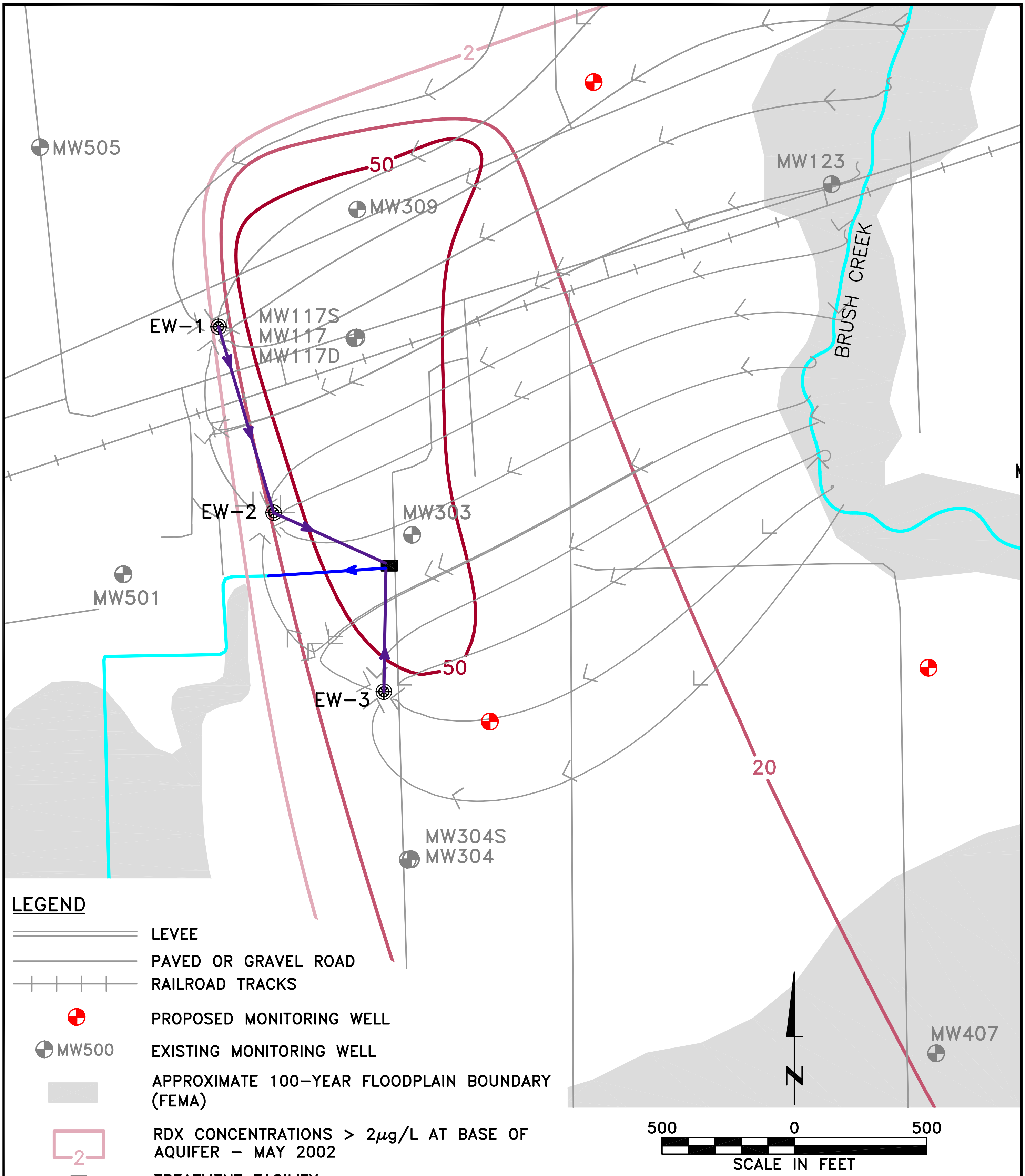
1000 500 0 1000
SCALE IN FEET

March 05, 2004 10:04:06 a.m.
Drawing: T:\IAAAP\16169419\00501\5-1.dwg

URS

ALTERNATIVE 2 SITE PLAN
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/25/03	PROJECT NO. 16169419	FIG. NO. 5-1
CHK'D. BY: DRH	DATE: 09/25/03		



URS

ALTERNATIVE 3 SITE PLAN
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO. 16169419	FIG. NO. 5-2
CHK'D. BY: DRH	DATE: 09/23/03		

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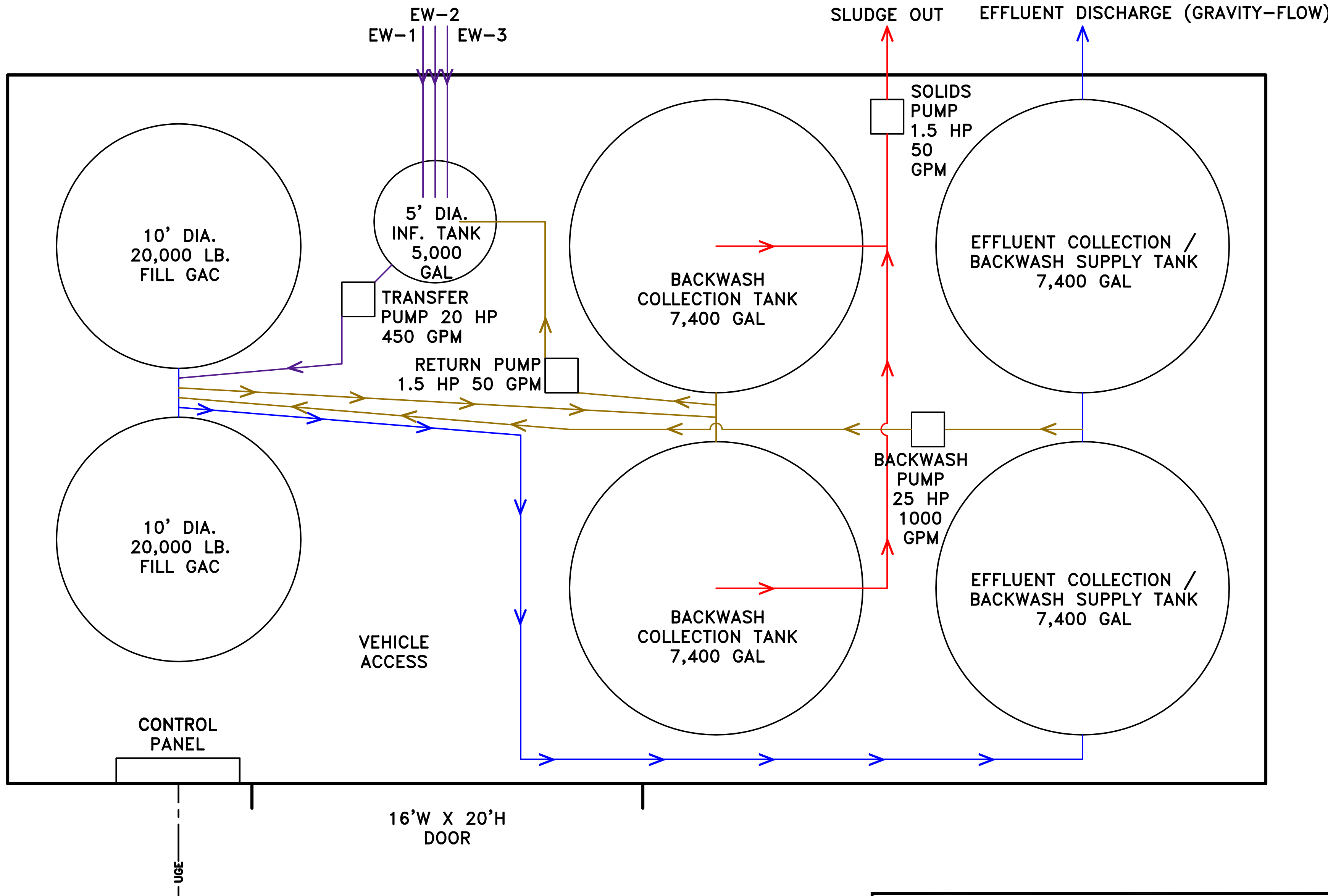


LEGEND

- INFLUENT LINES
- EFFLUENT DISCHARGE
- BACKWASH
- SLUDGE LINE
- UGE — UNDERGROUND ELECTRIC

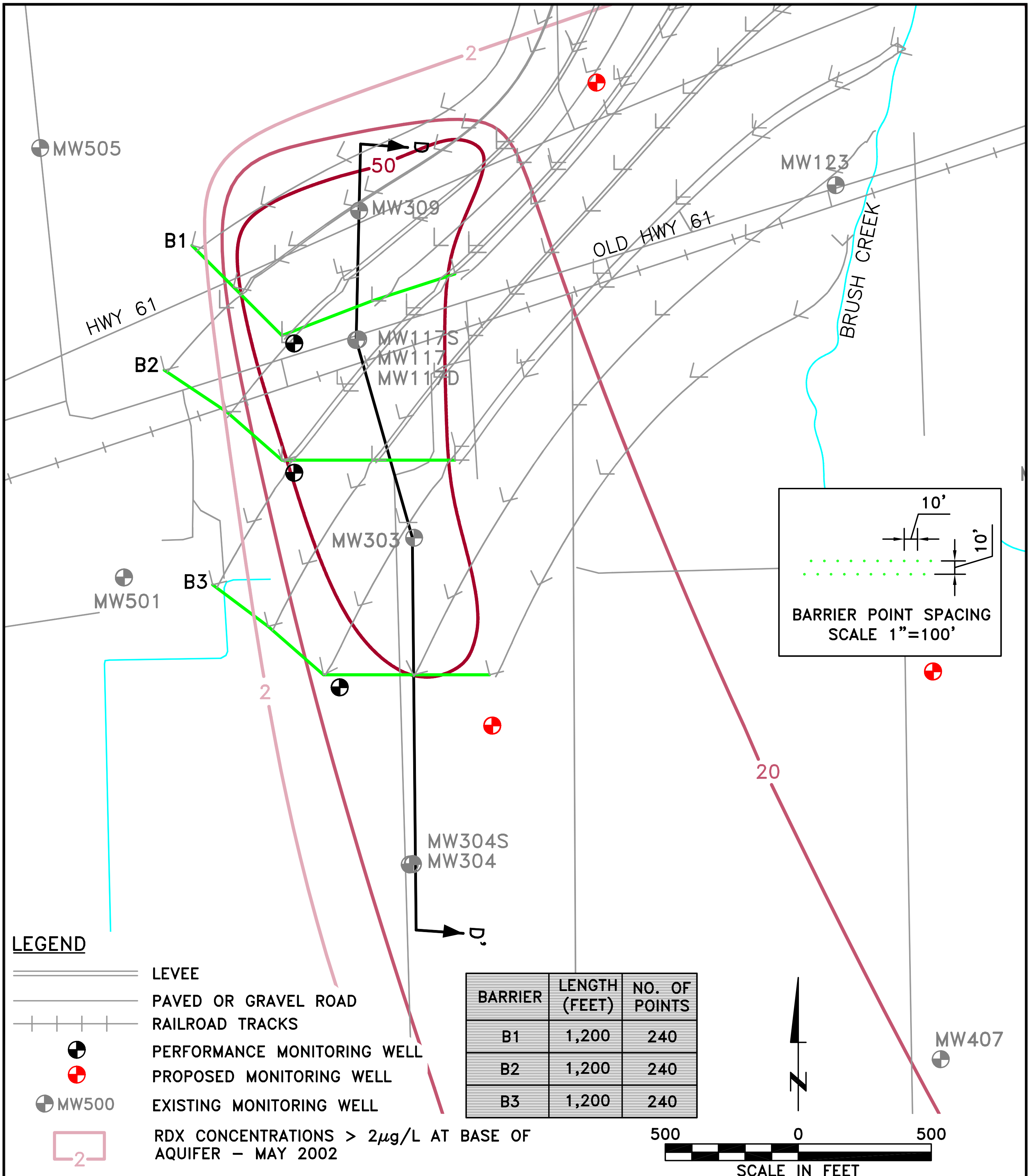
March 05, 2004 10:06:43 a.m.
Drawing: T:\IAAAP\16169419\00501\5-3.dwg

6 3 0 6
APPROXIMATE SCALE IN FEET

URS

ALTERNATIVE 3 CONCEPTUAL TREATMENT SYSTEM LAYOUT
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: DRH	DATE: 09/23/03	16169419	5-3



BARRIER	LENGTH (FEET)	NO. OF POINTS
B1	1,200	240
B2	1,200	240
B3	1,200	240

LEGEND

LEVEE

PAVED OR GRAVEL ROAD

RAILROAD TRACKS

PERFORMANCE MONITORING WELL

PROPOSED MONITORING WELL

MW500 EXISTING MONITORING WELL

2 RDX CONCENTRATIONS > 2μg/L AT BASE OF AQUIFER – MAY 2002

ENHANCED DEGRADATION BARRIER

MODEL PREDICTED FLOW LINES (ONE YEAR TRAVEL TIME BETWEEN ARROWS)

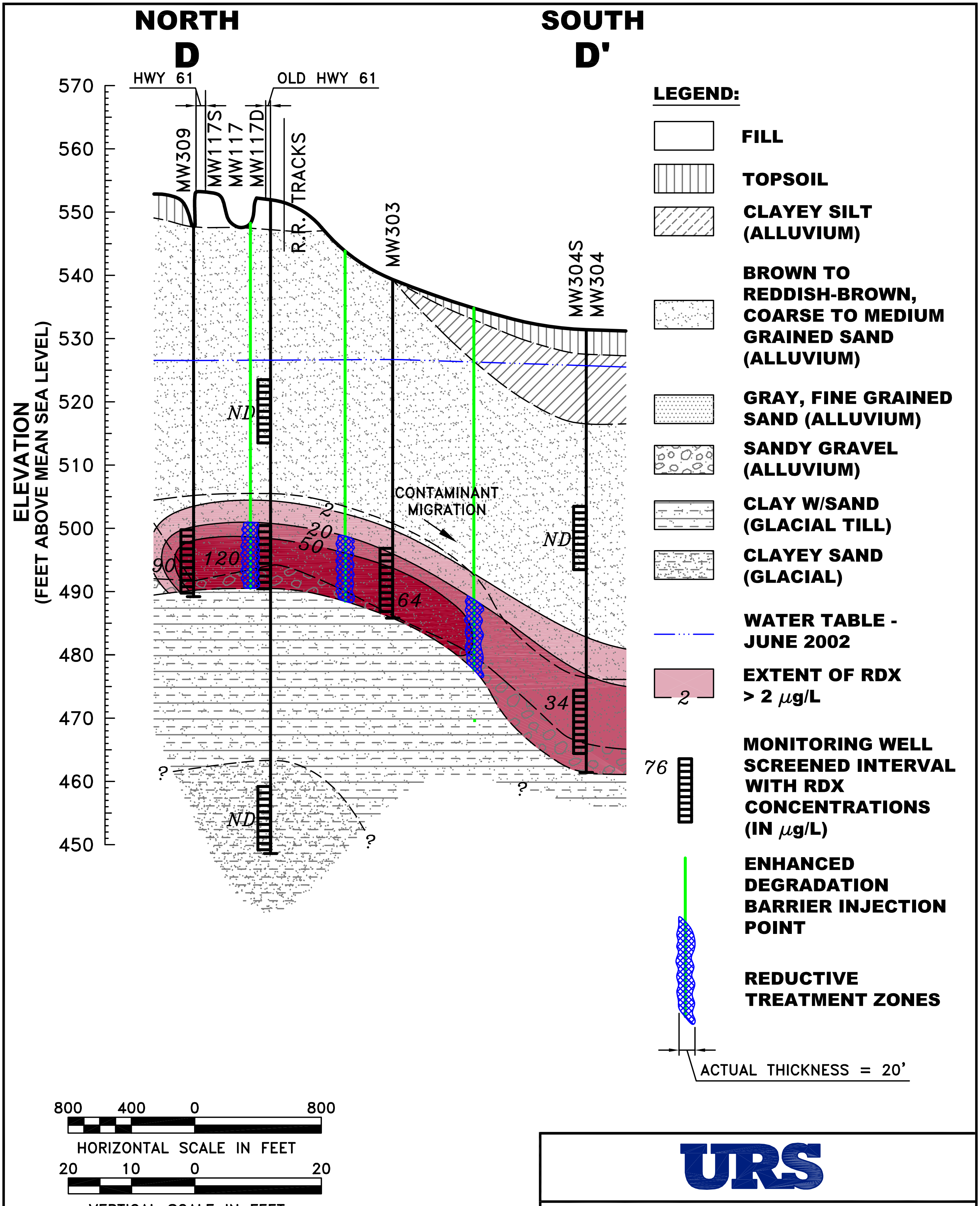
D D' CROSS SECTION LOCATION

March 05, 2004 10:06:24 a.m.
Drawing: T:\IAAAP\16169419\00501\5-4.dwg

URS

ALTERNATIVE 4 SITE PLAN
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: DRH	DATE: 09/23/03	16169419	5-4



NOTE: VERTICAL EXAGGERATION IS 40:1

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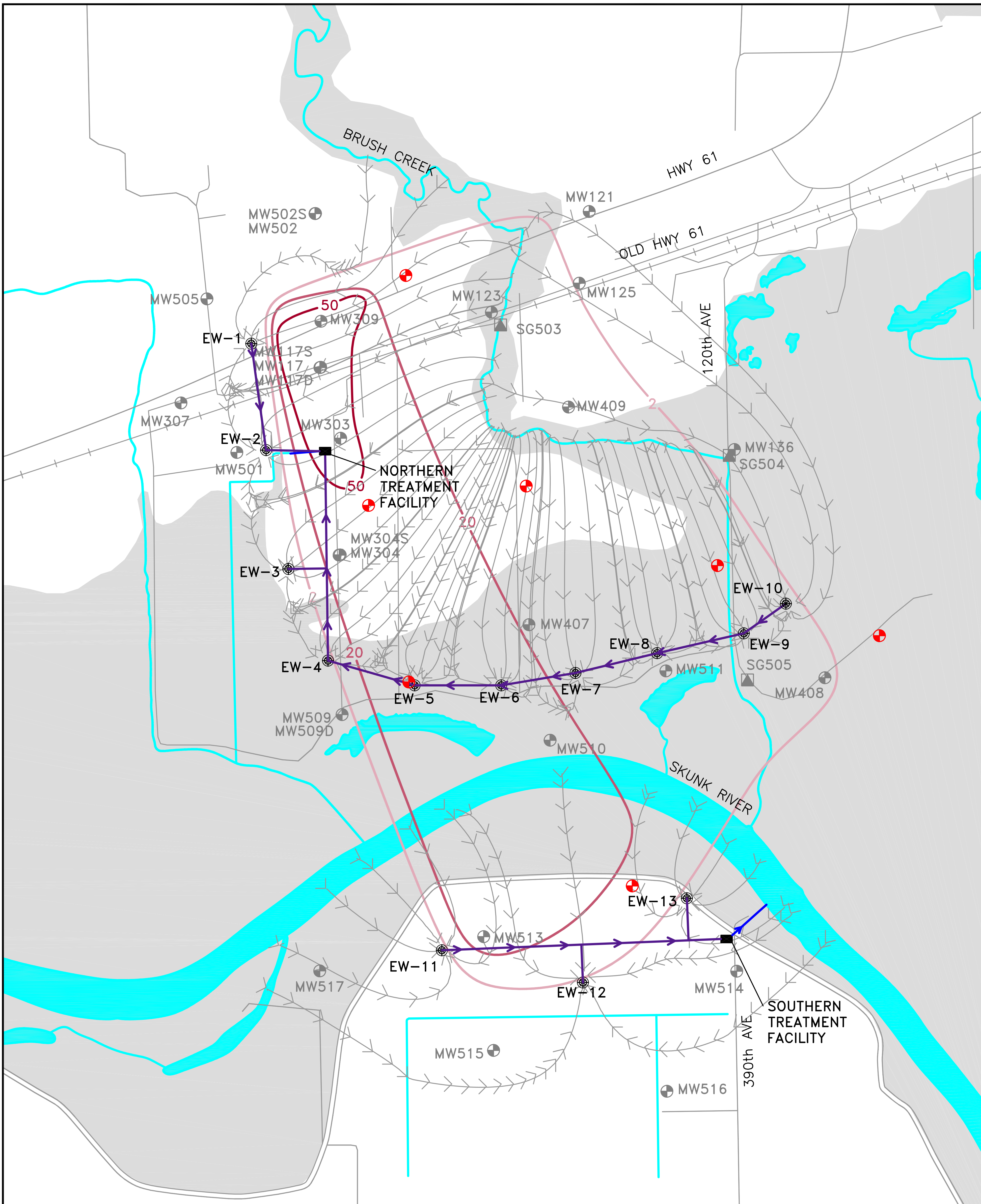
Drawing: T:\IAAAP\16169419\00501\SECT.dwg

URS

ALTERNATIVE 4 GEOLOGIC CROSS SECTION
OFF–SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/25/03	PROJECT NO.	FIG. NO.
CHK'D. BY: DRH	DATE: 09/25/03	16169419	5–5



LEGEND

LEVEE

PAVED OR GRAVEL ROAD

RAILROAD TRACKS

PROPOSED MONITORING WELL

MW500 EXISTING MONITORING WELL

SG501 STAFF GAUGE

RDX CONCENTRATIONS > 2μg/L AT BASE OF AQUIFER – MAY 2002

TREATMENT FACILITY

EXTRACTION WELLS

INFLUENT LINES

EFFLUENT DISCHARGE

MODEL PREDICTED FLOW LINES (ONE YEAR TRAVEL TIME BETWEEN ARROWS)

APPROXIMATE 100-YEAR FLOODPLAIN BOUNDARY (FEMA)

N

1000 500 0 1000

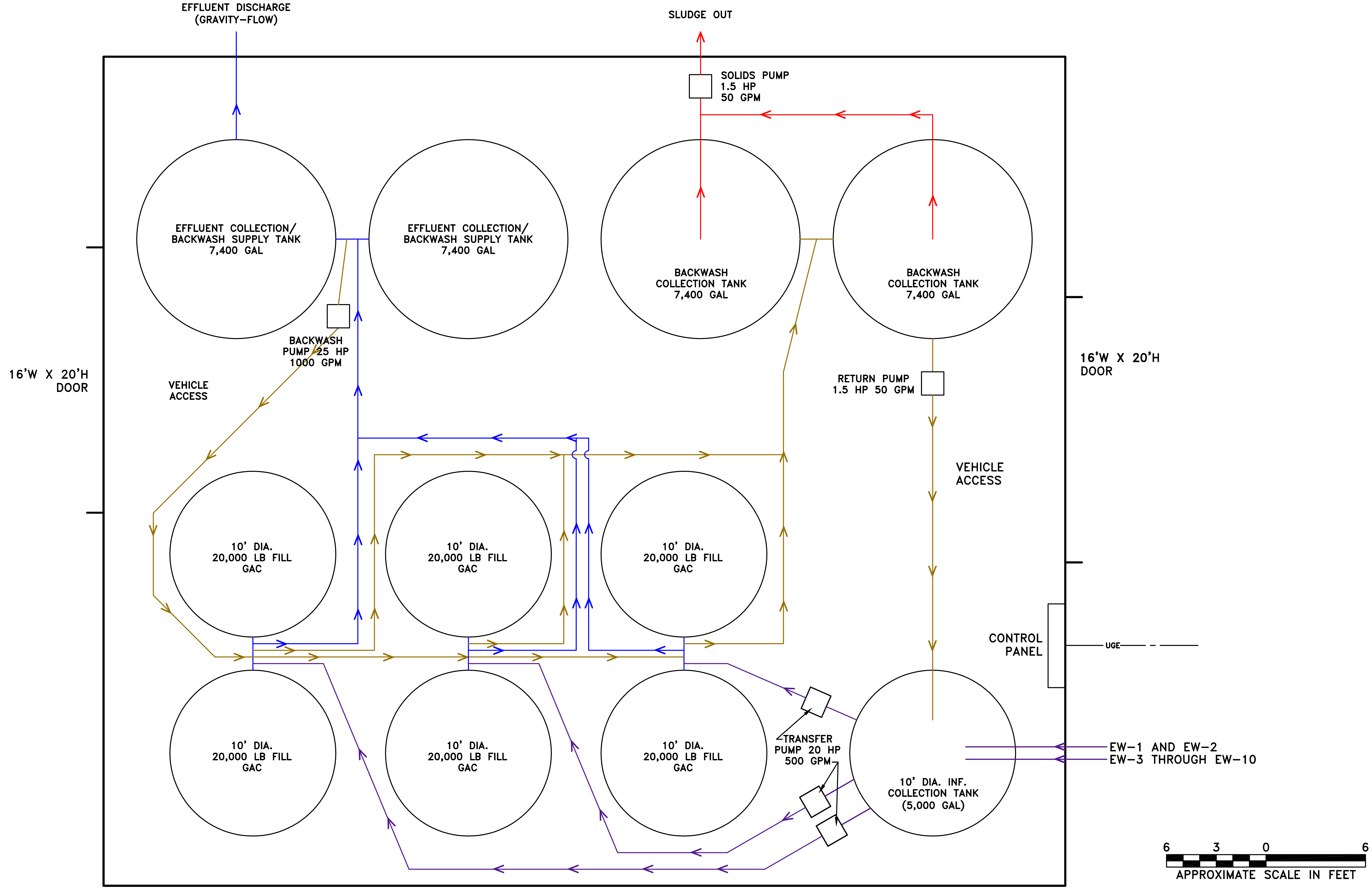
SCALE IN FEET

URS

ALTERNATIVE 5 SITE PLAN
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: DRH	DATE: 09/23/03	16169419	5-6

March 05, 2004 10:06:05 a.m.
Drawing: T:\IAAAP\16169419\00501\5-6.dwg



LEGEND

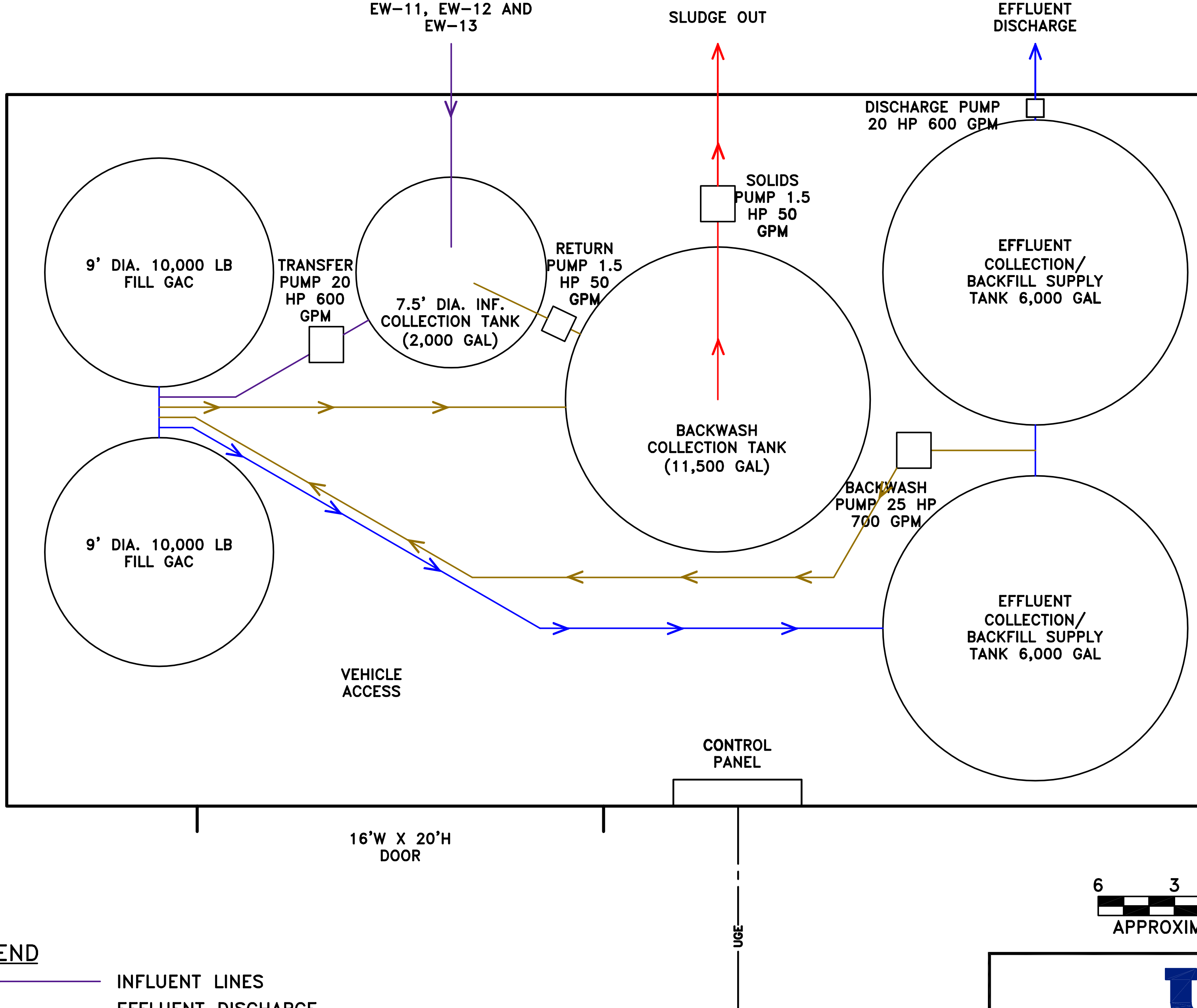
- INFLUENT LINES
- EFFLUENT DISCHARGE
- BACKWASH
- SLUDGE LINE
- UGE UNDERGROUND ELECTRIC

March 05, 2004 10:05:50 a.m.
Drawing: T:\IAAAP\16169419\00501\5–7.dwg

URS

ALTERNATIVE 5 CONCEPTUAL NORTHERN
TREATMENT SYSTEM LAYOUT
OFF–SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: DRH	DATE: 09/23/03	16169419	5–7



6 3 0 6

APPROXIMATE SCALE IN FEET

LEGEND

- INFLUENT LINES
- EFFLUENT DISCHARGE
- BACKWASH
- SLUDGE LINE
- UGE — — UNDERGROUND ELECTRIC

March 05, 2004 10:07:01 a.m.
Drawing: T:\IAAAP\16169419\00501\5-8.dwg

URS

ALTERNATIVE 5 CONCEPTUAL SOUTHERN TREATMENT SYSTEM LAYOUT
OFF–SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO. 16169419	FIG. NO. 5–8
CHK'D. BY: DRH	DATE: 09/23/03		

This section presents the detailed analysis of remedial action alternatives for IAAAP Off-Site groundwater, which were assembled and described in the preceding section. The detailed analysis includes a description of evaluation criteria and both individual and comparative analyses of the alternatives. Analyses are completed under the following evaluation scenarios:

- Scenario A: Contamination in Brush Creek surface water is reduced to the groundwater PRG for RDX of 2 µg/L.
- Scenario B: Contamination in Brush Creek surface water is not reduced.

Contaminant fate and transport modeling results for each alternative, under both scenarios, are summarized in **Table 6-1**. The model-predicted extents of the RDX plume in groundwater for each alternative, under both scenarios, are shown on **Figures 6-1** through **6-8**.

6.1 DESCRIPTION OF EVALUATION CRITERIA

Remedial action alternatives for Off-Site groundwater are analyzed in detail using criteria prescribed by the NCP (40 CFR Part 300.430). Nine criteria have been developed and are described below, according to the functional classes of threshold, primary balancing, and modifying criteria:

Threshold Criteria

- **Overall protection of human health and the environment**. This criterion provides a final assessment of whether the alternative provides adequate protection of human health and the environment, focusing on how each risk and associated pathway are eliminated, reduced, or controlled. The assessment of overall protection draws from the assessments conducted under other criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. This evaluation allows for consideration of whether an alternative poses any unacceptable short-term, long-term, or cross-media impacts resulting from remediation.
- **Compliance with ARARs**. This criterion is used to determine whether each alternative will meet the federal and state ARARs that have been identified during the FS process. A description of ARARs is provided in **Section 3**. If an identified ARAR is not met by an alternative, then an evaluation on the appropriateness of a waiver should be made. A waiver could be applied in any of six circumstances identified by CERCLA (USEPA 1988).

Primary Balancing Criteria

- **Long-term effectiveness and permanence**. This criterion addresses the risk remaining at the site after a particular remedial action has taken place and objectives have been met. The focus is on the risk posed by residuals and/or untreated wastes after the cleanup criteria have been reached. The primary considerations of this criterion are:
  - Magnitude of residual risk
  - Adequacy and reliability of long-term management controls to protect against residuals

- **Reduction of TMV**. This criterion addresses the statutory preference of CERCLA for remedial actions involving treatment that permanently and significantly reduce the TMV of principal hazardous substances or contaminants at a site. Each alternative is evaluated in terms of quantity reduced, degree of reduction, irreversibility of treatment, type and quantity of residuals remaining after treatment, and how treatment addresses the principal threat.
- **Short-term effectiveness**. This criterion addresses the short-term effectiveness of each alternative by assessing the risk to the community, workers, and environment during the construction and implementation of the remedial action and the time required to achieve the remedial objectives. Efforts to provide protection are a key factor in this determination.
- **Implementability**. This criterion assesses the implementability of each alternative in terms of technical feasibility, administrative feasibility, and availability of services and materials. Technical feasibility considers ease of construction and operation, reliability of technology, ease of undertaking possible additional remedial action, and monitoring. Administrative feasibility considers activities needed to coordinate with other offices and agencies (e.g., permits, rights-of-way). Availability of services and materials includes availability of off-site treatment, storage, and disposal services; necessary equipment and specialists; services and materials; and prospective technologies.
- **Cost**. The cost of each alternative is developed as the sum of capital costs, O&M costs, and periodic costs. Present value is the amount of money needed in the base year to cover the future costs associated with a particular time period at a particular interest or discount rate. Present value is developed at a discount rate of 7 percent for each alternative to provide a common basis for comparing alternatives. A feasibility-level cost estimate, intended to provide an accuracy range of –30 to +50 percent of actual cost, was prepared for each alternative using USEPA guidance (USEPA 2000). The final project cost of the selected alternative will depend on actual labor and material cost, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As such, the estimates provided in this FS should not be used for final project budgeting.

Modifying Criteria

- **Agency Acceptance.** This assessment evaluates the technical and administrative issues and concerns the support agency may have regarding each of the alternatives.
- **Community Acceptance.** This assessment evaluates the issues and concerns the public may have regarding each of the alternatives.

Both agency and community acceptance criteria will be evaluated following comment on the FS report and proposed plan and addressed in the record of decision (ROD) as part of the remedy selection process (Section 8.1).

6.2 INDIVIDUAL ANALYSIS OF ALTERNATIVES

A detailed individual analysis of the alternatives for Off-Site groundwater was completed using the criteria described in **Section 6.1** for Scenarios A and B. Results of these analyses are presented in **Tables 6-2** and **6-3**, respectively. Alternative-specific analysis of compliance with

ARARs or TBCs is presented in **Table 6-4**. A map for evaluation of location-specific ARARs is provided as **Figure 6-9**.

The individual analysis for Scenario B indicates that none of the five alternatives would meet RAOs if surface water contamination in Brush Creek is not addressed. For this reason, no cost estimates for remedial alternatives were developed for this scenario. **Appendix C** provides cost estimate summaries for each alternative, including cost worksheets for selected cost elements, using Scenario A.

6.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

The alternatives were compared to each other using the criteria presented in **Section 6.1** for Scenarios A and B. Results of these analyses for each scenario are presented below.

6.3.1 Scenario A – Brush Creek Surface Water Addressed

Overall Protection of Human Health and the Environment

- Alternative 1 would not provide any protection of human health in the short term. Alternatives 2 through 5 use institutional/engineering controls (deed notices, advisories, at-well treatment) to protect users of private wells until RDX in groundwater can be reduced to its PRG through natural attenuation, removal, and/or treatment.
- Under Alternative 1, RDX in groundwater would be expected to eventually be reduced to its PRG. Alternatives 2 through 5 would reduce levels of RDX in groundwater to its PRG through natural attenuation, removal, and/or treatment. Alternative 5 would reduce the downgradient migration of the plume at its leading edge south of Skunk River, while the other alternatives would not (**Figures 6-1** through **6-4**).

Compliance with ARARs

ARARs and TBCs were initially screened in **Section 3**. Key ARARs and TBCs for Off-Site groundwater were further evaluated in this detailed analysis of alternatives for Scenario A (**Table 6-4**). The results of this evaluation are summarized below:

- Alternative 1 would not meet ARARs or TBCs. The lifetime HAL for RDX would eventually be met through natural attenuation, but no actions would be taken until then to prevent drinking water exposure.
- Alternatives 2, 3, 4, and 5 would meet ARARs. No banned activities would take place within the floodplain or wetland areas (**Figure 6-9**).

Long-Term Effectiveness

- Under Alternatives 1 through 5, upon reduction to the PRG, residual contamination would pose no unacceptable risk.
- Alternative 1 would provide no controls. Deed notices, advisories, at-well treatment (if needed), and groundwater monitoring would be provided under Alternatives 2 through 5.

Alternatives 3 and 4 would actively remediate the high level area. Alternative 5 would actively remediate the entire plume.

- Controls for Alternatives 2, 3, and 5 are considered adequate and reliable. Although enhanced degradation (Alternative 4) is considered a developing technology for RDX in groundwater, it is expected to meet long-term objectives.
- At five years, the model-predicted extent of the plume greater than 2 µg/L for each alternative is about the same (**Figures 6-1** through **6-4**). At 35 years, under Alternatives 1 through 4, only a small portion of the plume greater than 2 µg/L is left on the south side of the Skunk River, while this portion is absent under Alternative 5.

Reduction of Toxicity, Mobility, and Volume

- Under Alternatives 1 and 2, toxicity and volume of RDX in groundwater would be reduced slowly through natural attenuation.
- Under Alternatives 3 and 4, toxicity and volume of RDX in groundwater would be reduced by focused removal and/or treatment and natural attenuation. Under Alternative 5, toxicity and volume of RDX in groundwater would be reduced through removal and treatment.
- Mobility of RDX would be not be reduced by any of the alternatives, although the ability of the RDX plume to migrate would be reduced by pumping under Alternative 3 (high level area only) and Alternative 5.

Short-Term Effectiveness

- The modeling results indicate that Alternatives 1, 2, 3, and 4 would reduce RDX in groundwater to its PRG in similar time frames, with Alternative 5 being slightly faster (**Table 6-1** and **Figures 6-1** through **6-4**). Model-predicted time estimates were made to assist in comparing alternatives only; actual remediation time frames are likely to vary, depending on the actual site-specific biodegradation rates. Estimates for each alternative to remediate both the entire plume to 2 µg/L and the high level area to 50 µg/L are summarized as follows:

Alternative	Future Plume (years)	High Level Area (years)
1 – No Action	40 to 45	5 to 8
2 – MNA	40 to 45	5 to 8
3 – Focused Extraction/MNA	40 to 45	less than 5
4 – EDB/MNA	40 to 45	less than 5
5 – Total Groundwater Restoration	30 to 35	less than 5

- Alternative 1 would have no short-term impacts, because the site remains as-is.
- For Alternatives 2 through 5, potential impact to the community would be low. Remediation workers would be protected through implementation of a health and safety plan.

Implementability

- Alternative 1 has no action to implement.
- Alternatives 2 through 5 are technically and administratively feasible, although field-scale testing of substrates would be required under Alternative 4. Services and equipment are available for these alternatives. Because the site is located on private property, owner easements or agreements would be required for access for various construction, O&M, and sampling activities. Access to the site could be restricted during flood events.
- Alternatives 3 and 5 would need to meet the substantive requirements of an NPDES surface water discharge permit.

Cost

The estimated capital cost, O&M costs, periodic costs, total cost, and total present value for alternatives under Scenario A are summarized below and in **Table 6-2**, along with the estimated project duration. The detailed development of these costs is presented in **Appendix C**. No capital, O&M, or periodic costs are associated with Alternative 1. The total present value, using a discount rate of 7 percent, ranges from $863,000 for Alternative 2 to $7,515,000 for Alternative 5, corresponding to the difference in capital costs. Alternative 4 has the highest periodic cost, due to the assumed reinjection of the entire length of each barrier. Alternative 5 has the highest O&M costs.

Description	**Alternative 1** **No Action**	**Alternative 2** **MNA**	**Alternative 3** **Focused Extraction/ MNA**	**Alternative 4** **EDB/MNA**	**Alternative 5** **Total Groundwater Restoration**
Total Project Duration (years)	0	45	45	45	35
Capital Cost	$0	$178,000	$793,000	$1,233,000	$2,045,000
Total O&M Cost	$0	$1,050,000	$2,033,000	$1,050,000	$13,829,000
Total Periodic Cost	$0	$367,000	$400,000	$966,000	$441,000
Total Cost of Alternatives	$0	$1,595,000	$3,226,000	$3,248,000	$16,315,000
Total Present Value of Alternative	**$0**	**$863,000**	**$2,267,000**	**$2,441,000**	**$7,515,000**

Figure 6-10 compares the total costs of Alternatives 1 through 5 graphically.

6.3.2 Scenario B – Brush Creek Surface Water Not Addressed

Overall Protection of Human Health and the Environment

- Alternative 1 would provide no protection of human health. Alternatives 2 through 5 would protect human health through institutional and engineering controls for an indefinite period of time, as long as those controls remain in place.

- Under all alternatives, groundwater would continue to be contaminated with RDX above its PRG. Under Alternative 5, the plume would not extend past Skunk River.

Compliance with ARARs

- No ARARs or TBCs would be met by any of the alternatives, because the lifetime HAL would not be met by any of the alternatives. Although the HAL is technically a TBC, a waiver of some sort would be required to implement these alternatives if Brush Creek surface water is not addressed.

Long-Term Effectiveness

- Under Alternative 1, residual contamination would continue to pose a risk above the level of the lifetime HAL for RDX. Under Alternatives 2 through 5, residual risk would be limited by institutional and engineering controls, as long as they are maintained.
- Alternative 1 would provide no controls. Under Alternatives 2 through 5, Brush Creek would continue to be a source of RDX contamination, loading the aquifer at a rate greater than or equal to the rate of natural attenuation, removal, and/or treatment.
- At five years, the model-predicted extent of the plume greater than 2 µg/L for each alternative is about the same (**Figures 6-5** through **6-8**). At 35 years, under Alternatives 1 through 4, a small portion of the plume greater than 2 µg/L extends to the south past Skunk River, while this portion is absent under Alternative 5.

Reduction of Toxicity, Mobility, and Volume

- Under Alternatives 1 and 2, toxicity and volume of RDX in groundwater would be reduced slowly through natural attenuation but to levels greater than the PRG.
- Under Alternatives 3 and 4, toxicity and volume of RDX in groundwater would be reduced by focused removal and/or treatment and natural attenuation. Under Alternative 5, toxicity and volume of RDX in groundwater would be reduced through removal, treatment, and natural attenuation. None of the alternatives would reduce RDX in groundwater to its PRG.
- Mobility of RDX would be not be reduced by any of the alternatives, although the ability of the RDX plume to migrate would be reduced by pumping under Alternative 3 (high level area only) and Alternative 5.

Short-Term Effectiveness

- The modeling results indicate that none of the alternatives would be able to reduce RDX in groundwater to PRGs within the modeled time period of 70 years.
- Alternative 1 does not have short-term impacts because the site remains as-is.
- For Alternatives 2 through 5, potential impact to the community would be low. Remediation workers would be protected through implementation of a health and safety plan.

Implementability

- Alternative 1 has no action to implement.
- Alternatives 2 through 5 are technically and administratively feasible, although field-scale testing of substrates would be required under Alternative 4. Services and equipment are available for these alternatives. Because the site is located on private property, owner easements or agreements would be required for access for various construction, O&M, and sampling activities. Access to the site could be restricted during flood events.
- Alternatives 3 and 5 would need to meet the substantive requirements of an NPDES surface water discharge permit.

Cost

No cost estimates were developed for alternatives under Scenario B because of their inability to meet RAOs within a definitive time frame.

TABLE 6-1
SUMMARY OF CONTAMINANT FATE AND TRANSPORT MODELING RESULTS FOR REMEDIAL ALTERNATIVES
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Alternative	Time for current high level area concentration to be reduced below 50 µg/L[1] (years)	Time for plume concentration to be reduced below:[2]		Maximum concentration remaining at plume equilibrium[4] (µg/L)
		20 µg/L	2 µg/L (PRG)[3]	
Alternative 1 - No Action				
A – Brush Creek Addressed	5-8	5-10	40-45	<2
B – Brush Creek Not Addressed	5-8	5-10	>70	18
Alternative 2 - MNA				
A – Brush Creek Addressed	5-8	5-10	40-45	<2
B – Brush Creek Not Addressed	5-8	5-10	>70	18
Alternative 3 - Focused Extraction/MNA				
A – Brush Creek Addressed	<5	5-10	40-45	<2
B – Brush Creek Not Addressed	<5	5-10	>70	18
Alternative 4 - EDB/MNA				
A – Brush Creek Addressed	<5	5-10	40-45	<2
B – Brush Creek Not Addressed	<5	5-10	>70	18
Alternative 5 - Total Groundwater Restoration				
A – Brush Creek Addressed	<5	5-10	30-35	<2
B – Brush Creek Not Addressed	<5	5-10	>70	18

NOTES:
[1] Current high level area is defined as the 50 µg/L isoconcentration line interpreted from the May 2002 sampling event.
[2] All concentrations in the plume are below the stated level.
[3] PRG: Lifetime HAL for RDX (USEPA 2002)
[4] Plume equilibrium is the point where the current high level area is no longer impacting the model and the RDX contribution from Brush Creek is no longer increasing concentrations in the model. For the addressed Brush Creek, this is when concentrations in the model are less than 2 µg/L.
See **Figures 6-1** to **6-8** for the model-predicted extent of RDX in groundwater for each alternative and scenario.

> = Greater than
< = Less than
µg/L = Micrograms per liter
EDB = Enhanced Degradation Barrier
HAL = Health Advisory Level
MNA = Monitored Natural Attenuation
PRG = Preliminary Remediation Goal
RDX = Common military explosive

TABLE 6-2
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES
SCENARIO A – BRUSH CREEK SURFACE WATER ADDRESSED
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Evaluation Criterion	Alternative 1 No Action	Alternative 2 MNA	Alternative 3 Focused Extraction/MNA	Alternative 4 EDB/MNA	Alternative 5 Total Groundwater Restoration
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT					
Human Health Protection	None in the short term, although RDX in groundwater would be expected to eventually decrease below its PRG.	Protects human health through institutional/engineering controls until RDX in groundwater is reduced to its PRG through natural attenuation (40 to 45 years).	Protects human health through institutional/engineering controls, focused removal, and natural attenuation until RDX in groundwater is reduced to its PRG (40 to 45 years).	Protects human health through institutional/engineering controls, focused in-situ treatment, and natural attenuation until RDX in groundwater is reduced to its PRG (40 to 45 years).	Protects human health through institutional/engineering controls, plume removal, and ex-situ treatment until RDX in groundwater is reduced to its PRG (30 to 35 years).
Environmental Protection	Natural processes would be expected to eventually reduce RDX in groundwater to its PRG.	Natural processes would eventually reduce RDX in groundwater to its PRG. Monitoring would allow for tracking of the plume.	Removal in high level area and natural processes would reduce RDX in groundwater to its PRG. Monitoring would allow for tracking of the plume.	In-situ treatment in high level area and natural processes would reduce RDX in groundwater to its PRG. Monitoring would allow for tracking of the plume.	Would reduce groundwater to its PRG and reduce downgradient migration of the plume.
COMPLIANCE WITH ARARs					
Compliance with ARARs	Would not meet ARARs.	Would meet ARARs as evaluated in Table 6-4, in combination with measures to address Brush Creek surface water.	Would meet ARARs as evaluated in Table 6-4, in combination with measures to address Brush Creek surface water.	Would meet ARARs as evaluated in Table 6-4, in combination with measures to address Brush Creek surface water.	Would meet ARARs as evaluated in Table 6-4, in combination with measures to address Brush Creek surface water.
Appropriateness of Waivers	Not appropriate.	None would be required.	None would be required.	None would be required.	None would be required.
LONG-TERM EFFECTIVENESS					
Magnitude of Residual Risk	Upon reduction to the PRG, residual contamination would pose no unacceptable	Upon reduction to the PRG, residual contamination would pose no unacceptable risk.	Upon reduction to the PRG, residual contamination would pose no unacceptable risk.	Upon reduction to the PRG, residual contamination would pose no unacceptable risk.	Upon reduction to the PRG, residual contamination would pose no unacceptable risk.
Adequacy and Reliability of Controls	Not applicable.	Groundwater monitoring would track the migration of contaminants. Deed notices and advisories would warn residents but would not be fail-safe until the PRG is achieved. At-well GAC treatment would protect private well users not connected to the public water system.	Proposed removal and treatment options are field-proven and are expected to meet long-term remedial objectives. Groundwater monitoring would track the migration of contaminants. Deed notices and advisories would warn residents but would not be fail-safe until the PRG is achieved. At-well GAC treatment would protect private well users not connected to the public water system.	Although enhanced biodegradation and in situ chemical oxidation of RDX are considered developing technologies, either one is expected to meet long-term remedial objectives. Groundwater monitoring would track the migration of contaminants. Deed notices and advisories would warn residents but would not be fail-safe until the PRG is achieved. At-well GAC treatment would protect private well users not connected to the public water system.	Proposed removal and treatment options are field-proven and are expected to meet long-term remedial objectives. Groundwater monitoring would track the migration of contaminants. Deed notices and advisories would warn residents but would not be fail-safe until the PRG is achieved. At-well GAC treatment would protect private well users not connected to the public water system.

TABLE 6-2
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES
SCENARIO A – BRUSH CREEK SURFACE WATER ADDRESSED
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Evaluation Criterion	Alternative 1 No Action	Alternative 2 MNA	Alternative 3 Focused Extraction/MNA	Alternative 4 EDB/MNA	Alternative 5 Total Groundwater Restoration
REDUCTION OF TOXICITY, MOBILITY, AND VOLUME					
Treatment Process Used	None, except for natural attenuation.	None, except for at-well treatment and the natural attenuation processes of dispersion, biodegradation, and adsorption.	Vertical extraction wells would remove contaminated groundwater in the high level area. Extracted groundwater would be treated by GAC adsorption and discharged to surface water. MNA would remediate the remaining areas of the plume.	Enhanced degradation barriers would remediate contaminated groundwater in the high level area. MNA would remediate the remaining areas of the plume.	Vertical extraction wells would remove contaminated groundwater across the site. Extracted groundwater would be treated by GAC adsorption and discharged to surface water.
Reduction of TMV	Toxicity and volume of contaminants would be reduced but not documented.	Toxicity and volume of RDX in groundwater would eventually be reduced to its PRG through natural processes.	Toxicity and volume of RDX in groundwater would be reduced to its PRG through focused removal and natural processes.	Toxicity and volume of RDX in groundwater would be reduced to its PRG through hot spot in-situ treatment and natural processes.	Toxicity and volume of RDX in groundwater would be reduced to its PRG through removal and ex-situ treatment.
SHORT-TERM EFFECTIVENESS					
Time Required to Achieve Remedial Action Objectives	RDX in groundwater would be reduced to its PRG within 45 years but would not be documented.	RDX in groundwater would be reduced to its PRG within 45 years.	RDX in groundwater would be reduced to its PRG within 45 years.	RDX in groundwater would be reduced to its PRG within 45 years.	RDX in groundwater would be reduced to its PRG within 35 years.
Protection of Community During Remedial Action	No action taken.	Potential impact to community would be low due to the nature of activities (e.g., groundwater sampling).	Potential impact to community would be low. Site is located on private property in a rural area and actions would generate minimal waste streams.	Potential impact to community would be low. Site is located on private property in a rural area and actions would generate minimal or no waste streams.	Potential impact to community would be low. Site is located on private property in a rural area and actions would generate minimal waste streams.
Protection of Workers During Remedial Action	No action taken.	Workers would need to take proper health and safety precautions during drilling and sampling activities.	Workers would need to take proper health and safety precautions during drilling, sampling, and construction activities.	Workers would need to take proper health and safety precautions during drilling and sampling activities. Special precautions would be needed during handling of chemical oxidants, if used.	Workers would need to take proper health and safety precautions during drilling, sampling, and construction activities.

TABLE 6-2
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES
SCENARIO A – BRUSH CREEK SURFACE WATER ADDRESSED
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Evaluation Criterion	Alternative 1 No Action	Alternative 2 MNA	Alternative 3 Focused Extraction/MNA	Alternative 4 EDB/MNA	Alternative 5 Total Groundwater Restoration
IMPLEMENTABILITY					
Ability to Construct and Operate	Not applicable.	An easement or agreement to install and access monitoring wells and to access at-well treatment systems for O&M on private property would be required. Sampling and analysis are easily implemented.	An easement or agreement to install monitoring and extraction wells, construct treatment facilities, and trench in system piping and electrical on private property would be required. Would also require permission to access wells and treatment facilities for O&M and sampling activities. Some access could be restricted during flood events. NPDES permit equivalency would be required for surface water discharge. Sampling and analysis are easily implemented.	An easement or agreement to install monitoring wells and inject EDBs and to access at-well treatment systems for O&M on private property would be required. Sampling and analysis are easily implemented.	An easement or agreement to install monitoring and extraction wells, construct treatment facilities, and trench in system piping and electrical on private property would be required. Would also require permission to access wells and treatment facilities for O&M and sampling activities. Access could be restricted during flood events. NPDES permit equivalency would be required for surface water discharge. Sampling and analysis are easily implemented.
Technical Feasibility	Not applicable.	Technology is reliable. Equipment and materials are available.	Technology is reliable. Equipment and materials are available.	Enhanced biodegradation and in situ chemical oxidation of RDX are considered developing technologies. Field scale treatability tests would be required to evaluate overall effectiveness, determine the best substrate, and confirm design parameters before full scale implementation.	Technology is reliable. Equipment and materials are available.
COST					
Assumed Project Duration (Years)	Indefinite.	45	45	45	35
Capital Cost	$0	$178,000	$793,000	$1,233,000	$2,045,000
Total O&M Cost	$0	$1,050,000	$2,033,000	$1,050,000	$13,829,000
Total Periodic Cost	$0	$367,000	$400,000	$966,000	$441,000
Total Cost of Alternative	$0	$1,595,000	$3,226,000	$3,248,000	$16,315,000
Total Present Value (7%)	$0	$863,000	$2,267,000	$2,441,000	$7,515,000

NOTES:

ARAR = Applicable or Relevant and Appropriate Requirement
EB = Enhanced Biodegradation
EDB = Enhanced Degradation Barrier
GAC = Granular Activated Carbon
HAL = Health Advisory Level
MNA = Monitored Natural Attenuation
NPDES = National Pollutant Discharge and Elimination System
O&M = Operation and Maintenance
PRB = Permeable Reactive Barrier
RDX = A common military explosive (cyclonite)
TMV = Toxicity, Mobility, and Volume

TABLE 6-3
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES
SCENARIO B – BRUSH CREEK SURFACE WATER NOT ADDRESSED
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Evaluation Criterion	Alternative 1 No Action	Alternative 2 MNA	Alternative 3 Focused Extraction/MNA	Alternative 4 EDB/MNA	Alternative 5 Total Groundwater Restoration
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT					
Human Health Protection	None.	Protects human health through institutional/engineering controls for an indefinite period of time (> 70 years).	Protects human health through institutional/engineering controls for an indefinite period of time (> 70 years).	Protects human health through institutional/engineering controls for an indefinite period of time (> 70 years).	Protects human health through institutional/engineering controls for an indefinite period of time (> 70 years).
Environmental Protection	Groundwater would continue to be contaminated with RDX above its PRG over most	Groundwater would continue to be contaminated with RDX above its PRG over most of the original plume area.	Groundwater would continue to be contaminated with RDX above its PRG over most of the original plume area.	Groundwater would continue to be contaminated with RDX above its PRG over most of the original plume area.	Groundwater would continue to be contaminated with RDX above its PRG, although the plume would not extend past Skunk River.
COMPLIANCE WITH ARARs					
Compliance with ARARs	Would not meet ARARs.	Would not meet ARARs.	Would not meet ARARs.	Would not meet ARARs.	Would not meet ARARs.
Appropriateness of Waivers	Not appropriate.	Although the PRG (Lifetime HAL) is technically a TBC, some kind of waiver would likely be required.	Although the PRG (Lifetime HAL) is technically a TBC, some kind of waiver would likely be required.	Although the PRG (Lifetime HAL) is technically a TBC, some kind of waiver would likely be required.	Although the PRG (Lifetime HAL) is technically a TBC, some kind of waiver would likely be required.
LONG-TERM EFFECTIVENESS					
Magnitude of Residual Risk	Residual contamination would continue to pose a risk above the level of the Lifetime HAL for RDX.	Residual risk would be limited by institutional/engineering controls as long as they are maintained.	Residual risk would be limited by institutional/engineering controls as long as they are maintained.	Residual risk would be limited by institutional/engineering controls as long as they are maintained.	Residual risk would be limited by institutional/engineering controls as long as they are maintained.
Adequacy and Reliability of Controls	Not applicable.	Brush Creek would continue to be a source of RDX contamination, loading the aquifer at a rate greater than or equal to the rate of natural attenuation.	Brush Creek would continue to be a source of RDX contamination, loading the aquifer at a rate greater than or equal to the rate of focused removal and natural attenuation.	Brush Creek would continue to be a source of RDX contamination, loading the aquifer at a rate greater than or equal to the rate of focused in-situ treatment and natural attenuation.	Brush Creek would continue to be a source of RDX contamination, loading the aquifer at a rate greater than or equal to the rate of removal and ex-situ treatment.
REDUCTION OF TOXICITY, MOBILITY, AND VOLUME					
Treatment Process Used	None, except for natural attenuation.	None, except for at-well treatment and the natural attenuation processes of dispersion, biodegradation, and adsorption.	Vertical extraction wells would remove contaminated groundwater in the high level area. Extracted groundwater would be treated by GAC adsorption and discharged to surface water. MNA would remediate the remaining areas of the plume.	Enhanced degradation barriers would remediate contaminated groundwater in the high level area. MNA would remediate the remaining areas of the plume.	Vertical extraction wells would remove contaminated groundwater across the site. Extracted groundwater would be treated by GAC adsorption and discharged to surface water.
Reduction of TMV	Toxicity and volume of contaminants would be reduced to levels greater than PRG, but not	Toxicity and volume of RDX in groundwater would be reduced to levels greater than PRG.	Toxicity and volume of RDX in groundwater would be reduced to levels greater than PRG through focused removal and natural processes.	Toxicity and volume of RDX in groundwater would be reduced to levels greater than PRG through focused in-situ treatment and natural processes.	Toxicity and volume of RDX in groundwater would be reduced to levels greater than PRG through removal and ex-situ treatment.

TABLE 6-3
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES
SCENARIO B – BRUSH CREEK SURFACE WATER NOT ADDRESSED
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Evaluation Criterion	Alternative 1 No Action	Alternative 2 MNA	Alternative 3 Focused Extraction/MNA	Alternative 4 EDB/MNA	Alternative 5 Total Groundwater Restoration
SHORT-TERM EFFECTIVENESS					
Time Required to Achieve Remedial Action Objectives	Indefinite.	Indefinite (> 70 years).	Indefinite (> 70 years).	Indefinite (> 70 years).	Indefinite (> 70 years).
Protection of Community During Remedial Action	No action taken.	Potential impact to community would be low due to the nature of activities (groundwater sampling).	Potential impact to community would be low. Site is located on private property in a rural area and actions would generate minimal waste streams.	Potential impact to community would be low. Site is located on private property in a rural area and actions would generate minimal or no waste streams.	Potential impact to community would be low. Site is located on private property in a rural area and actions would generate minimal waste streams.
Protection of Workers During Remedial Action	No action taken.	Workers would need to take proper health and safety precautions during drilling and sampling activities.	Workers would need to take proper health and safety precautions during drilling, sampling, and construction activities.	Workers would need to take proper health and safety precautions during drilling and sampling activities. Special precautions would be needed during handling of chemical oxidants, if used.	Workers would need to take proper health and safety precautions during drilling, sampling, and construction activities.
IMPLEMENTABILITY					
Ability to Construct and Operate	Not applicable.	Easements or agreements to install and access monitoring wells and to access at-well treatment systems for O&M on private property would be required. Sampling and analysis are easily implemented.	Easements or agreements to install monitoring and extraction wells, construct treatment facilities, and trench in system piping and electrical on private property would be required. Would also require permission to access wells and treatment facilities for O&M and sampling activities. Some access could be restricted during flood events. NPDES permit equivalency would be required for surface water discharge. Sampling and analysis are easily implemented.	Easements or agreements to install monitoring wells and inject EDBs and to access at-well treatment systems for O&M on private property would be required. Sampling and analysis are easily implemented.	Easements or agreements to install monitoring and extraction wells, construct treatment facilities, and trench in system piping and electrical on private property would be required. Would also require permission to access wells and treatment facilities for O&M and sampling activities. Access could be restricted during flood events. NPDES permit equivalency would be required for surface water discharge. Sampling and analysis are easily implemented.
Technical Feasibility	Not applicable.	Technology is reliable. Equipment and materials are available.	Technology is reliable. Equipment and materials are available.	Enhanced biodegradation and in situ chemical oxidation of RDX are considered developing technologies. Field scale treatability tests would be required to evaluate overall effectiveness, determine the best substrate, and confirm design parameters before full scale implementation.	Technology is reliable. Equipment and materials are available.

NOTES:

> = Greater Than
ARAR = Applicable or Relevant and Appropriate Requirement
EB = Enhanced Biodegradation
EDB = Enhanced Degradation Barrier
GAC = Granular Activated Carbon
HAL = Health Advisory Level
MNA = Monitored Natural Attenuation
NPDES = National Pollutant Discharge and Elimination System
O&M = Operation and Maintenance
PRB = Permeable Reactive Barrier
RDX = A common military explosive (cyclonite)
TMV = Toxicity, Mobility, and Volume

TABLE 6-4
ALTERNATIVE-SPECIFIC ANALYSIS OF COMPLIANCE WITH ARARs – SCENARIO A
OFF-SITE GROUNDWATER FEASIBILITY STUDY

CITATION	DESCRIPTION	Would Alternative Comply with ARARs or TBCs?				
		Alternative 1 - No Action	**Alternative 2 - MNA**	**Alternative 3 - Focused Extraction/MNA**	**Alternative 4 - EDB/MNA**	**Alternative 5 - Total Groundwater Restoration**
FEDERAL						
"2002 Edition of the Drinking Water Standards and Health Advisories," EPA Office of Water, Summer 2002						
Lifetime Health Advisory Levels (HALs)	Lifetime HALs provide the most currently available information on concentrations of drinking water contaminants at which adverse noncarcinogenic effects are anticipated to occur as a result of lifetime exposure.	No. The lifetime HAL for RDX would eventually be met due to natural attenuation, but no actions would be taken until then to prevent drinking water exposure.	Yes. Expected to meet HAL for RDX through natural attenuation.	Yes. Expected to meet HAL by focused removal and natural attenuation.	Yes. Expected to meet HAL through enhanced biodegradation or in situ chemical oxidation of high level area and natural attenuation.	Yes. Expected to meet HAL by groundwater extraction and treatment of entire plume.
Water Pollution Control Act (Clean Water Act), as amended, 33 USC Section 1251 et seq.						
40 CFR Part 125 National Pollutant Discharge Elimination System (NPDES) Regulations	Establishes procedures for determination of effluent limitations for discharges of pollutants to navigable waters.	N/A	N/A	Yes. Monitoring would ensure that discharged effluent is treated to acceptable levels before discharge.	N/A	Yes. Monitoring would ensure that discharged effluent is treated to acceptable levels before discharge.
40 CFR Part 131, Quality Criteria for Water Ambient Water Quality Criteria	Requires states to establish ambient water quality criteria (AWQC) for surface water based on use classifications and the criteria stated under Section 304(a) of the Clean Water Act.	N/A	N/A	Yes.	N/A	Yes.
40 CFR Part 136.1-5 and Appendices A-C Guidelines Establishing Test Procedures for the Analysis of Pollutants	Specific analytical procedures for NPDES applications and reports.	N/A	N/A	Yes.	N/A	Yes.
Solid Waste Disposal Act (SWDA), as amended, 42 USCA Section 6901-6992K						
40 CFR Part 260 Hazardous Waste Management Systems General (Subtitle C)	Provides definitions, general standards, and information applicable to 40 CFR Parts 260-265, 268.	N/A	N/A	Yes. GAC treatment would generate RDX-saturated carbon that may be considered a RCRA hazardous solid waste. Proper disposal procedures would be implemented to ensure compliance with applicable requirements.	N/A	Yes. GAC treatment would generate RDX-saturated carbon that may be considered a RCRA hazardous solid waste. Proper disposal procedures would be implemented to ensure compliance with applicable requirements.
40 CFR Part 261 Identification and Listing of Hazardous Wastes (Subtitle C)	Defines those solid wastes which are subject to regulations as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271.	N/A	N/A	Yes. GAC treatment would generate RDX-saturated carbon that may be considered a RCRA hazardous solid waste. Proper disposal procedures would be implemented to ensure compliance with applicable requirements.	N/A	Yes. GAC treatment would generate RDX-saturated carbon that may be considered a RCRA hazardous solid waste. Proper disposal procedures would be implemented to ensure compliance with applicable requirements.
40 CFR Part. 262 Standards Applicable to Generators of Hazardous Waste	Establishes standards for generators of hazardous waste.	N/A	N/A	Yes. GAC treatment would generate RDX-saturated carbon that may be considered a RCRA hazardous solid waste. Proper disposal procedures would be implemented to ensure compliance with applicable requirements.	N/A	Yes. GAC treatment would generate RDX-saturated carbon that may be considered a RCRA hazardous solid waste. Proper disposal procedures would be implemented to ensure compliance with applicable requirements.

TABLE 6-4
ALTERNATIVE-SPECIFIC ANALYSIS OF COMPLIANCE WITH ARARs – SCENARIO A
OFF-SITE GROUNDWATER FEASIBILITY STUDY

CITATION	DESCRIPTION	Would Alternative Comply with ARARs or TBCs?				
		Alternative 1 - No Action	**Alternative 2 - MNA**	**Alternative 3 - Focused Extraction/MNA**	**Alternative 4 - EDB/MNA**	**Alternative 5 - Total Groundwater Restoration**
FEDERAL						
40 CFR Part. 263 Standards Applicable to Transporters of Hazardous Waste	Establishes standards which apply to transporting hazardous waste within the U.S. if the transportation requires a manifest under 40 CFR Part 262.	N/A	N/A	Yes. GAC treatment would generate RDX-saturated carbon that may be considered a RCRA hazardous solid waste. Proper disposal procedures would be implemented to ensure compliance with applicable requirements.	N/A	Yes. GAC treatment would generate RDX-saturated carbon that may be considered a RCRA hazardous solid waste. Proper disposal procedures would be implemented to ensure compliance with applicable requirements.
Occupational Safety and Health Act, 29 USC 15						
29 CFR Part 1910 Occupational Safety and Health Standards	Regulates occupational health and safety. Requires proper precautions, equipment, and training before certain tasks are completed.	N/A	Yes. A health and safety program would be implemented to ensure worker safety and compliance with applicable requirements.	Yes. A health and safety program would be implemented to ensure worker safety and compliance with applicable requirements.	Yes. A health and safety program would be implemented to ensure worker safety and compliance with applicable requirements.	Yes. A health and safety program would be implemented to ensure worker safety and compliance with applicable requirements.
29 CFR Part. 1910.120 Hazardous Waste Operations and Emergency Response	Remediation efforts must be conducted in accordance with health and safety regulations. Requires a Health and Safety Plan for remedial actions that involve potential contact with contaminated environmental media to protect workers health and prepare for any foreseeable emergencies.	N/A	Yes. A health and safety program would be implemented to ensure worker safety and compliance with applicable requirements.	Yes. A health and safety program would be implemented to ensure worker safety and compliance with applicable requirements.	Yes. A health and safety program would be implemented to ensure worker safety and compliance with applicable requirements. Special precautions would be taken if chemical oxidants are handled.	Yes. A health and safety program would be implemented to ensure worker safety and compliance with applicable requirements.
29 CFR Part 1926 Safety and Health Regulations for Construction	Regulates construction health and safety.	N/A	Yes. A health and safety program would be implemented to ensure worker safety and compliance with applicable requirements.	Yes. A health and safety program would be implemented to ensure worker safety and compliance with applicable requirements.	Yes. A health and safety program would be implemented to ensure worker safety and compliance with applicable requirements.	Yes. A health and safety program would be implemented to ensure worker safety and compliance with applicable requirements.
Hazardous Materials Transportation Act, 49 CFR Parts 101, 106-107, 172-173, 178-180, 171, 173-177						
49 CFR Parts 107 and 171-177	Establishes standards applicable to transporters of hazardous materials.	N/A	N/A	Yes. GAC treatment would generate RDX saturated carbon that may be considered a RCRA hazardous solid waste. Proper disposal procedures would be implemented to ensure compliance with applicable requirements.	N/A	Yes. GAC treatment would generate RDX saturated carbon that may be considered a RCRA hazardous solid waste. Proper disposal procedures would be implemented to ensure compliance with applicable requirements.
Endangered Species Act, 16 USC Section 1531 et seq.						
50 CFR Part 17 Endangered and Threatened Wildlife and Plants 50 CFR Part 402 Interagency Cooperation--Endangered Species Act of 1973, as amended	Protects endangered species and the critical habitats upon which endangered species depend.	N/A	Yes. No critical habitat would be disturbed by remedial activities.	Yes. Treatment facility and extraction wells would be located on existing cropland. No critical habitat would be disturbed.	Yes. No critical habitat would be disturbed by remedial activities.	Yes. Treatment facility and extraction wells would be located on existing cropland. No critical habitat would be disturbed.
Bald and Golden Eagle Protection Act, 16 USC Section 668 et seq.						
16 USC 668 et seq.	Prohibits the taking, possession, and transportation or any bald or golden eagle, dead or alive, or any part, nest or egg.	N/A	Yes. The alternative does not involve taking, possessing or transporting eagles.	Yes. The alternative does not involve taking, possessing or transporting eagles.	Yes. The alternative does not involve taking, possessing or transporting eagles.	Yes. The alternative does not involve taking, possessing or transporting eagles.
Migratory Bird Treaty Act of 1972, 16 USC Section 703						
16 USC Section 703	Protects native migratory bird species from unregulated "take." Poisoning due to exposure at hazardous waste sites can be included under this Act.	N/A	Yes. The alternative does not involve taking native migratory birds. Birds would not be exposed to hazardous waste.	Yes. The alternative does not involve taking native migratory birds. Birds would not be exposed to hazardous waste.	Yes. The alternative does not involve taking native migratory birds. Birds would not be exposed to hazardous waste.	Yes. The alternative does not involve taking native migratory birds. Birds would not be exposed to hazardous waste.

TABLE 6-4
ALTERNATIVE-SPECIFIC ANALYSIS OF COMPLIANCE WITH ARARs – SCENARIO A
OFF-SITE GROUNDWATER FEASIBILITY STUDY

CITATION	DESCRIPTION	Would Alternative Comply with ARARs or TBCs?				
		Alternative 1 - No Action	Alternative 2 - MNA	Alternative 3 - Focused Extraction/MNA	Alternative 4 - EDB/MNA	Alternative 5 - Total Groundwater Restoration
FEDERAL						
National Archaeological and Historic Preservation Act of 1974, 16 USC Section 469						
16 USC Section 469 **36 CFR Part 65**	Must recover and preserve artifacts in area where alteration of terrain threatens significant scientific, prehistoric, historical, or archaeological data.	N/A	Yes. No terrain would be altered. No scientific, prehistoric, or historical data would be threatened.	Yes. Treatment facility foundation work and trenching activities would not significantly alter the terrain and are not expected to threaten scientific, prehistoric, or historical data.	Yes. No terrain would be altered. No scientific, prehistoric, or historical data would be threatened.	Yes. Treatment facility foundation work and trenching activities would not significantly alter the terrain and are not expected to threaten scientific, prehistoric, or historical data.
Floodplain Management, Executive Order 11988						
40 CFR Part 6.302	Limits activities in a floodplain, which is defined as "the lowland and relatively flat areas adjoining inland and coastal waters including at a minimum that area subject to a 1 percent or greater chance of flooding in any given year" (the 100-year floodplain).	N/A	Yes. MNA activities, including monitoring well installation, would be allowed within the 100-year floodplain.	Yes. Treatment facility would be located outside the Skunk River one-hundred year floodplain.	Yes. MNA activities, including monitoring well installation, would be allowed within the 100-year floodplain.	Yes. Treatment facility would be located outside the Skunk River one-hundred year floodplain.
Protection of Wetlands, Executive Order 11990						
Executive Order 12608 (amended) **40 CFR Part 6.302**	Addresses possible impacts of construction of facilities or management of property in wetlands; must avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.	N/A	Yes. Remedial activities would not affect wetlands.	Yes. Remedial activities would not take place within wetland areas. Treated effluent discharged to the drainage/tributary of the Skunk River would pass through a wetland area before entering the Skunk River. No adverse effects are expected.	Yes. Remedial activities would not affect wetlands.	Yes. Remedial activities would not take place within wetland areas. Treated effluent discharged to the drainage/tributary of the Skunk River would pass through a wetland area before entering the Skunk River. No adverse effects are expected.
STATE						
Effluent and Pretreatment Standards, 567 IAC, Title IV, Chapter 62						
567 IAC 62.1(455B)(1)	Establishes NPDES permit conditions for point source discharge of pollutants into navigable waters.	N/A	N/A	Yes.	N/A	Yes.
Water Quality Standards, 567 IAC, Title IV, Chapter 61						
567 IAC 61.2(455B)(2) **567 IAC 61.3(455B)**	Establishes an antidegredation policy for surface waters of the State of Iowa, including requirements to maintain certain flows and water quality criteria.		Yes. Would not affect surface water flows or water quality.	Yes. Following treatment with GAC, the effluent is expected to meet the antidegredation policy requirements.	Yes. Would not affect surface water flows or water quality.	Yes. Following treatment with GAC, the effluent is expected to meet the antidegredation policy requirements.
Nonpublic Water Supply Wells, 567 IAC, Division B, Chapter 49						
567 IAC 49(455b)	Establishes uniform minimum standards and methods for well construction and reconstruction for nonpublic water supply wells.	N/A	N/A	Yes. Extraction wells will be installed in areas where they will not adversely affect existing water supply wells.	N/A	Yes. Extraction wells will be installed in areas where they will not adversely affect existing water supply wells.
Criteria and Conditions for Authorizing Withdrawal, Diversion, and Storage of Water, 567 IAC, Division C, Chapter 52						
567 IAC 52(455b)	Establishes criteria for issuance of water permits, permit conditions, and conditions for modification, cancellation, or suspension of permits. Includes special criteria for particular types of water sources such as streams and groundwater.	N/A	N/A. Alternative would not include withdrawal, diversion, or storage of water.	Yes. A permit, or equivalent requirements thereof, may be required to extract groundwater.	N/A. Alternative would not include withdrawal, diversion, or storage of water.	Yes. A permit, or equivalent requirements thereof, may be required to extract groundwater.
Wastewater Treatment and Disposal, 567 IAC, Title IV						
567 IAC 61(455b) **Establishment of Water Quality Standards**	Sets standards for the point or nonpoint source pollution of state waters.	N/A	Yes. Would not affect surface water quality.	Yes. Monitoring would ensure that effluent is treated to acceptable levels before discharge to surface water.	Yes. Would not affect surface water quality.	Yes. Monitoring would ensure that effluent is treated to acceptable levels before discharge to surface water.
567 IAC 62(455b) **Effluent and Pretreatment Standards**	Sets standards for the treatment of water prior to discharge to either waters of the state or a POTW.	N/A	N/A	Yes. Monitoring would ensure that effluent is treated to acceptable levels before discharge to surface water.	N/A	Yes. Monitoring would ensure that effluent is treated to acceptable levels before discharge to surface water.

TABLE 6-4
ALTERNATIVE-SPECIFIC ANALYSIS OF COMPLIANCE WITH ARARs – SCENARIO A
OFF-SITE GROUNDWATER FEASIBILITY STUDY

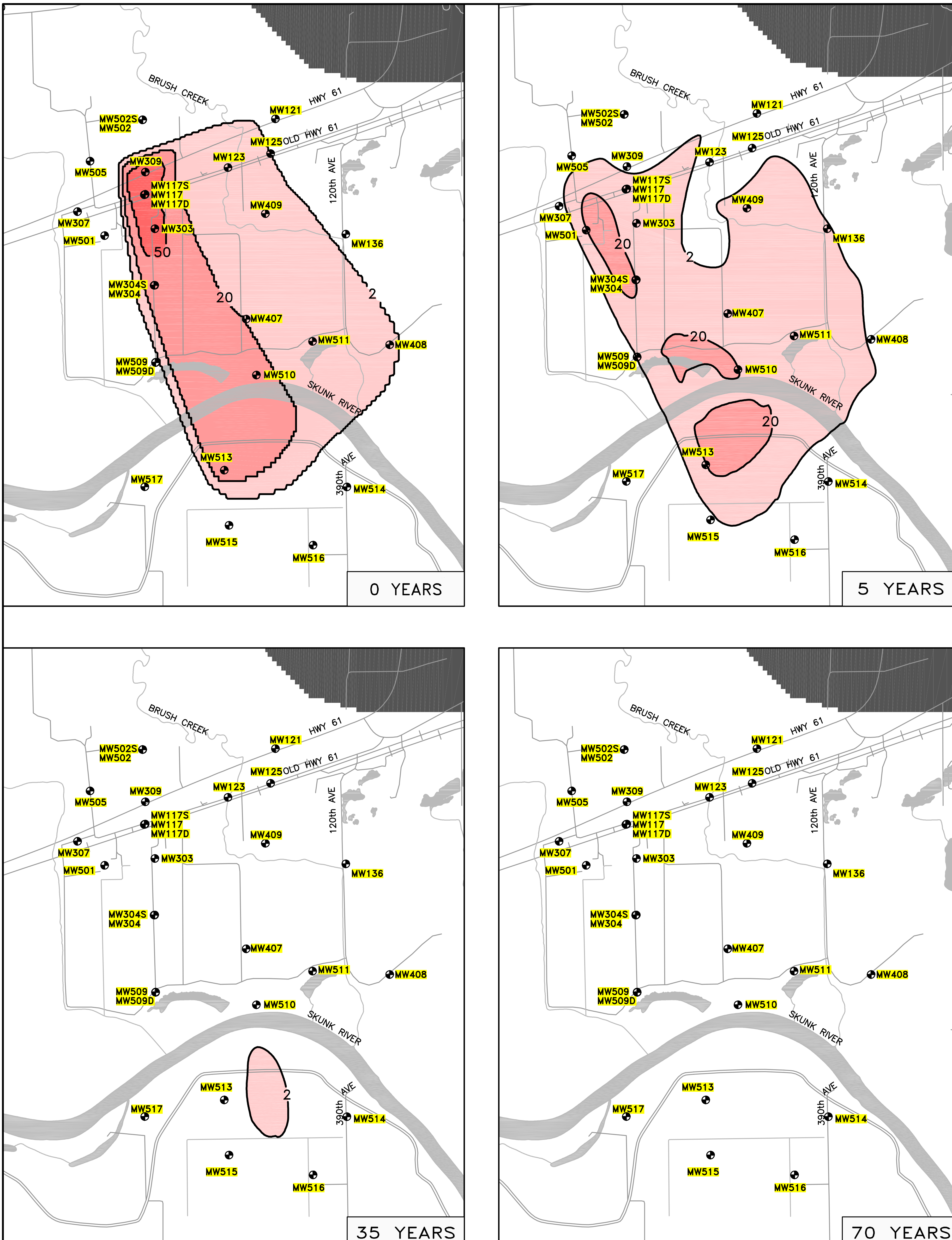
CITATION	DESCRIPTION	Would Alternative Comply with ARARs or TBCs?				
		Alternative 1 - No Action	Alternative 2 - MNA	Alternative 3 - Focused Extraction/MNA	Alternative 4 - EDB/MNA	Alternative 5 - Total Groundwater Restoration
STATE						
567 IAC 63(455b), 567 IAC 64(455b) Wastewater Disposal Systems	Sets construction, operation, discharge, monitoring, analytical and reporting requirements for the operation of wastewater disposal systems.	N/A	N/A	Yes. Treatment system would be designed, constructed, and operated to meet requirements.	N/A	Yes. Treatment system would be designed, constructed, and operated to meet requirements.
567 IAC 69(455b) On-Site Wastewater Treatment and Disposal Systems	Establishes rules for on-site wastewater treatment and disposal systems, including discharge restrictions and minimum distances.	N/A	N/A	Yes. Treatment system would be designed, constructed, and operated to meet requirements.	N/A	Yes. Treatment system would be designed, constructed, and operated to meet requirements.
Flood Plain or Floodway Development, 567 IAC, Title V, Chapter 71						
567 IAC 71(455b)	Establishes statutory requirements for approval of development in a flood plain or floodway.	N/A	N/A. Alternative does not include development activities.	Yes. Treatment facility would be located outside the Skunk River 100-year floodplain.	N/A. Alternative does not include development activities.	Yes. Treatment facilities would be located outside the Skunk River one-hundred year floodplain.
Solid Waste Comprehensive Planning Requirements, 567 IAC, Title VIII, Chapter 101						
567 IAC 101(455b, 455d) Iowa Solid Waste Management and Disposal General Requirements	Defines requirements for disposal of solid wastes.	N/A	Yes. Soil cuttings would be handled and disposed of as solid waste.	Yes. Soil cuttings would be handled and disposed of as solid waste.	Yes. Soil cuttings would be handled and disposed of as solid waste.	Yes. Soil cuttings would be handled and disposed of as solid waste.
Rules for Determining Cleanup Actions and Responsible Parties, 567 IAC, Title IX, Chapter 133						
567 IAC 133(455b, 455e)	These rules establish the procedures and criteria the Department will use to determine the parties responsible and cleanup actions necessary to meet the goals of the State pertaining to the protection of groundwater. These rules pertain to the cleanup of groundwater, soils, and surface water where groundwater may be impacted.	N/A	Yes. The IAAAP Off-Site area is being remediated under CERCLA and the responsible parties have already been determined. Requirements for source control would be met in combination with measures to address Brush Creek surface water as a continuing source to Off-Site groundwater.	Yes. The IAAAP Off-Site area is being remediated under CERCLA and the responsible parties have already been determined. Requirements for source control would be met in combination with measures to address Brush Creek surface water as a continuing source to Off-Site groundwater.	Yes. The IAAAP Off-Site area is being remediated under CERCLA and the responsible parties have already been determined. Requirements for source control would be met in combination with measures to address Brush Creek surface water as a continuing source to Off-Site groundwater.	Yes. The IAAAP Off-Site area is being remediated under CERCLA and the responsible parties have already been determined. Requirements for source control would be met in combination with measures to address Brush Creek surface water as a continuing source to Off-Site groundwater.
Hazardous Waste, 567 IAC, Title XI, Chapter 141						
567 IAC 141(455b)	Defines criteria for characterization and listing of RCRA hazardous waste.	N/A	N/A	Yes. GAC treatment would generate RDX saturated carbon. Initial sampling and analysis of spent carbon would determine if it is a RCRA hazardous solid waste. Proper disposal procedures would be implemented to ensure compliance with applicable requirements.	N/A	Yes. GAC treatment would generate RDX saturated carbon. Initial sampling and analysis of spent carbon would determine if it is a RCRA hazardous solid waste. Proper disposal procedures would be implemented to ensure compliance with applicable requirements.
Endangered Plants and Wildlife, 571 IAC, Chapter 77						
571 IAC 77(481b)	Protects endangered species and the critical habitats upon which endangered species depend.	N/A	Yes. No critical habitat would be disturbed by remedial activities.	Yes. Treatment facility and extraction wells would be located on existing cropland. No critical habitat would be disturbed.	Yes. No critical habitat would be disturbed by remedial activities.	Yes. Treatment facility and extraction wells would be located on existing cropland. No critical habitat would be disturbed.

NOTES:

This analysis assumes Scenario A - Brush Creek Surface Water Addressed. This is mainly relevant to consideration of the lifetime HALs.

Consideration of all other ARARs and TBCs is essentially the same for Scenarios A and B.

ARAR = Applicable or Relevant and Appropriate Requirement
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulations
GAC = Granular Activated Carbon
HAL = Health Advisory Level
IAAAP = Iowa Army Ammunition Plant
IAC = Iowa Code
MNA = Monitored Natural Attenuation
N/A = Not Applicable
NPDES = National Pollutant Discharge Elimination System
RCRA = Resource Conservation and Recovery Act
RDX = A common military explosive (cyclonite)
SWDA = Solid Waste Disposal Act
TBC = To Be Considered
USC = United States Code
USCA = United States Code Annotated



LEGEND

	LEVEE
	PAVED OR GRAVEL ROAD
	RAILROAD TRACKS
MW500	MONITORING WELL LOCATION
	INACTIVE FLOW BOUNDARY
2	HORIZONTAL EXTENT OF RDX $>2 \mu g/L$

NOTES

CONTAMINANT PLUMES SHOWN ARE FROM MODEL LAYER 3 (INTERMEDIATE SAND ALLUVIUM) BECAUSE THE GREATEST EXTENT OF RDX IS IN LAYER 3.

0 YEARS = MAY 2002 INPUT.

N

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SCALE IN FEET

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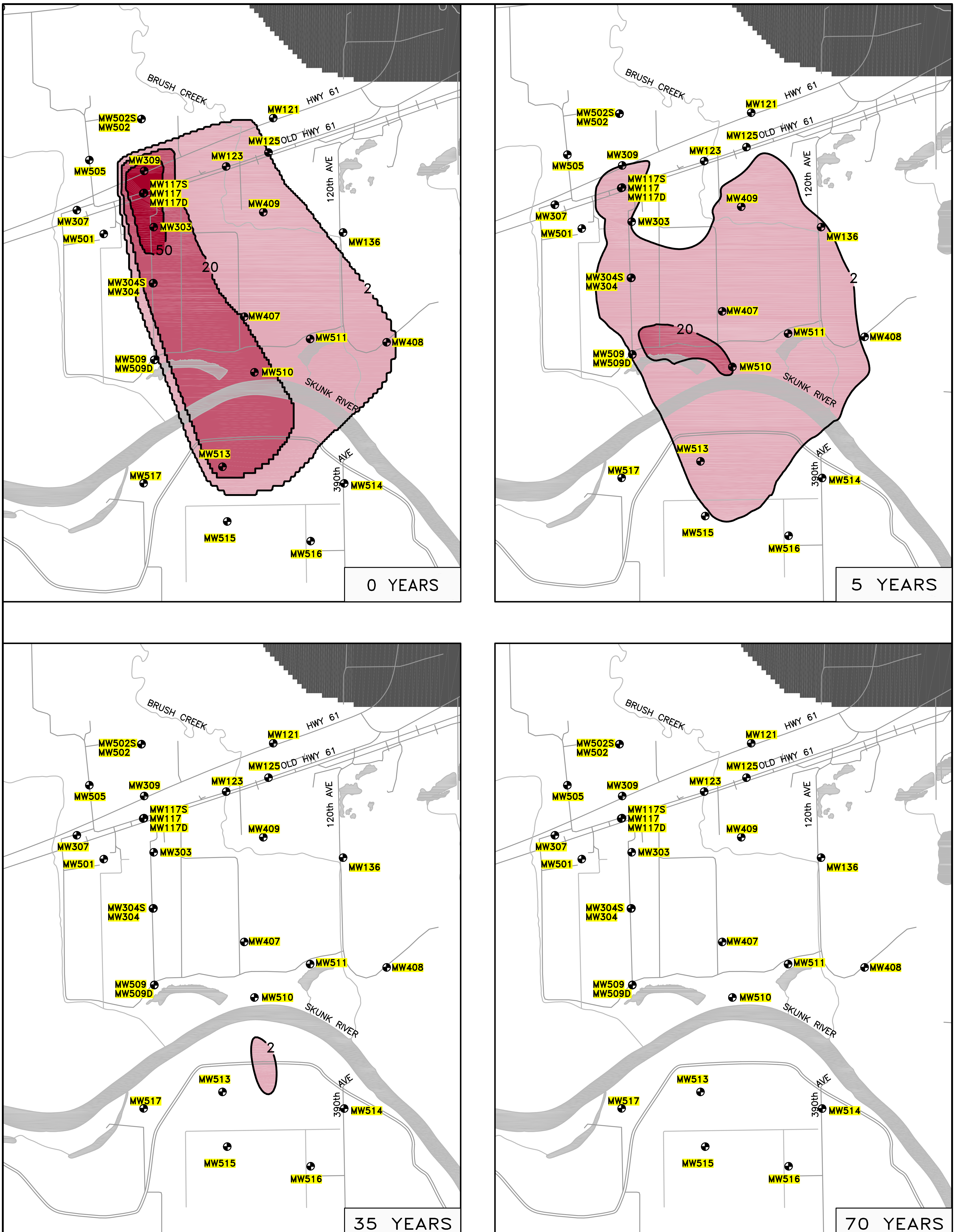
URS

ALTERNATIVES 1 AND 2 – SCENARIO A
MODEL-PREDICTED RDX CONCENTRATIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: JJS	DATE: 09/23/03	16169419	6–1



LEGEND

LEVEE

PAVED OR GRAVEL ROAD

RAILROAD TRACKS

MW500 MONITORING WELL LOCATION

INACTIVE FLOW BOUNDARY

2 HORIZONTAL EXTENT OF RDX >2μg/L

NOTES

CONTAMINANT PLUMES SHOWN ARE FROM MODEL LAYER 3 (INTERMEDIATE SAND ALLUVIUM) BECAUSE THE GREATEST EXTENT OF RDX IS IN LAYER 3.

0 YEARS = MAY 2002 INPUT.

N

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SCALE IN FEET

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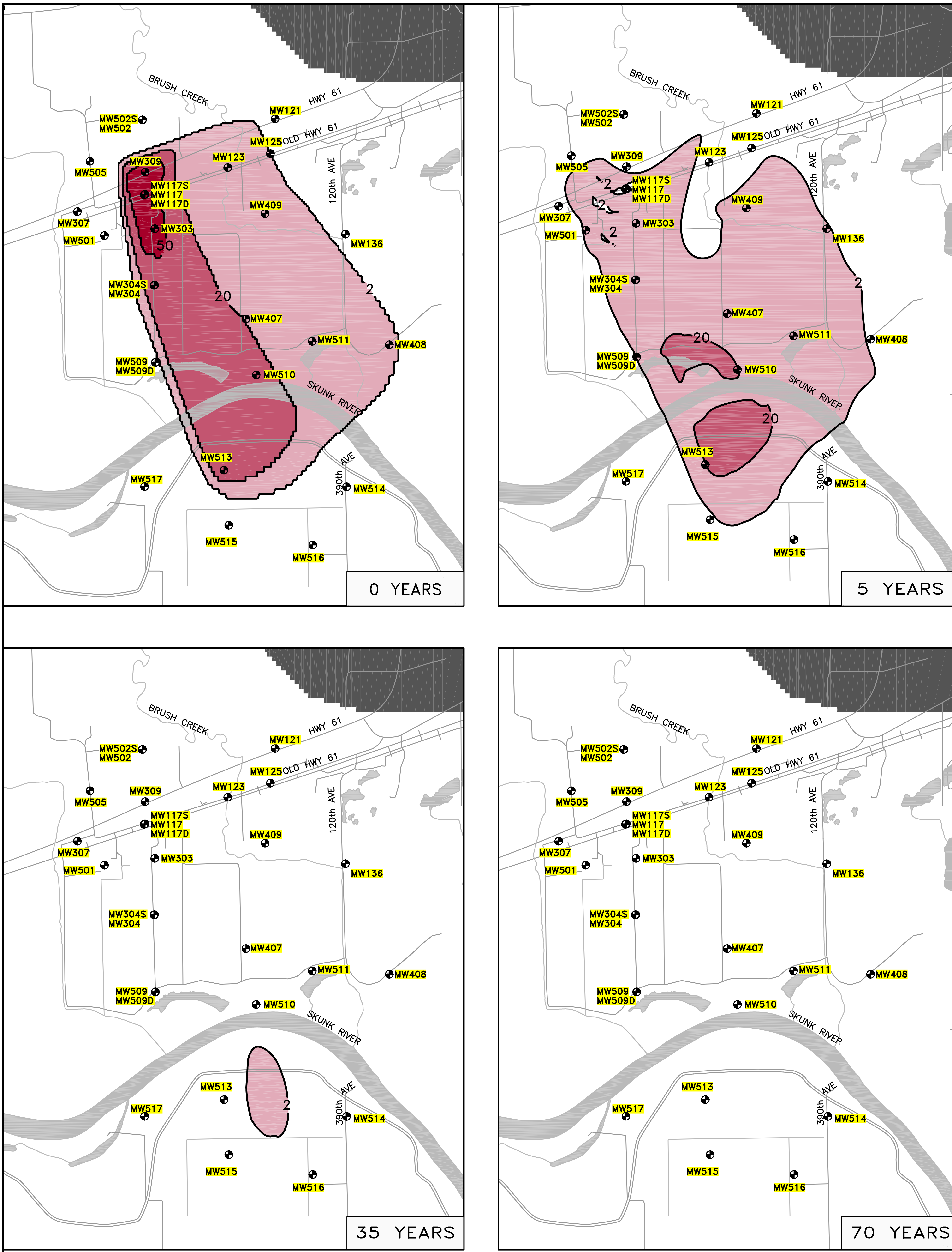
URS

ALTERNATIVE 3 – SCENARIO A
MODEL-PREDICTED RDX CONCENTRATIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO. 16169419	FIG. NO. 6-2
CHK'D. BY: JJS	DATE: 09/23/03		



LEGEND

LEVEE

PAVED OR GRAVEL ROAD

RAILROAD TRACKS

MW500 MONITORING WELL LOCATION

INACTIVE FLOW BOUNDARY

2 HORIZONTAL EXTENT OF RDX $>2\mu g/L$

NOTES

CONTAMINANT PLUMES SHOWN ARE FROM MODEL LAYER 3 (INTERMEDIATE SAND ALLUVIUM) BECAUSE THE GREATEST EXTENT OF RDX IS IN LAYER 3.

0 YEARS = MAY 2002 INPUT.

N

2000 1000 0 2000

SCALE IN FEET

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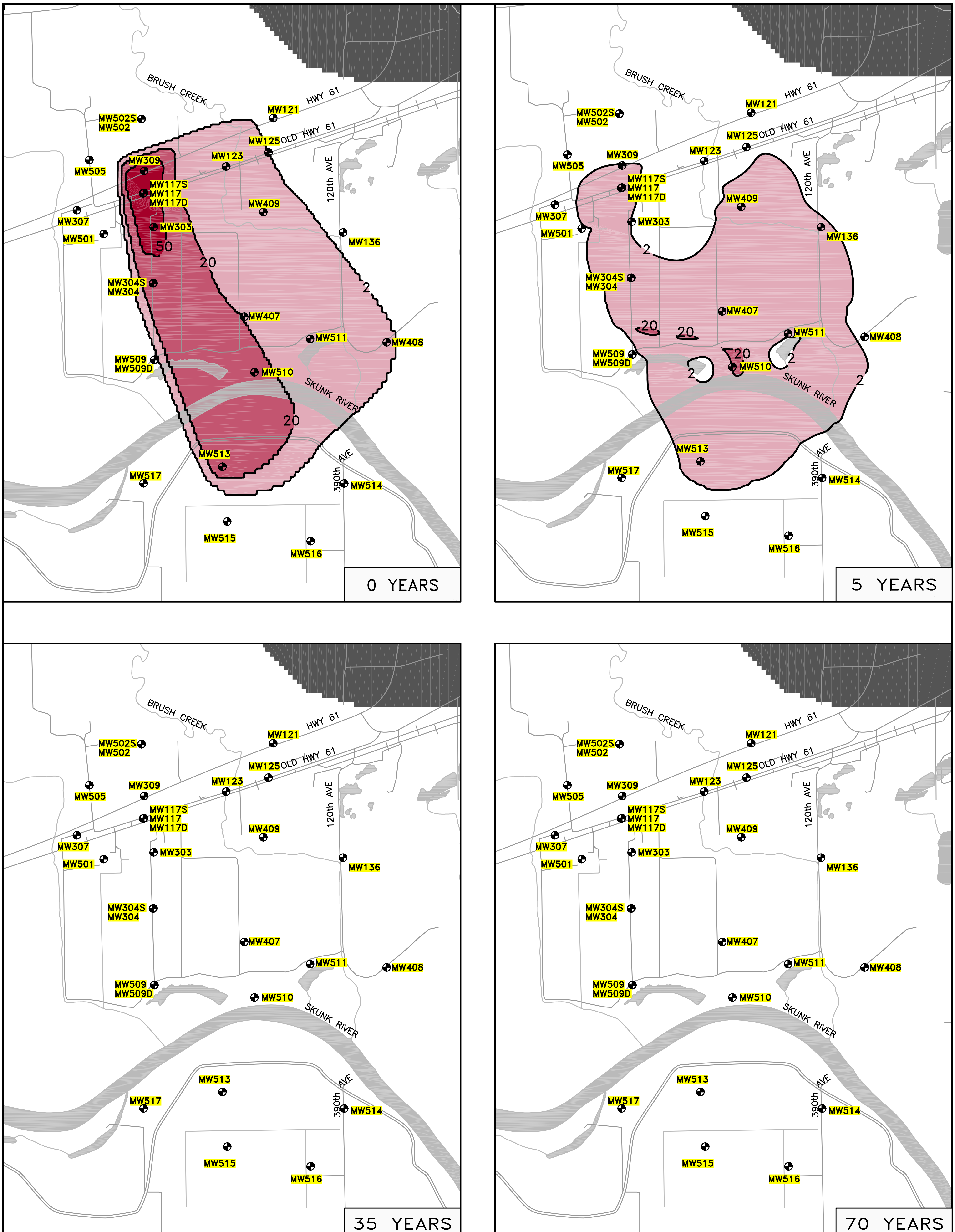
URS

ALTERNATIVE 4 – SCENARIO A
MODEL-PREDICTED RDX CONCENTRATIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO. 16169419	FIG. NO. 6-3
CHK'D. BY: JJS	DATE: 09/23/03		



LEGEND

LEVEE

PAVED OR GRAVEL ROAD

RAILROAD TRACKS

MW500 MONITORING WELL LOCATION

INACTIVE FLOW BOUNDARY

2 HORIZONTAL EXTENT OF RDX >2μg/L

NOTES

CONTAMINANT PLUMES SHOWN ARE FROM MODEL LAYER 3 (INTERMEDIATE SAND ALLUVIUM) BECAUSE THE GREATEST EXTENT OF RDX IS IN LAYER 3.

0 YEARS = MAY 2002 INPUT.

N

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SCALE IN FEET

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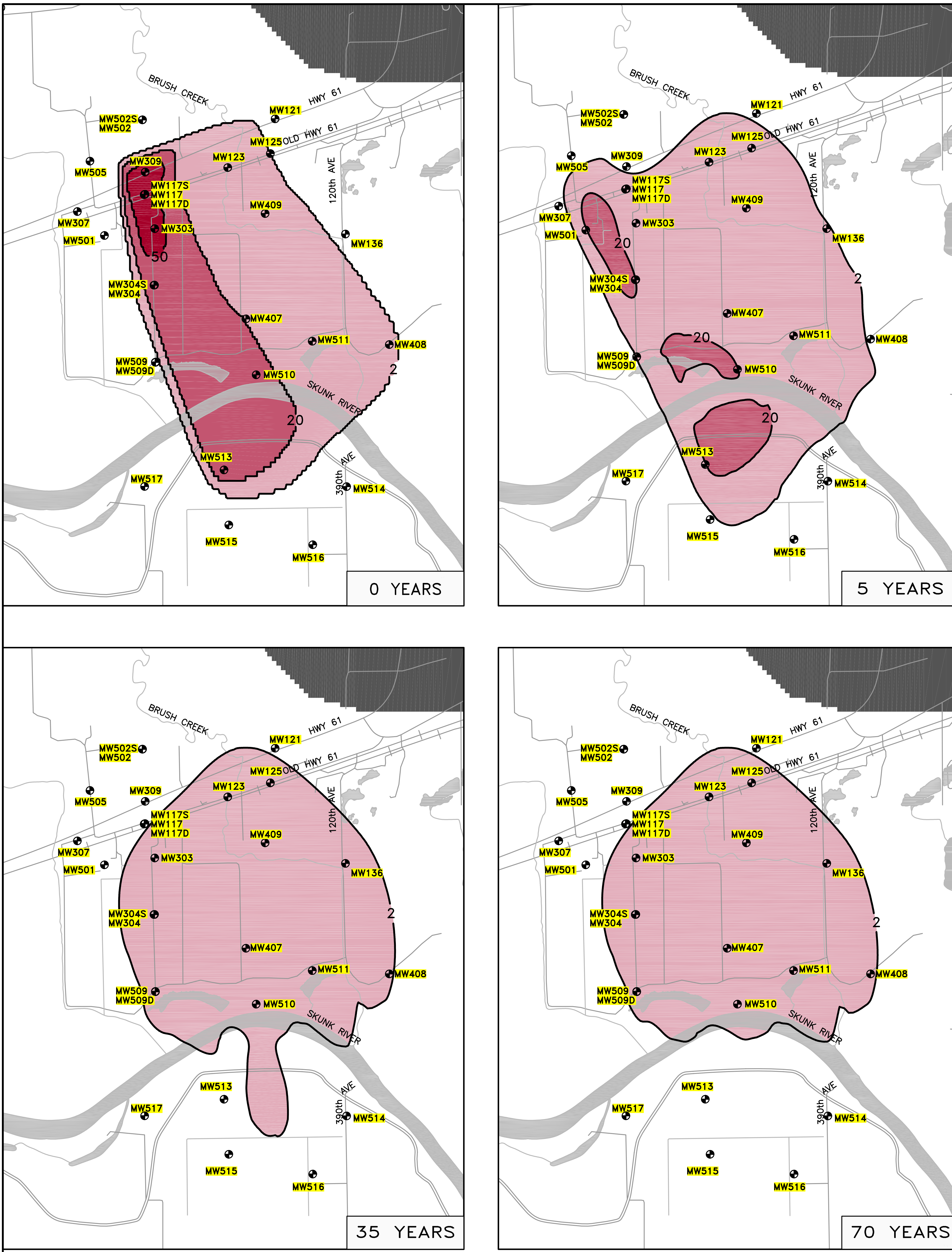
URS

ALTERNATIVE 5 – SCENARIO A
MODEL-PREDICTED RDX CONCENTRATIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO. 16169419	FIG. NO. 6-4
CHK'D. BY: JJS	DATE: 09/23/03		



LEGEND

LEVEE

PAVED OR GRAVEL ROAD

RAILROAD TRACKS

MW500 MONITORING WELL LOCATION

INACTIVE FLOW BOUNDARY

2 HORIZONTAL EXTENT OF RDX >2μg/L

NOTES

CONTAMINANT PLUMES SHOWN ARE FROM MODEL LAYER 3 (INTERMEDIATE SAND ALLUVIUM) BECAUSE THE GREATEST EXTENT OF RDX IS IN LAYER 3.

0 YEARS = MAY 2002 INPUT.

N

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SCALE IN FEET

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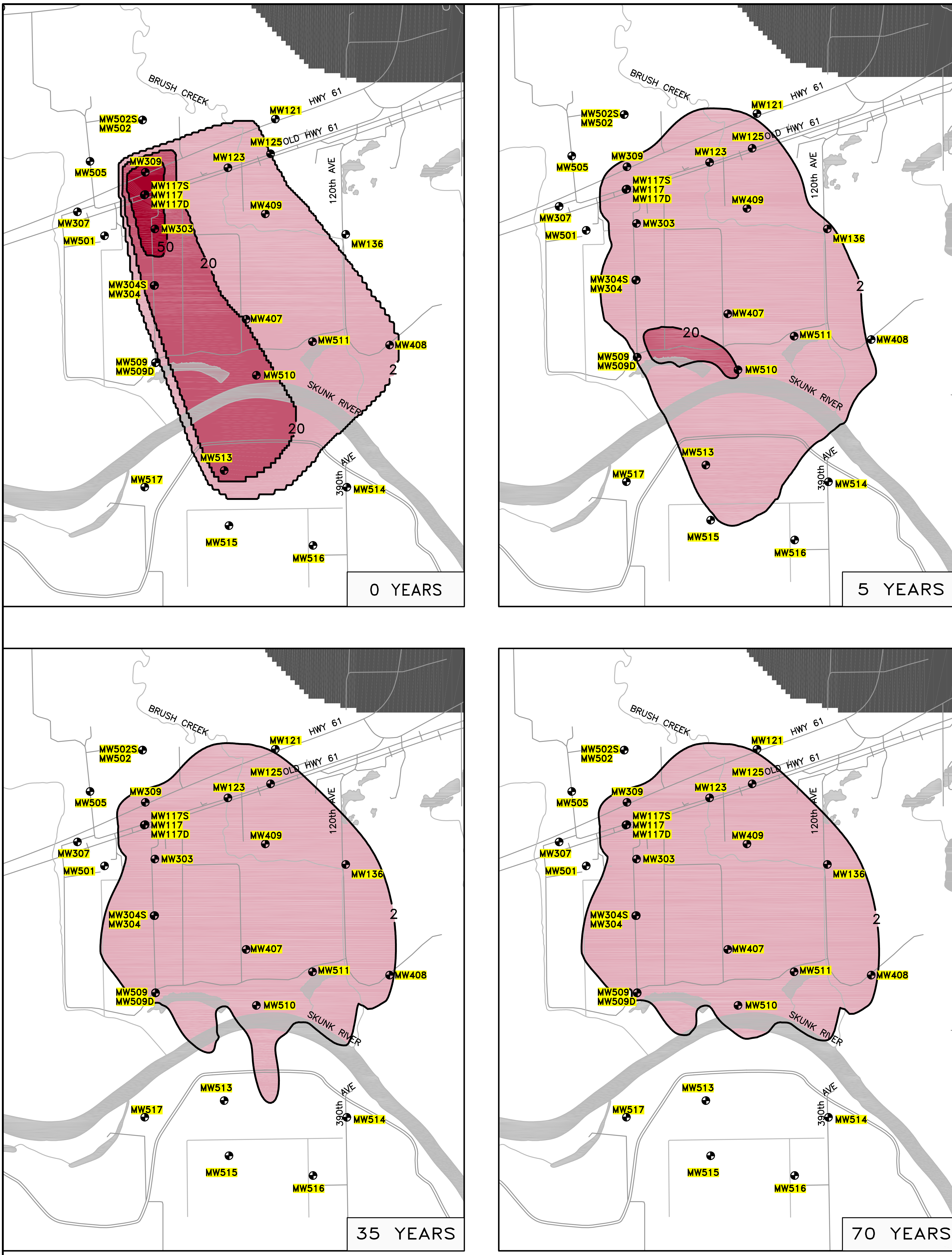
URS

ALTERNATIVES 1 AND 2 – SCENARIO B
MODEL–PREDICTED RDX CONCENTRATIONS
OFF–SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO. 16169419	FIG. NO. 6–5
CHK'D. BY: JJS	DATE: 09/23/03		



LEGEND

LEVEE

PAVED OR GRAVEL ROAD

RAILROAD TRACKS

MW500 MONITORING WELL LOCATION

INACTIVE FLOW BOUNDARY

2 HORIZONTAL EXTENT OF RDX >2μg/L

NOTES

CONTAMINANT PLUMES SHOWN ARE FROM MODEL LAYER 3 (INTERMEDIATE SAND ALLUVIUM) BECAUSE THE GREATEST EXTENT OF RDX IS IN LAYER 3.

0 YEARS = MAY 2002 INPUT.

N

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SCALE IN FEET

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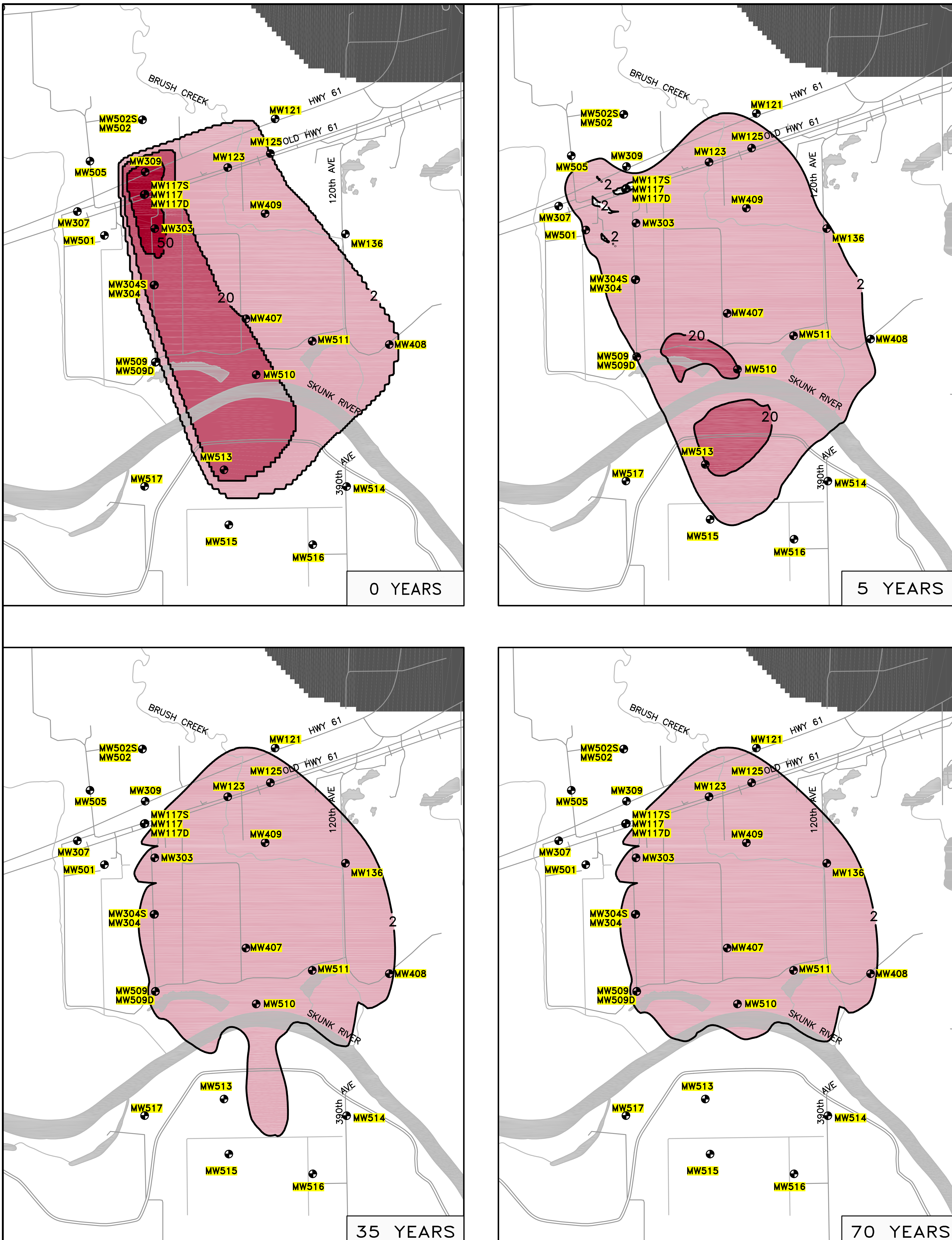
URS

ALTERNATIVE 3 – SCENARIO B
MODEL-PREDICTED RDX CONCENTRATIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: JJS	DATE: 09/23/03	16169419	6-6



LEGEND

LEVEE

PAVED OR GRAVEL ROAD

RAILROAD TRACKS

MW500 MONITORING WELL LOCATION

INACTIVE FLOW BOUNDARY

2 HORIZONTAL EXTENT OF RDX >2μg/L

NOTES

CONTAMINANT PLUMES SHOWN ARE FROM MODEL LAYER 3 (INTERMEDIATE SAND ALLUVIUM) BECAUSE THE GREATEST EXTENT OF RDX IS IN LAYER 3.

0 YEARS = MAY 2002 INPUT.

N

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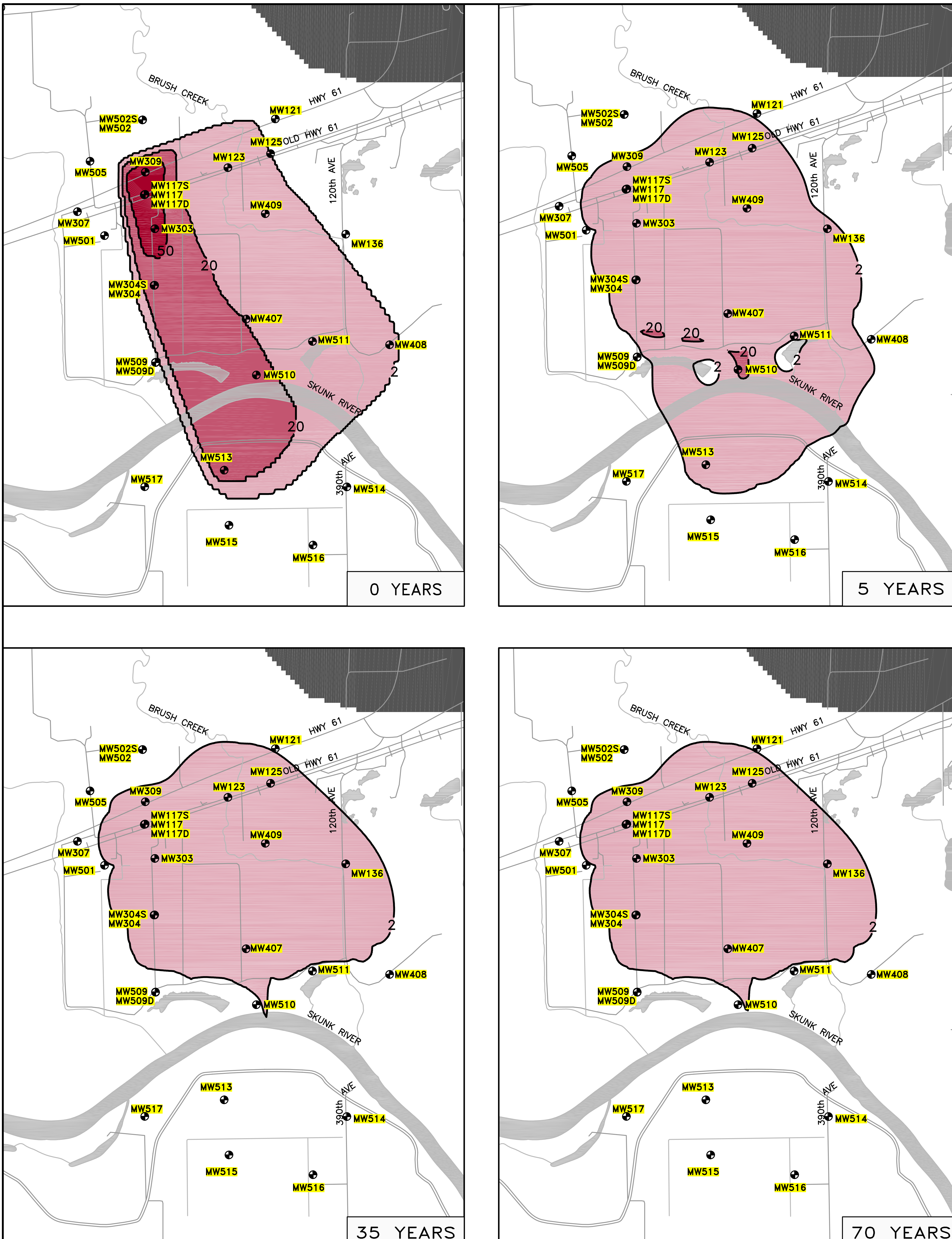
URS

ALTERNATIVE 4 – SCENARIO B
MODEL–PREDICTED RDX CONCENTRATIONS
OFF–SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: JJS	DATE: 09/23/03	16169419	6–7



LEGEND

LEVEE

PAVED OR GRAVEL ROAD

RAILROAD TRACKS

MW500 MONITORING WELL LOCATION

INACTIVE FLOW BOUNDARY

2 HORIZONTAL EXTENT OF RDX >2µg/L

NOTES

CONTAMINANT PLUMES SHOWN ARE FROM MODEL LAYER 3 (INTERMEDIATE SAND ALLUVIUM) BECAUSE THE GREATEST EXTENT OF RDX IS IN LAYER 3.

0 YEARS = MAY 2002 INPUT.

N

2000 1000 0 2000

SCALE IN FEET

URS

ALTERNATIVE 5 – SCENARIO B
MODEL-PREDICTED RDX CONCENTRATIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: JJS	DATE: 09/23/03	16169419	6-8

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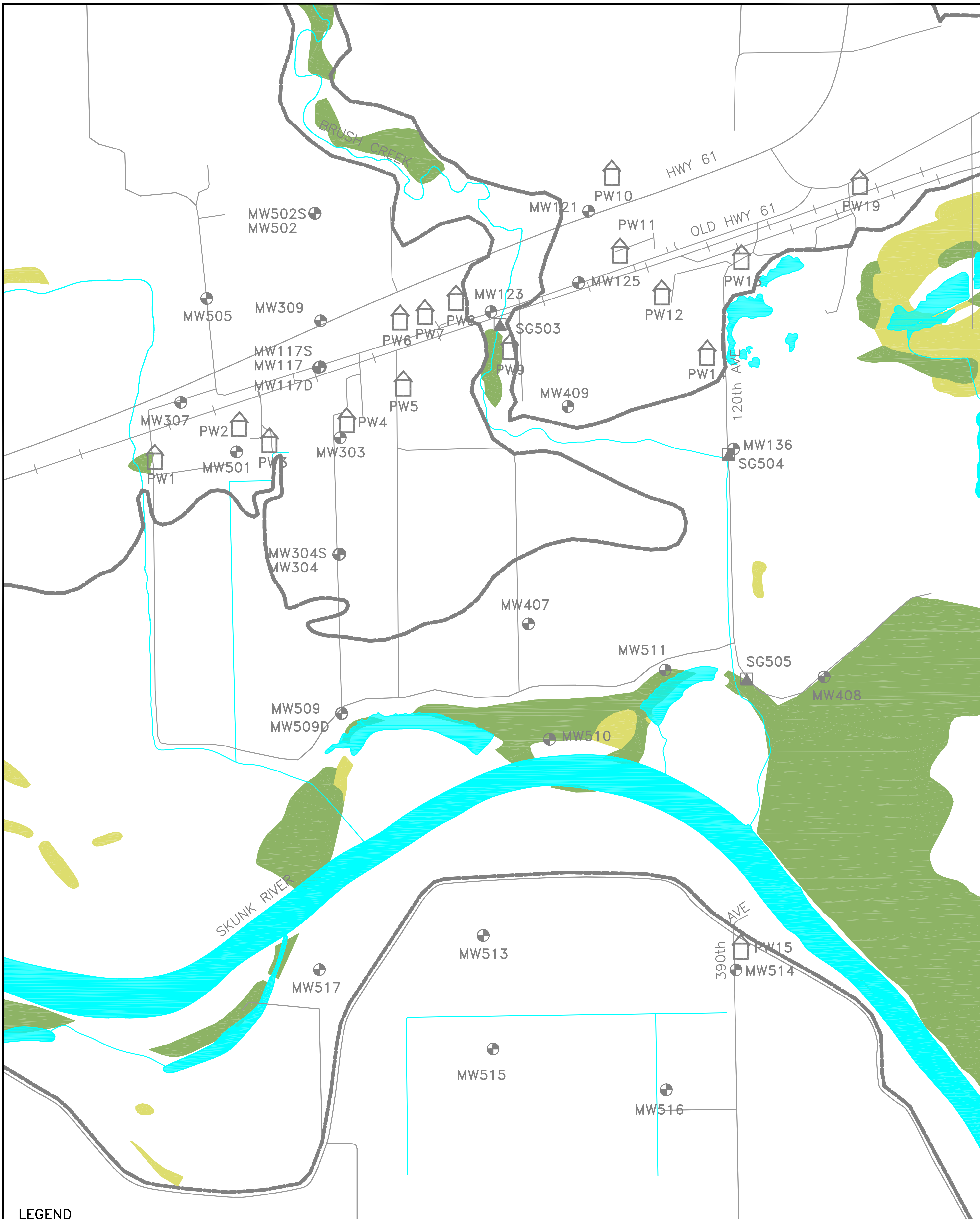

LEGEND

- LEVEE
- PAVED OR GRAVEL ROAD
- RAILROAD TRACKS
- MONITORING WELL LOCATION
- SG501 STAFF GAUGE LOCATION
- PW1 PRIVATE WELL
- APPROXIMATE 100-YEAR FLOODPLAIN BOUNDARY (FEMA)
- INLAND FORESTED WETLAND (NATIONAL WETLANDS INVENTORY)
- INLAND HERBACEOUS WETLAND (NATIONAL WETLANDS INVENTORY)

N

1000 500 0 1000

SCALE IN FEET

URS

LOCATION-SPECIFIC ARARs EVALUATION MAP
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: JMR	DATE: 09/23/03	16169419	6-9

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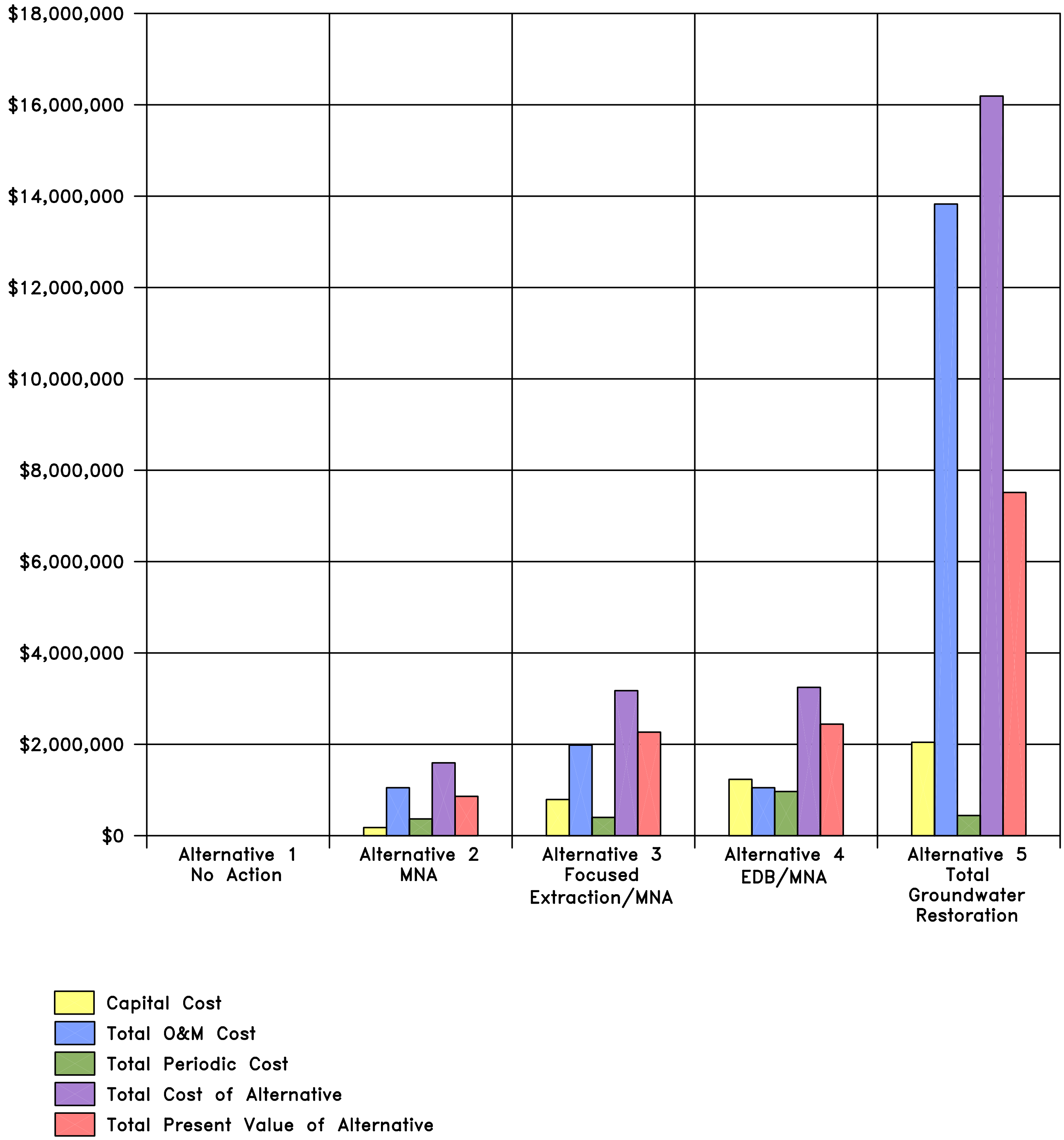

URS

COMPARISON OF TOTAL COSTS OF REMEDIAL ALTERNATIVES
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

DRN. BY: DAC	DATE: 09/23/03	PROJECT NO.	FIG. NO.
CHK'D. BY: DRH	DATE: 09/23/03	16169419	6-10

March 05, 2004 10:09:33 a.m.
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Uncertainties identified during the FS process for Off-Site groundwater need to be addressed prior to final design and implementation of remedial action. In addition, certain assumptions have been made to complete FS evaluations. Uncertainties and assumptions for the Off-Site Groundwater FS include the following:

Site Characteristics

- The extent to which seasonal fluctuations in the flow of surface water in Brush Creek (and Skunk River to the south) influence local groundwater flow direction is not known with certainty. It is possible that groundwater in the high level area of the plume flows southwest for up to four months out of the year and flows mostly south during the rest of the year. This is supported by the apparent predominantly southward migration and shape of the contaminant plume. Fate and transport modeling to locate extraction wells and EDBs for the purposes of the Off-Site Groundwater FS is based on June 2002 (URS 2003) water-level data and assumes a continuous southwestward flow direction in the high level area. The possibility of a seasonal change in groundwater flow, as described above, was compensated for in the location of extraction wells and EDBs presented in the alternatives.
- It is unclear if the majority of contaminant mass loading to the aquifer from Brush Creek surface water occurs during periods of high flow, high concentration, and short duration or during periods of base flow, low concentration, and long duration. It is also unclear to what extent each potential source, including groundwater discharge from contaminated sites, industrial discharges, stormwater inflow, and sediment load contributes to RDX contamination in Brush Creek surface water. Further study of the Brush Creek watershed and the interaction of Brush Creek surface water and Off-Site groundwater is needed and is currently planned as a separate project. For the purposes of discussion during planning, some options for preventing Brush Creek surface water from impacting Off-Site groundwater have been conceptually developed on a non-source control basis. These options are presented in **Appendix D**.

Groundwater Modeling

- The groundwater flow and contaminant fate and transport modeling was conservative and potentially overpredicted contaminant fate and transport results by using Spring 2002 Brush Creek RDX concentrations and groundwater levels to simulate contaminant fate and transport over time. The Spring 2002 conditions around Brush Creek showed steeper gradients and more influence from Brush Creek than Fall 2002, likely overestimating the mass coming into the aquifer from Brush Creek and subsequent transport of RDX once it entered the aquifer. The contaminant fate and transport model used initial RDX input concentrations that likely overpredicted the initial mass and a conservative half-life of 10 years to underestimate degradation rates of RDX in the model.

Remedial Alternative Components

- Projected extraction well pumping rates and locations are based on groundwater model predictions. Model inputs included hydraulic conductivity values calculated from slug test data collected at monitoring wells across the site. Aquifer pumping tests will be required to determine the actual pumping rates and optimum placement of wells.

- Enhanced degradation, using either a biodegradation or chemical oxidation approach, is considered a developing technology and has seen limited full-scale implementation for the treatment of explosives. If enhanced degradation is selected, treatability testing would be required to prove its effectiveness at degrading RDX and to determine the most effective degradation substrate or agent for full-scale implementation. Each barrier is assumed to be reinjected once across its entire length. In practice, reinjection length would be based on performance monitoring results but is not expected to be greater than the initial injection.
- The conceptual design of the GAC treatment systems was developed through consultation with various GAC vendors and from design experience with similar systems. Treatability testing would be required to identify pretreatment requirements and determine site-specific carbon usage rates.
- Alternatives 3 and 5 assume that the discharge of treated groundwater to surface water would be able to meet the substantive requirements of an NPDES permit.
- Alternatives 2 through 5 involve remedial activities that take place on private property. These alternatives assume that easements or agreements to conduct remedial activities could be obtained from landowner/owners.

This section describes the remedy selection process and presents the preferred remedial alternative for Off-Site groundwater at IAAAP, based on the detailed analysis (**Section 6**) and consideration of uncertainties and assumptions (**Section 7**).

8.1 REMEDY SELECTION PROCESS

The remedy selection process links the analysis of remedial action alternatives, conducted in an RI/FS, with the documentation of the selected remedy in a ROD (USEPA 1997). Section 121 of CERCLA established five principal requirements for the selection of remedies. Remedies must:

1. Protect human health and the environment.
2. Comply with ARARs unless a waiver is justified.
3. Be cost-effective.
4. Utilize permanent solutions and alternative treatment technologies to the maximum extent practicable.
5. Satisfy a preference for treatment as a principal element or provide an explanation in the ROD for why this preference was not met.

The nine NCP criteria (**Section 6.1**) are derived from these principal requirements as well as other important technical and policy considerations (USEPA 1997). Therefore, a remedial action that meets the nine criteria will satisfy the principal requirements of CERCLA.

The remedy selection process consists of two steps. The first step is presentation of a preferred remedial action to the public for comment in a proposed plan. The proposed plan summarizes the preliminary conclusions as to why the preferred option appears most favorable, based on the information available and considered during the FS. Following receipt and evaluation of public comments on the proposed plan, a final decision is made and the selected remedy is documented in a ROD.

8.2 SUMMARY OF PREFERRED ALTERNATIVE

Based on the comparative analysis of alternatives in **Section 6.3**, the preferred remedial alternative for Off-Site groundwater at IAAAP is Alternative 4 – Enhanced Degradation Barrier/ Monitored Natural Attenuation. This alternative consists of:

- Filing deed notices, issuing local advisories, and implementing a worker health and safety program. Residents of properties would be provided with connection to municipal water or, if public water supply is not available, with at-well treatment systems to remove RDX in groundwater by carbon adsorption. In addition, potential governmental controls to prevent new water supply wells from being installed in contaminated areas for domestic use will be further investigated by the U.S. Army. These controls may include zoning, local permits, and groundwater use restrictions.

- Installing EDBs to create treatment zones that intercept and either anaerobically degrade or chemically oxidize RDX in groundwater within the area of highest concentrations (greater than 50 µg/L). Each barrier would consist of a series of injection points.
- Conducting a field-scale test to determine the most effective biodegradation substrate or chemical oxidizing agent and optimal barrier layout. Field parameters, RDX concentrations, and geochemical parameters would be monitored for a period of about six to nine months, or until degradation and geochemical trends are identified.
- Performance sampling at selected wells until trends and substrate reapplication frequency have been determined. Substrate reapplication is assumed to occur once in Year 2.
- Monitored natural attenuation to document reduction of contaminant mass of the Off-Site groundwater plume not affected by the enhanced degradation system. This would include groundwater monitoring, reporting, and completion of five-year reviews.

Alternative 4 was selected because it protects human health and the environment, complies with ARARs, utilizes permanent solutions and alternative treatment technologies, and satisfies a preference for treatment as a principal element of the remedy. Although Alternative 4 costs more than some other alternatives and overall does not result in less time to remediate the entire plume, it would aggressively attack the area of the plume above 10^{-4} risk, reducing RDX concentrations to less than 50 µg/L within an estimated time frame of five years (compared to five to eight years for MNA).

Since ARARs would not be met until Brush Creek surface water is addressed, Alternative 4 would be considered an interim remedy if implemented prior to any response action at Brush Creek. The Brush Creek project will be completed pursuant to the FFA schedule and dispute resolution of February 2004.

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GAC SYSTEM CONCEPTUAL DESIGN CALCULATIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

Goal

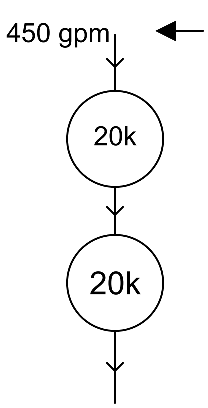
Determine for Alternative 3 and Alternative 5:

A) Number and capacity of GAC vessels
B) Empty bed contact time (EBCT)
C) Change-out frequency for lead bed (first vessel in series)

Assumptions

- Maximum vessel capacity = 20,000 lbs
- Capacity of delivery truck = 20,000 lbs
- Vessels will be operated in series (allows continuous operation)
- Usage rate for Alternative 3 (450 gpm @ 150 µg/L RDX)
  = 90 lbs (carbon)/day (vendor-provided)
- Usage rate for Alternative 5 (1,500 gpm @ 50 µg/L RDX)
  = 200 lbs (carbon)/day (vendor-provided)
- Usage rate for Alternative 5 (600 gpm @ 20 µg/L RDX)
  = 20 lbs (carbon)/day (estimated)
- Minimum change-out frequency = semiannual (182.5 days)
- Maximum change-out frequency = 1.5 years (547 days)
- Density of carbon = 30 lbs/cubic foot

Alternative 3 Solution (450 gpm, 150 µg/L RDX)



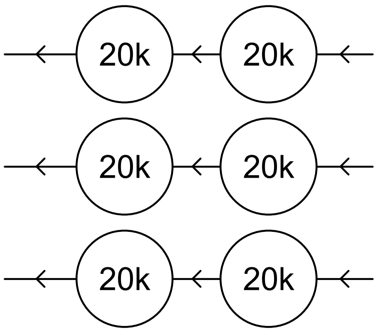
A) **Use two 20,000-pound** vessels in series (Envirotrol recommended)

B) EBCT = Vol/Q
= 4,989 gal/450 gpm
= 11 min/reactor
= **22 min total OK**

$$\text{Vol} = \frac{20{,}000\,lbs}{30\,lbs/ft^3} = 667\,ft^3 = 4{,}989\,gal$$

C) (20,000 lbs)/(90 lbs/day) = **222 days > 182.5 days OK**

Alternative 5 Solution (Northern System – 1,500 gpm, 50 µg/L avg RDX)



500 gpm each
(500 x 3 ≈ 1,500 gpm)

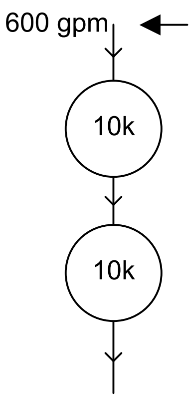
A) **Use three series of two 20,000-pound** vessels

B) EBCT = Vol/Q
= 4,989 gal/500 gpm
= 9.9 min/reactor
= **20 min total OK**

$$\text{Vol} = \frac{20{,}000\,lbs}{30\,lbs/ft^3} = 667\,ft^3 = 4{,}989\,gal$$

C) (3)(20,000 lbs)/(200 lbs/day) = **300 days OK**

Alternative 5 Solution (Southern System - 600 gpm, 20 µg/L avg RDX)



A) **Use two 10,000-pound** vessels in series

B) EBCT = Vol/Q
= 2,493 gal/600 gpm
= 4.2 min/reactor
= **8.4 min total OK**

$$\text{Vol} = \frac{10{,}000\,lbs}{30\,lbs/ft^3} = 333\,ft^3 = 2{,}493\,gal$$

C) (10,000 lbs)/(20 lbs/day) = **500 days < 547 days OK**

Computed By: DRH	Date: 02-June-2003
Checked By: JMR	Date: 06-June-2003

GAC BACKWASH SYSTEM DESIGN CALCULATIONS
OFF-SITE GROUNDWATER FEASIBILITY STUDY
IOWA ARMY AMMUNITION PLANT

Goal

Determine for Alternative 3 and Alternative 5:

A) Number and size of backwash collection tanks
B) Number and size of effluent collection/backwash supply tanks

Assumptions

- Backwash unit rate = 12 gpm/ft^2
- Backwash duration = 12 to 15 minutes
- Effluent collection/backwash supply tank capacity ≈ backwash collection tank capacity

Alternative 3 Solution (GAC Vessel 10-foot Diameter)

A) Surface area = $\pi R^2 = \pi(5\ ft)^2 = 78.5\ ft^2$
Backwash rate = $(12\ gpm/ft^2)(78.5\ ft^2) = 942.5\ gpm$
Backwash tank size = (942.5 gpm)(15 min) = 14,137.5 gal

Use two 7,400-gallon cone-bottom tanks

B) Same as backwash tank capacity

Use two 7,400-gallon flat-bottom tanks

Alternative 5 Solution (GAC Vessel 10-foot Diameter)

A) Surface area = $\pi R^2 = \pi(5\ ft)^2 = 78.5\ ft^2$
Backwash rate = $(12\ gpm/ft^2)(78.5\ ft^2) = 942.5\ gpm$
Backwash tank size = (942.5 gpm)(15 min) = 14,137.5 gal

Use two 7,400-gallon cone-bottom tanks

B) Same as backwash tank capacity

Use two 7,400-gallon flat-bottom tanks

Alternative 5 Solution (GAC Vessel 8.5-foot Diameter)

A) Surface area = πR^2 = $\pi(\frac{8.5}{2}\text{ ft})^2$ = 56.7 ft^2

Backwash rate = (12 gpm/ft^2)(56.7 ft^2) = 680.9 gpm

Backwash tank size = (681 gpm)(15 min) = 10,214 gal

Use one 11,500-gallon cone-bottom tanks

B) Same as backwash tank capacity

Use two 6,000-gallon flat-bottom tanks

Computed By:	DRH	Date:	02-June-2003
Checked By:	JMR	Date:	06-June-2003

HRC Barrier Design

REGENESIS Version 1

Technical Support (949) 366-8000

Site Name: Off-Site Groundwater
Location: IAAAP Middletown, Iowa
Consultant: URS - DRH

Basic Site Characteristics

Length of Barrier (intersecting flow)	3600	ft
Depth to contaminated zone	50	ft
Thickness of contaminated saturated zone	10	ft
Aquifer soil type	sand	
Porosity	0.3	
Hydraulic conductivity	300	ft/day
Hydraulic gradient	0.0006	ft/ft
Seepage velocity 0.600 ft/day =	219.0	ft/yr

Microbial Demand Factor	3	recommend 3-4x
Additional Demand Factor	2	recommend 2-3x
Lifespan for one application	2	year(s)

Delivery Point Spacing

Number of rows in barrier: 2; Spacing within rows (ft)	10
Effective spacing perpendicular to flow (ft)	5.0
Total number of HRC injection locations	720
Minimum required HRC per foot (lbs/feet)	8.0
Feasibility of above HRC per foot injection rate:	(ok)

Dissolved Phase Electron Donor Demand:

	(mg/l)
PCE	0.00
TCE	0.00
DCE	0.00
VC	0.00
Carbon tetrachloride	0.00
Chloroform	0.00
TCA	0.00
RDX	0.15

Competing Electron Acceptors (CEA) Demand:

	(mg/l)
Oxygen	5.00
Nitrate	10.00
Manganese reduction potential	5.00
Iron reduction (potential amount of Fe2+ that can be formed)	1.00
Sulfate reduction	18.00

Proposed HRC Barrier Specifications	
Proposed number of HRC delivery points (adjust as nec. for site)	720
Proposed HRC applic. rate lbs/foot (adjust as nec. for site)	8.0
Amt of HRC per point (lbs)	80
Total Amt of HRC (lbs)	**57,600**
HRC Unit Cost	$ 5.00
Total Material Cost	**$ 288,000**
Shipping and/or Tax Estimate	
HRC ($0.1 to $0.4/lb, call for exact rat cost per lb: 0.2	$ 11,520.00
Sales tax (call for exact rate) rate: 5.0%	$ 14,400.00
Total Regenesis Material Cost	**$ 313,920**

Input to cost worksheet – DRH

HRC Installation Cost Estimates (responsibility of customer to contract work)	
Footage for each inj. point = uncontaminated + HRC inj. interval (feet)	60
Total vertical feet for project (feet)	43,200
Estimated production rate (feet per hour: 50 for push, 25 for drilling)	50
Estimated hole completion rate (holes per hour)	0.8
Number of DP crews	2.0
Time per day spent pushing/drilling (hrs)	10
Required number of days	44
Mob/demob cost for injection subcontrator	$ 2,000
Daily rate for inj. subcontractor ($1-2K for geoprobe or $3-4K for drill rig)	$ 3,000
Total injection subcontrator cost for application	$ 134,000
Total Project Cost(not including consultant oversight, GWM, etc.)	**$ 447,920**

Reapplication Costs and Total Project Cost	
Injection subcontractor cost	$ -
HRC material cost per application	$ -
Total reapplication cost	$ -
Estimated number of years to operate	$ -
Number of reapplications	$ -
Total cost assuming constant mass loading on barrier	**$ -**
Present value cost assuming int rate of: 7%	**$ -**

APPENDIX B

Groundwater Modeling of Remedial Alternatives

This appendix discusses groundwater flow modeling and contaminant fate and transport modeling completed to help develop and evaluate the five remedial alternatives considered in the Off-Site Groundwater FS. The modeling was used to predict capture zones, generalized pumping rates (if applicable), and effectiveness of the various remedial alternatives. The modeling approach, methodology, construction details, and assumptions are presented in the Off-Site Groundwater Flow and Contaminant Fate and Transport Modeling Technical Memorandum (URS 2004).

B.1 GROUNDWATER FLOW MODELING REMEDIAL ALTERNATIVES EVALUATION AND CAPTURE ZONE PREDICTIONS

After model calibration and sensitivity analysis indicated that the model reasonably predicted the baseline groundwater elevations (URS 2003), the proposed groundwater remediation alternatives were evaluated. This evaluation was completed using a MODFLOW (Harbaugh 2000) baseline groundwater flow model and revising the model to simulate each of the remedial alternatives (e.g., adding extraction wells, barriers, etc.). Capture zone analysis for each alternative was completed using the reverse particle tracking option in MODPATH (Pollock 1994). Particle tracks were generally calculated for 70 years. A 70-year time period was considered sufficient to adequately simulate the capture zones. The model-predicted capture zones and flow rates assumed 100-percent well efficiency. However, subsurface conditions usually create actual efficiencies that are significantly lower (Driscoll 1986). Therefore, the remedial alternatives were typically designed in a conservative manner to compensate for potential inefficiencies.

Five different groundwater remediation alternatives were evaluated with the groundwater flow model. The five alternatives included:

- **Alternative 1: No Action** – The baseline flow model was used to simulate the no action remedial alternative.
- **Alternative 2: MNA** – The baseline model was also used to simulate the MNA alternative.
- **Alternative 3: Focused Extraction with MNA** – Three extraction wells were used in the high level area to remove RDX-contaminated groundwater (to below 50 µg/L) for treatment.
- **Alternative 4: EDBs with MNA** – Three EDBs were used to create treatment zones to intercept and degrade the contaminated groundwater in the high level area.
- **Alternative 5: Total Groundwater Restoration** – Thirteen extraction wells were used to capture the entire plume and remove all contaminated groundwater (to below PRGs) for treatment.

The objective of each modeling evaluation was to determine the optimum locations and extraction rates that would facilitate cleanup of the explosives plume to below the target cleanup goals for each alternative.

B.1.1 Alternative 1: No Action

The calibrated baseline groundwater flow model was used for the no action and MNA alternatives evaluations. Construction of this model did not differ from construction of the previously described baseline flow model. Baseline flow model advective particle tracking results indicated that after surface water leaves Brush Creek, it enters the groundwater and travels laterally to the Skunk River. Near the Skunk River, some particle tracks end in the river, while a minimal amount of particles go under the river.

B.1.2 Alternative 2: Monitored Natural Attenuation

The MNA alternative groundwater flow model was the same as the no action model.

B.1.3 Alternative 3: Focused Extraction with Monitored Natural Attenuation

Alternative 3 consisted of three groundwater extraction wells located within or in the immediate vicinity of the high level area (>50 µg/L RDX). **Figure 5-2** presents the extraction well locations and model-predicted capture zones created by pumping at the modeled flow rates. The three extraction wells were placed in model Layer 3 (just above the impervious layer) with 15-foot well screens. The modeled flow rates of the extraction wells were:

- EW-1 = 150 gpm
- EW-2 = 150 gpm
- EW-3 = 150 gpm
- Focused Treatment System Total = 450 gpm

Advective particle tracking results for the focused extraction alternative indicated effective capture and flushing of the high level area (>50 µg/L RDX). The particle tracking analysis also indicated much of the groundwater in the high level area would originate near Brush creek, flow through the high level area, and be extracted by the wells.

B.1.4 Alternative 4: Enhanced Degradation Barrier with Monitored Natural Attenuation

Alternative 4 consisted of three EDBs to intercept and degrade RDX-contaminated groundwater in the high level area. The barriers would be injected into the base of the aquifer (i.e., model Layer 3). Each barrier was positioned to intercept approximately one-third of the high level area as the plume migrates south towards the Skunk River (**Figure 5-4**). The length of the EDBs was 1,200 feet. The EDBs were simulated in the model by slightly reducing the K value in the cells along the alignment of the EDBs (K_x = 150 ft/d; K_y = 150 ft/d; and K_z = 15 ft/d) to compensate for potential K value decreases due to potential biological plugging. No other changes were made to the flow model. Additionally, the RDX half-life was decreased in the cells along the EDBs in the fate and transport model (described in **Section B.2.4**).

Advective particle tracking results indicated the EDBs effectively intercepted the groundwater flowing through the high level area. The results for the EDB alternative differed only slightly from the baseline groundwater flow model, due to the lower hydraulic conductivity of the EDBs.

B.1.5 Alternative 5: Total Groundwater Restoration

The total groundwater restoration alternative consisted of 13 extraction wells to capture the entire plume and remove all contaminated groundwater (to below PRGs) for treatment and discharge. **Figure 5-6** presents the groundwater extraction wells, and model-predicted capture zones created by pumping at the modeled flow rates. The thirteen extraction wells were placed at the base of the aquifer (model Layer 3) with 15-foot-long well screens. The modeled flow rates for the extraction wells were:

North of Skunk River (North Treatment Plant)

- EW-1 = 150 gpm
- EW-2 = 150 gpm
- EW-3 = 150 gpm
- EW-4 = 150 gpm
- EW-5 = 150 gpm
- EW-6 = 150 gpm
- EW-7 = 150 gpm
- EW-8 = 150 gpm
- EW-9 = 150 gpm
- EW-10 = 150 gpm
- North Treatment Plant Total = 1,500 gpm

South of Skunk River (South Treatment Plant)

- EW-11 = 200 gpm
- EW-12 = 200 gpm
- EW-13 = 200 gpm
- South Treatment Plant Total = 600 gpm

Advective particle tracking results for the total groundwater restoration alternative indicated effective capture and flushing of the entire plume area (>2 µg/L RDX).

B.2 CONTAMINANT FATE AND TRANSPORT MODELING REMEDIAL ALTERNATIVES EFFECTIVENESS EVALUATION

After model calibration and sensitivity analysis indicated the model reasonably predicted contaminant fate and transport, the model was used to predict baseline contaminant fate and transport conditions and the effectiveness of the groundwater remediation alternatives previously analyzed using the groundwater flow model. Five different groundwater remediation alternative scenarios were evaluated with MT3DMS (Zheng and Wang 1998). The five alternatives included:

- Alternative 1: No Action
- Alternative 2: MNA
- Alternative 3: Focused Extraction with MNA
- Alternative 4: EDBs with MNA
- Alternative 5: Total Groundwater Restoration

The contaminant fate and transport evaluations used the steady-state groundwater flow model (calibrated to May 2002 conditions) to predict contaminant transport. The use of this flow model was considered to be appropriate because it conservatively assumed the remedial alternatives would have to be effective during the higher groundwater elevations typically found in the spring in the Off-Site study area. Once the remedial alternatives were designed to compensate for the spring conditions, they were also effective during the lower groundwater elevations found during the rest of the year.

The objective of the fate and transport modeling remedial alternative evaluations was to estimate general timeframes required to reduce RDX concentrations below various concentrations of interest (e.g., 50 µg/L and 2 µg/L). For comparative purposes, model-predicted results for RDX are presented on **Figures 6-1** through **6-8**. Changes in RDX mass over time for each alternative are presented on **Table B-1**.

Each alternative was modeled twice, the first model assumed the May 2002 Brush Creek scenario (RDX concentrations of 15 µg/L to 20 µg/L in Brush Creek), and the second model assumed that Brush Creek will be addressed (RDX concentrations at 2 µg/L in Brush Creek). The modeling results for the May 2002 Brush Creek concentrations indicated that none of the five alternatives would remediate the groundwater explosives plume to below PRGs (**Figures 6-5** through **6-8**) unless levels in the creek are below 2 µg/L.

B.2.1 Alternative 1: No Action

The no action (baseline) contaminant fate and transport model was constructed using the RDX concentrations and extents interpreted from the May 2002 groundwater sampling results (URS 2003). Contaminant transport under this alternative assumes no groundwater removal from the affected area. The no action (baseline) contaminant fate and transport modeling results indicated that the RDX PRG (2 µg/L) cannot be achieved when the creek is not addressed

(**Figure 6-5**). Under the not addressed scenario, the maximum RDX concentrations remaining in the plume area would be 15 µg/L to 20 µg/L. However, when the creek is addressed, modeling results indicated that the RDX PRG can be achieved in about 40 to 45 years (**Figure 6-1**). The high level RDX concentrations would be lowered to below 50 µg/L in 5 to 8 years.

At 70 years, the masses of RDX remaining with Brush Creek addressed and not addressed were 8 percent and 70 percent, respectively, of the initial mass (**Table B-1**).

B.2.2 Alternative 2: Monitored Natural Attenuation

The contaminant fate and transport model for Alternative 2 was the same as Alternative 1. Results for the two models were the same and were discussed in **Section B.2.1**.

B.2.3 Alternative 3: Focused Extraction with Monitored Natural Attenuation

The focused extraction alternative was evaluated to simulate the performance of three extraction wells located in the immediate vicinity of the high level area. The contaminant fate and transport modeling results indicated that the RDX PRG (2 µg/L) cannot be achieved when the creek is not addressed (**Figure 6-6**). Under the not addressed scenario, the maximum RDX concentrations remaining in the plume area would be 15 µg/L to 20 µg/L. However, when the creek is addressed, modeling results indicated that the PRG can be achieved in about 40 to 45 years (**Figure 6-2**). The high level RDX concentrations would be lowered below 50 µg/L within five years.

At 70 years, the masses of RDX remaining with Brush Creek addressed and not addressed were 9 percent and 82 percent, respectively, of the initial mass (**Table B-1**).

B.2.4 Alternative 4: Enhanced Degradation Barrier with Monitored Natural Attenuation

The model for the EDB alternative was constructed by changing the baseline model by lowering the hydraulic conductivity (K_x = 150 ft/d; K_y = 150 ft/d; and K_z = 15 ft/d) and the RDX half-life ($t_{½}$ = 30 days) in the cells along the alignment of the EDBs. The EDB system fate and transport modeling results indicated that the PRG (2 µg/L) cannot be achieved when the creek is not addressed (**Figure 6-7**). The maximum RDX concentrations remaining in the plume area would be 15 µg/L to 20 µg/L. However, when the creek is addressed the model results indicate that the RDX PRG can be achieved in about 40 to 45 years (**Figure 6-3**). The high level RDX concentrations would be lowered below 50 µg/L within five years.

At 70 years, the masses of RDX remaining with Brush Creek addressed and not addressed were 8 percent and 68 percent, respectively, of the initial mass (**Table B-1**).

B.2.5 Alternative 5: Total Groundwater Restoration

The groundwater restoration alternative was evaluated to determine if an increased number of extraction wells would decrease the cleanup time of the explosives plume. The groundwater restoration fate and transport modeling results indicated that the RDX PRG (2 µg/L) cannot be achieved when the creek is not addressed (**Figure 6-8).** The maximum RDX concentrations remaining in the plume area would be 15 µg/L to 20 µg/L. However, when the creek is addressed, the modeling results indicate that the PRG can be achieved in about 30 to 35 years (**Figure 6-4**). The high level RDX concentrations would be lowered below 50 µg/L within five years.

At 70 years, the masses of RDX remaining with Brush Creek addressed and not addressed were 8 percent and 74 percent, respectively, of the initial mass (**Table B-1**).

B.3 GROUNDWATER FLOW AND CONTAMINANT FATE AND TRANSPORT MODELING REMEDIAL ALTERNATIVES EVALUATION SUMMARY

The groundwater flow modeling and the contaminant fate and transport modeling evaluation of the various remedial alternatives is summarized below:

- Advective particle tracking results for the no action and MNA alternatives indicated that water particles originating close to Brush Creek near Highway 61 (the interpreted original RDX plume source area) would be transported through the shallow aquifer to the Skunk River. Most particles would then discharge to the river, but a minor amount continued under the river to the south.
- Advective particle tracking results for the no action and MNA alternatives also indicated particles traveling in the shallow aquifer would not be transported into the deep aquifer, even in the location where the glacial till aquitard was absent (near MW509).
- Advective particle tracking results for the focused extraction alternative indicated effective capture and flushing of the high level area (>50 µg/L RDX). The particle tracking analysis also indicated much of the groundwater in the high level area would originate near Brush creek, flow through the high level area, and be extracted by the wells.
- Advective particle tracking results for the EDB alternative indicated the EDBs effectively intercepted the groundwater flowing through the high level area. The results for the EDB alternative differed only slightly from the baseline groundwater flow model, due to the lower hydraulic conductivity of the EDBs.
- The fate and transport modeling of the five alternatives indicated that overall remediation of the groundwater is not possible without addressing Brush Creek contamination (below the RDX PRG). With the creek not addressed, the plume concentrations remained above the RDX PRG indefinitely. However, when the creek is addressed, the PRG can be achieved within 30 to 45 years, depending on the alternative selected.
- The total mass of RDX may decrease only nominally (or possibly increase) in the contaminated area if the creek is not addressed.
- Fate and transport modeling results for all alternatives indicated that there is minimal difference between the alternatives with regard to the time required to achieve the RDX PRG. The PRG was not achieved during the first 70 years in all alternatives when the creek was not addressed. When the creek was addressed, the groundwater restoration alternative did not significantly decrease the overall cleanup time (e.g., 30 to 35 years) versus the focused, EDB, and no action/MNA alternatives (e.g., 40 to 45 years).

- The high level RDX concentrations were reduced to <50 µg/L within five years in the three active alternatives (Alternatives 3, 4, and 5). However, in the no action and MNA alternatives, the time required was only five to eight years.

TABLE B-1
MODEL-PREDICTED CHANGE IN MASS OVER TIME
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Model Alternatives 1 & 2 (No Action & MNA)

Time Elapsed (years)	Mass (of RDX) Remaining[1]			
	Brush Creek = 20 µg/L		Brush Creek = 2 µg/L	
	lb	% of Initial Mass	lb	% of Initial Mass
0	857	100	857	100
10	664	77	370	43
20	631	74	208	24
30	621	72	147	17
40	612	71	114	13
50	605	71	93	11
60	599	70	80	9
70	596	70	72	8

Model Alternative 3 (Hot Spot Extraction/MNA)

Time Elapsed (years)	Mass (of RDX) Remaining[1]			
	Brush Creek = 20 µg/L		Brush Creek = 2 µg/L	
	lb	% of Initial Mass	lb	% of Initial Mass
0	857	100	857	100
10	671	78	323	38
20	665	78	192	22
30	668	78	139	16
40	667	78	111	13
50	665	78	94	11
60	663	77	83	10
70	662	77	76	9

Model Alternative 4 (EDB/MNA)

Time Elapsed (years)	Mass (of RDX) Remaining[1]			
	Brush Creek = 20 µg/L		Brush Creek = 2 mg/L	
	lb	% of Initial Mass	lb	% of Initial Mass
0	857	100	857	100
10	637	74	345	40
20	610	71	190	22
30	603	70	134	16
40	597	70	105	12
50	591	69	86	10
60	587	69	74	9
70	584	68	68	8

Model Alternative 5 (Total Groundwater Restoration)

Time Elapsed (years)	Mass (of RDX) Remaining[1]			
	Brush Creek = 20 µg/L		Brush Creek = 2 µg/L	
	lb	% of Initial Mass	lb	% of Initial Mass
0	857	100	857	100
10	622	73	205	24
20	600	70	111	13
30	597	70	82	10
40	599	70	71	8
50	601	70	66	8
60	602	70	63	7
70	602	70	62	7

NOTES:

[1] Percent (%) of initial mass was calculated using the model-predicted mass at the respective time period, divided by the mass in the initial (0 year) time period. The initial mass used was the total RDX mass in the model at 1 day.

% = Percent
µg/L = Micrograms Per Liter
EDB = Enhanced Degradation Barrier
lb = Pound(s)
MNA = Monitored Natural Attenuation
RDX = A common military explosive (cyclonite)

List of Tables

Cost Worksheets

TABLE C-1
COMPARISON OF TOTAL COST OF REMEDIAL ALTERNATIVES
OFF-SITE GROUNDWATER FEASIBILITY STUDY

Site: Off-Site Groundwater
Location: IAAAP Middletown, Iowa
Phase: Feasibility Study (-30% to +50%)

Base Year: 2003
Date: 6/9/2003

Description	Alternative 1 No Action	Alternative 2 MNA	Alternative 3 Focused Extraction/ MNA	Alternative 4 EDB/MNA	Alternative 5 Total Groundwater Restoration
Total Project Duration (Years)	0	45	45	45	35
Capital Cost	$0	$178,000	$793,000	$1,233,000	$2,045,000
Total O&M Cost	$0	$1,050,000	$2,033,000	$1,050,000	$13,829,000
Total Periodic Cost	$0	$367,000	$400,000	$966,000	$441,000
Total Cost of Alternative	$0	$1,595,000	$3,226,000	$3,249,000	$16,315,000
Total Present Value of Alternative	**$0**	**$863,000**	**$2,307,000**	**$2,441,000**	**$7,515,000**

TABLE C-2
COST ESTIMATE SUMMARY – ALTERNATIVE 2
OFF-SITE GROUNDWATER FEASIBILITY STUDY

MONITORED NATURAL ATTENUATION

Site: Off-Site Groundwater
Location: IAAAP Middletown, Iowa
Phase: Feasibility Study (-30% to +50%)
Base Year: 2003
Date: 9-June-2003

Description: Alternative 2 consists of groundwater monitoring for 35 wells. No active remediation systems. Institutional and engineering controls used to mitigate potential risks. Capital costs occur in Year 0, annual O&M costs occur in Years 1-45, and periodic costs occur in Years 5, 10, 15, 20, 25, 30, 35, 40, and 45.

CAPITAL COSTS:

Description	Qty	Unit	Unit Cost	Cost	Notes
Mobilization/Demobilization					
Submittals/Implementation Plans	1	LS	$8,000	$8,000	FSP, QAPP, SSHP
Subtotal				**$8,000**	
Monitoring, Sampling, Testing, Analysis					
MW Installation, Development	1	LS	$50,387	$50,387	See cost worksheet
GW Sampling, Analysis - Initial	1	LS	$31,444	$31,444	See cost worksheet
Geotechnical Testing	1	LS	$1,500	$1,500	New MW screened interval
Surveying	1	LS	$790	$790	7 MWs + $300 data fee
Subtotal				**$84,121**	
At-Well Water Treatment System	1	EA	$3,500	$3,500	GAC vessel, pipe, meter, shelter
Subtotal 1				**$95,621**	
Contingency	25%			$23,905	10% scope + 15% bid
Subtotal 2				**$119,526**	
Project Management	10%			$11,953	
Remedial Design	20%			$23,905	
Construction Management	15%			$17,929	
Subtotal				**$53,787**	
Institutional Controls	1	LS	$5,000	$5,000	Plan, deed notices, advisories
TOTAL CAPITAL COST:				**$178,312**	

ANNUAL O&M COSTS (YEARS 1-10):

Description	Qty	Unit	Unit Cost	Cost	Notes
Site Monitoring					
Land Use Fees	1	LS	$3,500	$3,500	$100/MW to landowner
GW Sampling, Analysis	1	LS	$31,444	$31,444	See cost worksheet
At-Well Treatment, Inspection, Maintenance	1	LS	$1,000	$1,000	Carbon change-out, power, sampling
Data Management	1	LS	$3,500	$3,500	
Reporting	1	LS	$12,000	$12,000	Annual reporting
Subtotal				**$51,444**	
Contingency	25%			$12,860.93	10% scope + 15% bid
Subtotal				**$64,305**	
Project Management	10%			$6,430	
Technical Support	15%			$9,646	
Subtotal				**$16,076**	
TOTAL ANNUAL O&M COST (YEARS 1-10):				**$80,381**	

TABLE C-2
COST ESTIMATE SUMMARY – ALTERNATIVE 2
OFF-SITE GROUNDWATER FEASIBILITY STUDY

MONITORED NATURAL ATTENUATION

ANNUAL O&M COSTS (YEARS 11-45):

Description	Qty	Unit	Unit Cost	Cost	Notes
Site Monitoring					
Land Use Fees	1	LS	$3,500	$3,500	$100/MW to landowner
At-Well Treatment, Inspection, Maintenance	1	LS	$1,000	$1,000	Carbon change-out, power, sampling
Subtotal				**$4,500**	
Contingency	25%			$1,125	10% scope + 15% bid
Subtotal				**$5,625**	
Project Management	10%			$562.50	
Technical Support	15%			$843.75	
Subtotal				**$1,406**	
TOTAL ANNUAL O&M COST (YEARS 11-45):				**$7,031**	

PERIODIC COSTS:

Description	Year	Qty	Unit	Unit Cost	Cost	Notes
Five-Year Review Report	5	1	EA	$12,000	$12,000	
MW Maintenance	5	1	EA	$4,000	$4,000	Repair damage, redevelop
Subtotal					**$16,000**	
Five-Year Review Report	10	1	EA	$12,000	$12,000	
MW Maintenance	10	1	EA	$4,000	$4,000	Repair damage, redevelop
Subtotal					**$16,000**	
Five-Year Review Report	15,20,25,30,35,40	1	EA	$12,000	$12,000	
MW Maintenance	15,20,25,30,35,40	1	EA	$4,000	$4,000	Repair damage, redevelop
GW Sampling, Analysis	15,20,25,30,35,40	1	EA	$31,444	$31,444	
Subtotal					**$47,444**	
GW Sampling, Analysis	45	1	EA	$31,444	$31,444	
MW Abandonment	45	35	EA	$250	$8,750	
Remedial Action Report	45	1	EA	$10,000	$10,000	
Subtotal					**$50,194**	

PRESENT VALUE ANALYSIS:

Cost Type	Year	Total Cost	Total Cost Per Year	Discount Factor (7%)	Present Value	Notes
Capital Cost	0	$178,312	$178,312	1.000	$178,312	
Annual O&M Cost	1-10	$803,808	$80,381	7.024	$564,561	
Annual O&M Cost	11-45	$246,094	$7,031	6.582	$46,279	
Periodic Cost	5	$16,000	$16,000	0.713	$11,408	
Periodic Cost	10	$16,000	$16,000	0.508	$8,134	
Periodic Cost	15	$47,444	$47,444	0.362	$17,196	
Periodic Cost	20	$47,444	$47,444	0.258	$12,260	
Periodic Cost	25	$47,444	$47,444	0.184	$8,741	
Periodic Cost	30	$47,444	$47,444	0.131	$6,233	
Periodic Cost	35	$47,444	$47,444	0.094	$4,444	
Periodic Cost	40	$47,444	$47,444	0.067	$3,168	
Periodic Cost	45	$50,194	$50,194	0.048	$2,390	
		$1,595,000			**$863,126**	
TOTAL PRESENT VALUE OF ALTERNATIVE:					**$863,000**	

TABLE C-3
COST ESTIMATE SUMMARY – ALTERNATIVE 3
OFF-SITE GROUNDWATER FEASIBILITY STUDY

FOCUSED EXTRACTION/MONITORED NATURAL ATTENUATION

Site: Off-Site Groundwater
Location: IAAAP Middletown, Iowa
Phase: Feasibility Study (-30% to +50%)
Base Year: 2003
Date: 9-June-2003

Description: Alternative 3 consists of active removal and treatment of contaminated groundwater in the high level area using three extraction wells and a GAC treatment facility, and MNA for the remainder of the plume. The extraction system would be operated for five years. Institutional and engineering controls will be used to mitigate potential risks. Capital costs occur in Year 0, annual O&M costs occur in Years 1-45, and periodic costs occur in Years 5, 10, 15, 20, 25, 30, 35, 40 and 45.

CAPITAL COSTS:

Description	Qty	Unit	Unit Cost	Cost	Notes
Mobilization/Demobilization					
Submittals/Implementation Plans	1	LS	$15,000	$15,000	FSP, QAPP, SSHP
Subtotal				**$15,000**	
Monitoring, Sampling, Testing, Analysis					
MW Installation, Development	1	LS	$50,387	$50,387	See cost worksheet
GW Sampling, Analysis - Initial	1	LS	$31,444	$31,444	See cost worksheet
Geotechnical Testing	1	LS	$1,500	$1,500	New MW screened interval (1 ea)
Surveying	1	LS	$1,000	$1,000	7 MWs, 3 EWs + $300 data fee
Subtotal				**$84,331**	
Extraction Well Installation	1	LS	$93,390	$93,390	See cost worksheet
GAC Treatment System					
Collection/Surge Tank	1	EA	$600	$600	1,000-gal plastic, installed/plummed
Effluent Collection Tanks (Flat Bottom)	2	EA	$5,000	$10,000	7,400-gal plastic, installed/plummed
Backwash Collection Tanks (Cone Bottom)	2	EA	$5,500	$11,000	7,400-gal plastic, installed/plummed
Process Pumps/Piping/Controls/Electrical	1	LS	$67,153	$67,153	See cost worksheet
GAC Vessels	1	LS	$89,000	$89,000	Installed/plummed, 40,000-lb system
Control Building	1	LS	$50,000	$50,000	25x40x20 steel building, concrete foundation, HVAC, lighting
Subtotal				**$227,753**	
At-Well Water Treatment System	1	EA	$3,500	$3,500	GAC vessel, pipe, meter, shelter
Subtotal 1				**$423,974**	
Contingency	30%			$127,192	15% scope + 15% bid
Subtotal 2				**$551,166**	
Project Management	8%			$44,093	
Pre-Design Investigation	10%			$55,117	Optimize GAC treat, pump test
Remedial Design	15%			$82,675	
Construction Management	10%			$55,117	
Subtotal				**$237,001**	
Institutional Controls	1	LS	$5,000	$5,000	Plan, deed notices, advisories
TOTAL CAPITAL COST:				**$793,167**	

ANNUAL O&M COSTS (YEARS 1-5):

Description	Qty	Unit	Unit Cost	Cost	Notes
Site Monitoring					
Land Use Fees	1	LS	$3,500	$3,500	$100/MW to landowner
GW Sampling, Analysis	1	EA	$31,444	$31,444	See cost worksheet
At-Well Treatment, Inspection, Maintenance	1	EA	$1,000	$1,000	Carbon change-out, power, sampling
Data Management	1	LS	$3,500	$3,500	
Reporting	1	EA	$12,000	$12,000	Annual reporting
Subtotal				**$51,444**	

TABLE C-3
COST ESTIMATE SUMMARY – ALTERNATIVE 3
OFF-SITE GROUNDWATER FEASIBILITY STUDY

FOCUSED EXTRACTION/MONITORED NATURAL ATTENUATION

ANNUAL O&M COSTS (YEARS 1-5): (continued from previous page)

Description	Qty	Unit	Unit Cost	Cost	Notes
Treatment System Monitoring, Maintenance					
Land Use Fees	1	LS	$6,300	$6,300	$100/EW + $500/mo for trtmnt fac
GAC Removal, Disposal, Replacement	2	EA	$20,000	$40,000	Semiannual, 20,000 lbs
O&M Labor	12	EA	$1,000	$12,000	3 days/wk, includes sampling
Equipment/Repair	1	LS	$1,500	$1,500	
Power Usage	12	EA	$2,000	$24,000	Process, building @ $0.07/Kwh
Sampling, Analysis	4	LS	$1,000	$4,000	Qrtly for expl (2 inf, 1 comb inf, 1 eff)
Data Management	4	EA	$1,500	$6,000	Qrtly
Reporting	4	EA	$8,000	$32,000	Qrtly
Subtotal				**$125,800**	
Subtotal 1				**$177,244**	
Contingency	25%			$44,311	10% scope + 15% bid
Subtotal 2				**$221,555**	
Project Management	10%			$22,155	
Technical Support	15%			$33,233	
Subtotal				**$55,389**	
TOTAL ANNUAL O&M COST (YEARS 1-5):				**$276,943**	

ANNUAL O&M COSTS (YEARS 6-10):

Description	Qty	Unit	Unit Cost	Cost	Notes
Site Monitoring					
Land Use Fees	1	LS	$3,500	$3,500	$100/MW to landowner
GW Sampling, Analysis	1	EA	$31,444	$31,444	See cost worksheet
At-Well Treatment, Inspection, Maintenance	1	EA	$1,000	$1,000	Carbon change-out, power, sampling
Data Management	1	LS	$3,500	$3,500	
Reporting	1	EA	$12,000	$12,000	Annual reporting
Subtotal				**$51,444**	
Contingency	25%			$12,861	10% scope + 15% bid
Subtotal				**$64,305**	
Project Management	10%			$6,430	
Technical Support	15%			$9,646	
Subtotal				**$16,076**	
TOTAL ANNUAL O&M COST (YEARS 6-10):				**$80,381**	

ANNUAL O&M COSTS (YEARS 11-45):

Description	Qty	Unit	Unit Cost	Cost	Notes
Site Monitoring					
Land Use Fees	1	LS	$3,500	$3,500	$100/MW to landowner
At-Well Treatment, Inspection, Maintenance	1	EA	$1,000	$1,000	Carbon change-out, power, sampling
Subtotal				**$4,500**	
Contingency	25%			$1,125	10% scope + 15% bid
Subtotal				**$5,625**	
Project Management	10%			$563	
Technical Support	15%			$844	
Subtotal				**$1,406**	
TOTAL ANNUAL O&M COST (YEARS 11-45):				**$7,031**	

TABLE C-3
COST ESTIMATE SUMMARY – ALTERNATIVE 3
OFF-SITE GROUNDWATER FEASIBILITY STUDY

FOCUSED EXTRACTION/MONITORED NATURAL ATTENUATION

PERIODIC COSTS:

Description	Year	Qty	Unit	Unit Cost	Cost	Notes
Treatment Facility Closure						
Disassembly	5	1	LS	$10,000	$10,000	GAC process equipment
Demolition, disposal	5	1	LS	$20,000	$20,000	Building and foundation
EW Abandonment	5	3	EA	$1,000	$3,000	3 EWs
Five-Year Review Report	5	1	EA	$12,000	$12,000	
MW Maintenance	5	1	EA	$4,000	$4,000	Repair damage, redevelop
Subtotal					**$49,000**	
Five-Year Review Report	10	1	EA	$12,000	$12,000	
MW Maintenance	10	1	EA	$4,000	$4,000	Repair damage, redevelop
Subtotal					**$16,000**	
Five-Year Review Report	15,20,25,30,35,40	1	EA	$12,000	$12,000	
MW Maintenance	15,20,25,30,35,40	1	EA	$4,000	$4,000	Repair damage, redevelop
GW Sampling, Analysis	15,20,25,30,35,40	1	EA	$31,444	$31,444	
Subtotal					**$47,444**	
GW Sampling, Analysis	45	1	EA	$31,444	$31,444	
MW Abandonment	45	35	EA	$250	$8,750	
Remedial Action Report	45	1	EA	$10,000	$10,000	
Subtotal					**$50,194**	

PRESENT VALUE ANALYSIS:

Cost Type	Year	Total Cost	Total Cost Per Year	Discount Factor (7%)	Present Value	Notes
Capital Cost	0	$793,167	$793,167	1.000	$793,167	
Annual O&M Cost	1-5	$1,384,716	$276,943	4.100	$1,135,522	
Annual O&M Cost	6-10	$401,904	$80,381	2.923	$234,984	
Annual O&M Cost	11-45	$246,094	$7,031	6.582	$46,279	
Periodic Cost	5	$49,000	$49,000	0.713	$34,936	
Periodic Cost	10	$16,000	$16,000	0.508	$8,134	
Periodic Cost	15	$47,444	$47,444	0.362	$17,196	
Periodic Cost	20	$47,444	$47,444	0.258	$12,260	
Periodic Cost	25	$47,444	$47,444	0.184	$8,741	
Periodic Cost	30	$47,444	$47,444	0.131	$6,233	
Periodic Cost	35	$47,444	$47,444	0.094	$4,444	
Periodic Cost	40	$47,444	$47,444	0.067	$3,168	
Periodic Cost	45	$50,194	$50,194	0.048	$2,390	
		$3,226,000			**$2,307,454**	

TOTAL PRESENT VALUE OF ALTERNATIVE: **$2,307,000**

TABLE C-4
COST ESTIMATE SUMMARY – ALTERNATIVE 4
OFF-SITE GROUNDWATER FEASIBILITY STUDY

ENHANCED DEGRADATION BARRIER/MONITORED NATURAL ATTENUATION

Site: Off-Site Groundwater
Location: IAAAP Middletown, Iowa
Phase: Feasibility Study (-30% to +50%)
Base Year: 2003
Date: 9-June-2003

Description: Alternative 4 consists of groundwater monitoring, installation of an EDB system to remediate the high level area, and MNA for the remainder of the plume. Each of three barriers will be positioned to intercept one-third of the high level area as it migrates. Institutional and engineering controls will be used to mitigate potential risks. Substrate reapplication will occur in Year 2. Capital costs reflect initial application only and occur in Year 0. Annual O&M costs occur in Years 1-45. Periodic costs occur in Years 5, 10, 15, 20, 25, 30, 35, 40, and 45.

CAPITAL COSTS:

Description	Qty	Unit	Unit Cost	Cost	Notes
Mobilization/Demobilization					
Submittals/Implementation Plans	1	LS	$8,000	$8,000	FSP, QAPP, SSHP
Subtotal				**$8,000**	
Monitoring, Sampling, Testing, Analysis					
MW Installation, Development	1	LS	$50,387	$50,387	See cost worksheet
GW Sampling, Analysis - Initial	1	LS	$31,444	$31,444	See cost worksheet
Geotechnical Testing	1	LS	$1,500	$1,500	New MW screened interval
Surveying	1	LS	$790	$790	7 MWs + $300 data fee
Subtotal				**$84,121**	
EDB Injection					
EDB Installation	1	LS	$577,288	$577,288	See cost worksheet
Performance MWs	3	EA	$7,198	$21,594	Same as MW per-well cost
Subtotal				**$598,882**	
At-Well Water Treatment System	1	EA	$3,500	$3,500	GAC vessel, pipe, meter, shelter
Subtotal 1				**$694,503**	
Contingency	30%			$208,351	15% scope + 15% bid
Subtotal 2				**$902,854**	
Project Management	6%			$54,171	
Pre-Design Investigation	10%			$90,285	Confirm substrate type, quantities
Remedial Design	12%			$108,342	
Construction Management	8%			$72,228	
Subtotal				**$325,027**	
Institutional Controls	1	LS	$5,000	$5,000	Plan, deed notices, advisories
TOTAL CAPITAL COST:				**$1,232,881**	

ANNUAL O&M COSTS (YEARS 1-10):

Description	Qty	Unit	Unit Cost	Cost	Notes
Site Monitoring					
Land Use Fees	1	LS	$3,500	$3,500	$100/MW to landowner
GW Sampling, Analysis	1	EA	$31,444	$31,444	See cost worksheet
At-Well Treatment, Inspection, Maintenance	1	EA	$1,000	$1,000	Carbon change-out, power, sampling
Data Management	1	LS	$3,500	$3,500	
Reporting	1	EA	$12,000	$12,000	Annual reporting
Subtotal				**$51,444**	
Contingency	25%			$12,861	10% scope + 15% bid
Subtotal				**$64,305**	
Project Management	10%			$6,430	
Technical Support	15%			$9,646	
Subtotal				**$16,076**	
TOTAL ANNUAL O&M COST (YEARS 1-10):				**$80,381**	

TABLE C-4
COST ESTIMATE SUMMARY – ALTERNATIVE 4
OFF-SITE GROUNDWATER FEASIBILITY STUDY

ENHANCED DEGRADATION BARRIER/MONITORED NATURAL ATTENUATION

ANNUAL O&M COSTS (YEARS 11-45):

Description	Qty	Unit	Unit Cost	Cost	Notes
Site Monitoring					
Land Use Fees	1	LS	$3,500	$3,500	$100/MW to landowner
At-Well Treatment, Inspection, Maintenance	1	EA	$1,000	$1,000	Carbon change-out, power, sampling
Subtotal				**$4,500**	
Contingency	25%			$1,125	10% scope + 15% bid
Subtotal				**$5,625**	
Project Management	10%			$563	
Technical Support	15%			$844	
Subtotal				**$1,406**	
TOTAL ANNUAL O&M COST (YEARS 11-45):				**$7,031**	

PERIODIC COSTS:

Description	Year	Qty	Unit	Unit Cost	Cost	Notes
EDB Performance Sampling	1	4	EA	$2,695	$10,781	Qrtly, 3 wells
EDB Performance Sampling	2	4	EA	$2,695	$10,781	Qrtly, 3 wells
Substrate Reapplication	2	1	EA	$577,288	$577,288	Same as initial install cost
Subtotal					**$588,068**	
Five-Year Review Report	5	1	EA	$12,000	$12,000	
MW Maintenance	5	1	EA	$4,000	$4,000	Repair damage, redevelop
Subtotal					**$16,000**	
Five-Year Review Report	10	1	EA	$12,000	$12,000	
MW Maintenance	10	1	EA	$4,000	$4,000	Repair damage, redevelop
Subtotal					**$16,000**	
Five-Year Review Report	15,20,25,30,35,40	1	EA	$12,000	$12,000	
MW Maintenance	15,20,25,30,35,40	1	EA	$4,000	$4,000	Repair damage, redevelop
GW Sampling, Analysis	15,20,25,30,35,40	1	EA	$31,444	$31,444	
Subtotal					**$47,444**	
GW Sampling, Analysis	45	1	EA	$31,444	$31,444	
MW Abandonment	45	35	EA	$250	$8,750	
Remedial Action Report	45	1	EA	$10,000	$10,000	
Subtotal					**$50,194**	

PRESENT VALUE ANALYSIS:

Cost Type	Year	Total Cost	Total Cost Per Year	Discount Factor (7%)	Present Value	Notes
Capital Cost	0	$1,232,881	$1,232,881	1.000	$1,232,881	
Annual O&M Cost	1-10	$803,808	$80,381	7.024	$564,561	
Annual O&M Cost	11-45	$246,094	$7,031	6.582	$46,279	
Periodic Cost	1	$10,781	$10,781	0.935	$10,075	
Periodic Cost	2	$588,068	$588,068	0.873	$513,642	
Periodic Cost	5	$16,000	$16,000	0.713	$11,408	
Periodic Cost	10	$16,000	$16,000	0.508	$8,134	
Periodic Cost	15	$47,444	$47,444	0.362	$17,196	
Periodic Cost	20	$47,444	$47,444	0.258	$12,260	
Periodic Cost	25	$47,444	$47,444	0.184	$8,741	
Periodic Cost	30	$47,444	$47,444	0.131	$6,233	
Periodic Cost	35	$47,444	$47,444	0.094	$4,444	
Periodic Cost	40	$47,444	$47,444	0.067	$3,168	
Periodic Cost	45	$50,194	$50,194	0.048	$2,390	
		$3,249,000			**$2,441,412**	
TOTAL PRESENT VALUE OF ALTERNATIVE:					**$2,441,000**	

TABLE C-5
COST ESTIMATE SUMMARY – ALTERNATIVE 5
OFF-SITE GROUNDWATER FEASIBILITY STUDY

TOTAL GROUNDWATER RESTORATION

Site: Off-Site Groundwater
Location: IAAAP Middletown, Iowa
Phase: Feasibility Study (-30% to +50%)
Base Year: 2003
Date: 9-June-2003

Description: Alternative 5 consists of active removal and treatment of groundwater from the contaminant plume using 13 extraction wells and two GAC treatment facilities. The extraction system would be operated for 35 years. Institutional and engineering controls would be used to mitigate potential risks. Capital costs occur in Year 0. Annual O&M costs occur in Years 1-35. Periodic costs occur in Years 5, 10, 15, 20, 25, 30, and 35.

CAPITAL COSTS:

Description	Qty	Unit	Unit Cost	Cost	Notes
Mobilization/Demobilization					
Submittals/Implementation Plans	1	LS	$12,000	$12,000	FSP, QAPP, SSHP
Subtotal				**$12,000**	
Monitoring, Sampling, Testing, Analysis					
MW Installation, Development	1	LS	$50,387	$50,387	See cost worksheet
GW Sampling, Analysis - Initial	1	LS	$31,444	$31,444	Explosives, NA parameters analysis
Geotechnical Testing	1	LS	$1,500	$1,500	New MW screened interval (1 ea)
Surveying	1	LS	$1,630	$1,630	7 MWs, 13 EWs + $300 data fee
Subtotal				**$84,961**	
Extraction Well Installation	1	LS	$399,957	$399,957	See cost worksheet
GAC Treatment System (northern, southern)					
Collection/Surge Tank	1	LS	$3,458	$3,458	5k-, 2k-gal plastic, installed/plummed
Effluent Collection Tanks (Flat Bottom)	1	LS	$17,040	$17,040	(2)7.4k-, (2)6k-gal plastic, inst/plum
Backwash Collection Tanks (Cone Bottom)	1	LS	$18,000	$18,000	(2)7.4k-, (1)11.5k-gal plastic, inst/plum
Process Pumps/Piping/Controls/Electrical	1	LS	$171,154	$171,154	See cost worksheet
GAC Vessels	1	LS	$344,000	$344,000	(3)40k-, (1)20k-lb systems
Control Building	1	LS	$100,000	$100,000	2 steel buildings, concrete
Subtotal				**$653,652**	foundation, HVAC, lighting
At-Well Water Treatment System	1	EA	$3,500	$3,500	GAC vessel, pipe, meter, shelter
Subtotal 1				**$1,154,070**	
Contingency	30%			$346,221	15% scope + 15% bid
Subtotal 2				**$1,500,291**	
Project Management	6%			$90,017	
Pre-Design Investigation	10%			$150,029	Optimize GAC treat, pump test
Remedial Design	12%			$180,035	
Construction Management	8%			$120,023	
Subtotal				**$540,105**	
Institutional Controls	1	LS	$5,000	$5,000	Plan, deed notices, advisories
TOTAL CAPITAL COST:				**$2,045,395**	

ANNUAL O&M COSTS (YEARS 1-10):

Description	Qty	Unit	Unit Cost	Cost	Notes
Site Monitoring					
Land Use Fees	1	LS	$3,500	$3,500	$100/MW to landowner
GW Sampling, Analysis	1	EA	$31,444	$31,444	See cost worksheet
At-Well Treatment, Inspection, Maintenance	1	EA	$1,000	$1,000	Carbon change-out, power, sampling
Data Management	1	LS	$3,500	$3,500	
Reporting	1	EA	$12,000	$12,000	Annual reporting
Subtotal				**$51,444**	

TABLE C-5
COST ESTIMATE SUMMARY – ALTERNATIVE 5
OFF-SITE GROUNDWATER FEASIBILITY STUDY

TOTAL GROUNDWATER RESTORATION

ANNUAL O&M COSTS (YEARS 1-10): (continued from previous page)

Description	Qty	Unit	Unit Cost	Cost	Notes
Treatment System Monitoring, Maintenance					
Land Use Fees	1	LS	$13,300	$13,300	$100/EW + $500/mo for trtmnt fac
GAC Removal, Disposal, Replacement (northern)	1	EA	$60,000	$60,000	Annual, 60,000 lbs
GAC Removal, Disposal, Replacement (southern)	1	EA	$6,666	$6,666	10k lbs every 1.5 yrs = 6.6k/yr
O&M Labor	12	MO	$1,500	$18,000	3 days/wk, includes sampling
Equipment/Repair	1	LS	$3,000	$3,000	
Power Usage	12	MO	$6,500	$78,000	Process, building @ $0.07/Kwh
Sampling, Analysis	4	LS	$4,000	$16,000	Qrtly for expl (2 inf, 1 comb inf, 1 eff)
Data Management	4	LS	$2,000	$8,000	Qrtly
Reporting	4	EA	$8,000	$32,000	Qrtly
Subtotal				**$234,966**	
Subtotal 1				**$286,410**	
Contingency	25%			$71,602	10% scope + 15% bid
Subtotal 2				**$358,012**	
Project Management	10%			$35,801	
Technical Support	15%			$53,702	
Subtotal				**$89,503**	
TOTAL ANNUAL O&M COST (YEARS 1-10):				**$447,515**	

ANNUAL O&M COSTS (YEARS 11-35):

Description	Qty	Unit	Unit Cost	Cost	Notes
Site Monitoring					
Land Use Fees	1	LS	$3,500	$3,500	$100/MW to landowner
At-Well Treatment, Inspection, Maintenance	1	EA	$1,000	$1,000	Carbon change-out, power, sampling
Subtotal				**$4,500**	
Treatment System Monitoring, Maintenance					
Land Use Fees	1	LS	$13,300	$13,300	$100/EW + $500/mo for trtmnt fac
GAC Removal, Disposal, Replacement (northern)	1	EA	$60,000	$60,000	Annual, 60,000 lbs
GAC Removal, Disposal, Replacement (southern)	1	EA	$6,666	$6,666	10k lbs every 1.5 yrs = 6.6k/yr
O&M Labor	12	MO	$1,500	$18,000	3 days/wk, includes sampling
Equipment/Repair	1	LS	$3,000	$3,000	
Power Usage	12	MO	$6,500	$78,000	Process, building @ $0.07/Kwh
Sampling, Analysis	4	LS	$4,000	$16,000	Qrtly for expl (2 inf, 1 comb inf, 1 eff)
Data Management	4	LS	$2,000	$8,000	Qrtly
Reporting	4	EA	$8,000	$32,000	Qrtly
Subtotal				**$234,966**	
Subtotal 1				**$239,466**	
Contingency	25%			$59,867	10% scope + 15% bid
Subtotal				**$299,333**	
Project Management	10%			$29,933	
Technical Support	15%			$44,900	
Subtotal				**$74,833**	
TOTAL ANNUAL O&M COST (YEARS 11-35):				**$374,166**	

TABLE C-5
COST ESTIMATE SUMMARY – ALTERNATIVE 5
OFF-SITE GROUNDWATER FEASIBILITY STUDY

TOTAL GROUNDWATER RESTORATION

PERIODIC COSTS:

Description	Year	Qty	Unit	Unit Cost	Cost	Notes
Five-Year Review Report	5	1	EA	$12,000	$12,000	
MW/EW Maintenance	5	1	EA	$20,000	$20,000	Repair damage, redevelop
Subtotal					**$32,000**	
Five-Year Review Report	10	1	EA	$12,000	$12,000	
MW/EW Maintenance	10	1	EA	$20,000	$20,000	Repair damage, redevelop
Subtotal					**$32,000**	
Five-Year Review Report	15,20,25,30	1	EA	$12,000	$12,000	
MW/EW Maintenance	15,20,25,30	1	EA	$20,000	$20,000	Repair damage, redevelop
GW Sampling, Analysis	15,20,25,30	1	EA	$31,444	$31,444	
Subtotal					**$63,444**	
GW Sampling, Analysis	35	1	EA	$31,444	$31,444	
MW Abandonment	35	35	EA	$250	$8,750	
Remedial Action Report	35	1	EA	$10,000	$10,000	
Treatment Facility Closure						
Disassembly	35	1	LS	$20,000	$20,000	GAC process equipment
Demolition, disposal	35	1	LS	$40,000	$40,000	Building and foundation
EW Abandonment	35	13	EA	$1,000	$13,000	13 EWs
Subtotal					**$123,194**	

PRESENT VALUE ANALYSIS:

Cost Type	Year	Total Cost	Total Cost Per Year	Discount Factor (7%)	Present Value	Notes
Capital Cost	0	$2,045,395	$2,045,395	1.000	$2,045,395	
Annual O&M Cost	1-10	$4,475,152	$447,515	7.024	$3,143,159	
Annual O&M Cost	11-35	$9,354,141	$374,166	5.924	$2,216,591	
Periodic Cost	5	$32,000	$32,000	0.713	$22,816	
Periodic Cost	10	$32,000	$32,000	0.508	$16,267	
Periodic Cost	15	$63,444	$63,444	0.362	$22,995	
Periodic Cost	20	$63,444	$63,444	0.258	$16,395	
Periodic Cost	25	$63,444	$63,444	0.184	$11,689	
Periodic Cost	30	$63,444	$63,444	0.131	$8,334	
Periodic Cost	35	$123,194	$123,194	0.094	$11,539	
		$16,315,000			**$7,515,181**	

TOTAL PRESENT VALUE OF ALTERNATIVE: **$7,515,000**

Capital Cost Sub-Element
MONITORING WELL INSTALLATION AND DEVELOPMENT

COST WORKSHEET

Site: Off-Site Groundwater
Location: IAAAP Middletown, Iowa
Phase: Feasibility Study (-30% to +50%)
Base Year: 2003

Prepared By: DRH **Date:** 6/9/03
Checked By: JMR **Date:** 6/9/03

Work Statement:

Install (10 days), develop (2 day), and slug test (2 day) additional LTM monitoring wells. Assume 7 intermediate depth (60-foot) wells. Installation includes drilling with 4-1/4-inch ID hollow stem augers, continuous soil sampling, installation of 2-inch Schedule 40 PVC blank and factory-slotted screen, and flush mount completions.

Cost Analysis:

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	NOTES
Field Oversight Labor								
Field preparation	8	HR	43	-	-	43	344	$43/hr tech
Digging permits	8	HR	43	-	-	43	344	$43/hr tech
Drilling Oversight	150	HR	113	-	-	113	16950	$70/hr geo + $43/hr tech, Inc.trav. time
SUBTOTAL							17,638	
Supplies, Rental, and Travel								
PPE/Decon/Misc.Supplies	1	EA	-	-	150	150	150	
Hermit Transducer and Logger	4	DAY	-	100	-	100	400	Slug testing
Horiba U-10	4	DAY	-	21	-	21	84	development
Submersible Pump	4	DAY	-	63	-	63	252	2" dia.
Polyethylene Tubing	70	LF	-	-	0.25	0.25	18	
Water Level Probe	10	DAY	-	40	-	40	400	
Minirae PID	10	DAY	-	35	-	35	350	
Oversight Per Diem (2 man crew)	10	DAY	-	-	-	170	1700	($30+$55)x2
Mileage	1300	MI	-	-	-	0.36	468	800mi mob/demob + 50 mi/day x 10 days
SUBTOTAL							3,822	
G&A Markup						5.0%	191	
SUBTOTAL							4,013	
Subcontract Drilling								
Drillers Mob/demob	1	LS	-	-	-	500	500	
Drillers Per Diem (3 man crew)	8	DAY	-	-	-	150	1200	
Install Temp. Decon Pads	1	EA	-	-	-	200	200	
Overburden Drilling w/ 2" SS	420	LF	-	-	-	18	7560	4-1/4-inch H.S.A.
2" PVC, Sch. 40 Riser	350	LF	-	-	-	8.7	3045	10 ' sections
2" PVC, Sch. 40 Fact. Slot Screen	70	LF	-	-	-	12.25	858	10 ' sections
Filter Pack Sand	84	LF	-	-	-	9	756	Colorado silica
Bentonite Seal	7	EA	-	-	-	33.5	235	3/8" chips
Annular Seal	336	LF	-	-	-	5	1680	Bentonite grout
Completions/Protective Cover	7	EA	-	-	-	250	1750	
55 Gal Drums Filled and Staged	30	EA	-	-	-	65	1950	Includes drums
Offsite Transport of IDW	1	LS	-	-	-	495	495	Subcontract disposal service
Offsite Disposal of IDW	30	EA	-	-	-	45	1350	Subcontract disposal service
SUBTOTAL							21,578	
Prime Contractor Overhead						15.0%	3,237	Applies to subcontract only
SUBTOTAL							46,465	
Prime Contractor Profit						10.0%	3,922	Applies to labor and subcontract only
TOTAL COST							**$50,387**	
						OR	$7,198	/monitoring well

Source of Cost Data:
Previous experience with drilling in 2003. RSMeans 2003, Environmental Remediation Cost Data, 9th Annual Edition.

Cost Adjustment Checklist:

	FACTOR:	NOTES:
✓	H&S Productivity (labor & equip only)	Level D
✓	Escalation to Base Year	Current year (2003) is base year
✓	Area Cost Factor	0.86, based on area code (RSMeans data only)
✓	Subcontractor Overhead and Profit	Included in cost
✓	Prime Contractor Overhead and Profit	Includes 15% overhead and 10% profit

Cost Sub-Element
GROUNDWATER SAMPLING AND ANALYSIS

COST WORKSHEET

Site:	Off-Site Groundwater	**Prepared By:** DRH	**Checked By:** JMR
Location:	IAAAP Middletown, Iowa	**Date:** 6/9/03	**Date:** 6/9/03
Phase:	Feasibility Study (-30% to +50%)		
Base Year:	2003		

Work Statement:

Groundwater sampling cost per event (35 wells total). Assume 2.5 hours per well by a 2 person team (87.5 hours total). Explosives and natural attenuation parameters will be analyzed in the laboratory.

Cost Analysis:

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	NOTES
Labor								
Technician	97.5	HR	43	-	-	43	4,193	Includes travel time
Geo/chem/eng.	97.5	HR	70	-	-	70	6,825	Includes travel time
SUBTOTAL							11,018	
Supplies, Rental, and Travel								
Minirae PID	10	DAY	-	35	-	35	350	
Water Level Probe	10	DAY	-	8	-	8	80	
Horiba U-10	10	DAY	-	21	-	21	210	
Submersible Pump	10	DAY	-	63	-	63	630	2" dia.
Polyethylene Tubing	2500	LF	-	-	0.25	0.25	625	
PPE/Decon/Misc.Supplies	1	EA	-	-	150	150	150	
Per Diem (2 person crew)	10	DAY	-	-	-	170	1700	($30+$55)x2
Mileage	1150	MI	-	-	-	0.36	414	800mi mob/demob + 50 mi/day x 7days
Package and Ship	10	EA	-	-	90	90	900	
SUBTOTAL							5,059	
G&A Markup						5.0%	253	
SUBTOTAL							5,312	
Subcontract Lab Analysis								
Natural Attenuation Parameters	38	EA	-	-	-	150	5,700	Includes duplicates
Explosives	38	EA	-	-	-	145	5,510	Includes duplicates
SUBTOTAL							11,210	
Prime Contractor Overhead						15.0%	1,682	Applies to subcontract only
SUBTOTAL							29,221	
Prime Contractor Profit						10.0%	2,223	Applies to labor and subcontract only
TOTAL COST							**$31,444**	
						OR	$898	/monitoring well

Source of Cost Data:

Previous experience with sampling at IAAAP in 2003. RSMeans 2003, Environmental Remediation Cost Data, 9th Annual Edition.

Cost Adjustment Checklist:

	FACTOR:	NOTES:
✓	H&S Productivity (labor & equip only)	Level D
✓	Escalation to Base Year	Current year (2003) is base year
✓	Area Cost Factor	0.86, based on area code (RSMeans data only)
✓	Subcontractor Overhead and Profit	Included in cost
✓	Prime Contractor Overhead and Profit	Includes 15% overhead and 10% profit

Capital Cost Sub-Element
FOCUSED EXTRACTION WELL INSTALLATION AND DEVELOPMENT

COST WORKSHEET

Site: Off-Site Groundwater
Location: IAAAP Middletown, Iowa
Phase: Feasibility Study (-30% to +50%)
Base Year: 2003

Prepared By: DRH **Date:** 6/9/03
Checked By: JMR **Date:** 6/9/03

Work Statement:

Install and develop 3 intermediate depth (60-foot) groundwater extraction wells (6 days total drilling time). Installation includes drilling with mud rotary equipment, installation of 6-inch stainless steel riser and screen, vault construction, and submersible pump installation.

Cost Analysis:

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	NOTES
Field Oversight Labor								
Field preparation	8	HR	43	-	-	43	344	$43/hr tech
Digging permits	8	HR	43	-	-	43	344	$43/hr tech
Drilling Oversight / Development	85	HR	113	-	-	113	9605	$70/hr geo + $43/hr tech, Inc.trav. time
Pump Install Oversight	15	HR	70	-	-	70	1050	$70/hr geo
SUBTOTAL							11,343	
Supplies, Rental, and Travel								
PPE/Decon/Misc.Supplies	1	EA	-	-	150	150	150	
Horiba U-10	2	DAY	-	21	-	21	42	Development
Submersible Pump	2	DAY	-	0	-	63	126	2" dia.
Polyethylene Tubing	70	LF	-	-	0.25	0.25	18	
Water Level Probe	9	DAY	-	40	-	40	360	
Minirae PID	9	DAY	-	35	-	35	315	
Oversight Per Diem (2 person crew)	9	DAY	-	-	-	170	1530	($30+$55)x2
Mileage	1100	MI	-	-	-	0.36	396	800mi mob/demob + 50 mi/day x 9 days
SUBTOTAL							2,937	
G&A Markup						5.0%	147	
SUBTOTAL							3,083	
Subcontract Drilling								
Drillers Mob/demob	1	LS	-	-	-	1000	1000	
Drillers Per Diem (3 man crew)	6	DAY	-	-	-	150	900	2 days per well
Install Temp. Decon Pads	1	EA	-	-	-	200	200	
Overburden Drilling	180	LF	-	-	-	57.5	10350	10 " dia. mud rotary
6" SS Riser	144	LF	-	-	-	181	26064	10 ' sections
6" SS Screen	30	LF	-	-	-	188	5640	10 ' sections
Filter Pack Sand	36	LF	-	-	-	23	828	12 ', #2 Morie silica
Bentonite Seal	3	EA	-	-	-	33.5	101	3/8" chips
Vault Completions/Protective Cover	3	EA	-	-	-	750	2250	
55 Gal Drums Filled and Staged	30	EA	-	-	-	65	1950	Cuttings & fluids
Offsite Transport of IDW	1	LS	-	-	-	495	495	Subcontract disposal service
Offsite Disposal of IDW	30	EA	-	-	-	45	1350	Subcontract disposal service
SUBTOTAL							51,128	
Subcontract Pump Installation	3	EA	500	3212	-	3712	11,136	4" Dia.,96-200gpm, 5 hp
Prime Contractor Overhead						15.0%	9,340	Applies to subcontract only
SUBTOTAL							86,029	
Prime Contractor Profit						10.0%	7,361	Applies to labor and subcontract only
TOTAL COST							**$93,390**	
						OR	$31,130	/extraction well

Source of Cost Data:
Previous experience with drilling in 2003. RSMeans 2003. Environmental Remediation Cost Data, 9th Annual Edition.

Cost Adjustment Checklist:

	FACTOR:	NOTES:
✓	H&S Productivity (labor & equip only)	Level D
✓	Escalation to Base Year	Current year (2003) is base year
✓	Area Cost Factor	0.86, based on area code (RSMeans data only)
✓	Subcontractor Overhead and Profit	Included in cost
✓	Prime Contractor Overhead and Profit	Includes 15% overhead and 10% profit

Capital Cost Sub-Element

FOCUSED TREATMENT SYSTEM PUMPS/PIPING/CONTROLS/ELECTRICAL

COST WORKSHEET

Site: Off-Site Groundwater
Location: IAAAP Middletown, Iowa
Phase: Feasibility Study (-30% to +50%)
Base Year: 2003

Prepared By: DRH **Date:** 6/9/03
Checked By: JMR **Date:** 6/9/03

Work Statement:

Subcontractors to supply and install piping, metering, electirical, and controls hookup in GAC treatment facility. Assumes two influent lines and one effluent line.

Cost Analysis:

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	NOTES
Exterior Pipe Installed								
Equipment Mob/demob	1	LS	-	-	-	1000	1000	
Trenching	304	CY	-	-	-	4	1216	1' W x 4' D x 2,050'L
4" HDPE	1600	LF	-	-	-	3	4800	To treatment facility
6" HDPE	450	LF	-	-	-	4.75	2138	Discharge from treatment facility
SUBTOTAL							9,154	
Process Pumps Installed								
Transfer Pump, 20 hp, 450gpm	1	EA	-	-	-	3763	3763	
Backwash Pump, 25 hp, 1,000gpm	1	EA	-	-	-	5583	5583	
Solids Pump, 1.5 hp, 50gpm	1	EA	-	-	-	2886	2886	
SUBTOTAL							12,232	
Interior Process Pipe Installed								
4" Class 200 PVC	40	LF	-	-	-	7	280	Includes fittings
6" Class 200 PVC	100	LF	-	-	-	10	1000	Includes fittings
SUBTOTAL							1,280	
Valves and Meters Installed								
4" Check Valve	3	EA	-	-	-	260	780	
4" Ball Valve	2	EA	-	-	-	220	440	
6" Ball Valve	6	EA	-	-	-	300	1800	
Air Release/Vacuum Valve	1	EA	-	-	-	400	400	
Flow Meters	8	EA	-	-	-	500	4000	
Pressure Meters	12	EA	-	-	-	250	3000	
SUBTOTAL							10,420	
Electrical Hookup	1	LS	-	-	-	20000	20,000	Includes controls, process, building
SUBTOTAL 1							53,086	
Prime Contractor Overhead						15.0%	7,963	Applies to all
SUBTOTAL 2							61,048	
Prime Contractor Profit						10.0%	6,105	
TOTAL COST							**$67,153**	

Source of Cost Data:
RSMeans 2003. Environmental Remediation Cost Data, 9th Annual Edition.

Cost Adjustment Checklist:

	FACTOR:	NOTES:
✓	H&S Productivity (labor & equip only)	Level D
✓	Escalation to Base Year	Current year (2003) is base year
✓	Area Cost Factor	0.86, based on area code (RSMeans data only)
✓	Subcontractor Overhead and Profit	Included in cost
✓	Prime Contractor Overhead and Profit	Includes 15% overhead and 10% profit

Capital Cost Sub-Element
ENHANCED DEGRADATION BARRIER INSTALLATION

COST WORKSHEET

Site: Off-Site Groundwater
Location: IAAAP Middletown, Iowa
Phase: Feasibility Study (-30% to +50%)
Base Year: 2003

Prepared By: DRH
Date: 6/9/03

Checked By: JMR
Date: 6/9/03

Work Statement:

Work involves introducing an enhanced biodegradation substrate (actual substrate will be determined by pilot test) into the contaminant plume using direct push injection methods. Three barriers would cross the hot spot area, running perpendicular to the direction of groundwater flow. Each barrier will be positioned to intercept one-third of the hot spot plume as it migrates. The barriers will consist of 240 points each. All points will be spaced on 10-foot centers to an average depth of 60 feet. Prices are based on Regenesis HRC Grid Design Software Version 1. Estimated 44 Days to complete using two direct push rigs. Costs reflect one-time application only.

Cost Analysis:

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	NOTES
Field Oversight Labor								
Field preparation	8	HR	43	-	-	43	344	$43/hr tech
Digging permits	8	HR	43	-	-	43	344	$43/hr tech
Oversight	440	HR	140	-	-	140	61,600	2 x $70/hr geo/engineer
SUBTOTAL							62,288	
Supplies, Rental, and Travel								
Field Office Rental	1.5	MO	-	-	-	500	750	
Minirae PID	44	DAY	-	35	-	35	1540	
PPE/ H&S Setups	1	LS	-	250	-	250	250	
Oversight Per Diem	44	DAY	-	-	-	170	7480	($30+$55)x2
Mileage	3000	MI	-	-	-	0.36	1,080	800mi mob/demob + 50 mi/day x 44 days
HRC Product	57,600	LB	-	-	5.0	5	288,000	See HRC barrier design sheet
HRC Tax	1	LS	-	-	-	5.0%	14,400	
HRC Shipping	1	LS	-	-	-	11520	11,520	
SUBTOTAL							325,020	
G&A Markup						5.0%	16,251	
SUBTOTAL							341,271	
Subcontract Direct Push Services								
Mob/demob	2	LS	-	-	-	1000	2,000	2 rigs & 2 crews
Direct Push	44	DAY	-	-	-	3000	132,000	$1500 / day / rig
SUBTOTAL							134,000	
Prime Contractor Overhead						15.0%	20,100	Applies to subcontact only
SUBTOTAL							557,659	
Prime Contractor Profit						10.0%	19,629	Applies to labor and subcontact only
TOTAL UNIT COST							**$577,288**	Per application

Source of Cost Data:

Regenesis HRC Barrier Design Version 1 and cost information from Regenesis sales rep.

Cost Adjustment Checklist:

	FACTOR:	NOTES:
✓	H&S Productivity (labor & equip only)	Level D
✓	Escalation to Base Year	Current year (2003) is base year
✓	Area Cost Factor	Used local sales tax and delivery rate
✓	Subcontractor Overhead and Profit	Included in cost
✓	Prime Contractor Overhead and Profit	Includes 15% overhead and 10% profit

Capital Cost Sub-Element

TOTAL GW REST. EXTRACTION WELL INSTALLATION AND DEVELOPMENT

COST WORKSHEET

Site: Off-Site Groundwater
Location: IAAAP Middletown, Iowa
Phase: Feasibility Study (-30% to +50%)
Base Year: 2003

Prepared By: DRH **Date:** 6/9/03
Checked By: JMR **Date:** 6/9/03

Work Statement:

Install and develop 13 intermediate depth (60-foot) groundwater extraction wells. Installation includes drilling w/ mud rotary equipment , installation of 6-inch stainless steel riser and screen, vault construction, and submersible pump installation (40 days to complete).

Cost Analysis:

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	NOTES
Field Oversight Labor								
Field preparation	8	HR	43	-	-	43	344	$43/hr tech
Digging permits	8	HR	43	-	-	43	344	$43/hr tech
Drilling Oversight / Development	330	HR	113	-	-	113	37290	Inc. 10 hr trav. + 32, 10 hr days
Pump Install Oversight	70	HR	70	-	-	70	4900	$70/hr geo
SUBTOTAL							42,878	
Supplies, Rental, and Travel								
Field Office Rental	1.5	MO	-	-	-	500	750	
PPE/Decon/Misc.Supplies	1	EA	-	-	300	300	300	
Horiba U-10	6	DAY	-	21	-	21	126	development, 2 wells per day
Submersible Pump	6	DAY	-	0	-	63	378	2" OD
Polyethylene Tubing	70	LF	-	-	0.25	0.25	18	
Water Level Probe	40	DAY	-	40	-	40	1,600	
Minirae PID	40	DAY	-	35	-	35	1400	
Oversight Per Diem (2 person crew)	40	DAY	-	-	-	170	6800	(($30+$55)x2) inst. well, dev., inst. pumps
Mileage	2800	MI	-	-	-	0.36	1,008	800mi mob/demob + 50 mi/day x 40 days
SUBTOTAL							12,380	
G&A Markup						5.0%	619	
SUBTOTAL							12,998	
Subcontract Drilling								
Drillers Mob/demob	1	LS	-	-	-	1000	1000	
Drillers Per Diem (3 man crew)	26	DAY	-	-	-	150	3900	2 days per well
Install Temp. Decon Pads	2	EA	-	-	-	200	400	
Overburden Drilling	780	LF	-	-	-	57.5	44850	10 " dia. mud rotary
6" SS riser	650	LF	-	-	-	181	117650	10 ' sections installed
6" SS screen	130	LF	-	-	-	188	24440	10 ' sections installed
Filter pack sand	156	LF	-	-	-	23	3588	12 ', #2 Morie silica
Bentonite seal	13	EA	-	-	-	33.5	436	3/8" chips
Vault Completions/Protective Cover	13	EA	-	-	-	750	9750	
55 gal drums filled and staged	130	EA	-	-	-	65	8450	Cuttings & fluids
Offsite Transport of IDW	4	LS	-	-	-	495	1980	Subcontract disposal service
Offsite Disposal of IDW	130	EA	-	-	-	45	5850	Subcontract disposal service
SUBTOTAL							222,294	
Subcontract Pump Installation	13	EA	500	3212	-	3712	48,256	4" Dia.,96-200gpm, 5 hp
Prime Contractor Overhead						15.0%	47,014	Applies to subcontract only
SUBTOTAL							373,440	
Prime Contractor Profit						10.0%	26,517	Applies to labor and subcontract only
TOTAL UNIT COST							**$399,957**	
						OR	$30,766	/extraction well

Source of Cost Data:

Previous experience with drilling in 2003. RSMeans 2003, Environmental Remediation Cost Data, 9th Annual Edition.

Cost Adjustment Checklist:

	FACTOR:	NOTES:
✓	H&S Productivity (labor & equip only)	Level D
✓	Escalation to Base Year	Current year (2003) is base year
✓	Area Cost Factor	0.86, based on area code (RSMeans data only)
✓	Subcontractor Overhead and Profit	Included in cost
✓	Prime Contractor Overhead and Profit	Includes 15% overhead and 10% profit

Capital Cost Sub-Element
TOT. GW REST TREATMENT SYSTEM PUMPS / PIPING / CONTROLS / ELECTRICAL

COST WORKSHEET

Site: Off-Site Groundwater
Location: IAAAP Middletown, Iowa
Phase: Feasibility Study (-30% to +50%)
Base Year: 2003

Prepared By: DRH **Date:** 6/9/03
Checked By: JMR **Date:** 6/9/03

Work Statement:

Subcontractors to supply and install piping , metering , electirical and controls hookup in northern and southern treatment buildings. Assumes 2 influent lines and one effluent line for the northern treatment building. One influent and one effluent line for the southern treatment building.

Cost Analysis:

DESCRIPTION	QTY	UNIT	LABOR	EQUIP	MTRL	UNIT TOTAL	TOTAL	NOTES
Exterior Pipe								
Equipment Mob/demob	1	LS	-	-	-	1000	1000	
Trenching	1,030	CY	-	-	-	4	4120	1' W x 4' D x 6,950'L
4" HDPE	1,800	LF	-	-	-	3	5400	Influent only
6" HDPE	1,300	LF	-	-	-	4.75	6175	Influent, and south discharge
8" HDPE	750	LF	-	-	-	6.71	5033	Influent, and north discharge
SUBTOTAL							21,728	
Process Pumps Installed (Northern System)								
Transfer Pump, 20 hp, 500gpm	3	EA	-	-	-	3763	11289	
Backwash Pump, 25 hp, 1,000gpm	1	EA	-	-	-	5583	5583	
Solids Pump, 1.5 hp, 50gpm	1	EA	-	-	-	2886	2886	
Return Pump, 1.5 hp, 50gpm	1	EA	-	-	-	2886	2886	
SUBTOTAL							22,644	
Process Pumps Installed (Southern System)								
Transfer Pump, 20 hp, 600gpm	1	EA	-	-	-	3763	3763	
Backwash Pump, 25 hp, 700gpm	1	EA	-	-	-	4649	4649	
Solids Pump, 1.5 hp, 50gpm	1	EA	-	-	-	2886	2886	
Return Pump, 1.5 hp, 50gpm	1	EA	-	-	-	2886	2886	
Discharge Pump, 20 hp, 600gpm	1	EA	-	-	-	4355	4355	
SUBTOTAL							18,539	
Interior Process Pipe Installed (Combined)								
4" Class 200 PVC	50	LF	-	-	-	7	350	Includes fittings
6" Class 200 PVC	400	LF	-	-	-	10	4000	Includes fittings
8" Class 200 PVC	30	LF	-	-	-	11.3	339	Includes fittings
SUBTOTAL							4,689	
Valves and Meters Installed (Combined)								
4" Check Valve	7	EA	-	-	-	260	1820	
6" Check Valve	3	EA	-	-	-	300	900	
8" Check Valve	2	EA	-	-	-	400	800	
4" Ball Valve	4	EA	-	-	-	220	880	
6" Ball Valve	20	EA	-	-	-	300	6000	
8" Ball Valve	6	EA	-	-	-	300	1800	
Air Release/Vacuum Valve	1	EA	-	-	-	500	500	
Flow Meters	20	EA	-	-	-	500	10000	
Pressure Meters	20	EA	-	-	-	250	5000	
SUBTOTAL							27,700	
Electrical Hookup	1	LS	-	-	-	40000	40,000	Includes controls, process, building
SUBTOTAL 1							135,300	
Prime Contractor Overhead						15.0%	20,295	Applies to all
SUBTOTAL 2							155,594	
Prime Contractor Profit						10.0%	15,559	
TOTAL COST							**$171,154**	

Source of Cost Data:
RSMeans 2003, Environmental Remediation Cost Data, 9th Annual Edition.

Cost Adjustment Checklist:

	FACTOR:	NOTES:
✓	H&S Productivity (labor & equip only)	Level D
✓	Escalation to Base Year	Current year (2003) is base year
✓	Area Cost Factor	0.86, based on area code (RSMeans data only)
✓	Subcontractor Overhead and Profit	Included in cost
✓	Prime Contractor Overhead and Profit	Includes 15% overhead and 10% profit

This appendix presents a limited number of alternatives that could be used, on a non-source control basis, to address Brush Creek surface water contaminated with RDX that is a continuing source of contamination to Off-Site groundwater downstream of IAAAP. These measures have been developed only conceptually and are based on limited information. They are provided for discussion purposes only. More information is needed to better define and fully evaluate these alternatives, as well as to develop other alternatives that provide a full range of GRAs to address Brush Creek surface water.

Characteristics of Brush Creek Surface Water

Based on observation of flow conditions in Brush Creek, the following assumptions or estimations were made:

- The base flow in Brush Creek near the plant boundary is estimated to be about 2 cfs (approximately 900 gpm), based on cross-section dimensions and velocity measurements made in April 2003.
- Brush Creek becomes a losing stream beginning about 1,300 feet north of Highway 61, extending south approximately one mile.
- The water in the creek has elevated turbidity following storm events.

The interpreted extent of RDX in Brush Creek is based on analytical data from surface water samples collected in May 2002 (URS 2003) and November 2002 (HGL 2003). Off-Site surface water sampling results indicated the following:

- RDX contamination is transported via surface water in Brush Creek from the IAAAP facility boundary through the Off-Site area to the Skunk River. The highest Off-Site surface water concentrations are located near the IAAAP boundary and decline downstream to the southeast, near the Skunk River.
- Surface water samples collected during higher-than-normal flow conditions showed slightly elevated RDX concentrations (maximum of 22 µg/L, May 2002) compared to concentrations in samples collected during more normal flow conditions (maximum of 7.6 µg/L, November 2002).

Alternative 1 – Impermeable Channel Liner

Alternative 1 consists of installing an impermeable liner along the Brush Creek channel, from where the creek becomes a losing stream to its confluence with Skunk River, to prevent contaminated surface water from infiltrating to Off-Site groundwater.

During construction, surface water would be temporarily diverted to provide access. Beginning at the downstream end of the reach, the channel would be cleared of vegetation, excavated, and re-graded to prepare a uniform surface on which to install a 40-mL high-density polyethylene (HDPE) or equivalent geomembrane liner underlain by geotextile. The natural channel shape and geometry would be maintained to ensure stream stability. Liner installation would consist of placing multiple segments of geomembrane across the channel, perpendicular to the direction of flow. Each segment would overlap the previous segment and be heat-welded to form a continuous barrier. The liner ends would be held in place by anchor trenches on both sides of and parallel to the channel. A protective layer (geotextile fabric and stone) would be placed on the liner to help hold it in position. The liner would need to be designed to withstand shear forces within the channel during high flow events.

The results of regular surface water and groundwater monitoring would be used to help assess the performance of the liner. Monitoring and periodic liner maintenance would continue for as long as RDX in surface water is above the groundwater PRG.

Alternative 2 – Constructed Wetlands

Alternative 2 consists of constructing a series of wetlands within the Brush Creek channel (on-post) to intercept and treat contaminated surface water (base flow of 2 cfs or 900 gpm) before it flows downstream and enters the Off-Site groundwater. Peak flows from storm events would be allowed to bypass.

The Brush Creek channel would be widened and re-graded to create a series of wetland cells. A detention/sedimentation basin would be constructed upstream of the wetland cells to regulate flow rates through the wetlands and remove those particles that can settle from the surface water prior to treatment. This is expected to increase the overall effectiveness of the system by reducing turbidity and removing RDX that may be adsorbed to sediment particles. Natural treatment processes would include sedimentation, ultraviolet (UV) photolysis, and phytoremediation. The system's effectiveness would be limited during cold weather.

Surface water monitoring would be used to evaluate the system's effectiveness. Monitoring and periodic maintenance activities would continue for as long as RDX in surface water upstream of the wetlands is above the groundwater PRG.

Alternative 3 – Treatment Facility

Alternative 3 consists of diverting contaminated surface water (base flow of 900 gpm) from Brush Creek (on-post) to a facility for treatment by GAC. Treated water would be returned to the Brush Creek channel. Peak flows from storm events would be allowed to bypass.

A sedimentation basin would be constructed to reduce suspended solids content of the surface water prior to treatment, aided possibly by the addition of flocculants. Water would be pumped from the basin and treated using an appropriately sized GAC system. The frequency of carbon change-out and system backwash activities would depend on influent RDX concentrations, influent geochemistry, and the overall effectiveness of the pretreatment system.

Influent and effluent monitoring would be used to evaluate the system's effectiveness. Monitoring and periodic maintenance activities would continue for as long as RDX in surface water upstream of the point of diversion to the treatment facility is above the groundwater PRG.

Effectiveness

The effectiveness of the preceding alternatives at preventing RDX-contaminated surface water from entering Off-Site groundwater is discussed below:

Alternative 1

Alternative 1 would prevent RDX-contaminated surface water from entering the groundwater by retarding infiltration. Contaminated surface water would remain in the channel and be carried downstream.

Alternative 2

Alternative 2 would degrade RDX in Brush Creek surface water on-post through natural treatment processes and detain RDX adsorbed to settleable particles upstream of Off-Site groundwater. The system's effectiveness would be limited during high flow conditions and cold weather. The system could potentially be designed to treat higher flows, pending the results of further hydrologic and hydraulic analysis. Peak flows from storm events would still be allowed to bypass.

Alternative 3

Alternative 3 would remove RDX from surface water in Brush Creek on-post, treat through adsorption, and detain RDX adsorbed to settleable particles upstream of Off-Site groundwater. The system's effectiveness would be limited during high flow conditions. As with Alternative 2, the system could potentially be designed to treat higher flows, but at a greater cost.

Results of Groundwater and Surface Water Sampling and Analysis for Depleted Uranium Conducted by FUSRAP, November 2003

Results of the Iowa Army Ammunition Plant (IAAAP) ER,A Off Post Ground Water and Surface Water sampling for Radioactive Materials, Specifically Depleted Uranium (DU)

The St. Louis District Corps of Engineers Formerly Utilized Sites Remedial Action Program (FUSRAP) analyzed forty (40) off-post ground water and surface water samples taken by the ER,A contractor during November 2003. The samples were collected in accordance with the contractor's approved procedures and sent to the St. Louis FUSRAP Laboratory for analysis in accordance with the FUSRAP Laboratory approved Quality Assurance Project Plan (QAPP) and the Sampling and Analysis Guide (SAG). The samples were analyzed for total uranium by Kinetic Phosphorescence Analysis (KPA) and for isotopic uranium, specifically uranium-238 (^{238}U), uranium-234 (^{234}U), and uranium-235 (^{235}U) measurement via alpha spectroscopy. Depleted uranium (DU) is primarily ^{238}U.

KPA analysis is used to measure total uranium in the water sample by employing a pulse laser to phosphoresce the sample. The detector system quantifies the photons produced over a series of time gates and compares to known standards. A final total uranium concentration is provided, along with uncertainty and a Minimal Detectable Concentration (MDC) value. The standard operating procedure (SOP) for this method is kept within the FUSRAP Laboratory Procedures Manual, ML-021, Rev. 1, Operation of The Kinetic Phosphorescence Analyzer. This method follows the guidance of ASTM, D5174-97.

Isotopic uranium analysis was conducted using sample dissolution and chemical separation techniques, along with alpha spectroscopy. The method used follows the fluoride fusion technique developed by Claude Sill in Radioactivity and Radiochemistry, Volume 11, No. 3 (1974). The SOPs used for isotopic uranium determination are found in FUSRAP Laboratory Procedures Manual, ML-015, ML-001, ML-004, and associated quality assurance procedures. The methods employed have proven to be consistent and accurate through multiple performance evaluation studies conducted by Department of Energy's Environmental Measurements Laboratory (EML) the Mixed Analyte Performance Evaluation Program (MAPEP).

Data produced was compiled using FUSRAP Laboratory Procedures Manual ML-014. Results were presented in hardcopy known as a Sample Delivery Group (SDG), containing raw data; custody records, calibration results, and summarized values. All results were reviewed and verified by laboratory management and independently validated. The SDG provides the necessary information to convert raw data to the final result calculation.

In summary, of the forty samples collected, fourteen had a result that was greater than the Minimum Detectable Concentration (MDC) of the analyses. The highest result was 4.4 picocuries per liter (pCi/L) of uranium-234 (^{234}U). The MDC for Total Uranium (TotalU), which was not reached by any sample, was 4.6 pCi/ L. The results of the analyses are presented in Table 1.

An analysis of the data shows that there are low concentrations of the three most prevalent isotopes of uranium present in the waters sampled by the ER,A contractor at the IAAAP. The accepted percentages of the three isotopes for natural uranium are; 0.7 percent uranium-235, 99.3 percent uranium-238, and a trace of uranium-234 by weight. In terms of the amount of radioactivity, it contains approximately 2.2 percent uranium-235, 48.6 percent uranium-238, and 49.2 percent uranium-234. The data supports the conclusion that the uranium detected was naturally occurring rather than DU in that the isotopic ratios are not consistent with those expected of DU.

Table 1 Results of Analyses

Sample ID	Analyte	Result	Error	Units	MDC	Instrument
MW136	TotalU	ND	0.04	pCi/L	4.65	KPA
MW136	U-234	ND	0.71	pCi/L	1.65	AlphaSpec
MW136	U-235	ND	0.28	pCi/L	1.66	AlphaSpec
MW136	U-238	ND	0.75	pCi/L	2.54	AlphaSpec
MW303	TotalU	ND	0.04	pCi/L	4.65	KPA
MW303	U-234	ND	0.65	pCi/L	0.62	AlphaSpec
MW303	U-235	ND	0.57	pCi/L	0.77	AlphaSpec
MW303	U-238	ND	0.00	pCi/L	0.62	AlphaSpec
MW304	TotalU	ND	0.03	pCi/L	4.65	KPA
MW304	U-234	ND	0.84	pCi/L	1.39	AlphaSpec
MW304	U-235	ND	0.29	pCi/L	1.72	AlphaSpec
MW304	U-238	1.50	1.27	pCi/L	1.39	AlphaSpec
MW304S	TotalU	ND	0.04	pCi/L	4.65	KPA
MW304S	U-234	ND	0.52	pCi/L	0.70	AlphaSpec
MW304S	U-235	ND	0.00	pCi/L	0.87	AlphaSpec
MW304S	U-238	ND	0.52	pCi/L	0.70	AlphaSpec
MW501	TotalU	ND	0.06	pCi/L	4.65	KPA
MW501	U-234	ND	0.50	pCi/L	1.34	AlphaSpec
MW501	U-235	ND	0.00	pCi/L	0.74	AlphaSpec
MW501	U-238	ND	0.00	pCi/L	0.60	AlphaSpec
MW502	TotalU	ND	0.03	pCi/L	4.65	KPA
MW502	U-234	ND	1.06	pCi/L	1.76	AlphaSpec
MW502	U-235	ND	0.73	pCi/L	0.98	AlphaSpec
MW502	U-238	ND	0.00	pCi/L	0.79	AlphaSpec
MW509	TotalU	ND	0.04	pCi/L	4.65	KPA
MW509	U-234	ND	0.73	pCi/L	0.69	AlphaSpec
MW509	U-235	ND	0.63	pCi/L	0.85	AlphaSpec
MW509	U-238	ND	0.51	pCi/L	0.69	AlphaSpec
MW509D	TotalU	ND	0.07	pCi/L	4.65	KPA
MW509D	U-234	2.97	1.72	pCi/L	0.62	AlphaSpec
MW509D	U-235	ND	0.63	pCi/L	1.69	AlphaSpec
MW509D	U-238	2.50	1.57	pCi/L	0.62	AlphaSpec
MW513	TotalU	ND	0.07	pCi/L	4.65	KPA
MW513	U-234	1.4	1.15	pCi/L	0.63	AlphaSpec
MW513	U-235	ND	0.29	pCi/L	1.71	AlphaSpec
MW513	U-238	ND	0.51	pCi/L	1.38	AlphaSpec
MW515	TotalU	ND	0.03	pCi/L	4.65	KPA
MW515	U-234	2.23	1.46	pCi/L	0.60	AlphaSpec
MW515	U-235	ND	0.83	pCi/L	1.65	AlphaSpec
MW515	U-238	2.00	1.37	pCi/L	0.60	AlphaSpec
MW516	TotalU	ND	0.06	pCi/L	4.65	KPA
MW516	U-234	ND	0.59	pCi/L	1.77	AlphaSpec
MW516	U-235	ND	0.00	pCi/L	0.81	AlphaSpec
MW516	U-238	ND	0.00	pCi/L	0.65	AlphaSpec

Sample ID	Analyte	Result	Error	Units	MDC	Instrument
MW517	TotalU	ND	0.03	pCi/L	4.64	KPA
MW517	U-234	ND	0.00	pCi/L	0.68	AlphaSpec
MW517	U-235	ND	0.00	pCi/L	0.84	AlphaSpec
MW517	U-238	ND	0.50	pCi/L	0.68	AlphaSpec
MW407	TotalU	ND	0.05	pCi/L	4.65	KPA
MW407	U-234	ND	0.81	pCi/L	1.33	AlphaSpec
MW407	U-235	ND	0.00	pCi/L	0.74	AlphaSpec
MW407	U-238	ND	0.92	pCi/L	1.33	AlphaSpec
MW502S	TotalU	ND	0.09	pCi/L	4.64	KPA
MW502S	U-234	2.31	1.53	pCi/L	1.55	AlphaSpec
MW502S	U-235	ND	0.26	pCi/L	1.55	AlphaSpec
MW502S	U-238	ND	1.45	pCi/L	2.38	AlphaSpec
MW117	TotalU	ND	0.04	pCi/L	4.65	KPA
MW117	U-234	ND	0.00	pCi/L	0.55	AlphaSpec
MW117	U-235	ND	0.25	pCi/L	1.50	AlphaSpec
MW117	U-238	ND	0.45	pCi/L	1.21	AlphaSpec
MW117D	TotalU	ND	0.03	pCi/L	4.65	KPA
MW117D	U-234	ND	0.67	pCi/L	0.64	AlphaSpec
MW117D	U-235	ND	0.29	pCi/L	1.75	AlphaSpec
MW117D	U-238	ND	0.67	pCi/L	0.64	AlphaSpec
MW117S	TotalU	ND	0.04	pCi/L	4.65	KPA
MW117S	U-234	ND	0.70	pCi/L	2.10	AlphaSpec
MW117S	U-235	ND	0.00	pCi/L	0.95	AlphaSpec
MW117S	U-238	ND	0.57	pCi/L	0.77	AlphaSpec
MW121	TotalU	ND	0.03	pCi/L	4.65	KPA
MW121	U-234	1.70	1.32	pCi/L	0.66	AlphaSpec
MW121	U-235	ND	0.00	pCi/L	0.81	AlphaSpec
MW121	U-238	1.70	1.31	pCi/L	0.66	AlphaSpec
MW123	TotalU	ND	0.04	pCi/L	4.65	KPA
MW123	U-234	ND	0.99	pCi/L	1.28	AlphaSpec
MW123	U-235	ND	0.00	pCi/L	0.71	AlphaSpec
MW123	U-238	0.85	0.86	pCi/L	0.58	AlphaSpec
MW125	TotalU	ND	0.07	pCi/L	4.65	KPA
MW125	U-234	ND	0.60	pCi/L	1.89	AlphaSpec
MW125	U-235	ND	0.00	pCi/L	0.75	AlphaSpec
MW125	U-238	ND	0.00	pCi/L	0.61	AlphaSpec
MW307	TotalU	ND	0.05	pCi/L	4.65	KPA
MW307	U-234	ND	0.92	pCi/L	1.84	AlphaSpec
MW307	U-235	ND	0.00	pCi/L	1.02	AlphaSpec
MW307	U-238	ND	0.97	pCi/L	2.24	AlphaSpec
MW309	TotalU	ND	0.05	pCi/L	4.65	KPA
MW309	U-234	ND	1.03	pCi/L	1.78	AlphaSpec
MW309	U-235	ND	0.30	pCi/L	1.79	AlphaSpec
MW309	U-238	ND	0.93	pCi/L	2.74	AlphaSpec

Sample ID	Analyte	Result	Error	Units	MDC	Instrument
MW408	TotalU	ND	0.04	pCi/L	4.65	KPA
MW408	U-234	4.41	3.30	pCi/L	1.49	AlphaSpec
MW408	U-235	ND	0.00	pCi/L	1.84	AlphaSpec
MW408	U-238	3.29	2.81	pCi/L	1.49	AlphaSpec
MW505	TotalU	ND	0.02	pCi/L	4.65	KPA
MW505	U-234	ND	0.49	pCi/L	1.32	AlphaSpec
MW505	U-235	ND	0.81	pCi/L	1.62	AlphaSpec
MW505	U-238	ND	0.22	pCi/L	1.31	AlphaSpec
MW510	TotalU	ND	0.04	pCi/L	4.65	KPA
MW510	U-234	ND	0.51	pCi/L	0.69	AlphaSpec
MW510	U-235	ND	0.00	pCi/L	0.85	AlphaSpec
MW510	U-238	ND	0.51	pCi/L	0.69	AlphaSpec
MW511	TotalU	ND	0.07	pCi/L	4.65	KPA
MW511	U-234	2.12	1.79	pCi/L	0.96	AlphaSpec
MW511	U-235	ND	0.00	pCi/L	1.18	AlphaSpec
MW511	U-238	ND	0.86	pCi/L	2.59	AlphaSpec
MW514	TotalU	ND	0.04	pCi/L	4.65	KPA
MW514	U-234	ND	0.43	pCi/L	1.16	AlphaSpec
MW514	U-235	ND	0.00	pCi/L	0.64	AlphaSpec
MW514	U-238	ND	0.55	pCi/L	0.52	AlphaSpec
BC1	TotalU	ND	0.07	pCi/L	4.65	KPA
BC1	U-234	ND	0.67	pCi/L	0.90	AlphaSpec
BC1	U-235	ND	0.27	pCi/L	2.21	AlphaSpec
BC1	U-238	ND	0.70	pCi/L	1.78	AlphaSpec
BC2	TotalU	ND	0.04	pCi/L	4.65	KPA
BC2	U-234	ND	1.16	pCi/L	0.89	AlphaSpec
BC2	U-235	ND	0.27	pCi/L	2.19	AlphaSpec
BC2	U-238	ND	0.66	pCi/L	0.89	AlphaSpec
BC3	TotalU	ND	0.06	pCi/L	4.65	KPA
BC3	U-234	ND	0.86	pCi/L	1.88	AlphaSpec
BC3	U-235	ND	0.00	pCi/L	0.96	AlphaSpec
BC3	U-238	ND	1.01	pCi/L	0.78	AlphaSpec
BC4	TotalU	ND	0.10	pCi/L	4.65	KPA
BC4	U-234	ND	1.29	pCi/L	2.26	AlphaSpec
BC4	U-235	ND	0.76	pCi/L	1.02	AlphaSpec
BC4	U-238	1.53	1.39	pCi/L	0.83	AlphaSpec
BC5	TotalU	ND	0.09	pCi/L	4.65	KPA
BC5	U-234	ND	1.10	pCi/L	1.66	AlphaSpec
BC5	U-235	ND	0.00	pCi/L	1.03	AlphaSpec
BC5	U-238	ND	0.29	pCi/L	2.00	AlphaSpec
BC6	TotalU	ND	0.09	pCi/L	4.65	KPA
BC6	U-234	ND	1.47	pCi/L	2.30	AlphaSpec
BC6	U-235	ND	0.92	pCi/L	2.35	AlphaSpec
BC6	U-238	ND	1.37	pCi/L	3.46	AlphaSpec
BC7	TotalU	ND	0.09	pCi/L	4.65	KPA

Sample ID	Analyte	Result	Error	Units	MDC	Instrument
BC7	U-234	1.46	1.49	pCi/L	0.99	AlphaSpec
BC7	U-235	ND	0.00	pCi/L	1.22	AlphaSpec
BC7	U-238	ND	1.04	pCi/L	0.99	AlphaSpec
BCOFF1	TotalU	ND	0.07	pCi/L	4.65	KPA
BCOFF1	U-234	ND	1.21	pCi/L	1.83	AlphaSpec
BCOFF1	U-235	ND	0.28	pCi/L	2.26	AlphaSpec
BCOFF1	U-238	ND	1.39	pCi/L	1.82	Alpha Spec
BCOFF2	TotalU	ND	0.07	pCi/L	4.65	KPA
BCOFF2	U-234	1.01	1.18	pCi/L	0.91	AlphaSpec
BCOFF2	U-235	ND	0.00	pCi/L	1.12	AlphaSpec
BCOFF2	U-238	ND	0.96	pCi/L	0.91	AlphaSpec
BCOFF3	TotalU	ND	0.07	pCi/L	4.65	KPA
BCOFF3	U-234	ND	0.68	pCi/L	0.92	AlphaSpec
BCOFF3	U-235	ND	0.00	pCi/L	1.13	AlphaSpec
BCOFF3	U-238	ND	1.22	pCi/L	2.19	AlphaSpec
BCOFF4	TotalU	ND	0.11	pCi/L	4.65	KPA
BCOFF4	U-234	ND	1.28	pCi/L	2.35	AlphaSpec
BCOFF4	U-235	ND	0.00	pCi/L	1.46	AlphaSpec
BCOFF4	U-238	ND	0.87	pCi/L	1.18	AlphaSpec
BCOFF5	TotalU	ND	0.07	pCi/L	4.65	KPA
BCOFF5	U-234	ND	1.24	pCi/L	2.29	AlphaSpec
BCOFF5	U-235	ND	1.05	pCi/L	1.42	AlphaSpec
BCOFF5	U-238	1.27	1.49	pCi/L	1.14	AlphaSpec
MW409	TotalU	ND	0.06	pCi/L	4.65	KPA
MW409	U-234	ND	0.00	pCi/L	0.95	AlphaSpec
MW409	U-235	ND	0.00	pCi/L	1.18	AlphaSpec
MW409	U-238	ND	1.00	pCi/L	0.95	AlphaSpec

Note 1: Each of the results that were greater than the MDC, were given a validation code of 'J', an approximation. The results were deemed approximations due to the low amount of activity in the analysis aliquot and the final radionuclide sample concentration relative to statistical uncertainty.

Note 2: ND means that the resultant value was less than the MDC (Not Detected)

RESPONSE TO USEPA COMMENTS 16 APRIL 2004

URS RESPONSE TO USEPA COMMENTS
DRAFT FINAL OFF-SITE GROUNDWATER FEASIBILITY
STUDY (FS) REPORT
IOWA ARMY AMMUNITION PLANT

Comments by Scott Marquess, USEPA Project Manager, dated April 16, 2004.

General Comments

Comment 1. In the future, please provide a complete submittal of the draft final document. The "errata page" format is inconvenient and creates some inconsistencies in our filing and document retrieval system.

> **Response:** Comment noted. As discussed during the May 4, 2004 conference call, errata pages will be used for the next revision. Future submittals will consist of complete documents, where appropriate.

Comment 2. In future submittals, in responding to comments, it would be helpful to indicate how the text of the document is going to be changed in response to the comment. Further, if the Army were to provide "redline/strikeout" pages indicating revised text, it would help focus EPA's review of draft final submittals, and perhaps streamline the process, possibly lessening the potential for disputes to arise. In several instances, as identified below, it does not appear that the text has been revised consistent with the response to comment. Please consider this suggestion.

> **Response:** Agree. In future response to comment submittals, "*italics*" will be used to designate new text, and "~~strikethroughs~~" will be used to designate deleted text.

Comment 3. As noted in Specific Comment #41 on the draft FS, EPA indicated that the parties should have discussions regarding the process by which institutional controls would be documented, evaluated, and established in the remedy selection process. The Army agreed with this comment, however, unfortunately, we have not yet had substantive discussions on this matter. We therefore offer the following comments for your consideration and wish to discuss with you how best to address and integrate these concerns in the remedy selection process:

(3.a.) The Army should investigate governmental controls, such as zoning and groundwater overlay ordinances, to prevent new wells from being installed in contaminated areas for domestic use.

Response: Agree. As discussed during our May 4, 2004 conference call, the text will be revised in multiple locations within the Feasibility Study document:

1) Additional text will be added to Section 5.2, near the top of page 5-2. The last existing bullet is presented below, followed by the new text.

   - Residents of affected properties would be connected to municipal water or, if they cannot be connected, would be provided with at-well treatment systems to remove RDX from drinking water by granular activated carbon (GAC) adsorption. Treatment systems would include an appropriately sized carbon vessel, associated piping and metering, and appropriately sized shelter. Treated water would periodically be sampled for RDX concentrations to confirm system effectiveness.

   "Potential governmental controls (such as zoning and groundwater use restrictions) to prevent new water supply wells from being installed in contaminated areas for domestic use will be further investigated by the U.S. Army. The details of the controls, if implemented, will be described in detail during remedial design."

2) The embedded table on page 4-5 describing "General Response Actions" and "Representative Process Options" will also be revised to include the governmental and proprietary control process options presented below in *italics*:

General Response Action	Representative Process Option
No Action	No Action
Institutional Controls	*Zoning* *Local Permits* *Groundwater Use Restrictions* *Easements* Deed Notices Advisories Health and Safety Program

3) Table 4-1, page 1 of 5, the shading will be removed from the line titled “Zoning”. In addition, the text under the “Potentially Applicable” heading will be revised to say “*Yes*” for Zoning as shown below.

Response Action	Technology	Process Option	Description	Potentially Applicable?
No Action	None	None	Do nothing to achieve remedial action objectives.	Yes
Institutional Controls	Governmental Controls	Zoning	Zoning authority exercised by local governments to specify land use for certain areas.	~~No~~ *Yes*

4) Table 4-2, page 1 of 6, the shading will be removed from “Governmental Controls” and “Proprietary Controls”, and the text revised under the heading “Screening Comments” to say “*Retained*”. A line describing “Zoning” will also be added to the table as presented below.

Response Action	Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
No Action	None	None	Do nothing to achieve remedial action objectives.	The current site status would remain unchanged. May achieve remedial objectives after long period of time due to natural processes.	No action required.	No capital. No O&M.	Retained. Required for comparison with other alternatives.
Institutional Controls	Government Controls	*Zoning*	*Zoning authority exercised by local governments to specify land use for certain areas.*	*Limits potential exposures through legal restrictions on land use.*	*Survey and legal assistance required. Requires a single governmental entity with the ability to enforce.*	*Low capital.* *No O&M.*	*Retained.*
		Local Permits	Special permits outlining specific requirements before an activity can be authorized.	Effective for satisfying specific ARARs (e.g., surface water discharge requirements).	Readily implemented. Requires regulatory approval and periodic monitoring for compliance.	Low capital. Low O&M.	~~Not retained. May be required for certain remedial actions but not as an integral part of the remedy.~~ *Retained.*
		Groundwater Use Restrictions	Place restrictions to control future groundwater use.	Limits potential exposures through legal restrictions on groundwater use.	Survey and legal assistance required. Restricts future land use. *Requires a single governmental entity with the ability to enforce.*	Low capital. No O&M.	~~Not retained. Would not be able to legally enforce on private land and, therefore, not practical for the area in question.~~ *Retained.*

Response Action	Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Proprietary Controls	Easements	A property right conveyed by a landowner to another party which gives the second party rights with regard to the first party's land. An "affirmative" easement allows the holder to enter upon or use another's property for a particular purpose. A "negative" easement imposes limits on how the landowner can use his or her own property.	Allows access to specified areas of private property.	Survey and legal assistance required.	Low capital. No O&M.	~~Not retained. May be required for certain remedial actions but not as an integral part of the remedy.~~ *Retained.*

4) Section 8.2, page 8-1, first bullet – the text will be revised to read:

- *"*Filing deed notices, issuing local advisories, and implementing a worker health and safety program. Residents of properties would be provided with connection to municipal water or, if public water supply is not available, with at-well treatment systems to remove RDX in groundwater by carbon adsorption. *In addition, potential governmental controls to prevent new water supply wells from being installed in contaminated areas for domestic use will be further investigated by the U.S. Army. These controls may include zoning, local permits, and groundwater use restrictions.*"

(3.b.) It should be clarified that Institutional and Engineering controls are needed to prevent or restrict groundwater use or access until the cleanup levels are met. Language should be added to the remedy descriptions in the FS that reflect that "Land Use (Institutional/Engineering) Controls will be maintained until the concentration of RDX in the groundwater is at or below the HAL to allow for unrestricted use and exposure."

Response: Comment noted. As discussed during the May 4, 2004 conference call, this comment will be addressed in the Proposed Plan response to comments.

(3.c.) It is unclear how the Army will be able to include notices on the deeds of privately owned property without the consent of the property owner. How do you intend to implement this action?

Response: Comment noted. As discussed during the May 4, 2004 conference call, this comment will be addressed during remedial design.

(3.d.) Who will issue "local advisories" and how? How would the advisories be monitored and/or maintained? Please describe the mechanism for issuing such advisories.

Response: Comment noted. As discussed during the May 4, 2004 conference call, this comment will be addressed during remedial design.

(3.e.) A program for monitoring/identifying new groundwater use/users in the area should be developed as part of all remedies under consideration. EPA provided important information to serve as a starting point for such a monitoring program in the data base which was given to the Army several years ago.

Response: Comment noted. As discussed during the May 4, 2004 conference call, this comment will be addressed during remedial design.

(3.f.) Please indicate somewhere in the FS that "The U.S. Army is responsible for implementing, maintaining, reporting on, and enforcing the land use/institutional controls selected as part of the Preferred Alternative. The Army will present the results of monitoring the controls in regular Operations and Maintenance reports."

Response: Comment noted. As discussed during the May 4, 2004 conference call, the Record of Decision document will identify who is responsible for implementing, maintaining, monitoring, and enforcing the land use/institutional controls.

(3.g.) A commitment by the Army should be added to the FS to indicate that a Land Use Control (LUC) Remedial Design will be prepared to address the land use component of the remedy in the Remedial Design (RD). In accordance with the FFA schedule for the submittal of the RD, and as a component of the RD, the Army will prepare a LUC RD that shall identify the specific institutional controls and contain implementation and maintenance actions, including periodic inspections.

Response: Comment noted. As discussed during the May 4, 2004 conference call, this comment will be addressed in the Proposed Plan response to comments and in the ROD.

Specific Comments

Comment 1. **See EPA Specific Comment** #1 - AEC activities and COCs should be discussed, other COCs should be identified, and nearby/impacted residences should be identified.

Response: Comment noted. General information about AEC activities was previously added to Section 2.1. Given the fact that sampling results were below levels of concern, it is unclear what value providing more detail would provide.

Comment 2. **See EPA Specific Comment # 6** - Additional discussion should be provided in the text to indicate the nature of the radiological sampling/evaluation. Further, clarification should be provided to indicate that uranium was detected in off-site groundwater. A discussion of whether this uranium was determined to be a result of a release at the site, or from naturally occuring conditions, should be included.

> **Response:** Comment noted. As discussed during our May 4, 2004 conference call, Section 2.4 states that uranium was not detected above the MCL and refers to Appendix E, which states that detected uranium appears to be naturally occurring.

As previously noted, clarification should be provided regarding the COPCs for ecological risks. It has not yet been concluded that metals should be eliminated as a COPC for ecological concerns, which should be reflected in the text.

> **Response:** Comment noted. As discussed during our May 4, 2004 conference call, Section 2.4 deals with human-health risks, not ecological risks. As described in the original response, ecological risks related to Brush Creek are being assessed separately (by the U.S. Army under another contract).

Comment 3. **See EPA Specific Comment** #9 - As suggested in the comment, the text should reflect that the comparison to Region 9 PRGs does not reflect potential ecological concerns, and that eco-risk is still being evaluated.

> **Response:** Comment noted. No text change was suggested in the response to the original comment and no indication was given by the USEPA that the response was unacceptable. Therefore, no change was made.

Comment 4. **See EPA Specific Comment # 21** - The assumed concentration of RDX in surface water and the basis for that assumption should be identified.

> **Response:** Comment noted. This comment was resolved during the May 4, 2004 conference call discussions.

Comment 5. **See EPA Specific Comments #23 and #24** - In Table 4-2, Government and Proprietary Controls are eliminated from further consideration in the remedy, although they "may be required to meet ARARs," as indicated in the table. As discussed in the General Comments, EPA believes that a more thorough evaluation/discussion of potential institutional controls that may be useful to address site conditions is warranted. The FS includes little rationale supporting why these control options are eliminated. One option for proceeding may be to revise the draft final FS to include both Government and Proprietary controls as potential remedial options, and to further address these options in detail in the pending LUC RD. Thus, the preferred alternative would need to be revised to reflect that these types of institutional controls would potentially be included in the remedy, subject to the LUC RD.

> **Response:** Agree. See response to General Comment No. 3 above.

Also, please identify the changes made to Table 4-2.

Response: See response to General Comment No. 3 above.

Comment 6. **See EPA Specific Comment #27** - In each of the alternative descriptions (discussed primarily under Alternative 2), it should be made clear that groundwater monitoring to evaluate remedy performance (for all remedy elements; active and passive) will be conducted, with a detailed monitoring plan developed as part of the Remedial Design.

Response: Comment noted. As discussed during the May 4, 2004 conference call, this comment will be addressed in the Proposed Plan document.

Further, in paragraph 2 of Section 5.2.4, a description of the EDB system is provided (3 EDBs, each 1200 feet long, 240 injection points per EDB, depth of 50-60 feet). Such a description is acceptable for cost estimation purposes in the FS, however, a detailed design (and rationale) will be required in the Remedial Design, based on performance criteria established in the ROD.

Response: Comment noted. As discussed during the May 4, 2004 conference call, this comment will be addressed in the Proposed Plan response to comments.

Comment 7. **Section 6.1, Modifying Criteria** - The text in this section has been slightly changed relative to the draft FS. It should be understood that the remedy selected in the ROD is to be jointly selected by EPA and the Army (see FFA Section IX(C)(2)). Also, given the FFA process, there would be no outstanding EPA comments on either the "final" FS or the "final" Proposed Plan. That is, EPA will fully support the final FS and final Proposed Plan. While this may be a somewhat minor point in the FS, these are important concepts that should be understood. We suggest that the Army and EPA discuss what, if any, changes may be needed to this section to address the points we are raising in this comment.

Response: Comment noted. This comment was resolved during the May 4, 2004 conference call discussions.

Comment 8. **Section 6** - Please clarify the nature of any changes to Tables 6-2 and 6-4.

Response: Comment noted. This comment was resolved during the May 4, 2004 conference call discussions.

Comment 9. **See EPA Specific Comment** #39 - The FS references uncertainty in surface water/groundwater flow direction, and indicates that the uncertainty was accommodated in the development of the remedies. This is not readily apparent. A more detailed evaluation, analysis, and presentation of this information will be required in the Remedial Design. Additional potentiometric data may be required to adequately design the preferred alternative.

Response: Comment noted. This comment was resolved during the May 4, 2004 conference call discussions.

Comment 10. **See EPA Specific Comment #43** - In the second part of this comment, EPA indicated that the nature of the institutional controls associated with the preferred alternative should be clarified, especially given the statements regarding institutional controls in the draft FS on page 7-1, last paragraph. In the draft final FS, the statement on page 7-1, last paragraph, has been deleted. This change has not helped to clarify the nature of institutional controls that will (and should) be included in the preferred alternative. See General Comment #3.

Response: Agree. See response to General Comment No. 3 above.

Comment 11. **Section 8.2** - See previous comments regarding bullet 1 (institutional controls).

Response: Comment noted. This comment was resolved during the May 4, 2004 conference call discussions.

It should be made clear in the Summary of the Preferred Alternative that groundwater monitoring to evaluate remedy performance (for MNA and EDBs) is a component of the remedy, and that a detailed monitoring plan will be developed as part of the Remedial Design.

Response: Comment noted. As discussed during the May 4, 2004 conference call, this comment will be addressed in the Proposed Plan document.

Comment 12. The FFA schedule for the "Brush Creek project" should be stated.

Response: Comment noted. As discussed during the May 4, 2004 conference call, the FFA schedule for the Brush Creek point source control actions and ROD will be included in the Proposed Plan response to comments.