DOE/GJ/79491-943
CONTRACT NO. DE-AC01-02GJ79491

# REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN FOR THE FINAL REMEDIAL ACTION FOR THE GROUNDWATER OPERABLE UNIT AT THE WELDON SPRING SITE

WELDON SPRING SITE REMEDIAL ACTION PROJECT
WELDON SPRING, MISSOURI

**JULY 2004** **FINAL**

U.S. Department of Energy
Grand Junction Office
Weldon Spring Site Remedial Action Project

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# 1 INTRODUCTION

The Groundwater Operable Unit (GWOU) is the second of two operable units established for the Chemical Plant area of the Weldon Spring site. The Chemical Plant Operable Unit, which was the first operable unit, addressed the treatment of sludges, excavation of soil, and placement of these materials and the quarry bulk wastes, treated sludge, contaminated soils, buildings, drums, process equipment, and debris in the on-site engineered disposal cell. The GWOU addresses contaminated groundwater and springs in the vicinity of the Chemical Plant. The selected remedy for groundwater and springs at the Chemical Plant constitutes the final component of the phased cleanup process implemented at the Weldon Spring site.

## 1.1 PURPOSE AND SCOPE

This *Work Plan* is intended to fulfill the requirements for both the remedial design and the remedial action work plans for the implementation of the *Record of Decision for Final Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site* (ROD; Ref. 1). This *Work Plan* is the primary document used in defining the design and implementation of the selected final remedial action for the GWOU. This plan has been prepared in accordance with the *Federal Facilities Agreement* between the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA) (Ref. 2) and the Comprehensive Environmental Response, Compensation, and Liability Act of 1986 (CERCLA). This *Work Plan* provides the following:

- The design strategy for the selected remedy,
- The implementation approach for this activity,
- The overall schedule under which the remedial design and remedial action activities will be conducted, and
- General cost estimates for the selected remedy.

## 1.2 BACKGROUND

The ROD presents the selected final remedial action for the GWOU. The action was selected following the requirements of CERCLA. The selected remedy for the remaining groundwater contamination at the Chemical Plant area is monitored natural attenuation (MNA), with institutional controls (ICs) to restrict groundwater and springwater use during the restoration period. Calculations performed to estimate the amount of time that will be required for the natural occurrences of dilution and dispersion to reduce contaminant concentrations to levels equivalent to chemical-specific cleanup standards indicate time frames of approximately 100 years (Ref. 3). Information presented in the *Remedial Investigation/Feasibility Study Work Plan* (Ref. 4), *Remedial Investigation* (Ref. 5), *Baseline Risk Assessment* (Ref. 6), *Feasibility*

*Study* (Ref. 7), *Supplemental Feasibility Study* (Ref. 8), *Supporting Evaluation for the Proposed Plan for Final Remedial Action for the Groundwater Operable Unit* (Ref. 3), and *Proposed Plan* (Ref. 9) prepared for the operable unit was used to develop the selected action.

The ROD (Ref. 1) also serves as an amendment to the *Interim Record of Decision for Remedial Action for the Groundwater Operable Unit* (IROD; Ref. 10) signed in September 2000. The IROD focused on the trichloroethylene (TCE) plume and selected in situ chemical oxidation (ICO) as the appropriate remedy. The maximum contaminant level (MCL) for TCE was identified as the cleanup goal. The other contaminants were not addressed. Pilot-phase ICO was performed in April and May 2002. The treatment did not perform adequately under actual field conditions and was not implemented in full scale. The treatment method that will be used to address cleanup of TCE was reevaluated as part of the evaluation process for the ROD. The selected remedy for TCE constitutes a fundamental change to the remedy selected in the IROD.

## 1.3 DOCUMENT ORGANIZATION

The remaining sections of the document are:

- 2, Monitored Natural Attenuation: Discusses the design criteria for the groundwater monitoring program stipulated in the selected remedy. This discussion includes design criteria for new monitoring wells.
- 3, Institutional Controls: Discusses the design criteria for developing the IC measures that will be employed for the GWOU.
- 4, Construction Activities: Summarizes the construction specifications of the activities that will be undertaken to implement the selected remedy.
- 5, Project Schedule: Provides an overall schedule for the design and implementation of the different activities discussed in this plan.
- 6, Summary of Project Costs: Summarizes the costs for designing and constructing the selected remedy, as well as operations and maintenance (O&M) costs.
- 7, Quality Assurance Program Plan: Provides a brief abstract on the project quality assurance program plan.
- 8, Emergency Preparedness Plan: Provides a brief abstract on the project emergency preparedness plan.
- 9, Post-ROD Documents: Summarizes the primary and secondary documents that will be prepared for the remedial design and remedial action phases of the GWOU.

- 10, References: Lists the reference documents used for preparation of this plan.

# 2 MONITORED NATURAL ATTENUATION

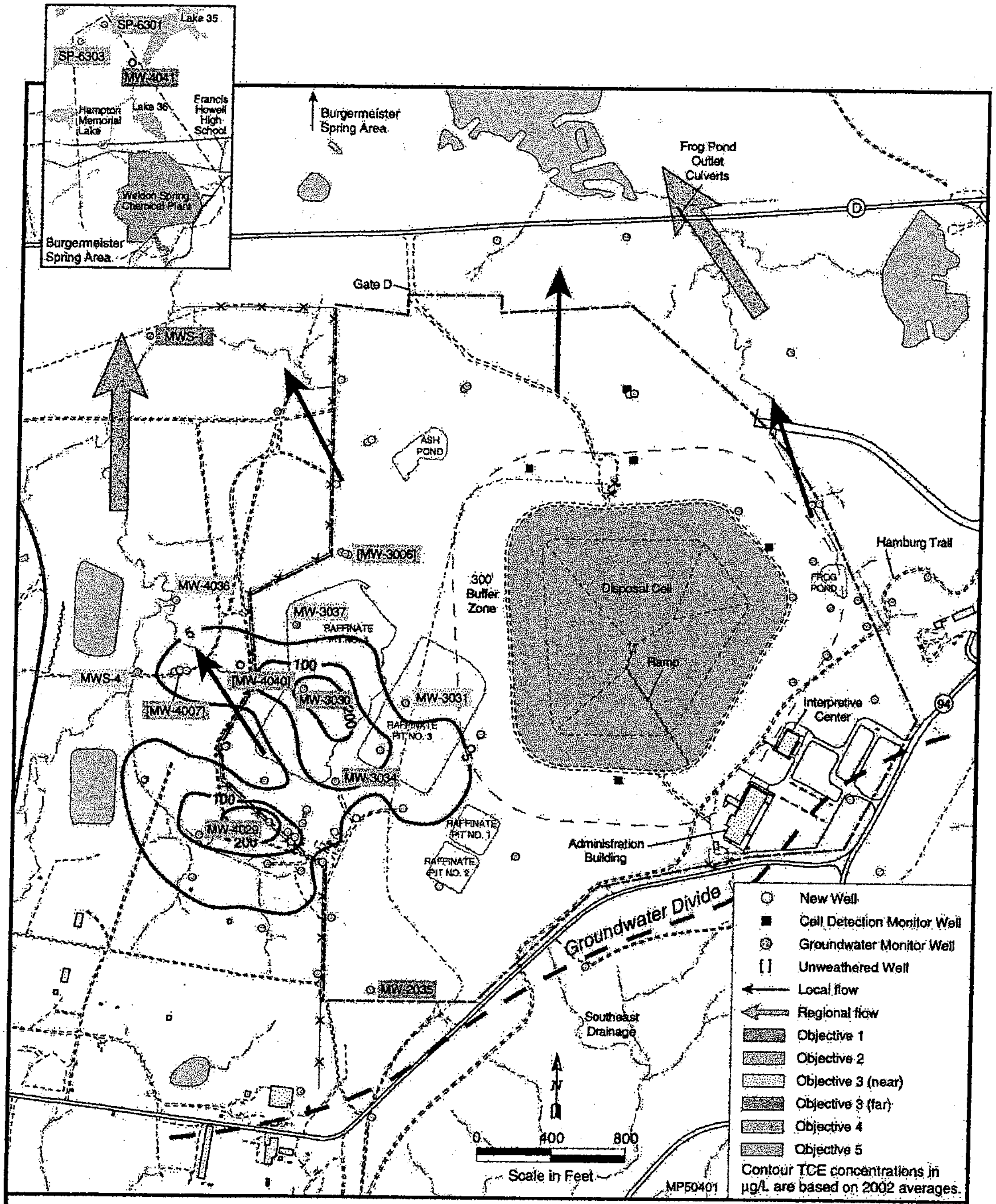
The selected remedy provides for monitored natural attenuation (MNA) with institutional controls (ICs) to limit groundwater use. This remedial action is being performed to comply with the ROD (Ref. 1). The remedial objective is to monitor groundwater concentrations and restrict groundwater use until contaminant concentrations decrease to the cleanup standards specified in the ROD. The ultimate objective for the groundwater portion of this remedial action is to restore contaminated groundwater in the shallow aquifer to its beneficial use. The aquifer could potentially be used as a drinking water source; however, it is not currently being used as such. Because yields are low and because municipal drinking water sources are available in the area, it is unlikely that the aquifer would ever be used for that purpose.

This section outlines the following components of the groundwater monitoring program:

- Monitoring strategy,
- Monitoring locations,
- Monitoring parameters,
- Monitoring frequencies,
- Data analysis and interpretation, and
- Contingency actions to be performed as a result of monitoring.

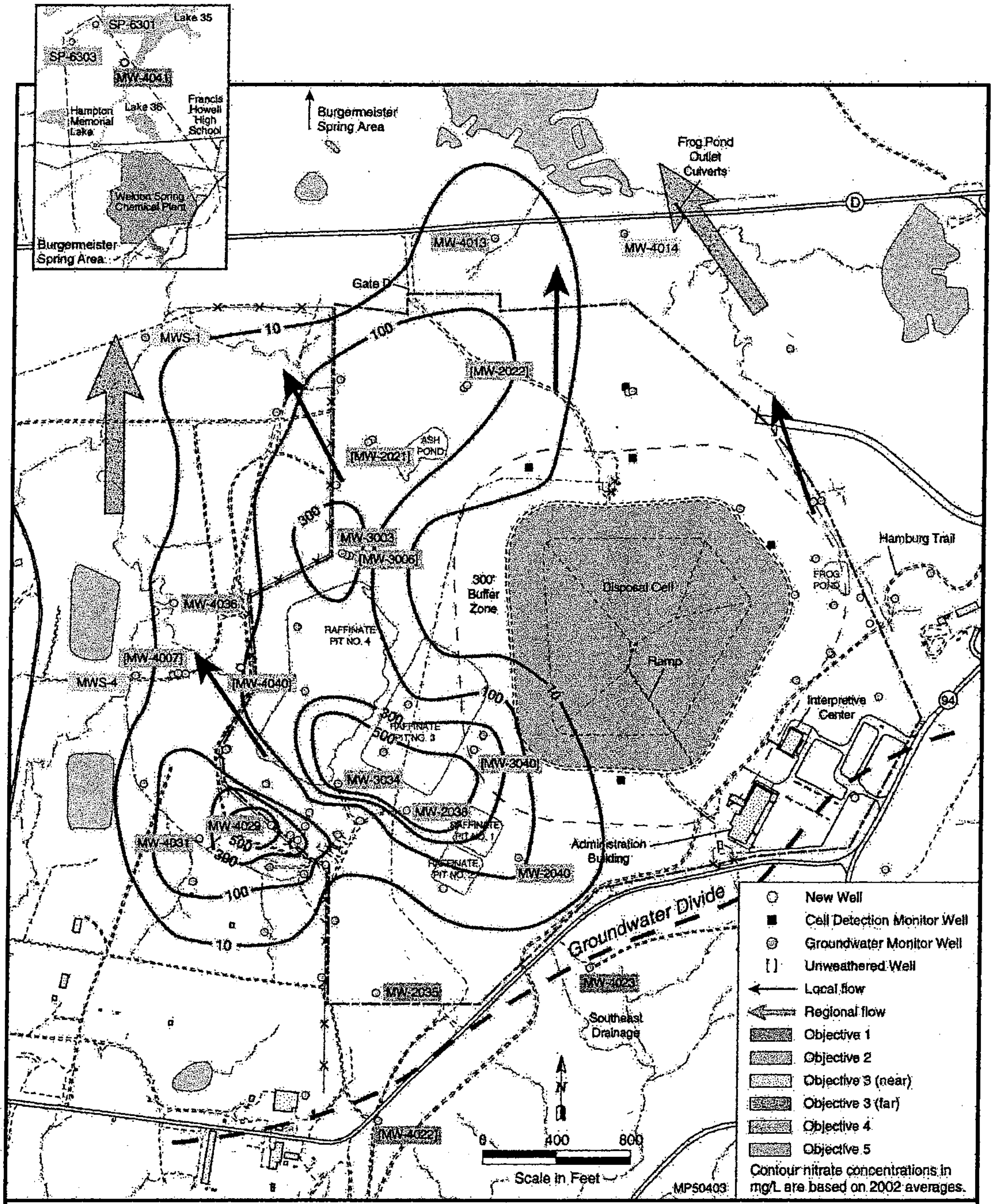
## 2.1 MONITORING STRATEGY

Groundwater at the Chemical Plant is contaminated with TCE, nitrate, uranium, and nitroaromatic compounds (Figures 2-1 through 2-8). The groundwater contamination originated with the Raffinate Pits and other source areas of the Chemical Plant site that have been removed. Contaminated surface water infiltrated to the uppermost groundwater, which occurs in the weathered unit of the Burlington-Keokuk Limestone, the uppermost bedrock unit at the site. An east-west trending groundwater divide results in two flow systems in the shallow aquifer beneath the Chemical Plant area (Figure 2-9). Of primary importance is groundwater north of the divide, where residual groundwater contamination is located and flows northward. Contaminated groundwater ultimately finds its way off site through preferential flow paths in the weathered bedrock (Figure 2-10). The preferential flow paths are made up of more weathered and fractured limestone that generally occurs in lows or troughs in the weathered unit.



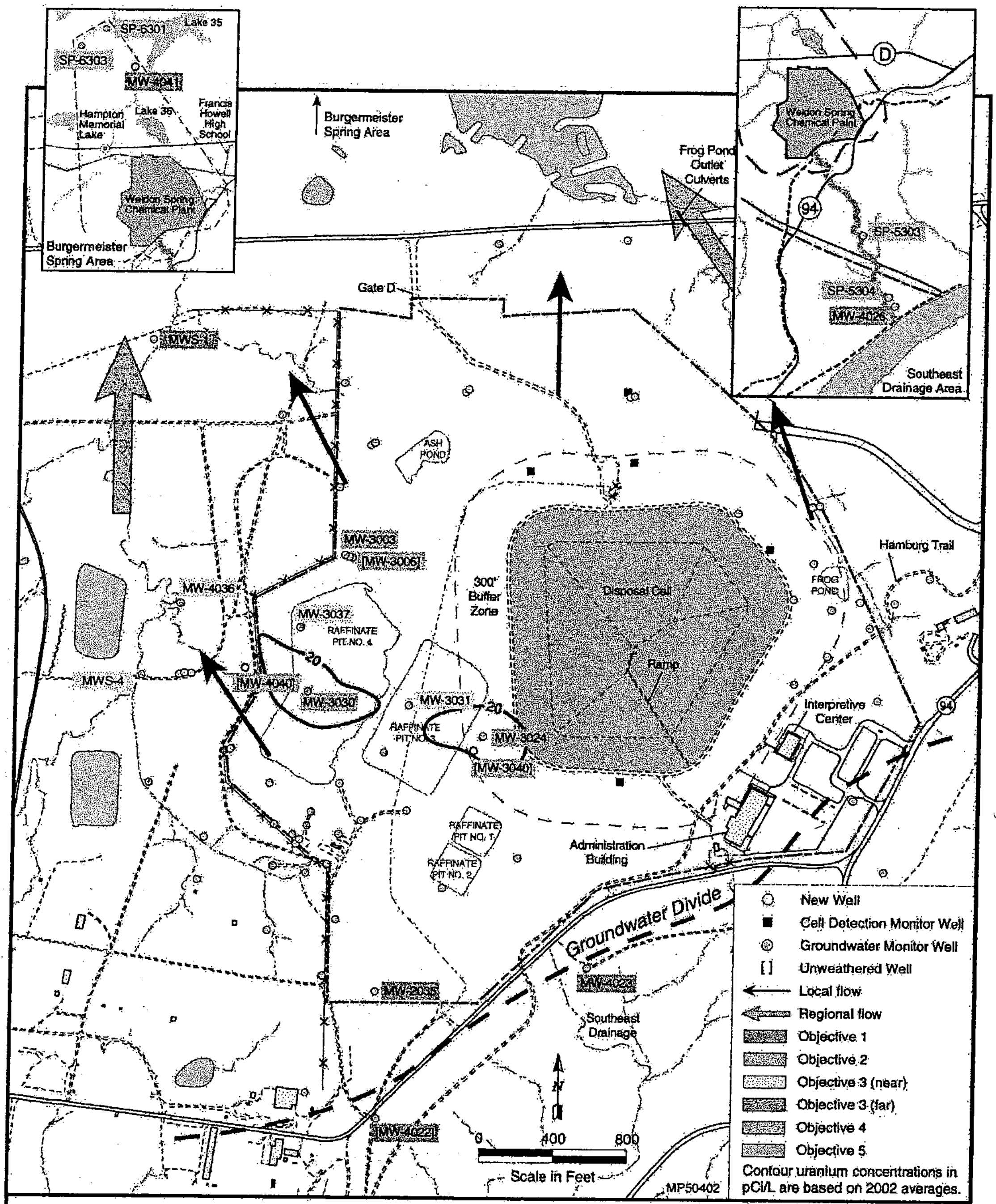
| Objective 1 | Objective 2 | Objective 3 (near) | Objective 3 (far) | Objective 4 | Objective 5 |
|---|---|---|---|---|---|
| MW 2035 | MW 3030<br>MW 3034<br>MW 4029 | MW 3031<br>MW 3037<br>MW 4036<br>MWS-4 | MWS-1<br>MW 4041 | MW 3006<br>MW 4007<br>MW 4040 | SP 6301<br>SP 6303 |

**FIGURE 2-1 TCE Contamination Contour Based on Average Concentrations in 2002 at the Chemical Plant Area**



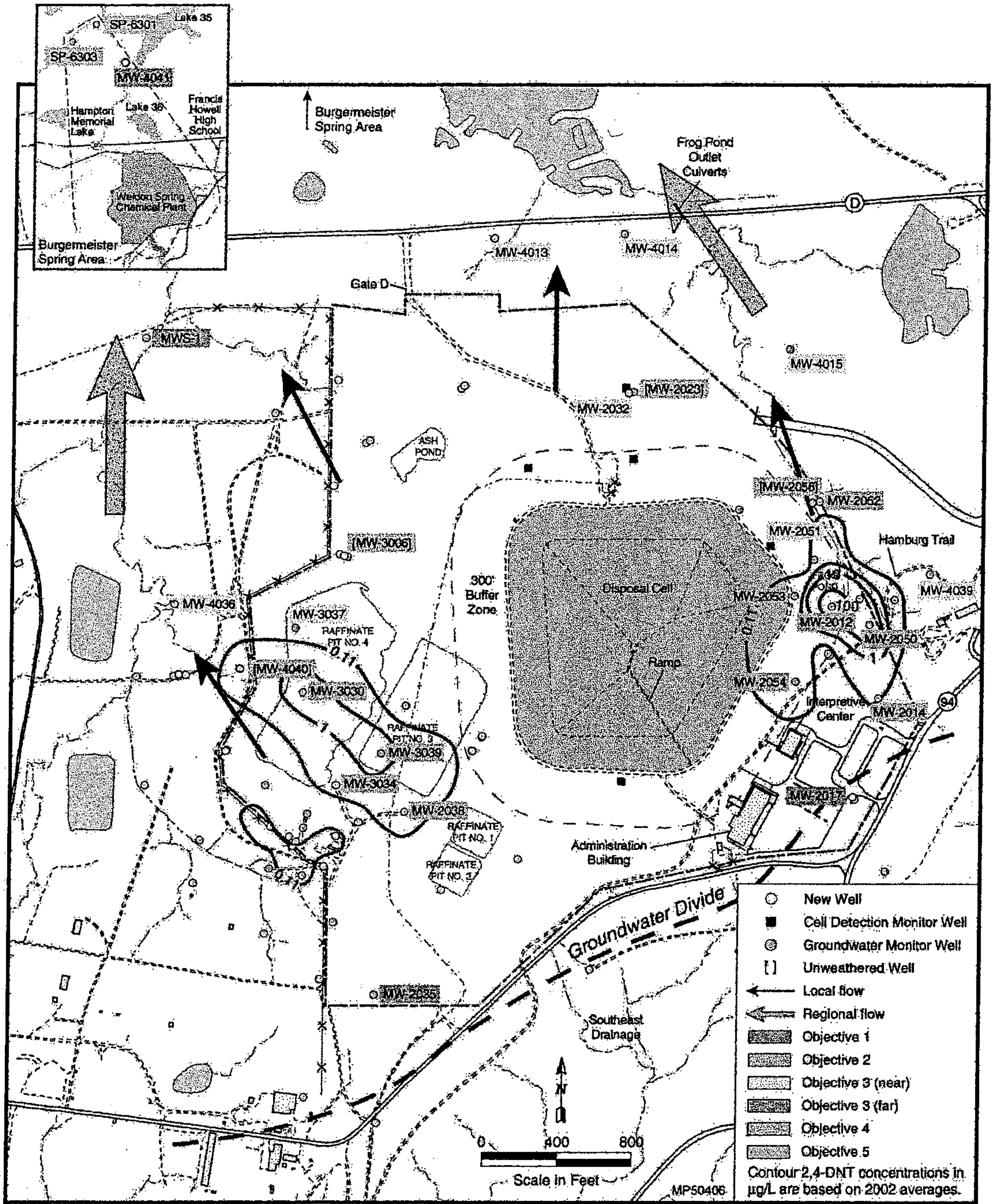
| Objective 1 | Objective 2 | | Objective 3 (near) | Objective 3 (far) | Objective 4 | | Objective 5 |
|---|---|---|---|---|---|---|---|
| MW 2035 | MW 2038 | MW 2040 | MW 4014 | MW 4041 | MW 2021 | MW 4007 | SP 6301 |
| MW 4022 | MW 3034 | MW 4031 | MWS-4 | | MW 2022 | MW 4040 | SP 6303 |
| MW 4023 | MW 4029 | MW 4013 | MWS-1 | | MW 3006 | | |
| | MW 4036 | MW 3003 | | | MW 3040 (replacement well for MW 3024) | | |

**FIGURE 2-2 Nitrate Contamination Contour Based on Average Concentrations in 2002 at the Chemical Plant Area**



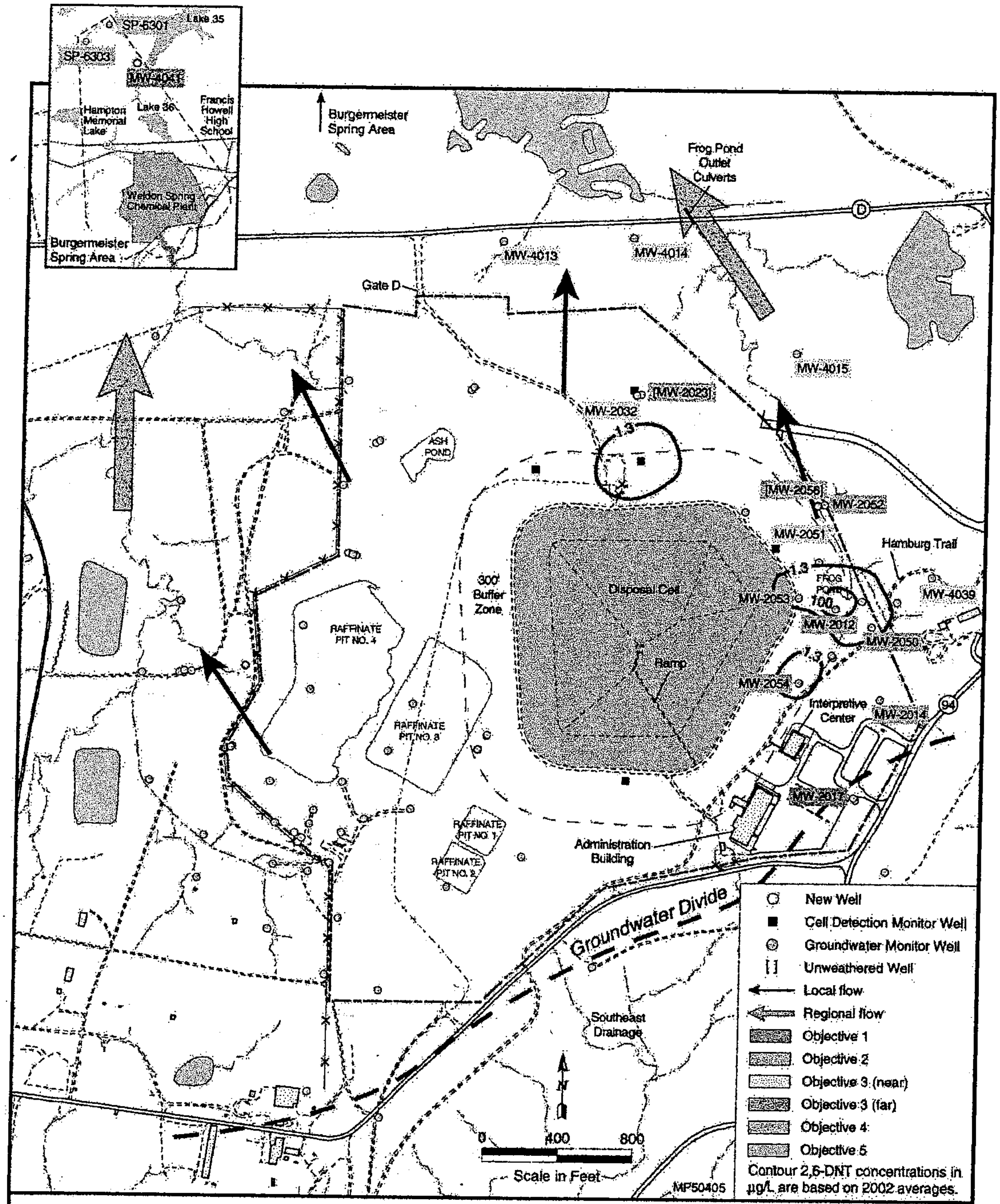
| Objective 1 | Objective 2 | Objective 3 (near) | Objective 3 (far) | Objective 4 | Objective 5 |
|---|---|---|---|---|---|
| MW 2035<br>MW 4022<br>MW 4023 | MW 3003<br>MW 3024 (Until replaced by MW 3040 which will be an Obj. 4 well)<br>MW 3030 | MW 3031<br>MW 3037<br>MW 4036<br>MWS-4 | MW 4026<br>MW 4041<br>MWS-1 | MW 3006<br>MW 3040 (replacement well for MW 3024)<br>MW 4040 | SP 5303<br>SP 5304<br>SP 6301<br>SP 6303 |

**FIGURE 2-3 Uranium Contamination Contour Based on Average Concentrations in 2002 at the Chemical Plant Area**



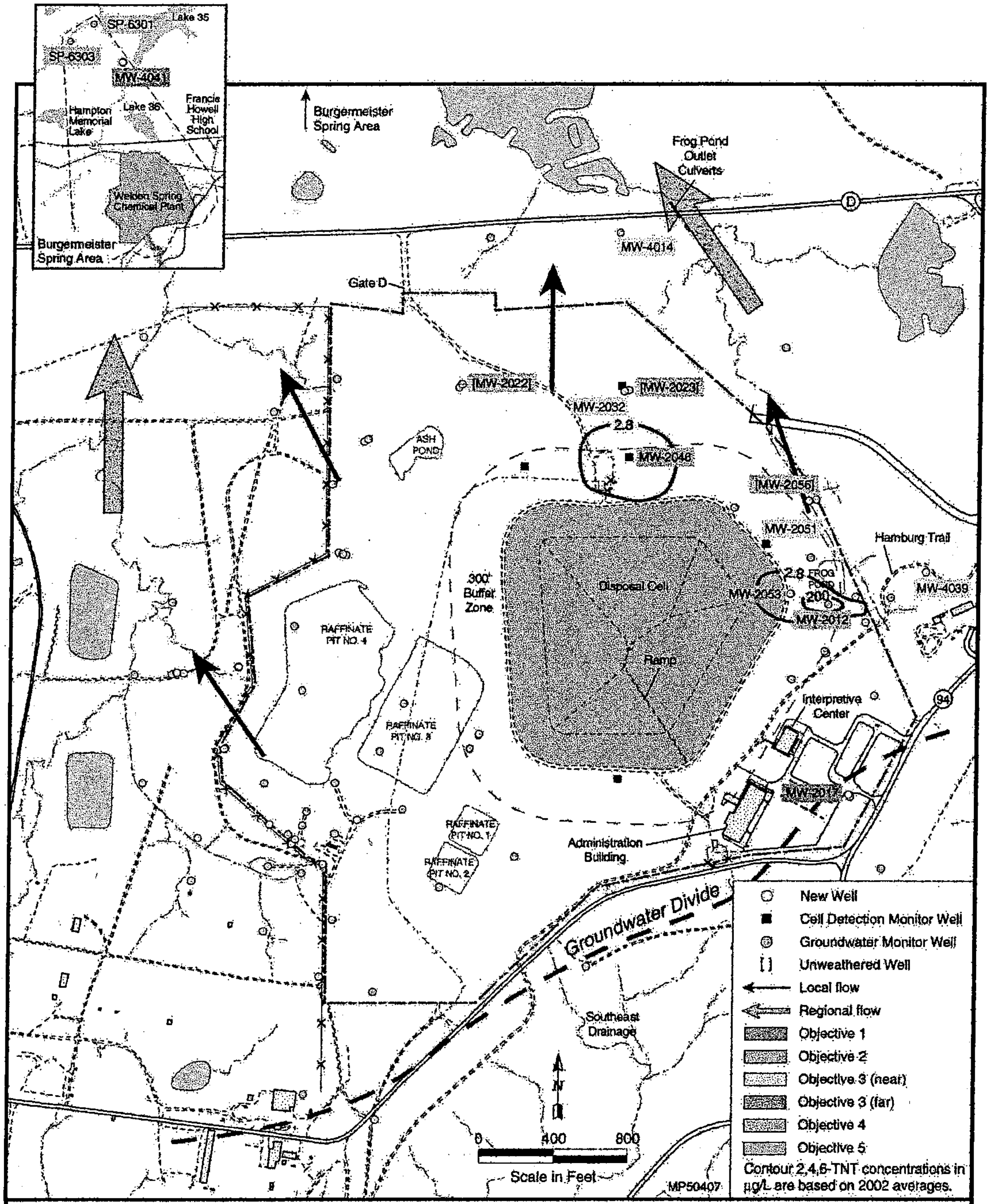
| Objective 1 | Objective 2 | | Objective 3 (near) | | Objective 3 (far) | Objective 4 | Objective 5 |
|---|---|---|---|---|---|---|---|
| MW 2017 | MW 2038 | MW 2014 | MW 2032 | MW 4015 | MW 4041 | MW 2023 | SP 6301 |
| MW 2035 | MW 3030 | MW 2050 | MW 2051 | MW 4039 | MWS-1 | MW 2056 | SP 6303 |
| | MW 3034 | MW 2052 | MW 4013 | MW 3037 | | MW 3006 | |
| | MW 3039 | MW 2053 | MW 4014 | MW 4036 | | MW 4040 | |
| | MW 2012 | MW 2054 | | | | | |

**FIGURE 2-4 2,4-DNT Contamination Contour Based on Average Concentrations in 2002 at the Chemical Plant Area**



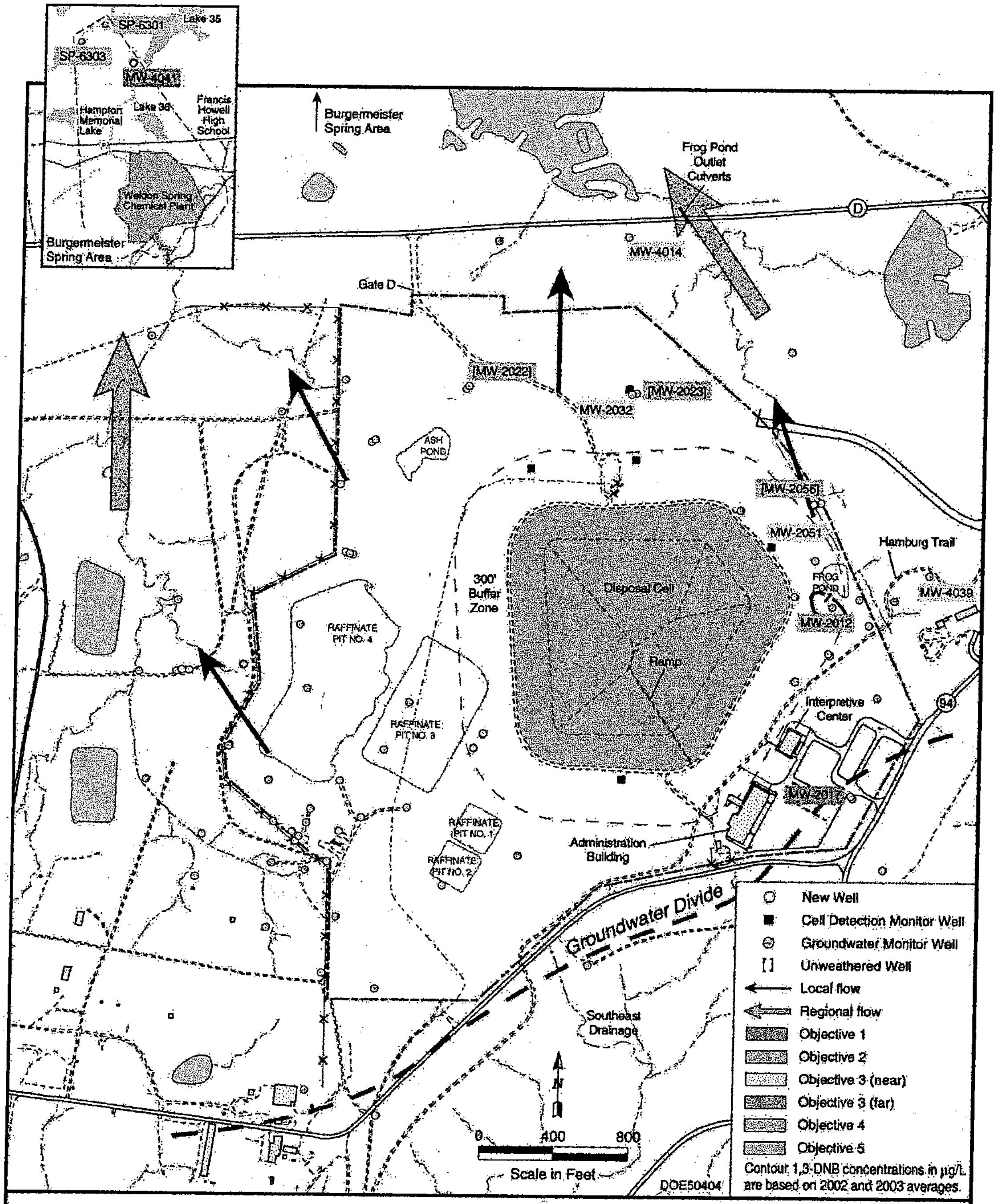
| Objective 1 | Objective 2 | | Objective 3 (near) | | Objective 3 (far) | Objective 4 | Objective 5 |
|---|---|---|---|---|---|---|---|
| MW 2017 | MW 2012 | MW 2052 | MW 2032 | MW 4014 | MW 4041 | MW 2023 | SP 6301 |
| | MW 2014 | MW 2053 | MW 2051 | MW 4015 | | MW 2056 | SP 6303 |
| | MW 2050 | MW 2054 | MW 4013 | MW 4039 | | | |

**FIGURE 2-5 2,6-DNT Contamination Contour Based on Average Concentrations in 2002 at the Chemical Plant Area**



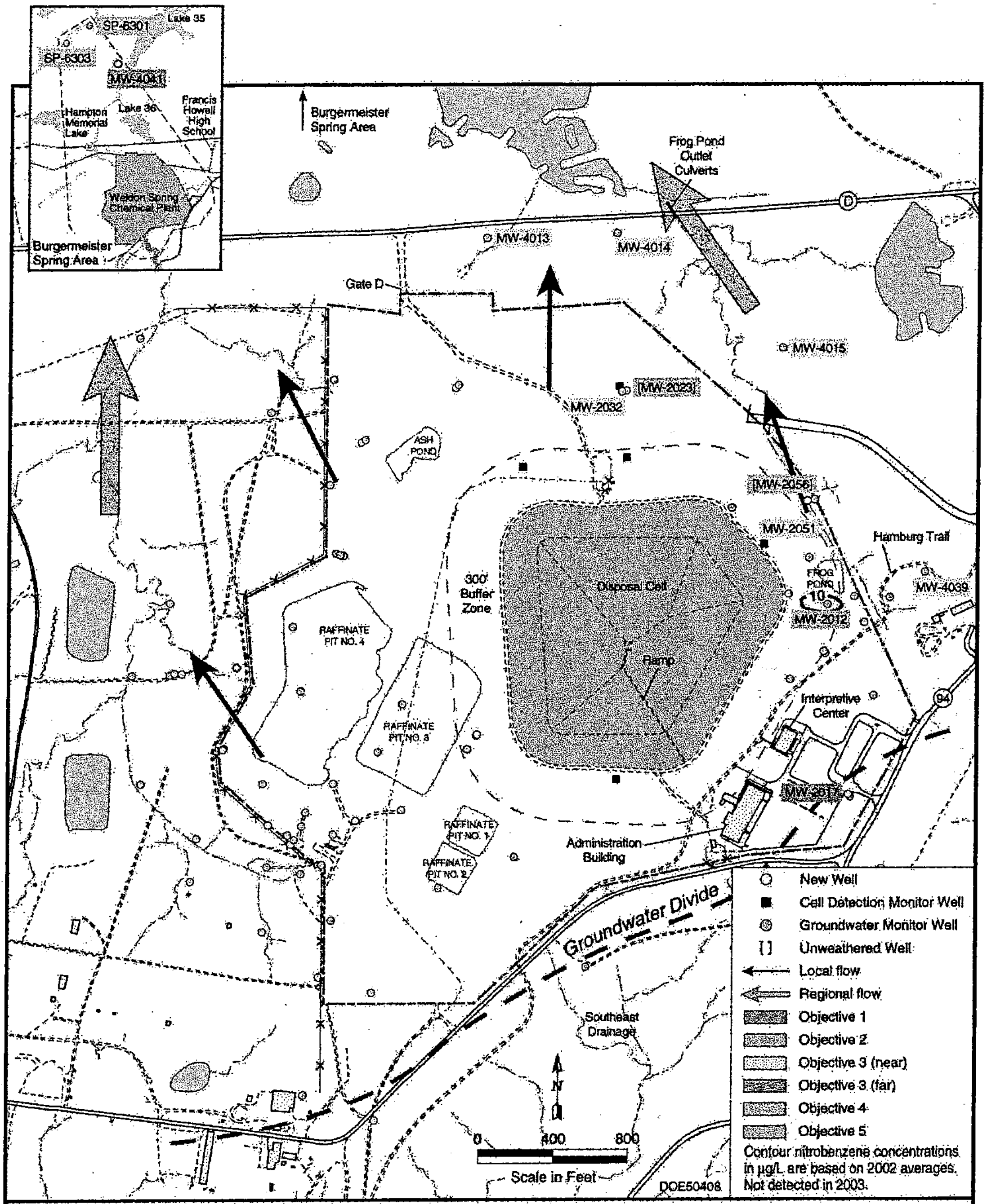
| Objective 1 | Objective 2 | Objective 3 (near) | Objective 3 (far) | Objective 4 | Objective 5 |
|---|---|---|---|---|---|
| MW 2017 | MW 2046<br>MW 2012<br>MW 2053 | MW 2032<br>MW 2051<br>MW 4014<br>MW 4039 | MW 4041 | MW 2022<br>MW 2023<br>MW 2056 | SP 6301<br>SP 6303 |

**FIGURE 2-6 2,4,6-TNT Contamination Contour Based on Average Concentrations in 2002 at the Chemical Plant Area**



| Objective 1 | Objective 2 | Objective 3 (near) | Objective 3 (far) | Objective 4 | Objective 5 |
|---|---|---|---|---|---|
| MW 2017 | MW 2012 | MW 2032<br>MW 2051<br>MW 4014<br>MW 4039 | MW 4041 | MW 2022<br>MW 2023<br>MW 2056 | SP 6301<br>SP 6303 |

**FIGURE 2-7 1,3-DNB Contamination Contour Based on Average Concentrations in 2002 at the Chemical Plant Area**



| Objective 1 | Objective 2 | Objective 3 (near) | | Objective 3 (far) | Objective 4 | Objective 5 |
|---|---|---|---|---|---|---|
| MW 2017 | MW 2012 | MW 2032 | MW 4014 | MW 4041 | MW 2023 | SP 6301 |
| | | MW 2051 | MW 4015 | | MW 2056 | SP 6303 |
| | | MW 4013 | MW 4039 | | | |

**FIGURE 2-8** **Nitrobenzene Contamination Contour Based on Average Concentrations in 2002 at the Chemical Plant Area**

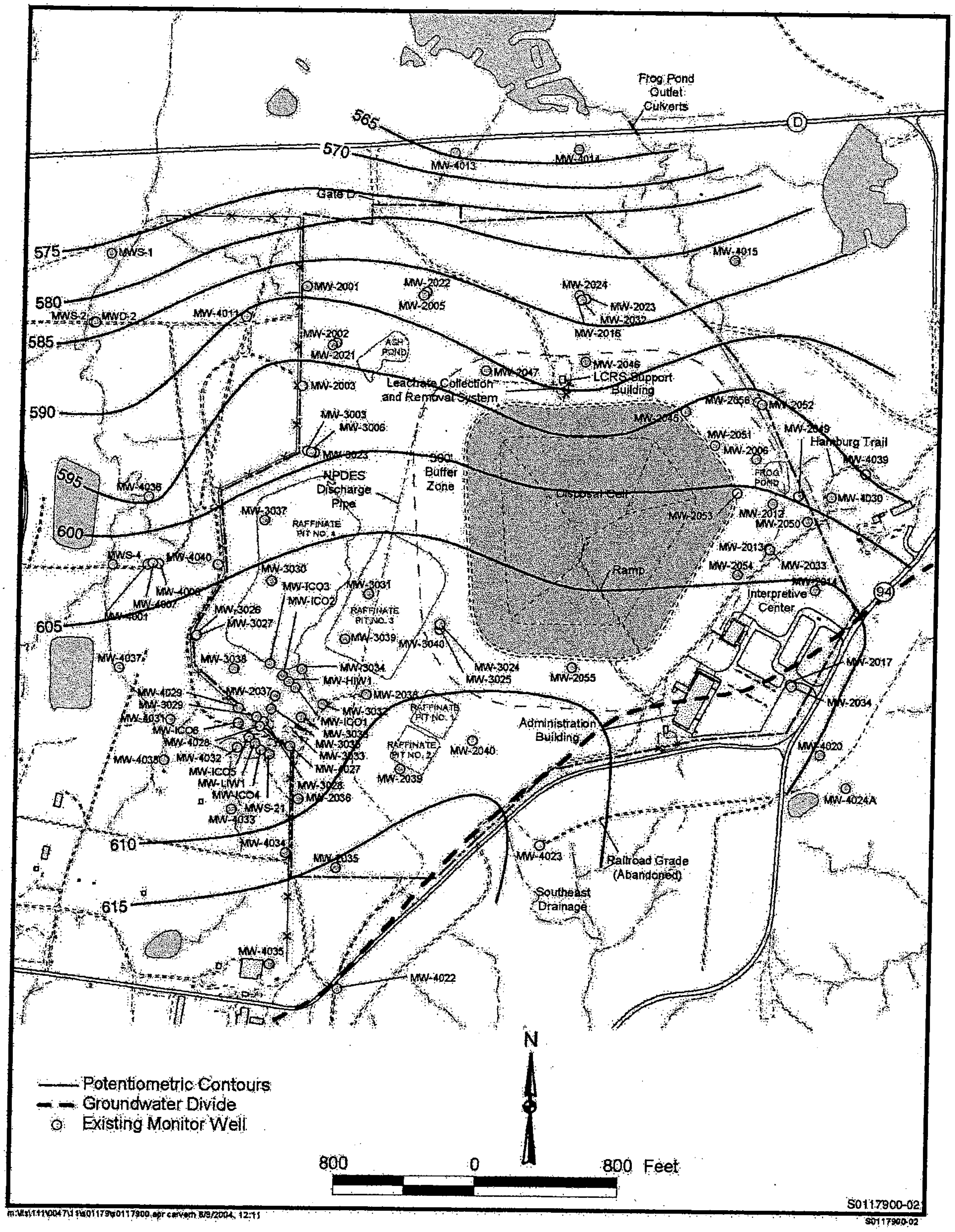
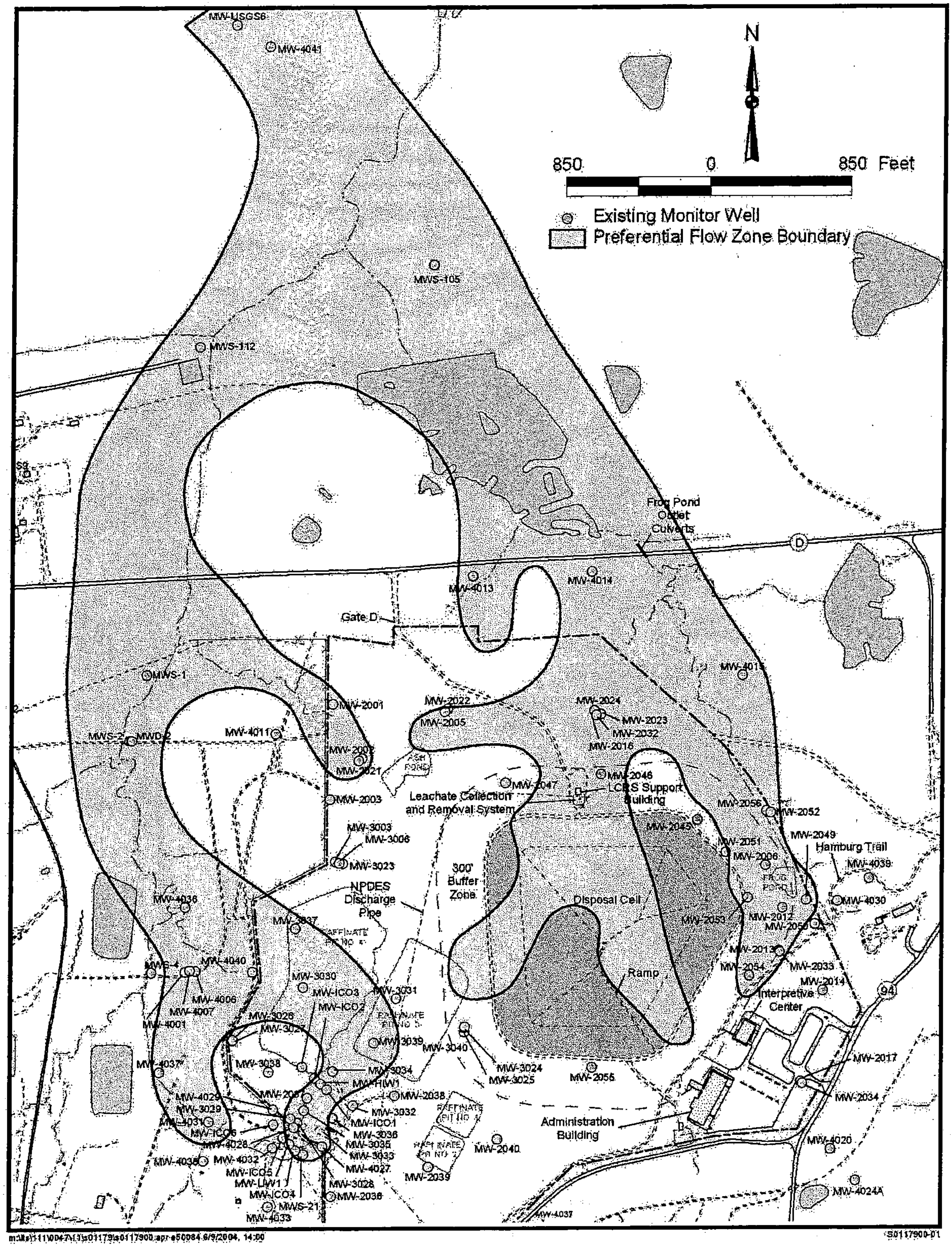


FIGURE 2-9 Potentiometric Surface of the Shallow Aquifer at the Chemical Plant Area



m:\as\111\0047\13\s01179\s0117900.apr e50084 6/9/2004, 14:00

S0117900-01

**FIGURE 2-10 Preferential Flow Paths in the Weathered Bedrock at the Chemical Plant Area**

Off-site migration occurs laterally through solution-enlarged conduits and bedding planes in the weathered Burlington-Keokuk Limestone. No well-defined plumes of high concentrations have been detected north of the site, although site contaminants have been detected in springs in the August A. Busch Conservation Area. The western and northern portions of the site are within the recharge area of the two impacted springs: Burgermeister Spring (SP-6301) and SP-6303. The expectation is that the contaminant plumes will continue to disperse along existing flow paths and become more dilute with natural recharge from precipitation and lateral flow. Concentrations in the areas of highest impact will decrease, but because of dispersion, concentrations in some downgradient locations may exhibit temporary increases. These changes in concentrations have already been observed at some locations. Since the sources of contamination have been removed, groundwater quality should continue to improve. The overall area of contamination should not become significantly larger than it currently is. The distribution of contaminants is controlled by the structure of the bedrock, which controls the groundwater flow direction in the shallow aquifer beneath the Chemical Plant area. The areas of highest contamination generally occur along the more weathered, preferential flow pathways, and migration occurs primarily along these linear flow features.

Contamination should not go any deeper than it already has. Historically, a slight impact from nitrate, nitroaromatic compounds, and uranium has been observed in the unweathered Burlington-Keokuk Limestone in the Raffinate Pits and Ash Pond areas at the Chemical Plant. Groundwater flow has a preferential horizontal component, and vertical movement of groundwater is limited by structural controls of the bedding planes and abundant horizontal fractures found in the upper weathered unit.

The performance goals for the monitoring program are as follows:

1. Contaminants will attenuate at a rate sufficient to meet cleanup standards in approximately 100 years.
2. Contaminant migration will remain confined to the currently impacted groundwater system.
3. Contaminant levels at potential exposure points (springs) will not pose unacceptable risks to receptors.
4. Contaminant levels at the springs will decline over time.

Groundwater at both the Chemical Plant and the adjacent former Ordnance Works has been impacted by sources that were present on both sites. DOE will monitor for nitroaromatic compounds at locations on both the Chemical Plant and Ordnance Works that are or could be impacted by migration from source areas that have been remediated at the Chemical Plant site. Impacted areas west of the DOE property boundary will be addressed under the groundwater remedy for the Weldon Spring Ordnance Works. These are locations associated with impacted soils near the foundations remaining along Production Line #4, which is along the southwest boundary of the Chemical Plant.

## 2.2 MONITORING LOCATIONS

The hydrogeologic conceptual model for the fate and transport of contaminants at the site was used to develop the monitoring strategy for this operable unit. To assure these goals are being met, a groundwater monitoring program will be developed that uses new and/or existing monitoring wells to evaluate contaminant behavior. The strategy is presented below:

Objective 1 is to monitor the unimpacted water quality at upgradient locations in order to maintain a baseline of naturally occurring constituents from which to evaluate changes in downgradient locations. The objective will be met by using wells located upgradient of the contaminant plume.

Objective 2 is to verify that contaminant concentrations are declining with time at a rate and in a manner so that cleanup standards will be met in approximately 100 years as established by predictive modeling. This objective will be met by using wells at or near the locations with the highest concentrations of contaminants, both near the former source areas and along expected migration pathways. The objective will be to evaluate the most contaminated zones. Long-term trend analysis will be performed to confirm downward trends in contaminant concentrations over time. Performance will be gauged against long-term trends. It is anticipated that some locations could show temporary upward trends as a result of recent source control remediation, ongoing dispersion, analytical variability, or other factors. However, concentrations are not expected to exceed historical maximums.

Objective 3 is to ensure that lateral migration remains confined to the current area of impact. Contaminants are expected to continue to disperse within known preferential flow paths associated with bedrock lows (paleochannels) in the upper Burlington-Keokuk Limestone and become more dilute over time. This objective will be met by monitoring various downgradient perimeter locations that are either not impacted or minimally impacted. Contaminant impacts in these locations are expected to remain minimal or nonexistent.

Objective 4 is to monitor locations underlying the impacted groundwater system to confirm that there is no significant vertical migration of contaminants. This will be evaluated by using deeper wells screened and influenced by the unweathered unit of the Burlington-Keokuk Limestone. Contaminant impact at these locations should be minimal or nonexistent.

Objective 5 is to monitor contaminant levels at the impacted springs, which are the only potential points of exposure under current land use conditions. The springs discharge groundwater that includes contaminated groundwater originating from the Chemical Plant area. Current contaminant concentrations at these locations are protective of human health and the environment under current recreational land uses. Continued improvement of the water quality in these affected springs should be observed.

Objective 6 is to monitor the hydrologic conditions at the site over time in order to identify any changes in groundwater flow that might affect the protectiveness of the selected remedy. The static groundwater elevation of the monitoring network will be measured to establish that groundwater flow is not changing significantly and resulting in changes in contaminant migration.

### 2.2.1 Groundwater Monitoring Locations

Wells were initially evaluated on the basis of whether the data from the wells exceeded the cleanup standards and on the basis of the bedrock unit in which the well was completed. Locations where concentrations exceed cleanup standards were first evaluated for performance monitoring. Those locations that did not exceed cleanup standards were evaluated as detection monitoring locations. Each of the existing monitoring wells at the Chemical Plant was evaluated by using this approach to determine which objective the wells would best satisfy. In some cases, a well could meet the criteria for performance and detection monitoring because of the distribution of different contaminants.

Because of the large density of wells in some areas, duplication of monitoring occurred, since the evaluation approach did not take into account the distance between wells in some of the categories. Further evaluation of the data was performed on the basis of the proximity of the wells to each other. If locations were within approximately 500 ft of each other, then either the location with the higher concentrations, the wells that better monitored the desired zone, or the locations with a longer monitoring history were selected, and the other well was evaluated as a hydrologic monitoring location.

Three new wells were installed to supplement the existing monitoring well network. Two of these wells are screened in the unweathered unit and are located in areas of the site where there is not adequate monitoring of this unit below the areas of impact. The first well (MW-2056) is clustered with MW-2052 in the Frog Pond area and is located within the leading edge of the nitroaromatic compound plume and within the preferential flow pathway in this area. The second unweathered well (MW-4040) is located west of MW-3030 near the property boundary. This well is located within the leading edge of the TCE, uranium, nitroaromatic compound, and nitrate plumes and within the preferential flow pathway in this area. Both of these wells are Objective 4 wells.

One new weathered well (MW-4041) is located north of the site on the Busch Conservation Area north of the Chemical Plant. The purpose of this well is to attempt to intersect the confluence of the two preferential flow pathways that originate at the Chemical Plant site. The location of this well was based on the topography of the top of the weathered Burlington-Keokuk Limestone and the troughs in the potentiometric surface in this area. Four boreholes were drilled to better define the paleochannel in this area. This well is an Objective 3 well.

A new well (MW-3040) was installed to monitor the unweathered Burlington-Keokuk Limestone near an existing well cluster (MW-3024 and MW-3025) in the Raffinate Pits area. A review of the hydrologic and contaminant data and of the previous reconstruction of the unweathered well MW-3024 led to suspicions regarding the integrity of the well and the reliability of the contaminant and groundwater level data. This new well will be monitored to assess previous information regarding the unweathered unit in this area.

The final monitoring network consists of 49 wells and four springs. The locations and the objectives they satisfy are summarized in Table 2-1 and are depicted on Figure 2-11.

The remainder of the existing wells will be retained only for contingency sampling (Section 2.6). These wells will be maintained until abandonment is required as a result of deterioration, damage, or other circumstances. Certain wells may be selected for earlier abandonment if they are clearly not within the established flow path or are no longer within the desired monitoring interval because of groundwater elevation changes. Once MNA monitoring establishes a downward trend within the areas of impact, the need to retain contingency wells will be reevaluated. These wells will be used as hydrologic monitoring locations until their abandonment or incorporation into the monitoring program (see Section 2.5.4).

### 2.2.2 Spring Monitoring Locations

Contaminated groundwater migrates off site through solution-enlarged conduits and bedding planes. No well-defined plumes of large concentration have been detected north of the

**TABLE 2-1 Monitoring Locations Retained for MNA Monitoring for the GWOU**

| Objective 1 | Objective 2 | Objective 3 | Objective 4 | Objective 5 | Objective 6 |
|---|---|---|---|---|---|
| MW-2017 | MW-2012 | MW-2032 | MW-2021 | SP5303 | MW-2005 |
| MW-2035 | MW-2014 | MW-2051 | MW-2022 | SP5304 | MW-2055 |
| MW-4022 | MW-2038 | MW-3031 | MW-2023 | SP6301 | MW-3025 |
| MW-4023 | MW-2040 | MW-3037 | MW-2056 | SP6303 | MW-3038 |
| | MW-2046 | MW-4013 | MW-3006 | | MW-4001 |
| | MW-2050 | MW-4014 | MW-3040 | | MW-4011 |
| | MW-2052 | MW-4015 | MW-4007 | | MW-4020 |
| | MW-2053 | MW-4026 | MW-4040 | | MW-4037 |
| | MW-2054 | MW-4036 | | | |
| | MW-3003 | MW-4039 | | | |
| | MW-3024 | MW-4041 | | | |
| | MW-3030 | MWS-1 | | | |
| | MW-3034 | MWS-4 | | | |
| | MW-3039 | | | | |
| | MW-4013[a] | | | | |
| | MW-4029 | | | | |
| | MW-4031 | | | | |
| | MW-4036[a] | | | | |

[a] Location is also an Objective 3 location.

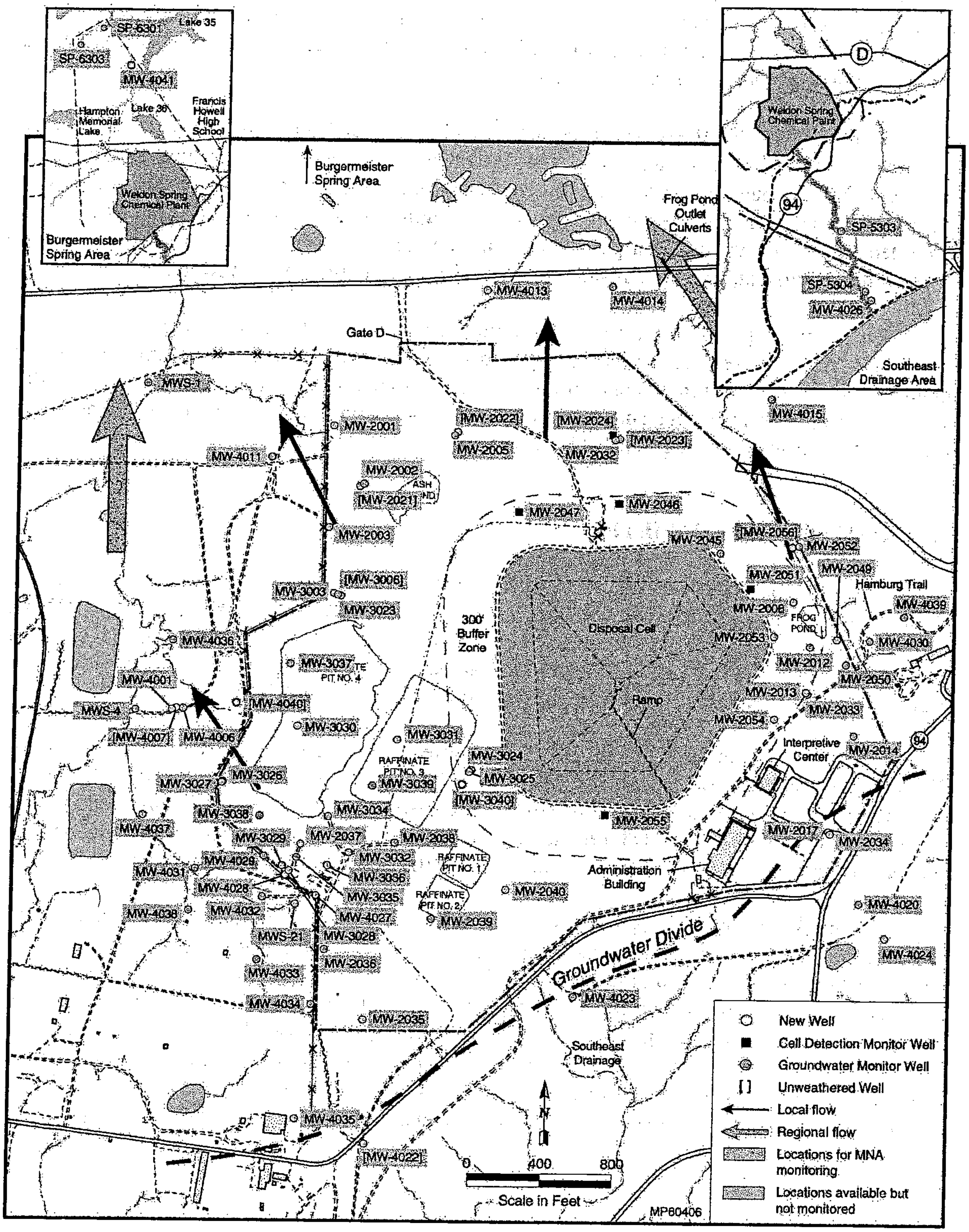


**FIGURE 2-11 MNA Monitoring Locations**

site, although site contaminants have been detected in springs in the Busch Conservation Area. The western and northern portions of the site are within the recharge area of the two impacted springs: Burgermeister Spring (SP-6301) and SP-6303.

Springs in the Southeast Drainage also indicate impact from site-derived contaminants. Historically, contaminated groundwater from Raffinate Pits 1 and 2 flowed into the Southeast Drainage. This drainage was also used as discharge point for effluent from the Chemical Plant operations. Because this drainage has losing stream segments in its upper reaches, surface water infiltrated the subsurface where a portion of contaminated sediment was deposited in fractures and solution features and acts as a residual source of contamination to springwater.

Contaminant levels at the impacted springs SP-6301, SP-6303, SP-5303, and SP-5304 (Figure 2-11), which are potential points of exposure under current land use conditions, will be monitored. Current contaminant concentrations at these locations are protective of human health and the environment under current recreational land uses. Continued improvement of the water quality in these affected springs should be observed

## 2.3 MONITORING PARAMETERS

The contaminants of concern identified in the groundwater at the Chemical Plant are TCE, nitrate (as nitrogen), nitroaromatic compounds (1,3-dinitrotoluene [DNB], 2,4,6-trinitrotoluene [TNT], 2,4-dinitrotoluene [DNT], 2,6-DNT, and nitrobenzene [NB]), and uranium (Ref. 1). These constituents will be measured at some or all of the monitoring locations, depending on the well's proximity to each contaminant plume (Table 2-2).

Nitrate and uranium were derived from wastes and sludge disposed of in the Raffinate Pits and other surface water bodies (Ash Pond and Frog Pond) at the Chemical Plant. The source of TCE contamination was drums discarded in Raffinate Pit 4. Nitroaromatic compounds occur in portions of the site where TNT production lines associated with the former Ordnance Works site were located on both the Chemical Plant site and the adjacent Department of the Army site.

Uranium in the springs is derived from the residual uranium contamination in the subsurface flow path. At Burgermeister Spring, uranium concentrations are also the result of some groundwater contribution from the Chemical Plant area. Residual uranium was the result of overland flow lost to the subsurface in losing streams. Uranium concentrations measured in the springs are generally higher than those measured in the groundwater because of the additional contribution of the residual uranium. Nitroaromatic compounds in the Southeast Drainage are the result of a similar process of surface discharges into the drainage. Nitrate and nitroaromatic compounds in the Burgermeister Spring and associated springs are the result of groundwater discharge.

## TABLE 2-2 Monitoring Parameters for MNA Locations

| | | Monitoring Parameters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location | Sampling Frequency[a] | TCE | Nitrate (as N) | Uranium | 1,3-DNB | 2,4,6-TNT | 2,4-DNT | 2,6-DNT | NB |
| MW-2012 | S | | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| MW-2014 | S | | | | | | ✓ | ✓ | |
| MW-2017 | S | | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| MW-2021 | S | | ✓ | | | | | | |
| MW-2022 | Q | | ✓ | | ✓ | ✓ | | | |
| MW-2023 | Q | | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| MW-2032 | S | | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| MW-2035 | S | ✓ | ✓ | ✓ | | | ✓ | | |
| MW-2038 | S | | ✓ | | | | ✓ | | |
| MW-2040 | S | | ✓ | | | ✓ | | | |
| MW-2046 | S | | | | | ✓ | | | |
| MW-2050 | S | | | | | | ✓ | ✓ | |
| MW-2051 | S | | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| MW-2052 | S | | | | | | ✓ | ✓ | |
| MW-2053 | S | | | | | ✓ | ✓ | ✓ | |
| MW-2054 | S | | | | | | ✓ | ✓ | |
| MW-2056 | Q | | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| MW-3003 | S | | ✓ | ✓ | | | | | |
| MW-3006 | S | ✓ | ✓ | ✓ | | | ✓ | | |
| MW-3024 | S | | | ✓ | | | | | |
| MW-3030 | S | ✓ | | ✓ | | | ✓ | | |
| MW-3031 | S | ✓ | | ✓ | | | | | |
| MW-3034 | S | ✓ | ✓ | | | | ✓ | | |
| MW-3037 | S | ✓ | | ✓ | | | ✓ | | |
| MW-3039 | S | | | | | | ✓ | | |
| MW-3040 | Q | ✓ | ✓ | ✓ | | | | | |
| MW-4007 | S | ✓ | ✓ | | | | | | |
| MW-4013 | S | | ✓ | | | | ✓ | ✓ | ✓ |
| MW-4014 | S | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| MW-4015 | S | | | | | | ✓ | ✓ | ✓ |
| MW-4022 | S | | ✓ | ✓ | | | | | |
| MW-4023 | S | | ✓ | ✓ | | | | | |
| MW-4026 | S | | | ✓ | | | | | |
| MW-4029 | S | ✓ | ✓ | | | | | | |
| MW-4031 | S | | ✓ | | | | | | |
| MW-4036 | S | ✓ | ✓ | ✓ | | | ✓ | | |
| MW-4039 | S | | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| MW-4040 | Q | ✓ | ✓ | ✓ | | | ✓ | | |
| MW-4041 | Q | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| MWS-1 | Q | ✓ | ✓ | ✓ | | | ✓ | | |

**TABLE 2-2 (Cont.)**

| | | Monitoring Parameters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location | Sampling Frequency[a] | TCE | Nitrate (as N) | Uranium | 1,3-DNB | 2,4,6-TNT | 2,4-DNT | 2,6-DNT | NB |
| MWS-4 | Q | ✓ | ✓ | ✓ | | | | | |
| SP-5303 | S | | | ✓ | | | | | |
| SP-5304 | S | | | ✓ | | | | | |
| SP-6301 | S | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| SP-6303 | S | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

[a] Monitoring frequencies may be decreased to annual or biennial on the basis of trends in at least the first 2 years of data. S = semiannual and Q = quarterly. Quarterly frequency will be for the initial 2-year period, decreasing to less frequent monitoring thereafter.

## 2.4 MONITORING FREQUENCIES

The frequency of monitoring should be adequate to detect, in a timely manner, the potential changes in site conditions. Flexibility for adjusting the monitoring frequency over the life of the remedy is also necessary. It may be appropriate to decrease the monitoring frequency at some point in time, once it has been determined that natural attenuation is progressing as expected. In contrast, the monitoring frequency may need to be increased if unexpected conditions are observed.

Sampling frequencies initially will be semiannual at most locations. Newly installed wells or wells where limited data are available will be sampled quarterly until at least eight data points are available for statistical evaluation. If, after 2 years of monitoring, downward trends are observed, the sampling frequencies will be decreased to an annual basis at those locations. Sampling frequencies for each well are summarized in Table 2-2.

## 2.5 DATA ANALYSIS AND INTERPRETATION

The monitoring network is designed either to collect data that shows that natural attenuation processes are acting as predicted or to trigger the implementation of contingencies when these processes are not acting as predicted (e.g., unexpected expansion of the plume or sustained increases in concentrations within the area of impact). The data analysis and interpretation will ensure that the following have occurred:

- Performance monitoring locations (Objective 2) indicate that concentrations within the area of impact are decreasing as expected.

- Detection monitoring locations (Objective 3, 4, and 5) indicate when a trigger has been exceeded.

- Baseline (upgradient) conditions (Objective 1) have remained unchanged.

Two documents — *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tanks Sites* (OSWER 9200.4-17P; Ref. 11) and the *Technical Guidance for the Long-Term Monitoring of Natural Attenuation Remedies at Department of Energy Sites* (Ref. 12) — were used during the development of this monitoring program.

Initially, sampling will be performed to gather baseline data on the new wells and on some existing wells selected for inclusion in the MNA program that lack sufficient recent data. This sampling will be performed for 2 years. After this timeframe, calculations of the MNA timeframes will be regenerated, and data analysis and interpretation will be performed as outlined in the following sections. The program will be modified at that time, if necessary, on the basis of these data.

### 2.5.1 Performance Monitoring (Objective 2 Locations)

Concentrations of contaminants of concern are expected to decrease to cleanup standards within a reasonable timeframe (i.e., approximately 100 years). Estimates for predictive timeframes were presented in the *Supporting Evaluation for the Proposed Plan for Final Remedial Action for the Groundwater Operable Unit* (Ref. 3). These calculations assumed that natural attenuation processes at the Chemical Plant area involve dilution and dispersion. Long-term trend analysis will be performed to confirm downward trends in contaminant concentrations over time. Performance will be gauged against long-term trends. It is anticipated that some locations could show temporary upward trends as a result of recent source control remediation, ongoing dispersion, analytical variability, or other factors. However, concentrations are not expected to exceed historical maximums. A similar methodology will be followed to recalculate MNA timeframes when needed to support the performance monitoring program. A detailed discussion of this methodology is presented in Appendix A.

A trend method using the nonparametric Mann-Kendall test will be employed (Ref. 12). This test is based on the relative magnitudes of the data rather than the actual values and does not require distributional assumptions. This nonparametric method is valid for scenarios where there are a high number of "non-detect" (ND) data points. Also, data reported as trace concentrations or less than the detection limit can be used by assigning them a common value that is smaller than the smallest measured value in the data set (i.e., one-half the specified quantitation limit). Also, use of this method will be consistent with previous methods employed at the Weldon Spring site. Results of the trend analyses will indicate the potential presence of statistically significant trends, as well as their direction and magnitude.

The two-tailed version of the Mann-Kendall test will be employed to detect either an upward or downward trend for each data set. In this approach, a test statistic, A, is calculated on the basis of the mean and variance of the data set. A positive value of Z indicates that the data are skewed in an upward direction, and a negative value of Z indicates that the data are skewed in a downward direction. The error limit ($\alpha$) used to identify a significant trend will be 0.05. In the two-tailed test where $\alpha$ is 0.05, the null hypothesis of "no trend" is rejected if the absolute value of the Z statistic is greater than $Z_{1-\alpha/2}$, where $Z_{1-\alpha/2}$ is obtained from a cumulative normal distribution table.

The linear slope, which is calculated independently of the trend, will be established for all data sets. The slope is estimated by using a nonparametric procedure. A 95% two-sided confidence interval about the true slope is calculated to indicate the variability of the values upon which the line is based.

Long-term monitoring will be concluded whenever a contaminant has been less than its respective cleanup level for four consecutive sampling periods spanning a minimum of 1 year at all of monitoring locations where that contaminant is monitored. Monitoring for 2,4-DNT in the eastern and western portions of the site will be evaluated separately, since these areas of groundwater impact had separate source areas.

Trigger levels will be set for the performance monitoring (Objective 2) locations in the event unexpected increases occur within the area of impact (Table 2-3). The first trigger will be a statistically significant increase in contaminant concentrations outside those that have been measured for the most recent eight data points. Concentrations that exceed the mean plus 3 standard deviations for that location will be considered to show a statistically significant increase. A second trigger will be established for each contaminant that will invoke a more vigorous response. Because of the greater concentrations of nitroaromatic compounds in the Frog Pond area (MW-2012, MW-2014, MW-2050, MW-2052, MW-2053, MW-2054, and MW-4015) when compared with the remainder of the site, separate triggers have been established for each area. Contingency actions associated with trigger exceedences are discussed in Section 2.6.

### 2.5.2 Detection Monitoring (Objective 3, 4, and 5 Locations)

Contaminants are expected to continue to disperse within known preferential flow paths associated with bedrock lows (paleochannels) in the upper Burlington-Keokuk Limestone and to become more dilute over time. This objective will be met by monitoring various downgradient perimeter locations that are either not impacted or minimally impacted. Contamination should not go any deeper than it already has. Historically, a slight impact from nitrate, nitroaromatic compounds, and uranium has been observed in the unweathered Burlington-Keokuk Limestone in the Raffinate Pits and Ash Pond areas at the Chemical Plant. Contaminant impacts in these locations are expected to remain minimal or nonexistent.

The springs discharge groundwater that includes contaminated groundwater originating from the Chemical Plant site. Current contaminant concentrations at these locations are protective of human health and the environment under current recreational land uses. Continued improvement of the water quality in these affected springs should be observed. Trend analysis (Section 2.5.1) will be performed at the springs (Objective 5) to evaluate if downward trends are occurring.

**TABLE 2-3 Trigger Levels for the Performance and Detection Monitoring Programs**

| Parameter | Objective 1 | Objective 2 | Objective 3 (near) | Objective 3 (far) | Objective 4 | Objective 5 |
|---|---|---|---|---|---|---|
| TCE | Mean + 3sd | 1000 µg/l | 15 µg/l | 5 µg/l | 10 µg/l | 5 µg/l |
| Nitrate | Mean + 3sd | 1350 mg/l | 30 mg/l | 10 mg/l | 20 mg/l | 20 mg/l |
| Uranium | Mean + 3sd | 100 pCi/l | 50 pCi/l | 20 pCi/l | 40 pCi/l | 150 pCi/l |
| 1,3-DNB | Mean + 3sd | 20 µg/l | 4 µg/l | 1 µg/l | 2 µg/l | 1 µg/l |
| 2,4,6-TNT | Mean + 3sd | 500 µg/l | 11.2 µg/l | 2.8 µg/l | 5.6 µg/l | 2.8 µg/l |
| 2,4-DNT | | | | | | |
| East | Mean + 3sd | 2300 µg/l | 1.1 µg/l | 0.11 µg/l | 0.22 µg/l | 0.22 µg/l |
| West | Mean + 3sd | 5 µg/l | 0.55 µg/l | 0.11 µg/l | 0.22 µg/l | 0.22 µg/l |
| 2,6-DNT | Mean + 3sd | 2000 µg/l | 13 µg/l | 1.3 µg/l | 2.6 µg/l | 1.3 µg/l |
| NB | Mean + 3sd | 50 µg/l | 34 µg/l | 17 µg/l | 17 µg/l | 17 µg/l |

Maximum trigger levels will be set for each contaminant for the detection monitoring locations and the springs. These triggers are summarized in Table 2-3. Contingency actions (Section 2.6) will be initiated if concentrations exceed established trigger levels.

### 2.5.3 Upgradient Groundwater Monitoring (Objective 1 Locations)

Groundwater quality will be monitored at upgradient unimpacted locations (Objective 1) in order to maintain a baseline of naturally occurring constituents to determine if downgradient conditions may be showing natural changes rather than contaminant-based changes.

Groundwater data from the upgradient locations will be compared with previously collected data from each respective location. If a statistically significant increase, defined as concentration(s) that exceed(s) the mean plus 3 standard deviations for the previous eight data points, is measured, then investigation of the validity of that data point will be initiated (Section 2.6). For those locations that are ND, a statistically significant increase is considered to be the respective cleanup standard, measured for two consecutive sampling periods. Contingency actions (Section 2.6) will be initiated if concentrations exceed established trigger levels.

### 2.5.4 Hydrologic Monitoring (Objective 6 Locations)

Hydrologic conditions at the site over time will be monitored in all remaining DOE wells in order to identify any changes in groundwater flow that might affect the protectiveness of the selected remedy. A set of wells has been selected as the minimum required to adequately evaluate the hydrologic conditions at the site. The static groundwater elevation of the monitoring network will be measured to establish that groundwater flow is not changing significantly and not resulting in changes in contaminant migration. Objective 6 wells are supplemental wells to the groundwater monitoring network that will provide sufficient coverage for hydrologic monitoring. Groundwater quality samples will not be collected from Objective 6 wells.

Groundwater elevation maps will be created and evaluated to verify that the groundwater flow directions and rates are sufficient to support the attenuation of the contaminants in the predicted timeframes. Also, groundwater flow directions will be evaluated against the IC boundary to verify that the restricted use area is adequate.

## 2.6 CONTINGENCY ACTIONS

The monitoring program has also been developed to recognize any of the following observations that could lead to reconsideration of the remedy:

- A sustained upward trend in contaminant concentrations in groundwater or springwater, indicating that undiscovered sources may be present;
- Trends in contaminant concentrations that are inconsistent with meeting cleanup goals within a reasonable timeframe; or
- Significant increases in the areal or vertical extent of contamination, resulting in new impacts to adjacent (both horizontal and vertical) unimpacted groundwater systems.

Trigger concentrations have been assigned at appropriate locations as indicators of changed conditions or of having a potential for impact outside those areas where migration is expected to occur (i.e., paleofeatures). Responses will range from data verification and increased monitoring to reevaluation of MNA timeframes. Changes in the monitoring program may be implemented and could include increased sampling, addition of monitoring parameters, or addition of monitoring locations (existing wells or new wells). Decision trees have been developed for each monitoring program (Figures 2-12 through 2-17) that outline courses of action for exceeding trigger levels.

In the event that recalculation of the MNA timeframes is required, the methodology to be used, which is presented in Appendix A, is consistent with the approach used in the *Supporting Evaluation* (Ref. 3). The original calculations were based on a larger set of wells than the set used to monitor MNA. Collection of data from nearby existing wells will be necessary to complete this task; therefore, it is not expected that recalculation will be performed routinely as a performance measure of MNA.

Should an alternative to MNA be needed, it will be implemented in accordance with the CERCLA process for post-ROD changes. If the remedy requires immediate action, a time-critical removal will be conducted. Alternatives other than MNA will be reevaluated and will include ICO as well as other treatment or containment technologies that may be available in the future.

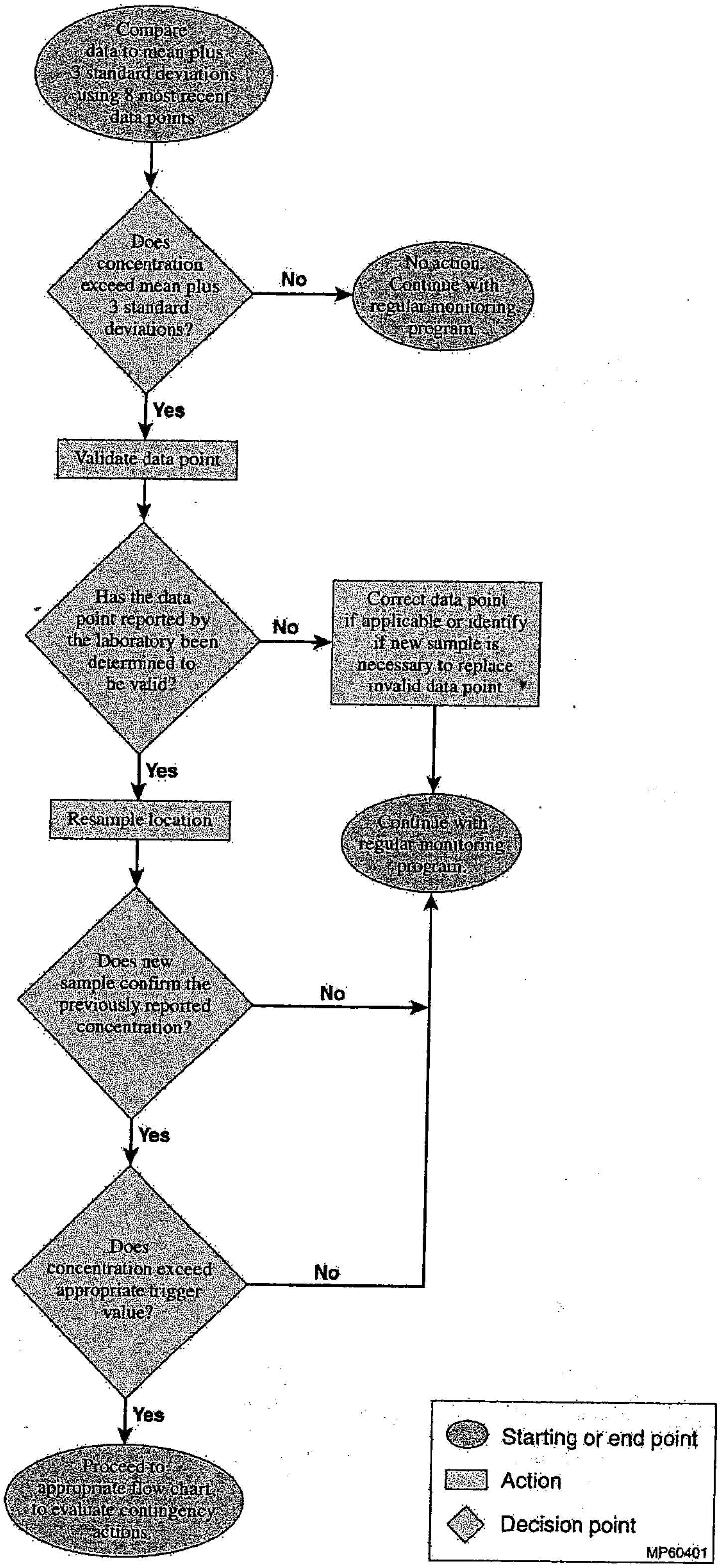


**FIGURE 2-12 Validation and Statistical Evaluation Scheme**

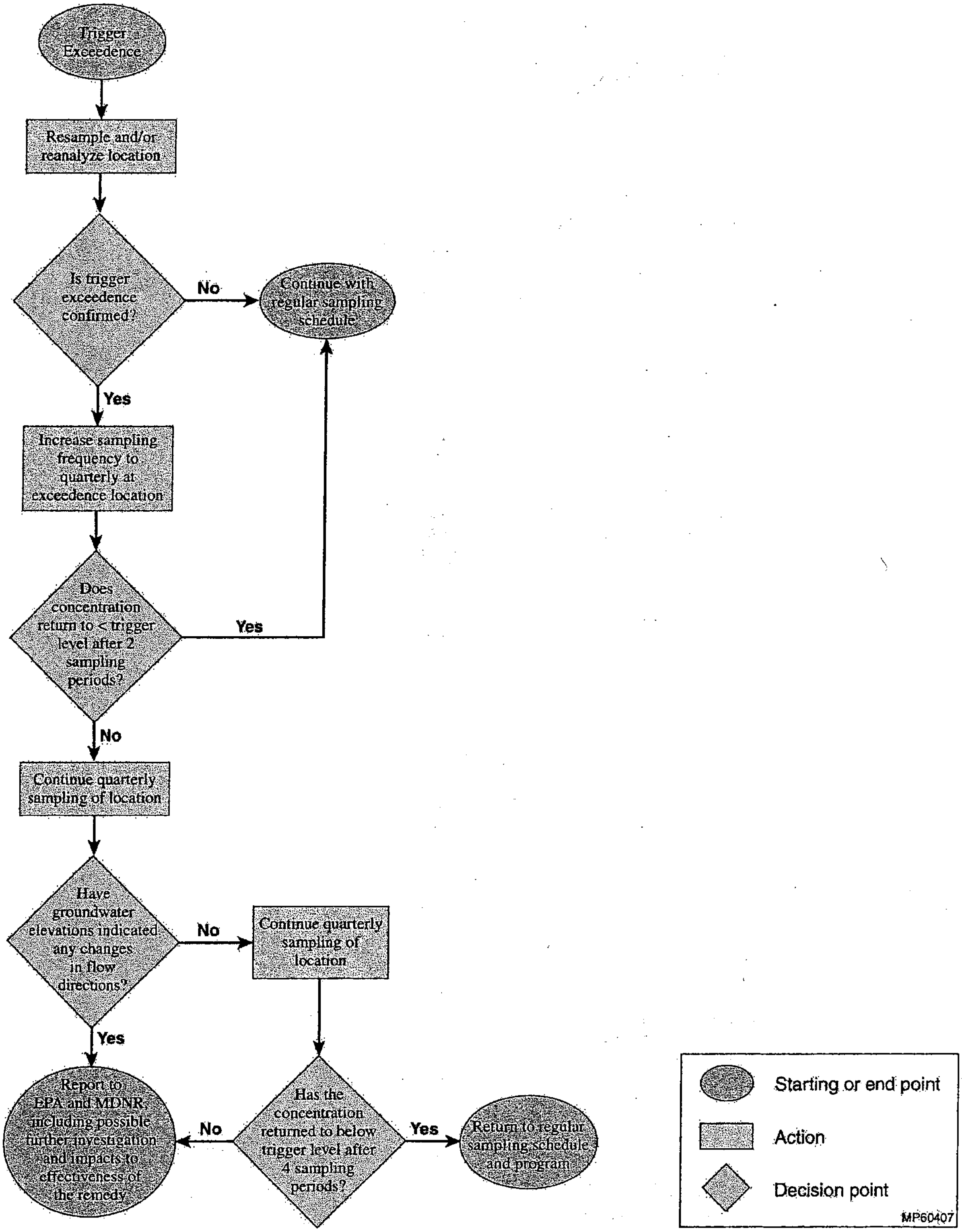


FIGURE 2-13 Decision Tree for Objective 1 Data

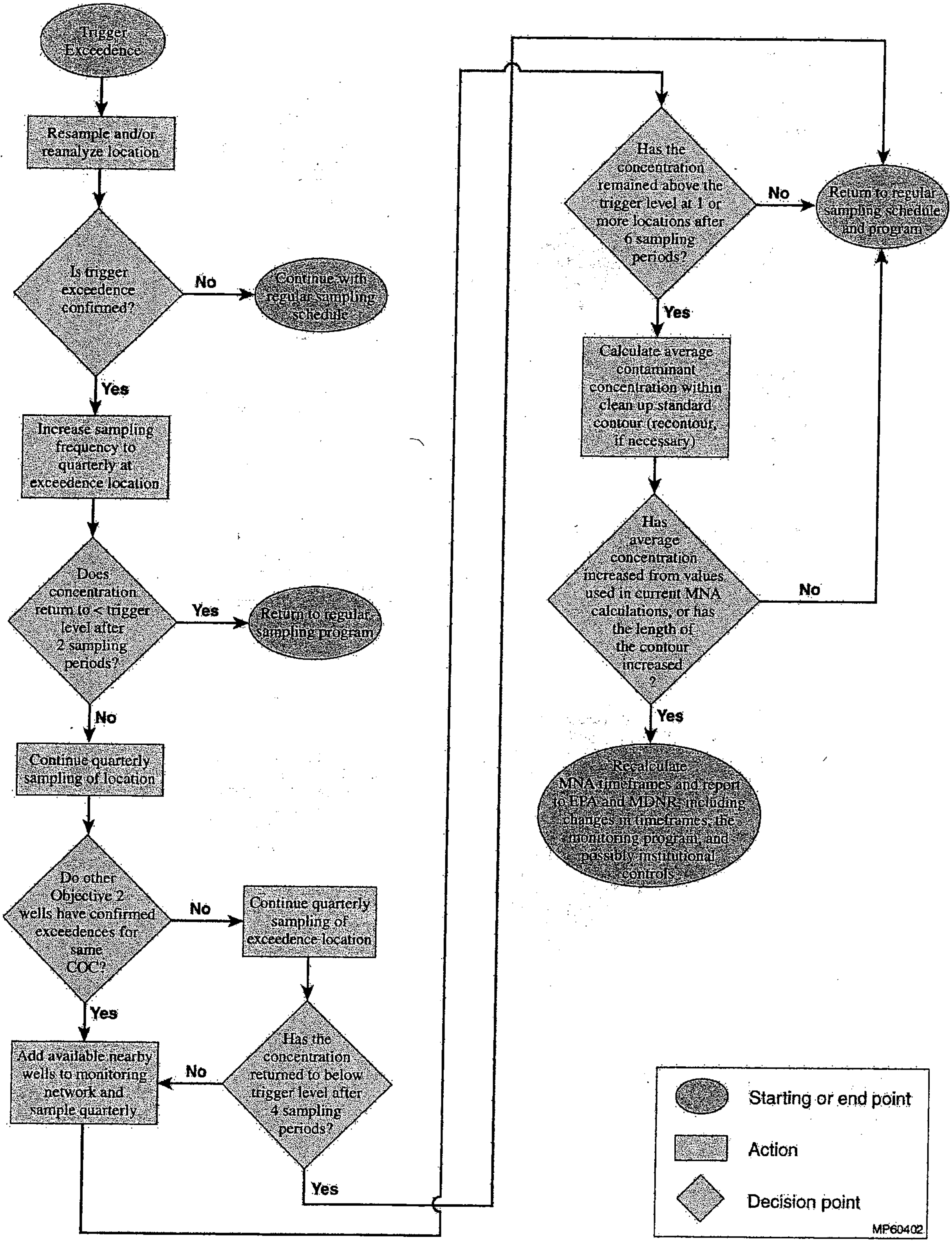


FIGURE 2-14 Decision Tree for Objective 2 Data

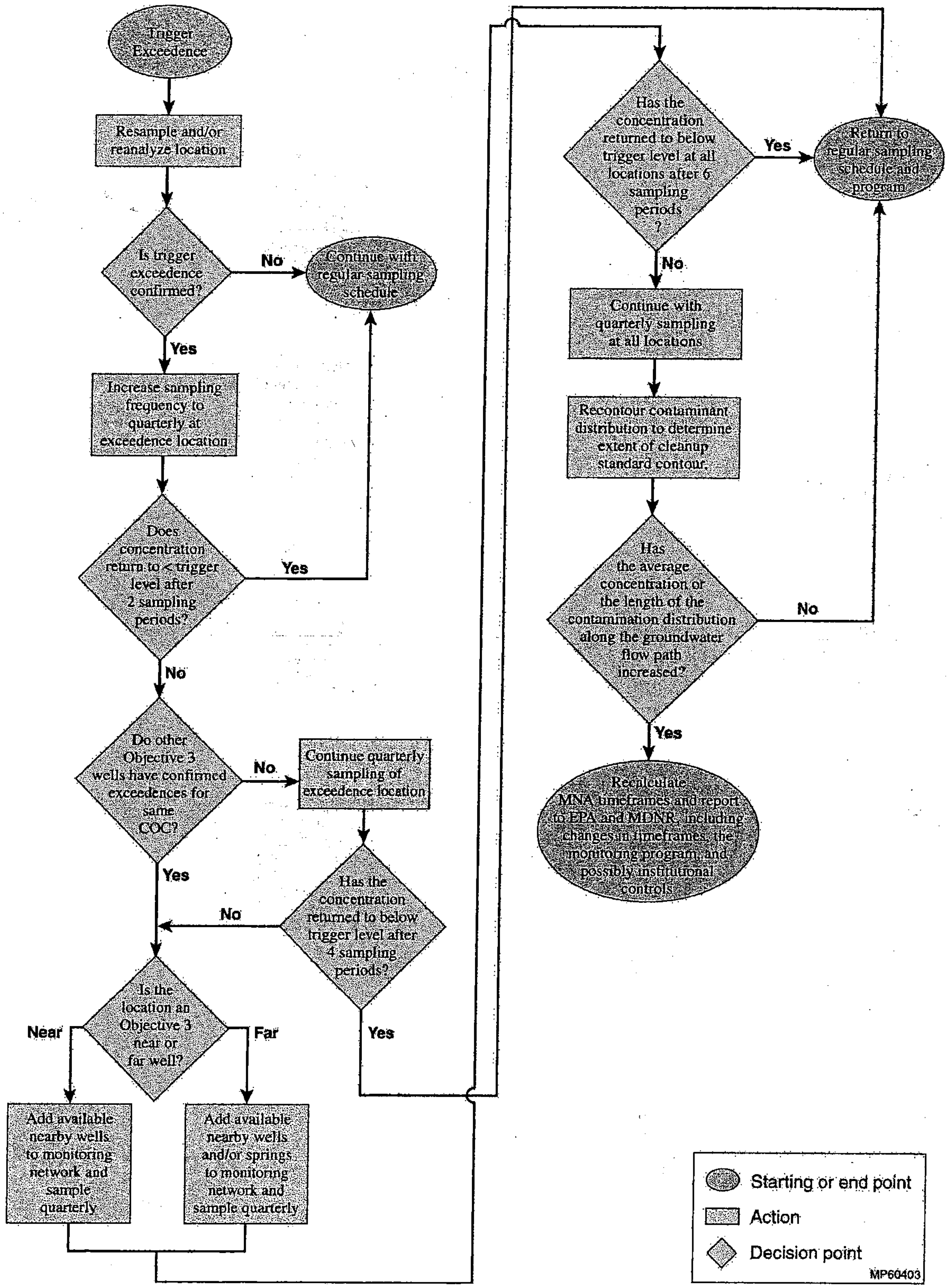


FIGURE 2-15 Decision Tree for Objective 3 Data

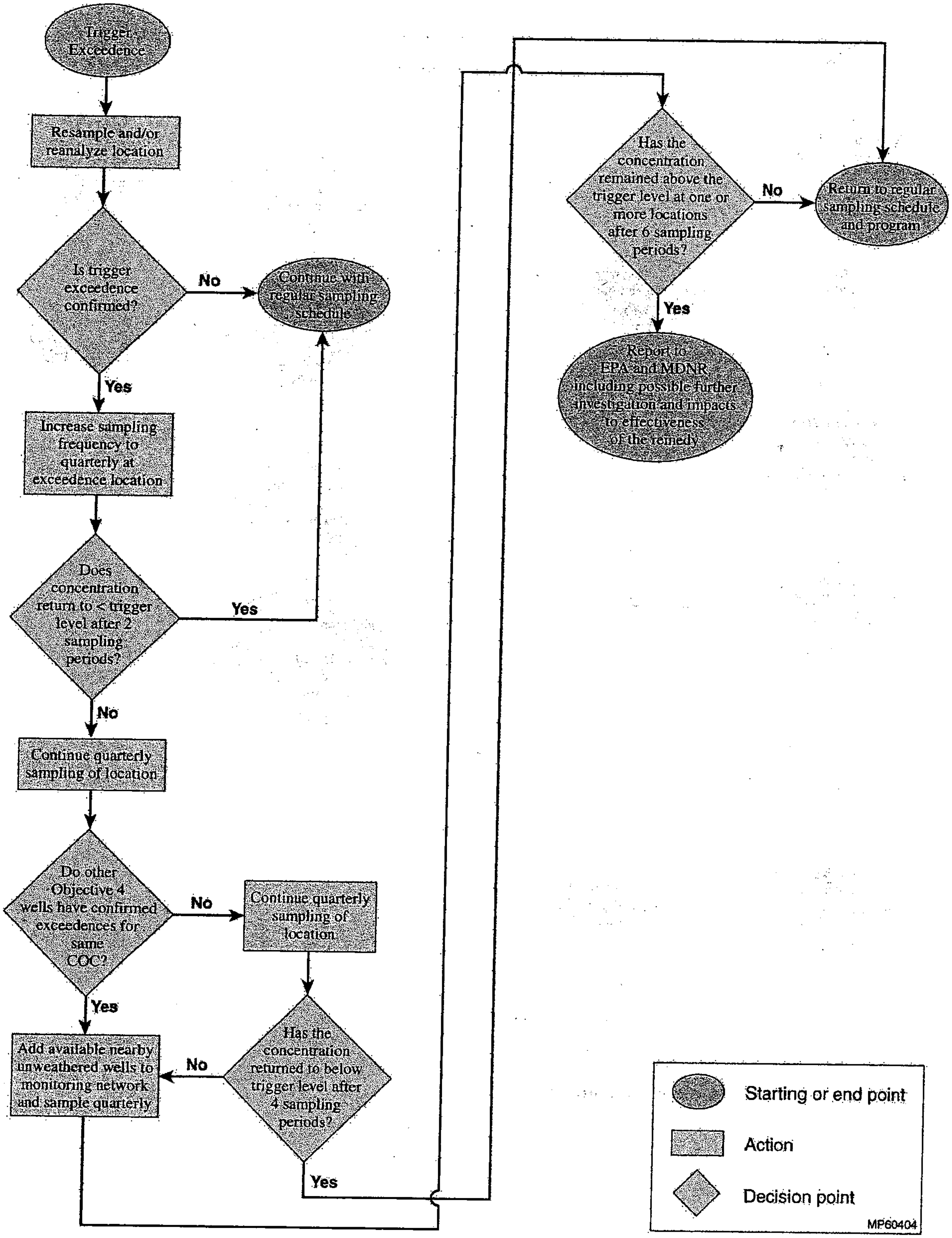


FIGURE 2-16 Decision Tree for Objective 4 Data

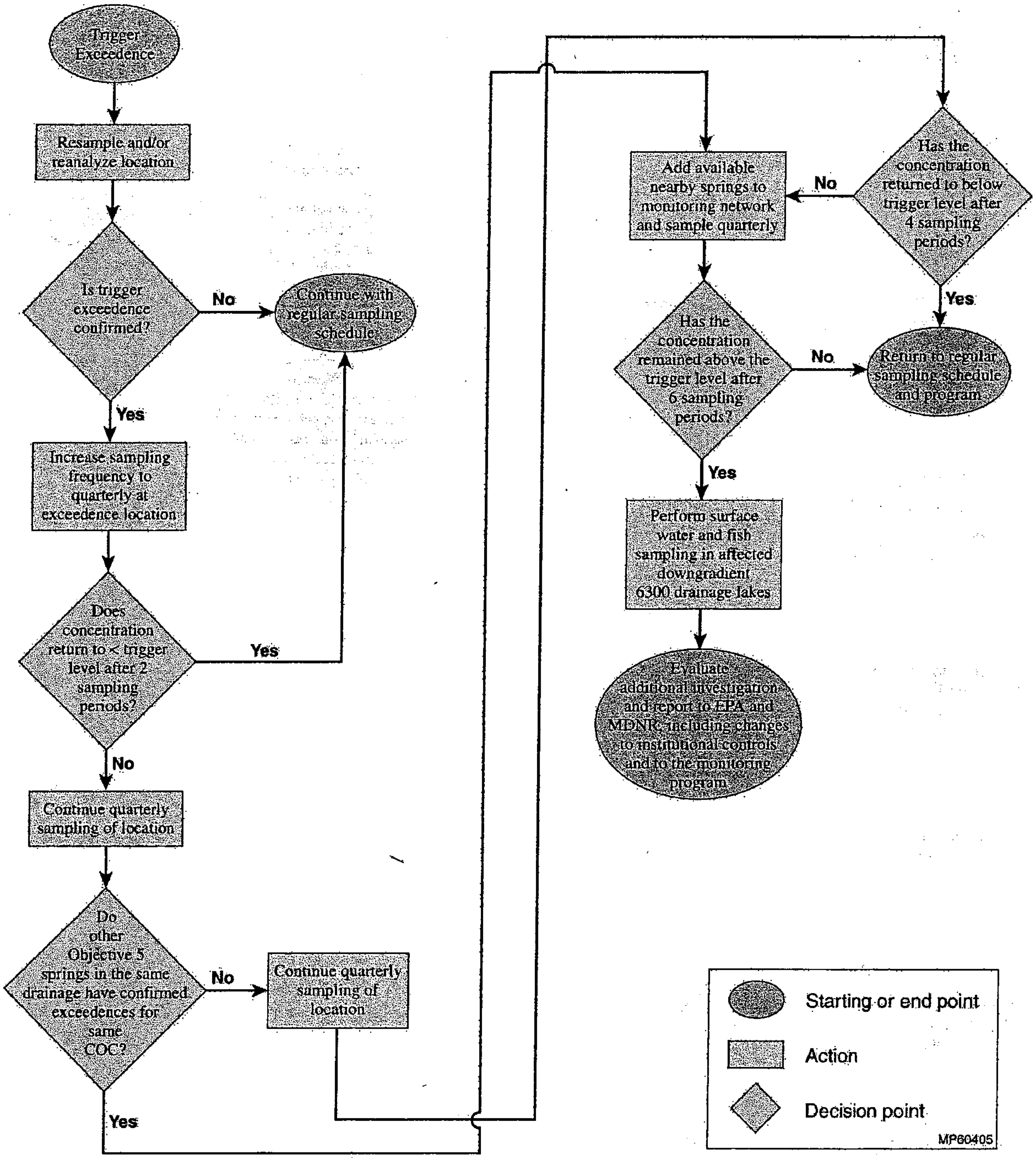


**FIGURE 2-17 Decision Tree for Objective 5 Data**

# 3 INSTITUTIONAL CONTROLS

Because groundwater contamination remains beneath and in close proximity to the Chemical Plant, institutional controls (ICs) will be incorporated into the selected remedy for the GWOU. Depending on the levels of contamination, the groundwater cannot be used for residential drinking water purposes; therefore, ICs will be imposed until the groundwater can be released. Also, several springs have been impacted by groundwater and/or contaminated surface water run-off from the Chemical Plant and cannot be used for residential drinking water purposes.

## 3.1 AFFECTED AREAS

### 3.1.1 Area of Groundwater Impact

ICs are needed to restrict groundwater usage. The ICs are needed within the property boundary of the Chemical Plant and areas outside the property boundary where the cleanup standard is exceeded for any of the contaminants of concern, plus an additional buffer (Figure 3-1). This buffer will delineate an area where extraction of the shallow groundwater should be prevented, not because of groundwater quality but because of the possibility of intercepting the groundwater plume as a result of a well's area of influence.

The buffer will extend 1,000 ft from the edge of the contaminant plume, as delineated on Figure 3-1. This distance is based on data from two groundwater studies performed at the site during 1998 and 2001. The area of hydraulic capture around a hypothetical well was estimated to be 600 to 1,000 ft (Ref. 2). This value is based on information from MW-3028 and is considered conservative, since the well is located in a more transmissive portion of the aquifer.

Off-site nitroaromatic contamination southwest of the Chemical Plant has not been addressed in this evaluation. This impact originates from Department of the Army property and should be addressed by its remedy selection processes. Nitroaromatic contamination originating from within the Chemical Plant boundary and migrating off site is addressed in this evaluation.

### 3.1.2 Subsurface Pathway to Burgermeister Spring

The results of numerous investigations indicate that a subsurface conduit is present between the unnamed tributary of Schote Creek and Burgermeister Spring (Ref. 4). Overland flow from the northwestern portion of the Chemical Plant is lost in a losing reach of an unnamed tributary of Schote Creek about 1,000 ft northwest of Ash Pond. The travel time to Burgermeister Spring, which is located approximately 6,500 ft away, was estimated to be 48 to 72 hours, depending on previous rainfall. Dye tracing of two angled borings and one monitoring well, which were selected for high hydraulic conductivity, was performed during the remedial

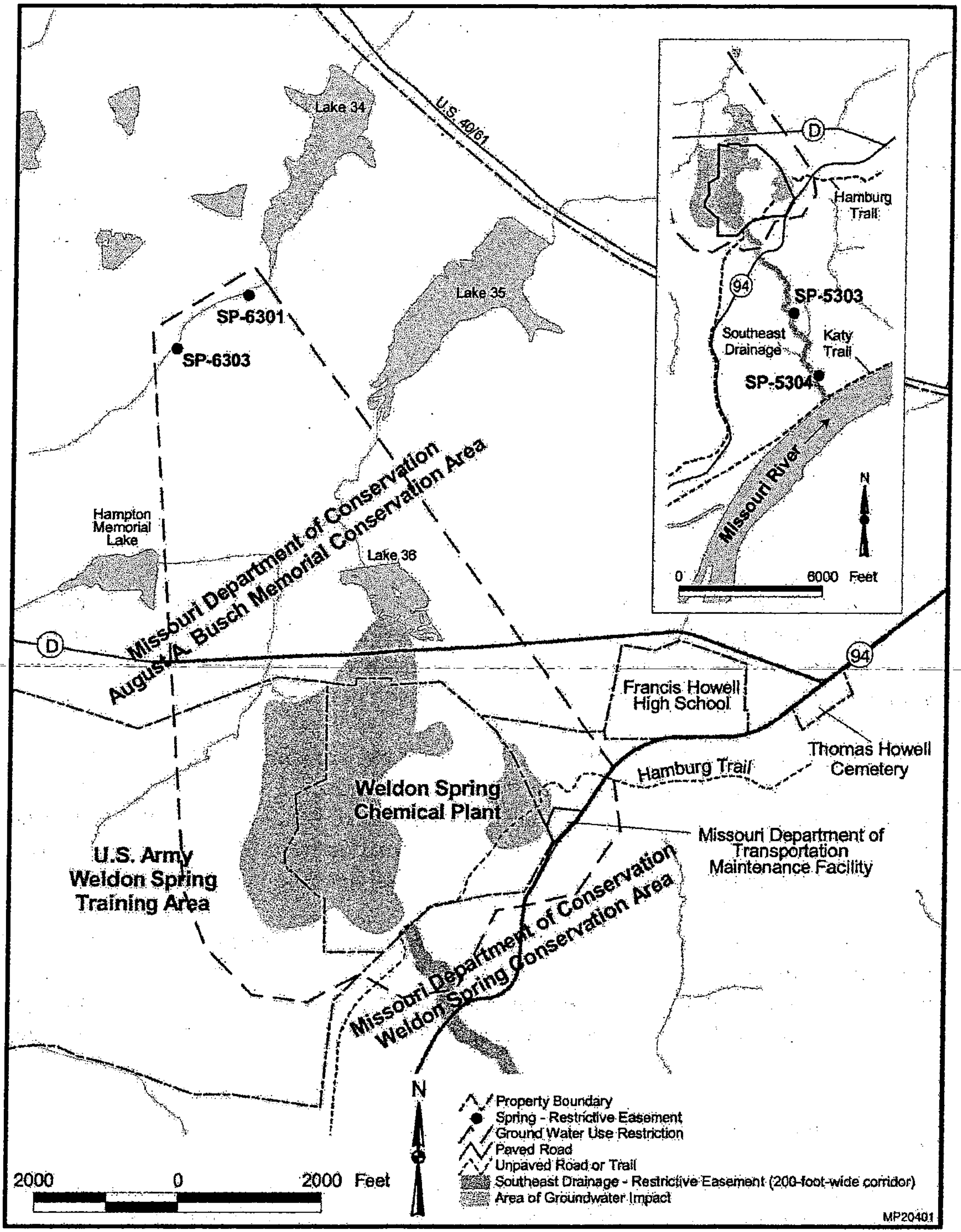


**FIGURE 3-1 Area with Institutional Controls for the GWOU**

investigation. Three springs in the 6300 drainage were monitored for resurgence of the dye; however, the dye was detected only in Burgermeister Spring. Dye was initially detected in Burgermeister Spring 2 to 7 days after injection. The approximate location of this preferred flow feature is depicted in Figure 2-8.

### 3.1.3 Springs

ICs will be implemented to preclude the residential use of groundwater or springwater in the vicinity of the two springs in the Burgermeister Spring drainage. The boundary where the ICs will be implemented will extend from 1000 ft from the springs. ICs will also be implemented along the Southeast Drainage to preclude any groundwater or springwater use. The boundary where the ICs will be implemented will be a 200-ft corridor centered on the existing stream flow. The Southeast Drainage is a closed system with little observable loss to adjacent drainages or the underlying groundwater system (Ref. 5). The 200-ft corridor extends to the edges of this drainage.

## 3.2 IMPLEMENTATION

The affected properties are under either federal (DOE or Army) or state (MDC) ownership. This ownership, which maintains the land use as nonresidential, provides a primary IC to restrict access to the shallow aquifer. The majority of the area of impact is on federal property where the landowners project long-term ownership. All parties are aware of the long-term commitments under CERCLA to address groundwater contamination in this area.

Additional ICs will consist of state regulatory restrictions and agreements between DOE and the affected landowners. The objective of the ICs is to limit future access to properties or media contaminated above prescribed standards. For groundwater, this restriction will consist of limited access to and use of groundwater in the shallow aquifer. The procedures for establishing ICs for the GWOU and the enforcement of these controls are integrated in the *Long-Term Surveillance and Maintenance Plan for the Weldon Spring, Missouri, Site* (Ref. 13).

### 3.2.1 Primary Restriction on Shallow Groundwater Access

The primary IC to restrict access to the shallow impacted groundwater is federal and state ownership of the affected properties. It is expected that long-term management of the property will continue and that landowners will preclude activities that would impact the performance of the remedy. The present conditions are protective of human health and the environment. Secondary ICs will be established as a layering to provide additional restrictions to prevent access to the impacted shallow aquifer.

An additional primary IC to restrict access to the shallow impacted groundwater on nonfederal property is the State of Missouri's *Well Construction Code* (10 CSR 23-3). Several notations provide restrictions on the placement of private drinking water wells. The regulation specifies in 10 CSR 23-3.010 (2) (A) 1 that a well should be at least 300 ft from a landfill. This would restrict drinking water wells within the 300-ft buffer zone around the disposal cell. The regulation also recommends in 10 CSR 23-3.010 (2) (B) that wells not be located in an area between a landfill and the point of groundwater discharge to a surface water source. This would be applicable to the area between the disposal cell and Burgermeister Spring or the Southeast Drainage springs. The regulation specifies in 10 CSR 23-3.030 (2) that the wells should be watertight to such depth as may be necessary to exclude contaminants. The regulation indicates in 10 CSR 23-3.090 (1) for bedrock wells in Area 1 (a limestone or dolomite area), the well driller must set the minimum protective casing depth at no less than 80 ft, with at least 30 ft of casing set in the bedrock in an agricultural or drinking water well. The portion of the shallow aquifer that is impacted is the weathered unit of the Burlington-Keokuk Limestone, which extends to a depth of approximately 80 ft below the ground surface. All wells must be certified and registered with the state. Although installation of wells does occur prior to registration, the location and construction of each well is submitted and reviewed by the state before it grants a registration number. Therefore, this state regulation provides additional primary protection restricting access to the contaminated groundwater within the upper portion of the shallow aquifer.

### 3.2.2 Secondary Restriction on Shallow Groundwater Use at the DOE Site Proper

This IC has been established through a notation placed on the Federal Acquisition land records and filed with the St. Charles County Recorder. Restrictions within this notation will accrue to succeeding owner(s) of the land. The notation contains language stating that current owners or users shall not access the groundwater for any use-type activity. DOE shall continue to monitor and analyze the groundwater through approved investigative techniques. Should the land be conveyed to another party, notice of the restrictions and/or prohibitions will be placed within the conveyance document noting such restrictions and/or prohibitions on use. These restrictions will be for an indefinite term. Restrictions on the use of groundwater will remain in effect until cleanup standards are met. The *Long-Term Surveillance and Maintenance Plan for the Weldon Spring, Missouri, Site* (Ref. 13) will contain the details of this restriction.

### 3.2.3 Secondary Restriction on Shallow Groundwater Use in Areas Surrounding the Chemical Plant

These ICs will be restrictive easements or permits as applicable. The restrictive realty estate will contain restrictions and/or prohibitions such that the current owners or users of the land will not access the shallow groundwater or Burgermeister Spring (SP-6301) or SP-6303 for residential use. The instrument will also provide that DOE will continue to have the right to monitor and analyze the groundwater and springwater through approved investigative techniques. These restrictions will remain in effect until cleanup standards are met. The *Long-Term Surveillance and Maintenance Plan for the Weldon Spring, Missouri, Site* (Ref. 13) will contain more information regarding these restrictions, including an implementation plan.

### 3.2.4 Secondary Restriction on Shallow Groundwater Use in the Southeast Drainage

This IC will be a restrictive easement or permit and will contain language to restrict and prohibit any and all residential development and residential usage within a 200-ft corridor (100 ft on either side) of the existing Southeast Drainage stream flow. This IC will also prohibit the residential use of the groundwater or springwater in this drainage. DOE will continue to have the right to monitor and analyze the groundwater and springwater through approved investigative techniques. The restriction will remain in effect until cleanup standards are met. The *Long-Term Surveillance and Maintenance Plan for the Weldon Spring, Missouri, Site* (Ref. 13) will contain more information regarding this restriction, including an implementation plan.

# 4 CONSTRUCTION ACTIVITIES

The construction activity associated with this remedy was the installation of three wells and the replacement of one well that had questionable integrity. The possible abandonment of 31 existing monitoring wells will be performed over a longer period of time (Section 2.5). All drilling and well installation and abandonment activities will be performed in accordance with 10 CSR 23, *Missouri Well Construction Rules*.

Two monitoring wells were installed in the unweathered portion of the Burlington-Keokuk Limestone to monitor potential vertical migration of contaminated groundwater. These wells are MW-2056 and MW-4040 (Figure 2-11). Well MW-2056 is clustered with the existing weathered well MW-2052, and well MW-4040 is located west of existing weathered well MW-3030. The unweathered wells are cased through the weathered unit to prevent downward migration of overlying contaminated groundwater into the unweathered zone.

One well was installed north of the Chemical Plant on the Busch Conservation Area. This well is MW-4041 and is completed at the interface of the overburden and the Burlington-Keokuk Limestone (Figure 2-11). This well is constructed within the paleochannel connected to Burgermeister Spring to monitor groundwater within a preferential flow path from the Chemical Plant. Four borings were drilled to locate and delineate the cross section of the paleochannel and to identify the most transmissive area of the shallow aquifer in this area. One of the borings was completed as a well.

A well was installed near a weathered/unweathered well cluster in the Raffinate Pits area. This well is MW-3040 and is completed in the unweathered unit. This well was installed because the integrity and therefore the reliability of the data obtained from MW-3024 (unweathered) were in question. This well will be monitored, and the data will be compared to data from well MW-3024, which will continue to be sampled. On the basis of information from these two wells, the continued monitoring of MW-3024 will be determined.

The bedrock portion of each borehole was logged in the field. Packer testing was performed on the bedrock portion of all the boreholes to optimize the placement of screens and filter packs in the wells. All wells were constructed of stainless steel materials. Each new well location was surveyed to establish its location and to establish the ground and top of casing elevations, which were surveyed to 0.1 ft. The coordinates, the ground and top of casing elevations, and the depth of the screened interval for each well are summarized in Table 4-1.

**TABLE 4-1 New Monitoring Well Information**

| | Coordinates | | Elevations (ft) | | |
|---|---|---|---|---|---|
| Well ID | Northing | Easting | Ground | Top of Casing | Monitoring Interval (ft)[a] |
| MW-2056 | 1043939.0 | 756027.0 | 622.2 | 624.9 | 70.0–83.0 |
| MW-3040 | 1042632.8 | 754252.0 | 654.3 | 656.8 | 92.0–105.0 |
| MW-4040 | 1042990.8 | 753001.3 | 631.7 | 633.9 | 52.0–65.0 |
| MW-4041 | 1048463.8 | 753070.9 | 581.0 | 583.1 | 43.0–58.0 |

[a] Feet below ground surface.

## 5 PROJECT SCHEDULE

The milestones associated with the implementation of this *Work Plan* are as follows:

| | |
|---|---|
| Award drilling subcontract | April 4, 2004 |
| Start monitoring well installation | April 26, 2004 |
| Complete monitoring well installation | May 27, 2004 |
| GWOU completion inspection | July 15, 2004 |
| Initiate MNA monitoring | July 31, 2004 |
| Submit draft interim remedial action report | July 31, 2004 |

# 6 SUMMARY OF PROJECT COSTS

Groundwater and springs will be monitored at the Chemical Plant site until cleanup standards are attained. It is estimated that this will occur within a period of approximately 100 years. It is assumed that three wells (one in the weathered zone and two in the unweathered zone) will be installed to augment the existing monitoring network and that 25 existing wells that will not be included in the monitoring network will be abandoned. Abandonment may be carried out in phases at future dates. Costs are presented in Table 6-1, and a breakdown in presented in Appendix B. O&M costs do not include additional monitoring costs associated with implementation of contingency actions.

**TABLE 6-1 Summary of Costs for Monitored Natural Attenuation**

| Cost Item | Cost (in dollars)[a] |
|---|---|
| Capital Costs:<br>Costs include installation and abandonment of wells. Engineering and oversight costs are also included (15% of subcontractor costs). | 466,000 |
| O&M Costs (annual):<br>Costs include analytical costs and well replacement costs. Engineering oversight costs (15% of subcontractor costs) and contingency (10%) are included. | 339,000 |

[a] Present worth.

# 7 QUALITY ASSURANCE PROGRAM

The Technical Assistance Contractor (TAC), as obligated by DOE Order 414.1A, *Quality Assurance*, has developed a quality assurance program as documented in the *Grand Junction Office Quality Assurance Manual* (Ref. 14). This manual includes requirements for organization, personnel training, quality improvement, documents and records, work processes, design, procurement, inspection and acceptance testing, and a routine assessment program. The elements of the manual apply to all activities of the Weldon Spring site.

## 7.1 PURPOSE

The TAC implements and maintains a written quality assurance program in the form of the *GJO Quality Assurance Manual.* The manual describes the organizational structure, functional responsibilities, levels of authority, and interfaces for those managing, achieving, and assessing adequacies of work. The manual also describes the management system, including planning, scheduling, and cost control considerations. The *GJO Quality Assurance Manual* satisfies the requirements of:

- DOE Order 414.1A, *Quality Assurance*, and
- 10 CFR 830.120, *Quality Assurance*.

American Society of Mechanical Engineers (ASME) NQA-1, EPA documents, and American National Standards Institute/American Society for Quality (ANSI/ASQ) E4 were also used as guidance documents in developing the quality assurance program.

## 7.2 DESCRIPTION

The *GJO Quality Assurance Manual* reflects the mission, policies, and objectives for all work performed by the TAC on the Weldon Spring site. The program is broad-based and applies to every aspect of work performed by the TAC. The *GJO Quality Assurance Manual* identifies mechanisms necessary for the planning, implementation, and assessment of quality-affecting activities. These mechanisms are applied by using a graded approach, which takes into account that not all items, processes, or services have the same impact on the quality, safety, or reliability of an activity. Mechanisms outlined in the manual are:

- Quality program description,
- Personnel indoctrination and training,
- Quality improvement,
- Documents and records,

- Work processes,
- Design,
- Procurement,
- Inspection and acceptance testing,
- Management assessment, and
- Independent assessment.

## 7.3 IMPLEMENTATION

The TAC Quality Assurance Manager and his designees conduct independent assessments of the performance of the project with regard to the requirements of the *GJO Quality Assurance Manual,* project planning documents, and departmental standard operating procedures and instructions. These assessments are performed in accordance with the *GJO Quality Assurance Manual.*

The *GJO Quality Assurance Manual,* together with implementing procedures and instructions, forms an integrated management system that ensures compliance with specified standards, personnel safety, and protection of the environment. The significant features are:

- Quality verification and overview of activities that demonstrate the completeness and appropriateness of achieved quality,
- Assurance that activities are performed to specified requirements, and
- Assurance that structures, systems, and components will perform as intended.

Quality is achieved by ensuring that managers at all levels are responsible and accountable for achieving and improving upon quality. All TAC personnel are responsible for the quality of their work.

The quality assurance/quality control (QA/QC) requirements for specific tasks performed under the scope of this work plan will be addressed in future documents. The QA/QC requirements for sampling and characterization activities will be addressed in the appropriate sampling or monitoring plans.

## 8 EMERGENCY PREPAREDNESS PLAN

### 8.1 PURPOSE

The *Weldon Spring Site Project Safety Plan* (Ref. 15) establishes the planning, preparedness, and response concepts for emergencies at the Weldon Spring Site Remedial Action Project (WSSRAP). The emergency response measures established by the *Project Safety Plan* are intended to afford protection for the health and safety of on-site personnel and the public, limit damage to facilities and equipment, minimize impacts to on-site operations, and limit adverse impacts on the environment. The plan is implemented whenever an emergency situation is declared or conditions exist that constitute, or could result in, an operational emergency at the WSSRAP. The *Project Safety Plan* also defines the health and safety requirements for the work performed as part of the remedial action.

### 8.2 DESCRIPTION

The *Project Safety Plan* is designed to address the health and safety aspects of the operations conducted by the WSSRAP. The scope and extent of the planning is commensurate with the hazards currently present at the WSSRAP.

The *Project Safety Plan* addresses the following topics:

- Scope and applicability of plan,
- Identification and responsibilities of key health and safety personnel,
- Notification and communication,
- Hazard assessment process,
- General safe work practices,
- Personal protective equipment,
- Emergency procedures and notifications,
- Emergency facilities and equipment,
- Training,
- Physical health hazards, and
- Task-specific job safety analysis.

## 8.3 IMPLEMENTATION

It is the policy of DOE and the WSSRAP management to conduct operations in a responsible manner so as to be protective of human health and the environment. The primary focus of site management is the prevention of accidents, emergency situations, and other incidents, which could adversely affect on-site personnel, the public, property, or the environment. These objectives are attained through the implementation of effective planning and preparedness for emergencies during the initial stages of site activities. Also, the use of protective actions and training encourages personnel to maintain an awareness of potential emergencies and of the appropriate responses required for prevention or mitigation of problems that could occur.

Specific provisions for responding to emergencies that are unique to individual tasks within the remedial action activities are incorporated into job-specific health and safety plans, safe work plans, and/or task-specific safety assessments. For each activity, the *Project Safety Plan* is the primary working document that governs initial safety, health, and emergency response requirements. The *Project Safety Plan* also provides subcontractors with the process for identifying potential emergency conditions and notifying the appropriate WSSRAP contact.

# 9 POST-ROD DOCUMENTATION

This section outlines the primary and secondary documents that will be prepared to support the design and implementation of the selected interim remedy for the GWOU. Primary documents include those documents that are major, discrete portions of the remedial design and remedial action activities. Secondary documents are typically feeder documents to a primary document. A secondary document may be finalized in the primary document that it supports or it may be issued as a stand-alone document. The schedule for the documents being prepared in support of the design and construction for this operable unit will be included and updated in the quarterly reports prepared in accordance with the *Federal Facilities Agreement* (Ref. 2).

## 9.1 PRIMARY DOCUMENTS

### 9.1.1 Final Design Submittals

A final design submittal for this work will not be provided for review. The construction activities (monitoring well installation and abandonment) associated with this remedial action will be performed in accordance with 10 CSR 23, *Missouri Well Construction Rules.* Standard drilling and well construction methods will be employed. The scope of the construction activities is provided in Section 4.

### 9.1.2 Operations and Maintenance Plan

A separate *Operations and Maintenance Plan,* as outlined in the *Federal Facilities Agreement* (Ref. 2), will not be prepared for the GWOU. Long-term monitoring activities, such as those associated with MNA, are presented in the *Long-Term Surveillance and Maintenance Plan* (LTS&MP) (Ref. 13). Implementation of ICs is also presented in the LTS&MP. This plan explains how DOE will fulfill its surveillance and maintenance obligation at the Weldon Spring site. Long-term surveillance and maintenance refers to all activities necessary to ensure protection of human health and the environment following completion of cleanup, disposal, or stabilization at a site.

## 9.2 SECONDARY DOCUMENTS

### 9.2.1 Preliminary Design Submittals

A preliminary design submittal for this work will not be provided for review.

### 9.2.2 Construction Progress Reports

The quarterly reports for the *Federal Facilities Agreement* will fulfill the requirements for the *Construction Progress Report* for this operable unit. Copies of reports submitted by the subcontractor, as well as quality control inspections, are maintained by the project. These documents can be made available, upon request, to the regulators for inspection.

## 10 REFERENCES

1. U.S. Department of Energy, 2004, *Record of Decision for the Final Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site*, DOE/GJ/79491-936, prepared by U.S. Department of Energy, Office of Legacy Management, Weldon Spring Site Remedial Action Project, Weldon Spring, MO, January.

2. U.S. Environmental Protection Agency, 1992, *First Amended Federal Facilities Agreement*, Docket No. CERCLA-VII-85-F-0057, prepared for the U.S. Department of Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, MO, January.

3. U.S. Department of Energy, 2003, *Supporting Evaluation for the Proposed Plan for Final Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site*, DOE/OR/21548-934, prepared by Argonne National Laboratory, Argonne, IL, for the U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN, September.

4. U.S. Department of Energy, 1995, *Work Plan for the Remedial Investigation/Feasibility Study for the Groundwater Operable Unit at the Chemical Plant Area and Ordnance Works Area*, DOE/OR/21548-567, prepared by Argonne National Laboratory, Argonne, IL, for the U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN, August.

5. U.S. Department of Energy and U.S. Department of the Army, 1997, *Remedial Investigation for the Groundwater Operable Units at the Chemical Plant Area and the Ordnance Works Area of the Weldon Spring Site*, DOE/OR/21548-571, prepared by MK-Ferguson and Jacobs Engineering Group, Weldon Spring, MO, and Argonne National Laboratory, Argonne, IL, for the U.S. Department of Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, MO, and U.S. Department of the Army, Corps of Engineers, Kansas City District, Kansas City, MO, July.

6. U.S. Department of Energy and U.S. Department of the Army, 1997, *Baseline Risk Assessment for the Groundwater Operable Units at the Chemical Plant Area and the Ordnance Works Area of the Weldon Spring Site*, DOE/OR/21548-568, prepared by Argonne National Laboratory, Argonne, IL, for the U.S. Department of Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, MO, and U.S. Department of the Army, Corps of Engineers, Kansas City District, Kansas City, MO, July.

7. U.S. Department of Energy and U.S. Department of the Army, 1998, *Feasibility Study for the Groundwater Operable Units at the Chemical Plant Area and the Ordnance Works Area of the Weldon Spring Site*, DOE/OR/21548-569, prepared by Argonne National Laboratory, Argonne, IL, for the U.S. Department of Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, MO, and U.S. Department of the Army, Corps of Engineers, Kansas City District, Kansas City, MO, December.

8. U.S. Department of Energy, 1999, *Supplemental Feasibility Study for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site*, DOE/OR/21548-783, prepared by Argonne National Laboratory, Argonne, IL, for the U.S. Department of Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, MO, June.

9. U.S. Department of Energy, 1999, *Proposed Plan for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site*, DOE/OR/21548-733, prepared by Argonne National Laboratory, Argonne, IL, for the U.S. Department of Energy, Weldon Spring Site Remedial Action Project, Weldon Spring, MO, July.

10. U.S. Department of Energy, 2000, *Interim Record of Decision for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site*, DOE/OR/21548-798, prepared by Argonne National Laboratory, Argonne, IL, for the U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN, September.

11. U.S. Environmental Protection Agency, 1999, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, OSWER 9200.4-17P, prepared by U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C., April.

12. U.S. Department of Energy, 1999, *Technical Guidance for the Long-Term Monitoring of Natural Attenuation Remedies as Department of Energy Sites*, prepared by U.S. Department of Energy, Office of Environmental Restoration, Washington, D.C., October.

13. U.S. Department of Energy, 2003, *Long-Term Surveillance and Maintenance Plan for the U.S. Department of Energy Weldon Spring, Missouri, Site —DRAFT*, GJO-2002-342-TAC, prepared by the U.S. Department of Energy, Grand Junction Office, Grand Junction, CO, May.

14. U.S. Department of Energy, 2004, *Grand Junction Office Quality Assurance Manual*, Manual STO-1, prepared by the Stoller-Grand Junction Team for the U.S. Department of Energy, Grand Junction Office, Grand Junction, CO, March.

15. U.S. Department of Energy, 2003, *Weldon Spring Site Project Safety Plan*, GJO-2003-442-TAC, prepared by the U.S. Department of Energy, Grand Junction Office, Grand Junction, CO, April.

# APPENDIX A:

## Method for Reevaluating MNA Timeframes for the GWOU Remedial Action Period

# APPENDIX A:

## Method for Reevaluating MNA Timeframes for the GWOU Remedial Action Period

To support the preferred alternative presented in the proposed plan and subsequently the selected remedy in the record of decision (ROD) for the Chemical Plant groundwater operable unit (GWOU), calculations were performed to estimate predictive times (the number of years) when natural attenuation processes (primarily dispersion and dilution) would likely reduce concentrations of the contaminants of concern (COCs) to levels equal to or below the cleanup standards. These calculations were initially presented in the *Supplemental Feasibility Study* (FS) (DOE 1999) and were subsequently revised and presented in the *Supporting Evaluation Report* (DOE 2003). The estimates presented in the *Supporting Evaluation Report* incorporated observations from the field studies completed in 2001 (MK-Ferguson Company and Jacobs Engineering Group 2002) and more representative values for several of the input parameters. Table A.1 presents the input parameters and the results that were presented in the *Supporting Evaluation Report.*

A similar method will be used to reevaluate monitored natural attenuation (MNA) timeframes on the basis of new data that will be collected as part of the remedial action implemented for the GWOU. The methodology for the reevaluation is discussed in Section A.1.

## A.1 ESTABLISHING A NEW BASELINE

Upon implementing the performance monitoring required for the selected action, new baselines for MNA times will be established for the COCs. These times will be derived from field-measured concentrations from eight rounds of monitoring data for each of the wells included in the network. For the purpose of reevaluating MNA timeframes, data collected as part of monitoring for Objective 2 will be used. These wells are a subset of the original set of wells used to represent the location and spatial extent in the aquifer of interest where concentrations of the COCs have been observed to be at or greater than cleanup standards.

An average concentration for each of the COCs for each well will be calculated from the most recent eight data points for each well. The reestimation of the MNA timeframes will be based on the average concentrations from the averages of all the wells considered. For well locations that were not sampled as part of the performance monitoring program (not part of Objective 2 sampling) but were included in the MNA calculations presented in the *Supporting Evaluation Report,* the most recent eight data points will be used in the calculations for the baseline timeframes. The resulting timeframe will be used to compare (as the baseline) against future calculations.

In general, the reevaluation will involve a revised or new average COC concentration, but the other parameters are expected to remain the same unless a significant change in the size of

**TABLE A.1 Predictive Monitored Natural Attenuation Cleanup Times Based on the Flushing Model as Presented in the *Supporting Evaluation Report*[a]**

| Contaminant | Contour | Wells Included | $K_d$[b] (mL/g) | R | K[c] (UL 95) (cm/s) | Actual GW Velocity (ft/yr) | L (ft) | ∇h | Initial Conc. (avg.) | Regulatory Standard or RBC[d] | Time (yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Uranium | Contour 1 | 3030 | 0.4 | 5.5 | 0.0012 | 103.3 | 1,050 | 0.0125 | 54 pCi/L | 20 pCi/L | 56 |
| | Contour 2 | 3025 | 0.4 | 5.5 | 0.003 | 258.7 | 460 | 0.0125 | 29 pCi/L | 20 pCi/L | 4 |
| TCE | Contour 1 | 4006, 4001, 3030, 3025, 4037, 3039, 3034, 2037, 2038, 4029, 3035, 4031, 3036, 3029, 3028, 4028, 3033, 4027, 4032, MWS 21, 4038, 3032 | 0.3 | 4.4 | 0.00411 | 141.7 | 1,300 | 0.005 | 61 µg/L | 5 µg/L | 101 |
| Nitrate | Contour 1 | | | | | | | | | | |
| | Area 1 | 4036, 3037, 4006, 4001, 3030, 3031, 3027, 3026, 3039, 3025, 4027, 3038, 3034, 2037, 2038, 4029, 3035, 3032, 3028, 3029, 3036, 4031, 4028, 3033, 4038, 4032 | 0 | 1 | 0.00315 | 130.4 | 2,750 | 0.006 | 198 mg/L | 10 mg/L | 63 |
| | Area 2 | 4013, 2001, 2005, 4011, 2021, 2002, 2047, 2003, 3003, 3023 | 0 | 1 | 0.00173 | 238.7 | 2,350 | 0.02 | 173 mg/L | 10 mg/L | 28 |
| 2,4-DNT | Contour 1 | 3038, 2037, 4029, 3035, 3029, 3028, 4028, 3033, 4032, MWS 21, 4033, 4006, 4001, 3030, 3039, 3034, 2038 | 0.09 | 2.0 | 0.001 | 55.2 | 1,600 | 0.008 | 0.43 µg/L | 0.11 µg/L | 79 |
| | Contour 2 | 2047, 2046 | 0.09 | 2.0 | 0.00104 | 43.0 | 400 | 0.006 | 0.18 µg/L | 0.11 µg/L | 9 |
| | Contour 3 | 2052, 2006, 2053, 2054, 2013, 2012, 2049, 2050, 2033, 4030, 2014 | 0.09 | 2.0 | 0.00352 | 267.1 | 1,400 | 0.011 | 114 µg/L | 0.11 µg/L | 73 |
| 1,3-DNB | Contour 1 | 2012 | 0 | 1.0 | 0.001 | 76 | 500 | 0.011 | 1.7 µg/L[e] | 1.0 µg/L | 4 |
| NB | Contour 1 | 2012 | 0 | 1.0 | 0.001 | 76 | 500 | 0.011 | 69 µg/L[e] | 17 µg/L | 9 |

**TABLE A.1 (Cont.)**

| Contaminant | Contour | Wells Included | $K_d$[b] (mL/g) | R | K[c] (UL 95) (cm/s) | Actual GW Velocity (ft/yr) | L (ft) | $\nabla h$ | Initial Conc. (avg.) | Regulatory Standard or RBC[d] | Time (yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2,6-DNT | Contour 1 | 4036, 4006, MWS-4, 4001, 3030, 3039, 3034, 4037, 3038, 4031, 4029, 3029, 3028, 4028, 3033, 3036, 4027, 4032 | 0.2 | 3.3 | 0.0012 | 98.2 | 1,700 | 0.0119 | 0.34 µg/L[f] | 0.13 µg/L[f] | 55[f] |
| | Contour 2 | 2002, 2003, 3003, 3023 | 0.2 | 3.3 | 0.00019 | 21.9 | 1,050 | 0.0167 | 0.41 µg/L[f] | 0.13 µg/L[f] | 182[f] |
| | Contour 3 | 2005 | 0.2 | 3.3 | 0.000021 | 1.8 | 400 | 0.0125 | 0.27 µg/L[f] | 0.13 µg/L[f] | 536[f] |
| | Contour 4 | 2047, 2046 | 0.2 | 3.3 | 0.00104 | 89.7 | 500 | 0.0125 | 0.81 µg/L[f] | 0.13 µg/L[f] | 34[f] |
| | Contour 5 | 4015, 2045, 2052, 2051, 2006, 2053, 2049, 2012, 4030, 4039, 2050, 2013, 2033, 2054, 2014 | 0.2 | 3.3 | 0.00341 | 555.1 | 2,300 | 0.0236 | 66 µg/L | 0.13 µg/L | 85 |
| 2,4,6-TNT | Contour 1 | 2046 | 0.04 | 1.5 | 0.0014 | 482.8 | 400 | 0.05 | 4.2 µg/L[g] | 2.8 µg/L[g] | 0.6[g] |
| | Contour 2 | 2053, 2049, 2012 | 0.04 | 1.5 | 0.00396 | 341.4 | 350 | 0.0125 | 75 µg/L[g] | 2.8 µg/L[g] | 5[g] |
| 1,3,5-TNB | Contour 1 | 4031 | 0.16 | 2.7 | 0.0007 | 24.1 | 500 | 0.005 | 2.9 µg/L[h] | 1.8 µg/L[h] | 27[h] |
| | Contour 2 | 4007, 4006, 4001 | 0.16 | 2.7 | 0.00005 | 5.9 | 500 | 0.017 | 17 µg/L[h] | 1.8 µg/L[h] | 514[h] |
| | Contour 3 | 4013 | 0.16 | 2.7 | 0.00006 | 10.4 | 200 | 0.025 | 24 µg/L[h] | 1.8 µg/L[h] | 135[h] |
| | Contour 4 | 2046 | 0.16 | 2.7 | 0.0014 | 280 | 400 | 0.029 | 2.6 µg/L[h] | 1.8 µg/L[h] | 1[h] |
| | Contour 5 | 4015, 2052, 2006, 2053, 2013, 2033, 2014, 2050, 2012, 2049, 4030 | 0.16 | 2.7 | 0.0026 | 179.3 | 2,400 | 0.010 | 20 µg/L[h] | 1.8 µg/L[h] | 87[h] |

[a] Calculations presented in this table were performed by using the same methodology (i.e., Flushing Model) as that presented in the *Supplemental Feasibility Study* (DOE 1999). The following input parameters were also used in the calculations in addition to those shown in this table: bulk density at 1.7 g/cc and effective porosity at 0.15. Concentrations are based on maximum values detected in 2002. In column heads, R = retardation for the contaminant; L = length of the contaminated zone in a direction parallel to the direction of groundwater flow; $\nabla h$ = hydraulic gradient present.

[b] Sources for distribution coefficients or $K_d$'s presented in this table are as follows: uranium (EPA 2000); TCE and 2,6-DNT (DOE and DA 1997); nitrate (Strenge and Peterson 1989); 2,4-DNT, 2,4,6-TNT, 1,3,5-TNB, 1,3-DNB, and NB (Brannon and Pennington 2002).

[c] Hydraulic conductivities or K's presented are upper 95% limits of the arithmetic means of the hydraulic conductivities for the monitoring wells included in the contours.

[d] Regulatory standards include the MCLs for TCE, uranium, and nitrate and the Missouri Water Quality Standards for 2,4-DNT, 1,3-DNB, and NB. Risk-based concentrations (RBCs) developed for 2,6-DNT and 2,4,6-TNT are based on concentrations that are equivalent to a risk of 1 in 1 million to 1 in 10,000 ($10^{-6}$ to $10^{-4}$ risk) for a hypothetical resident scenario. See footnote h for an explanation for 1,3,5-TNB.

**Footnotes continue on next page.**

**TABLE A.1 (Cont.)**

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[e] Concentrations for 1,3-DNB and NB presented in this table represent the maximum concentration reported for 2002 for these contaminants from MW-2012. The average of 2002 did not exceed the standards listed for these contaminants.

[f] The initial concentrations shown are within the acceptable RBC range for 2,6-DNT and would be protective. The RBCs for 2,6-DNT that would be equivalent to a risk of 1 in 1 million to 1 in 10,000 for a resident scenario are estimated to be 0.13 to 13 µg/L. The calculations are based on the RBC that is equivalent to the $10^{-6}$ risk.

[g] The RBC range for 2,4,6-TNT is estimated to be 2.8 to 280 µg/L (equivalent to $10^{-6}$ to $10^{-4}$) for a resident scenario. The initial concentrations shown are within this range; however, calculations are based on the RBC that is equivalent to the $10^{-6}$ risk.

[h] The RBC of 1.8 µg/L shown for 1,3,5-TNB was estimated on the basis of toxicity information (reference dose) available during the preparation of the baseline risk assessment (BRA). The reference dose has since been updated by the EPA after the BRA was finalized. On the basis of the current reference dose, the RBC that is equivalent to a hazard index of 1 for a resident scenario for 1,3,5-TNB is estimated to be 1,100 µg/L. Therefore, site concentrations are well below this level and would already be protective, and calculations of cleanup times based on the updated RBC would not be required.

the plume is observed (i.e., a change in the "L" in the equation; see Section A.2). In that case, L values will be estimated from the current set of isocontours for each of the COCs. Calculations based on new isocontours could also involve the reevaluation of other parameters, such as the hydraulic conductivity of the new ensemble of wells, the hydraulic gradient for the area of contamination determined from the isocontour maps, and the effective porosities of the zones of contamination. Retardation coefficients will be the same as those used in previous calculations.

Table A.2 summarizes the well locations that will be monitored for each of the COCs for Objective 2 and the well locations that were used for the calculations presented in the *Supporting Evaluation Report*. Equations for the calculations are discussed in Section A.2.

Once new baselines for MNA times have been established, future trends in MNA times can be evaluated by comparing future MNA times against the baseline. The MNA times for future conditions will be calculated by using the same method as that used to establish the MNA baseline times discussed below. Because the MNA wells are a subset of the wells originally used to calculate the timeframes and are typically the wells with higher contaminant concentrations, using only this subset to recalculate the MNA timeframes would result in a high bias. The MNA contingency flowchart anticipated this data gap by incorporating sufficient time for sampling additional wells within the isocontours before recalculating MNA timeframes.

## A.2 ESTIMATING MNA TIMEFRAMES

Under the processes of advection and diffusion, dissolved contaminants in the groundwater beneath the Chemical Plant area would primarily move in the direction of natural groundwater flow. The concentrations of the COCs in the groundwater would be reduced by the processes of dispersion and dilution. In general, the direction of natural groundwater flow would be to the west and northwest for groundwater north of the groundwater divide. The total flux (volume of contaminated water/time) of contaminated water out of a plume that has a flow area perpendicular to the direction of transport can be defined as follows:

$$\text{Flux} = \frac{V_d}{\phi} A_t \phi = K \nabla h t W ,$$

where

$V_d$ = Darcy's groundwater velocity given by $K\nabla h$ (Freeze and Cherry 1979),

$\phi$ = effective porosity of the porous medium,

$A_t$ = total area of the aquifer perpendicular to the direction of groundwater flow,

$K$ = hydraulic conductivity of the porous medium material,

$\nabla h$ = hydraulic gradient present,

**TABLE A.2 Monitoring Locations Included in Estimating MNA Timeframes**

| Contaminant | Contour Area[a] | 2002 Average Conc. | 2003 Average Conc. | Cleanup Standard |
|---|---|---|---|---|
| Uranium | [3030][b] | 53 pCi/L | 54 pCi/L | 20 pCi/L |
| | [3024][b] | 30 pCi/L | 53 pCi/L | 20 pCi/L |
| TCE | [3030, 3034, 4029][b] | 427 µg/L | 305 µg/L | 5 µg/L |
| | [4006, 4001, 3025, 4037, 3039, 2037, 2038, 3035, 4031, 3036, 3029, 3028, 4028, 3033, 4027, 4032, MWS 21, 4038, 3032][c] | - | - | |
| Nitrate | [2038, 3034, 4029, 4036, 2040, 4031][b] | 328 mg/L | 440 mg/L | 10 mg/L |
| | [3037, 4006, 4001, 3030, 3031, 3027, 3026, 3039, 3025, 4027, 3038, 2037, 3035, 3032, 3028, 3029, 3036, 4028, 3033, 4038, 4032][c] | - | - | |
| | [4013, 3003][b] | 258 mg/L | 177 mg/L | 10 mg/L |
| | [2001, 2005, 4011, 2021, 2002, 2047, 2003, 3023][c] | - | - | |
| 2,4-DNT | [2038, 3030, 3034, 3039][b] | 0.085 µg/L | .7 µg/L | 0.11 µg/L |
| | [3038, 2037, 4029, 3035, 3029, 3028, 4028, 3033, 4032, MWS 21, 4033, 4006, 4001][c] | - | - | |
| | [2012, 2014, 2050, 2052, 2053, 2054][b] | 315 µg/L | 330 µg/L | 0.11 µg/L |
| | [2006, 2013, 2049, 2033, 4030][c] | - | - | |
| 2,6-DNT | [2012, 2014, 2050, 2052, 2053, 2054][b] | 250 µg/L | 236 µg/L | 1.3 µg/L |
| | [4015, 2045, 2051, 2006, 2049,4030, 4039, 2013, 2033][c] | - | - | |
| 2,4,6-TNT | [2046][b] | 5.0 µg/L | 4.6 µg/L | 2.8 µg/L |
| | [2012, 2053][b] | 138 µg/L | 128 µg/L | 2.8 µg/L |
| 1,3-DNB | [2012][b] | 4.0 µg/L | 1.1 µg/L | 1.0 µg/L |
| NB | [2012][b] | 0 µg/L | 8.6 µg/L | 17 µg/L |

[a] The calculations presented in the *Supporting Evaluation Report* (DOE 2003) included all well locations listed.

[b] The use of "b" after a bracketed group of well locations indicates that those well locations would be monitored as part of the MNA program for Performance Objective 2.

[c] The use of "c" after a bracketed group of well locations indicates that those well locations would not be monitored as part of the MNA program, although they were included with footnote "b" in the calculations as presented in the *Supporting Evaluation Report*. These wells would be available for additional sampling if needed.

$t$ = thickness of the aquifer, and

$W$ = width of the contaminated zone.

When the absence of degradation processes is assumed, the number of pore volumes for contaminated water that must be discharged from a contaminated plume in order to meet cleanup standards was defined by Cohen et al. (1997) as follows:

$$\text{Number of pore volumes} = R \ln\left(\frac{C_0}{C_W}\right),$$

where $R$ is a retardation coefficient for the COC given by:

$$R = 1 + \frac{\rho_b K_d}{\phi},$$

where

$K_d$ = contaminant's distribution coefficient (mL/g),

$\rho_b$ = bulk density of the porous medium,

$\phi$ = effective porosity,

$C_0$ = initial average contaminant concentration, within the cleanup standard contour, and

$C_W$ = contaminant's cleanup standard concentration.

A single pore volume for a contaminated zone was calculated by assuming that the contaminated zone was a parallelepiped, that is,

$$\text{Pore volume} = tLW\phi,$$

where $L$ is the length of the contaminated zone in a direction parallel to the direction of groundwater flow.

The time required to reach the cleanup standards by natural attenuation was obtained by integrating the volumetric flux over time. For a flux that is constant in time, the result is given by the following relationship:

$$\Delta t = \frac{R \ln\left(\frac{C_0}{C_W}\right) tWL\phi}{K\nabla htW} = \frac{R \ln\left(\frac{C_0}{C_W}\right) L\phi}{K\nabla h}.$$

Use of this last equation above implies that once contaminated groundwater leaves a contaminated plume, it is removed from the system (i.e., downgradient locations that are initially clean do not become contaminated because of contaminant transport). For the Chemical Plant area, this assumption is reasonable because of the proximity of paleochannels that transport contaminated groundwater rapidly to the vicinity of Burgermeister Spring. With the exception of uranium, measured contaminant concentrations in groundwater have been low at Burgermeister Spring because of dilution.

Dissolved contaminants in shallow groundwater leaving the contaminated plumes would be diluted by being mixed with recharge water, mixed with water in the conduit system to Burgermeister Spring, diluted with water in Lake 34, and diluted with water flowing in Dardenne Creek. The initial dilution of the shallow groundwater occurs when it is with infiltrating precipitation. A dilution factor for the process can be calculated by means of the following expression (Tomasko 1992):

$$\text{Dilution factor} = 1 + \frac{IL\phi}{K\nabla ht},$$

where $I$ is the effective recharge to the aquifer.

Additional dilution occurs when contaminated water from the Chemical Plant area mixes with initially clean water in the conduit system to Burgermeister Spring. As discussed in the remedial investigation for the GWOU (DOE and DA 1997), about 80% of the effective recharge to the shallow groundwater system beneath the Chemical Plant area discharges in the vicinity of Burgermeister Spring. For an effective recharge of 6.4 cm/yr (2.5 in./yr) (Kleeschulte and Imes 1994), approximately 40 acre-ft of water per year would be discharged from the Chemical Plant area north of the groundwater divide. In calendar year 1996, the total flow from Burgermeister Spring was about 168 acre-ft (Kleeschulte 1997). For this flow, the discharge from the Chemical Plant area would be diluted by about a factor of four if all of the water from the Chemical Plant area discharged at Burgermeister Spring.

Once in the springs, aside from the processes of dilution and dispersion, any TCE would volatilize, nitrate could be taken up by plants on the edge of the springs and drainages, nitroaromatic compounds would photolyze, and uranium could be sorbed by sedimentary material or plants in the springs. This degradation is evident from monitoring data obtained from the springs and downstream reaches, including Burgermeister Spring; all COCs other than uranium have been reported at concentrations much lower than concentrations measured in the Chemical Plant area groundwater monitoring wells. Uranium concentrations have been reported at levels slightly higher than the current maximum concentrations reported for the monitoring wells because of residuals in fractured zones along losing stream segments.

Any discharge water that is not evaporated or used by plants flows into Lake 34, which provides additional dilution and discharge water to Dardenne Creek. This creek provides a natural hydrogeologic boundary between watersheds and is the northernmost boundary for water originating in the Chemical Plant area.

In summary, unless the isocontours would change significantly, MNA timeframes could be recalculated on the basis of an observed change to $C_0$ or $L$.

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# APPENDIX B:

## MNA Cost Breakdowns

### Groundwater Operable Unit
### Monitored Natural Attenuation
### Cost Breakdown Summary

**Capitol Costs**

| | | |
|---|---|---|
| Well Installation (Table 1) | | $ 119,055.00 |
| Abandonment (Table 2) | | $ 285,910.00 |
| | Total Subcontract Costs | $ 404,965.00 |
| Engineering/Oversight (15%) | | $ 60,744.75 |
| | Total Capitol Cost | $ 465,709.75 |

**Operations/Maintenance (Annual Costs)**

| | | |
|---|---|---|
| Sampling: | Analytical (Table 3) | $ 9,275.00 |
| | Shipping/Supplies (10%) | $ 927.50 |
| | Labor (Existing Contract) | $ 160,000.00 |
| | Total Sampling Cost | $ 170,202.50 |
| Well Maintenance | Install/Abandon (Table 4) | $ 42,945.00 |
| | Supplies (paint, fix, etc.) (5%) | $ 2,147.25 |
| | Total Maintenance Cost | $ 45,092.25 |
| Oversight (15%) | | $ 32,294.21 |
| Contingency (10%) | | $ 21,529.48 |
| Annual Inspection/Reporting | | $ 70,000.00 |
| | Total O&M Costs (Annual) | $ 339,118.44 |