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SOUTH PLUME GROUNDWATER RECOVERY SYSTEM DESIGN, MONITORING, AND EVALUATION PROGRAM PLAN APRIL 1993 REVISION NO. 1

DOE-FN/EPA

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REPORT

South Plume Groundwater Recovery System Design, Monitoring, and Evaluation Program Plan

Fernald Environmental Management Project
April 1993
Revision No. 1

Submitted by:
U.S. Department of Energy
Fernald Office
P.O. Box 398705
Cincinnati, Ohio 45239-8705

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South Plume Groundwater Recovery System Design, Monitoring and Evaluation Program Plan

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LIST OF ACRONYMS AND ABBREVIATIONS

AWWT	Advanced Waste Water Treatment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DMEPP	South Plume Recovery System - Design, Monitoring and Evaluation Program Plan
DOE	United States Department of Energy
EE/CA	Engineering Evaluation/Cost Analysis
ERMC	Environmental Restoration Management Contractor
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation
gpm	gallons per minute
IAWWT	Interim Advanced Wastewater Treatment
Ohio EPA	Ohio Environmental Protection Agency
O&M	Operation and Maintenance
OU	Operable Unit
PRRS	Paddy's Run Road Site
PTWP	Pump Test Work Plan
QAPjP	Quality Assurance Project Plan
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SCQ	FEMP Sitewide CERCLA Quality Assurance Project Plan
SOWC	Southwest Ohio Water Company
SWRB	Stormwater Retention Basin
US EPA	United States Environmental Protection Agency
WEMCO	Westinghouse Environmental Management Company of Ohio

SECTION 1

INTRODUCTION

1.1 Purpose and Description

This Design, Monitoring, and Evaluation Program Plan (DMEPP) (formerly the Operation and Maintenance Manual) has been prepared to delineate a program of design confirmation, monitoring and evaluation activities associated with the groundwater recovery system for the south groundwater contamination plume (south plume) removal action at the Fernald Environmental Management Project (FEMP) near Fernald, Ohio. The south plume removal action (Removal Action 3) is required pursuant to the 1990 Consent Agreement between the United States Environmental Protection Agency (US EPA) and the United States Department of Energy (DOE).

To facilitate ~~more efficient design and construction, the south plume removal action has been~~ the design process, the selected alternative was divided into five parts:

Part 1) Alternative Water Supply
Part 2) Pumping and Discharge System
Part 3) Interim Advanced Wastewater Treatment System
Part 4) Groundwater Monitoring and Institutional Controls
Part 5) Groundwater Modeling and Geochemical Investigation

The DMEPP is needed to confirm the design assumptions and to effectively operate the groundwater recovery system over a period of time. The DMEPP is required in the Part 2 - Pumping and Discharge System and Part 3 - Interim Advanced Wastewater Treatment System Work Plan WEMCO 1992a. This document fulfills this requirement.

~~The DMEPP describes system objectives and management programs to help ensure that the system meets these objectives. These management programs are a design confirmation program, a monitoring program, and an evaluation/response program. The detailed operation and maintenance procedures will be included in a separate document.~~

The DMEPP describes four basic management programs which will be used to ensure system objectives are achieved. These programs consist of monitoring, design confirmation, evaluation/response, and model improvement.

1.2 Background

Operable Unit 5 (OU-5) - Environmental Media, of the FEMP Remedial Investigation/Feasibility Study (RI/FS), includes those environmental media that serve as migration pathways and/or environmental receptors of radiological or chemical releases from the FEMP. RI/FS findings have determined that a uranium contaminant plume exists in an area outside of FEMP property to the south. Because of the associated potential threats to human health and the environment, a removal action to address this plume outside of the FEMP boundary has been planned. The 1990 Consent Agreement between the DOE and the US EPA, Section IX, A.3, requires the submission of a proposal for additional monitoring wells, Engineering Evaluation/Cost Analysis (EE/CA), and a work plan for the south plume removal action. Figure 1-1 provides a flowchart of activities for the South Plume Removal Action.

The ~~Engineering Evaluation/Cost Analysis - South Plume~~ South Plume EE/CA (DOE 1990a) was initially submitted in May 1990; and after the public comment process (and resolution to the dispute between the US EPA and DOE), it was finalized in November 1990. The South Plume EE/CA selected alternative 4 which included groundwater pumping and discharge, an alternative water supply for two industrial users, installation of an Interim Advanced Wastewater Treatment System (IAWWT), and enhanced monitoring and institutional controls. The initial location of recovery wells, based on groundwater modeling simulations, was along New Haven Road just west of its intersection with State Route 128 (see Section 2 for maps and further description).

As a result of information obtained from a separate remedial investigation that is being performed at the Paddy's Run Road Site (PRRS), additional concerns were identified in the South Plume area. The PRRS consists of several industries (e.g., Mobil Mining and Minerals Co. Inc., Albright & Wilson Americas Co., and Rutgers and Nease) that, over the past years, have reportedly released both organics and inorganics into the environment which have now found their way to the Great Miami aquifer. Some of these contaminants include cumene, toluene, benzene, arsenic, ~~mercury,~~ and others. The PRRS plume has been determined to extend to very near the location of the proposed recovery well field as described in the November 1990 South Plume EE/CA. Therefore, operation of a uranium recovery well field at the location originally described could result in the extraction and discharge of PRRS contaminants to the Great Miami River (IAWWT system will only address uranium) and could result in the further spreading of the PRRS contaminants as has been predicted by computer modeling.

As a result of these conditions, it has been deemed necessary to relocate the Part 2 well field to an area north of the PRRS. Modeling efforts have been performed to determine a location where pumping of the recovery well field will not significantly affect the PRRS plume and will not draw PRRS contaminants into the recovery well field (DOE 1993a). In addition, it was necessary to alter the November 1990 South Plume EE/CA with an addendum entitled "Explanation of Significant Differences" which restructured the EE/CA objectives to accommodate these conditions.

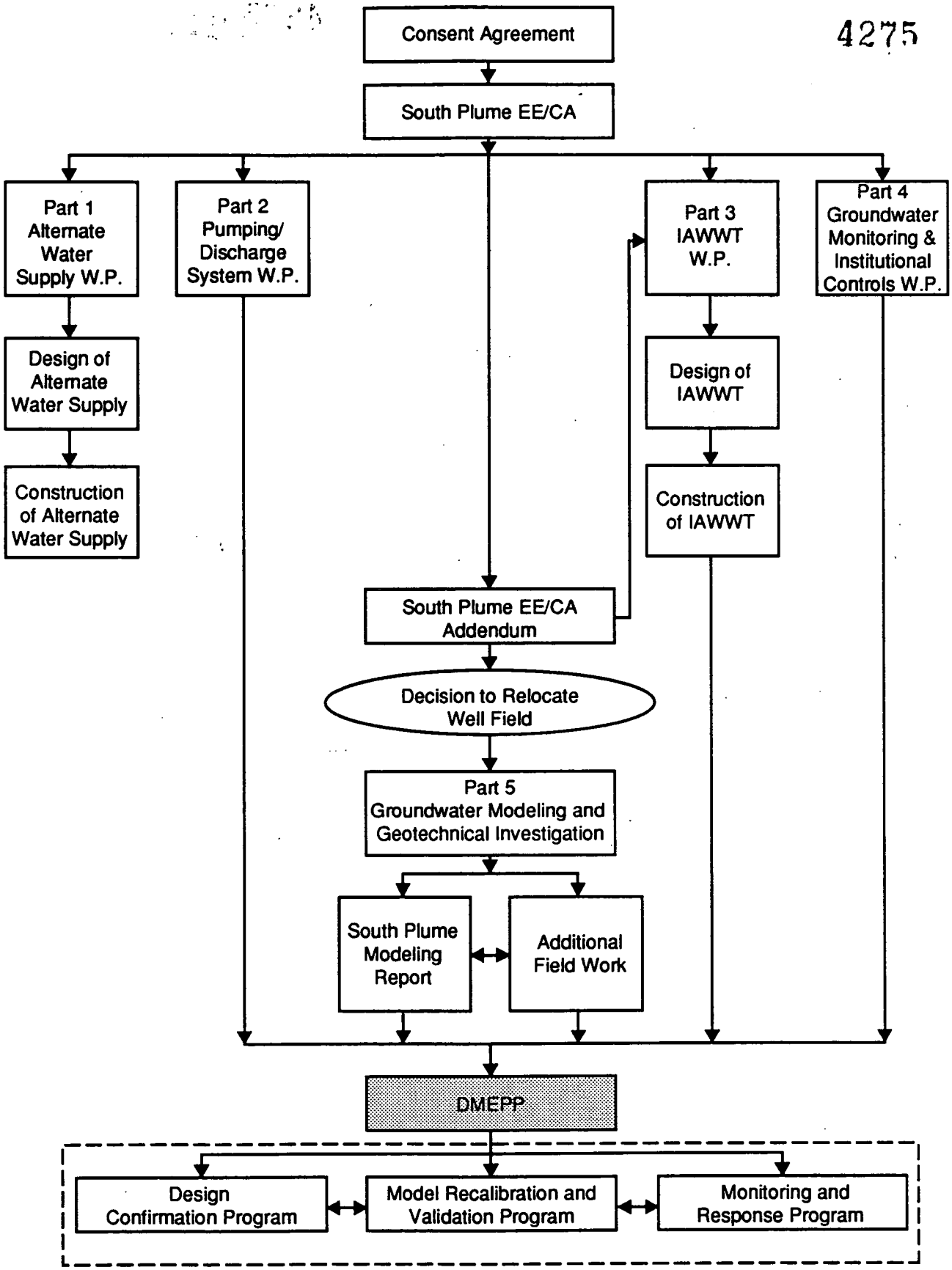

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Figure 1-1 - South Plume Removal Action Activities

This relocation of the Part 2 well field has generated several additional requirements. The new location is in an area of higher uranium concentration which jeopardizes the equivalent mass treatment concept as described in the November 1990 EE/CA. Accordingly, the Part 3 IAWWT system has been expanded in size to provide the additional treatment necessary to meet the equivalent mass discharge concept.

In addition, the relocated well field is upgradient of an area of known 30 μg/l uranium contamination. The computer model for the south plume predicts that other areas could also exist where the level of uranium concentration is above 30 μg/l (DOE 1992a). Therefore, an additional investigation is being performed under a new Part 5 of the south plume removal action (DOE 1992b). The Part 5 investigation includes hydropunching and soil vapor survey of the area south and north of the well field. The investigation will identify the location of the 30 μg/l uranium isopleth. Because the US EPA has recently issued a proposed revised limit of 20 μg/l for uranium in drinking water, the investigation will also identify the location of the 20 μg/l isopleth. The information obtained will be used to allow the FEMP to limit access to this water until additional response action in this area is implemented. The data from this investigation will also be used to define the vertical length of recovery well screen (see Section 3).

Currently, it is envisioned that the remediation of the south plume will be addressed by dividing the area into 3 zones. The purpose of the zones is to distinguish the areas of contamination for purposes of treatment. The zones are as follows:

1) Zone 1 would be the area of aquifer containing only uranium at levels greater than 20 μg/l as the contaminant of concern. This will be the area addressed by the south plume removal action project described in the EE/CA, as modified above.

2) Zone 2 would be the area of aquifer containing uranium, inorganics, and organics as contaminants of concern. This area will need to be addressed jointly by the FEMP and PRRS.

3) Zone 3 would include inorganics and organics as contaminants of concern. The area may also contain uranium contamination, but at a level below that may be specified in the FEMP Operable Unit 5 Record of Decision (ROD) in August 1995. This area will need to be addressed solely by the PRRS, but will need to be coordinated with FEMP efforts for Zones 1 and 2.

1.3 Objectives

The South Plume EE/CA identified one primary and two secondary objectives for the south plume removal action:

1) Primary--Protection of public health by limiting access to and use of groundwater with uranium concentrations exceeding the derived concentration limit of 30 μg/l for uranium in drinking water, as well as other appropriate, risk-based levels for various potential exposure scenarios.

2) Secondary

(1) Protection of the groundwater environment which, in this case, is represented by a sensitive, sole-source aquifer.

(2) Control of plume migration toward additional receptors further south.

For the pumping and discharge system (Part 2) portion of the removal action, specific objectives need to be restated and expanded to take into account the impact of the PRRS and to clarify the specific performance criteria for evaluation of the system. The groundwater recovery system needs to meet--to the extent possible--the following ~~four~~ three objectives:

1) The groundwater recovery wells need to be pumped at a sufficient rate to create a hydraulic barrier along a line running approximately perpendicular to the longitudinal axis of the plume in the shallow portion of the Great Miami Aquifer, creating an elongated groundwater trough. This hydraulic barrier needs to extend sufficiently outward from the centerline of the plume to intercept the width of the Zone 1 plume as defined by contamination above the 20 μg/l total uranium level (20 μg/l is used in place of the previously identified 30 μg/l limit based on the US EPA proposed revision for drinking water).

2) The magnitude of the hydraulic trough needs to be minimized while still meeting Objective 1 in order to minimize the impact on the overall hydrogeologic system. If extensive capture zones are created, then the PRRS plumes may be pulled toward the recovery wells. Also, minimal disturbance to the local hydrologic system is desired to prevent impacts on groundwater users in the area, to minimize the possible velocity increases of movement of on-site plumes, and to not significantly deflect the PRRS contaminant flow trajectory. In addition by minimizing the impact, the recovery system will more likely be consistent with final remediation. The recovery wells, therefore, need to create a hydraulic sink to prevent plume movement by the wells and to minimize capture zones and large scale reversals of groundwater flow.

3) Contamination within the aquifer needs to be removed as soon as feasible to prevent further plume movement and degradation of the groundwater environment. ~~Removal of contaminants near the source or in the shallow portion of the aquifer is more efficient and prevents further damage.~~ The recovery system should be operated to prevent further spread of contamination.

~~4) The operation of the removal action recovery system needs to be consistent with the final site remediation. This standard is difficult because the final site remediation systems are unknown at the present time. However, probably the most relevant issue regarding impacts of pump and treat systems is the possible expansion of other plumes caused by increasing hydraulic slope, thus increasing potential spread of contamination. This issue is the basis of Objective 2 which requires the minimizing of impacts on the natural system.~~

To meet the multiple objectives requires that the system balance the two opposing factors of creating sufficient drawdown to prevent migration around, between, or beneath the recovery wells and of minimizing drawdown to prevent gradient changes over a large area. Therefore, the system must be evaluated in relation to balancing these objectives. The primary objective (Objective 1) will carry more weight. However, any recommended change to operation or design of the system needs to evaluate its impact on all the objectives.

1.4 Overview of the Operation Methodology

Figure 1-2 presents an overview of the program~~, defined in Volume I- Operation Methodology,~~ to start up and operate the recovery system within the stated objectives. ~~Four types of activities are defined as horizontal blocks across the page: design/construct, operation, modeling, and monitoring. Also,~~ The ~~three~~ four programs defined in this document: monitoring, design confirmation, evaluation/response, and model improvement are described by different colors. Deliverables associated with tasks are enclosed in circles. Copies of these deliverables will be provided to the US EPA and Ohio EPA.

1.4.1 Design Confirmation Program

The purpose of the design confirmation program (represented as brown blocks on Figure 1-2) is to test the design basis with a dynamic test of the system and to adjust parameters, if necessary, based on the results of this test. The design confirmation program is described in detail in Section 3. This program consists of a pumping test; verification of the extraction well depth prior to the installation of the five extraction well casings, and confirmation that pumping rates (based on the hydraulic conductivity calculated with the pump test) fall within the pre-established range (see the South Plume Modeling Report) (DOE 1993a). Details of the design confirmation program and its associated deliverables are contained in the Pump Test Work Plan (PTWP) (DOE 1993b). ~~Validation of the groundwater model based on the results of the pump test; and model recalibration (if necessary) based on model validation, pump test results, and other monitoring data. Five deliverables accompany these activities:~~

~~1) Pump Test and Model Validation Work Plan (see Appendix A)~~
~~2) Verification of Extraction Well Depth Letter Report~~
~~3) Pump Test Report~~
~~4) Model Validation Report~~
~~5) Model Recalibration Report (if necessary)~~

1.4.2 Monitoring Program

The purpose of the monitoring program (represented as purple blocks on Figure 1-2) is to take environmental samples and measurements over time to provide data for the performance of the system. The monitoring program is described in detail in Section 4. This program consists of routine monitoring at specified intervals. The data collected will be fed into the evaluation/response program (see description below). ~~One deliverable accompanies these activities:~~

~~1) Groundwater Monitoring and Response Plan (see Appendix B)~~

1.4.3 Evaluation/Response Program

The purpose of the evaluation/response program (represented as yellow blocks on Figure 1-2) is to analyze whether the system is meeting its objectives and to respond accordingly. The evaluation/response program is described in detail in Section 5. This program consists of periodic system evaluation reports; development of system modifications; and implementation of either design, operation, or monitoring program changes (as needed). ~~Four deliverables accompany these activities:~~

~~1) System Evaluation Report~~
~~2) System Modification Report (if necessary)~~
~~3) Construction Documents (if necessary)~~
~~4) Revised O&M Manual (if necessary)~~

1.4.4 Model Improvement Program

A model improvement program (represented as green blocks on Figure 1-2) has been developed to address weaknesses which have been identified during applications of the groundwater model over the last 2 years. This program will use hydrogeologic and solute transport parameters developed under the design confirmation program along with other associated data to improve the ability of the groundwater model to predict groundwater flow and solute transport. The connection between the modeling improvement program and other programs in the DMEPP is further illustrated in Figure 1-3. Details of this program will be discussed in a Model Improvement Plan which will be issued separately.

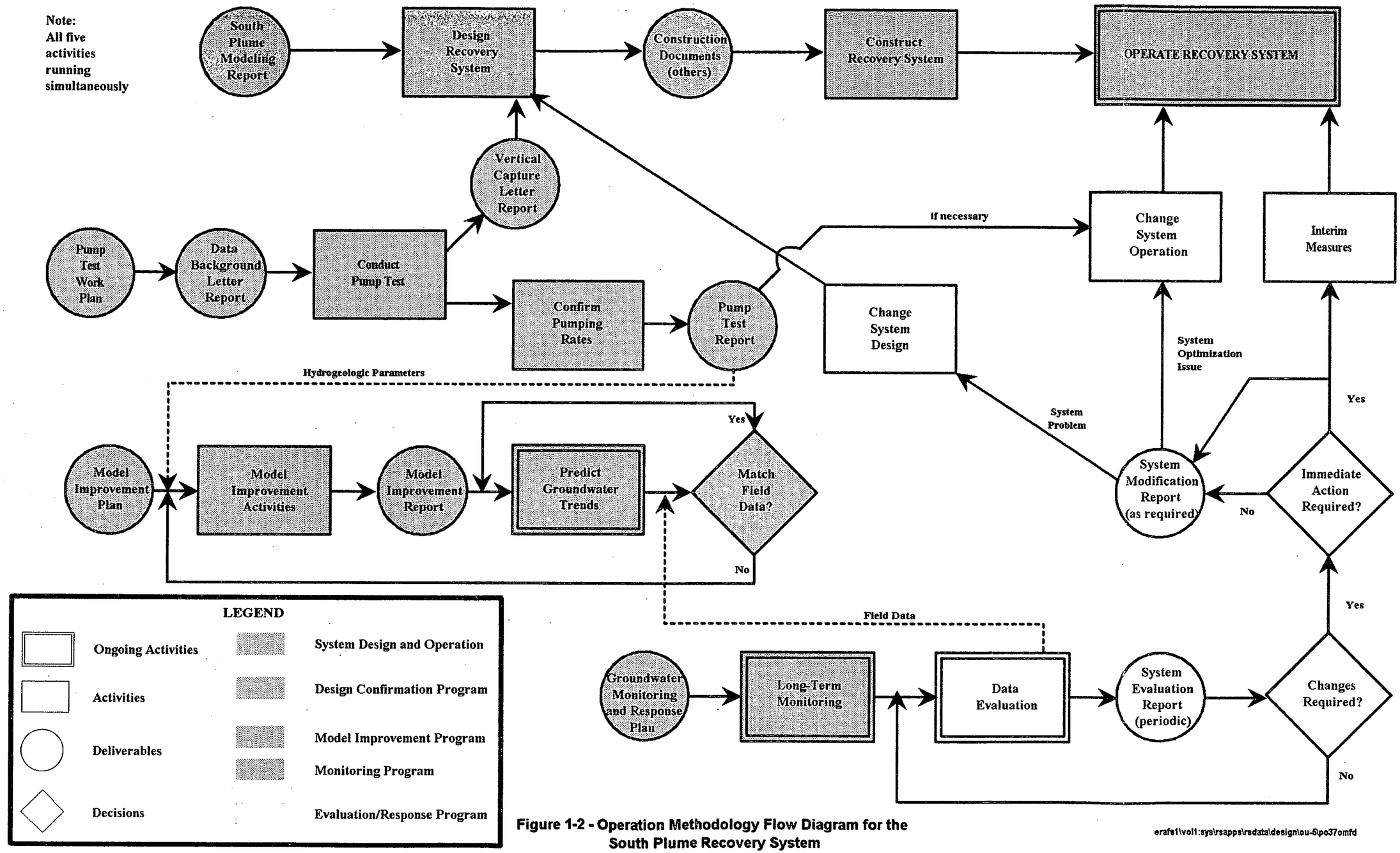

Figure 1-2 - Operation Methodology Flow Diagram for the South Plume Recovery System

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Figure 1-2 - Operation Methodology Logic Diagram for the South Plume Recovery System

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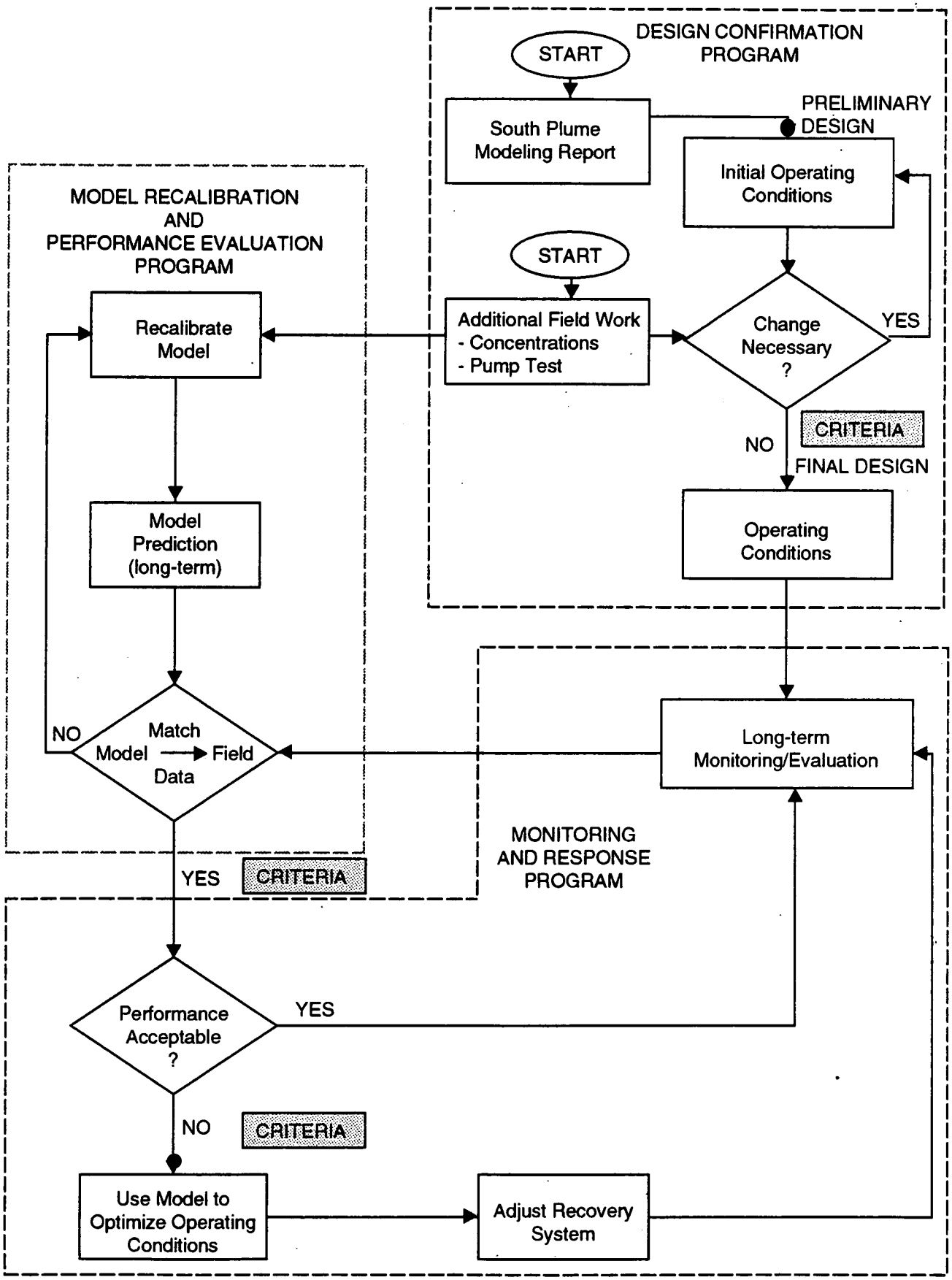

Figure 1-3 - Model Improvement and DMEPP Integration

SECTION 2

TECHNICAL PROJECT SUMMARY

2.1 Hydrogeologic Summary

The hydrogeologic setting is defined to provide the appropriate background for the operation of the groundwater recovery system. The following summary has been developed from previously written documents (DOE 1990a, DOE 1990b, WEMCO 1992a).

The FEMP and the South Plume area is located above an extensive aquifer system known as the Great Miami Aquifer. This aquifer system extends over 100 miles from the Ohio River to the northeast. This aquifer has been designated a "sole source aquifer" because of its significance as a water supply. The aquifer system consists of a linear system of branching bedrock channels varying in width from less than a mile to several miles wide and up to 200 feet deep. These bedrock valleys formed as a result of pleistocene glaciation and subsequently filled with coarse grained glacial outwash materials and varying amounts of glacial till. In the vicinity of the FEMP, five branches of the system converge. Figure 2-1 shows these branches of the aquifer and depicts generalized flow directions in the aquifer system.

The bedrock in the vicinity of the FEMP is predominantly flat-lying olive gray Ordovician shales with thin, interbedded layers of limestone. This shale forms the floor and valley walls of the bedrock channels in the vicinity of the site. In the vicinity of the FEMP, the buried channel is generally carved into this shale between 60 to more than 200 feet below the pre-erosional land surface.

Approximately 150 feet of regionally extensive Pleistocene glacial valley fill deposits unconformably overlie the shales in the bedrock channel. As indicated by the site location plan (Figure 2-2) and typical hydrogeologic cross sections from the South Plume area (Figures 2-3 and 2-4), the buried valley is about one half to over two miles wide and is U-shaped, having a broad, relatively flat bottom and steep valley walls. Interbedded glacial till deposits occur within the outwash deposits, but in most cases are of limited lateral extent. The till deposits are composed primarily of poorly sorted pebbles, cobbles, and boulders in a predominantly clay matrix.

Within some areas, till deposits overlie the bedrock uplands and portions of the outwash materials where they form the thick unconsolidated sediment layers beneath the soil zone. This glacial till is composed of dense, silty clay that varies in composition vertically and laterally. The silty clay till contains lenses of poorly sorted fine- to medium-grained sand and gravel, silty sand, and silt with layers of silty clay. The FEMP lies on top of one of these terrace remnants (consisting of till) left after the establishment of the present day Great Miami River channel. The lower reaches of Paddy's Run have cut through this till and lie on the sands and gravels of the buried outwash deposits.

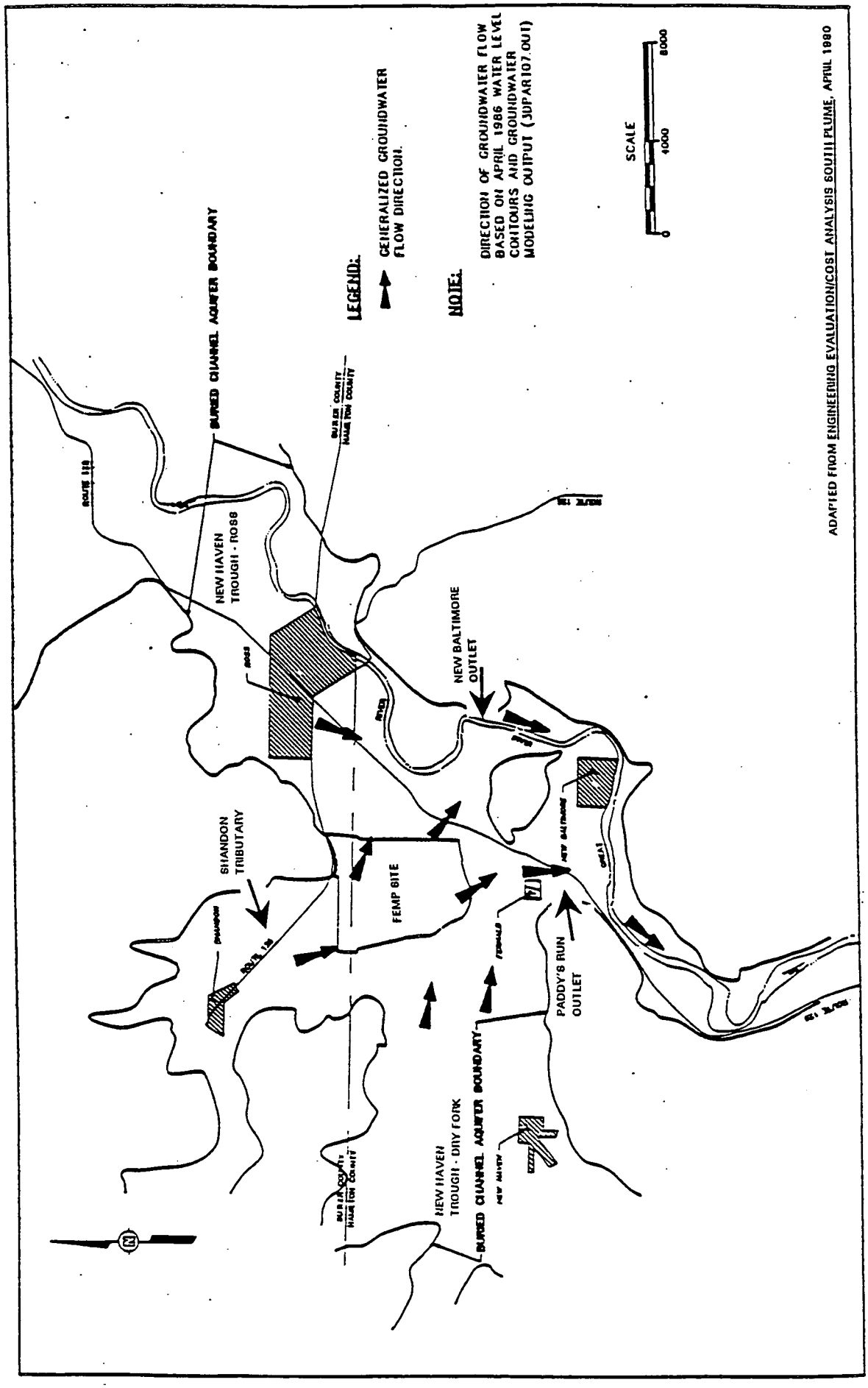

Figure 2-1 - Generalized Groundwater Flow in Buried Channel Aquifer

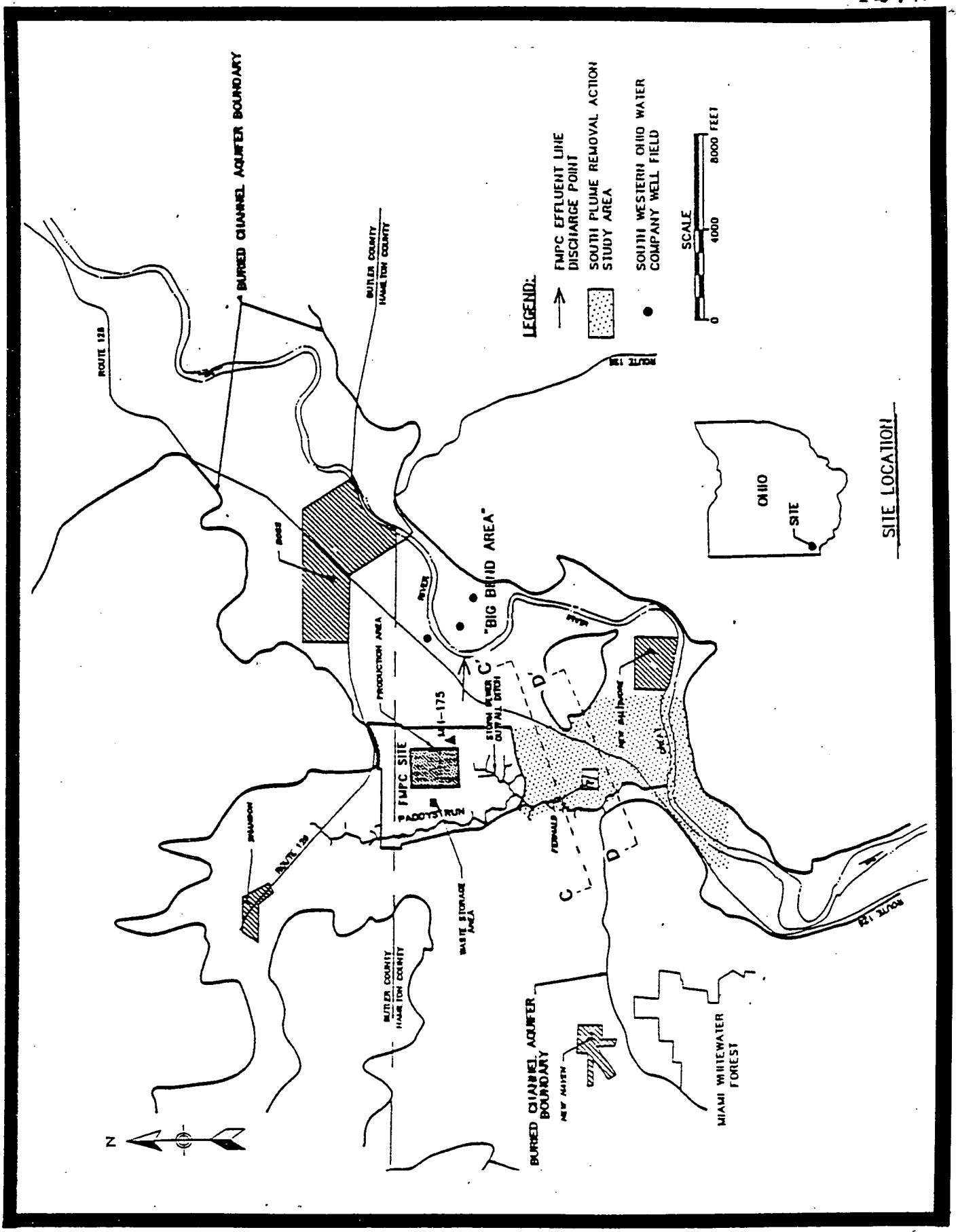

Figure 2-2 - Site Location Plan

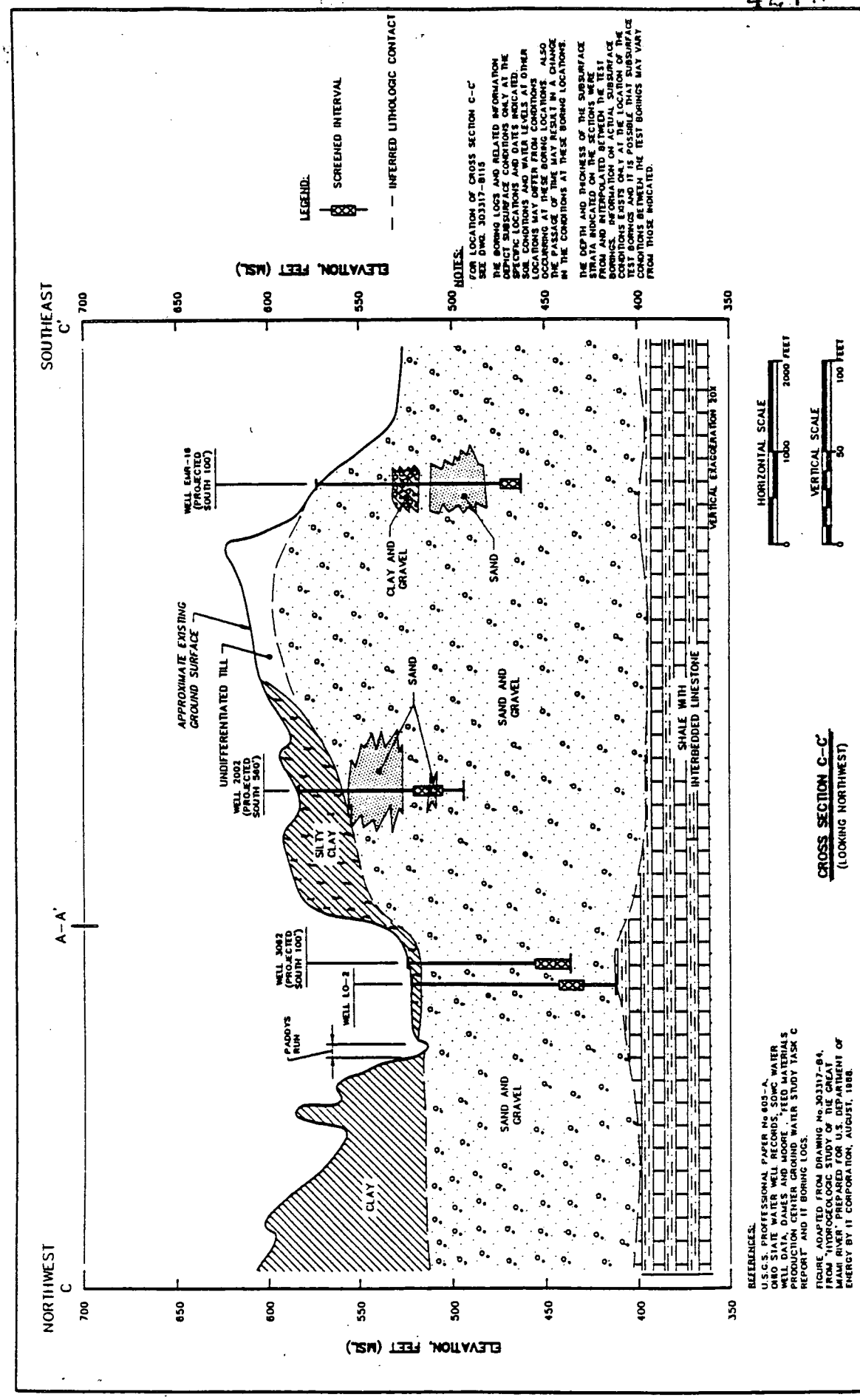

Figure 2-3 - Cross Section C-C'

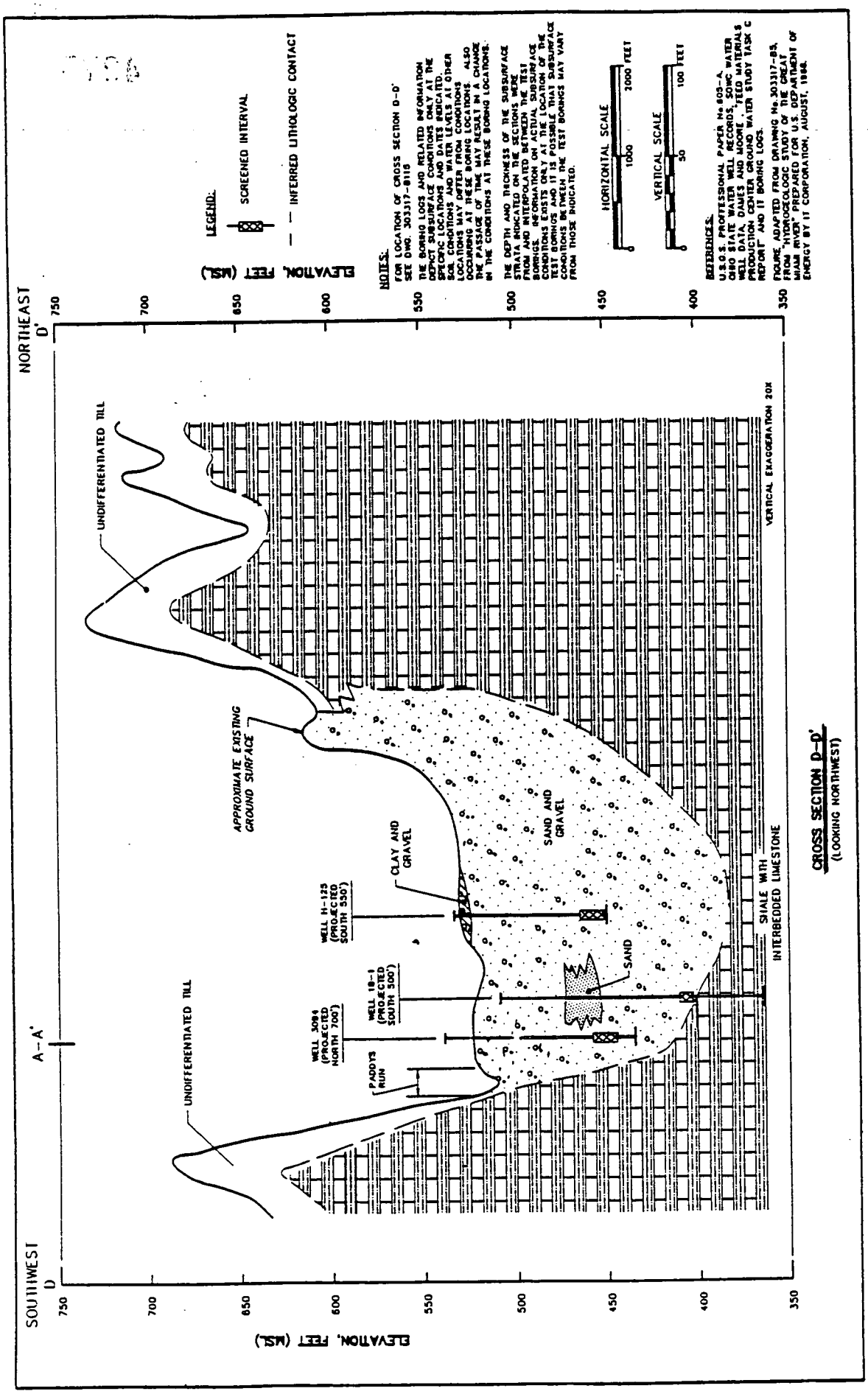

Figure 2-4 - Cross Section D-D'

The groundwater in the regional aquifer beneath the FEMP flows from the buried valleys west, north, and east towards the center of the FEMP study area (Figure 2-1). Groundwater would naturally exit the area by flowing south-southwest through the Paddy's Run Outlet. However the large capacity pumping wells of the Southwest Ohio Water Company (SOWC) in the "Big Bend" meander of the Great Miami River (Figure 2-2) east of the FEMP and just upstream of the FEMP discharge to the Great Miami River (Figure 2-5) produce a pronounced and persistent cone of depression in the potentiometric surface centered on the pumping wells. Groundwater elevation maps indicate that the resultant cone of depression from the SOWC well influences groundwater flow pattern beneath the FEMP. In particular, a groundwater flow divide is created such that groundwater underlying the northern portion of the ~~FMPC~~ FEMP flows to the east toward the SOWC wells and the Great Miami River. Groundwater from the southern/southwestern portion of the FEMP continues to flow along the natural gradient to the south-southeast through the Paddy's Run Outlet buried valley.

Elevated levels of uranium have been recorded as early as 1981 in groundwater south of the FEMP. Based on the distribution of contaminants found in monitoring wells, several investigations have concluded that the south plume originates from infiltration into the groundwater from the Storm Sewer Outfall Ditch and from Paddy's Run and potentially from leachate generated from the Southfield area. Paddy's Run and the outfall ditch directly contact the Great Miami Aquifer providing a direct pathway for contaminants entering the aquifer. ~~Efforts to define the extent of the plume have been hampered by difficulties in accessing private properties and lack of public roads near the plume's leading edge. However,~~ Recent and proposed future investigations are further defining the plume's leading edge. To date, the groundwater model has been used to extrapolate the definition of the South Plume based on time-related source loadings at reaches of the Storm Sewer Outfall Ditch and Paddy's Run, calibrated to existing levels of uranium found in monitoring wells in 1989. The South Plume Groundwater Monitoring and Response Plan shows the most recent monitored uranium levels in wells in the vicinity of the South Plume and depicts model predicted uranium concentrations (Appendix B).

2.2 System Design Summary

As stated in Section 1 the South Plume Removal Action consists of five related parts. Part 2 of the South Plume Removal Action (pumping and discharge system) consists of the design and installation of five recovery wells, the discharge force main and gravity pipeline from the recovery wells to the Great Miami River and associated mechanical, electrical, and instrumentation systems. Figure 2-5 shows a simplified depiction of the system. Because design is ongoing at the present time, there is still the potential for the system to be altered.

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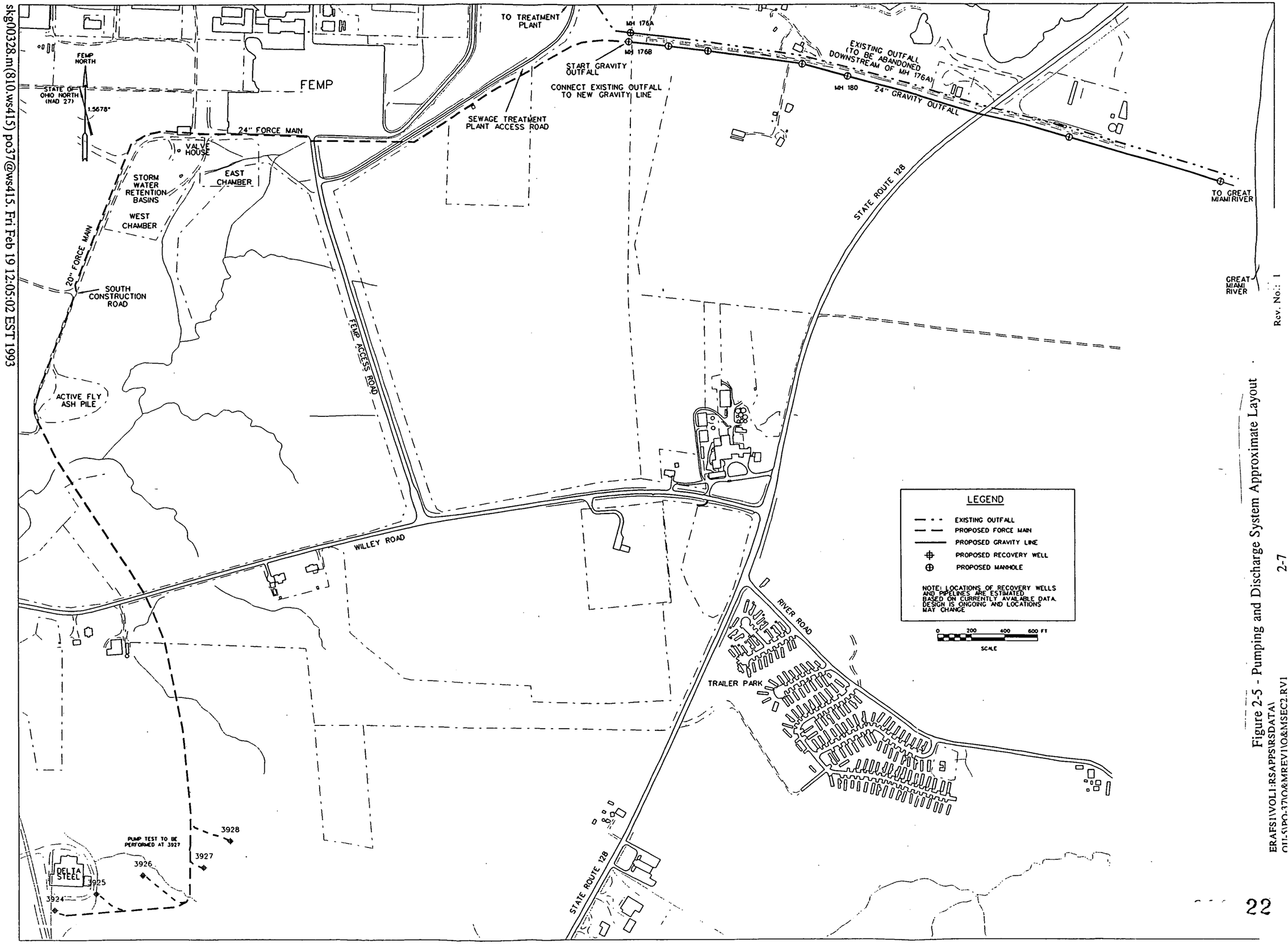

Figure 2-5 - Pumping and Discharge System Approximate Layout

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The line of recovery wells (oriented about 25 degrees north of due east) will be located approximately perpendicular to the axis of the south plume approximately 1,600 feet south of Wiley Road and just east of Paddy's Run Road. The line of wells will be approximately 1,200 feet long from the first to the fifth well with each well spaced approximately 300 feet apart. The well casings will be sized to accommodate maximum flow of 800 gpm and will be screened at the top 40 feet (to be verified - see Section 3) of the saturated zone of the aquifer. Model simulations (DOE 1992) have set flows for four wells spaced at 350 feet apart at 500 gallons per minute (gpm) for a total of 2,000 gpm. To add conservatism to the design, the original line of wells have been lengthened slightly (approximately 100 feet) and a fifth well has been added. Pumps are sized for a nominal 400 gpm each (total 2,000 gpm and a maximum flow of 650 gpm each (total 3,250 gpm) so that flows may be increased if necessary.

Groundwater from the south plume will be conveyed from the South Plume to the Great Miami River by a combination of a force main and gravity sewer (Figure 2-5). The force main and gravity sewer have been designed for excess capacity to allow additional future flow. The 20-inch force main (capacity of 5,000 gpm) picks up flow from the five recovery wells, runs north cross country, and bears northwest across Wiley Road to the western corner of the active fly ash pile. The force main turns to the northeast at the active fly ash pile and runs along the South Construction Road to the western and northern edges of the Storm Water Retention Basin (SWRB) west chamber to a new valve house just north of the SWRB. The valve house has been designed to allow a future diversion of the force main flow to a new Advanced Wastewater Treatment Plant (AWWT) and the return pumping of the future AWWT discharge flow to the force main and gravity sewer. From the valve house, a 24-inch force main runs 1,400 feet east and then follows the sewage treatment plant access road to the northeast. At a location just south of the existing sewage treatment plant, the force main discharges into an effluent aeration facility where the dissolved oxygen level of the water is raised to meet existing NPDES discharge limits. The outlet of the facility discharges to ~~joining~~ a new gravity pipeline at new Manhole No. 176B. The new 24-inch gravity pipe line runs approximately parallel to the existing outfall line. MH 180B, the gravity line, changes to a 28-inch line at a flatter slope (capacity 7,000 gpm) and continues to the Great Miami River (a total of 4,000 lineal feet). When the new gravity line is completed, the existing outfall line will be connected to the new line at Manhole 176B and the portion downstream of Manhole 176B abandoned. Additional wyes with valves and blind flanges have been left within the proposed wellfield and along the 20-inch force main, including the south field areas, to allow for additional connections if future wells are needed.

Instrumentation systems will provide the ability to control the system operation and to measure operating parameters. Each pump will be operated with a flow control valve to throttle the flow on the discharge pipe of each well. Flow will be measured at each discharge line with flowmeters and on site in the force main at the valve house. Adjustments to flow at individual pumps can be made by throttling the valves. The capability of remotely (on site) monitoring the performance of the pumping wells will be included in the design.

SECTION 3

DESIGN CONFIRMATION PROGRAM

3.1 Introduction

A design confirmation program has been included within the DMEPP to verify and improve (if necessary) the design and operation of the recovery system. Because of the high transmissivity of the aquifer, the long duration and high pumping rates necessary for an unconfined aquifer pumping test, and the extreme difficulties of managing large volumes of uranium-contaminated water; a site-specific pump test could not be performed until water handling facilities were available. In addition, the complexities of land acquisition, design and construction interdependencies, and Consent Agreement schedules required that recovery well design proceed prior to and in parallel with conducting the pump test and collecting additional characterization data. Therefore, an approach to meet the Consent Agreement schedule was developed. The approach consisted of using the groundwater model and field data to preliminarily design the system, add conservatism and flexibility into the design, include confirmation processes to check the design, and provide a mechanism to make future changes to the design.

The recovery system design was based primarily on ~~the SWIFT III site flow and contaminant transport groundwater model simulations~~ groundwater flow modeling use the SWIFT code and particle tracking using the STLINE code. This modeling was applied and documented in the South Plume Removal Action Groundwater Modeling Report (DOE 1993a) prepared specifically to simulate and optimize the recovery system locations and pumping rates. Because the model contains certain inherent limitations (for example, estimation of physical parameters and simplifications of the physical system), a design confirmation program was developed to assure the successful operation of the groundwater recovery system. Portions of this design confirmation program will be conducted prior to construction of the recovery wells. In the event that the pump test or monitoring results indicate a problem with the operating range provided by the design, an engineering change proposal will be processed to modify the design of the recovery system.

The model accuracy issues can be divided into two basic questions:

1) Is the horizontal plume system and predicted model capture accurately portrayed?

2) Is the vertical plume system and predicted model capture accurately portrayed?

The program developed to address these issues is described below.

3.1.1 Horizontal Capture

Because of the fast track schedule ~~and the reluctance of land owners to allow the use of property~~, planar definition of well locations (x and y coordinates) ~~had to be~~ were defined early in the design effort without the benefit of the results of the pump test or the Part 5 characterization. The approach to dealing with this situation consists of the following steps:

1) Baseline Conceptual Design - The groundwater model, with particle tracking, was used to set preliminary recovery well locations and flowrates which would establish a hydraulic barrier minimizing impact on PRRS plumes (DOE 1993a). The model predicted capture of the plume with 4 wells along a 1,080 foot line pumping a total of 2,000 gpm.

2) Design Flexibility and Conservatism - Because of potential accuracy issues associated with the model, operational flexibility was incorporated into the recovery well design. Five wells were placed over a 1,200 foot line increasing well coverage and density. Pumping rate capacity was increased over 60 percent to 3,250 gpm for the well field (including the throttling capability to allow the operation at any lower flow rate). Wyes, valves and blind flanges were left at many locations in the force main to simplify future connections (if required). Excess capacity (approximately 5,000 gpm) was incorporated into the force main design to allow for future connections.

3) Additional Characterization and System Evaluation - The Part 5 investigation, routine sampling programs, the pump test, and the proposed additional south plume monitoring wells will provide additional information regarding the aquifer system and the extent of horizontal contamination in the south plume. Because of the schedule and land owner issues discussed above, these data cannot be used to revise the locations of the recovery wells; however, these data (as available) will be utilized to set the initial pumping rates of the recovery system. Moreover, the system evaluation process (see Section 4) will periodically assess the system and determine if the removal action objectives are being met. Pumping rates may be altered or additional recovery wells may be constructed if they are needed to meet the system objectives.

4) Model ~~Validation~~ Improvement - Because of the reliance of the design on the flow model, a test will be performed on the model to determine the accuracy of the flow portion of the model. Based on the results of the test, the model will be recalibrated.~~, if necessary.~~ In addition, a refined model grid has been created in the south plume area by telescoping the solute transport subgrid. The solute transport grid is a 78 by 102 cell grid (each cell 125 feet square) which is used for flow and transport modeling at the FEMP. The refined grid telescopes the South Plume area using smaller cells (62.5 feet square). This new grid will provide better resolution of the model in this vicinity by providing smaller cells. The ~~validated~~ recalibrated and telescoped model

will provide a better tool for understanding and evaluating the south plume recovery system. These activities will be described in the Model Improvement Plan.

3.1.2 Vertical Capture

Vertical definition of the length of the recovery well screen does not require the long lead times that establishment of well locations require, provided the horizontal well locations remain fixed. Thus, screen depths can be set based on the latest available data. New data that will become available include the results of the pump test and results from the hydropunched samples from the Part 5 investigation and the south plume monitoring wells. The approach to dealing with this situation consists of the following steps:

1) Baseline Conceptual Design - Preliminary screen lengths were set based on the modeled uranium plume, monitoring data and particle tracking simulations. The modeled plume and available monitoring data showed that the plume was primarily at shallow depths in the 2000 series wells. Table B-1 of the South Plume Groundwater Modeling Report (DOE 1993a) lists the total uranium analytical results for monitoring wells from first quarter 1990 through second quarter 1992. The particle tracking was accomplished by seeding particles at various depths and locations and determining capture of these particles by pumping at selected depths (DOE 1992a).

2) Design Flexibility and Conservatism - Because of potential accuracy issues associated with the model, operational flexibility was incorporated into the recovery well design. Five wells were placed over a 1,200 foot line increasing well coverage and density. Pumping rate capacity was increased over 60 percent to 3,250 gpm for the well field (including the throttling capability to allow the operation at any lower flow rate). Wyes, valves and blind flanges were left at many locations in the force main to allow and simplify future connections (if required). Excess capacity (approximately 5,000 gpm) was incorporated into the force main design to allow for future connections.

3) Additional Characterization and System Evaluation - The Part 5 investigation, routine sampling programs, the pump test, and the proposed additional south plume monitoring wells will provide additional information regarding the aquifer system, vertical capture, and the extent of vertical contamination in the south plume prior to construction. Hydropunching in the Part 5 investigation and for the south plume monitoring wells will provide depth discrete samples over the entire depth of the aquifer (DOE 1992b). The pump test contains provisions for defining vertical capture as a function of pumping rate. With these data, the vertical length of screen of the remaining recovery wells will be established (see discussion below under item 5). In addition, the system evaluation process (see Section 4) will periodically assess the system and determine if the removal action objectives are being met. Pumping rates may be altered or additional recovery wells will be constructed if they are needed to meet the system objectives.

4) Model ~~Validation~~ Improvement - Because of the reliance of the design and operation of the recovery system on the ~~flow~~ groundwater model, a program of model improvement activities is being developed. This program will include model recalibration and performance evaluation activities. ~~a test will be performed on the model to determine the accuracy the flow portion of the model. Based on the results of the test, the model will be recalibrated, if necessary.~~ In addition, a refined model grid has been created in the south plume area by telescoping the solute transport subgrid as discussed in Item 4) of Subsection 3.1.1. This new grid will provide better resolution of the model in this vicinity by providing smaller cells. The ~~validated~~ improved and telescoped model will provide a better tool for understanding and evaluating the south plume recovery system.

5) Preparation of Vertical Capture Letter Report - A letter report will be prepared ~~to analyze~~ on the analysis and verification of the vertical location of the recovery well screens. This report will be prepared using recently available monitoring data, the Part 5 characterization data (including the south plume monitoring wells hydropunch samples), and the pump test data. This letter report will be prepared prior to the installation of the rest of the recovery well casings. This report will require preparation under an accelerated schedule because of the construction schedule requirement to start recovery well installation immediately after the pump test. Changing screen lengths may have an impact on the horizontal capture. Therefore, the establishment of screen lengths will be limited based on horizontal capture objectives. In addition, flow rates may be increased to compensate for any additional length. This report will also define the initial pumping rates for the recovery system using the latest available data as a basis. If findings dictate a different course of action, a removal action schedule variance will be requested from Ohio EPA and US EPA and further analysis using the latest available information including model simulations will be performed to determine appropriate screen lengths.

3.2 Pumping Test

Step-drawdown and constant rate pumping tests will be conducted on the test well. The Pump Test ~~and Model Validation~~ Work Plan (PTWP) describes, in detail, rates, locations of pumped and observation wells, and pump test procedures. This section and Subsection 3.3 describe the philosophy and requirements for the PTWP which ~~is included as~~ has been removed from Appendix A and issued as a separate document (DOE 1993b).

The step-drawdown test well will be pumped at ~~three~~ four different rates over uniform intervals that are specified in the Pump Test ~~and Model Validation~~ Work Plan ~~(Appendix A)~~. The constant rate test will be run at the optimum rate indicated by the step drawdown test. This rate will ~~range~~ be between 500 and ~~1,200~~ 1,500 gpm. The constant rate test will be conducted over a 72-hour period or until water levels substantially stabilize. The maximum duration for conducting both tests (including recovery periods between tests) will be 12 days. The particular well for testing was selected based on representativeness

of location (interior wells preferred) and depth, availability of monitoring points at comparable aquifer depths, and other system restrictions. Pump test water will be discharged through the new force main as explained in Subsection 2.2 ~~to the SWRB. This pump test water will be treated by the SWRB Interim Advanced Waste Water Treatment Plant to the maximum extent practical.~~ A detailed description of the handling of pump test water is contained in the Pump Test ~~and Model Validation~~ Work Plan.

Water elevations in a minimum of ~~four~~ five monitoring wells or observation wells will be continuously measured during the test (both during the pumping of the test well and during the recovery period). These wells may be existing monitoring wells, new monitoring wells associated with the south plume removal action, other recovery wells, or observation wells constructed for the test. These wells will be selected based on screen elevations, screen lengths, and well locations with respect to the pumped well.

The distance between these wells and the recovery well will be based on scoping calculations using estimated aquifer parameters. Three wells will be in one direction from the recovery well. The other two observation wells will be located at 90 degrees and 180 degrees around the test well from ~~to the orientation of~~ the other three observation wells. ~~to~~ Data obtained from these observation wells will indicate the shape of the cone of influence and anisotropic (preferred orientation) characteristics of the hydraulic conductivity distribution. Depths of piezometers will be based on the chosen method of analysis. At one location, multiple screened intervals of piezometers will be located to determine depth of influence. If appropriately located, additional monitoring wells will also be utilized in the pumping test to further delineate the hydraulic conductivity distribution.

Water levels will be continuously measured with multichannel data loggers and strip recorders in the recovery well and in the selected observation and monitoring wells during pumping of the test well and during the recovery period of the constant rate test. Water samples will be collected from the pumped well and analyzed for total uranium. These water samples will also be analyzed for temperature, specific conductance, and pH in the field to determine water chemistry changes during the test. It is projected that four samples will be taken the first day of the test and two samples on each of the remaining days.

Except as noted below, procedures for conducting the pump test and associated measurements, sampling, and analysis will be developed in accordance with the ~~draft~~ FEMP Sitewide CERCLA Quality Assurance Project Plan ~~(QAPjP)~~ (SCQ) (WEMCO 1992b). Because of the need for a quick response, site laboratories will be utilized for total uranium analysis. As a confirmation, 10 percent of the samples will be split and sent to laboratories approved in the ~~FEMP QAPjP~~ SCQ.

Standard hydrogeologic software packages will be utilized to analyze the data and to determine hydraulic conductivity and storativity values. The data will also be analyzed for vertical flow characteristics and for the presence or absence of boundaries affecting flow.

3.3 Model ~~Validation~~ Improvement

Information derived from the South Plume Pump Test will be used in the Model Improvement Program to evaluate and recalibrate the groundwater model. Calibration criteria will be determined from statistical and geostatistical analysis performed as part of the Model Improvement Program. This program will also provide for checks on the predictive capabilities of the groundwater model. The recalibrated model will be used in the long-term monitoring and evaluation program to analyze the performance of the South Plume Groundwater Recovery System. Model recalibration and performance evaluation reports generated by the Model Improvement Program will be provided to the US EPA and the Ohio EPA for review and comment. Figures 1-2 and 1-3 provide illustrations of these planned activities.

Figure 1-3 "Model Improvement and the DMEPP Approach" shows a flowchart with the three management programs associated with the design and operation of the south plume recovery system. One of these, the model recalibration and performance evaluation program, is being addressed separately and will be described in the Model Improvement Plan. These activities will assess the performance of the model by comparing predicted conditions to the field data obtained from the south plume monitoring program. Initially the model will be recalibrated using the pump test results and the latest monitoring data. Next, conditions predicted by the recalibrated model will be compared to recent monitoring data from the south plume area. If model predictions match the field data, then the performance of the model will be deemed acceptable. If model predictions do not match the field data, the model will be recalibrated. If system performance is not acceptable, the model will be used to optimize the operating parameters of the recovery system. Criteria for performing this performance evaluation will be defined in the Model Improvement Plan.

As shown on Figure 1-3, this program is cyclic in nature. Initially, model performance assessments will be conducted every year. The time increment of these assessments may be increased in the future due to a presumed increased confidence in the use of the model over time. Assessment frequencies will be discussed in detail in the Model Improvement Plan.

~~The south plume area of the existing groundwater flow model domain will be validated by comparing the pump test hydraulic results with the groundwater model simulating the same conditions. This model validation will be performed during the first quarter after the system is operational so that a validated model may be used to help design system modifications in subsequent quarters. The Pump Test and Model Validation Work Plan describes in detail the evaluation criteria and validation procedures (see Appendix A).~~

~~The recovery well and applicable monitoring and observation wells will be located on the existing groundwater model grid, and pumping will be simulated in the model at the actual flow rate of the pump test. Other model assumptions such as depth of screen penetration of aquifer will be matched to field conditions to the extent possible. The model will be utilized in a transient mode to determine the changes~~

~~over time in water levels at the recovery well and observation wells. The simulated changes and the pump test measured changes will be compared at applicable time intervals and in a steady state mode.~~

~~After the groundwater recovery wells are operational, a second experiment will be performed comparing the water elevations produced by the constant pumping of the recovery wells versus a modeled steady state simulation of these recovery wells pumping at this assigned rate. This data will become available after continuous operation of a month or more of the multiple recovery wells. Monthly water level readings during the first quarter of operation will be utilized for this test.~~

~~The results of this model validation activity will be described in a report. Model versus pump test results will be analyzed and conclusions will be stated regarding the ability of the model to match the above two tests. Recommendations will also be made, if warranted, regarding recalibration of the model.~~

~~3.4 Model Recalibration~~

~~If the model validation conclusions and recommendations deem it necessary, the model will be recalibrated in the vicinity of the south plume to approximate the conditions determined by the pump test and the model validation procedure. The recalibrated model will then be ready for use in supporting activities to develop system modifications.~~

~~Model recalibration will be conducted in accordance with procedures established in the Pump Test and Model Validation Work Plan (see Appendix A). Calibration criteria will be established prior to recalibrating the model. Repeated simulations using varying hydraulic conductivity distributions will be conducted to attempt to bring the model heads within the established calibration criteria. When the model has met the calibration criteria, two simulations will be run to confirm the new model assumptions. One, the pump test simulation matching the performed pump test will be rerun in transient and steady state modes, and the results will be compared and evaluated. Two, simulation of the recovery well pumping (of all wells) will be compared to the actual drawdown produced and measured (steady state). These results will also be compared and evaluated.~~

~~The calibration process is iterative and may require the adjustment of other parameters (infiltration, boundaries, etc.) in order to bring the model within the established criteria. A model recalibration report will be written which describes the recalibration assumptions, procedures, simulations, results, and which draws conclusions based on these results. This report will be provided to the US EPA and the Ohio EPA for information purposes.~~

SECTION 4

MONITORING PROGRAM

4.1 Introduction

Groundwater elevation and geochemical data will be collected at specified time intervals and locations to provide data for evaluating system performance and to assist in ~~validating and recalibrating~~ the recalibration and performance evaluation of the groundwater model. This section describes the monitoring requirements for the routine monitoring program. The specifics of the monitoring program are contained in the South Plume Groundwater Monitoring and Response Plan included as Appendix B. Monitoring associated with the pump test is not included in this section but rather is described in the PTWP.

4.2 Objectives

The objectives of the monitoring program for the South Plume Removal Action are:

1) To delineate the cone of depression caused by the recovery wells

2) To provide supporting hydraulic data for the model ~~validation and model calibration tasks~~ improvement program

3) To provide information for evaluating the recovery system's performance (evaluation/response program). This information, at a minimum, will:
   (1) Delineate the uranium concentration distribution in the vicinity of the recovery wells
   (2) Anticipate the uranium concentrations that will be pumped in the future
   (3) Determine the potential impact of plumes from the Paddy's Run Road Site

The following ~~describes a program constructed~~ provides a summary overview of the program designed to meet these objectives. Specifics of this program are contained in ~~the South Plume Groundwater Monitoring and Response Plan (see~~ Appendix B.

4.3 Water Level Measurements

Water levels will be measured at recovery wells, south plume monitoring wells, and selected additional monitoring or observation wells ~~(see the South Plume Groundwater Monitoring and Response Plan Appendix B). The frequency of these measurements will be as follows:~~ at frequencies specified in Appendix B.

~~Time Increment~~	~~Frequency~~
~~1st week of operation~~	~~Daily~~
~~1st month of operation~~	~~Weekly~~
~~1st year of operation~~	~~Monthly~~
~~Subsequent operation~~	~~Quarterly~~

The ~~above~~ monitoring schedule ~~of measurements~~ has been selected to have more frequent data collection at the beginning of recovery pump operation because of transient effects. Measurements are made monthly over the first year to build a database for the system evaluation process. As operation continues and a relative steady state is achieved, the water levels will change less with time, and quarterly readings will provide a picture of annual variation.

Data from monitoring wells in the area of the pumping wells, measured for groundwater elevations as part of the regular sitewide monitoring program, will also be evaluated to provide as complete a picture as possible.

Procedures for measuring water levels will be in accordance with the approved ~~FEMP QAPP~~ SCQ and the South Plume Groundwater Monitoring and Response Plan (see Appendix B). The evaluation of this data is described in Section 5.

4.4 Geochemical Monitoring

Samples will be collected at recovery wells and south plume monitoring wells and will be analyzed for total uranium, pH, specific conductance, and temperature. ~~(see the South Plume Groundwater Monitoring and Response Plan Appendix B).~~ Selected monitoring wells south of the recovery wells will be sampled and analyzed for volatile organic compounds (VOCs) and inorganics in order to directly determine if the Paddy's Run Road Site organic or inorganic plume is expanding toward the recovery wells. These monitoring wells will provide advance information if the plume is migrating. The South Plume Groundwater Monitoring and Response Plan (see Appendix B) indicates specific monitoring wells that will provide this barrier monitoring and specific indicator parameters and frequencies for monitoring ~~that will be monitored.~~

~~The frequency of these measurements will be as follows:~~

~~Time Increment~~	~~Frequency~~
~~1st week of operation~~	~~Daily~~
~~1st month of operation~~	~~Weekly~~
~~1st quarter of operation~~	~~Monthly~~
~~Subsequent operation~~	~~Quarterly~~

Like the water level measurement program, more samples will be collected at the beginning of the program when there are more transient effects. Because of the distance between the PRRS organic plume and the recovery wells, only the monthly and quarterly scheduled samples will be collected for PRRS organics.

Except as noted below, procedures for sampling and analysis of monitoring wells will be in accordance with the FEMP ~~QAPjP~~ SCQ ~~and the South Plume Groundwater Monitoring and Response Plan (see Appendix B)~~. Because of the need for a quick response, so that system evaluations and adjustments can be accomplished in a timely manner, on-site laboratories will be used for total uranium and PRRS organic and inorganic parameter analysis. In the event the on-site lab cannot meet project needs for PRRS parameters, an off-site lab capable of Level 3 Data Quality Objective will be utilized. As a confirmation, 10 percent of the samples will be split and sent to laboratories on the approved list in the FEMP ~~QAPjP~~ SCQ, Appendix A, Table 3-2. The evaluation of this data is described in Section 5.

SECTION 5

EVALUATION/RESPONSE PROGRAM

5.1 Introduction

This section provides a summary overview of the evaluation/response program. Program details are provided in Appendix B.

The purpose of the Evaluation/Response Program is to analyze whether the system is meeting its objectives and to take appropriate action to bring it back in conformance with its objectives. Monitoring data will be utilized to evaluate whether the system is meeting its objectives. If this evaluation determines that the program objectives are being met, then no further action will be taken until the next monitoring period when the data is again evaluated. If the evaluation shows that the system is not meeting its objectives, the model (and other analytical tools) will be utilized to develop modifications to bring the system in line with its objectives. Possible system changes may involve design, operation, or monitoring program modifications. This section of the DMEPP defines the general requirements for the Evaluation/Response Program. Specifics of the Evaluation/Response Program are described in detail in the South Plume Groundwater Monitoring and Response Plan (see Appendix B).

Because of spatial and temporal variations in the hydrogeologic system that is being analyzed, system evaluation and follow-on activities will be performed according to the following schedule:

Time Increment	Frequency
1st year	Quarterly
Subsequent years	Semi-annually

This schedule does not completely coincide with the monitoring schedule. Certain system evaluations will cover more than a single monitoring data set and will analyze available data sets at the time of evaluation.

5.2 System Evaluation

At each scheduled time interval, a system evaluation will be performed. The purpose of this evaluation is to determine whether the system is meeting the defined objectives. Factors that will be considered include the following:

1) The present distribution of groundwater elevations in planar view and vertical section.

2) The change over time in the distribution of groundwater elevations.

3) The flow rate of pumping over the last evaluation cycle.

4) The rainfall over the last evaluation cycle.

5) Other aquifer stresses such as nearby production wells occurring over the last evaluation cycle.

6) The present distribution of uranium concentration in planar view and vertical section.

7) The change over time in uranium concentration.

8) The present distribution of PRRS organic and inorganic constituents.

9) The change-over time of PRRS organic and inorganic constituents.

10) Other geochemical factors.

Specific criteria for the system evaluation based upon these factors are presented in Appendix B. Based upon these criteria, it will be determined whether the system is meeting its objectives. Statistical procedures will be used to determine significance of changes. These statistical procedures will be included in Appendix B. ~~This evaluation will need to balance possibly competing objectives~~. This evaluation will need to be cognizant of time and spatial variability and will need to react to general trends but not to every possible system upset; i.e., a global approach needs to be taken. Conclusions and recommendations to this system evaluation may state that:

1) The system is not meeting its objectives.

2) Specific changes need to be made to the system to bring it in line with the objectives.

3) The monitoring program needs to be changed to determine if objectives are met. The evaluation may recommend the specific monitoring program changes (frequency, locations, parameters, etc.) that need to be made.

4) The system is functioning in accordance with its objectives and recommends that no changes be made.

5) The system has met its objective. The evaluation may recommend ceasing operation of the system and continuation of monitoring for a specified period as a confirmation.

A system evaluation report will be prepared containing the described analysis, conclusions, and recommendations. The system evaluation report may recommend minor pumping rate changes to accommodate seasonal variation or other temporal factors without triggering the more formal system modification process described below. This report will be submitted to the US EPA and Ohio EPA for ~~information purposes~~ review and comment.

5.3 Development of System Modifications

If recommended by the system evaluation report, an effort will be undertaken to develop system modifications. The groundwater model will be utilized to assist in this development effort by allowing the simulation of possible system changes and an analysis of the effects of these changes. Other analytical tools may also be used to assist in this effort.

Potential modifications identified in the system evaluation report will be classified as either system problems or as system optimization issues. System problems are defined as a situation identified in the system evaluation report which may compromise the four objectives stated in Section 1. These types of situations include significant upgradient contamination circumventing the hydraulic barrier created by the recovery wells; a southerly extending capture zone causing PRRS contaminants to migrate toward the recovery wells or to significantly deflect; or a situation which somehow compromises the long term remediation of the site. System optimization issues are primarily efficiency issues that do not affect the system's ability to meet the objectives. These types of issues include minor adjustment of pumping rates or cycles to increase efficiency, save power, etc.; a minor adjustment to prevent a system problem in the future; or minor changes in the monitoring program (adding a constituent or an existing well to the program). System optimization changes may be handled as part of the system evaluation report and may not require the system modification process as determined by the complexity of the recommended change.

Different response actions and schedules will be carried out for system problems versus system optimization issues. System problems will be reacted to with an aggressive schedule. The system modification report will be completed within 60 days after the system evaluation report is submitted. If construction is necessary then an aggressive design and construction schedule will also be pursued. This schedule, included and justified in the system modification report, will be based on the complexities of the design and the scope of construction. If very serious situations are encountered as identified in the system evaluation report, it may be necessary to implement immediate "interim measures" such as adjustment of pumping rates using the best data available. The US EPA and Ohio EPA will be informed if "interim measures" are instituted. However any "interim measures" will be checked with the formal system evaluation and modification process and final adjustments will be made.

Attempts will be made to anticipate future problems so that system problems can be prevented and a proactive approach to modifying the system can be carried out. The monitoring program and the system evaluation report will provide a periodic review of the system and will identify existing problems and

conclude if there are future problems which demand attention, thereby preventing the need for aggressive schedules or "interim measures." System optimization issues will be reacted to within a more normal schedule typically by submission of the system modification report within 90 days.

Three types of system modifications are possible. These are described in the following sections.

5.3.1 Operation Changes

The preferred choice in modifying the system will be with an operating change. Specific operating changes include:

1) Varying the constant pumping rate of any pump. Different rates may be applicable to each pump depending on the identified need of the system.

2) Instituting pulsed pumping (stop/start cycles) at any pump. Different pulsed pumping rates and intervals may be applicable to each pump depending on the identified need of the system.

3) Turning off a particular pump depending on the needs of the system.

A system modification report will describe the simulations and analysis conducted to arrive at the selected operational changes. This report will also analyze the effect of the change on other parts of the removal action. Upon finalizing this report, the operational changes will be implemented by operating personnel. This report will be submitted to the US EPA and Ohio EPA for review and approval.

5.3.2 Design Changes

If an operational change is unable to modify the system sufficiently to bring it in line with the objectives, then a design change may have to be conducted. Design changes typically will require that new recovery wells be added to the system with the location determined by the needs of the system. Design changes may dictate accompanying operational or monitoring modifications.

The system modification report will describe the simulations and analysis used to arrive at the design change and will recommend a particular system addition. Based on the recommendations of this report, detailed design activities will commence. Factors involved in the design include the procurement of easement, the need for ancillary equipment to support the new recovery well(s), and the schedule of design and construction.

After completion of appropriate construction documents, the job will be bid and a construction contractor will be selected. The construction contractor will construct the new system component, and another start-up procedure will commence. The DMEPP will be updated (if required) to reflect the new components

in the system. The revised DMEPP will be submitted to the US EPA and Ohio EPA for review and approval.

5.3.3 Monitoring Program Changes

Changes in the monitoring program may be recommended directly from the system evaluation report or may be recommended in the system modification report (see Figure 1-2). Monitoring program changes do not necessarily need to go through a system modification development since changes could be very routine (for example, analyzing for an additional a parameter, sampling an additional existing well, or changing a sampling frequency). Other monitoring program changes may accompany an operational or design change to match the monitoring program to the new system parameters. New monitoring wells will require a minimal design activity since established procedures will be followed. Increased frequency of monitoring during start up may be required to accompany a major system change.

The South Plume Groundwater Monitoring and Response Plan will need to be changed or amended when monitoring program changes are prescribed. This revised plan will be submitted to the US EPA and Ohio EPA for review and approval.

SECTION 6

REFERENCES

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APPENDIX A

PUMP TEST AND MODEL VALIDATION WORK PLAN

The Pump Test Work Plan was previously issued as a stand-alone document in February 1993. The model validation work plan has been removed from this document and will be issued as part of the Model Improvement Plan at a later date.

APPENDIX B

SOUTH PLUME GROUNDWATER MONITORING AND RESPONSE PLAN

Appendix B
South Plume Groundwater Recovery System
South Plume Groundwater Monitoring and Response Plan

Fernald Environmental Management Project
April 1993
Revision No. 1

Submitted by:
U.S. Department of Energy
Fernald Office
P.O. Box 398705
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Appendix B
South Plume Groundwater Recovery System
South Plume Groundwater Monitoring and Response Plan

Fernald Environmental Management Project
April 1993
Revision No. 1

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South Plume Removal Action
South Plume Groundwater Monitoring and Response Plan

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LIST OF ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of Variance Procedure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DMEPP	Design, Monitoring, and Evaluation Program Plan
DOE	United States Department of Energy
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation
GMRP	Groundwater Monitoring and Response Plan
Ohio EPA	Ohio Environmental Protection Agency
~~QAPjP~~	~~Quality Assurance Project Plan~~
PRRS	Paddy's Run Road Site
SCQ	Sitewide CERCLA Quality Assurance Project Plan
WEMCO	Westinghouse Environmental Management Company of Ohio

SECTION 1

INTRODUCTION

1.1 Purpose

The primary purpose of the South Plume Groundwater Monitoring and Response Plan (GMRP) is to define a system evaluation and response program that will evaluate the effectiveness of the South Plume groundwater recovery system. The South Plume Groundwater Recovery System - Design, Monitoring and Evaluation Program Plan (DMEPP) (see main text) defined the general requirements of this program in Sections 4 and 5. The DMEPP divides this program into two mutually dependent activities:

1) South Plume Groundwater Monitoring
2) South Plume System Evaluation and Response

As stated in the DMEPP, groundwater monitoring wells (both existing and proposed) will be utilized to collect groundwater elevation and chemical data at specified time intervals and locations. Periodic system evaluations are performed to determine if the recovery system continues to meet its objectives despite spatial and temporal changing variables and proposes a process of corrective action through routine changes or through a more formal system modification procedure.

The GMRP defines the specific requirements for these activities. The GMRP includes definition of the following:

1) Management responsibilities and schedule

2) The monitoring well network layout

3) Design information for new well construction

4) Details of water level measurements, groundwater sampling and analysis, and other data acquisition methods

5) System response criteria

6) Recovery well design criteria

7) Data reduction and analysis tasks

8) Statistical methods

9) Reporting requirements

1.2 Management and Responsibilities

Figure 1-1 shows the relationships between the organizations who will be involved in groundwater monitoring and system evaluation. PARSONS, as monitoring and system evaluation program designer, provides design criteria for new monitoring wells. PARSONS also defines recovery well design criteria to the extent that system evaluation requirements affect the well design. A.M. Kinney is responsible for designing the recovery and monitoring wells. PARSONS provides well sampling requirements to ~~Westinghouse Environmental Management Company of Ohio (WEMCO)~~ Fernald Environmental Restoration Management Corporation (FERMCO) Environmental Monitoring, who will conduct the actual monitoring.

Field activities associated with drilling, measuring, and sampling will be conducted in accordance with this work plan. PARSONS and A. M. Kinney will provide technical guidance during associated field activities.

1.3 Program Schedule

Figure 1-2 shows the schedule of the monitoring program and the system evaluation and response program. Implementation of this program will be dependent on the acquisition of baseline data and the construction and start-up of the recovery system.

In an effort to provide timely reporting, system evaluations are scheduled to be completed 90 days after the end of a particular quarter. A 30-day lab turnaround is assumed for this schedule. The results of confirmatory split samples sent to approved off-site labs ~~approved~~ listed in the Fernald Environmental Management Project (FEMP) Sitewide Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Quality Assurance Project Plan ~~(QAPjP)~~ (SCQ) (WEMCO 1992b) will not be available for a particular quarter so unconfirmed data will be used. Best professional judgement will be used to eliminate the use of suspect data when confirmatory data is pending. Since system evaluations are a continuous process, any data not available at the time of one evaluation will be included in the next scheduled evaluation.

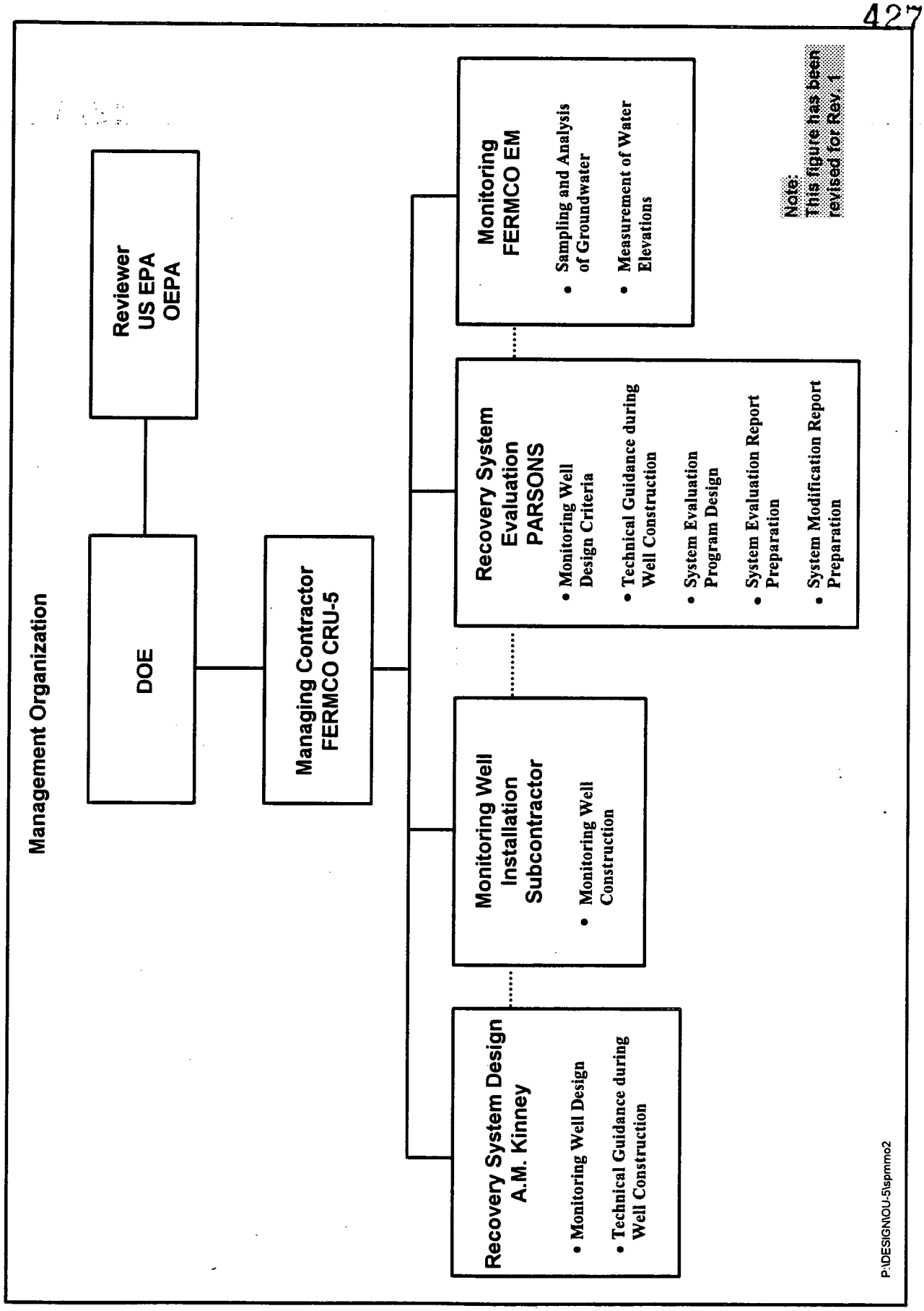
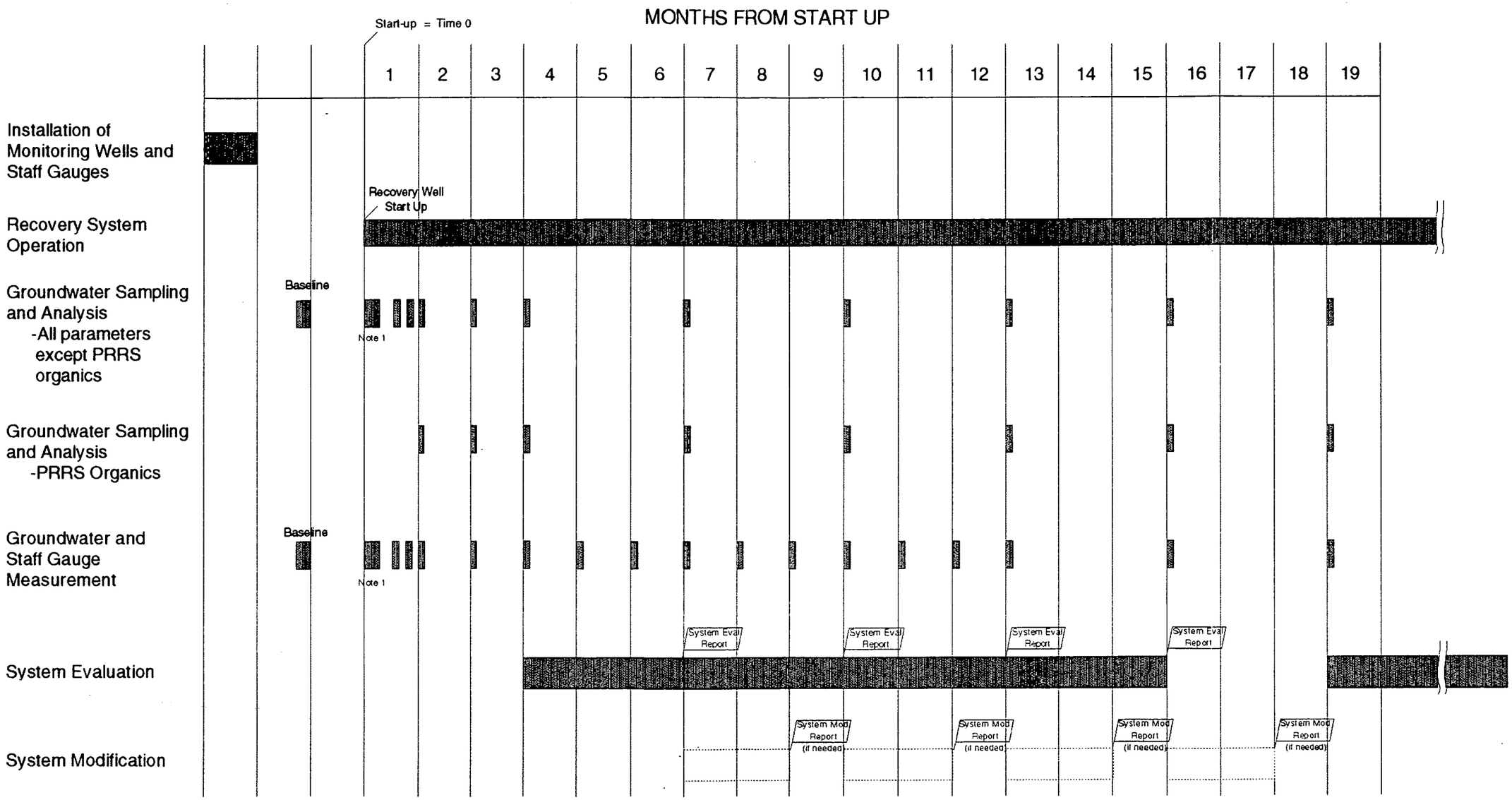


Figure 1-1 - South Plume Monitoring Management Organization

FIGURE 1-2 - MONITORING AND SYSTEM EVALUATION PROGRAM SCHEDULE



Note 1: First block represents 8 daily samples.
7 daily samples for the first week and
and an eighth sample for week two.

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Figure 1-2 - Monitoring and System Evaluation Program Schedule
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SECTION 2

GROUNDWATER MONITORING

2.1 Objectives

As stated in Section 3 of the DMEPP, the objectives of the South Plume Groundwater Monitoring Program are:

1) To delineate the cone of depression caused by the recovery wells

2) To provide supporting hydraulic data for the model ~~validation and model calibration tasks~~ improvement program

3) To delineate the uranium concentration distribution in the vicinity of the recovery wells

4) To anticipate the uranium concentrations that will be pumped in the future

5) To determine the potential impact of plumes from the Paddy's Run Road Site (PRRS)

To meet the objectives stated above, two types of field data will be collected from monitoring wells in the vicinity of the recovery wells: hydraulic (groundwater elevation) data and groundwater quality data. Since hydraulic and groundwater quality data are time dependent, these field data will be collected at specified intervals (see Figure 1-2). Additional monitoring wells are proposed to increase the data coverage of the south plume area.

2.2 Data Collection Network

Table 2-1 summarizes the data collection approach along with well location considerations for each of the five objectives stated above. The first two objectives require the collection of hydraulic data to define and evaluate the capture zone created by the recovery wells. The last three objectives require sampling and analysis for applicable constituents. Objectives 4 and 5 also require supporting hydraulic data. The "Considerations" field in Table 2-1 selects applicable considerations for each objective. In some cases, these considerations are used to meet more than one objective. Each of these considerations is discussed in relation to proposed monitoring wells in the following text.

Twelve monitoring wells will be installed as six pairs. Each pair will consist of a 2000 series and a 3000 series monitoring well. Figure 2-1 shows the proposed monitoring wells along with more than 70 existing wells in the South Plume area. These wells include United States Department of Energy (DOE) monitoring wells, PRRS monitoring wells, and private water supply wells. Most are available to the DOE for sampling; most of these wells are concentrated in the western portion of the study area especially along Paddy's Run Road, with less dense coverage in other portions of the study area. Many of these existing wells are appropriately located to support south plume monitoring efforts.

Figure 2-1 shows the estimated extent of the total uranium plume (using the 20 μg/l isopleth from 4th quarter 1991 values in the 2000 series wells) and of the PRRS inorganic and organic plumes (using values above background from 4 rounds of 1991 data). These depictions of plumes are based on the most recent, although preliminary, data (WEMCO 1992a; Ohio Environmental Protection Agency [Ohio EPA] 1992).

2.2.1 Proposed Monitoring Wells North of Recovery Wells

Three paired wells are proposed approximately 400 to 700 feet north of the recovery well line (~~SPM-2001/3001~~ 2880/3880, ~~SPM-2002/3002~~ 2881/3881, and ~~SPM-2003/3003~~ 2897/3897 on Figure 2-1). These three new well pairs along with two existing paired 2000 and 3000 series wells (2095, 3095, 2093, and 3093) will generally form a southwest/northeast trending line of monitoring wells to the north of the five well recovery system.

The locations of the new north monitoring wells were selected to fulfill the monitoring program objectives. These wells will be installed 400 to 700 feet north of the recovery wells to measure drawdown associated with recovery system pumping (modeling predicts approximately 1.8 to 2.4 feet of drawdown at this distance with total well field pumping at 2,000 gpm (DOE 1992). Using the Darcy Equation with gradients predicted by modeling (DOE 1992) and a hydraulic conductivity value of 450 feet/day (DOE 1990) and 1 as the retardation coefficient, a groundwater travel time is calculated as approximately 57 to 100 days over the 400 to 700 feet. Since uranium does retard to some degree in porous flow systems, this travel time represents a conservative low level. This distance will provide a sufficient time frame to react to trends reflected in monitoring wells prior to the arrival at the recovery wells. These locations provide a reasonable warning time while still providing a location within the projected cone of depression. In addition, other monitoring wells north and south of this line of wells will be measured and sampled to discern trends, thus additional supporting data will be provided. These proposed wells also provide two new monitoring locations in an area where there are few wells.

Table 2-1 - Considerations in Collection of Hydraulic and Groundwater Quality Data

Objective	Approach	Considerations
1) To delineate the cone of depression caused by the recovery wells	Water elevation data collected at appropriate wells and stream stations	1) Location within cone of depression 2) Coverage of area by existing wells 3) Presence of recharge boundaries (Paddy's Run)
2) To provide supporting hydraulic data for the model ~~validation and model calibration validation tasks~~ improvement program	Water elevation data collected at appropriate wells and stream stations	1) Location within cone of depression 2) Coverage of area by existing wells 3) Presence of recharge boundaries (Paddy's Run)
3) To delineate the uranium concentration distribution in the vicinity of the recovery wells	Uranium sampling data collected at appropriate wells	1) Coverage of area by existing wells 2) Line system of monitoring north of recovery wells 3) Line system of monitoring south of recovery wells
4) To anticipate the uranium concentrations that will be pumped in the future	Uranium sampling data collected at appropriate wells supported by water elevation data	1) Line system of monitoring north of recovery wells 2) Warning time (function of distance north) 3) Spacing based on uranium plume features
5) To determine the potential impact of plumes from the Paddy's Run Road Site	PRRS parameter sampling data collected at appropriate wells supported by water elevation data	1) Line system of monitoring south of recovery wells 2) Warning time (function of distance south) 3) Spacing based on PRRS plume(s) features

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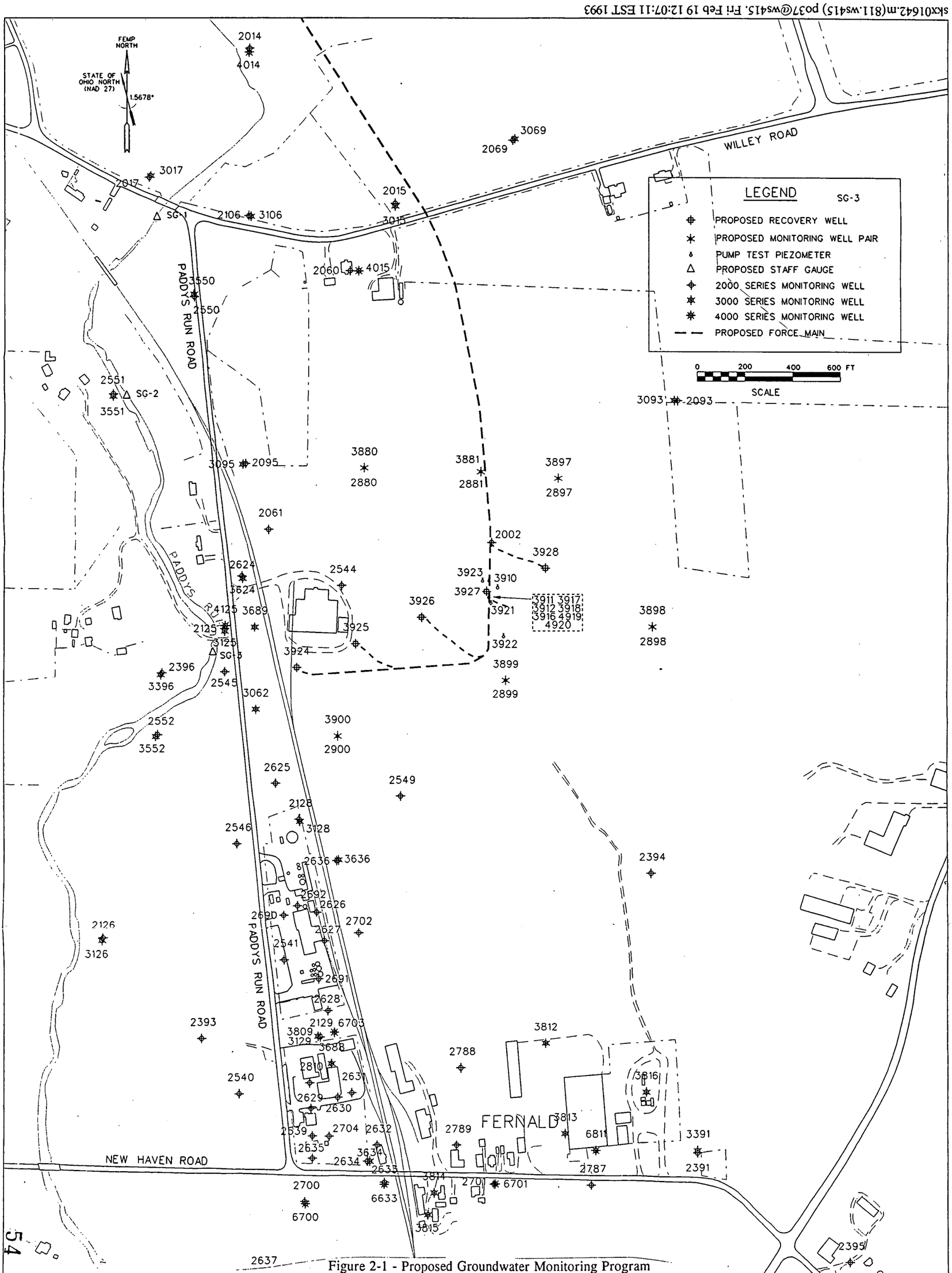

Figure 2-1 - Proposed Groundwater Monitoring Program

The wells of this line are spaced approximately 500 feet apart between the ~~SPM-2001/3001~~ 2880/3880 and the ~~SPM-2002/3002~~ 2881/3881 pairs, and 400 feet apart between the ~~SPM-2002/3002~~ 2881/3881 and ~~SPM-2003/3003~~ 2897/3897 pairs. Based on a recent plume definition from groundwater monitoring data, the plume is over 2,000 feet wide at the 10 μg/l total uranium contour north of the monitoring wells at Willey Road (Figure 2-1); therefore, this spacing is sufficient to estimate the size and concentration of the plume passing this point (i.e., important trends will not be missed). To provide an additional level of protection, additional existing wells will also be monitored at locations between these wells (see Sections 2.4 and 2.5 for definition of sampling and measurement program).

2.2.2 Proposed Monitoring Wells South of Recovery Wells

Three additional paired wells are proposed south of the recovery wells. These three new well pairs (~~SPM-2004/3004~~ 2900/3900, ~~SPM-2005/3005~~ 2899/3899, ~~SPM-2006/3006~~ 2898/3898 on Figure 2-1) will form a southwest/northeast trending line approximately 350 feet south of the recovery well system.

The locations of the new south monitoring wells were also selected to fulfill the monitoring program objectives. These south monitoring wells will provide drawdown data south of the recovery wells, to determine and forewarn if northward migration from PRRS is occurring, and to determine if the uranium plume is escaping past the recovery wells. At approximately 350 to 400 feet from the line of recovery wells, these wells will measure drawdown associated with recovery well pumping (modeling predicts 2.5 to 3.0 feet of drawdown at this distance with total well field pumping at 2,000 gpm [DOE 1992]). Potential northward migration from the PRRS would be discovered by sampling new wells ~~SPM-2004/3004~~ 2900/3900, as well as existing wells 2549 and 2625 for PRRS inorganic parameters (see Figure 2-1). Sections 2.4 and 2.5 below describe the measurement and sampling program.

It is not anticipated that the PRRS organic plume could migrate as far north as the new line of monitoring wells; however, if northward migration did occur, sampling for organics at ~~SPM-2004/3004~~ 2900/3900 as well as ~~SPM-2005/3005~~ 2899/3899 and existing wells 2702 and 2548, would detect this northward migration (see Figure 2-1). In addition, the two easterly well pairs (~~SPM-2005/3005~~ 2899/3899 and ~~SPM-2006/3006~~ 2898/3898) will provide monitoring information in a location that has few monitoring wells.

The distance between the line of proposed monitoring wells and the recovery wells was selected based on groundwater travel time and drawdown factors. Since model simulations (DOE 1992) show a slight gradient from the recovery wells to the south monitoring wells, then flow should occur in a generally southern direction although at a slower rate than north of the recovery wells. The 350 foot distance was chosen to provide a reasonable travel time for determining if uranium contamination is passing the recovery wells or for determining if PRRS constituents are migrating toward the recovery

wells. A shorter distance between south monitoring wells and recovery wells (than the equivalent north distance) was selected because of this time factor and because the natural gradient restricts the development of the drawdown impacts to the south.

2.2.3 Stream Gauging

Three staff gages will be installed along the 2,000 foot reach of Paddy's Run west and north of the recovery wells (see Figure 2-1) to measure the effects of the recovery system on Paddy's Run. Appropriately located stilling wells may be substituted for staff gages. The staff gages/stilling wells will be used to monitor Paddy's Run stream elevation under transient (during the pumping test and early recovery system start-up) and steady state (achieved after recovery system start-up) conditions. The results of these measurements will help to determine if Paddy's Run interferes as a recharge boundary to the recovery system.

2.3 Monitoring Well Construction

Locations and criteria for monitoring well construction are defined in Table 2-2. These locations may be minimally altered based on field constraints. Screen depths will conform to the established 2000 and 3000 well series depths. The 2000 series monitoring wells will be installed at the water table using 15-foot screens. The screens in the 2000 series wells will extend 5 feet above the water table surface. The 3000 series wells will be screened approximately 50 to 65 feet (depending on well location) below the water table surface using 10-foot screens.

Drilling and well construction specifications will be prepared by the design contractor, A.M Kinney. Procedures for monitoring well construction will be in accordance with the FEMP Sitewide CERCLA ~~QAPjP~~ Quality Assurance Project Plan, March 1992, ~~draft (QAPjP)~~ (SCQ) (WEMCO 1992b). Table 2-3 lists the procedures from the ~~QAPjP~~ SCQ for performing the activities.

Split spoon samples will not be required in the glacial overburden and the upper unsaturated sands of the Great Miami Aquifer. Continuous corings (minimum 3 inches in diameter) will be collected over the screened interval of each well. Samples will be classified in accordance with the Unified Soil Classification System. Samples will be retained by the field geologist and archived as directed by ~~WEMCO~~ FERMCO. Soil samples will be selected for sieve and other geotechnical parameter analyses as determined by PARSONS or A.M. Kinney. Gamma ray logs will be run from surface to total depth on the deepest well of each well pair.

2.4 Water Level Measurements

Water levels will be measured at staff gages/stilling wells, recovery wells, south plume monitoring wells, and selected existing monitoring wells. The locations and frequency of these measurements are shown on Table 2-4.

The schedule of measurements shown on Table 2-4 has been selected to obtain more frequent data measurements at the beginning of recovery pump operation because of transient effects. Measurements are made daily over the first week, weekly over the first month, and monthly over the first year to build a database for the system evaluation process. As operation continues and a relative steady state is achieved, the water levels will change less with time and quarterly readings will be sufficient to provide a picture of annual variation.

Table 2-2 - Criteria for Monitoring Well Construction

Well Number*	Location Coordinates*	Approx. Depth (ft.)	Screen Length (ft.)	Materials
2880	475034 N 1380070 E	80	15	Casing: 2-inch (minimum) ID stainless steel; Screen: 0.01 inch slot stainless steel set at base of boring; Filter Pack: Natural
3880		145	10	
2881	475017 N 1380567 E	80	15	
3881		145	10	
2897	474989 N 1380899 E	80	15	
3897		145	10	
2900	473904 N 1379959 E	25	15	
3900		75	10	
2899	474137 N 1380676 E	85	15	
3899		150	10	
2898	474362 N 1381300 E	85	15	
3898		150	10	

* FEMP Drawing Number 18A-4445-C-1186 Revision 1, dated February 18, 1993

This table has been revised for Revision 1.

Table 2-3 - Well Installation Procedures

Administrative Procedures	REFERENCE ~~QAPjP~~ SCQ (WEMCO 1992b)
Chain-of-Custody	Section 7.1
Corrective Action	Section 15.2
Daily Logs	Section 5.1 and Appendix J, Subsection J.4.1
Variances	Section 15.4
Field Procedures	
General Drilling Practices	Section 5.2.1 and Appendix J, Subsection J.4.2
Subsurface Soil Sampling	Appendix K, Subsection K.5.3
Monitoring Well/Piezometer Design, Installation, and Abandonment	Section 5.2.2 and Appendix J, Subsection J.4.3
Well Development	Section 5.2.3 and Appendix J, Subsection J.4.4
Borehole Geophysical Logging	Section 5.3.1 Section 5.2.5 and Appendix J, Subsection J.4.6
Field Screening of Samples for Radioactive Contamination	Appendix K, Subsection K.5.3.2
Decontamination	Appendix K, Subsection K.11
Field Storage and Shipment of Samples	Appendix K, Subsection K.10
Well Maintenance	Section 5.2.4 and Appendix J, Subsection J.4.7

Table 2-4 - Wells Requiring Water Elevation Measurements and Frequency of Measurements

Recovery Wells	South Plume Monitoring Wells/ Staff Gages	Other Monitoring Wells	Frequency of Measurements For All Wells in Program	
3924	2880	2002		
3925	3880	2093		
3926	2881	3093		
3927	3881	2544		
3928	2897	2061		
	3897	2095		
	2900	3095		
	3900	2624		
	2899	3624		
	3899	2125	1st Week of Operation	Daily
	2898	3125		
	3898	2396	1st Month of Operation	Weekly
	SG-1	3396		
	SG-2	2552	1st Year of Operation	Monthly
	SG-3	3062		
		2625	Subsequent Operation	Quarterly
		2128		
		3128		
		3636		
		2636		
		2549		
		2548		
		2543		
		2394		

This table has been revised for Revision 1.

Table 2-5 - Procedures for Groundwater Measurements, Sampling, and Analysis

Administrative Procedures	REFERENCE ~~QAPjP~~ SCO (WEMCO 1992b)
Chain-of-Custody	Section 7.1
Corrective Action	Section 15.2
Daily Logs	Section 5.1 and Appendix J, Subsection J.4.1
Variances	Section 15.4
Data Validation	Appendix D
Field Procedures	
Groundwater Level Measurement	Appendix K, Subsection K.4.2.1
Groundwater Sampling	Appendix K, Subsection K.4.2
Collection of Quality Assurance/Quality Control (QA/QC) Samples	Appendix K, Subsection K.5.4
Field Screening of Samples for Radioactive Contamination	Appendix K, Subsection K.5.3.2
Decontamination	Appendix K, Subsection K.11
Field Storage and Shipment of Samples	Appendix K, Subsection K.10
Field Calibration Requirements	Appendix I
Field Analytical Methods for Natural Water Samples	Appendix K, Subsection K.4.1
Field Test:	
Temperature	Appendix K, Subsection K.4.1.1
pH	Appendix K, Subsection K.4.1.2
Specific Conductance	Appendix K, Subsection K.4.1.3
Dissolved Oxygen	Appendix K, Subsection K.4.1.4
Laboratory Test Procedures	
Organics, Inorganics, and Radionuclides	Attachment I

Data from monitoring wells, not listed on Table 2-4 and measured for groundwater elevations as part of the regular sitewide monitoring program, will be used as supporting data.

Procedures for measuring water levels will be in accordance with the ~~QAPjP~~ SCQ (WEMCO 1992b). Table 2-5 defines the procedures for activities associated with water level measurements.

2.5 Groundwater Sampling and Analysis

Samples will be collected at recovery wells, south plume monitoring wells, and other selected existing area wells and will be analyzed for total uranium, pH, specific conductance, dissolved oxygen, and temperature. Selected monitoring wells will be sampled and analyzed for Volatile Organic Compounds (VOCs) and inorganics in order to directly determine if the Paddy's Run Road Site organic or inorganic plume is expanding toward the recovery wells. The ~~QAPjP~~ SCQ procedures related to sampling are shown on Table 2-5. Table 2-6 defines the sampling and analytical methods that will be used for the South Plume groundwater monitoring program while Table 2-7 defines the wells that will be sampled and the corresponding constituent analysis that will be required.

Similar to water elevations, more samples will be collected at the beginning of the program when transient conditions are most prevalent (see Figure 1-2 for schedule). In order to establish a recovery system evaluation baseline, program wells (see Table 2-7) will be similarly sampled prior to system start-up.

Except as noted below, procedures for sampling and analysis of monitoring wells will be in accordance with the ~~QAPjP~~ SCQ (WEMCO 1992b). Table 2-5 lists the procedures associated with groundwater sampling and analysis. Because of the need for quick response, on-site laboratories will be used for total uranium and PRRS organic and inorganic parameter analysis so that system evaluations and adjustments can be accomplished in a timely manner. In the event the on-site lab cannot meet project needs for the PRRS parameters, an off-site capable of Level 3 Data Quality Objective will be utilized. As a confirmation, 10 percent of the samples will be split and sent to outside laboratories approved in the FEMP ~~QAPjP~~ SCQ.

Table 2-6 - Sampling and Analysis Parameters and Methods

Parameter Group	Description	Compound	FEMP SCQ Method*
A	Field Parameters	pH	Appendix K Subsec. K.4.1
		Specific Conductance	
		Temperature	
		Dissolved Oxygen	
B	Radionuclides	Total Uranium	FM-RAD-0120
C	PRRS Inorganics	Arsenic	FM-INO-0010
		Sodium	FM-INO-0020
		Potassium	FM-INO-0030
		Phosphorus (total)	FM-CON-0220
D	PRRS Organics	Benzene	FM-ORG-0050
		Ethylbenzene	
		Cumene (isopropyl benzene)	
		Xylene	
		Toluene	

* ~~QAPjP~~ SCQ (WEMCO, 1992b)

Table 2-7 - Sampling Requirements

Monitoring Location	Parameter Group	Daily for 1st Week of Operation	Weekly - 1st Month of Operation Monthly - 1st Quarter of Operation Quarterly - Subsequent Operation
3924, 3925, 3926, 3927, 3928	A, B	X	X
2880, 2881, 2897	A, B	X	X
3880, 3881, 3897	A, B		X
2900, 3900, 2899, 3899, 2898, 3898	A, B, C, D[1]		X
2002, 2061, 2544, 2624	A, B	X	X
2093, 3093, 2095, 3095, 2125, 3125, 2545, 3624	A, B		X
2625, 2128, 3128, 2636, 3636, 2548, 2549	A, B, C, D[1]		X

1 Because of the distance between the recovery wells and the organic plume, samples for organic analysis will not be collected for the daily and weekly start-up sampling periods.

This table has been revised from Revision 0.

SECTION 3

PERFORMANCE EVALUATION AND RESPONSE

3.1 Purpose

The purpose of the evaluation/response program is to determine whether the groundwater recovery system is meeting its objectives and, if not, to take appropriate action to bring it back in conformance with its objectives. Using background information and monitoring data periodically collected in accordance with Section 2, an evaluation is performed at scheduled intervals. If this evaluation shows that the program objectives are being met, then no further action will be taken at that time. If the evaluation shows that the system is not meeting its objectives, then the groundwater model (and other analytical tools) will be utilized to develop modifications to bring the system in line with its objectives. Possible system changes may involve design, operation, or monitoring program modifications.

Section 5 of the DMEPP presents the general requirements of the system evaluation and response program. In accordance with the DMEPP, a more detailed presentation of this program is provided in this section including a specific discussion of system response criteria, data analysis tasks, statistical procedures, and reporting requirements. Because the system modification program is contingent upon findings in the system evaluation report and because its scope is variable based on the system evaluation findings and the system needs, only general requirements may be established for the system modification report. Therefore, the description of the system modification program in the DMEPP provides sufficient detail.

Figure 3-1 summarizes the system evaluation process and the decision making logic in the system evaluation report and the system modification report. The text in the DMEPP and the following sections describes the system evaluation process in more detail.

3.1.1 Objectives of System Evaluation

The DMEPP defines four overall objectives for the South Plume Removal Action. In summary, these objectives are:

1) The groundwater recovery wells need to be pumped at a sufficient rate to create a hydraulic barrier to intercept the width of the Zone 1 plume as defined by contamination above the 20 μg/l total uranium level.

Figure 3-1
Flowchart of Evaluation and Response Program Logic

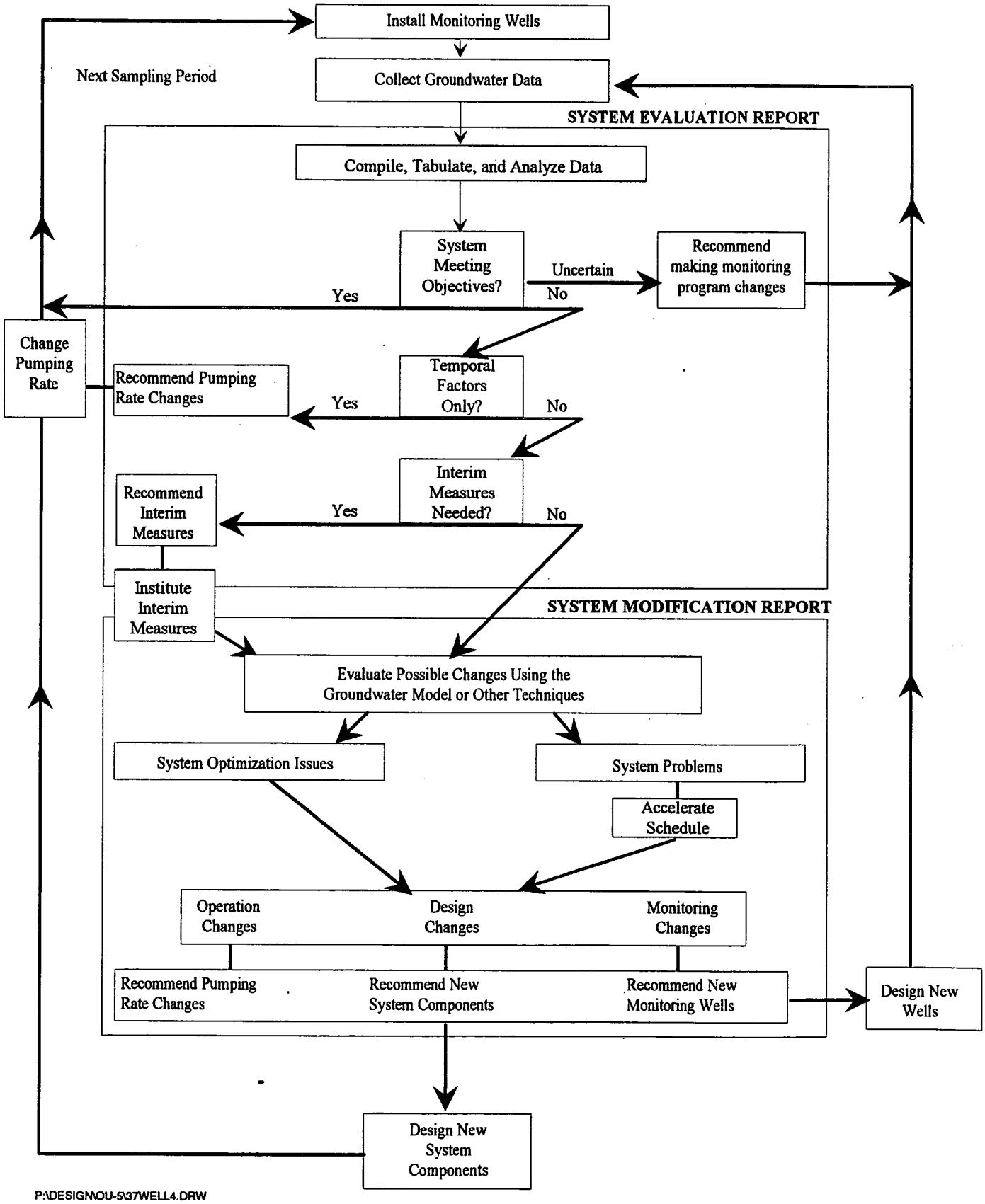

Figure 3-1 - Flow Chart of Evaluation and Response Program Logic

2) The magnitude of the hydraulic trough needs to be minimized to prevent PRRS plumes from being pulled toward the recovery wells or significantly deflected.

3) Contamination within the aquifer needs to be removed as soon as feasible to prevent further plume movement and degradation of the groundwater environment.

4) The operation of the removal action recovery system needs to be consistent with the final site remediation.

In essence, these objectives reduce to two factors; creating sufficient drawdown to prevent migration around, between, or beneath the recovery wells (Objectives 1 and 3) and minimizing drawdown to prevent gradient changes over a large area (Objectives 2 and 4). Therefore, the system will be evaluated in relation to balancing these two factors.

3.2 System Response Criteria

The most effective method of operating the recovery well system would be with definitive criteria. These criteria would define the action to be taken in response to a particular variable value or change. For example, a defined change in groundwater elevation at a particular monitoring well or a defined change in uranium concentration may require an alteration of the recovery well pumping rate. In the south plume case, certain variables allow the development of more quantitative response action more than others. The aquifer hydraulic parameters appear to be more predictable than the chemical analysis parameters. Therefore, it is easier to define a systematic response to a finding for the hydraulic system parameters.

It would be best to establish quantitative type criteria which will provide a definitive response to a finding and if possible allow automatic feedback response to changes in a particular variable. The definition of feedback response-type operation is most effectively developed through groundwater monitoring and modeling. However, ~~three~~ two obstacles exist which prevent the establishment of this type of criteria at the present time.

~~1) The SWIFT groundwater flow model has never been formally validated in the vicinity of the south plume; consequently, the model may be inaccurate and calculations performed with the model may also be inaccurate.~~

1) There is no operating history of the system since the recovery wells do not presently exist. New monitoring wells have been located as part of this plan. A time dependent database of monitoring data is needed to obtain a picture of the system parameters and to support modeling efforts.

2) Preliminary calibration of the SWIFT model was performed using steady-state conditions. Seasonal and transient conditions may be encountered in the field that are different. Feedback response criteria need to be built on seasonal effects.

Efforts are underway or available to overcome these obstacles. The site groundwater SWIFT model will be ~~validated and~~ recalibrated in the vicinity of the south plume with a pump test and with first quarter monitoring data. Monitoring data will be collected during the start up and operation of the recovery system. The refined model will be used to simulate possible transient effects caused by a decrease or increase in rainfall or effects caused by the changes in Paddy's Run stage. However, this data or analysis will not be available until the system has been operated for at least one quarter.

Therefore, only general criteria are developed in this document along with the requirements for developing more definitive criteria in the periodic system evaluation reports. Criteria development will be to some extent an iterative process responsive to increases in understanding of the recovery system. The periodic system evaluation report will provide a mechanism to define these criteria.

3.2.1 General Response Criteria

The system evaluation report will determine whether the system is meeting its objectives and whether system changes are needed. This evaluation will use standard scientific and engineering decision making techniques. This evaluation will need to be cognizant of time and spatial variability and will need to react to general trends but not to every possible system upset; i.e., a global approach needs to be taken.

Table 3-1 shows a sample of possible field findings and interpretations of these findings. Statistical procedures described in Section 3.4 will be used to determine trends or significance of changes. Determination of action to these findings will be through an assessment of all data collected and engineering and scientific judgement. The first few system evaluations will be somewhat qualitative; as data is collected and the model is refined, the evaluations will be more quantitative.

3.2.2 Hydraulic System Response Criteria

Groundwater hydraulic criteria will be established as part of the first system evaluation report. This criteria will be based on the results of the pump test and on the results of the first quarter monitoring. Subsequent system evaluation reports may modify these criteria based on subsequent monitoring and analysis.

Table 3-1 - Potential Findings and Responses

General Finding Based on Evaluation	Objective Affected*	Tentative Conclusion
Minimal drawdown in recovery and monitoring wells in south plume area	1	Capture zone appears insufficient to prevent migration past recovery wells
Upward trend in uranium concentration data in down gradient monitoring wells	1	Capture zone appears insufficient to prevent migration past recovery wells
Upward trend in PRRS inorganic concentration data in south boundary well	2	Capture zone affecting areas south and reversing flow
Upward trend in PRRS organic concentration data in south boundary well	2	Capture zone affecting areas far south and reversing flow
South monitoring wells show significant reversal of gradient	2	Capture zone affecting areas south and reversing flow
South monitoring wells or other monitoring suggest deflection of PRRS plumes	2	Capture zone affecting areas south
North monitoring wells show significant drawdown and long range effects of pumping	4	Capture zone affecting areas north
Recovery wells show very little uranium capture	3	Clean water being pulled from uncontaminated areas
Monitoring data shows plume movement around recovery wells	1	Capture zone not wide enough

* (Re: Section 3.1.1, Objectives of System Evaluation)

The design of the recovery system has included a significant range of pumping capacity (2,000 to 4,000 gpm with all wells pumping) to allow flexibility in operation. Lower flow rates could be achieved by only pumping selected wells. For example, only wells ~~RW-1, 3, and 5~~ 3924, 3926, and 3928 could be pumped at 400 gpm for a total of 1,200 gpm. Many other options are possible since each well could be pumped at different rates. This may be desirable if, for example, an edge of the plume needs to be captured at a particular end of the well field. With this extensive flexibility, it is expected that the chief method of system fine tuning or modification will be through the changing of pumping rates.

Groundwater hydraulics data analysis will provide the primary source of information for control of the system. As discussed above, the groundwater model will be an important tool for establishing criteria. After the model ~~validation and~~ recalibration is completed, the model will be more accurate and can be used as a method of developing criteria. Model refinement will be supported by the collection of new monitoring data.

The chief issue facing hydraulic control of the system are effects caused by temporal variation of recharge and variation in stream stage. Generally these effects are seasonal, but they could occur over longer time cycles (wet or dry years). The model will be used to simulate possible transient effects caused by a decrease or increase in recharge or effects caused by the changes in Paddy's Run flow and elevation. Pumping at different rates for different values of rainfall and stream stage will be simulated to determine drawdown effects at various locations and to establish sensitivity of these parameters versus pumping. Based on these simulations and the associated monitoring data, the drawdown control criteria will be established.

It is reasonable to assume that the defined control criteria will only operate within a certain range. This range, based on historical monitoring data or system behavior predicted from model simulations, will be established for recovery wells and monitoring wells. If appropriate, control charts will be developed for these wells which define these limits. Because the plume may change with time and plume movement is, to a large degree, determined by groundwater hydraulics, this criteria will need to be periodically reviewed.

3.2.3 Chemical System Response Criteria

Chemical system response criteria will be established as part of the first system evaluation report. Subsequent system evaluation reports may modify these criteria based on subsequent monitoring and analysis.

Uranium and PRRS data analysis will also provide data for control of the system. Unlike hydraulic control described above, it is more difficult to establish specific finding-response criteria for chemical system control. These difficulties exist because of precision problems in groundwater sampling,

varying contaminant source or plume concentrations, complicated chemical interactions between liquid and solid media, and other heterogeneous effects associated with contaminant transport. The contaminant transport system has more difficulties in reaching equilibrium than the flow system and consequently effects are more difficult to predict. In essence, the groundwater chemical system is more complicated than the hydraulic system.

The primary methods for evaluating the data is by trend analysis for each parameter at each monitoring location and by globally looking at spatial distribution of uranium. Statistical methods (see Section 3.4) will be used to determine whether a particular monitored constituent is increasing, decreasing, or not significantly changing. In certain cases there is a fairly clear interpretation of a particular trend result, while in other situations it is much less clear. For PRRS parameters, an increasing trend in a previously uncontaminated well would strongly suggest northward migration of a PRRS plume. Uranium data is more complicated. If, for example, uranium levels increase in monitoring wells downgradient of the recovery wells, it may or may not be the result of the plume passing the recovery wells. Other interpretations could be precision problems, desorption of uranium, or even a reversal of gradient could cause a more contaminated portion of the plume to move to that well location. For these reasons, it is important to not overreact to findings, but to inspect all of the data and to respond to more general and confirmed trends. Since objectives need to be balanced, there is a real possibility that overreaction could result in creating additional, perhaps more serious, system problems. Thus, a conservative approach to change will be followed.

The collection of monitoring data over time and the groundwater model will be important tools for understanding the chemical system and establishing more rigorous response criteria. Baseline values of constituents will be established with monitoring data and general trends over time will be seen. Once the flow model is ~~validated and~~ recalibrated as described above, particle tracking will be used to determine capture zones at the prescribed pumping rate. In performing the periodic system evaluations, particle tracking may be used to explain findings. The solute transport part of the groundwater model may also be used in response to a particular finding. Over time, a better understanding of system behavior will be developed. As part of the periodic system evaluation report, more quantitative response criteria will be defined as the system is better understood.

3.2.4 Recovery Well Design Criteria

Based on the above discussion, the system evaluation process requires that certain elements be incorporated in the design of the recovery wells. These are:

1) Each recovery well needs instrumentation with the ability to continuously measure drawdown in the well.

2) Each recovery well needs a method of controlling pumping rate within the prescribed range of 400 to 800 gpm (IT 1992).

3) Each recovery well needs instrumentation capable of accurately measuring flowrate on the pump discharge.

4) If consistent with other design elements, each recovery well should have instrumentation with the ability to adjust pumping rate as a function of well drawdown, i.e., with the ability to maintain constant drawdown. Manual procedures to perform this function will be acceptable.

3.3 Data Analysis

An important part of the system evaluation is the analysis of the monitoring data collected in accordance with Section 2. The first system evaluation effort will be more involved with the development of baseline data and the conceptual model. Subsequent evaluations will be simpler and will build on the content of the initial evaluation.

Standard data compilation, tabulation, and analysis techniques will be used. State-of-the-art software packages will be utilized as part of this effort. In addition, it is projected that a GIS system with incorporated data analysis software packages will be the primary system used to allow the rapid development of the many graphs and plots, streamlining the data analysis effort. Since the GIS system contains both database and graphical information, it allows the rapid correlation of related data sets.

The data that will be collected can be divided into three categories for analysis. In the following sections, tasks for these three categories are defined.

3.3.1 Aquifer Hydraulics Data Analysis

Data evaluation tasks that will be performed relating to groundwater hydraulics are described below:

1) Background data from the south plume study area will be reviewed. Baseline hydraulic system parameters including the identification of boundary conditions, recharge, and discharge areas will be determined. Significant pumping in the area will be determined. Conceptual model of groundwater flow based on this data will be developed.

2) Rainfall, stream gaging data, and recovery well pumping data over period of evaluation will be compiled and tabulated. Summary statistics (mean, minimum, maximum, range, standard deviation) on data will be performed. The data over the period of evaluation will be graphed.

3) Groundwater elevation data for each well will be compiled and tabulated. Summary statistics (mean, minimum, maximum, range, standard deviation) on data by well will be performed.

4) Groundwater elevations will be graphed over time to discern trends. Comparison graphical techniques (multiple line, stacked bar) to discern relationships across wells will be used. Rainfall, stream gaging and pumping data will be compared and correlated.

5) Contour plots of 2000 and 3000 series wells groundwater elevations for selected representative time measurement events will be created. Flow pattern changes over time will be evaluated.

6) Three cross sections will be defined for analysis, two parallel to the recovery well line and one perpendicular to the recovery well line. Groundwater pressure distribution will be depicted for each cross section for selected representative time measurement events.

7) Vertical gradients at each well cluster in the program will be assessed. These vertical gradients will be plotted and contoured in plan view to determine spatial distribution and to discern patterns.

8) The above data sets will be correlated by inspection of tables, graphs, and plots to determine possible relationships between parameters.

3.3.2 Uranium Data Analysis

Data evaluation tasks that will be performed relating to the total uranium distribution are described below:

1) Background data from the south plume study area will be reviewed. Uranium plume system including the identification of potential source areas, existing plume concentrations, general flow patterns, uranium transport properties, aquifer properties, and major ion and anion concentrations in groundwater will be reviewed. A conceptual model of uranium contaminant transport based on this data will be developed.

2) Total uranium data for each well will be compiled and tabulated. Summary statistics (mean, minimum, maximum, range, standard deviation) on data for each well will be calculated.

3) Uranium data will be graphed over time to discern trends. Comparison graphical techniques (multiple line, stacked bar) will be used to discern relationships across wells.

4) Contour plots of 2000 and 3000 series wells uranium concentrations for selected representative time measurement events will be developed. Concentration pattern changes over time will be evaluated.

5) Three cross sections for analysis; two parallel to the recovery well line and one perpendicular to the recovery well line will be considered. Uranium concentration distribution will be depicted for each cross section for selected representative time measurement events.

6) Statistics will be performed on the total uranium data to determine if a particular well's concentration is increasing or decreasing over time or if a significant change has occurred.

3.3.3 PRRS Constituent Data Analysis

Data evaluation tasks that will be performed relating to the PRRS constituent distribution are described below:

1) Background data from the south plume study area will be reviewed. Available data on the PRRS plume system including the identification of potential source areas, constituents of concern, and background concentrations in groundwater will be reviewed. A conceptual model of PRRS plumes will be developed based on this data.

2) PRRS indicator inorganic and organic data by well will be compiled and tabulated. Summary statistics (mean, minimum, maximum, range, standard deviation) will be calculated on well data.

3) If appropriate, PRRS indicator data will be graphed over time to discern trends and use comparison graphical techniques (multiple line, stacked bar) to discern relationships across wells.

4) If appropriate, contour plots of 2000 and 3000 series wells PRRS indicator concentrations for selected representative time measurement events will be created. Concentration pattern changes over time will be evaluated.

5) Statistics will be performed on the PRRS indicator data to determine if a particular well's concentration is increasing or decreasing over time or if a significant change has occurred.

3.4 Statistical Analysis

Analytical results obtained from groundwater sampling will be statistically examined as appropriate at selected wells to determine whether there has been a statistically significant change in the concentrations of constituents of concern. Descriptive statistical functions which will be included in these examinations will include the mean, range, standard deviation, variance, maximum, and minimum. Other statistical functions will be applied as necessary. It is expected that the primary statistical analysis will be to determine trends at a particular well or to determine whether a change is significant. In response to particular situations, a concentration versus standard or upgradient to downgradient comparison may be necessary. Several statistical procedures are specified below to allow the flexibility to respond to changes in monitoring conditions. Different databases available at different wells will also affect the selection of statistical methods. The statistical procedures specified here cover several anticipated conditions. However, should these procedures prove inadequate for a currently unforeseen situation, additional statistical procedures may be necessary.

3.4.1 Trend Analysis

Statistical procedures will be used to determine time dependent changes in concentrations at a particular well. Different tests may be used as described below depending on the data sets.

1) Mann-Kendall Test - The Mann-Kendall test is a nonparametric test for trend and can be viewed as a nonparametric test for zero slope of the linear regression of time ordered data versus time. This procedure allows for missing values, data that do not conform to any particular distribution, and use of data reported as trace or less than the detection limits by assigning them a common value that is smaller than the smallest measured value in the data set. This approach can be used because the Mann-Kendall test uses only the relative magnitudes of the data rather than their measured values (Gilbert 1987, p. 217).

2) Sen's Nonparametric Estimator of Slope - Sen's method estimates the true slope (change per unit time) at a sampling station by using a simple nonparametric procedure. This method is not greatly affected by gross data errors or outliers, and it can be computed when data are missing. Sen's estimator is closely related to the Mann-Kendall test. Sen's estimator can be calculated for only one datum in each time period or for multiple observations in one or more time periods Gilbert, 1987, p. 217).

3) Seasonal Kendall Test - The seasonal Kendall test is a generalization of the Mann-Kendall test. It was developed for use with 12 seasons (months). The test consists of computing the Mann-Kendall test statistic S and its variance separately for each month with data collected over several years (Gilbert, 1987, p. 225).

3.4.2 Background to Downgradient Well Comparisons

Statistical procedures will be used to compare background to downgradient concentrations. Different tests may be used as described below depending on the percentage of non detections.

1) Cochran's Approximation to Behrens-Fisher Student's t-Test - If 0 to 15 percent of the observations are below the detection limit, Cochran's Approximation to Behrens-Fisher Student's t-Test will be the primary statistical procedure for downgradient to upgradient well data comparisons. An analysis of variance procedure (ANOVA) may be performed in cases where the Student's t-Test proves to be inadequate and also to provide some assurance against false positive or negatives.

2) ANOVA - If 15 to 60 percent of the observations are below the detection limit, then an ANOVA will be the first choice for the determination of statistical significance. A one-way analysis of variance statistical procedures will be used to determine whether differences in mean concentrations among wells or groups of wells are statistically significant. A one-way parametric analysis of variance procedure will be used for situations where data for a monitoring parameter are available from several wells but only for one time period, or when data which do not exhibit seasonality are available from several wells for several time periods. A one-way nonparametric analysis of variance procedure will be used for interwell comparisons when the data or the residuals from a parametric ANOVA have been found to be significantly different from normal and when a log transformation fails to adequately normalize the data.

3) Test of Proportions - In situations where 60 to 99 percent of the observations are below the detection limit, a test of proportions may be used to compare the background well data with the downgradient well data. A higher proportion of quantitated values in the downgradient wells may indicate the presence of contamination.

3.4.3 Comparisons with Regulatory Standards

Statistical procedures will also be utilized when comparisons are being made between concentrations of monitored constituents in wells and regulation specified concentration limits. The mean well concentration will be compared against the set standards through the construction of a confidence level. These techniques may be useful to determine if the recovery system has met a clean-up standards at some future date.

1) Using the 99th percentile of the t-distribution for the mean concentration, confidence intervals may be constructed with downgradient well data. Once constructed, the interval may be compared with the regulatory-based standard to determine whether the mean concentration

significantly exceeds the standard. This statistical procedure will be used for both normal and log-normal data. Log-normal data will be compared to the log-normal of the regulation specified limit. If the well data do not adequately follow the normal distribution even after logarithm transformation, a nonparametric confidence interval will be constructed using a minimum of seven observations in order to obtain a one-sided significance level of 10 percent (confidence of 90 percent). This may require pooling of data from two or more wells or sampling periods.

2) Tolerance Intervals Based on the Normal Distribution - Tolerance intervals may be constructed from data on downgradient wells. The tolerance limit may then be compared with regulatory standards. If the tolerance limit falls above the standard, this would indicate statistically significant evidence of concentrations above the limit. A coverage and a tolerance coefficient of 95 percent will be employed providing at least a 95 percent confidence level.

3.5 Reporting

Because of spatial and temporal variations in the hydrogeologic system that is being analyzed, system evaluation reports will be prepared according to the following schedule:

Time Increment	Frequency
1st year	Quarterly
Subsequent years	Semi-annually

This schedule does not completely coincide with the monitoring schedule. Certain system evaluations will cover more than a single monitoring data set and will analyze available data sets at the time of evaluation.

Each periodic evaluation will be built on data gathered during the previous evaluation cycle; therefore, subsequent evaluations will include the previous and current evaluation periods data. The initial evaluation will also include baseline data prior to pumping. The system evaluation can be divided into groundwater hydraulics and chemistry parts as described below.

A system evaluation report will be prepared containing the described analysis, conclusions, and recommendations. Table 3-2 shows a sample outline for this report. The system evaluation report may recommend minor pumping rate changes to accommodate seasonal variation or other temporal factors without triggering the more formal system modification process described below. This report will be submitted to United States Environmental Protection Agency (US EPA) and Ohio EPA for information purposes.

Table 3-2 - Outline of System Evaluation Report

I. Introduction

II. Baseline Data

A. Hydraulic System
1. Background Review
2. Conceptual Model

B. Uranium Chemistry System
1. Background Review
2. Conceptual Model

C. PRRS Constituent System
1. Background Review
2. Conceptual Model

III. Current Monitoring Period Results

A. Groundwater Elevation Data
1. Tabulated Summary
2. Space Relationships
3. Time Relationships
4. Statistics

B. Rainfall, Stream Gaging and Recovery Well Pumping Data
1. Tabulated Summary
2. Space Relationships
3. Time Relationships
4. Statistics

C. Uranium Data
1. Tabulated Summary
2. Space Relationships
3. Time Relationships
4. Statistics

Table 3-2 - Outline of System Evaluation Report (Continued)

D. PRRS Inorganic and Organic Data
   1. Tabulated Summary
   2. Space Relationships
   3. Time Relationships
   4. Statistics

E. Cross Correlation of Data Sets
   1. Space Relationships
   2. Time Relationships
   3. Statistics

IV. Development of Evaluation Criteria

A. Modeling Of Recharge and Stream Stage

B. Definition of Future Operating Criteria

V. Conclusions and Recommendations

A. Summary of Findings

B. Conclusions

C. Recommendations

Conclusions and recommendations to this system evaluation may state that:

1) The system is not meeting its objectives and a system modification report needs to be conducted.

2) Interim measures should be undertaken to expeditiously solve a serious problem. A subsequent system evaluation report will be submitted.

3) Operation parameters require adjustment for seasonal or temporal affects and a system modification report is not needed.

4) Operation parameters require adjustment for system optimization or efficiency reasons. The system evaluation may either specify the change or recommend a system modification report depending on the complexity of the proposed change.

5) The monitoring program needs to be changed to determine if objectives are met. The evaluation may recommend the specific monitoring program changes (frequency, locations, parameters, etc.) that need to be made.

6) The system is functioning in accordance with its objectives and recommend that no changes be made. Another system evaluation will be performed according to the schedule.

7) The system has met its objective. The evaluation may recommend ceasing operation of the system and continuation of monitoring for a specified period as a confirmation.

As stated above, response criteria will be established as part of the first system evaluation report. Subsequent system evaluation reports may modify this criteria based on subsequent monitoring and analysis.

SECTION 4

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