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ENGINEERING EVALUATION/COST ANALYSIS SOUTH PLUME FEED MATERIALS PRODUCTION CENTER FERNALD, OHIO APRIL 1990

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REPORT

Engineering Evaluation/Cost Analysis South Plume

FEED MATERIALS PRODUCTION CENTER

Fernald, Ohio

April 1990

U. S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE

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Draft

Engineering Evaluation/Cost Analysis South Plume

FEED MATERIALS PRODUCTION CENTER
Fernald, Ohio

Prepared by

Advanced Sciences Inc.
International Technology Corporation

April 1990
0003. EPA

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ACRONYM LIST

AEC	Atomic Energy Commission
ARAR	applicable or relevant and appropriate requirement
ASI	Advanced Sciences, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEDE	Committed Effective Dose Equivalent
CFR	Code of Federal Regulations
COE	U.S. Army Corp of Engineers
DOE	Department of Energy
EE/CA	engineering evaluation/cost analysis
FFCA	Federal Facility Compliance Agreement
FMPC	Feed Materials Production Center
HI	Hazard Index
IT	International Technology Corp.
NCP	National Contingency Plan
NEPA	National Environmental Policy Act of 1969
NLO	National Lead Company of Ohio
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
O&M	operations and maintenance
OEPA	Ohio Environmental Protection Agency
OSHA	Occupational Safety and Health Administration
OAC	Ohio Administrative Code
RI/FS	Remedial Investigation and Feasibility Study
SARA	Superfund Amendments and Reauthorization Act
SOWC	Southwest Ohio Water Company
TBC	To Be Considered
USDA	U.S. Department of Agriculture
U.S. EPA	U.S. Environmental Protection Agency
WMCO	Westinghouse Materials Company of Ohio

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

PURPOSE FOR EE/CA

On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) was jointly signed by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (U.S. EPA) pertaining to environmental impacts associated with DOE's Feed Materials Production Center (FMPC) in Fernald, Ohio. The FFCA is intended to ensure that environmental impacts associated with past and present activities at the FMPC are thoroughly and adequately investigated so that appropriate response actions can be formulated, assessed, and implemented.

In response to the FFCA, and consistent with modifications agreed to in March 1990, a Remedial Investigation and Feasibility Study (RI/FS) is in progress pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The technical strategy adopted for the RI/FS is to issue distinct RI/FS reports for each of five operable units into which the FMPC has been separated. By accommodating separate schedules for each operable unit, the remedial action decision process is proceeding to completion for the most problematical units while data collection and analysis continue for other operable units.

One of the identified operable units for the FMPC includes those environmental media that serve as migration pathways and/or environmental receptors of radiological or chemical releases from the FMPC. Important elements of this operable unit are the on- and off-site areas of the regionally important Great Miami Aquifer that exhibit elevated levels of uranium. Because of the off-site location of portions of the plume within developed areas south of the FMPC and the associated potential threat to human health, the DOE is considering a removal action for this off-site area or "south plume" pending the outcome of the RI/FS and the implementation of a final remedial action for the regional aquifer.

Removal actions, as described in the National Oil and Hazardous Substances Contingency Plan (NCP) of March 1990 (40 Code of Federal Regulations [CFR] 300.415), are primarily intended to abate, minimize, stabilize, mitigate, or eliminate a release or a threat of release prior to a final action if there is a threat to public health or welfare or the environment. A second reason for implementing a removal action is to mitigate contaminant migration pending final action if site conditions permit a straightforward mitigative action and significant migration would occur in the interim if no action is taken. Additionally, based on proposed revisions to this portion of the NCP, removal actions are to be consistent with the anticipated long-term remedial action and to contribute to the efficient performance of the long-term remedy to the extent practicable.

Once a removal action is deemed appropriate (in the case of the south plume, a non-time critical removal action since there is more than six months time available for planning), an engineering evaluation/ cost analysis (EE/CA) is performed to analyze removal action alternatives and to support the selection of a preferred alternative. This document represents the EE/CA for the south plume removal action at the FMPC. The National Environmental Policy Act of 1969 (NEPA) requires that Federal agencies include in their decision-making processes appropriate and careful consideration of all environmental effects of proposed actions. Therefore, this document has been prepared so as to integrate both the requirements of CERCLA and NEPA. It will be used by DOE as the basis for remedy selection and implementation.

SITE BACKGROUND

The FMPC site is located on 1050 acres in a rural area approximately 20 miles northwest of downtown Cincinnati, Ohio. The villages of Fernald, New Baltimore, Ross, New Haven, and Shandon are all located within a few miles of the plant.

The FMPC was constructed and operations began at the Fernald site in the early 1950s. A variety of chemical and metallurgical processes are utilized at the FMPC for the manufacture of uranium products. Large quantities of liquid and solid wastes are generated by these various operations.

Solid waste materials associated with uranium metals production are presently stored on site in steel drums awaiting further processing or off-site disposal at approved facilities. Prior to 1985, solid and slurried wastes from FMPC processes were disposed of in the on-site Waste Storage Area. This area, which is west of the production facilities, includes six low-level radioactive waste storage pits, two earthen-bermed concrete silos containing K-65 residues (high specific activity, low level radium-bearing residues resulting from the pitchblende refining process), one concrete silo containing metal oxides, two lime sludge ponds, a sanitary landfill and all affected adjoining areas.

Two fly ash piles are located approximately 3000 feet south/southeast of the Waste Storage Area. One pile remains active for the disposal of fly ash from the FMPC boiler plant. An area north of and adjacent to the fly ash piles, known as the Southfield Area, is believed to be the disposal site for construction debris and possibly other types of solid wastes from FMPC operations.

Surface water runoff from the Waste Storage Area, fly ash piles, and other affected areas within the western portion of the FMPC enters Paddys Run, a tributary of the Great Miami River. Paddys Run originates just north of the FMPC and flows south-southeast along the western edge of the site, and for a part of the year it is a dry streambed with occasional rainfall-induced flows.

Leachate from these same areas can potentially migrate vertically to the regionally important Great Miami Aquifer which underlies the site. This aquifer serves as a principal source of domestic, municipal, and industrial water throughout the region.

Liquid waste effluent generated from FMPC process operations is sent to a general plant sump for treatment and analysis prior to release to the Great Miami River through the main effluent line. The main effluent line to the Great Miami River represents a permitted discharge for wastewater from the FMPC.

Elevated levels of uranium have been recorded as early as 1981 in groundwater south of the FMPC. During the RI/FS process at the site, additional monitoring wells were installed and others are

proposed for on- and off-site locations to evaluate further the extent and magnitude of the uranium plume and to determine if other radionuclides or chemicals are present.

JUSTIFICATION FOR REMOVAL ACTION

RI/FS analytical data available as of September 15, 1989 were utilized for the evaluation of the south plume removal action. This data indicates the presence of radionuclides and inorganic metals in the groundwater south of the FMPC. Most of the radionuclides are found at natural background concentrations. None of the radionuclides or metals exceed established or derived drinking water limits with the exception of uranium. Certain organic chemicals have also been observed in some samples, but these observations have not been persistent for the same monitoring wells and are far below allowable maximum concentration levels for all organics detected. For this reason, uranium has been designated as the contaminant of concern for the south plume removal action. All considered actions that account for public health and environmental protection against uranium will also provide protection against other radionuclides and chemicals due to the low levels present.

Uranium presents potential health risks due to its chemical toxicity and as a result of alpha radiation emissions. Insoluble uranium compounds primarily pose a radiological hazard resulting from inhalation and lung irradiation. Chemical toxicity is considered the controlling hazard for soluble uranium compounds of principal concern in the groundwater of the south plume. If ingested at sufficiently high rates, these compounds can lead to kidney damage and arterial lesions. Other potential adverse health effects that can result from ingestion of soluble uranium compounds are damage to the cardiovascular, hematopoietic, endocrine, and immunological systems.

EXTENT OF CONTAMINATION

The extent and distribution of uranium in the south plume have been established by combining groundwater monitoring data with the results of a groundwater flow/solute transport model. The monitoring data were utilized to establish the following: (1) a lower limit on the maximum concentration in the south plume [i.e., the maximum observed off-site RI/FS value of 292 micrograms per liter (µg/ℓ)]; (2) a conservative estimate of the shape and extent of the plume (as defined by those

wells closest to the plume that exhibit background levels of uranium); (3) direct evidence of the uranium levels at actual receptor locations; and (4) the general shape of the uranium plume for use in calibrating the model.

The model was then used to interpolate between and extrapolate beyond the points of field observation. By doing so, the full distribution pattern of uranium in the south plume both today and under assumed future conditions could be estimated. The plume is predicted by the model to be an elongated ellipse oriented in a northwest/southeast direction due to the groundwater flow patterns through a narrow, north/south trending buried channel. The center of the plume is predicted to lie approximately 800 feet south of Willey Road and north of the developed areas along Paddys Run and New Haven Road.

Based on this representation of the plume, approximately 100 acres of off-site property is underlain by groundwater with uranium concentrations exceeding the Derived Concentration Guide which is applicable for uranium in drinking water and is equivalent to 33μg/ℓ. This value is calculated from the 50-year committed effective dose equivalent (CEDE) limit of 4 millirems (mrem) from an annual intake of radioactive materials in drinking water. The DOE has specified that this CEDE limit shall apply to releases to all off-site areas where water could be used as a drinking water source (DOE 5400.5).

POTENTIAL RISKS

In the case of the south plume, exposure to the contaminants can occur only if the groundwater reaches the land surface. The primary mechanisms are groundwater discharge to a surface water course and pumping. Because the south plume is not predicted by the model to migrate to the Great Miami River or any other surface water course within the projected life of the removal action (i.e., within five years), groundwater discharge to surface waters is not considered as an exposure pathway for purposes of this EE/CA. An exception is that exposure pathways associated with pumped groundwater discharged to a surface water course are considered in the evaluation of the effectiveness of the removal action alternatives that involve pumping.

There is no known use of groundwater with uranium levels exceeding the derived concentration limit of 33 µg/ℓ from the south plume areas for drinking water, feedstock watering, or crop irrigation. Residences along Paddys Run Road to the west reportedly use cisterns with imported water. Groundwater monitoring results from commercial and residential wells along New Haven Road in or near the Village of Fernald indicate no elevated levels of uranium in the water supply. These results indicate that the uranium plume either is not present at the level of aquifer pumping or has not yet migrated to these locations.

The only known users of groundwater with uranium levels exceeding the derived concentration for uranium in drinking water are the two industries located along Paddys Run Road southwest of the projected center of the plume.

Potential future receptors of the uranium in groundwater south of the FMPC include: (1) persons who pump groundwater for potable use, crop irrigation, or livestock feeding from areas not currently impacted but located along the future migration pathway of the plume, and (2) persons who would use surface waters into which contaminated groundwater has been discharged.

SCOPE OF REMOVAL ACTION EE/CA

The scope of the proposed removal action can be broadly defined as management of radioactively contaminated groundwater in an off-site area south of the FMPC. The fundamental objective of the removal action for the south plume is to protect public health by limiting access to and use of groundwater with uranium concentrations exceeding the derived concentration limit of 33 µg/ℓ for uranium in drinking water, as well as other appropriate, risk-based levels for various potential exposure scenarios. For purposes of this removal action, this objective represents a minimum requirement that would have to be achieved by any removal action. Additionally, secondary objectives have been formulated for the south plume removal action which include the following:

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

- Mitigation of the source of groundwater contamination, which in this case is represented by the prevention of future releases across the FMPC site boundary
- Control of plume migration toward additional receptors farther south

Based on these identified objectives and on the preliminary results of the development and screening of specific remedial action alternatives in the RI/FS for the contaminated groundwater, the following alternatives have been selected for evaluation in the South Plume EE/CA:

- No Action
- Groundwater Monitoring and Institutional Controls
- Alternate Water Supply with Groundwater Monitoring and Institutional Controls (referred to hereafter as Alternate Water Supply)
- Groundwater Pumping Without Treatment, Alternate Water Supply, Groundwater Monitoring, and Institutional Controls (referred to hereafter as Pump and Discharge)
- Groundwater Pumping With Treatment, Alternate Water Supply, Groundwater Monitoring and Institutional Controls (referred to hereafter as Pump and Treat).

Alternative 1 - No Action

Under the no-action alternative, no additional remediation, monitoring, or security activities in the vicinity of the south plume would be provided to further minimize risk to the public health or the environment. Any changes to the existing site environment are assumed to develop only as a result of natural occurrences. This alternative is being considered as a baseline for comparison with the other alternatives.

Alternative 2 - Monitoring and Institutional Controls

This alternative consists of the continued or additional monitoring of selected off-site south plume wells in the study area. At present, no residential wells containing concentrations of uranium in excess of the derived concentration limit of 33 μg/ℓ for uranium in drinking water are being used. The

monitoring program associated with this alternative will be designed to detect increases in uranium content which may indicate movement of the plume into or toward industrial, commercial, or residential wells. Quarterly monitoring for uranium will take place in the selected wells until a modified monitoring program is implemented as part of the final remedial action. If increasing uranium concentrations are detected in any wells during the monitoring program, the potential for exceeding the derived concentration limit for uranium in drinking water will be evaluated and, if necessary, an appropriate additional response action will be taken which is not within the scope of this Removal Action.

Alternative 3 - Alternate Water Supply

This alternative consists of groundwater monitoring, implementing institutional controls, and providing an alternate water supply to the two industrial receptors known to be using groundwater with uranium concentrations exceeding 33 μg/ℓ.

Alternative 4 - Pump and Discharge

This alternative includes the installation of recovery wells near the southern limit of the uranium plume south of the FMPC, pumping the groundwater to the FMPC site, and discharging the untreated groundwater to the Great Miami River via the existing main effluent line. An alternate water supply, monitoring of the groundwater, and institutional controls similar to those proposed for Alternative 3 are also included as part of this alternative.

Alternative 5 - Pump and Treat

This alternative is similar to Alternative 4 in that it includes the installation of recovery wells near the southern limit of the uranium plume south of the FMPC, pumping the groundwater to the FMPC site, and discharging of the untreated groundwater through Manhole 175 to the Great Miami River. An alternate water supply for impacted groundwater users, a groundwater monitoring program, and institutional controls would also be included in this alternative. An additional feature of this alternative would be a new treatment facility installed on site to treat a currently untreated FMPC effluent and a portion of the flow from the south plume, as necessary. The treatment system would be

designed to ensure that the total mass of uranium released via the effluent pipeline does not exceed the existing FMPC release value.

Each of these alternatives were evaluated according to the following criteria:

- Effectiveness
- Implementability
- Cost

The evaluation process and findings are discussed in Chapter 5.0. Table ES-1 provides a summary of this evaluation.

PREFERRED ALTERNATIVE

Based on the comparison of alternatives, Alternative 4, which includes groundwater pumping with direct discharge to the Great Miami River, an alternate water supply to two currently affected industrial users and enhanced monitoring and institutional controls, is selected as the alternative that most comprehensively satisfies the evaluation criteria.

As documented in this EE/CA, the current data base and the results of the groundwater and solute transport models are considered sufficient and adequately reliable to support the selection of Alternative 4.

To most effectively accommodate the resolution of key technical issues, a phased approach is proposed for the south plume removal action. Upon approval of this EE/CA and the recommended alternative, design efforts will commence on the alternate water supply component of the removal action. Implementation of the alternate water supply, as well as the monitoring and institutional control components, will follow once the design is accepted. The second phase of activities will involve the

TABLE ES-1
ALTERNATIVE EVALUATION SUMMARY

CRITERIA	NO ACTION ALTERNATIVE 1	MONITORING AND INSTITUTIONAL CONTROLS ALTERNATIVE 2	ALTERNATE WATER SUPPLY ALTERNATIVE 3	PUMP AND DISCHARGE ALTERNATIVE 4	PUMP AND TREAT ALTERNATIVE 5
EFFECTIVENESS					
o Time Until Action is Complete	N/A	Monitoring and institutional controls will continue for 5 years (estimated time until the final remedial action is implemented).	An alternate water supply would be provided within 16 months.	The alternate water supply portion of this alternative would be provided within 16 months. Pumping and discharging of groundwater would also begin within 16 months, and continue as part of the final remedial action or until the final action is implemented.	The alternate water supply portion of of this alternative would be provided within 16 months. The treatment system will be in operation within 20 months. Action will continue until implementation of the final remedial action (5 years), or as part of tne final remedial action.
o Community Protection					
- Groundwater Ingestion (present users)	88 mrem - Maximum exposure 47 mrem - Average exposure Combined groundwater ingestion pathways: 1) Direct ingestion of groundwater 2) Ingestion of crops grown in fields irrigated by the groundwater 3) Ingestion of beef from cattle exposed to uranium through water and crops 4) Ingestion of milk from cows exposed to uranium through groundwater and crops 36 mrem - Maximum exposure 18 mrem - Average exposure (drinking water pathway only)	For this alternative, it is assumed that south plume groundwater with concentrations exceeding the 33 µg/ℓ limit will not be used for potable water or irrigation of crops.	For this alternative, the combination of monitoring and institutional controls and an alternate water supply effectively eliminate the groundwater exposure pathways.	This alternative also provides institutional controls restricting access to groundwater within the South Plume area.	This alternative also provides institutional controls restricting access to groundwater within the South Plume area.
- Groundwater Ingestion (future users)	Assumed historical release. Concentrations are assumed to decrease with time.	Assumed historical release. Concentrations are assumed to decrease with time.	Assumed historical release. Concentrations are assumed to decrease with time.	Assumed historical release. Concentrations are assumed to decrease with time.	Assumed historical release. Concentrations are assumed to decrease with time.
- Surface Water Ingestion (present users)	0.8 mrem - Maximum exposure 0.4 mrem - Average exposure Pathways to man from releases to surface water are via: 1) Irrigation of crops 2) Drinking water supplies downstream from the release point 3) Ingestion of beef cattle which ingest water from the river and irrigated forage 4) Ingestion of milk from which ingest water from the river and irrigated forage	0.8 mrem - Maximum exposure 0.4 mrem - Average exposure (Four pathways) 0.3 mrem - Maximum exposure 0.2 mrem - Average exposure (Drinking water pathway)	0.8 mrem - Maximum exposure 0.5 mrem - Average exposure (Four pathways) 0.3 mrem - Maximum exposure 0.2 mrem - Average exposure (Drinking water pathway)	First year of pumping: (Should increase a total of 16 percent over the five-year period.) 0.69 mrem - Maximum exposure 0.25 mrem - Average exposure (Four pathways) 0.4 mrem - Maximum exposure 0.2 mrem - Average exposure (Drinking water pathway)	First year of pumping: (Should increase slightly over the five-year period.) 0.6 mrem - Maximum exposure 0.3 mrem - Average exposure (Four pathways) 0.3 mrem - Maximum exposure 0.2 mrem - Average exposure (Drinking water pathway)
- Surface Water Ingestion (future users)	Assumed historical release. Concentrations are assumed to decrease with time.	Assumed historical release. Concentrations are assumed to decrease with time.	Assumed historical release. Concentrations are assumed to decrease with time.	Assumed historical release. Concentrations are assumed to decrease with time.	Assumed historical release. Concentrations are assumed to decrease with time.
- Other Applicable Media	None	None	None	None	None

TABLE ES-1
(Continued)

CRITERIA	NO ACTION ALTERNATIVE 1	MONITORING AND INSTITUTIONAL CONTROLS ALTERNATIVE 2	ALTERNATE WATER SUPPLY ALTERNATIVE 3	PUMP AND DISCHARGE ALTERNATIVE 4	PUMP AND TREAT ALTERNATIVE 5
EFFECTIVENESS (Cont.)					
o Worker Protection	Not applicable.	Health and safety procedures will be followed during sampling and analysis.	Necessary safety measures will be taken during construction.	Necessary safety measures will be taken during construction.	Necessary health and safety measures will be taken during construction and operation activities.
- Accidents					
- Radiological Exposures	Not applicable.	Potential risk occurs only by ingestion or inhalation. None expected.	Potential risk occurs only by ingestion or inhalation. None expected.	Potential risk occurs only by ingestion or inhalation. None expected.	Potential risk occurs only by ingestion or inhalation. None expected.
o Environmental Impacts					
- Plume Control					
Southern Migration (ft) Concentration (µg/ℓ) Plume Mixing	1100 ft. (leading edge) 510 µg/ℓ (maximum) None	1100 ft. (leading edge) 510 µg/ℓ (maximum) None	1100 ft. (leading edge) 510 µg/ℓ (maximum) None	440 ft. (leading edge) 496 µg/ℓ (maximum) None	440 ft. (leading edge) 496 µg/ℓ (maximum) None
- Source Control					
Source Reduction	No control of ultimate sources such as discharges to Paddys Run or the storm water outfall ditch is considered under this South Plume removal action.	No control of ultimate sources such as discharges to Paddys Run or the storm water outfall ditch is considered under this South Plume removal action.	No control of ultimate sources such as discharges to Paddys Run or the storm water outfall ditch is considered under this South Plume removal action.	No control of ultimate sources such as discharges to Paddys Run or the storm water outfall ditch is considered under this South Plume removal action.	No control of ultimate sources such as discharges to Paddys Run or the storm water outfall ditch is considered under this South Plume removal action.
Contaminant Flow Across FMPC Boundary	This alternative provides no control of the amount of uranium crossing the FMPC boundary.	This alternative provides no control of the amount of uranium crossing the FMPC boundary.	This alternative does not limit contaminated groundwater from leaving the FMPC boundary.	This alternative provides no reduction in the amount of uranium crossing the southern boundary of the FMPC.	This alternative provides no reduction in the amount of uranium crossing the southern boundary of the FMPC.
- Surface Water					
Discharge Concentration	825 µg/ℓ - average	825 µg/ℓ - average	810 µg/ℓ - average	150 µg/ℓ Lower uranium concentration in the flow from the wells will reduce the concentration in the FMPC discharge from the current release concentration limit of 825 µg/ℓ to approximately 150 µg/ℓ for each of the five years or a 550 percent decrease.	138 µg/ℓ - average (due to uranium removal and sixfold volume increase in effluent with no increase in uranium release.)
Total Uranium Released	1500 lbs./yr. (448 mCi)	1500 lbs./yr.	1470 lbs./yr. (reduction of 2%)	Annual uranium loading to the river will increase from its current level of 1500 pounds to 1590 pounds (5 percent increase) during the first years of pumping and 1750 pounds during the fifth year of pumping (17 percent increase).	1470 lbs./yr.

TABLE ES-1
(Continued)

CRITERIA	NO ACTION ALTERNATIVE 1	MONITORING AND INSTITUTIONAL CONTROLS ALTERNATIVE 2	ALTERNATE WATER SUPPLY ALTERNATIVE 3	PUMP AND DISCHARGE ALTERNATIVE 4	PUMP AND TREAT ALTERNATIVE 5
EFFECTIVENESS (Cont.)					
Increased Water Flow	None	None	None	2,000 gallons per minute or 4.5 cfs. No change to the hydrodynamic patterns of the Great Miami River, whose average flow rate is 3460 cfs, is expected.	4.5 cfs increased flow. No changes to the hydrodynamic patterns of the Great Miami River are expected. The Great Miami River's average flow rate is 3460 cfs.
- NEPA					
Aquatic Ecology	No effect if no withdrawal of water from aquifer.	No effect, reduced chance of withdrawal from aquifer.	Small short-term disturbance to Paddys Run due to need for a stream crossing by the water supply pipeline.	Same as for Alternative 3 for Paddys Run. Marginal positive impact on Great Miami River due to decreased uranium concentrations in FMPC combined effluent.	Same as Alternative 3 for Paddys Run. Marginal positive impact on Great Miami River. FMPC-derived uranium concentration decreases at average Great Miami River flow.
Terrestrial Ecology Habitats/Wetlands	No effect if no withdrawal. Effect of withdrawal depends on use.	No effect, reduced chance of withdrawal.	Small, short-term disturbance at wells and along pipeline route.	Small, short-term disturbance at alternate water supply and extraction wells.	Same as Alternative 4, with marginal positive impact on Great Miami River.
Endangered Species	No impact on Indiana Bat Communities.	No impact.	No impact.	No impact.	No impact.
Noise/Air Quality	No impact.	No impact.	Construction impacts lasting six months; not significant.	Construction impacts lasting six months; not significant.	Construction impacts; off-site construction similar to Alternative 4 on-site construction impacts lasting 6 months; not significant.
Historical Resources	No impact.	No impact.	No impact.	No impact.	No impact.
Waste Management	No change.	No change.	No change.	No change.	Generate concentrated uranium sludge.
IMPLEMENTABILITY					
o Ability to Construct and Operate	N/A	No construction activities are associated with this alternative.	Design and installation represent standard engineering efforts and should present no major technical difficulties. The water supply system will be fully automated, requiring daily maintenance checks.	The installation, construction, and operation of a groundwater recovery system utilizes commonly practices engineering techniques. No difficulties expected in the construction or operation of this system.	Similar to Alternative 4, with the addition of factors related to the treatment process. The treatment equipment and instrumentation are of proven reliability and design. Requires a longer period of design and construction than Alternative A; however, no difficulties are expected in the construction or operation.
o Ease of Doing More Action if Needed	Actions can be implemented if necessary; however, this alternative would require the most time intensive effort for adding monitoring, and an alternative water supply or treatment system, if needed.	Additional actions can also be taken under this scenario if necessary. However, a time intensive effort is required for any necessary design, construct, and implementation activities.	The addition of more action under this alternative is relatively less difficult than Alternatives 1 or 2. This would require only an expansion to an existing water supply or the addition of a pump and treat system.	The difficulty in taking more action under this alternative is less than Alternatives 1, 2, and 3. Expansion of the pumping network or the addition of a treatment system may be added, if needed.	This alternative provides the greatest ease of taking additional action. Potential expansion of either the alternate water supply or treatment system may be required.

TABLE ES-1
(Continued)

CRITERIA	NO ACTION ALTERNATIVE 1	MONITORING AND INSTITUTIONAL CONTROLS ALTERNATIVE 2	ALTERNATE WATER SUPPLY ALTERNATIVE 3	PUMP AND DISCHARGE ALTERNATIVE 4	PUMP AND TREAT ALTERNATIVE 5
o Ability to Obtain Approvals and Coordinate with other Agencies	The acceptance of the no-action alternative by the public and the agencies is not likely.	Individual landowner approvals needed for access. Difficulties obtaining access in the past. Coordination between DOE the state of Ohio, and local communities necessary and possible.	Property acquisition is necessary. Additionally access to private properties and public rights-of-way are required. Difficulties obtaining access in the past. Coordination with local and state agencies for permitting requirements. However, permit acquisition is not expected to be a significant factor in implementation schedule.	Expected that a new permit or major modifications to the existing FMPC NPDES permit is required. May be a lengthy process and may result in permit disapproval. Construction permits required from the state. Access to private property required.	Modification to existing permit will be required. Landowner access required, as well as coordination with state and local agencies.
o Availability of Services and Capabilities	N/A	Services for monitoring and analyses are readily available.	Necessary services are readily available.	Necessary services for this alternative are readily available.	Necessary services for this alternative are readily available.
o Availability of Equipment, Specialists, and Materials	N/A	Monitoring equipment and laboratory equipment and materials are readily available.	The necessary equipment and materials associated with this operation are commonly and readily available.	The necessary materials and equipment for this alternative are readily available.	Equipment and materials are readily available.
o Availability of Technologies	N/A	N/A	N/A	This alternative uses standard technologies which are readily available.	This alternative uses standard treatment processes which are readily available.
CONSISTENCY WITH FINAL REMEDIAL ACTION	N/A	This alternative is consistent with any final remedial action.	This alternative is consistent with any final remedial action.	This alternative is consistent with any final action that would remove groundwater from the aquifer. The removal of uranium and control of plume migration should reduce the scope of the final action.	This alternative is consistent with any final remedial action that would remove and treat groundwater from the aquifer and would reduce the scope of the final action.
REDUCTION IN MOBILITY, TOXICITY, OR VOLUME	No treatment proposed.	No treatment proposed.	No treatment proposed.	No treatment proposed.	Meets requirements of preference for treatment to reduce mobility, toxicity, or volume.
COST	No costs are associated with the no-action alternative.	Capital - $0.00 Annual - $33 600/yr Present Worth - $145,500	Capital - $900,000 Annual - $145 500/yr Present Worth - $1,530,000	Capital - $7,405,000 Annual - $751,000/yr Present Worth - $10,657,000	Capital - $14,702,000 Annual - $2,590,000/yr Present Worth - $25,915,000

pump and discharge component of Alternative 4. The final selection of the number, location, and pumping rates of the wells will be part of this second design phase.

1.0

1.0 INTRODUCTION

On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) was jointly signed by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (U.S. EPA) pertaining to environmental impacts associated with DOE's Feed Materials Production Center (FMPC) in Fernald, Ohio. The FFCA is intended to ensure that environmental impacts associated with past and present activities at the FMPC are thoroughly and adequately investigated so that appropriate response actions can be formulated, assessed, and implemented.

In response to the FFCA, and consistent with modifications agreed to in March 1990, a Remedial Investigation and Feasibility Study (RI/FS) is in progress pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The technical strategy adopted for the RI/FS is to issue distinct RI/FSreports for each of five operable units into which the FMPC has been separated. By accommodating separate schedules for each operable unit, the remedial action decision process is proceeding to completion for the most problematical units while data collection and analysis continue for other operable units.

One of the identified operable units for the FMPC includes those environmental media that serve as migration pathways and/or environmental receptors of radiological or chemical releases from the FMPC. Important elements of this operable unit are the on- and off-site areas of the regionally important Great Miami Aquifer that exhibit elevated levels of uranium. Because of the off-site location of portions of the uranium plume within developed areas south of the FMPC and the associated potential threat to human health, the DOE is considering a removal action for this off-site area or "south plume" pending the outcome of the RI/FS and the implementation of a final remedial action for the regional aquifer.

Removal actions, as described in the National Oil and Hazardous Substances Contingency Plan (NCP) of March 1990 (40 Code of Federal Regulations [CFR] 300.415), are primarily intended to abate,

minimize, stabilize, mitigate, or eliminate a release or a threat of release prior to a final action if there is a threat to public health or welfare or the environment. A second reason for implementing a removal action is to mitigate contaminant migration pending final action if site conditions permit a straightforward mitigative action and significant migration would occur in the interim if no action is taken. Additionally, based on proposed revisions to this portion of the NCP, removal actions are to be consistent with the anticipated long-term remedial action and to contribute to the efficient performance of the long-term remedy to the extent practicable.

Once a removal action is deemed appropriate (in the case of the south plume a non-time critical removal action since there is more than six months time available for planning), an engineering evaluation/cost analysis (EE/CA) is performed to analyze removal action alternatives and to support the selection of a preferred alternative. The document contained herein represents the EE/CA for the south plume removal action at the FMPC. The National Environmental Policy Act of 1969 (NEPA) requires that Federal agencies include in their decision making processes appropriate and careful consideration of all environmental effects of proposed actions. Therefore, this EE/CA has been prepared so as to integrate the requirements of both CERCLA and NEPA, and will be used by DOE as the basis for remedy selection and implementation.

2.0

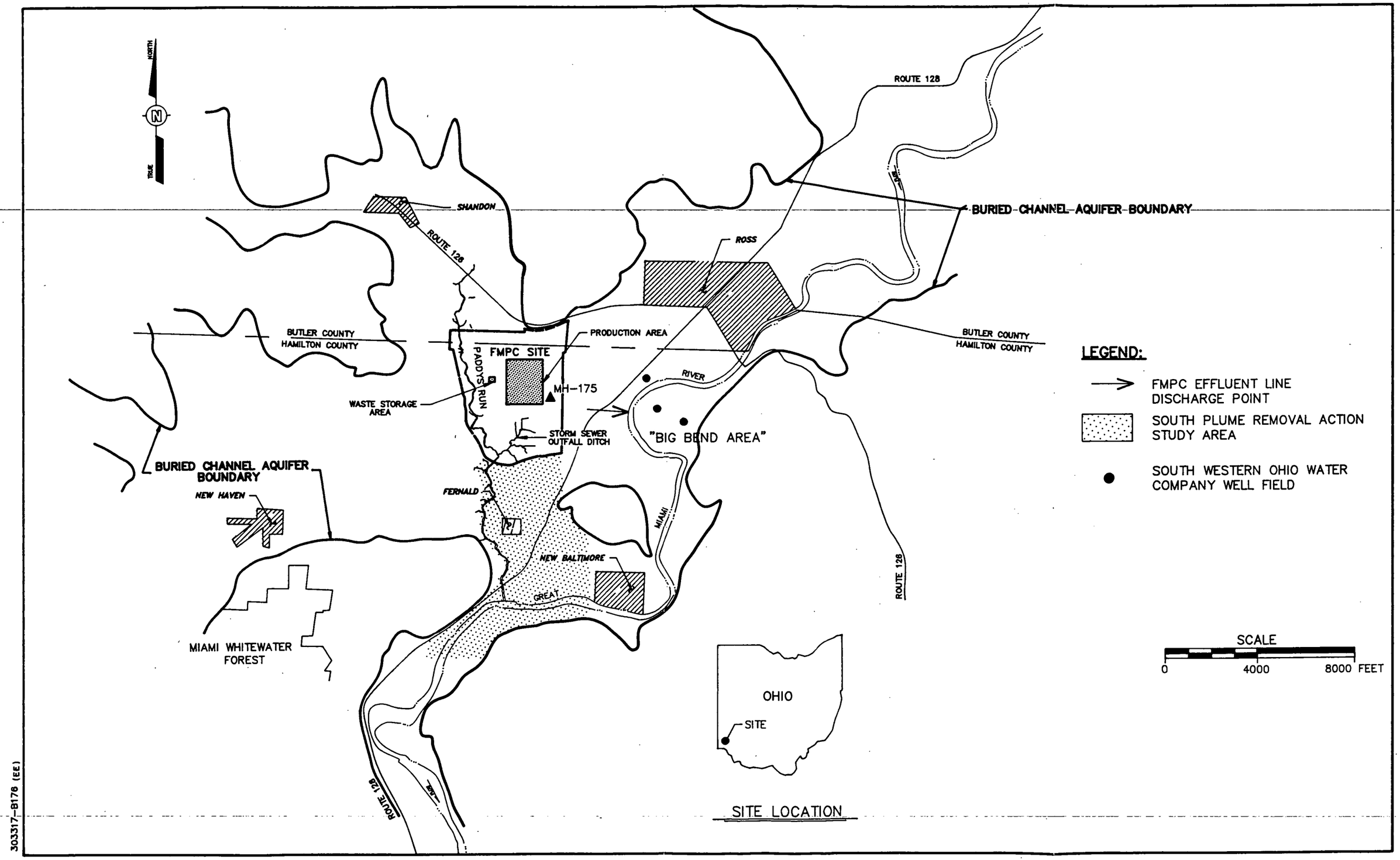


FIGURE 2-1
STUDY AREA AND VICINITY

2.0 SITE CHARACTERIZATION

2.1 SITE BACKGROUND

The United States Atomic Energy Commission (AEC), predecessor to the DOE, established the FMPC for processing uranium and its compounds from natural uranium ore concentrates for U.S. Government needs. This integrated production complex began operations in conformance with AEC Orders in the early 1950s. In 1951, NLO Inc. (formerly National Lead Company of Ohio) entered into contract with the AEC as Operations and Maintenance (O&M) Contractor. This contractual relationship lasted until January 1, 1986. Westinghouse Materials Company of Ohio (WMCO), a wholly-owned subsidiary of Westinghouse Electric Corporation, then assumed management responsibilities of the site operations and facilities for a minimum five-year period.

The FMPC site is located on 1050 acres in a rural area approximately 20 miles northwest of downtown Cincinnati, Ohio. The Production Area is limited to an approximate 136-acre tract near the center of the FMPC site. The villages of Fernald, New Baltimore, Ross, New Haven, and Shandon are all located within a few miles of the plant (Figure 2-1).

A variety of chemical and metallurgical processes are utilized at the FMPC for the manufacture of uranium products. During the manufacturing process, high quality uranium compounds are introduced into the FMPC processes at several points. Impure starting materials are dissolved in nitric acid and the uranium is removed through solvent extraction to yield a solution of urinal nitrate. Evaporation and heating convert the nitrate solution to uranium trioxide (UO_3) powder. This compound is reduced with hydrogen to uranium dioxide (UO_2) and then converted to uranium tetrafluoride (UF_4) by reaction with anhydrous hydrogen fluoride. Uranium metal is produced by reacting UF_4 and magnesium metal in a refractory-lined reduction vessel. This primary uranium metal is then remelted with scrap uranium metal to yield a purified uranium ingot. Various uranium metal working processes also exist.

Large quantities of liquid and solid wastes are generated by the various operations at the FMPC. Solid waste materials associated with uranium metals production are presently stored on site in steel drums awaiting further processing or off-site disposal at approved facilities. These wastes include oils,

sludges, contaminated combustibles, filter cake, off-spec UF_4 or thorium tetrafluoride (ThF_4), and reject UO_3. The drums sit on various pads and/or in warehouses and are inspected on a weekly basis. Contents of deteriorated drums are repackaged. Other waste materials, stored in drums on contained surfaces, include spent degreasing solvents and PCB-contaminated material.

Prior to 1985, solid and slurried wastes from FMPC processes were disposed of in the on-site Waste Storage Area. This area, which is located west of the production facilities, includes six low-level radioactive waste storage pits, two earthen-bermed concrete silos containing K-65 residues (i.e., high specific activity, low-level radium-bearing residues resulting from the pitchblende refining process), a concrete silo containing metal oxides, two lime sludge ponds, and a sanitary landfill.

Two fly ash piles are located approximately 3000 feet south/southeast of the Waste Storage Area. One pile remains active for the disposal of fly ash from the FMPC boiler plant. An area north of and adjacent to the fly ash piles, known as the Southfield Area, is believed to be the disposal site for construction debris and possibly other types of solid wastes from FMPC operations.

Surface water runoff from the Waste Storage Area, fly ash piles, and other affected areas within the western portion of the FMPC enters Paddys Run, a tributary of the Great Miami River. Paddys Run originates just north of the FMPC and flows south-southeast along the western edge of the site, and for a part of the year it is a dry streambed with occasional rainfall-induced flows.

Leachate from these same areas can potentially migrate vertically to the regionally important Great Miami Aquifer which underlies the site. This aquifer serves as a principal source of domestic, municipal, and industrial water throughout the region. A portion of the flow in Paddys Run is also known to enter this aquifer downstream from the Waste Storage Area as a result of leakage through the stream bottom.

Liquid waste effluent generated from FMPC process operations is sent to a general plant sump for treatment and analysis prior to release to the Great Miami River through the main effluent line

(Figure 2-1). Storm water runoff from the production area is collected in storm water retention basins to allow for solids removal prior to being analyzed and released to the Great Miami River through the same effluent line. During major storm events, storm water may be discharged through an outfall ditch to Paddys Run if the storm water retention basins overflow.

The main effluent line to the Great Miami River represents a permitted discharge for wastewater from the FMPC and would be expected to serve as the discharge facility for any groundwater pumped from the south plume. The discharge is regulated by an NPDES permit and DOE Orders, with compliance monitoring performed at Manhole 175 before the effluent leaves the site boundary. The wastewater conveyed by the main effluent line currently comes from four principal sources:

- Treated water from raw water treatment and boiler blowdown are discharged from the general sump to Manhole 175
- Treated effluent from the sanitary sewage treatment plant
- Storm water runoff from the Production Area, the storm sewer lift station, and the storm water retention basin
- Low concentration nitrate streams from the general sump and biodenitrification facility

The effluent line is a 4200-foot-long, 16-inch-diameter cast iron pipe constructed in 1952. Seven concrete manholes are located along the line for access and maintenance purposes. The depth of burial of the pipeline ranges from approximately 4 to 16 feet, with a maximum and minimum slope of 12.7 and 0.1 percent, respectively. The invert of the concrete-encased submerged discharge is located near the bottom of the Great Miami River, approximately 15 inches below the lowest recorded water level at the discharge point.

Because the lower reaches of the effluent pipeline would be submerged under high water conditions in the Great Miami River, the pipeline was designed to accommodate pressure flow in these lower reaches. The flow capacity of the pipeline has been computed to be about 6.5 million gallons per day

(mgd), or 10 cubic feet per second (cfs) (WMCO 1989). This greatly exceeds the value that would be realized under gravity flow only. In 1987, the average rate of discharge from the pipeline was 0.576 mgd or 0.89 cfs (WMCO 1988), far below the design capacity. The maximum discharge rate observed in 1987 was 1.134 mgd (1.76 cfs), and the minimum flow rate was 0.248 mgd (0.38 cfs) (WMCO, 1988).

The NPDES permit for the FMPC specifies seven sampling locations (two external and five internal), the sampling method (24-hour composite or weekly grab), and the effluent characteristics to be monitored (flow rate, biological oxygen demand, pH, suspended solids, ammonia, oil and grease, residual chlorine, and nitrate). DOE Orders also require daily sampling for radionuclides, with the daily samples composited on a weekly basis for laboratory analysis.

Based on the analytical data from the weekly composites, the average concentration of total uranium in the FMPC effluent discharge in 1987 was found to be 660 picocuries per liter (pCi/ℓ) [990 micrograms per liter (μg/ℓ)]. This was about the same as the average value of 661 pCi/ℓ (992 μg/ℓ) measured in 1985 and more than the average value of 450 pCi/ℓ (675 μg/ℓ) measured in 1986 (WMCO 1986 and 1987).

2.2 SITE SETTING

The following description of the physical setting of the FMPC and surrounding area was derived from various existing reports. Two documents were relied on substantially (IT 1988, DOE 1987) and are not specifically referenced in the text. Other documents used to support individual statements are appropriately cited within the text.

2.2.1 Climate

Data from the Greater Cincinnati International Airport are satisfactory to characterize the climatic regime of the FMPC area. Windflow data from the Dayton Airport have been utilized as a secondary data source.

The regional climate is defined as continental, with temperatures ranging from a monthly average of 29.0 degrees Fahrenheit in January to 75.5 degrees Fahrenheit in July. The highest temperature recorded from 1950 through 1984 was 102 degrees Fahrenheit in August 1962 and the lowest was minus 25 degrees Fahrenheit in January 1977. The average number of days per year with a minimum temperature of 32 degrees Fahrenheit or less is 110 days, and the average number of days with a maximum temperature of 90 degrees Fahrenheit or above is 20 days per year. Frost depth ranges from 30 to 36 inches.

The average annual precipitation for the period 1955 through 1984 was 37.75 inches and ranged from 29.22 to 40.64 inches. The highest precipitation occurs during the spring and early summer; precipitation is lowest in late summer and fall. The average annual snowfall for the same period was 24.0 inches, with heaviest snowfall in January.

2.2.2 Surface Water Hydrology

The FMPC is located within the Great Miami River Basin drainage, but above the river's present day floodplain. The Great Miami River is the receiving stream for the FMPC effluent discharge and represents the main surface water feature in the vicinity of the FMPC (Figure 2-1). The river flows generally to the southwest and has a drainage area of approximately 3360 square miles at the Hamilton gage, which is located about 10 miles upstream from the FMPC discharge outfall.

The river exhibits meandering patterns that result in sharp directional changes over distances of less than 3000 feet. Directly east of the FMPC and within the RI/FS study area, the river passes through a 180-degree curve known as the "Big Bend" (Figure 2-1). A 90-degree bend in the river also occurs near New Baltimore, approximately two miles downstream from the FMPC point of discharge.

The average discharge of the Great Miami River at Hamilton, based on 55 years of records, is 3305 cfs. Using drainage area scaling, the corresponding average flow at the FMPC point of discharge has been estimated to be 3460 cfs. The maximum discharge ever recorded for the Great Miami River at Hamilton occurred on March 26, 1913 and was estimated to be 352,000 cfs. The maximum

discharge since the construction of five retarding basins in 1922 was 108,000 cfs and occurred on January 21, 1959. The 10-year flood discharge has been calculated to be 81,455 cfs for the site reach. The minimum daily discharge of 155 cfs was recorded on September 27, 1941. This value is approximately half of the 7-day, 10-year low flow value (Q7-10) of 267 cfs, as computed by the U.S. Geological Survey (USGS) for the Hamilton Gage. This translates to 280 cfs at the site reach.

Natural surface drainage from the FMPC is primarily to Paddys Run. Paddys Run originates north of the site, drains southward along the west side of the FMPC, and eventually enters the Great Miami River approximately 1.5 miles south of the FMPC (Figure 2-1). This stream loses flow to the groundwater along much of its course due to its highly permeable channel bottom and limited elevation above the regional groundwater table. Paddys Run is an ungaged, intermittent stream that flows primarily between January and May, with an estimated discharge for this period ranging between 0.2 and 4.0 cfs. Peak flows have not been gaged.

Runoff from the FMPC Waste Storage Area flows west and southwest to Paddys Run. A separate removal action is currently underway by the DOE to capture and divert the majority of this runoff to the Great Miami River following treatment. This project will be documented in a forthcoming EE/CA.

A principal drainage feature of the FMPC is a tributary to Paddys Run known as the storm water outfall ditch. This drainage course originates south of the Production Area, flows southwest across the southern portion of the site, and enters Paddys Run near the southwest corner of the property (Figure 2-1). Much of the stream bottom of this drainage course, which also collects runoff from an area east of the plant, is composed of sand and gravel. For this reason vertical seepage rates through the stream bottom may be high. This drainage course is generally dry throughout most of the year with flows occurring during and immediately after precipitation.

The storm water outfall ditch historically conveyed surface water runoff from the Production Area directly to Paddys Run when the capacity of the storm sewer lift station, which diverts low flow to Manhole 175, was exceeded. Two storm water retention basins were recently constructed at the head

of the storm water outfall ditch. Storm water runoff from the Production Area is now conveyed to these retention basins. The basins, designed to retain the runoff from a 10-year, 24-hour rainfall event, essentially eliminate the contribution of storm water from the Production Area to the outfall ditch. After at least a 24-hour retention period to allow for settling of suspended solids, the water is pumped out to the Great Miami River via the FMPC's main effluent line.

2.2.3 Groundwater Hydrology

Geologic History

The FMPC is located within the area of a two- to three-mile wide subterranean valley known as the New Haven Trough. This valley formed as a result of Pleistocene glaciation and subsequently filled with glacial outwash materials and till. The geological history of the FMPC area is briefly summarized below:

- In Late Ordovician time (approximately 450 million years ago), sediments which would become a predominantly flat-lying shale with thin interbedded limestone were deposited in a shallow sea. This shale (a part of the Cincinnatian Series) is the relatively impermeable bedrock which now underlies the FMPC site area and forms the highlands to the north.

- Sometime prior to, or perhaps contemporaneous with Pleistocene glaciation, a large watercourse (larger than the present-day Great Miami River) cut its channel into this shale bedrock to a level of more than 200 feet below that of the present-day Great Miami River. This approximately two-mile wide channel is termed the New Haven Trough and may be an abandoned course of the ancestral Ohio River.

- During subsequent Pleistocene glacial advances and retreats across the site (Illinoisan--approximately 300,000 years to 400,000 years ago, and Wisconsin--approximately 100,000 years ago), the New Haven Trough was filled with about 200 feet of glacial sediments form the buried valley. These sediments were deposited by water running from the margins of the glaciers and consisted mainly of well-sorted sands and gravels. Deposited on top of these sediments was a blanket of clay-rich glacial till.

- Erosion by the Great Miami River and its tributaries then removed significant portions of the glacial till and left terrace remnants which stand topographically higher than surrounding bottom lands.

The FMPC site lies on top of one of these terrace remnants left after the establishment of the present day Great Miami River channel. The lower reaches of Paddys Run have cut through this till and lie on the sands and gravels of the buried outwash deposits.

Hydrogeologic Setting

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

Unconformably overlying the shales in the bedrock channel are approximately 150 feet of regionally extensive Pleistocene glacial valley fill deposits. As indicated by the study area map (Figure 2-1) and the hydrogeologic cross sections (Figures 2-2 through 2-8), 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. Inter-bedded 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.

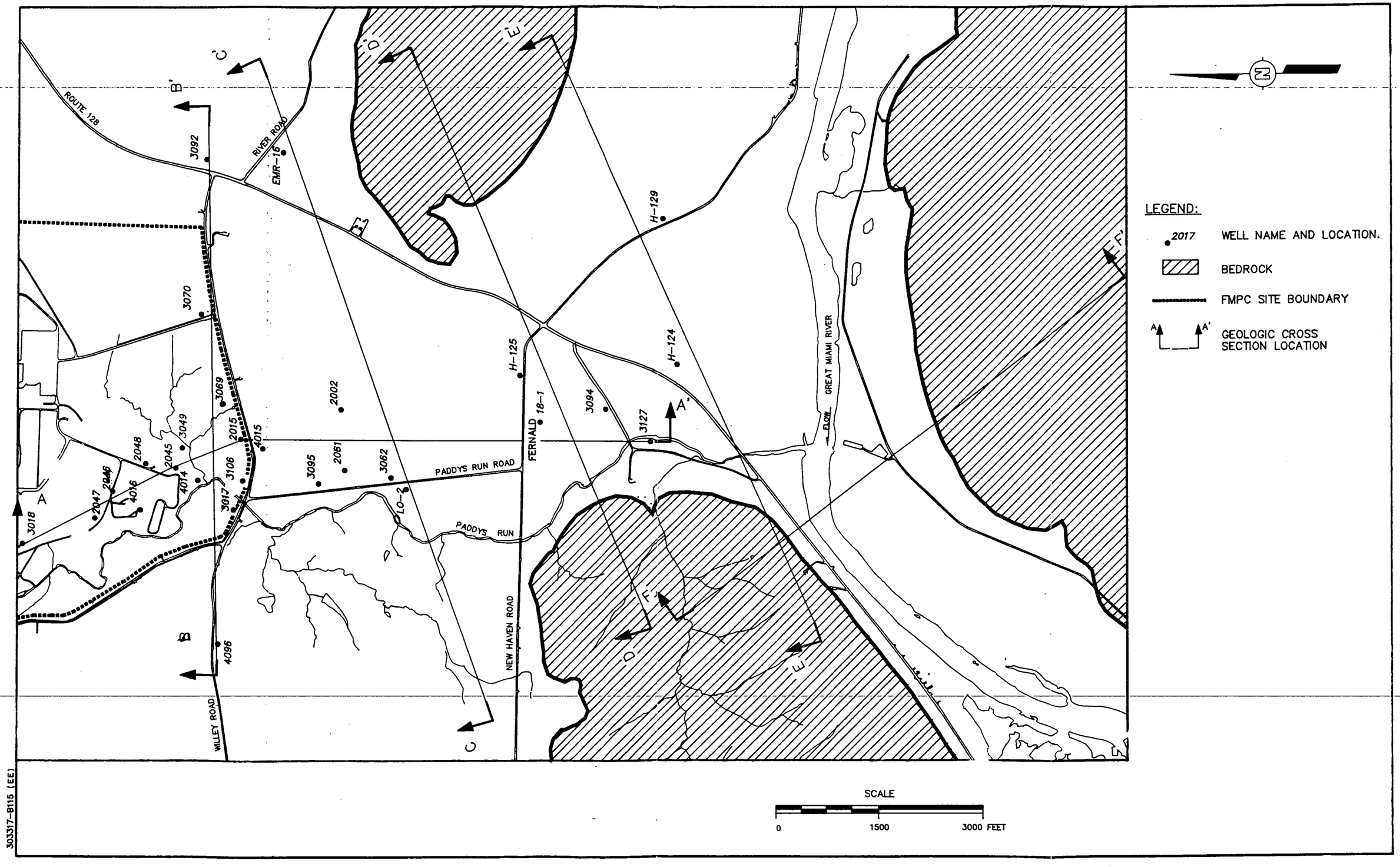


FIGURE 2-2
SOUTH PLUME GROUNDWATER STUDY
LOCATION OF CROSS SECTIONS

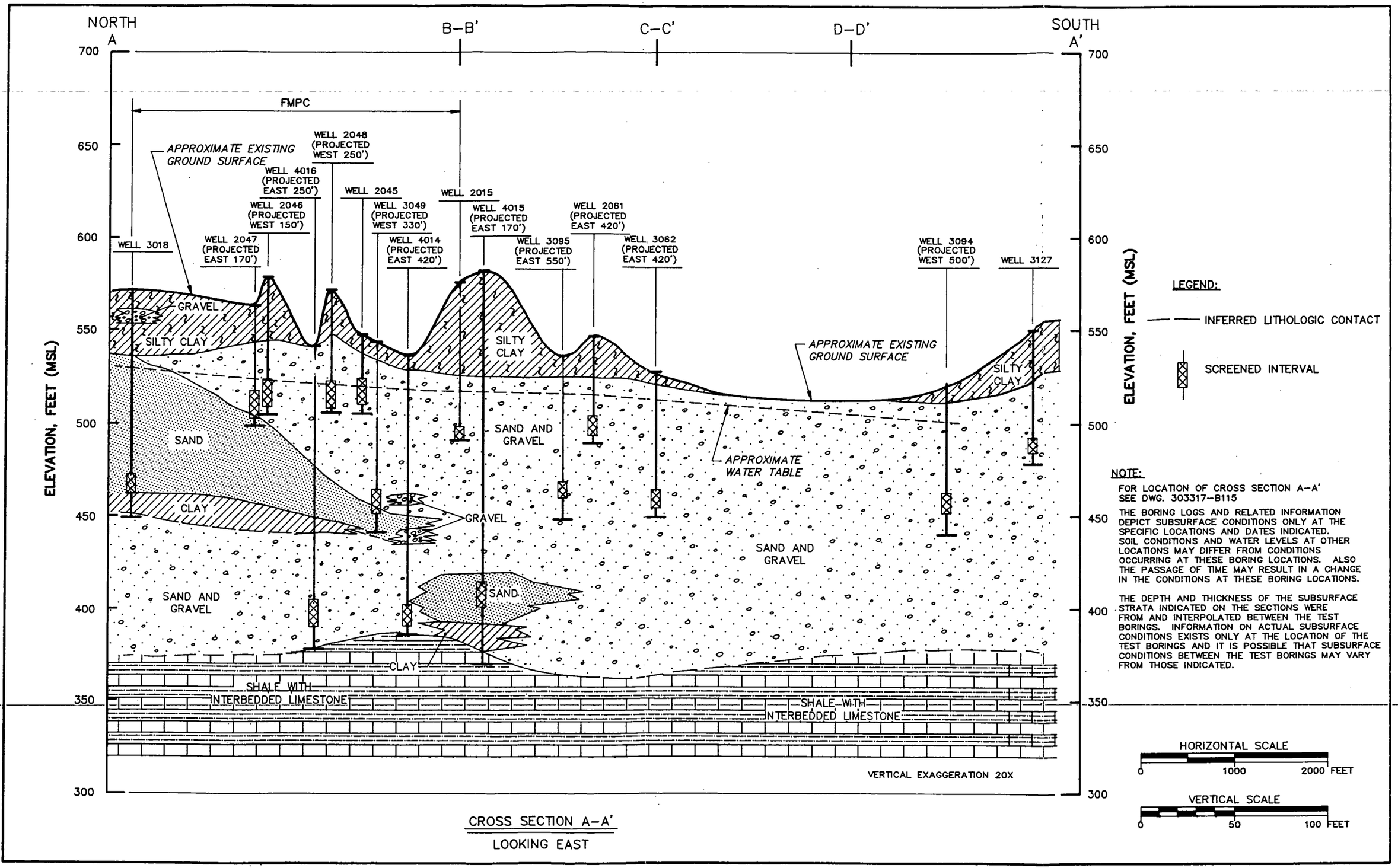
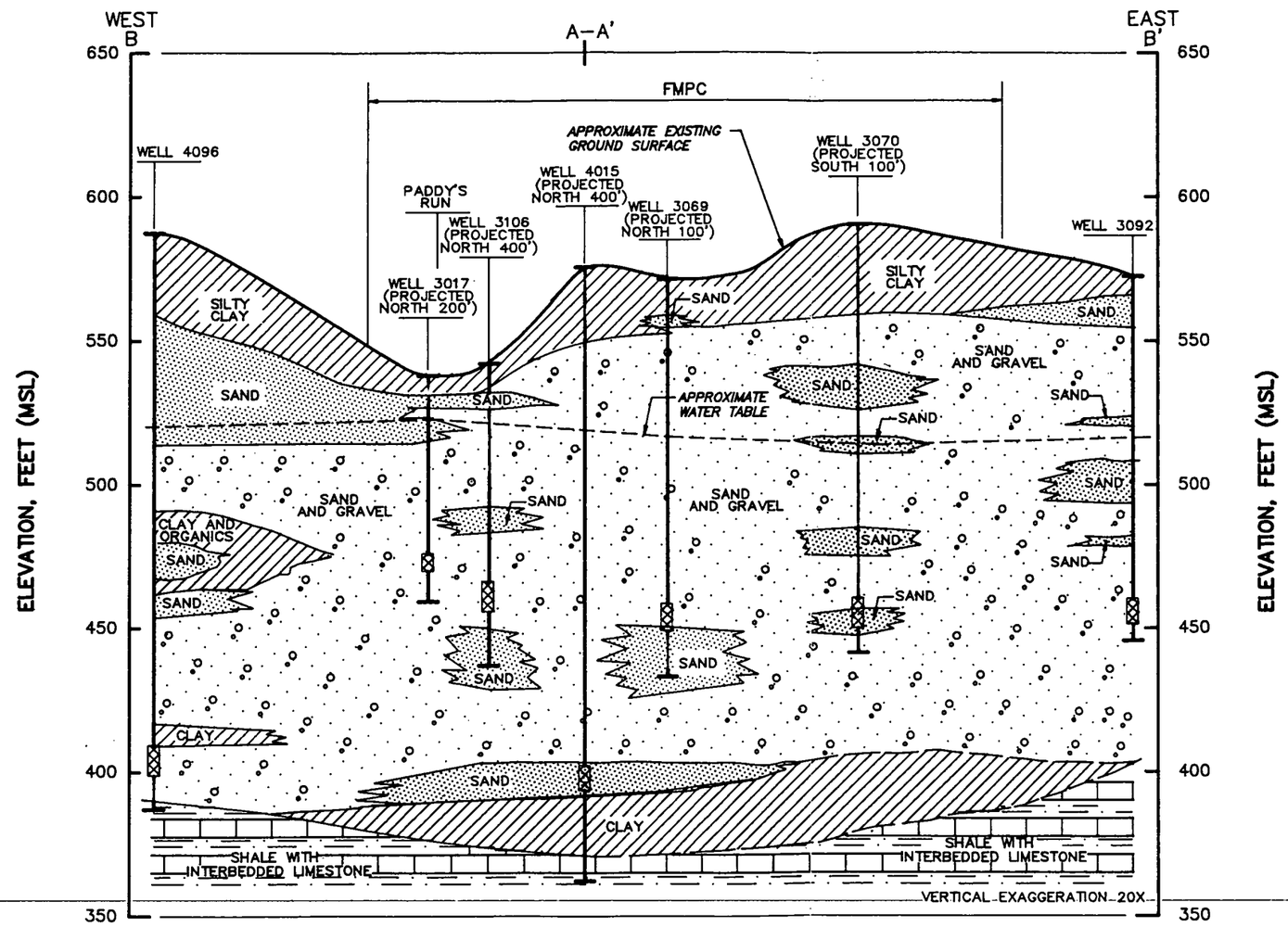


FIGURE 2–3
SOUTH PLUME GROUNDWATER STUDY
GEOLOGIC CROSS SECTION A–A'



CROSS SECTION B–B'
LOOKING NORTH

LEGEND:

SCREENED INTERVAL

INFERRED LITHOLOGIC CONTACT

NOTE:

FOR LOCATION OF CROSS SECTION B–B' SEE DWG. 303317–B115

THE BORING LOGS AND RELATED INFORMATION DEPICT SUBSURFACE CONDITIONS ONLY AT THE SPECIFIC LOCATIONS AND DATES INDICATED. SOIL CONDITIONS AND WATER LEVELS AT OTHER LOCATIONS MAY DIFFER FROM CONDITIONS OCCURRING AT THESE BORING LOCATIONS. ALSO THE PASSAGE OF TIME MAY RESULT IN A CHANGE IN THE CONDITIONS AT THESE BORING LOCATIONS.

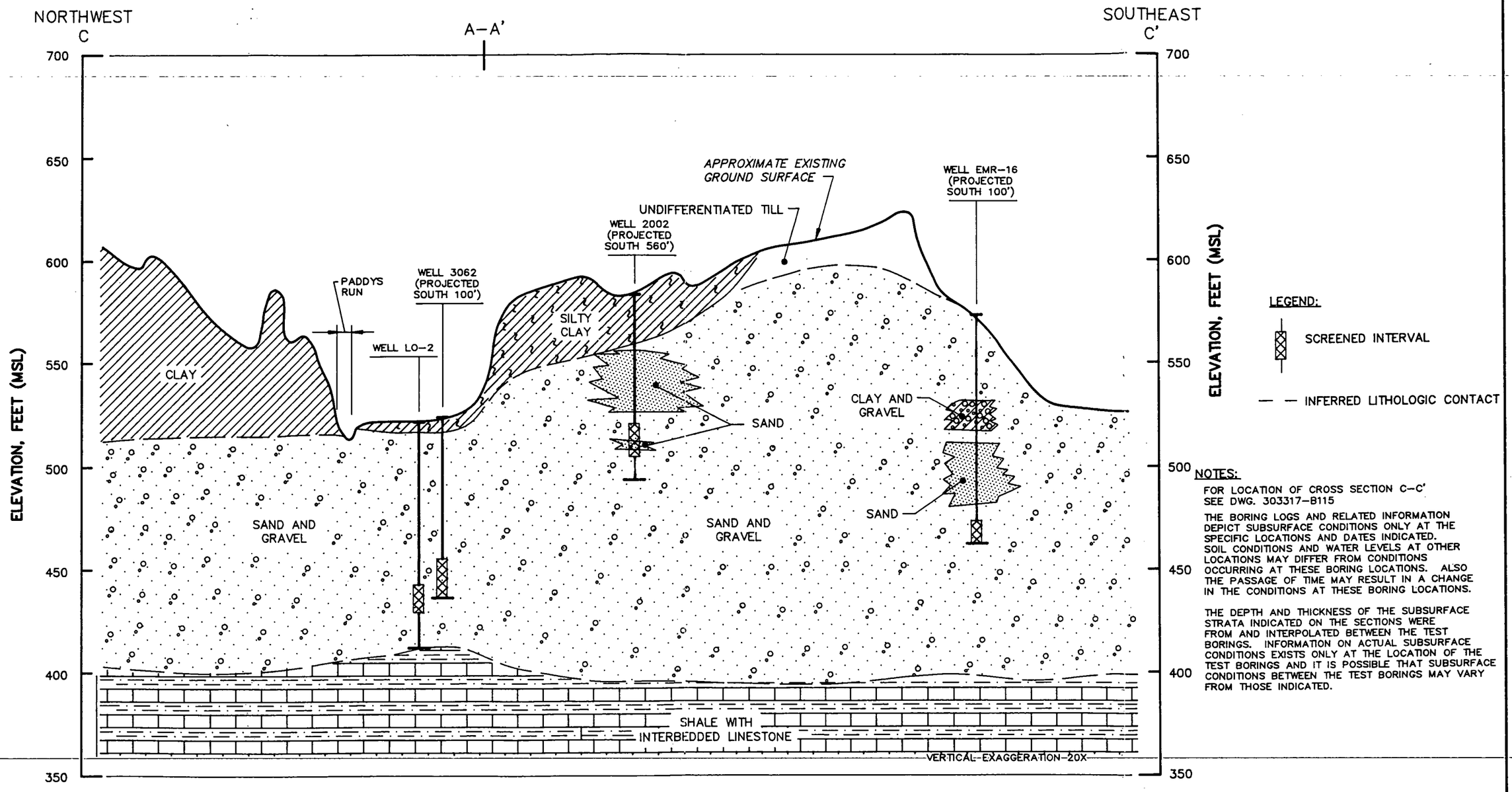
THE DEPTH AND THICKNESS OF THE SUBSURFACE STRATA INDICATED ON THE SECTIONS WERE FROM AND INTERPOLATED BETWEEN THE TEST BORINGS. INFORMATION ON ACTUAL SUBSURFACE CONDITIONS EXISTS ONLY AT THE LOCATION OF THE TEST BORINGS AND IT IS POSSIBLE THAT SUBSURFACE CONDITIONS BETWEEN THE TEST BORINGS MAY VARY FROM THOSE INDICATED.

HORIZONTAL SCALE
0 1000 2000 FEET

VERTICAL SCALE
0 50 100 FEET

303317–B108 (EE)

FIGURE 2–4
SOUTH PLUME GROUNDWATER STUDY
GEOLOGIC CROSS SECTION B–B'



NOTES:

FOR LOCATION OF CROSS SECTION C–C' SEE DWG. 303317–B115

THE BORING LOGS AND RELATED INFORMATION DEPICT SUBSURFACE CONDITIONS ONLY AT THE SPECIFIC LOCATIONS AND DATES INDICATED. SOIL CONDITIONS AND WATER LEVELS AT OTHER LOCATIONS MAY DIFFER FROM CONDITIONS OCCURRING AT THESE BORING LOCATIONS. ALSO THE PASSAGE OF TIME MAY RESULT IN A CHANGE IN THE CONDITIONS AT THESE BORING LOCATIONS.

THE DEPTH AND THICKNESS OF THE SUBSURFACE STRATA INDICATED ON THE SECTIONS WERE FROM AND INTERPOLATED BETWEEN THE TEST BORINGS. INFORMATION ON ACTUAL SUBSURFACE CONDITIONS EXISTS ONLY AT THE LOCATION OF THE TEST BORINGS AND IT IS POSSIBLE THAT SUBSURFACE CONDITIONS BETWEEN THE TEST BORINGS MAY VARY FROM THOSE INDICATED.

REFERENCES:

U.S.G.S. PROFFESSIONAL PAPER No.605–A, OHIO STATE WATER WELL RECORDS, SOWC WATER WELL DATA, DAMES AND MOORE , "FEED MATERIALS PRODUCTION CENTER GROUND WATER STUDY TASK C REPORT" AND IT BORING LOGS.

FIGURE ADAPTED FROM DRAWING No.303317–B4, FROM "HYDROGEOLOGIC STUDY OF THE GREAT MIAMI RIVER" PREPARED FOR U.S. DEPARTMENT OF ENERGY BY IT CORPORATION, AUGUST, 1988.

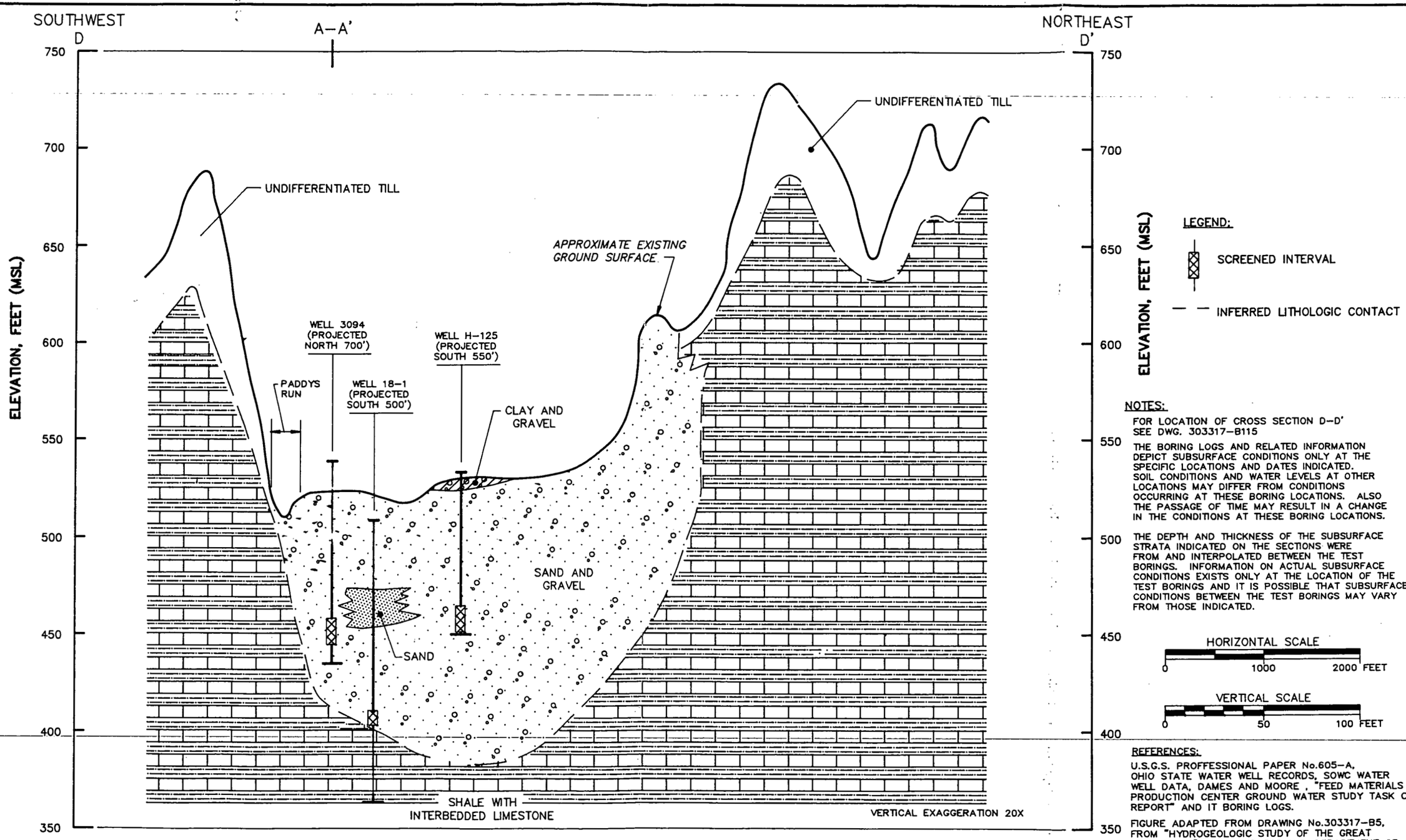
CROSS SECTION C–C'
(LOOKING NORTHWEST)

HORIZONTAL SCALE
0 1000 2000 FEET

VERTICAL SCALE
0 50 100 FEET

303317–B162 (EE)

FIGURE 2–5
SOUTH PLUME GROUNDWATER STUDY
GEOLOGIC CROSS SECTION C–C'



CROSS SECTION D–D'
(LOOKING NORTHWEST)

FIGURE 2–6
SOUTH PLUME GROUNDWATER STUDY
GEOLOGIC CROSS SECTION D–D'

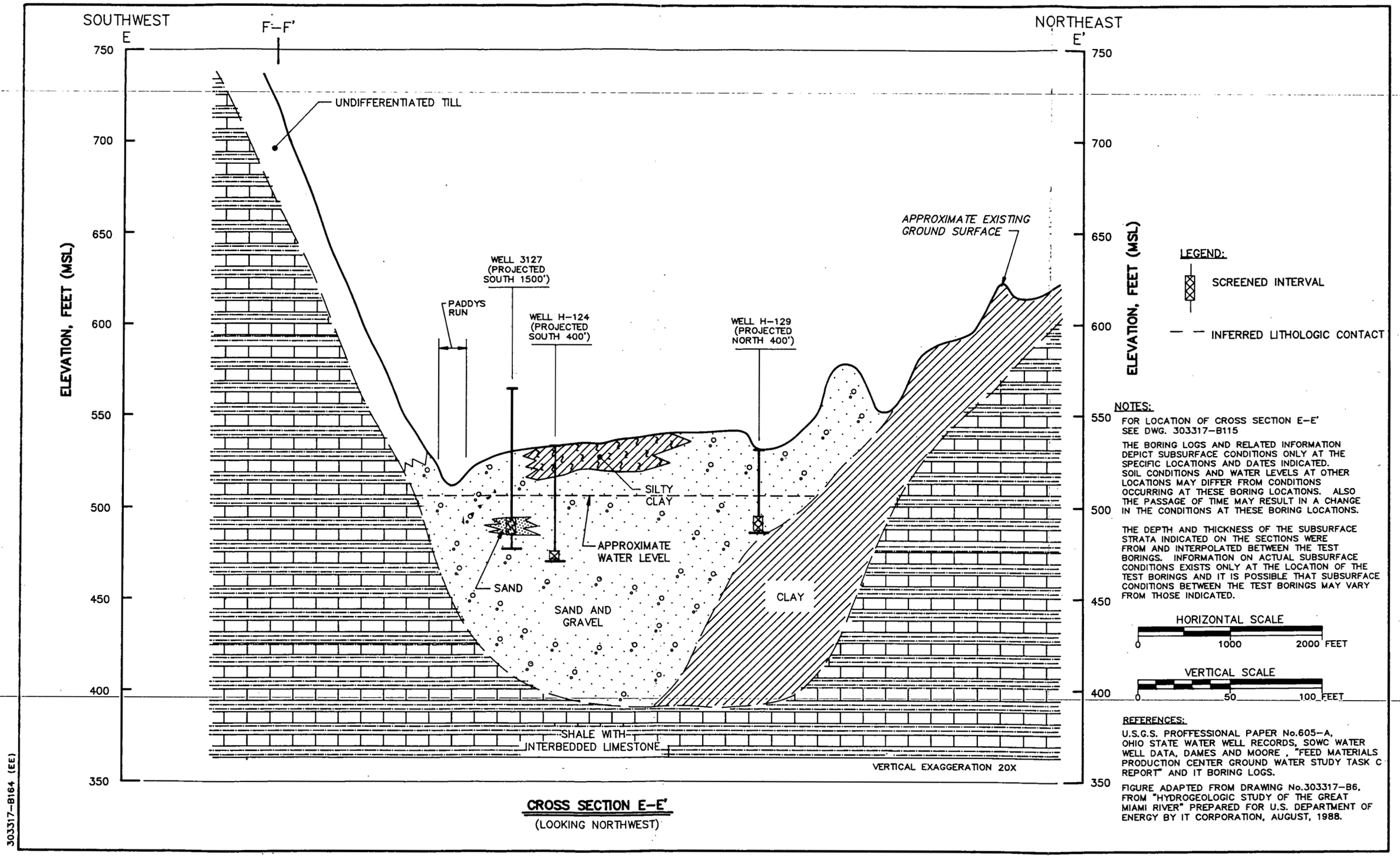


FIGURE 2–7
SOUTH PLUME GROUNDWATER STUDY
GEOLOGIC CROSS SECTION E–E'

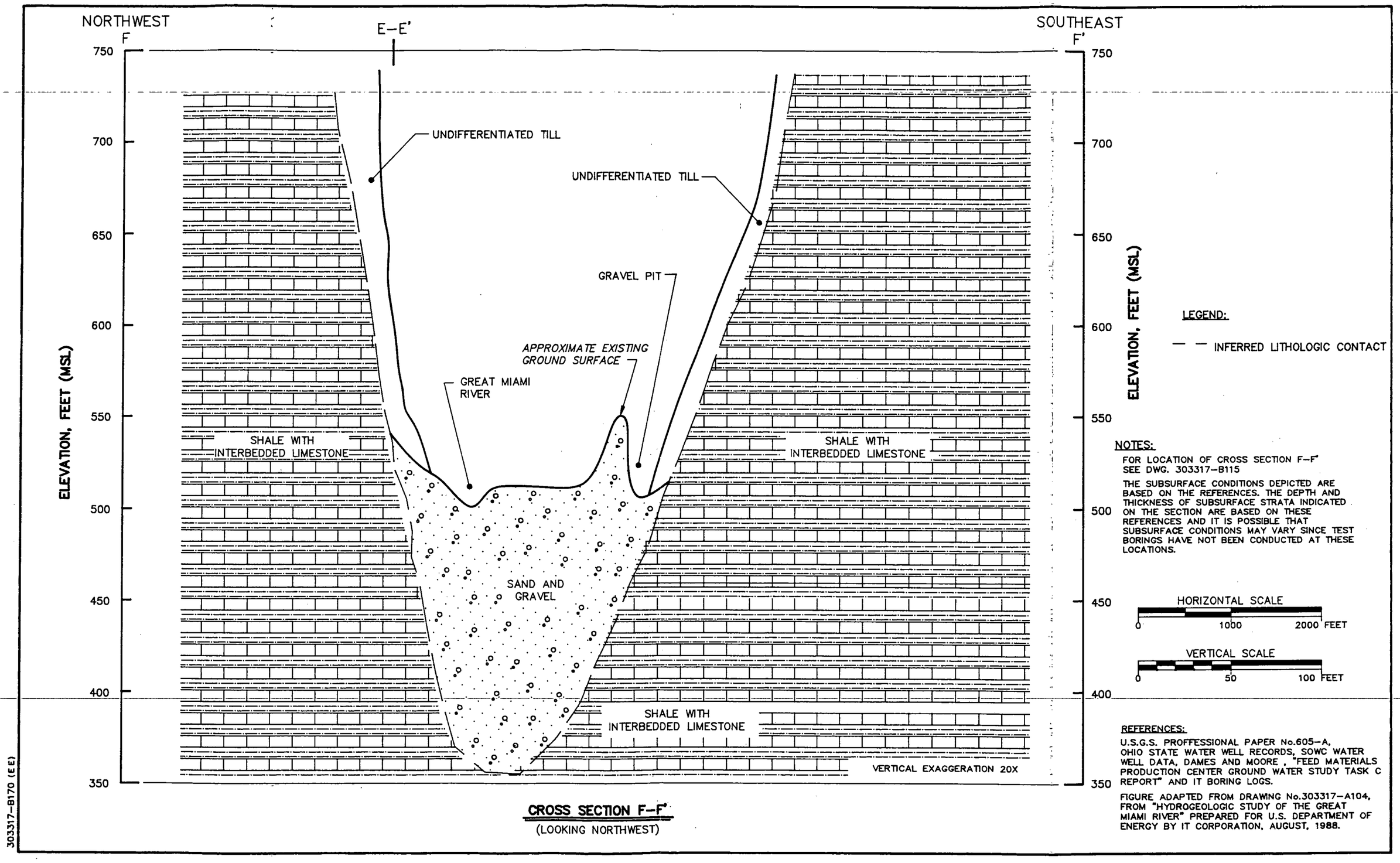


FIGURE 2–8
SOUTH PLUME GROUNDWATER STUDY
GEOLOGIC CROSS SECTION F–F'

Regional hydrogeologic environments of the buried channel aquifer have been investigated and reported by the USGS. A hydrogeologic environment describes a portion of an aquifer possessing hydrologic and geologic properties that differ from the properties of aquifers in adjacent areas. Five major hydrogeologic environments have been identified and mapped in the Great Miami River Valley. Types I, III, and V environments generally describe the hydrogeologic conditions in the vicinity of the FMPC and the south plume study area. The characteristics of these aquifer environments in the area south of the FMPC are summarized in Table 2-1 and described in the following paragraphs.

The Type I Hydrogeological Environment is found along the floodplain of the Great Miami River to the south and east of the FMPC facility. The lithology of the aquifer consists principally of sand and gravel. Scattered lenses of clay and other fine-grained material may exist anywhere in the environment; however, these lenses are not of sufficient thickness or areal extent to act as semiconfining layers or to otherwise affect groundwater movement. The potential for induced stream infiltration exists in these areas. Transmissivity values generally range from 40,000 to 67,000 square feet per day (ft^2/day). The Type I aquifer may be classified with a storage coefficient of about 0.2. Individual wells can yield as much as 3000 gallons per minute (gpm).

The Type III Hydrogeologic Environment consists of the buried channel aquifer covered by 50 or more feet of clayey till. In the region of the FMPC, the buried channel aquifer, characterized by the Type III Hydrogeologic Environment, is divided into upper and lower parts by a semipervious clay layer approximately 10 to 20 feet thick, occurring approximately 120 feet below land surface. Hence, the lower aquifer is classed as a semiconfined or leaky confined aquifer. An estimated coefficient of storage of 0.001 was made for the lower sand and gravel aquifer. Estimated transmissivities range from 4700 to 40,000 ft^2/day.

The Type V Hydrogeologic Environment includes bedrock areas outside of the buried channel. These areas are uplands and consist of shale with interbedded limestone overlain by 50 or less feet of clay-rich till. Large quantities of groundwater are not generally transported through this material. Well 2-1 yields vary widely, typically ranging from near 0 to 10 gpm. However, because sand and gravel

TABLE 2-1
GREAT MIAMI AQUIFER CHARACTERISTICS
SOUTH PLUME STUDY AREA

DESCRIPTION	QUANTITIES/UNITS	REFERENCES/COMMENTS[a]
Geology	Glacial outwash sand and gravel	Reference 1
Aquifer Dimensions		
Area	South Plume Study Area - 2.5 square miles (1560 acres)	
Saturated Thickness	130 feet	Reference 1 - Average, from cross sections
Hydrogeology		
Hydraulic Conductivity	250 to 500 feet per day	Reference 1 - Transmissivity is equal to the product of the hydraulic conductivity and saturated thickness
Porosity	25 percent	Reference 1
Depth to Water	10 to 60 feet	Reference 1 - Below land surface
Contaminants in Ground Water		
Uranium	Assumed primary contaminant	
Organics	Magnitude and extent unknown	Organics have been detected in ground water south of the Albright and Wilson plant associated with other industrial plant discharges

[a]Reference:

1. Hydrogeologic Study of FMPC Discharge to the Great Miami River, August 1, 1988, IT Corp. Final Report.

lenses are erratically distributed throughout this material, wells completed in these units may yield up to 50 gpm. Large groundwater supplies occur in the outwash deposits (buried channel aquifer) and are recharged by three principal sources: recharge from bedrock, precipitation recharge, and recharge by stream infiltration. Although the shales and limestones have a low permeability, small amounts of water occur in erratically distributed joints and cracks and produce seepage into the glacial deposits. The permeability of the bedrock has been estimated to be five gallons per day per square foot (gpd/ft^2) of contact with the glacial deposits. Recharge by precipitation amounts to approximately 570,000 gpd per square mile of catchment area. Under natural conditions, the gradient of groundwater flow is from the aquifer to the Great Miami River, except during dry periods when the gradient is reversed. Intermittent recharge to the aquifer also occurs along Paddys Run.

The groundwater in the regional aquifer beneath the FMPC flows from the buried valleys west, north, and east towards the center of the FMPC study area (Figure 2-9). Groundwater would naturally exit the area by flowing south-southwest through the branch of the buried channel aquifer west of New Baltimore. However, the large capacity pumping wells of the Southwest Ohio Water Company (SOWC) in the "Big Bend" meander of the Great Miami River east of the FMPC produce a pronounced and persistent cone of depression in the potentiometric surface centered on the pumping wells. Due to bedrock geometry, the cone of depression extends more in the east-west direction than in the north-south direction.

Groundwater elevation maps indicate that the resultant cone of depression from the SOWC wells influences groundwater flow patterns beneath the FMPC. In particular, a groundwater flow divide is created such that groundwater underlying the northern portion of the FMPC, including those areas underlying the Waste Storage Area and the Production Area, flows to the east toward the SOWC wells and the Great Miami River. Groundwater from the southern/southwestern portion of the FMPC continues to flow along the natural gradient to the south-southeast through the buried valley. In the vicinity of the south plume, a groundwater component from the west is also present due to the western leg of the buried channel (Figure 2-9). This causes the recharge from certain reaches of Paddys Run to flow to the east/southeast toward the southern plume.

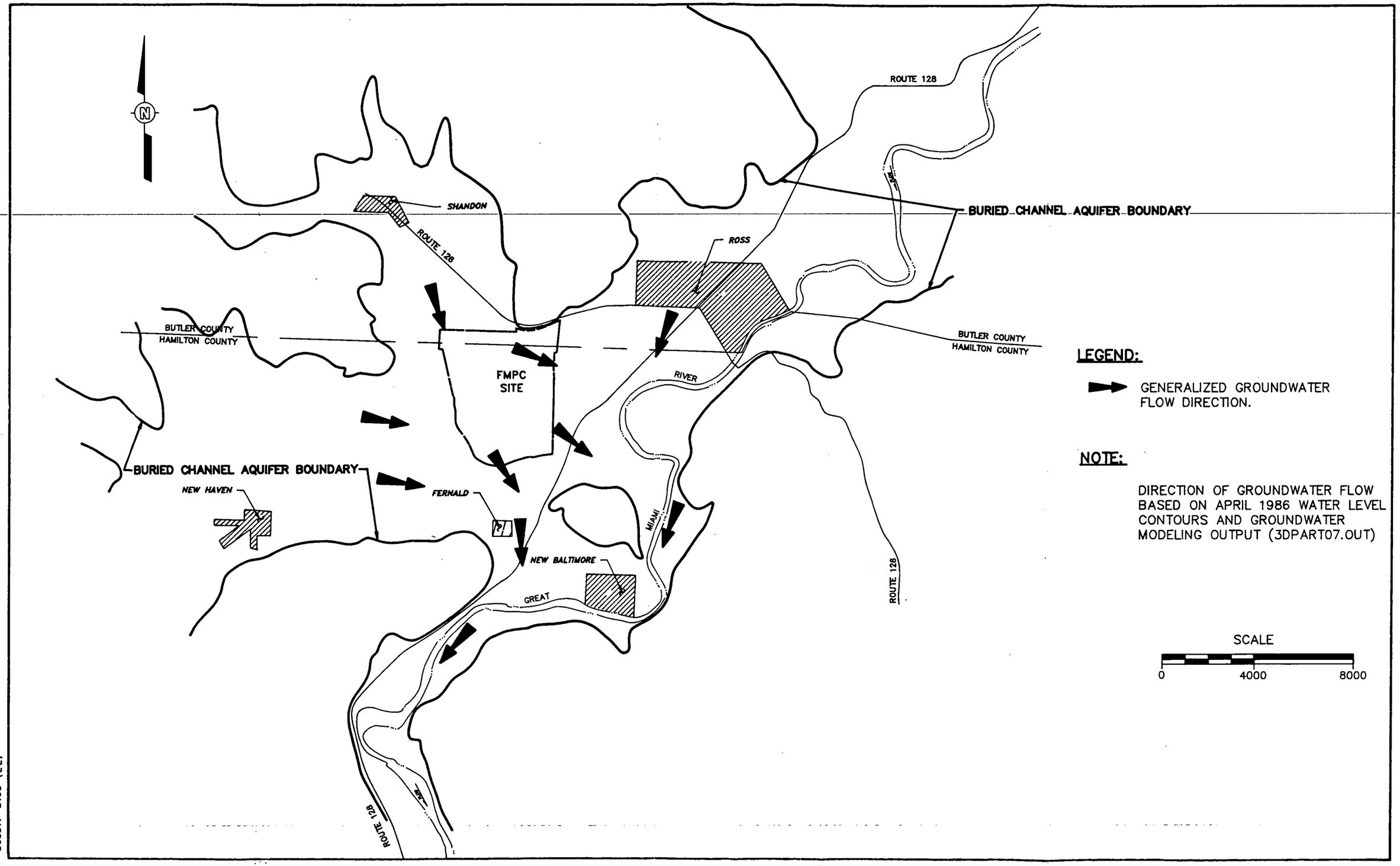


FIGURE 2-9
GENERALIZED GROUNDWATER FLOW
IN BURIED CHANNEL AQUIFER

2.2.4 Soils

Soils in the region were formed from parent materials deposited by the action of Wisconsin and Illinoisan glaciers. These glacial till materials consist of sands, gravels, silts, and clays. Soil variations result from different parent materials, variations in relief and drainage, and differences in the time of weathering. In many areas where surficial glacial deposits contain interbeds or where erosion has occurred, sand and gravel are at shallow depths.

Soils at the FMPC site and adjacent areas are primarily categorized as Fincastle-Xenia silt loams. These soils are light colored, medium acid, and moderately high in productivity when properly managed. Moisture-supplying capacity is moderate, as is fertility and organic content. The soils have formed as 18 to 40 inches of wind-blown material (loess) over limey loam till of Wisconsin age. Fincastle soils have poor drainage; in areas where these soils are predominant, artificial drainage is required for moderate crop productivity. If artificial drainage is not used, the water content remains high for extended periods in winter and spring. Due to FMPC development projects, native soils on site have been covered by paving materials, gravels, and buildings.

Soils along Paddys Run are categorized as Fox-Genesee loams. These soils are light colored, high in productivity, and moderate in fertility and organic matter. Fox soils are slightly to medium acid, moderate in moisture-supplying capacity, and well drained. They have formed as 24 to 40 inches of silty materials over sand and gravel on level areas of the first terrace above the stream's normal floodplain. Genesee soils occur on the stream's normal floodplain. They are well drained, high in moisture-supplying capacity, and are subject to flooding.

2.2.5 Vegetation and Wildlife

The FMPC is in a region containing beech and mixed deciduous forests. Generalized habitats in the area have been described as grazed pastures, ungrazed pastures, pine plantations, riparian zones, and woodlots (WMCO 1987). Woods occur mainly along Paddys Run and north of the Production Area, and contain ash, sugar maple, sycamore, and cottonwood. Grasses and herbs dominate the pasture

areas. Aquatic species such as cattails and rushes grow along drainage ditches. Area habitats support a number of species, although the habitats have not been described as unique.

Mammals in the FMPC area predominantly include the whitetail deer, eastern cottontail, fox squirrel, eastern chipmunk, wood chuck, and raccoon. Birds requiring open pasture, wooded, and shrubby field habitats have been observed on the site. These include the red-winged blackbird, mourning dove, blue jay, tufted titmouse, song sparrow, and common yellow throat.

The FMPC is within the geographic ranges of several species determined by the U.S. Fish and Wildlife Service to be endangered or threatened. These include the Indiana bat, bald eagle, peregrine falcon, and northern wild monkshood (50 CFR 17.11 and 17.12). The potential habitat for these species along the Great Miami River and Paddys Run is generally fair or poor. Areas along Paddys Run adjacent to the south plume project area range from poor to excellent habitat areas. There are no critical habitats in the vicinity of the FMPC.

During the RI/FS biological sampling activity, Indiana bats were not found on or adjacent to the FMPC but were netted at a monitoring site three miles northeast of the FMPC boundary. The bald eagle and peregrine falcon do not nest in the counties surrounding the FMPC site; they would occur in the area only as rare transients along the Great Miami River. No indication of the northern wild monkshood was observed within the FMPC area.

A number of fish have been identified in the area, mainly minnows and darters in Paddys Run, and carp, gizzard shad, and sunfish in the Great Miami River (WMCO 1988). Fish populations in the Great Miami River remain healthy and have not changed appreciably since 1984 (WMCO 1988).

A study to assess the acute and chronic toxic effects of effluent from the FMPC on the algae, invertebrates, and fish in the Great Miami River is being conducted as part of the RI/FS for the environmental media operable unit. Additionally, the effects of the effluent on the macroinvertebrate community structure in the Great Miami River are being examined during the RI/FS.

2.2.6 Land Use and Population

The area surrounding the FMPC is mainly agricultural, with dairy, beef, corn, and soy bean production. Several industries, including Delta Steel, Albright & Wilson Chemical Company, Ruetgers-Nease Chemical Company, two commercial gravel operations, and a cement plant are located south of the site. The Miami Whitewater Forest, a Hamilton County park, is located five miles to the southwest of the FMPC.

Scattered residences and several villages, including Fernald, New Baltimore, Ross, and Shandon, are located near the FMPC. The city of Cincinnati and its suburbs are 10 to 15 miles southeast of the FMPC and the town of Hamilton is eight miles to the northeast. There is an estimated population of over 14,000 within a five-mile radius of the site.

The area surrounding the FMPC contains several sites of historical interest, but none are within the immediate study area of the south plume. The National Register of Historic Places lists four prehistoric Indian sites within a three-mile radius. These include the Adena Circle, the Demoret Mound, the Colerain Work, and the Dunlap Work. The closest site, the Colerain Work, is situated approximately one mile east of the FMPC. The State Historical Preservation Officer reports that there are no known sites of archaeological significance on the FMPC site. There are also no known archaelogical sites in the area of the South Plume removal action being considered.

2.3 ANALYTICAL DATA

Elevated levels of uranium have been recorded as early as 1981 in groundwater south of the FMPC. During the RI/FS process, additional monitoring wells have been installed and others are proposed for on- and off-site locations to further evaluate the extent and magnitude of the uranium plume and to determine if other radionuclides or chemicals are present. The locations of the existing monitoring wells in the south plume study area are shown in Figure 2-10. The 2000-Series wells are screened approximately five feet above to ten feet below the water table. The 3000-Series wells have ten feet of screen located approximately near the middle of the aquifer. The 4000-Series wells have ten feet of screen near the bottom of the aquifer.

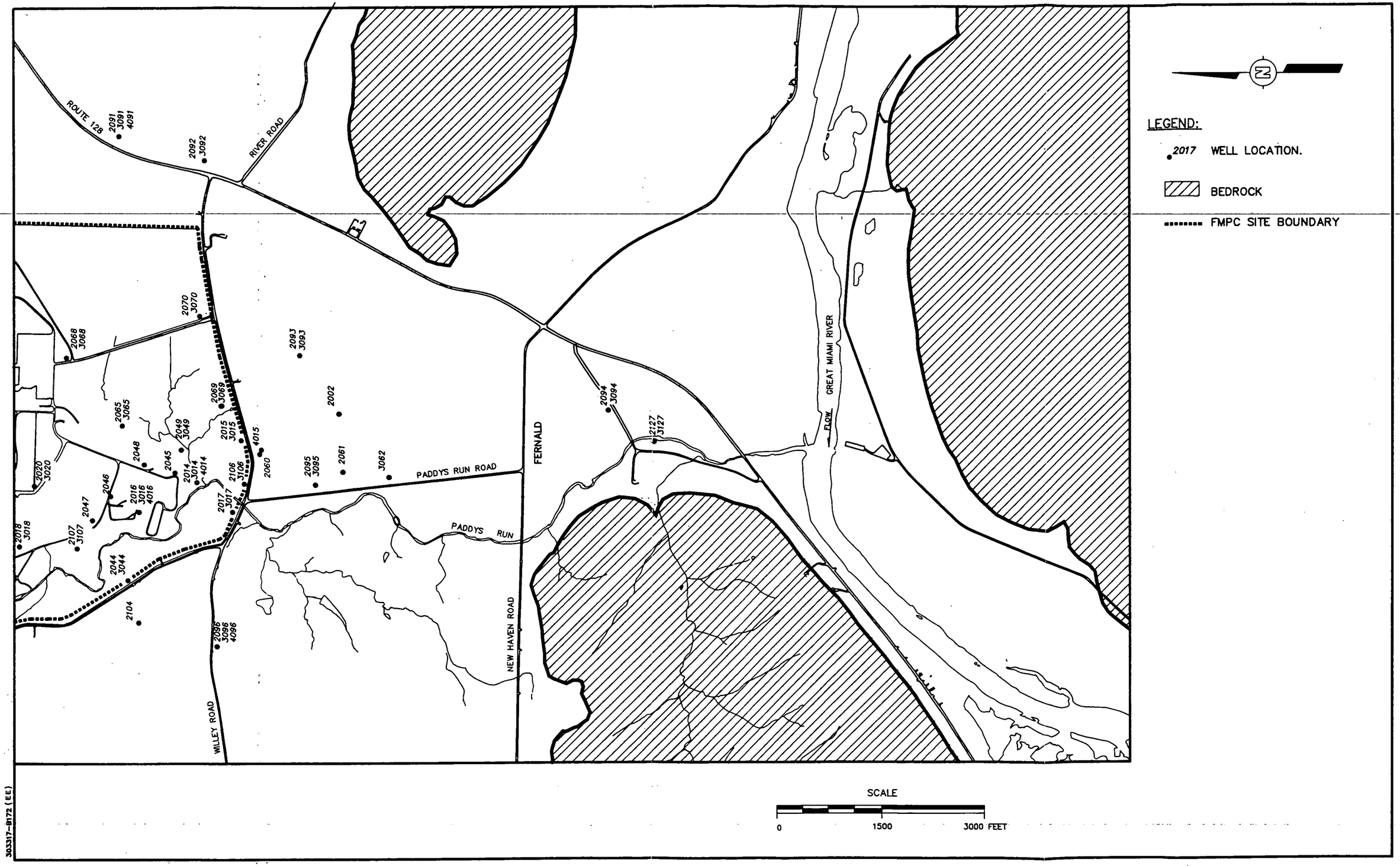


FIGURE 2–10
SOUTH PLUME GROUNDWATER STUDY
MONITORING WELL LOCATIONS

RI/FS analytical data available as of September 15, 1989 were utilized for the evaluation of the south plume removal action. The dates of the quarterly groundwater sampling program for the RI/FS are shown in Table 2-2. Wells were sampled as they were completed and on a quarterly basis for one year. Wells completed during the first year of the sampling program have already been sampled four times. Wells completed later in the program have been sampled at least twice.

As will be discussed in Section 2.4.3.1, uranium is the principal constituent of concern to the south plume groundwater study. Uranium data from Rounds 1 through 6 of the RI/FS sampling program are tabulated in Tables 2-3 through 2-5. The range of uranium concentrations in groundwater in the study area is from less than 1 µg/ℓ to approximately 850 µg/ℓ. The highest uranium value (850 µg/ℓ) was observed in Well 2046, which is located on site near the Southfield Area (Figure 2-10), during Round 5 sampling. Round 4 sampling for this same well measured a uranium value of 309 µg/ℓ. Round 6 sampling measured a value of 232 µg/ℓ for total uranium. The reason for the increase in uranium concentration during round 5 sampling of well 2046 is currently being investigated as part of the ongoing RI. The highest uranium value recorded off site during RI/FS sampling was 292 µg/ℓ for Well 2061.

Uranium concentration distributions based on Round 4 data are shown in Figures 2-11 through 2-13 for the three levels of the aquifer monitored. This data set was selected since the greatest number of wells were sampled during Round 4. The groundwater monitoring data show that a uranium plume emanates from the FMPC site and is moving toward the south in a narrow band east of Paddys Run.

As indicated in Figures 2-11 through 2-13, the highest uranium concentrations are located in the upper layer of the aquifer (2000-Series wells), with a substantial reduction in concentrations with depth (3000- and 4000-Series wells). The highest uranium concentration recorded for a 3000-Series well during RI/FS sampling events is 62 µg/ℓ for Well 3062, an industrial water supply well pumping from near the middle of the aquifer (see below). The 4000-Series wells have had uranium concentrations consistently less than 1 µg/ℓ.

TABLE 2-2

FERNALD RI/FS
GROUNDWATER SAMPLING DATES

ROUND NO.	START DATE	FINISH DATE	YEAR/QUARTER
1	03/20/88	06/30/88	88/Second
2	07/13/88	09/21/88	88/Third
3	10/20/88	12/16/88	88/Fourth
4	01/09/89	04/02/89	89/First
5	04/19/89	06/07/89	89/Second
6	07/25/89	08/02/89	89/Third

TABLE 2-3

FERNALD RI/FS
SOUTH PLUME TOTAL URANIUM CONCENTRATIONS
2000-SERIES WELLS

	TOTAL URANIUM, µg/ℓ					
WELL NO.	ROUND 1	ROUND 2	ROUND 3	ROUND 4	ROUND 5	ROUND 6
2002	a	a	a	a	2	<1
2014	32	33	35	17	b	33
2015	168	169	185	186	b	b
2016	21	18	17	22	b	d
2017	3	4	3	4	b	b
2018	2	<1	3	4	b	b
2020	3	<1	<1	<1	b	b
2044	2	1	33	1	b	b
2045	a	a	a	283	265 291[c]	341
2046	a	a	a	309	850	232
2047	a	a	a	15	10	9
2048	a	a	a	<1	<1	<1
2049	130	8	3 2[c]	6	175	147
2060	242 203[c]	225	171	250	b	b
2061	247	260	260	292	b	b
2065	10	9	7	9 8[c]	b	12 11[c]
2068	<1 3[c]	2	<1	<1	b	b
2069	6	13	12	12	b	b
2070	<1	1	<1	<1	b	b
2091	a	<1	<1	1	1.2	b
2092	a	7	<1	1	1.5	b
2093	a	<1 1[c]	<1	1.0	0.5	b

See footnotes at end of table.

TABLE 2-3
(Continued)

WELL NO.	TOTAL URANIUM, µg/ℓ ROUND 1	ROUND 2	ROUND 3	ROUND 4	ROUND 5	ROUND 6
2094	a	2	<1	4.5	<0.1	b
2095	a	169	177	146	208 195[c]	b
2096	a	1	<1	0.4	1.4	b
2104	<1	0.3	0.4	0.4	b	b
2106	a	a	a	61	16	b
2107	a	a	a	14	9	b
2127	a	a	a	37	6	14

[a]Well installation not completed.

[b]Well not sampled.

[c]Duplicate sample.

[d]Data not available.

Notes: Data validation is not complete for Rounds 5 and 6.

Uranium values reported with a decimal fraction reflect laboratory detection limits of 0.1 µg/ℓ. All other values reflect laboratory detection limits of 1 µg/ℓ.

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TABLE 2-4
FERNALD RI/FS
SOUTH PLUME TOTAL URANIUM CONCENTRATIONS
3000-SERIES WELLS

WELL NO.	TOTAL URANIUM, µg/ℓ ROUND 1	ROUND 2	ROUND 3	ROUND 4	ROUND 5	ROUND 6
3014	23	29	28	30	b	b
3015	4	<1	<1	<1	b	b
3016	11	9	8	7	b	b
3017	<1	<1	<1	<1	b	b
3018	2	2	1	2	b	b
3020	<1	<1	<1	<1	b	b
3044	2	<1	<1	<1	b	b
3049	a	a	a	<1	<1	b
3062	62	37	41	44	b	b
3065	a	a	a	<1	<1	b
3068	2	<1 <1[c]	<1	<1	b	b
3069	3	1	11	<1	b	b
3070	2	2	<1	<1	b	b
3091	a	<1	<1	<1	0.1	b
3092	a	<1	<1	<1	0.2	b
3093	a	<1	<1	<1	0.5	b
3094	a	<1	<1	0.6	<0.1	b
3095	a	13	5	6	4	b
3096	a	<1	1	0.7	0.8	b
3106	a	a	a	2	<1	b
3107	a	a	a	2	1	b
3127	a	a	a	<1	<1	<1

[a]Well installation not completed.

[b]Well not sampled.

[c]Duplicate sample.

Notes: Data validation is not complete for Rounds 5 and 6.

Uranium values reported with a decimal fraction reflect laboratory detection limits of 0.1 µg/ℓ. All other values reflect laboratory detection limits of 1 µg/ℓ.

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TABLE 2-5

FERNALD RI/FS
SOUTH PLUME TOTAL URANIUM CONCENTRATIONS
4000-SERIES WELLS

	TOTAL URANIUM, µg/ℓ					
WELL NO.	ROUND 1	ROUND 2	ROUND 3	ROUND 4	ROUND 5	ROUND 6
4014	a	a	a	<1	<1	b
4015	<1 <1[c]	<1	<1	<1	b	b
4016	a	a	a	<1	<1	b
4091	a	2	<1 <1[c]	<1	<0.1	b
4096	a	2	0.5 0.7[c]	0.5	0.8	b

[a]Well installation not completed.

[b]Well not sampled.

[c]Duplicate sample.

Notes: Data validation is not complete for Round 5 and 6.

Uranium values reported with a decimal fraction reflect laboratory detection limits of 0.1 µg/ℓ. All other values reflect laboratory detection limits of 1 µg/ℓ.

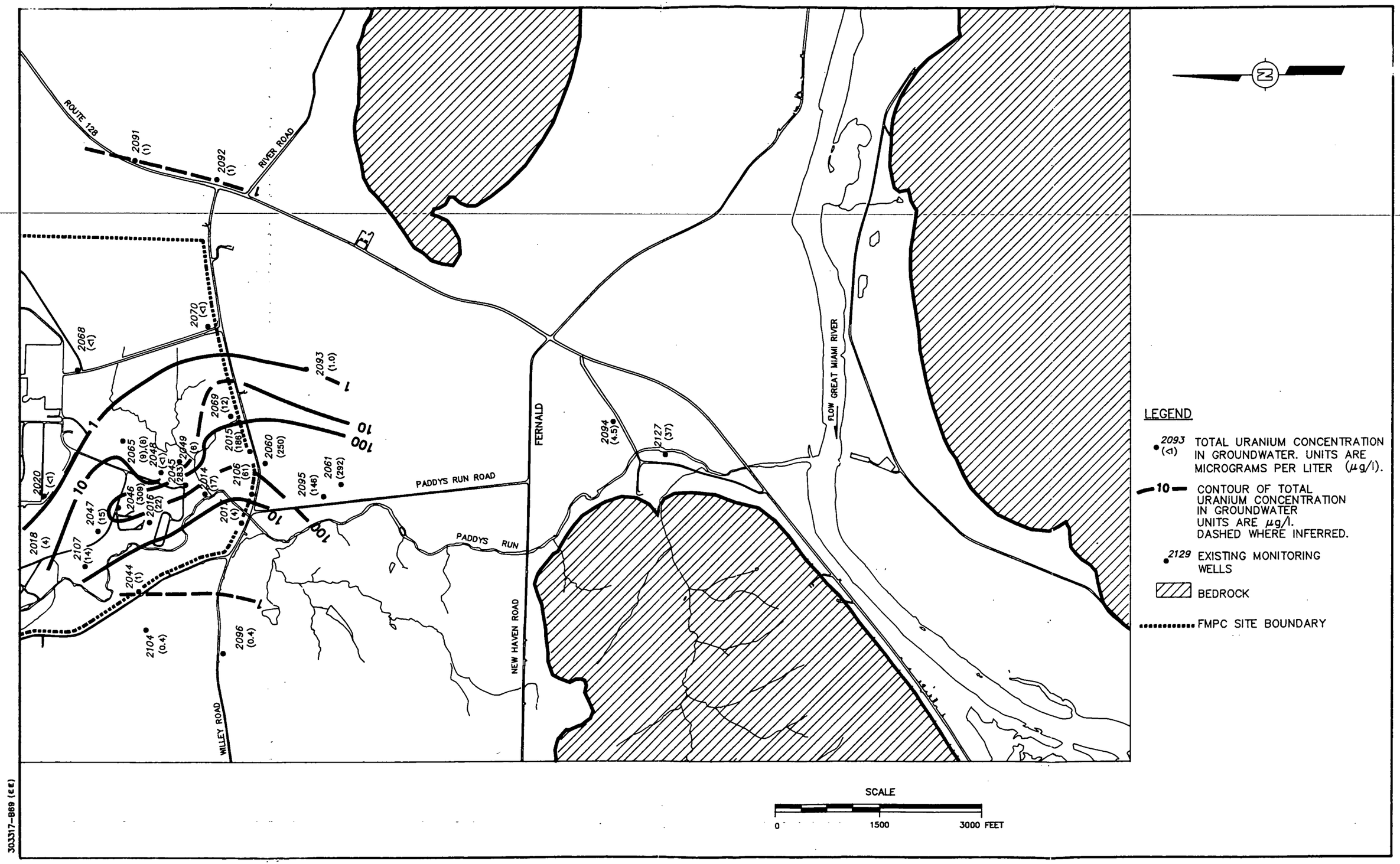


FIGURE 2–11
ROUND 4 – FIRST QUARTER 1989
URANIUM CONCENTRATION IN GROUNDWATER
2000 SERIES WELLS

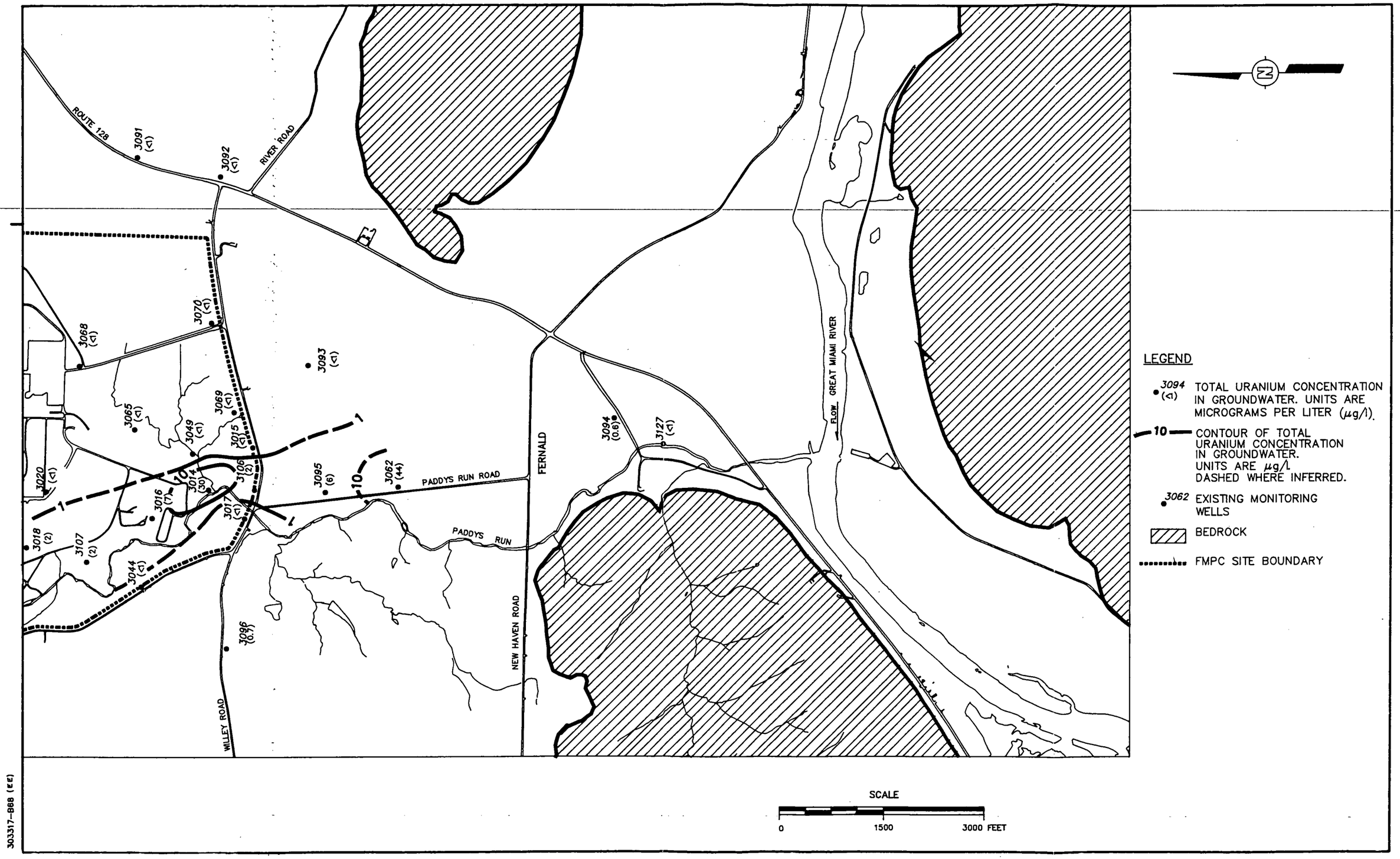


FIGURE 2-12
ROUND 4 – FIRST QUARTER 1989
URANIUM CONCENTRATION IN GROUNDWATER
3000 SERIES WELLS

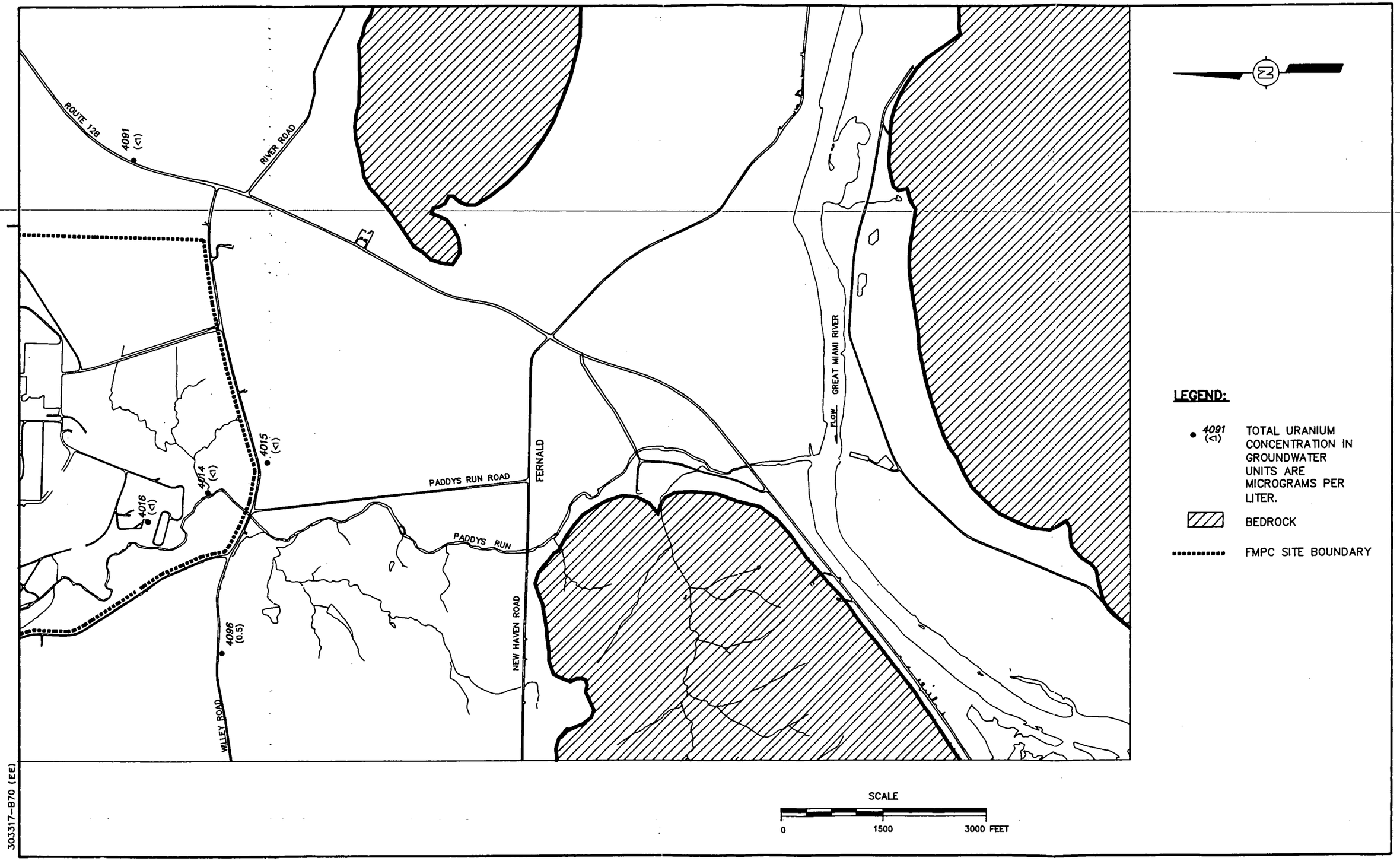


FIGURE 2-13
ROUND 4 – FIRST QUARTER 1989
URANIUM CONCENTRATION IN GROUNDWATER
4000 SERIES WELLS

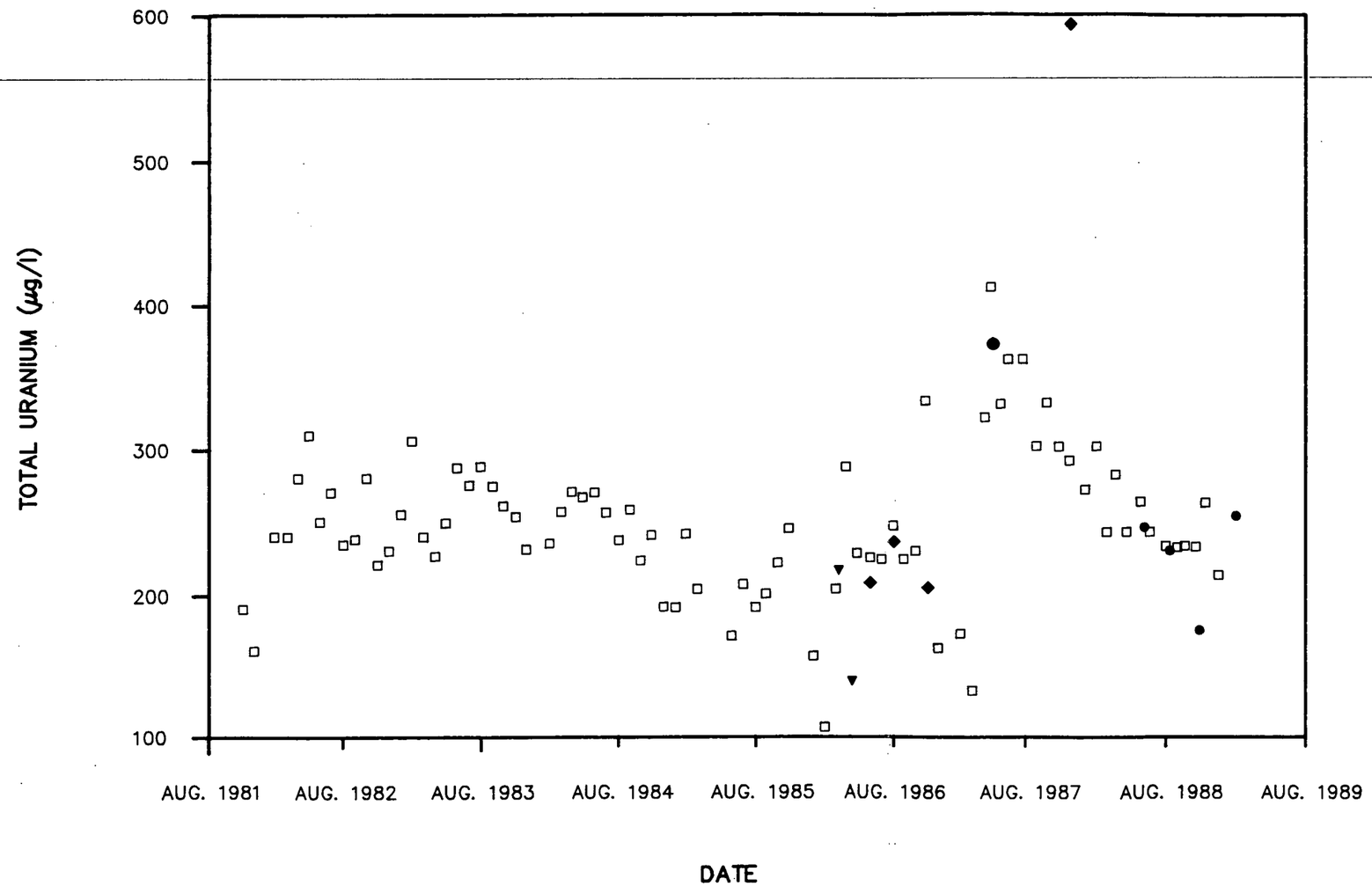
Wells 2060, 2061, and 3062 are located south of the FMPC (Figure 2-10). They are being used as RI/FS monitoring wells even though they were not installed and are not owned by DOE. The purpose of incorporating them into the RI/FS well network is that they have been sampled by DOE for many years and provided a substantial data base for uranium concentrations within the regional aquifer.

Elevated levels of uranium were first reported for these wells in mid-1981 (Figures 2-14 through 2-16). Uranium concentrations for Well 2060 have generally been between 200 and 300 µg/ℓ, with values periodically fluctuating above and below this range. Uranium concentrations for Well 2061 dropped from values above 400 µg/ℓ during the early monitoring period to current values generally between 200 and 350 µg/ℓ. Uranium concentrations for Well 3062 have historically ranged between 40 and 80 µg/ℓ.

It is not expected that the uranium concentration levels observed in samples from Well 3062 are representative of the aquifer at this depth. Well 3062 is a pumping well used for industrial water supply purposes. The well is screened near the middle of the aquifer. It is likely that water containing higher levels of uranium is being pulled downward from the upper zone of the aquifer and then diluted by water of varying uranium concentrations being drawn radially into the well from other directions.

2.4 SITE CONDITIONS THAT JUSTIFY A REMOVAL ACTION

The threats posed by the off-site migration of uranium in the south plume are not of a time-critical nature, i.e., no imminent or substantial endangerment of the public or the environment related to contaminants currently exists that would necessitate initiation of a response action within six months. However, the site conditions do meet certain criteria listed in the NCP for categorization of specific cleanup efforts as removal actions. The eight factors to be considered in determining the appropriateness of a removal action, as listed in Section 300.415 of the March 1990 version of the NCP, are:

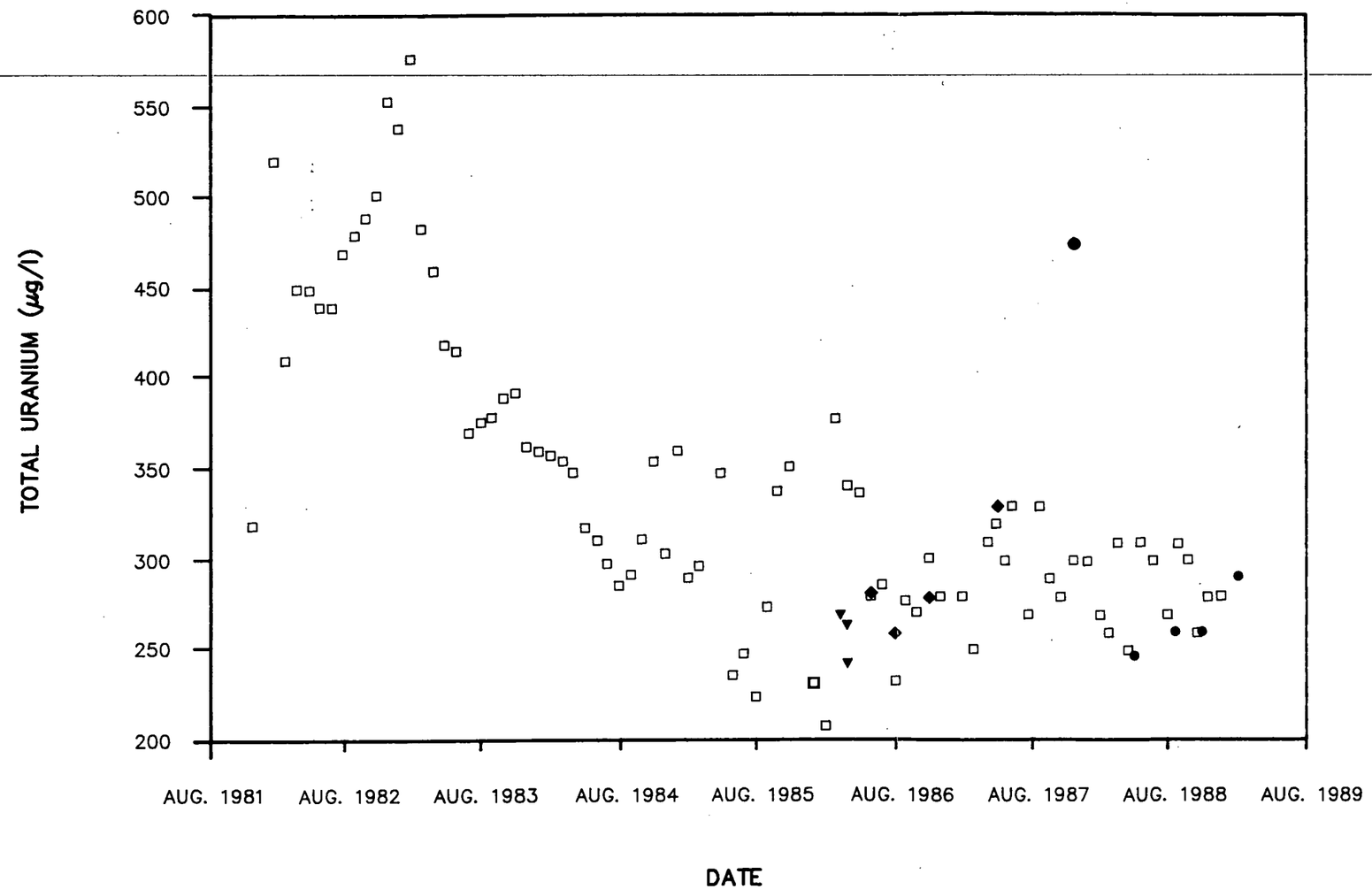


LEGEND:

- □ NATIONAL LEAD OF OHIO INC./ WESTINGHOUSE MATERIALS COMPANY OF OHIO, UNPUBLISHED ENVIRONMENTAL MONITORING DATA, NOVEMBER 1981–DECEMBER 1988.
- ▼ IT CORPORATION; "ADDENDUM TO FINAL INTERIM REPORT; AIR, SOIL, WATER, AND HEALTH RISK ASSESSMENT IN THE VICINITY OF THE FMPC; FERNALD OHIO;" MARCH 1986–APRIL 1986. CONVERTED FROM pCi/l TO (µg/l) USING 1pCi=1.4925 µg.
- ◆ DAMES AND MOORE, VOL. 2–5; ADVANCED SCIENCES CORPORATION AND IT CORPORATION, VOL 6; RCRA GROUND WATER MONITORING REPORT; JUNE 1986–NOVEMBER 1987. VOL. 6 DATA CONVERTED FROM pCi/l TO µg/l USING 1pCi=1.4925 µg.
- ● ADVANCED SCIENCES CORPORATION AND IT CORPORATION, REMEDIAL INVESTIGATION AND FEASIBILITY STUDY SAMPLING, MAY 1988–FEBRUARY 1989.

303317–B161 (EE)

FIGURE 2–14
TEMPORAL TOTAL URANIUM VARIATION
IN GROUNDWATER
WELL 2060

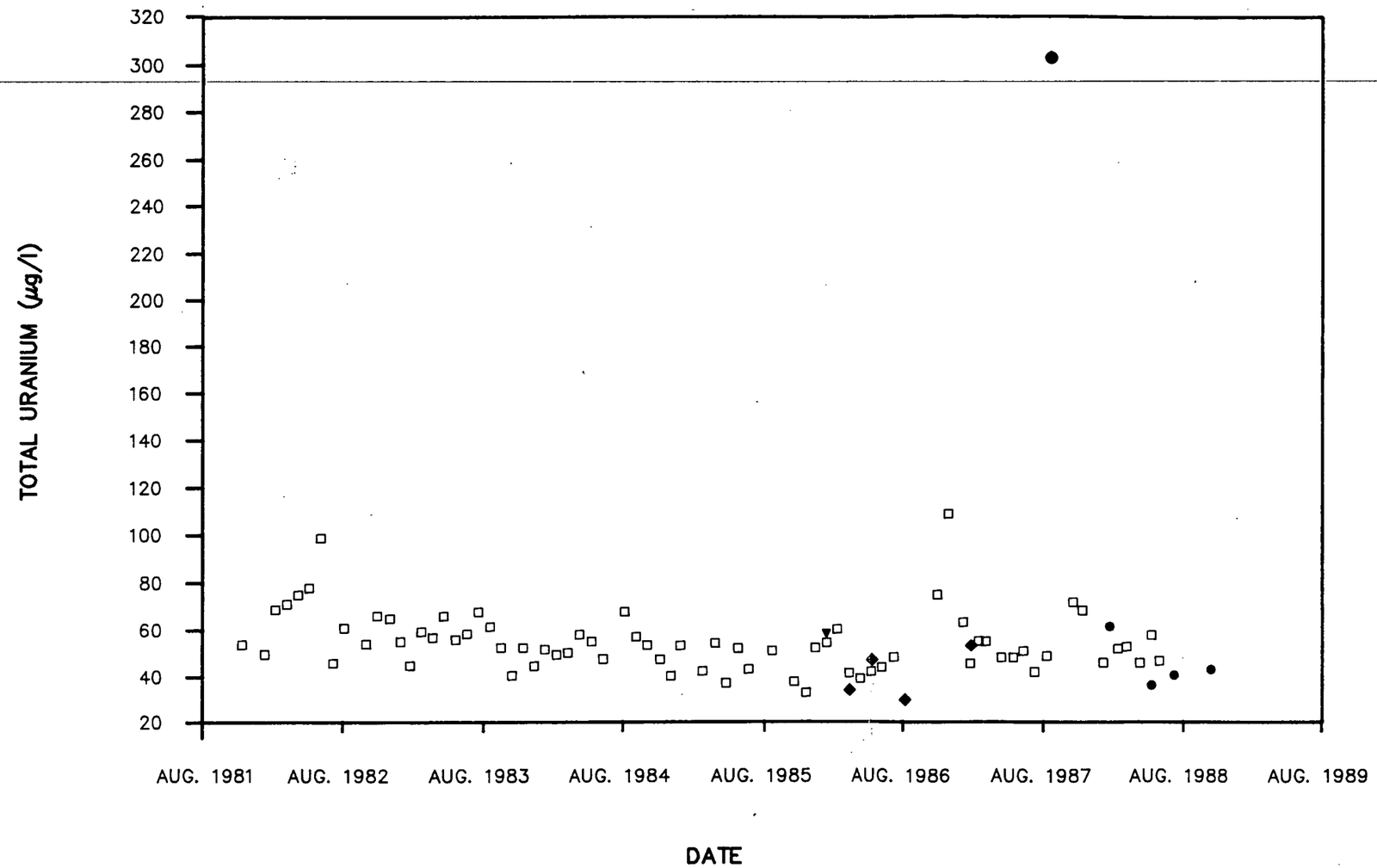


LEGEND:

- □ NATIONAL LEAD OF OHIO INC./ WESTINGHOUSE MATERIALS COMPANY OF OHIO, UNPUBLISHED ENVIRONMENTAL MONITORING DATA, NOVEMBER 1981–DECEMBER 1988.
- ▼ IT CORPORATION; "ADDENDUM TO FINAL INTERIM REPORT; AIR, SOIL, WATER, AND HEALTH RISK ASSESSMENT IN THE VICINITY OF THE FMPC; FERNALD OHIO;" MARCH 1986–APRIL 1986. CONVERTED FROM pCi/l TO (µg/l) USING 1pCi=1.4925 µg.
- ◆ DAMES AND MOORE, VOL. 2–5; ADVANCED SCIENCES CORPORATION AND IT CORPORATION, VOL 6; RCRA GROUND WATER MONITORING REPORT; JUNE 1986–NOVEMBER 1987. VOL. 6 DATA CONVERTED FROM pCi/l TO µg/l USING 1pCi=1.4925 µg.
- ● ADVANCED SCIENCES CORPORATION AND IT CORPORATION, REMEDIAL INVESTIGATION AND FEASIBILITY STUDY SAMPLING, MAY 1988–FEBRUARY 1989.

303317-B159 (EE)

FIGURE 2–15
TEMPORAL TOTAL URANIUM VARIATION
IN GROUNDWATER
WELL 2061



LEGEND:

- ◻ NATIONAL LEAD OF OHIO INC./ WESTINGHOUSE MATERIALS COMPANY OF OHIO, UNPUBLISHED ENVIRONMENTAL MONITORING DATA, NOVEMBER 1981–DECEMBER 1988.
- ▼ IT CORPORATION; "ADDENDUM TO FINAL INTERIM REPORT; AIR, SOIL, WATER, AND HEALTH RISK ASSESSMENT IN THE VICINITY OF THE FMPC; FERNALD OHIO;" MARCH 1986–APRIL 1986. CONVERTED FROM pCi/l TO (µg/l) USING 1pCi=1.4925 µg.
- ◆ DAMES AND MOORE, VOL. 2–5; ADVANCED SCIENCES CORPORATION AND IT CORPORATION, VOL 6; RCRA GROUND WATER MONITORING REPORT; JUNE 1986–NOVEMBER 1987. VOL. 6 DATA CONVERTED FROM pCi/l TO µg/l USING 1pCi=1.4925 µg.
- ● ADVANCED SCIENCES CORPORATION AND IT CORPORATION, REMEDIAL INVESTIGATION AND FEASIBILITY STUDY SAMPLING, MAY 1988–FEBRUARY 1989.

303317–B160 (EE)

FIGURE 2–16
TEMPORAL TOTAL URANIUM VARIATION
IN GROUNDWATER
WELL 3062

1. Actual or potential exposure to hazardous substances or pollutants or contaminants by nearby populations, animals, or food chains

2. Actual or potential contamination of drinking water supplies or sensitive ecosystems

3. Hazardous substances, pollutants or contaminants--in drums, barrels, tanks, or other bulk storage containers--that may pose a threat of release

4. High levels of hazardous substances or pollutants or contaminants in soils, largely at or near the surface, that may migrate

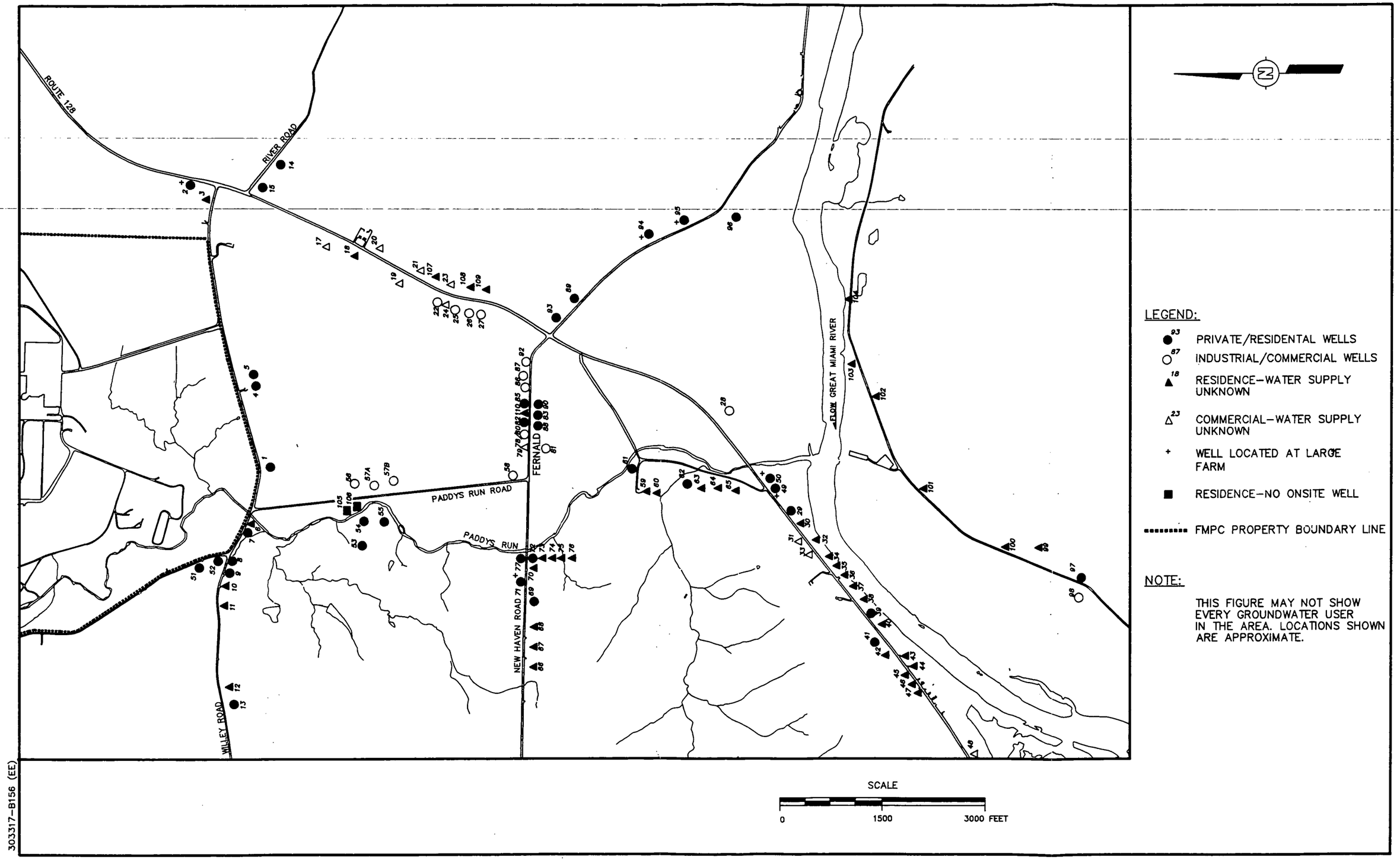
5. Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released

6. Threat of fire or explosion

7. Availability of other appropriate federal or state mechanisms to respond to a release

8. Other situations or factors that may pose threats to public health or welfare and the environment

Of the eight factors to be considered, the potential contamination of drinking water supplies and the associated potential for exposure reflected in the first two factors are relevant to the south plume removal action. Groundwater containing uranium at concentration levels exceeding the derived concentration of 33 µg/ℓ for uranium in drinking water is present at off-site locations south of the FMPC. DOE Order 5400.5 (DOE 1990) sets guidelines now in effect for the FMPC for the discharge of radionuclides. Concentrations established from these guidelines are called "derived concentrations". The derived concentration in air or water (in this case water) is that concentration, which under conditions of exposure of one year by one exposure mode (i.e., ingestion of groundwater), would result in an effective dose equivalent of 100 milirems (mrem). Potential groundwater users are located in and adjacent to the study area (Figure 2-17). Only two of these groundwater users currently remove groundwater at locations known to contain elevated levels of uranium exceeding the 33 µg/ℓ value; the use of this water is limited to industrial/commercial purposes.



303317-B156 (EE)

FIGURE 2-17
POTENTIAL AND KNOWN
GROUNDWATER USERS
SOUTH OF THE FMPC

The impacted aquifer is within the buried valley aquifer of the Great Miami River Basin, which has been designated as a Sole-Source Aquifer by the U.S. EPA under Section 1424(e) of the Safe Drinking Water Act (Federal Register, Vol. 53, No. 131, Friday, July 8, 1988). Under this designation, the of Administrator of Region V of the U.S. EPA has determined that this aquifer is the sole or principal source of drinking water for this area and that if contaminated would create a significant hazard to public health.

2.4.1 Release Mechanisms

If left unattended, the plume of elevated uranium concentrations in groundwater south of the FMPC would be expected to continue to migrate south-southeast along the regional groundwater flow path in the buried channel aquifer. This projected path would carry the plume beneath New Haven Road near State Highway 128 and eventually to the Great Miami River just upstream from the confluence of Paddys Run with the river. Groundwater flow velocities along this path are estimated to be about 1300 feet per year. The migration rate of the plume would be less than the estimated groundwater flow velocities as a result of the retardation effects caused by the physiochemical interchange of the dissolved uranium with the solid matrix through which it is flowing. Results of the groundwater flow/solute transport model indicate a calculated plume movement of approximately 220 feet per year.

Current data indicate that two distinct areas of elevated uranium concentrations may exist in the groundwater within the southerly flow regime beneath the FMPC and adjacent off-site areas. The primary focus of the south plume removal action is a plume that is centered off site to the northeast of the industrial/commercial facilities along Paddys Run Road. A second plume may exist on site in the vicinity of the Southfield Area and the fly ash piles. Considerably lower levels of uranium have been measured in wells between these two areas during several of the sampling rounds.

The reason for the dual plume theory is the potential existence of multiple sources of uranium. Based on the current understanding of plant operations and records, site hydrology, and results of the groundwater modeling study, the principal source of the off-site plume has been determined to be historical releases of uranium-enriched water from Paddys Run and the storm water outfall ditch.

Because the bottom sediments of these water courses are highly permeable in the reaches north and west of the south plume, the uranium-enriched water directly entered the regional aquifer. This recharge water became part of the groundwater flow which was moving toward the south plume area. (Figures 2-1 and 2-9). The uranium in Paddys Run and the storm water outfall ditch had its source in storm water runoff prior to controls and the historic pumping of groundwater from the Waste Storage Area to Paddys Run.

The on-site plume may be caused by a slower and more recent infiltration of uranium from the Southfield Area and possibly the fly ash piles into the underlying aquifer. Infiltration along Paddys Run also continues, but the associated uranium levels are greatly reduced. Another possible explanation for the two concentration distributions is that the current recharge of water containing much lower levels of uranium along the storm water outfall ditch dilutes the more recent, southerly migrating groundwater plume. Additional field studies of this area are planned under the RI/FS to accurately define the source(s) and concentrations of uranium. Any remedial actions deemed necessary to prevent a continuing off-site problem due to releases across the FMPC site boundary will be addressed under the RI/FS for the environmental media operable unit. The elimination or reduction of the ultimate sources of the releases is the focus of the other operable units concerned with the various waste areas.

The RI/FS study area for the environmental media operable unit has been defined to include both the on-site and off-site areas of the Great Miami Aquifer. This definition is consistent with the requirement that long-term migration potential and remediation goals be considered in the RI/FS. Only the existing off-site plume is being considered for the south plume removal action. The reasons are the apparent historic nature of the plume area, the current conclusion that no continuing source contributes significantly to further groundwater contamination in the south plume, and the anticipated accelerated movement of the existing plume as it passes through the narrow buried channel south of the FMPC. Even though the removal action is limited to the off-site groundwater plume, the uranium that continues to cross the site boundary as surface flow in Paddys Run and in the groundwater is considered in the evaluation of both the no-action alternative and the various removal methods.

2.4.2 Environmental Fate

As described in the previous section, the south plume is expected to continue to migrate southward and will eventually be released into the Great Miami River. Upon release to the river, the uranium concentrations would be significantly less than at the current observation points due to the dispersion and dilution of the plume along its migration path. Additionally, substantial dilution of the groundwater will occur as it discharges to the river and mixes with surface water. Unless contaminated groundwater is removed via pumping, no other environmental exposure is expected due to the depth of the plume.

Imposed pumping stresses can highly influence groundwater migration pathways, as evidenced by the effects of the SOWC wells on groundwater behavior beneath the FMPC. No pumping of this magnitude currently exists in the south plume area and none is projected unless as part of a removal or final remedial action. The effects of the existing industrial wells have been accounted for in the interpretation of field data and the evaluation of removal action alternatives.

2.4.3 Potential Risks

Public health risk requires the presence of contaminants that pose either a radiological or chemical hazard, pathways for potential exposure, and human and environmental receptors subject to exposure. Each of these components is summarized in the following sections for the off-site plume of uranium in groundwater south of the FMPC.

2.4.3.1 Contaminants of Concern

Groundwater data collected to date from the sand and gravel aquifer indicates the presence of radionuclides and inorganic metals in the south plume. Most of the radionuclides are found at natural background concentrations. None of the radionuclides or metals exceed established or derived drinking water limits with the exception of uranium. Certain organic chemicals have also been observed in some samples, but these observations have not been persistent for the same monitoring wells and are below published allowable maximum concentration levels for organics detected. For this reason, uranium has been designated as the contaminant of concern for the south plume removal

action. All considered actions that account for public health and environmental protection against uranium will also provide protection against other radionuclides and chemicals due to the low levels present.

Uranium presents potential health risks due to its chemical toxicity and as a result of alpha radiation emissions. Insoluble uranium compounds primarily pose a radiological hazard resulting from inhalation and lung irradiation. Chemical toxicity is considered the controlling hazard for soluble uranium compounds of principal concern in the groundwater of the south plume. If ingested at sufficiently high rates, these compounds can lead to kidney damage and arterial lesions. Other potential adverse health effects that can result from ingestion of soluble uranium compounds are damage to the cardiovascular, hematopoietic, endocrine, and immunological systems.

For purposes of the South Plume EE/CA, the extent and distribution of uranium in the south plume have been established by combining groundwater monitoring data with the results of a groundwater flow/solute transport model (Appendix A). The monitoring data were utilized to establish the following: (1) a lower limit on the maximum concentration in the south plume (i.e., the maximum observed off-site RI/FS value of 292 µg/ℓ); (2) a conservative estimate of the shape and extent of the plume (as defined by those wells closest to the plume that exhibit background levels of uranium); (3) direct evidence of the uranium levels at actual receptor locations; and (4) the general shape of the uranium plume for use in calibrating the model.

The model was then used to interpolate between and extrapolate beyond the points of field observation. By doing so, the full distribution pattern of uranium in the south plume both today and under assumed future conditions could be estimated. Figure A-3 presents the estimated current distribution of uranium in the upper aquifer (2000-Series Wells) as developed from model results. These results could vary depending on the actual parameter values assumed in the model. The plume is shown as an elongated ellipse oriented in a northwest/southeast direction due to the groundwater flow patterns through a narrow, north/south trending buried channel. The center of the plume is predicted to lie approximately 800 feet south of Willey Road and north of the developed areas along

Paddys Run and New Haven Road. The maximum concentration predicted with the model is approximately 600 µg/ℓ and exceeds the maximum off-site value observed during the current RI/FS sampling (292 µg/ℓ) by a factor of approximately two.

Based on this representation of the plume, approximately 100 acres of off-site property is underlain by groundwater exceeding the derived concentration of 33 µg/ℓ for uranium in drinking water. This value is based on the 50-year committed effective dose equivalent (CEDE) limit of 4 mrems from an annual intake of radioactive materials in drinking water. (The basis for this value is discussed further in Section 5.1.1). The DOE has specified that this CEDE limit shall apply to releases to all off-site areas where water could be used as a drinking water source (DOE 5400.5).

2.4.3.2 Exposure Pathways

In the case of the south plume, exposure to the contaminants can occur only if the groundwater reaches the ground surface. The primary mechanisms are groundwater discharge to a surface water course and pumping. Because the model predicts that the south plume will not migrate to the Great Miami River or any other surface water course within the projected life of the removal action (five years), groundwater discharge to surface waters is not considered as an exposure pathway for purposes of this EE/CA. An exception is that exposure pathways associated with pumped groundwater discharged to the Great Miami River are considered in the evaluation of the effectiveness of the removal action alternatives that involve pumping.

Pumping occurs and will continue to occur in the south plume area. The potential exposure pathways associated with pumping include direct ingestion of groundwater used as drinking water, ingestion of plants after use of the groundwater for irrigation, and ingestion of meat or milk from livestock exposed to the groundwater through direct intake or from irrigated crops.

2.4.3.3 Potential Receptors

There is no known use of groundwater with uranium levels exceeding the derived concentration limit of 33µg/ℓ from the south plume area for drinking water, feedstock watering, or crop irrigation.

Residences along Paddys Run Road to the west reportedly use cisterns with imported water. Groundwater monitoring results from commercial and residential wells along New Haven Road in or near the Village of Fernald indicate no elevated levels of uranium in the water supply. These results indicate that the uranium plume either is not present at the level of aquifer pumping or has not yet migrated to these locations.

The only known users of groundwater with uranium levels exceeding the derived concentration for uranium in drinking water are the industries located along Paddys Run Road southwest of the projected center of the plume. One of the two industries treats the water to remove uranium and other radionuclides and chemicals prior to its use. Untreated water is not used for drinking water supplies.

Potential future receptors of the uranium in groundwater south of the FMPC include the following:

- Persons who pump groundwater for potable use, crop irrigation, or livestock feeding from areas not currently impacted but located along the future migration pathway of the plume
- Persons who would use surface waters into which contaminated groundwater has been discharged following pumping

Locations of known and potential groundwater users south of the FMPC are shown in Figure 2-17.

3.0

3.0 REMOVAL ACTION OBJECTIVES

The principle objective of the removal action for the south plume is to reduce or mitigate the potential threat to the public and the environment from elevated uranium concentrations in groundwater. This and other objectives are further defined in Sections 3.1 through 3.3 in terms of response authority, scope and purpose, and compliance with applicable or relevant and appropriate requirements (ARARs) and other criteria or guidelines to be considered (TBCs).

3.1 RESPONSE AUTHORITY

Authority for responding to releases or threats of releases from a hazardous waste site is addressed in Sections 104 and 106 of CERCLA. Executive Order 12580 delegates Section 104 response authority to the Secretary of Energy for DOE sites. However, the U.S. EPA maintains response authority if an action is carried out in response to a Section 106 enforcement order. In accordance with the FFCA and the proposed revisions to this compliance agreement, the south plume action is being conducted under the U.S. EPA's Section 106 enforcement authorities. Section 300.415 of the March 1990 NCP contains the CERCLA removal authorities.

3.2 SCOPE AND PURPOSE

The scope of the proposed removal action can be broadly defined as management of radioactively contaminated groundwater in an off-site area south of the FMPC. As discussed in Section 2.4.3.1, the only contaminant of concern for the south plume removal action is uranium. Although the nature and extent of the south plume are not precisely known at this stage of the RI/FS environmental media operable unit, bounds have been determined to the south, east, and west of the known areas of elevated uranium concentrations based on the current understanding of local geology and hydrology, groundwater monitoring data, and groundwater modeling results. A reduced, yet continuing source of uranium appears to exist from on-site areas to the north. Although not a focal point of the removal action, this continuing source will be considered in the evaluation of removal action alternatives.

The fundamental objective of the removal action for the south plume is to protect public health by limiting access to and use of groundwater with uranium concentrations exceeding the derived concentration limit of 33 µg/ℓ for uranium in drinking water, as well as other appropriate risk-based levels for various potential exposure scenarios. For purposes of this removal action, this objective represents a minimum requirement that would have to be achieved by any removal action. Additionally, secondary objectives have been formulated for the south plume removal action which include the following:

- Protection of the groundwater environment, which in this case is represented by a sensitive, sole source aquifer
- Control of plume migration to additional receptors further south

As will be discussed in Chapter 5.0, the removal action alternatives being considered for the south plume will satisfy these secondary objectives to varying degrees. No alternative will fully satisfy all of these objectives. Therefore, the final selection of the preferred removal action will balance the effectiveness of each alternative in satisfying the secondary objectives against any additional cost and time required for implementation. Potential adverse impacts of each alternative will also be considered. This selection strategy is being executed so as not to hinder or foreclose viable options for a long-term remedial action for the regional aquifer that will fully satisfy all applicable or relevant and appropriate requirements established for that important environmental unit.

3.3 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA OR GUIDELINES TO BE CONSIDERED

CERCLA Section 121 requires that remedial actions obtain a level or standard of control which is applicable or relevant and appropriate to any hazardous substances, pollutants, or contaminants that will remain on site. Although Section 121 does not require that removal actions attain all ARARs and TBCs, the U.S. EPA policy on removal actions is that ARARs and TBCs will be identified and attained to the extent practicable.

Three classifications of ARARs and TBCs are considered. These include: (1) contaminant specific ARARs and TBCs, (2) location specific ARARs and TBCs, and (3) action specific ARARs and TBCs. Contaminant-specific ARARs and TBCs address the acceptable amount or concentration of a specific pollutant that may be found in or discharged to soil, water, and air. Location-specific ARARs and TBCs are based on the specific setting and nature of the site, and action-specific ARARs and TBCs relate to technology- or activity-based requirements or limitations on the specific response actions taken with respect to the type of wastes.

The identification of potential ARARs and TBCs for the south plume removal action will be based on the nature of the contamination (radioactively contaminated groundwater), the location of the site (within a populated groundwater usage area and within 1.5 miles of the Great Miami River), and the general scope of the identified removal action alternatives. A summary of these ARARs and TBCs and a discussion as they pertain to the proposed alternatives are included in Chapter 5.0.

4.0

4.0 REMOVAL ACTION ALTERNATIVES

4.1 DEVELOPMENT OF INITIAL ALTERNATIVES

The ongoing Feasibility Study for the environmental media operable unit has already proceeded through the development and preliminary screening of alternatives, in accordance with the U.S. EPA's current CERCLA guidance (U.S. EPA 1989). Based on the preliminary results of the development and screening of specific remedial action alternatives in the RI/FS for the contaminated groundwater, and considering the identified removal action objectives, the following removal alternatives have been selected for evaluation in the South Plume EE/CA:

- No Action
- Groundwater Monitoring and Institutional Controls
- Alternate Water Supply with Groundwater Monitoring and Institutional Controls (referred to hereafter as Alternate Water Supply)
- Groundwater Pumping Without Treatment, Alternate Water Supply, Groundwater Monitoring, and Institutional Controls (referred to hereafter as Pump and Discharge)
- Groundwater Pumping With Treatment, Alternate Water Supply, Groundwater Monitoring, and Institutional Controls (referred to hereafter as Pump and Treat)

4.2 DESCRIPTION OF REMOVAL ACTION ALTERNATIVES

A description of each proposed removal action is provided in the following sections.

4.2.1 Alternative 1 - No Action

Routine monitoring and security activities will continue to occur at the FMPC in accordance with DOE and WMCO operational requirements. Under the no-action alternative, no additional remediation, monitoring, or security activities would be provided in the vicinity of the south plume to further minimize risk to public health or the environment. Any changes to the existing site environment is assumed to develop only as a result of natural occurrences. This alternative is being considered as a baseline for comparison with the other alternatives.

4.2.2 Alternative 2 - Monitoring and Institutional Controls

This alternative consists of the continued or additional monitoring of selected off-site wells in the south plume study area. At present, no residential wells containing concentrations of uranium in excess of the derived concentration limit of 33 µg/ℓ for uranium in drinking water are being used. The monitoring program associated with this alternative will be designed to detect increases in uranium content which may indicate movement of the plume into or toward industrial, commercial, or residential wells. Quarterly monitoring for uranium will take place in the selected wells until a modified monitoring program is implemented as part of the final remedial action. If increasing uranium concentrations are detected in any wells during the monitoring program, the potential for exceeding the derived concentration limit for uranium in drinking water will be evaluated and, if necessary, an appropriate additional response action will be taken, which is not within the scope of this removal action.

DOE cannot exercise direct access control over the off-site areas. Therefore, the institutional controls will be limited to the following: (1) regular communications with state and local officials responsible for well installation applications and approvals, (2) formal notification by the same officials to DOE of any well applications and approvals within the south plume area and, (3) monitoring of any newly installed wells upon installation and quarterly thereafter as part of the aforementioned monitoring network.

4.2.3 Alternative 3 - Alternate Water Supply

This alternative consists of groundwater monitoring, implementing institutional controls, and providing an alternate water supply to the two industrial receptors known to be using groundwater with uranium concentrations exceeding 33 µg/ℓ. The monitoring and institutional control program will be the same as that described for Alternative 2.

The alternate water supply for the currently affected industrial user with the largest usage demand (350 gpm) will be drawn from a well located and installed along Willey Road northwest and upgradient from the south plume area (Figure 4-1). The location of this well shown in Figure 4-1 is preliminary

and was selected for preliminary design and costing purposes. Final placement of this well will be at a location far enough upgradient so that the direction of plume migration is not altered. A water line connecting the wellhead to the user will convey a sufficient volume of water to replace the existing water supply at the affected facility. This water line will be located along Willey Road and Paddys Run Road, as shown in Figure 4-1. A standby well will also be installed at the same location for use during maintenance and emergency shutdown of the primary well.

A new well completed in the bottom portion of the aquifer, near bedrock, will provide the alternate water supply for the other known affected industrial user. This well, to be located on the receptor's property (Figure 4-1), will have an estimated capacity of 50 gpm. The reason that a deeper replacement well will suffice in this case is the much lower flow rate. At this level of pumping demand, contaminated groundwater in the shallow zone will not be drawn vertically downward into the lower aquifer and the replacement well.

Prior to selecting this alternative for detailed evaluation, other methods of providing alternate water supplies were examined and rejected. The options of supplying bottled drinking water or filling cisterns from either the Cleves Waterworks or the Cincinnati Waterworks were not applicable for the replacement of industrial water supplies.

An extension of the nearest public water supplies was also investigated. The largest supplier, Cincinnati Waterworks, is currently negotiating a contract to bring a water supply to Crosby Township. Service for the area near Miamitown is scheduled to begin in two to five years and service for the New Baltimore area is tentatively scheduled for the next five to ten years. This schedule is inconsistent with the near-term objectives of the removal action. A smaller supplier, Cleves Waterworks, serves portions of Miamitown approximately five miles southwest of Fernald. The current service is incapable of being extended north to Fernald at the flow rates required for the industrial users.

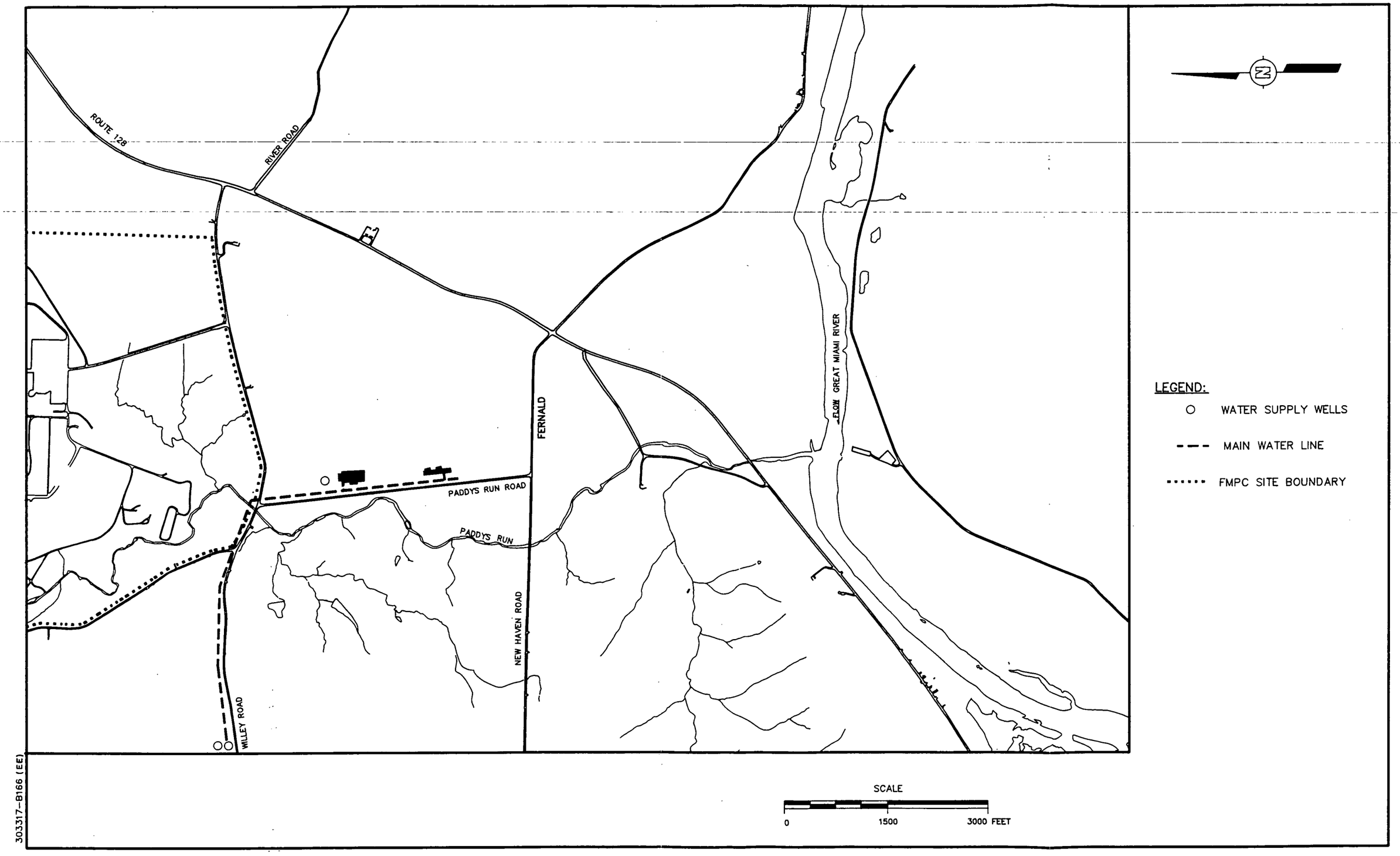


FIGURE 4-1
ALTERNATIVE 3
ALTERNATE WATER SUPPLY

4.2.4 Alternatives 4 and 5 - Groundwater Pumping

The development of the most responsive groundwater pumping alternative required the evaluation of several suboptions for the removal, discharge, and treatment activities. The selection of the general location for the pumping wells represented an additional decision point due to the consequential impacts on the degree to which the removal action objectives would be met. Each of these suboptions is separately discussed in the following sections.

4.2.4.1 Well Location

Three general well location scenarios were considered for the south plume removal action. The first was to locate the wells at the southern property line of the FMPC for the purpose of prohibiting future releases from the site into the northern portion of the south plume. The second location would be near the current center of the plume to achieve maximum uranium removal efficiency over the expected life of the removal action. A third location would be along the southern, leading edge of the plume, with the objective of preventing further migration of the entire plume.

The location of pumping wells along the FMPC property boundary was eliminated as an option for the following reasons. First, the focal point of the removal action--the existing off-site plume with uranium concentrations exceeding the derived concentration limit for uranium in drinking water--would not be affected by wells located to the north of the off-site plume. Second, the continuing releases across the site boundary via groundwater transport are not considered significant when compared to the historical releases that represent the hypothesized underlying cause of the off-site plume. Third, any continuing source of uranium in groundwater will be dealt with as part of a complete source-pathway-receptor framework under the appropriate RI/FS operable unit.

The location of pumping wells near the projected center of the existing plume has several advantages. This location provides an effective short-term response by achieving maximum uranium removal efficiency over the expected life of the removal action. The action would be consistent with any final action that will focus on the residual plume south of the proposed pumping location. Potential

receptors south of the pumping location will be protected by the monitoring and alternate water supply provisions of the complete alternative.

However, this option has several critical shortcomings. Although more uranium would be removed by locating the pumping wells near the center of the plume, the pumping of the highest concentration water would represent the worst-case condition for either releasing untreated water to a surface water course or treating the water and generating residual sludges. More importantly, the area nearest the wells that would be directly affected by groundwater removal is not the most important area in terms of the primary objective of public health protection. Areas of the plume downgradient from this location with uranium concentrations exceeding 33 μg/ℓ are a threat to groundwater users along New Haven Road and points further to the south-southeast. Model predictions indicate that pumping wells near the center of the plume will not reverse the regional gradient throughout the south plume area so as to draw groundwater from this area back into the wells. In fact, the area directly affected by the pumping wells over the five-year project period is relatively small and a major portion of the plume south of the pumping wells will continue to migrate as if no action had been taken. This is illustrated by model predictions in Figure 4-2. As a consequence, a future remedial action for the southern portion of the plume would likely be needed if the removal action is implemented near the center of the plume.

Locating the pumping wells near the southern, leading edge of the plume represents the most responsive option for the south plume removal action. Implementation of such an option would provide proactive protection of groundwater users at downgradient locations. The future reliance on either an alternate water supply at every affected user location or an additional remedial action under the RI/FS for the environmental media operable unit would no longer be required. An additional advantage of locating the wells to the south is that local hydrogeologic conditions cause the plume to be narrower near its leading edge than along its center. This condition, which allows the use of fewer wells, is shown in Figure 4-2. It is important to note that the RI/FS for the environmental operable unit still allows for pumping from the center of the plume as a future remedial action. However, such

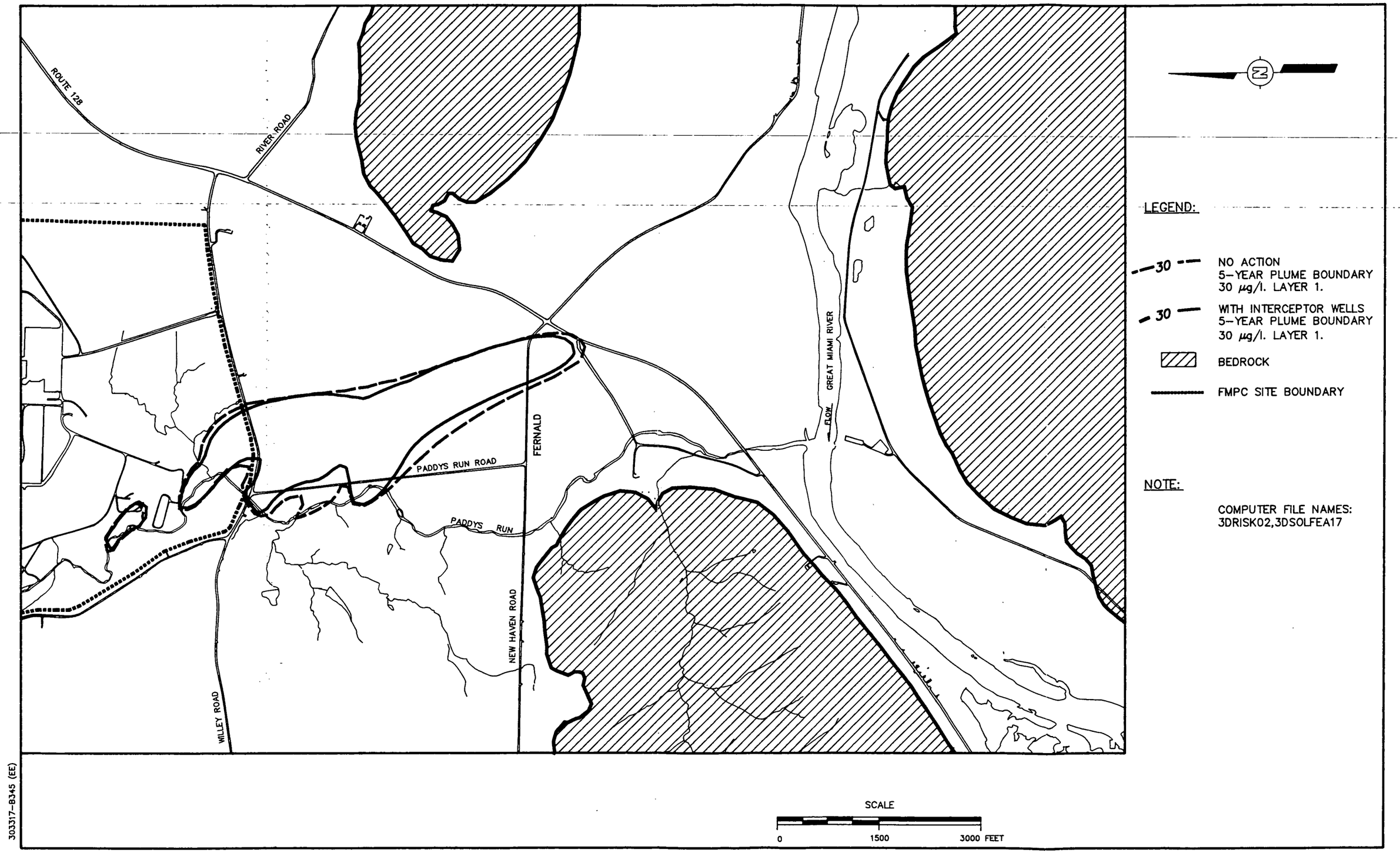


FIGURE 4-2

NO ACTION VS PUMPING
AT PLUME CENTER

an action would have to be independently justified against the option of waiting for the plume to reach any southern pumping wells installed as part of the removal action.

The option of pumping from the southern edge of the plume is currently limited by uncertainties as to the location and nature of the leading edge of the plume, and thereby the optimum location of any proposed pumping well scheme. A related concern is the possible presence of an overlapping plume of hazardous chemicals from industries in the area that is being independently studied under a separate RI/FS. The presence of hazardous chemicals could restrict DOE's ability to accept and manage the pumped water. As will be discussed in later chapters, plans are in place for the collection of additional data that would reduce these uncertainties prior to the final selection of a pumping scheme.

4.2.4.2 Removal Options

Once the general location of the pumping wells is established, the removal options become limited to the orientation, number, and size of the pumping wells. An east-west orientation of the wells provides the optimum scheme for controlling the entire width of the plume exceeding the derived concentration limit for uranium in drinking water without causing a widespread reversal of flow at points south of the pumping wells. Based on a sensitivity analysis using the groundwater flow model, four wells capable of pumping 500 gallons per minute (gpm) each are proposed along the east-west transect. A final decision on the number and location of wells will be made once additional field data are collected and the supporting analysis is performed.

4.2.4.3 Discharge Options

Four options were considered for the discharge of the pumped groundwater, including: (1) direct discharge via pipeline to the Great Miami River south through the Village of Fernald, (2) direct discharge via pipeline to Paddys Run, (3) discharge via a force main to Manhole 175 at the FMPC and release to the Great Miami River through the existing main effluent line, and (4) groundwater reinjection. The last option was rejected due to the sole-source classification of the underlying aquifer. Release to Paddys Run was considered problematic due to the seasonal low flows, the associated

potential impacts on the aquatic environment, the potential problems associated with recharge of this water to the aquifer, and the consequent difficulties in obtaining a permit for the discharge.

The two options involving discharge to the Great Miami River vary only slightly. The use of FMPC facilities introduces a greater level of administrative control and security. Easier access for pipeline construction is also anticipated under this option. For these reasons, the selected discharge option is to pump the groundwater back to Manhole 175 along the main effluent line, from which point the water would be discharged to the Great Miami River.

4.2.4.4 Treatment Options

For the groundwater pumping alternative that includes treatment of the water prior to discharge (alternative 5), three treatment options were considered. The first involved use of an existing industry's treatment plant already operating near the projected point of pumping. This option was eliminated from further consideration based on the limited capacity of the treatment plant (<250 gpm), as well as the confirmation that the industry would require continued treatment of their water supply to achieve their process requirements even if an alternate water supply is provided.

A second option would be to construct a new treatment facility for the sole purpose of treating the removed groundwater to lower the uranium concentrations below the derived concentration limit for uranium in drinking water. While this option is technically feasible, it is not cost-effective due to the high flow, low concentration nature of the extracted groundwater.

The third and selected treatment option also calls for a new treatment plant, but in this case the wastewater stream will be the higher concentration storm water runoff currently discharged through the main effluent line from the FMPC. The concept is to remove an equivalent mass of uranium through treatment so that the pumped groundwater can be discharged directly to the river.

4.2.4.5 Alternative 4 - Pump and Discharge

Based on the foregoing discussions, the alternative of groundwater pumping and direct discharge will include the installation of recovery wells near the southern limit of the uranium plume south of the FMPC, pumping the groundwater to the FMPC site, and discharging the untreated groundwater to the Great Miami River via the existing main effluent line. An alternate water supply, monitoring of the groundwater, and institutional controls similar to those proposed for Alternative 3 are also included as part of this alternative.

Three to five pumping wells are tentatively planned for installation just south of New Haven Road to intercept the plume. Four wells are shown conceptionally in Figure 4-3. The exact number and location of these wells will be determined by exploratory drilling and sampling to verify the location of the extent of the plume exceeding the 33 μg/ℓ limit. This wellfield is designed to intercept the plume while not reversing the aquifer flow south of the wellfield.

The wells will be screened in the top 40 feet of the aquifer and provide a combined pumping rate from 1500 to 2500 gpm. These well locations, pumping rates, and depths are based on results obtained from the site investigation and groundwater modeling programs. Details of the modeling effort are presented in Appendix A. The current evaluation of the recovery system indicates that initial pumping of four wells at 500 gpm (1.1 cfs) each would capture the uranium in the plume north of the wellfield. Although the recovery system is designed to capture groundwater from the upper layer of the sand and gravel aquifer containing concentrations of uranium greater than 33 μg/ℓ, groundwater containing lower concentrations of uranium will also be captured. The well locations and flow rates may be modified based on ongoing monitoring programs and refinements to the groundwater modeling program continuing in support of the RI/FS.

The flow from the wellfield will be pumped through a force main piping system to Manhole 175, the existing NPDES discharge monitoring point for the FMPC, and discharged to the Great Miami River. To the extent practicable, the force main will run along New Haven Road, Paddys Run Road, and Willey Road, utilizing the public rights-of-way and then onto DOE property.

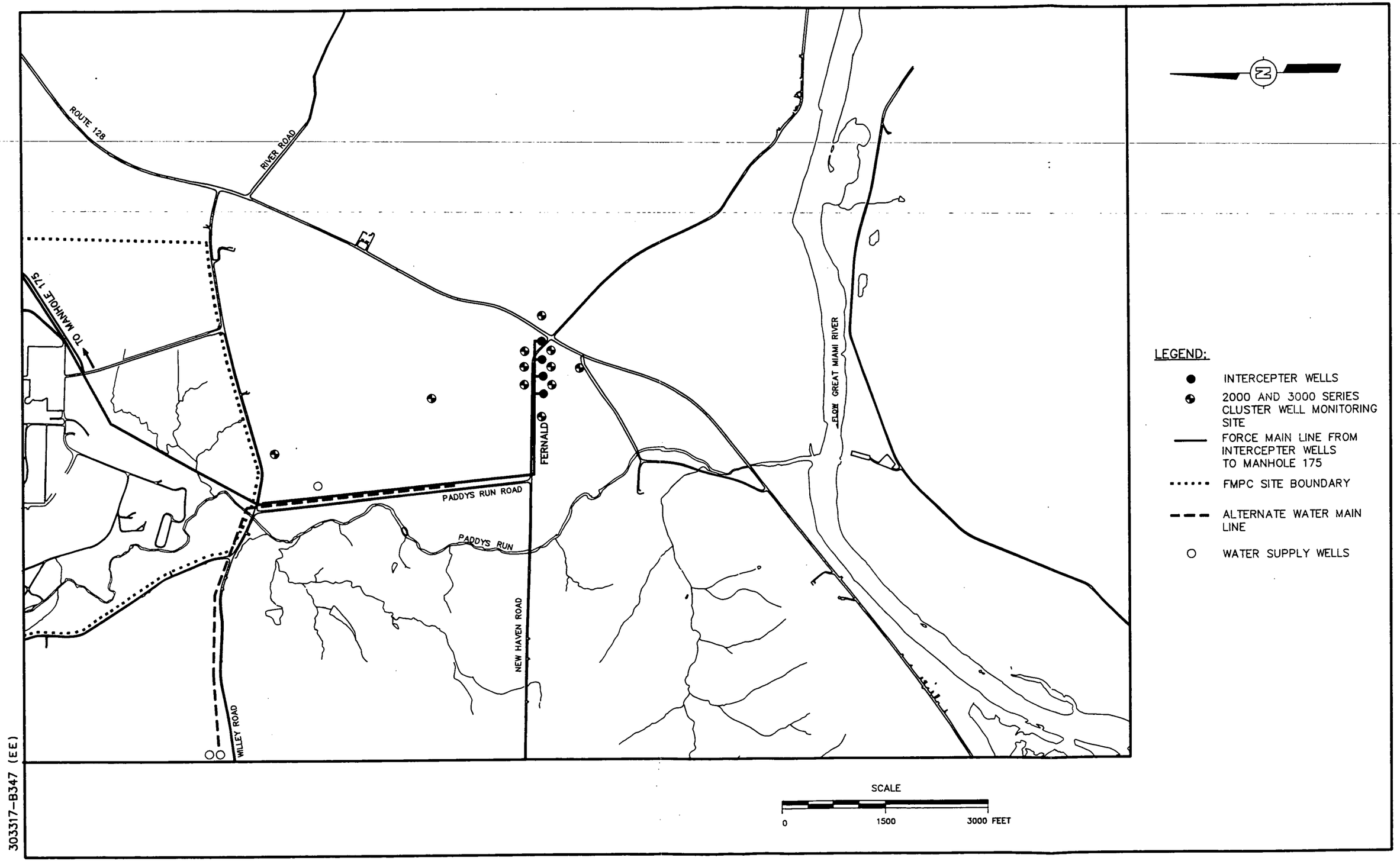


FIGURE 4-3
ALTERNATIVE 4 – PUMP AND DISCHARGE

Monitoring of the plume is also included in this alternative. This monitoring program would include sampling and analysis of the well network discussed in Alternative 2, in addition to sampling and analysis of newly installed monitoring wells in the south plume area (Figure 4-3). Monitoring wells will be installed to two depths in the aquifer. The shallower wells (2000-Series) will be 4 inches in diameter with a 15-foot screened interval starting approximately 5 feet above the water table and extending downward to a depth of approximately 10 feet below the water table. The deeper 3000-Series wells will be 4 inches in diameter with the top of screen approximately 60 feet below the water table and extending downward 10 feet. Six 2000-Series and six 3000-Series wells are currently proposed for monitoring the effectiveness of this alternative.

4.2.4.6 Alternative 5 - Pump and Treat

This alternative is similar to Alternative 4 in that it includes the installation of recovery wells near the southern limit of the uranium plume south of the FMPC, pumping the groundwater to the FMPC site, and discharging the untreated groundwater through Manhole 175 to the Great Miami River. An alternate water supply for currently impacted groundwater users, a groundwater monitoring program, and institutional controls would also be included in this alternative. An additional feature of this alternative would be a new treatment facility installed on site to treat a currently untreated FMPC effluent, as well as a portion of the flow from the south plume, as necessary. The treatment system would be designed to ensure that the total mass of uranium released via the effluent pipeline would not increase the FMPC release value.

The wellfield design is the same as that discussed in Alternative 4. However, water extracted from the wells will be first pumped via underground piping from the off-site south plume to a 60,000-gallon capacity surge tank. Four pumps will draw water from the surge tank and pump it through the force main to Manhole 175 and/or to the treatment system at Building 51 (Figure 4-4). The force main pumps, electrical equipment, and monitoring instrumentation will be located within a pumphouse.

The treatment system will receive an FMPC effluent stream which will include flow from the storm water retention basin, with make-up flow from the south plume, as necessary. The treatment system

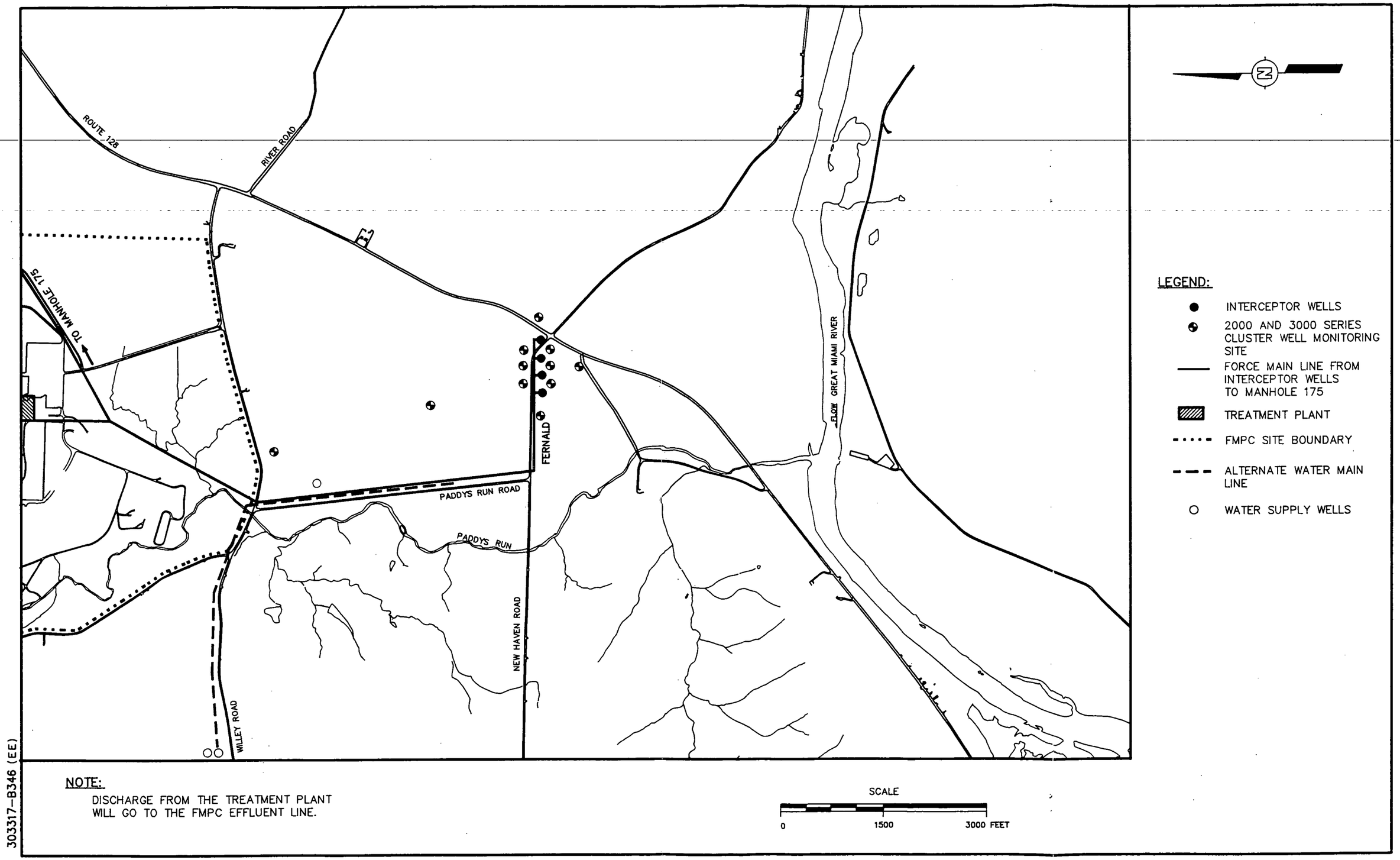


FIGURE 4-4
ALTERNATIVE 5 – PUMP AND TREAT

will consist of pretreatment, ion exchange for uranium removal, and sludge dewatering. The system will be able to process a nominal 700 gpm of water from either the storm water retention basin or the south plume/pumping system and will be designed to remove uranium such that the effluent concentration is less then 20 µg/ℓ. The treatment program will be designed to ensure that the uranium discharged to the Great Miami River is not increased over current levels, which are in conformance with DOE Orders for derived concentrations.

The piping to the new treatment system will be routed such that the treatment system can receive water either from the south plume force main or from the storm water retention basin via existing pumps. Piping from the new treatment system will be routed to join the water from the south plume prior to entry into Manhole 175, thereby accommodating NPDES and DOE required monitoring of the combined flow at Manhole 175. A schematic of this system is presented in Figure 4-5.

A highly concentrated uranium sludge will be generated as a result of the treatment system. This sludge will contain the same radionuclides and chemicals processed, produced, or otherwise used at the FMPC. The disposal of this sludge will be accomplished in accordance with all regulatory requirements as part of WMCO's ongoing waste management activities.

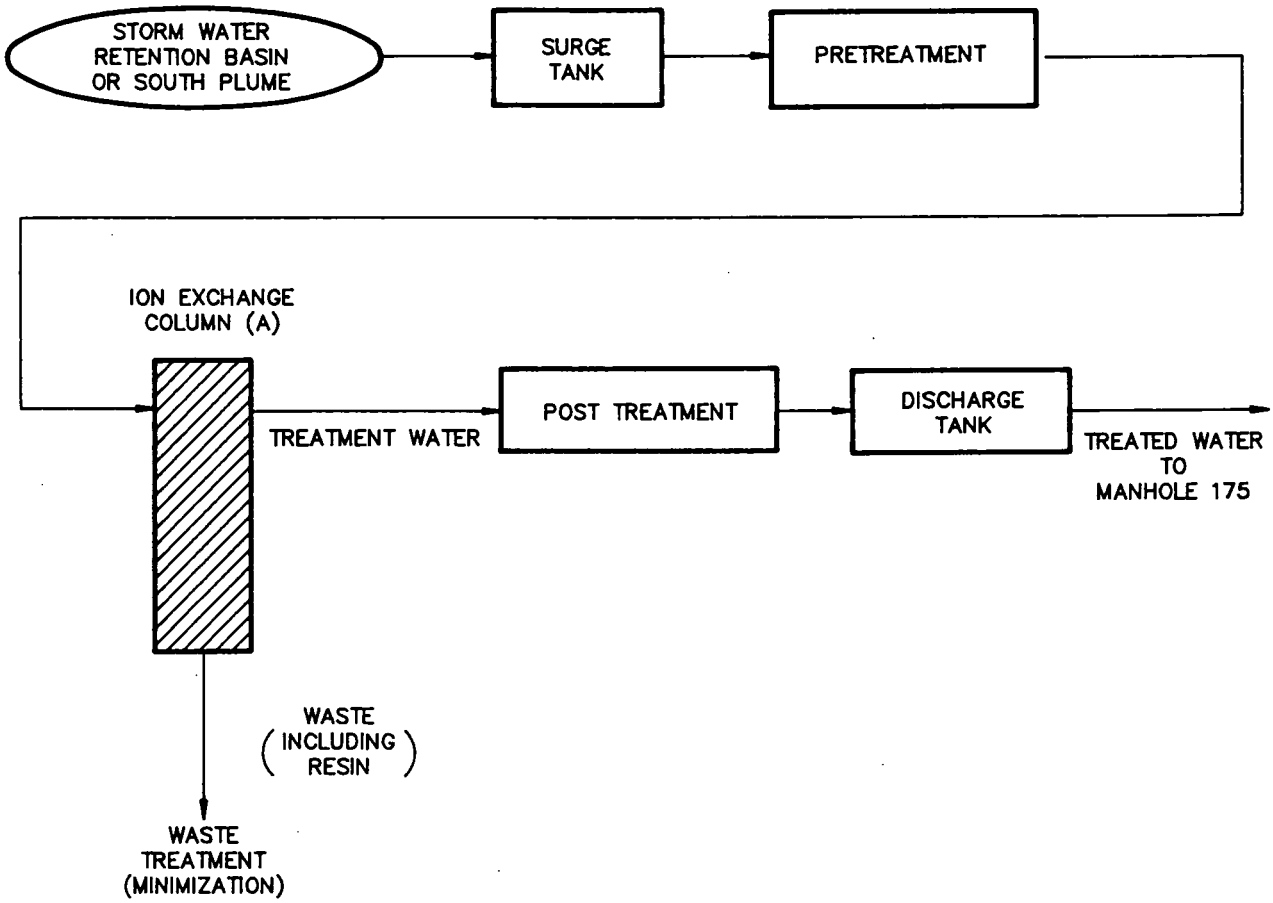


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FIGURE 4-5. ALTERNATIVE 5 - TREATMENT SYSTEM SCHEMATIC

5.0

5.0 EVALUATION OF ALTERNATIVES

The evaluation of the removal action alternatives is presented in this chapter. Section 5.1 describes the evaluation criteria. The evaluations of the individual alternatives are presented in Sections 5.2 through 5.6, respectively, and a separate discussion of the ARARs and TBCs is presented in Section 5.7.

5.1 EVALUATION CRITERIA

The five alternatives described in Chapter 4.0 are evaluated according to the following criteria:

- Effectiveness
- Implementability
- Cost

To achieve consistency with the removal action objectives identified in Chapter 3.0 and to accommodate the selection of a preferred alternative in Chapter 6.0, the effectiveness criterion is divided into two components. The first reflects the effectiveness in achieving the principal objective of public health protection, while the second addresses the effectiveness in meeting the three secondary objectives of environmental protection, plume migration control, and control of off-site uranium discharges.

5.1.1 Effectiveness: Public Health

The first component of the effectiveness of an alternative is defined by its ability to ensure the protection of and to minimize impacts to public health. The evaluation of this factor will focus on the extent to which the completed action reduces or mitigates identified threats, as well as compliance with chemical-specific ARARs and TBCs. This component also involves an assessment of the potential for future exposure to residual conditions at the site, as well as the potential for failure of the alternative and any potential threats from such a failure.

Exposure Pathways

Uranium is the only constituent of the off-site south plume that could present a public health risk from chemical or radiological exposures. The assessment of public health risks will, therefore, be limited to the radiation doses from and chemical toxicity of uranium.

In the absence of any penetrations into the groundwater plume, there are no exposure pathways to humans or to flora and fauna in the area. Only when water containing uranium is drawn from the plume will there be pathways for exposure to both humans and the environment. If access to the groundwater is not prevented, it is possible that groundwater taken from the aquifer could be ingested directly as drinking water by man and animals, used for the irrigation of human food crops and animal forage, or released into surface water pathways. Each of these scenarios presents exposure pathways to both the chemical and radiological properties of uranium in the water. Each of these scenarios was considered in an environmental pathways analysis, and the following four pathways emerged as pipeline contributors to the potential exposure of the public in relation to the south plume: (1) direct ingestion of water; (2) ingestion of crops grown in fields irrigated by the water; (3) ingestion of beef from cattle exposed to uranium through water and crops; and (4) ingestion of milk from cows exposed to uranium through water and crops.

The calculation methodology presented in the U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.109 (NRC 1977) was used to assess the transport of uranium from groundwater and surface water to off-site receptors. From this methodology, an environmental transport model was developed which used site-specific transport parameters whenever possible and recommended generic parameters otherwise. The model for mixing liquid effluents from the FMPC effluent discharge line into the Great Miami River was taken from the "Hydrogeologic Study of FMPC Discharge to the Great Miami River" (IT 1988). The irrigation rate was obtained from the "Ohio Irrigation Guide" (USDA 1970).

The environmental transport model was used to calculate the annual intake of uranium by humans via drinking water, vegetables, meat, and milk. The radiation dose (50-year committed effective dose

equivalent) was calculated by multiplying the annual intake rate of uranium by the respective dose conversion factors for isotopes of uranium (DOE 1988).

The annual intake rate calculated by the environmental transport model was also used to evaluate the potential for chemical toxicity from uranium. A Hazard Index (HI) for adults and children was calculated by dividing the estimated daily intake by the acceptable daily intake. A value of 2.7 microgram per kilogram per day (µg/ℓ/kg/day) used as the acceptable intake rate for uranium was derived in an earlier report (IT 1989). An HI greater than or equal to one implies that exposure at this level is potentially detrimental to human health and, conversely, an HI less than one implies that exposure is acceptable with respect to an individual's risk of chemical toxicity.

Chemical-Specific ARARs and TBCs

The chemical-specific TBC, which is the lowest proposed value for protection of public health and the environment from chemical and radiological constituents in the south plume, is the 50-year CEDE limit of 4 mrem from an annual intake of radioactive materials in drinking water. The DOE has specified that this CEDE limit shall apply to releases to all off-site areas where water could be used as a drinking water source (DOE 1990). It is important to note that this referenced DOE limit does not exclude uranium (which is specifically excluded by the U.S. EPA Drinking Water Standards).

Uranium isotopes are the only radioactive materials which exceed background concentrations in the off-site south plume. The concentration of uranium in drinking water which corresponds to the 4 mrem radiation dose limit is derived to be equal to 22 pCi/ℓ, or 33 µg/ℓ.

This derivation assumes equal activity concentrations of Uranium-234 and Uranium-238, which is equivalent to the natural abundance of uranium isotopes. This condition has been generally satisfied in groundwater at the FMPC based on the isotopic data collected in support of the RI/FS. The derivation also assumes that the intake pathway is via ingestion of two liters of water with the specified uranium concentration every day of the year (i.e., 730 liters per year [DOE 1990]). No other environmental transport pathways are considered for this derivation.

A concentration of uranium in drinking water at the limit of 33 µg/ℓ is below the derived concentration threshold of 95 µg/ℓ for chemical toxicity in humans. Consequently, the radiological-based limit, which is a lower value and would make the assessment more conservative, is utilized as the chemical-specific TBC for uranium in drinking water.

Water from the off-site south plume can be released to surface waters of the Great Miami River, where dilution occurs. This water may be a source of drinking water for persons downstream. For purposes of this evaluation, the concentration of uranium in the Great Miami River following dilution is directly compared with the drinking water limit, even though an additional reduction in uranium concentration in drinking water will most likely result as a consequence of municipal water treatment processes.

The evaluation of the effectiveness of each alternative will be made first with respect to the derived concentration limit for uranium in drinking water. Any alternative for which the drinking water concentration limit is exceeded will not be considered as acceptable. Alternatives for which the drinking water concentration limit is not exceeded will then be evaluated for public health risk under other exposure pathways.

A second TBC, which is less restrictive than the radiation dose limit for drinking water, is the total annual committed effective dose equivalent limit of 100 mrem for off-site individuals from all radiation exposures due to the site via all environmental transport pathways. The total radiation dose from all pathways is calculated for each alternative and compared with the annual radiation dose limit of 100 mrem.

5.1.2 Effectiveness: Other Factors

The degree to which the alternatives satisfy the secondary removal action objectives will be used to define the second component of effectiveness. Environmental protection will consider the degree to which uranium will be physically removed from the groundwater environment, thereby reducing the potential for exposure to environmental receptors such as fish, crops, irrigation water, cattle, etc. Any subsequent discharge of the uranium to surface waters will be considered as a negative measure of

effectiveness. Additionally, the environmental evaluation will consider factors necessary to meet requirements mandated under NEPA. This includes the consideration of environmental impacts that may result from implementing the removal action. This evaluation will also consider the extent to which the actions meet the location-specific ARARs and TBCs, particularly those pertaining to environmentally sensitive areas.

The objective of plume control will be evaluated with respect to the degree of hydraulic control of plume migration being effected by an alternative, as well as the portion of the south plume that will be controlled. A precise quantification of this factor is limited by the remaining uncertainties as to the nature and extent of the leading, southern edge of the plume.

For purposes of this evaluation, the control of the plume migration is limited to the containment of the contaminated groundwater to the presently affected area. No control of other potential sources, such as discharges to Paddys Run or the storm water outfall ditch, is considered under the south plume removal action.

There remains a lack of direct observations on both the chemical plume to the south of the FMPC (pending completion of the Paddys Run RI) and the degree to which the plumes have already mixed. Model results indicate, however, that a mixing of the plumes will not occur, due to distinct and generally parallel migration pathways from the respective sources.

5.1.3 Implementability

The implementability of an alternative is defined by its technical feasibility, the availability of applicable technologies, and administrative feasibility. Factors evaluated regarding an alternative's technical feasibility include the ability to construct and operate the alternative considering unknowns that may lead to schedule delays, the ability to meet the required process efficiencies or performance goals, compliance with action-specific ARARs and TBCs, and the previously demonstrated performance of a technology. The technical feasibility evaluation also considers if the action is consistent with the long-term remedy for the site.

The availability criterion is used to evaluate the availability of necessary equipment, materials, personnel, and adequate storage or disposal capacity, if appropriate. Availability also considers any measures that may be required at the completion of the action, including monitoring and the availability of a responsible party to assume these activities. The evaluation of administrative feasibility of an alternative includes the likelihood of public acceptance, activities necessary for coordination with other agencies, and the ability to obtain necessary approvals or permits.

5.1.4 Cost

The total cost of an alternative is the final factor considered. This factor includes direct capital costs, indirect capital costs, and any postremoval site control costs. The cost estimates are intended to provide an accuracy of ±25 percent. A present-worth analysis is conducted to provide a common basis of comparison. A discount rate of 5 percent is used over a five-year project duration. The five-year period is used in all alternatives as the expected duration of the removal action. Even though the associated activities may continue beyond this period, it has been assumed that the activities will be performed as part of the final remedial action after five years and the costs will be accounted for in the FS for the environmental media operable unit.

The cost criterion is applied differently than the effectiveness and implementability criteria. The objective of the cost evaluation is to eliminate removal action alternatives whose cost greatly exceeds that of other alternatives while providing only a marginal increase in the degree of satisfaction of the removal action objectives.

5.2 ALTERNATIVE 1: NO ACTION

5.2.1 Effectiveness: Public Health

Since there are no groundwater use restrictions assumed for the no-action alternative, it is assumed that an off-site receptor can use groundwater directly from the well having the highest measured concentration of uranium for potable water and for irrigation of crops. The calculated radiation doses for the assumed conditions via the drinking water pathway are 36 mrem for the hypothetical,

maximally exposed off-site receptor and 18 mrem for an off-site receptor having average exposure conditions.

The difference in these two scenarios is in the assumed rate of ingestion of drinking water. The maximum rate is twice the average rate for an individual. The calculated radiation doses for all pathways considered are approximately 88 mrem for the hypothetical maximally exposed off-site receptor and 47 mrem for the hypothetical average exposed off-site receptor. The difference in these two hypothetical receptors is the assumed rates of ingestion of drinking water, vegetables, meat, and milk.

For the no-action alternative, it is assumed that the two industrial users of groundwater from the south plume continue to use this water and release it into the Great Miami River as part of their industrial effluent streams. The concentration of uranium in the liquid effluent from each of these users is assumed to be equal to the concentration of uranium drawn from the aquifer. This results in a conservatively high concentration value since water treatment is provided by the largest industrial user. If treatment is provided, uranium-bearing sludges would be produced that would represent an additional public health and environmental concern. Liquid effluents from the FMPC which go to the Great Miami River are also included in this environmental pathway and dose calculation scenario. Under this no-action scenario, a total of 448 millicuries (mCi), or 1500 pounds, of uranium is calculated to be discharged to the Great Miami River each year at an average concentration of 550 pCi/ℓ (825 μg/ℓ).

Pathways to man from these releases to surface water are via irrigation of crops, drinking water supplies downstream from the release point, and beef cattle and milk cows which ingest water from the river and irrigated forage. Assuming a level of dilution commensurate with low flow conditions in the Great Miami River, the calculated above-background radiation doses (CEDE) from this scenario are approximately 0.8 mrem for the hypothetical maximally exposed off-site receptor and approximately 0.4 mrem for the hypothetical average exposed off-site receptor. Essentially all of these calculated radiation doses are a consequence of the uranium in the liquid effluents from the FMPC.

The no-action alternative is not effective in preventing potential risk to public health via the drinking water pathway since the calculated doses exceed the limit of 4 mrem. The overall off-site dose limit of 100 mrem is not exceeded even for the hypothetical maximally exposed off-site receptor; however, other exposure pathways from airborne particulate releases, radon releases, and direct external exposure from the FMPC have not been included in this analysis.

The HI calculated for the no-action alternative is 0.107 for the hypothetical maximally exposed off-site adult, 0.056 for the average exposed off-site adult, 0.164 for the hypothetical maximally exposed off-site child, and 0.083 for the average exposed off-site child. These values indicate that the daily intakes of uranium for the exposure pathways considered are below the acceptable intake level of 2.7 µg/kg/day for uranium.

5.2.2 Effectiveness: Other Factors

Under the no-action alternative, none of the secondary objectives would be satisfied to any extent. No lessening of environmental concentrations would occur except for the continued dispersion of the plume as it migrates, uncontrolled, toward the south-southeast.

The leading edge of the plume is not expected to reach the Great Miami River within the five-year time frame of the proposed action. Therefore, there would be no significant impact on aquatic or terrestrial communities unless contaminated water was withdrawn from the aquifer. Withdrawal of contaminated water could cause an adverse impact on aquatic and terrestrial communities depending on the use and disposal of the water. For example, irrigating crops with contaminated water would contaminate soil, vegetation, and any adjacent wetlands via runoff.

This alternative would have no impact on the Indiana bat habitat or the historical resources in the area. There would be no noise or air quality impacts related to this alternative and no change in existing land use practices or waste management requirements.

The amount of uranium crossing the FMPC boundary would continue at the currently projected level until an on-site removal or remedial action was implemented as part of another operable unit. Plume mixing would also continue or would occur in the future if hydraulic conditions result in the crossing of the two migration paths.

5.2.3 Implementability

The evaluation of the technical feasibility and availability factors related to implementability is not applicable to the no-action alternative. No construction, monitoring, or permitting activities are involved with this alternative. Acceptance of the no-action alternative by the public and the agencies is not likely.

5.2.4 Cost

There are no capital or operation and maintenance costs associated with the no-action alternative.

5.3 ALTERNATIVE 2: MONITORING AND INSTITUTIONAL CONTROLS

5.3.1 Effectiveness: Public Health

For this and all remaining alternatives, it is assumed that south plume groundwater with uranium concentrations exceeding the 33 μg/ℓ limit will not be used for potable water or irrigation of crops. This assumption has the greatest impact on dose calculations. The condition of nonuse of the south plume for potable water or irrigation will necessarily require that monitoring and institutional controls remain fully effective in preventing access to the aquifer in the south plume. If increasing uranium concentrations are detected in any wells during the monitoring program, the potential for exceeding the derived concentration limit for uranium in groundwater will be evaluated and an appropriate response action will be taken as necessary.

Under this alternative, the assumption is made that the two industrial users of water from the south plume will continue to draw water from their existing wells at the current rate and to ultimately release this water into the Great Miami River at the same concentration as drawn from the aquifer. This

results in a conservatively high concentration value since water treatment is provided by the largest industrial user. If treatment is provided, uranium-bearing sludges would be produced that would represent an additional public health and environmental concern. Liquid effluents discharged annually from the FMPC to the Great Miami River are again included in the source term for uranium to the river under this alternative.

Under this scenario, a total of 448 mCi (1500 pounds) of uranium is estimated to be discharged to the river each year at a concentration of 550 pCi/ℓ (825 μg/ℓ). Dilution by the river under low flow conditions is assumed. Water from the river is assumed to be used for irrigation of crops and for drinking water supplies downstream from the release point. The four pathways of importance for surface water release are potable water for humans, irrigation of food crops and animal feed, beef from cattle, and milk from cows.

The calculated above-background radiation dose for the hypothetical maximally exposed off-site receptor is approximately 0.8 mrem. For the hypothetical receptor with average ingestion levels, the calculated radiation dose is approximately 0.4 mrem. As with releases to the surface water considered in Alternative 1, essentially all of these calculated radiation doses are a consequence of the uranium in the FMPC liquid effluent released to the Great Miami River and not from the release of groundwater after industrial use.

The calculated above-background radiation doses for the assumed conditions via the drinking water pathway are approximately 0.3 mrem for the hypothetical maximally exposed off-site receptor and approximately 0.2 mrem for the off-site receptor having average exposure conditions. These doses are well below the radiation dose limit of 4 mrem for drinking water. Similarly, the total radiation dose calculated for all pathways is below the 100 mrem limit.

The HI calculated for this alternative is 0.002 for the hypothetical maximally exposed off-site adult, 0.001 for the average exposed off-site adult, 0.003 for the hypothetical maximally exposed off-site child, and 0.001 for the average exposed off-site child. These values were derived from intake rates

which included the calculated annual intake as a consequence of natural background concentrations of uranium in the river water. These values are less than the HIs for the no-action alternative (Alternative 1) by a factor of more than 50.

5.3.2 Effectiveness: Other Factors

The nature of the actions to be taken under this alternative do not change conditions of the plume or its sources. Consequently, the secondary factors would not be satisfied to any extent, although the probability of any impact on aquatic or terrestrial communities is reduced due to the decreased likelihood of contaminated water being withdrawn from the aquifer. The consequences of withdrawal and use of contaminated water would be the same as those for Alternative 1.

There would be no impacts related to endangered species, noise and air quality, historical resources, or waste management practices. The treatment of groundwater by the affected industries would generate a similar volume of sludges as is currently being produced. There may be some land use restrictions on well installation applications due to the institutional controls as implemented by state and local officials.

The discussion pertaining to the effectiveness of the no-action alternative (Section 5.2.2) in relation to other factors is also applicable to the monitoring and institutional control alternative and is not repeated herein.

5.3.3 Implementability

No construction activities are associated with the groundwater monitoring or institutional controls provided in this alternative. Approvals will be needed from individual landowners to gain access for well installation, sampling, and analysis. Coordination between DOE, the state of Ohio, and local communities will also be necessary to coordinate the installation of new wells in the study area so that the monitoring network can be expanded accordingly.

Although this alternative is consistent with any final remedial action, public and agency opposition is expected due to the lack of more direct action on the plume itself. The perception would be that this action involves no more than what is being routinely performed by DOE and WMCO.

5.3.4 Cost

The costs estimated for Alternative 2 are annual operating costs only, since no new wells will be installed, and include the sampling and laboratory analysis costs for the monitoring program at selected existing wells. These costs are estimated to be $33,600 per year. A present worth value of $145,500 was calculated using a 5 percent discount factor over a five-year project duration.

5.4 ALTERNATIVE 3: ALTERNATE WATER SUPPLY

5.4.1 Effectiveness: Public Health

The incorporation of an alternate water supply into Alternative 3 creates a more substantial "zero access" condition for groundwater in the south plume since treatment of the water by current industrial users would not have to be assumed. An alternate water supply will be provided only to the known users of the affected groundwater although provision is made for an alternative water supply for users that are affected in the future. Monitoring and institutional controls will reduce the likelihood of receptors being affected in the future. These conditions effectively eliminate the groundwater exposure pathways.

Under the assumptions described in Sections 5.2.1 and 5.3.1, the use of an alternate water supply by the industries will reduce the total quantity of uranium released to the Great Miami River by the FMPC and these industries by approximately 2 percent. The effective concentration of uranium introduced into the river will also decrease by a few percent under the assumption of no treatment by the industry. If treatment is assumed, the production of uranium-bearing sludges will be eliminated by the use of an alternate water supply.

The net effect of providing an alternate water supply on radiation doses from the surface water-based exposure scenarios is minimal. The calculated above-background radiation doses to the hypothetical receptors of the four pathways as a consequence of releases to the river are approximately 0.8 mrem and 0.4 mrem for the hypothetical, maximally exposed receptor and average receptor, respectively. Since the only remaining source of uranium into the surface water environment is the liquid effluent from FMPC operations, these calculated radiation doses are due entirely to liquid effluents from the FMPC and are not reflective of groundwater conditions in the south plume.

The calculated above-background radiation doses for the assumed conditions via the drinking water pathway are 0.3 mrem for the hypothetical maximally exposed off-site receptor and 0.2 mrem for the off-site receptor having average exposure conditions. These doses are well below the radiation dose limit of 4 mrem for the drinking water pathway. Similarly, the total radiation dose calculated for all pathways is below the 100 mrem annual limit.

The HI values calculated for this alternative are 0.002, 0.001, 0.003, and 0.001 for the maximum adult, average adult, maximum child, and average child, respectively. These values are equal to the HI values calculated for Alternative 2 and also include the contribution from natural background concentrations of uranium in the river water.

5.4.2 Effectiveness: Other Factors

As with the no-action and monitoring alternatives, Alternative 3 does not extract contaminated water from the subsurface environment, does not provide control of plume migration, does not limit contaminated groundwater from leaving the FMPC boundary, and does not prevent plume mixing. In short, the alternative is ineffective in satisfying any removal action objectives other than public health protection.

As with the first two alternatives, there should be no significant impact on aquatic or terrestrial communities if no contaminated water is withdrawn form the aquifer, since the plume is not expected to reach the Great Miami River within the five-year time frame of the proposed action.

It is assumed that the existing industrial wells will be shut down once an alternate water supply is provided. This raises a concern as to whether plume migration and mixing will actually accelerate upon implementation of the action under the hypothesis that the pumping of these wells currently exerts a degree of control on the migration pattern movement of the plume. The results of the modeling study do not indicate that this would be the case; one industrial well is of low capacity and the other industrial wells appear to lie on the western edge of the plume with a southeastern component of groundwater flow that does not highly influence the migration of the plume center. In fact, the shutdown of the larger industrial wells will cause a beneficial effect by reducing the vertical migration of the plume from the 2000-Series level in the aquifer downward to the 3000-Series depths from which the wells pump.

Implementation of this action will have several short-term environmental impacts. Air quality impacts could occur as the result of dust emissions from earth moving activities and increased traffic during construction of the wells, water and surge tanks, pump station, and water lines. These impacts are not expected to be significant and could be minimized by sprinkling roads and other exposed soil surfaces as necessary.

Alternative 3 would result in only minimal soil disturbance. No major soil excavation or grading would be required during construction, and negligible soil loss through water or wind erosion would be anticipated since controls would be implemented. Following construction, disturbed areas would require reseeding or resurfacing.

Construction impacts, including visual disturbance, noise, and dust, would be expected to have only a minimal impact on local vegetation and wildlife. Although habitats could be disturbed and mobile species displaced during construction, surrounding areas could absorb the displaced species. Habitats within the affected area do not appear to be unique or distinctly important compared to adjoining areas. It is anticipated that the disturbed areas would be repopulated after the construction period. Wetland habitat in Paddys Run could be temporarily disturbed due to the pipeline stream crossings required, but the long-term impact would be minimal. A Corp of Engineers permit may be required

for the stream crossings. There would be no impact on the Indiana bat communities or historical resources in the area.

Construction activities associated with this alternative could cause temporary traffic, dust, and noise disturbances to the agricultural and scattered residential areas near the site. The action would not, however, significantly impact land use following construction. The ancillary structural facilities would be low maintenance and would not require a large land area.

5.4.3 Implementability

The design and installation of water supply wells and associated facilities represent standard engineering efforts and should present no major technical difficulties. Although the system will be fully automated, daily maintenance checks will be required for valves, pumps, and instruments for flow regulation due to the expected variations in water demand. The necessary equipment, materials, and services associated with this option are commonly and readily available.

Acquisition of property is necessary for construction of the water supply wells. Additionally, access to private properties and public rights-of-way is required for installation of the water line. Coordination with local and State agencies is required to meet various permitting requirements for this alternative. The drilling contractor must be licensed and approval must be obtained from the county for drilling activities. Permits would also be required from the county for installation and operation of a water supply system. A permit from the state is also required for major construction activities. Approval for these types of permits can typically be obtained within several weeks and is not expected to be a significant factor in the implementation schedule. It is anticipated that the alternate water supply would be provided within 16 months of approval of the EE/CA.

The monitoring component of this alternative will require approval from and coordination with residents for installing new wells and for gaining access to private wells for sampling and analysis.

5.4.4 Cost

Capital costs for this alternative include direct capital costs for the equipment, labor, and materials necessary to install the water supply system. Indirect costs for engineering, subcontracting, and contingencies are also included. The total capital investment for this alternative is $900,000. Annual costs associated with this alternative include sampling, laboratory analysis, and operation and maintenance of the interceptor wells and water distribution system. The total estimated annual costs are $145,500 per year.

A present worth cost was calculated using a 5 percent discount factor and a five-year project period. The resultant present worth cost is $1,530,000.

5.5 ALTERNATIVE 4: PUMP AND DISCHARGE

5.5.1 Effectiveness: Public Health

Alternative 4 provides for zero access by current and potential users of the off-site groundwater within the south plume by the installation of an alternative water supply and the initiation of a monitoring and institutional control program (as in Alternative 3). Additionally, initiation of a groundwater pumping program to remove uranium-bearing water from the south plume aquifer will prevent plume migration to potentially affected users.

Water pumped from the wells will be released into the Great Miami River along with the liquid effluent from operations at the FMPC. Water will be pumped continuously at an estimated rate of 2,000 gpm to achieve the desired hydraulic control barrier, with the concentration of the pumped water fluctuating with time. The net effect of pumping on the total mass loading of uranium to the river will increase with time as the plume moves southward toward the pumping wells (Figure A-8 and A-9). Based on model predictions, it is estimated that the annual uranium loading to the river will increase from its current level of 440 mCi (1500 pounds) to 446 mCi (1590 pounds; 6 percent increase) during the first year of pumping and 520 mCi (1750 pounds; 17 percent increase) during the fifth year of pumping.

However, the lower uranium concentration in the flow from the wells will reduce the concentration in the FMPC discharge from the current release concentration limit of 550 pCi/ℓ (825 µg/ℓ) to approximately 100 pCi/ℓ (150 µg/ℓ) for each of the five years (550 percent decrease). (Note that current release rates from the FMPC exceed the discharge limit by about 15 percent; the discharge limit is used in this analysis with the expectation that production cutbacks and controls will bring the FMPC into compliance with DOE orders.)

The resultant above-background radiation dose to hypothetical off-site receptors for each of the five years of pumping is calculated to be approximately 0.7 mrem for the maximally exposed receptor and approximately 0.3 mrem for the receptor having average exposure conditions. The calculated radiation doses should increase by a total of 16 percent over the five year removal period with the calculated doses being 0.69 mrem (maximum) and 0.25 mrem (average) for the first year of pumping, and 0.78 mrem (maximum) and 0.29 mrem (average) for the fifth year of pumping.

The calculated above-background radiation doses for the assumed conditions via the drinking water pathway are 0.4 mrem for the hypothetical maximally exposed off-site receptor and 0.2 mrem for the off-site receptor having average exposure conditions. These doses are well below the radiation dose limit of 4 mrem for the drinking water pathway. Similarly, the total radiation dose calculated for all pathways is below the 100 mrem annual limit.

The HI values calculated for this alternative are 0.002, 0.001, 0.003, and 0.001 for the maximum adult, average adult, maximum child, and average child, respectively. These are indistinguishable from the HI values calculated for Alternatives 2 and 3 when rounded to this number of significant figures. They are approximately 5 percent higher than the HI values calculated from Alternatives 2 and 3.

5.5.2 Effectiveness: Other Factors

The alternative which includes groundwater pumping and discharge without treatment meets the secondary removal action objectives to a limited extent. The positioning of the pumping wells near the southern edge of the plume is minimally effective in reducing environmental concentrations in

groundwater over the short term. Figure A-7 indicates that the maximum uranium concentrations in groundwater north of the pumping wells will experience a minimal decrease over a five-year period due to the plume control measures and natural plume dispersion processes.

Any environmental improvements to groundwater are offset by the temporary increased loading of uranium (6 to 17 percent over five years) to the Great Miami River. The adverse impacts to the surface water system, including the aquatic biota, are not expected to be significant as a result of the small increase in uranium loading. The more dramatic decrease in uranium concentrations (550 percent decrease) in the combined effluent may, in fact, result in an improved environmental condition for the aquatic biota.

Control of plume migration is fully achieved by this alternative. Particle tracking algorithms were used to demonstrate that the proposed wells will be effective in capturing the uranium plume in these areas. No reduction in the amount of uranium crossing the southern boundary of the FMPC will be realized.

The projected pumping rates of the withdrawal wells are not expected to impact local groundwater availability or effect flow in Paddys Run. Once the industrial wells are replaced with the alternate water supply, no private wells with significant withdrawal requirements will be located in the vicinity of the pumping wells. Water levels will drop in the cone of depression of the wells, but the drawdown will not be significant in terms of the extent of the aquifer (Figure A-6). Existing wells located within the principal zone of drawdown are believed to be screened deeper in the aquifer and withdrawal rates should not be reduced by the new pumping wells.

Impacts to air quality, soils, vegetation, and land use would be similar to those discussed under Alternative 3. However, the degree of impacts will be slightly greater under Alternative 4 due to additional construction activities for the pumping wells, a pump house, an equalization basin, and the pipeline. The associated increase in the time of implementation will prolong the duration of such

impacts, particularly if the alternate water supply and the pumping system are installed in two phases as currently planned.

The construction period would last 12 months. There would be a short-term disturbance of three acres of land and the permanent commitment loss of 400 square feet of land for concrete pads for the wells. There would be no significant impact to endangered species or historical resources. Waste management requirements would be reduced under the assumption that a currently affected industry would no longer produce uranium-bearing sludges as the result of groundwater treatment. A Corps of Engineers permit may be required for the stream crossing.

5.5.3 Implementability

The installation, construction, and operation of a groundwater recovery system will utilize commonly practiced engineering techniques and pose no unusual technical difficulties. The necessary materials, equipment, and services are readily available.

The alignment of the force main will utilize public rights-of-way and DOE property wherever feasible. Minimal access to and easement across other properties will be required.

The discharge of the pumped groundwater to the Great Miami River will require coordination with and approval from the OEPA through the NPDES permitting program. A modification to the FMPC's existing discharge permit may be required. Other constituents currently regulated under the NPDES permit, such as nitrates, could also be problematical since any additional discharge to the river would increase the mass loadings of any chemicals present, regardless of the concentration levels.

Construction permits may also be required from the state. In addition, the installation of the pumping and monitoring wells will require access approvals as well as the use of a licensed drilling contractor. The alternate water supply portion of this alternative would be provided within 16 months of approval of the EE/CA. Pumping and discharging of groundwater would also begin within 16 months and continue as part of the final remedial action or until the final action is implemented.

The implementability of the alternate water supply and monitoring components of this alternative is the same as that discussed for Alternatives 2 and 3.

5.5.4 Cost

Capital, annual, and present worth costs were estimated for Alternative 4. Capital costs for this alternative include direct capital costs for equipment, labor costs, and the cost of materials necessary to install the alternate water supply system and the groundwater extraction and piping systems, including monitoring well installation. Indirect costs for engineering, subcontracting, and contingencies are also included. The total capital cost for this alternative is estimated to be $7,405,000.

Annual costs for this alternative include the costs of groundwater sampling and analysis of residential, commercial, and monitoring wells and the operation and maintenance of the water supply and groundwater extraction systems. Estimated annual costs are $751,000 per year.

Based on a 5 percent discount factor and a five-year project period, the present worth value of this alternative is estimated to be $10,657,000.

5.6 ALTERNATIVE 5: PUMP AND TREAT

5.6.1 Effectiveness: Public Health

This alternative is the same as Alternative 4, except that a water treatment facility will be installed to ensure that the total quantity of uranium released to the Great Miami River via the FMPC effluent line does not increase. This condition will cause the annual average uranium concentration in the FMPC liquid effluent to be decreased from the current release concentration limit of 550 pCi/ℓ (825 μg/ℓ) to approximately 92 pCi/ℓ (138 μg/ℓ).

The calculated above-background radiation doses to the hypothetical off-site receptors for the first year of this remedial action are approximately 0.6 mrem for the maximally exposed off-site receptor and approximately 0.3 mrem for the off-site receptor having average exposure parameters. The calculated

above-background radiation doses for the assumed conditions via the drinking water pathway are 0.3 and 0.2 mrem for the hypothetical maximally exposed off-site receptor and the average receptor, respectively. Radiation doses calculated for this alternative are well below both the drinking water limit and the total dose limit, and will remain so even if the concentrations of uranium in the pumped water increases over the five-year project life.

The HI values calculated for this alternative are 0.002, 0.001, 0.003, and 0.001 for the maximum adult, average adult, maximum child, and average child, respectively. These values indicate that the hypothetical intake rates are well below the level of potential chemical toxicity for uranium.

5.6.2 Effectiveness: Other Factors

The degree to which the secondary objectives would be satisfied as the result of implementing Alternative 5 is nearly identical to that achieved under Alternative 4, with the exception that the addition of a treatment step reduces the net discharge of uranium to the Great Miami River.

The proposed pumping rate of 2000 gpm, or 4.5 cfs, would add significantly to the current average effluent discharge of 0.89 cfs (WMCO 1988). This increased flow rate remains below the design capacity of the effluent line and is extremely small in comparison with the average flow rate of 3460 cfs in the Great Miami River (IT 1988). No changes to the hydrodynamic or scouring patterns of the river are expected as a result of the increased discharge.

A goal under this alternative is to install a treatment facility to remove a mass of uranium from an existing FMPC effluent equal to or greater than the average mass of uranium pumped from the south plume. This is to ensure that the total mass of uranium released via the effluent pipeline does not exceed the existing FMPC release value. The maximum projected uranium loading from the wells for the fifth year of operation is approximately 17 percent of the total current loading for the FMPC. Even though total removal of uranium from the FMPC effluent cannot be expected, it is likely that the goal of equivalent mass removal can be met even during the later years of pumping when the groundwater concentrations are at a maximum. A portion of the pumped water can even be directed

through the treatment plant during periods of low storm water runoff to further reduce the combined uranium loading to the river.

The interaction between the existing FMPC discharge, the Great Miami River, and the SOWC wellfield located east of the FMPC has been extensively studied (IT 1988). The study found that the incremental impact of the existing effluent on the water quality of the SOWC wells was nondetectable. It is unlikely, therefore, that the increased flow from the discharge line would cause a detectable change in conditions.

Treatment of storm water will generate sludge from two sources - suspended solids captured in the filters and the uranium that will be removed by the ion exchange resin. The total number of drums generated from these sources is estimated to be less than 350 per year. The FMPC currently is generating about 750 drums of sludge from the bottom of the storm water retention basin each year and 1000 drums each year from other water treatment operations. Thus, treatment of the storm water will increase the number of drums being generated from current FMPC water treatment operations by less than 20 percent.

The drums from the filtering process may be transported to the Rotary Kiln in Plant 8 for further volume reduction. All drums, including those from the ion exchange process, will be shipped to Nevada.

5.6.3 Implementability

The implementability of this alternative is similar to Alternative 4 (Section 5.5.3), with the addition of those factors related to the treatment process. The principal components of the water treatment system are assumed to include:

- Ion exchange and regeneration equipment
- Regenerant mixing equipment
- pH adjustment equipment
- Containment and sump pump
- Final filtration equipment
- Water tanks and pumps

These components of the treatment system represent standard treatment processes and equipment that are commonly available. The components can be obtained from manufacturers regularly engaged in the design and production of such equipment for similar applications. The treatment equipment, piping, valves, and other instrumentation are of proven reliability and design.

While this alternative will require a longer period for design and construction than Alternative 4, the NPDES permitting process, if required, should have a shorter duration and a higher probability of success.

In this case, it is expected that only a straightforward modification to the existing permit will be required. Public support is also expected for the groundwater pumping and effluent treatment alternative.

Construction impacts off-site would be similar to those identified in Alternative 4. On-site construction of the treatment facility would last six months and would be in operation within 20 months of approval of the EE/CA. No significant impacts are anticipated. There would be no impacts to endangered species or historical resources related to Alternative 5.

The implementability of the alternate water supply, monitoring, and institutional control components of this alternative is the same as that discussed for Alternatives 2 and 3.

5.6.4 Cost

The total capital cost for Alternative 5 is $14,702,000. This cost includes direct capital costs for equipment, labor costs, and the cost of materials necessary for the installation of the alternate water supply system, the groundwater extraction system and pipeline, and the effluent treatment system. Indirect capital costs for predesign, treatability studies, engineering, subcontracting, and contingencies are also included.

The annual costs for this alternative include groundwater sampling, laboratory analysis, and operation and maintenance costs associated with the water supply system and the groundwater extraction and treatment system. The annual costs for this alternative are $2,590,000 per year.

A present worth value was calculated for Alternative 5 using a 5 percent discount factor over a five-year project life. The present worth cost of this alternative was estimated to be $25,915,000.

5.7 REQUIREMENTS POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE AND OTHER CRITERIA OR GUIDELINES TO BE CONSIDERED FOR THE PROPOSED ACTIONS

The ARARs and TBCs for the proposed actions for the south plume are listed in Table 5-1. These potential ARARs and TBCs for the south plume are catergorized into the following U.S. EPA recommended classifications: chemical specific ARARs and TBCs, location specific ARARs and TBCs, and action specific ARARs and TBCs. A discussion of each group and its relation to the proposed actions is given below.

5.7.1 Chemical-Specific ARARs and TBCs

The chemical-specific ARARs and TBCs apply to all of the proposed removal actions since the contaminant concentration drives the action level for implementation of the removal action. The chemical-specific TBC identified for the south plume pertain to uranium and are derived from DOE Order 5400.5. The chemical-specific TBC, which protection public health and the environment from chemical and radiological constituents in groundwater, is the 50-year CEDE limit of four mrem from an annual intake of radioactive materials and drinking water. The second chemical-specific TBC for the south plume is the total annual committed effective dose limit equivalent of 100 mrem for off-site individuals from all radiation exposure due to the site via all environmental transport pathways. These limits are discussed in Section 5.1.1 and are used as the basis for the public health evaluations for each alternative.

TABLE 5-1

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA OR GUIDELINES TO BE CONSIDERED FOR THE SOUTH PLUME EE/CA

CONTAMINANT-SPECIFIC ARARS AND TBCS

REQUIREMENT	APPLICATION TO THE SOUTH PLUME
Radiation Protection of the Public and Environment (DOE 5400.5)	Chapter II.1.d sets the annual not to exceed effective dose limit of 4 mrems for human consumption through through drinking water and 100 mrems from all radiation exposure via all environmental transport pathways
Ohio Water Quality Standards (OAC 3745-1)	3745-01-04(D) set the criterion applicable to all waters, 3745-01-05 sets fourth the antidegradation policy for waters of the state, and 3745-1-21 describes the use designations for the Great Miami River 3745-1-32(c)(9) specifically excludes uranium from the Ohio River stream criteria
Ohio Drinking Water Rules (OAC 3745-81)	3745-81-15 and -16 establishes MCLs for gross alphas and beta particle activity but specifically excludes uranium
Ohio Radiation Protection Standards (OAC 3745-38)	3701-38-13(D) provides concentration limits for discharge of radioactive materials into air or water in unrestricted areas
NRC Regulations for Standards for Protection Against Radiation (10CFR20)	Establishes radiation dose limits in unrestricted areas (10CFR20.105-106) and for waste disposal (10CFR20.301-302)
U.S. EPA Regulations for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40CFR192)	40CFR192.32 establishes cleanup limits for radionuclides in groundwater (excluding uranium) pursuant to the Ground Water Protection Program 40CFR264.92, but also designates uranium as a hazardous constituent under 40CFR264.93-94
Safe Drinking Water Act	
a. Maximum Contaminant Levels (MCLs)	Groundwater MCLs for uranium are mandated for promulgation, but not yet proposed
b. Maximum Contaminant Level Goals (MCLGs)	Considered pursuant to SARA Section 121(d)(2)(A(ii))
Clean Water Act (PL92-500) Federal Ambient Existing Source and New Source Water Quality Criteria (AWQC)	Specifically excludes uranium from consideration in discharges to surface water

TABLE 5-1
(Continued)

LOCATION-SPECIFIC ARARS AND TBCS

REQUIREMENT	APPLICATION TO THE SOUTH PLUME
Regulation of Activities Affecting Waters of the U.S. (33CFR320-329), for Ohio (OAC 3745-32)	Corps of Engineers regulations apply to both wetlands and navigable waters. Pipeline construction may require 401 water quality certifications
U.S. EPA's Ground Water Protection Strategy	The classification of groundwater at the site will affect the level of remedial response
Endangered Species Act of 1978 (16USC1531)	The effects of No Action and the construction and discharge activities must be considered if endangered species are located in area impacted by the South Plume
Fish and Wildlife Coordination Act (16 USC 661)	The effects on wetlands and protected habitats by No Action, and by the construction and discharge portions of each alternative must be considered if any wetlands or protected habitats are located in the South Plume area
Fish and Wildlife Improvement Act of 1978 (16USC742)	The effects on wetlands and protected habitats by No Action, and by the construction and discharge portions of each alternative must be considered if any wetlands or protected habitats are located within the South Plume area
Executive Order 11990 Protection of the Wetlands	This order may affect the administrative ability of alternatives which cause disturbance or destruction of wetlands
Ohio Location Standards (OAC 3745-54-18)	Governs the location of hazardous waste treatment, storage, or disposal with respect to seismic conditions and floodplains
Ohio Conservancy District Rules governing activities within the boundaries of a conservancy district (ORC 6109.19)	Erection of obstruction/facilities within the bounds of the Great Miami River Conservancy District will require permit from the Board of Directors

TABLE 5-1
(Continued)

ACTION-SPECIFIC ARARS AND TBCS	
REQUIREMENT	APPLICATION TO THE SOUTH PLUME
Ohio water well standards, (including plan approval and well and test hole abandonment) for new water wells intended for human consumption (OAC 3745-9)	Plan approvals will be required for the well replacement and community water supply alternatives
Ohio rules which provide standards, procedures, and plan approval for construction or abandonment of private water systems (OAC 3701-28)	Approvals from the Department of Health will be required for the well replacement and treatment at the tap alternatives
Ohio drinking water rules for public drinking water (MCLs) (OAC 3745-81)	Rules governing water quality for the alternate water supply alternatives which use bottled water or a community well system
Ohio secondary contaminant standards for public drinking water (OAC 3745-82)	Rules governing water quality for the alternate water supply alternatives which use bottled water or a community well system
Ohio operational requirements for community and major noncommunity drinking water systems; industrial disinfection, approval of chemicals, minimum pressure, reporting (OAC 3745-83)	Rules governing water quality for the alternate water supply alternatives which use bottled water or a community well system
Ohio plans approval for construction or significant changes to public water systems requiring OEPA approval of plans (OAC 3745-91)	Approvals and rules governing the alternative water supply replacement with a community well system alternative
Ohio backflow prevention and cross connections control for water service connections to public water supply systems (OAC 3745-95)	Approvals and rules governing the alternative water supply replacement with a community well system alternative
Ohio criteria for issuing permits to construct new wastewater treatment facilities (OAC 3745-31)	On-site plant may be exempt under CERCLA

TABLE 5-1
(Continued)

ACTION-SPECIFIC ARARS AND TBCS

REQUIREMENT	APPLICATION TO THE SOUTH PLUME
CWA NPDES Requirements (40CFR121-125) and Ohio requirements for NPDES permit to discharge wastewater to the waters of the state (OAC 3745-33)	Program is mandated to state control; there are no standards for uranium discharge, but other limitations or criteria may be set by a permit (pH, flow, etc.) for all alternatives which have a discharge component
Underground injection control program to regulate the injection of fluids via wells (OAC 3745-34)	The alternative of extraction and injection of uncontaminated water for plume control will require an injection permit
Ohio River Quality Standards Antidegradation Policy [OAC 3745-1-05(A) and OAC 3745-1-05(B)]	Applies to all alternatives which discharge to surface waters
RCRA Requirements (40CFR260-279)	Uranium does not qualify as a solid or hazardous waste, but was added to the list of hazardous constituents subject to RCRA Groundwater Protection Program rules (40CFR264.92.94) under the uranium mill tailings regulations (40CFR192.32)
Ohio Solid Waste Management Facility operating rules and permit requirements (OAC 3745-27 and 37)	These rules may apply to residuals disposal from groundwater treatment facilities
Ohio Hazardous Waste Management Facility operating rules and permits (OAC 3745-50 through 70)	These rules may apply to groundwater treatment plant construction operations and permitting
Ohio Groundwater Protection Rules for Hazardous Waste Management Facilities, including groundwater protection standards, point of compliance, and monitoring programs (OAC 3745-54-90 through 99)	These rules may apply to groundwater cleanup for Operable Unit 6
Ohio Corrective Action Program (groundwater protection) (OAC 3745-55)	Includes monitoring requirements for hazardous waste management facilities
Ohio restrictions on fugitive dust emissions (OAC-17-08)	Requires dust control during any construction activities which may take place during the remedial response

TABLE 5-1
(Continued)

ACTION-SPECIFIC ARARS AND TBCS	
REQUIREMENT	APPLICATION TO THE SOUTH PLUME
OSHA Requirements (29CFR1910, 1926, and 1904)	Required worker safety requirements for exposure while engaged in on-site activities
Ohio General Radiation Protection Standards; all facilities that receive, possess, use, store, transfer, install, service, or dispose of any source of radiation require registration by their handlers (OAC 3701-70 and 71)	Required worker safety requirements for exposure while engaged in on-site activities
DOE Order for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Program (5400.4)	Authorizes CERCLA activity by the DOE at the FMPC
DOE Order for National Environmental Policy Act (NEPA) (5400.1C)	Establishes environmental policies and goals applicable to DOE and the FMPC
DOE Order for Radiological Effluent Monitoring and Environmental Surveillance (5400.XY)	Monitoring requirements for DOE facilities applicable to all alternatives
DOE Order for Hazardous and Radioactive Mixed Waste Management (5480.2)	Regulations by which FMPC currently operates for waste management
DOE Order for Radiation Protection of the Public and the Environment (5400.5)	Establishes exposure limits for public and the environment; this regulation is the basis for current cleanup levels
DOE Order for Environmental Protection, Safety, and Health Protection Information Reporting Requirements (5481.1)	Safety requirements for FMPC operations to be followed during remedial response actions
DOE Order for Quality Assurance (5700.6B)	Establishes the level of quality assurance for any work done at the FMPC for remedial response
DOE Order for Radioactive Waste Management (5820.2)	Policies and guidance for FMPC waste and contaminated facility management

TABLE 5-1
(Continued)

ACTION-SPECIFIC ARARS AND TBCS

REQUIREMENT	APPLICATION TO THE SOUTH PLUME
The Atomic Energy Act of 1954 (42USC2011)	This act authorizes the conduct of atomic energy activities
The DOE Organization Act (42USC7101)	Established powers and responsibilities of the DOE
The National Environmental Policy Act (NEPA) of 1969 (42USC4341)	Requires consideration of environmental concerns by the DOE at the FMPC consistent with national environmental policies and goals and provides a method for accomplishing these goals
Federal Compliance with Pollution Control Standards Executive Order (12088)	Requires the DOE to comply with applicable pollution control standards at the FMPC
Superfund Implementation Executive Order (12580)	Delegates CERCLA and SARA responsibilities to the DOE and to the U.S. EPA
NRC Rules for Land Disposal of Radioactive Wastes (10CFR61)	NRC rules may apply to alternatives containing groundwater treatment, disposal, or residual handling components
NRC Regulations for Standards for Protection Against Radiation (10CFR20)	NRC standards may apply for exposure limitations at the FMPC
U.S. EPA Regulations for Environmental Radiation Protection Standards for Nuclear Power Operations (40CFR190)	NRC standards for radiation doses received by members of the public in the general environment and to radioactive materials introduced into the general environment as a result of operations which are part of the nuclear fuel cycle
U.S. EPA Regulations for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailing (40CFR192)	Established cleanup standards for inactive uranium mill tailing sites; some standards may be applicable to the FMPC remedial response

5.7.2 Location-Specific ARARs and TBCs

Since the south plume currently has no definable impact on surface waters, wetlands, or wildlife, location-specific ARARs and TBCs are not applicable to the site for the no-action or monitoring and institutional control alternatives. These ARARs and TBCs will become applicable when an action is implemented which removes contaminated water from the aquifer for treatment and/or disposal, and for the proposed removal actions which include disposal outside of the FMPC or pipelines which cross streams (wetland impacts).

It is assumed for the purposes of this document that residual disposal from treatment processes will take place at the FMPC or as part of the approved FMPC off-site disposal practices. Therefore, the only ARARs and TBCs applicable to disposal activities will be those associated with disposal to surface water. The location-specific ARARs and TBCs listed in Table 5.1 apply to Alternative 4 (pump and discharge) and Alternative 5 (pump and treat) only. In addition, a Corps of Engineers (COE) wetlands permit may be required for the stream crossings necessary for the alternate water supply in Alternatives 3, 4, and 5.

5.7.3 Action-Specific ARARs and TBCs

Action-specific ARARs and TBCs regulate the process and operation of removal actions taken to mitigate the impact of the south plume. Any actions taken as a result of releases from the FMPC will be under the supervision of the DOE and the Nuclear Regulatory Commission (NRC) and are also subject to U.S. EPA pursuant to 40 CFR 264 and 40 CFR 300. The powers and responsibilities of the DOE and NRC are established by 42USC2011 and 42USC7101.

Executive Order 12088 defines the authority and scope of DOE compliance with environmental statutes. DOE programs of compliance with specific environmental statutes are defined in DOE5400.4 (CERCLA), Executive Order 12580 (Superfund), and 42USC4341 (NEPA). DOE Orders 5400.5 and 5480.12 and NRC regulation 10CFR20 set the radiation protection requirements for the public and the environment. The safety and protection rules under which the FMPC is required to operate are regulated by U.S. EPA under 10CFR190.

Monitoring and reporting requirements for DOE operations (including releases) are governed by DOE Order 5484.1 and by NRC requirements listed in 10CFR61.80 and 40 CFR 300.

Management of residuals from the treatment and disposal actions will be regulated under the NRC land disposal rules (10CFR61) and DOE Order 5820.2. Worker safety requirements for radiation exposure while handling contaminated wastewater and residuals, or while installing or operating wells in the contaminated plume, are governed by OSHA requirements in 29CFR1910, 1926, and 1904. Construction activities in areas unrelated to contamination (i.e., alternative drinking water supply) will be governed under standard OSHA requirements for worker safety in 29CFR.

Discharge of treated or contaminated water to surface water will be regulated under the Clean Water Act NPDES requirements, as delegated to the state of Ohio (40CFR121-125 and OAC3745-33). The discharges must meet national and state of Ohio ambient water quality and antidegradation criteria.

6.0

6.0 SELECTION OF PREFERRED ALTERNATIVE

In Chapter 5.0, the five removal action alternatives were evaluated on an individual basis against four criteria. These criteria included the effectiveness of the alternative in achieving the principal removal action objective of protecting public health, the effectiveness in achieving four secondary objectives, the implementability of the alternative, and the total present worth cost. A comparative evaluation of the alternatives against these same criteria to support the selection of a preferred alternative is the subject of this chapter.

6.1 BASIS FOR SELECTION

To fully support the selection process within the context of a CERCLA-based removal action, two additional criteria are introduced into the final comparison. The first is the degree to which the alternative achieves a reduction in contaminant mobility, toxicity, or volume; that is, the degree to which treatment is employed. Although consideration of this factor is not a requirement for removal actions, it is expected that the nature of both the south plume problem and the alternatives under consideration will lead to a direct incorporation of the removal action into the final remedial action. Therefore, by accounting for the preference for treatment in the removal action, potential shortcomings in the final action may be avoided. The second additional factor is the anticipated degree of consistency between the removal action and the remedial alternatives still under consideration in the companion Feasibility Study for the environmental media operable unit.

With the exception of cost, each of the criteria is given equal weight in the comparative evaluation. Cost is considered separately in order to differentiate those alternatives that satisfy the criteria to a similar extent but have very different costs.

6.2 ELIMINATION OF NONRESPONSIVE ALTERNATIVES

Based on the evaluation reported in Chapter 5.0, the no-action alternative was shown not to satisfy the minimum objective of being fully protective of public health. This alternative is, therefore, eliminated from further consideration.

The minimum action of continued monitoring and institutional controls has likewise been eliminated due to its general nonresponsiveness to the removal action objectives. It does not pro-actively address the fact that a uranium plume exceeding DOE's derived concentration standards exists off site and is being utilized as an industrial water supply. In addition, because of the off-site location, future usage of the groundwater cannot be controlled to the extent that would be necessary to ensure public health protection.

6.3 COMPARATIVE EVALUATION

This evaluation compares the three remaining alternatives in relation to the six evaluation criteria; effectiveness: public health; effectiveness: other factors; implementability; cost; preference for treatment; and consistency with final action. Each alternative is shown to satisfy the public health protection criterion. The pumping scenarios have been assigned a slight preference due to the pro-active position in removing uranium from the aquifer to minimize future exposure. The pumping alternative with treatment has, in turn, been given a slightly higher preference due to the lesser discharges to the surface water environment and the associated exposure pathways. It is important to note, however, that acceptable dose and exposure limits will not be exceeded even if treatment is not provided.

The remaining effectiveness criteria, which include an evaluation of the three secondary objectives and the environmental impacts, are satisfied to a significant degree only by the pumping scenarios. Again, the alternative involving treatment is preferred since the potential environmental impacts on the aquatic environment are minimized.

Each of the alternatives are implementable from a technical standpoint. The differences in the evaluations reflect administrative implementation factors and the potential adverse consequences on the time and cost of implementation. In the case of Alternative 3, the only negative factor is the likelihood that the regulatory agencies and the general public will oppose the alternative as being insufficient. The same concern is true for the pumping option with no treatment, which this case is magnified by the possible requirement for an NPDES permit. The latter condition can produce an

administrative situation that could delay, under a worst-case scenario, or force eventual postponement of this option. While the pumping with treatment option will likely be administratively acceptable, it carries with it the longest planning and implementation period. Note, however, that the alternate water supply portion of both pumping alternatives can be implemented prior to the complete action. This condition reduces the advantages that Alternative 3 would appear to have over Alternatives 4 and 5 in relation to implementation time.

The preference for treatment is satisfied only by Alternative 5. However, it must be recalled that treatment is actually being proposed for a separate effluent stream in order to achieve the objective of not increasing the mass loadings to the Great Miami River as a result of pumping. Because the pumping is targeted at the leading edge of the plume, the concentration of uranium in the pumped groundwater will be near the DOE-derived drinking water standard for the initial years of operation and will have no significant effect on the aquatic environment or public health. The need for treatment as part of the removal action is, therefore, highly questionable considering that the primary exposure scenarios would develop only after the low concentration groundwater enters the Great Miami River and would be dominated by the unassociated releases from FMPC operations.

Each of the three alternatives can be viewed as being consistent with a final action for the south plume. The pumping scenarios were again given a preference, however, since the consequent removal of uranium and the control of plume migration should reduce the scope of the final action under the environmental media operable unit. It is even possible that no further action for the off-site plume will be required since the pumping wells will fully control plume migration. The decision on the need for an additional action will be highly dependent on the relative effectiveness and cost of providing additional pumping in the more highly concentrated areas of the plume, thereby reducing project duration, versus waiting for the plume to reach the pumping wells that would be installed as part of the removal action. This eventual decision will also be dependent on forthcoming conclusions regarding the source(s) of uranium to the south plume and the continuing strength of the source(s).

6.4 PREFERRED ALTERNATIVE

It is apparent that the total present worth costs for Alternative 5 (Pump and Treat) are highly disproportionate to the relative level to which this alternative satisfies the evaluation criteria. Together with the following factors, this lack of cost-effectiveness provides sufficient justification for eliminating Alternative 5 from further consideration for the south plume removal action:

- Treatment is not deemed necessary for the protection of public health and the environment, particularly during the early years of pumping.
- The highly concentrated uranium sludge produced as a result of treatment introduces an otherwise unnecessary waste product and potential risk to public health and the environment.
- There is only a 12 μg/ℓ difference in uranium concentration from the discharge to the Great Miami River between Alternative 4 and Alternative 5.

Alternatives 3 and 4 have total present worth costs generally proportionate to the level to which these alternatives satisfy the evaluation criteria. Given this comparable level of cost-effectiveness, the selection of the preferred alternative becomes focused on the alternative that most comprehensively and uniformly satisfies the full set of criteria. Based on the previous discussions, this is shown to be Alternative 4, which includes groundwater pumping with direct discharge to the Great Miami River, an alternate water supply for two currently affected industrial users, and enhanced monitoring and institutional controls.

As documented in this EE/CA, the current data base and the results of the groundwater and solute transport models are considered sufficient and adequately reliable to support the selection of Alternative 4. This action is not highly sensitive to a limited redefinition of field conditions based on future data acquisition. Remaining uncertainties in the informational base must still be resolved prior to a final decision on the location, number, and design flow rate of the pumping wells. This enhancement of the current understanding is necessary to confirm that the wells are indeed located at or beyond the leading edge of the plume and that the lateral extent of the plume will be captured; that is, to confirm that the removal action objectives will be achieved. Current groundwater monitoring

plans and the follow-up refinement of model calibration in the south plume area will provide for the resolution of these issues.

A phased approach is proposed for the south plume removal action to most effectively accommodate the resolution of key technical issues. Upon approval of this EE/CA and the recommended alternative, design efforts will commence on the alternate water supply component of the removal action. Implementation of the alternate water supply, as well as the monitoring and institutional control components, will follow once the design is accepted. The second phase of activities will involve the pump and discharge component of Alternative 4. The final selection of the number, location, and pumping rates of the wells will be part of this second design phase. It is estimated that the alternate water supply will be on line approximately six months prior to the pump and discharge system.

Pending approval of this EE/CA, the Feasibility Study for the environmental media operable unit will be revised to account for the eventual implementation of the south plume removal action. That is, the "no action" alternative for the regional aquifer will assume that the removal action is implemented, and the evaluation of alternatives in the FS will incorporate any affects or changes in strategy introduced by the proposed pumping system and alternate water supply.

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APPENDIX
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APPENDIX A

EE/CA GROUNDWATER MODELING

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APPENDIX A

EE/CA GROUNDWATER MODELING
FEED MATERIALS PRODUCTION CENTER, FERNALD, OHIO

A.1.0 PURPOSE AND SCOPE

The purpose of this groundwater modeling investigation was to support the engineering evaluation and cost analysis (EE/CA) of removal action alternatives for the south plume at the Feed Materials Production Center (FMPC) in Fernald, Ohio. The alternatives include no action, aquifer monitoring and institutional control, installation of an alternate water supply, groundwater pumping (with and without effluent treatment) to control plume migration, and combinations thereof. The modeling study was necessary to supplement direct field observations so that the combined informational base would be sufficient to support: (1) the understanding of the current situation (i.e., the nature and extent of the contamination); (2) the public health and environmental risk assessment; and (3) the evaluation of the removal action alternatives.

Groundwater monitoring data provides insight into the nature and extent of contamination by establishing whether contamination is present at a specific location and to what level. The results of the modeling study utilize these same data as calibration points to approximate, through interpolation between and extrapolation beyond the field observations, the concentration distribution throughout the area of interest. This exercise can be used to establish the probable location and value of the absolute maximum concentration; estimate the total mass of a contaminant present in the aquifer; help explain the occurrence of the field observations; indicate whether or not any field observations should be considered as outliers; and determine the uncertainties for the planning of additional data collection efforts.

The public health risk assessment involves the evaluation of risk under both existing conditions and anticipated conditions (with and without an action). Direct field observations are often sufficient for the evaluation of current risk since groundwater at the specific locations of all known users can be

monitored. On the other hand, model results can be used for the prediction of future conditions. Model predictions describe expected uranium distribution (and thus potential levels of exposure) in both space and time.

The evaluation of alternatives is only sparingly supported by direct field observations. This is due to the limitation in utilizing current observations for the direct evaluation of future performance. The primary use of the field observations is to establish the present condition and to support the calibration of the model, which in turn is used to evaluate remedial action alternatives. In the case of the south plume, the model is intended to support the following:

- Projection of the likelihood that additional receptors would require an alternate water supply during the life of the action (Alternate Water Supply)
- Identification of the most susceptible receptor locations for additional "early warning" wells or control prioritization (Monitoring/Institutional Controls)
- Evaluation of the effects on plume migration if the industrial wells are shut down (Alternate Water Supply)
- Determination of the size and location of extraction wells to control plume migration (Groundwater Pumping with or without Treatment)
- Evaluation of the effects of pumping on plume behavior at other locations (Groundwater Pumping with or without Treatment)
- Estimation of the discharge rate, average concentration, and mass of uranium removed from extraction wells, either to support the evaluation of effects of the discharge on surface waters (without treatment) or to establish treatment plant design criteria (with treatment) (Groundwater Pumping)
- Time required to reach the target level for cleanup (Groundwater Pumping with and without Treatment)

The EE/CA, including the groundwater modeling study, was based on information available as of August 1989. The available water level data from numerous monitoring wells was sufficient for a complete and successful calibration of the groundwater flow model. The results of all applications of

the model that involved the groundwater flow component are, therefore, considered very reliable for their intended use.

On the other hand, the predictions of present and future uranium concentrations in the plume resulting from the application of the solute transport model should be viewed as approximations based on the best available data. The extent of the southern, leading edge of the plume remains uncertain due to a scarcity of field data in the area predicted (by the model) to contain the plume front. Results of additional field investigations forthcoming from the Remedial Investigation/Feasibility Study (RI/FS) for the Environmental Media Operable Unit will improve the reliability of solute transport model predictions in this area. Furthermore, the ongoing Paddys Run RI/FS will provide valuable data within the area of interest.

Because uranium migration is influenced by geochemical factors, the anticipated results of the ongoing geochemical program will also increase the level of confidence in the predictions of future conditions from the solute transport model. Even though concentrations predicted in the present report may be revised as a result, the level of change is not expected to be significant enough to cause a change in the overall findings and conclusions of the EE/CA.

A.2.0 MODEL DESCRIPTION

The groundwater model used in support of the EE/CA for the south plume is a finite-difference computer model of groundwater flow and solute transport. The computer program is SWIFT III, Version 2.25. A detailed presentation of the model, its development, and the baseline input data will be issued as part of the overall modeling report being prepared under the RI/FS. Only the most pertinent information is provided here. A comprehensive verification study of the SWIFT III code has also been completed and a report will be forthcoming under separate cover.

Steps in the development of the model for application to the FMPC have included:

- Construction and calibration of a regional, two-dimensional, steady state, groundwater flow model
- Construction and calibration of a regional, three-dimensional, steady state, groundwater flow model
- Application of two-dimensional analytical solute transport models to help strategize the numerical solute transport model
- Construction of a local, two-dimensional, transient solute transport model
- Construction of a local, three-dimensional, transient solute transport model
- Calibration of the solute transport part of the local model with uranium concentration data from the monitoring wells

The local model covers a smaller area than the regional model (Figure A-1). The smaller area allowed the use of a refined grid with a small cell size, which is necessary for solute transport modeling. The smaller grid area was established to include the area of the existing uranium plume. The local model also covered the area for which uranium concentration data is available from monitoring wells. The interrelationship between the local and regional models is established by imposing the steady-state flow field predicted by the regional model on the solute transport model.

The model contains five layers. The uppermost two layers represent the upper and lower parts of the upper alluvial aquifer that underlies the area. The middle layer represents a clay bed that is present in the immediate vicinity of the FMPC site, and the lowermost two layers represent the upper and lower parts of the lower alluvial aquifer. The layers extend laterally into bedrock at the edges of a buried valley that contains the alluvium.

Pumping wells are located in the area spanned by the local model. These include an FMPC production well and three industrial wells located south of the FMPC site. Pumping from each of these wells was assigned to the proper cell and layer in the model. The three industrial wells are within the south plume study area.

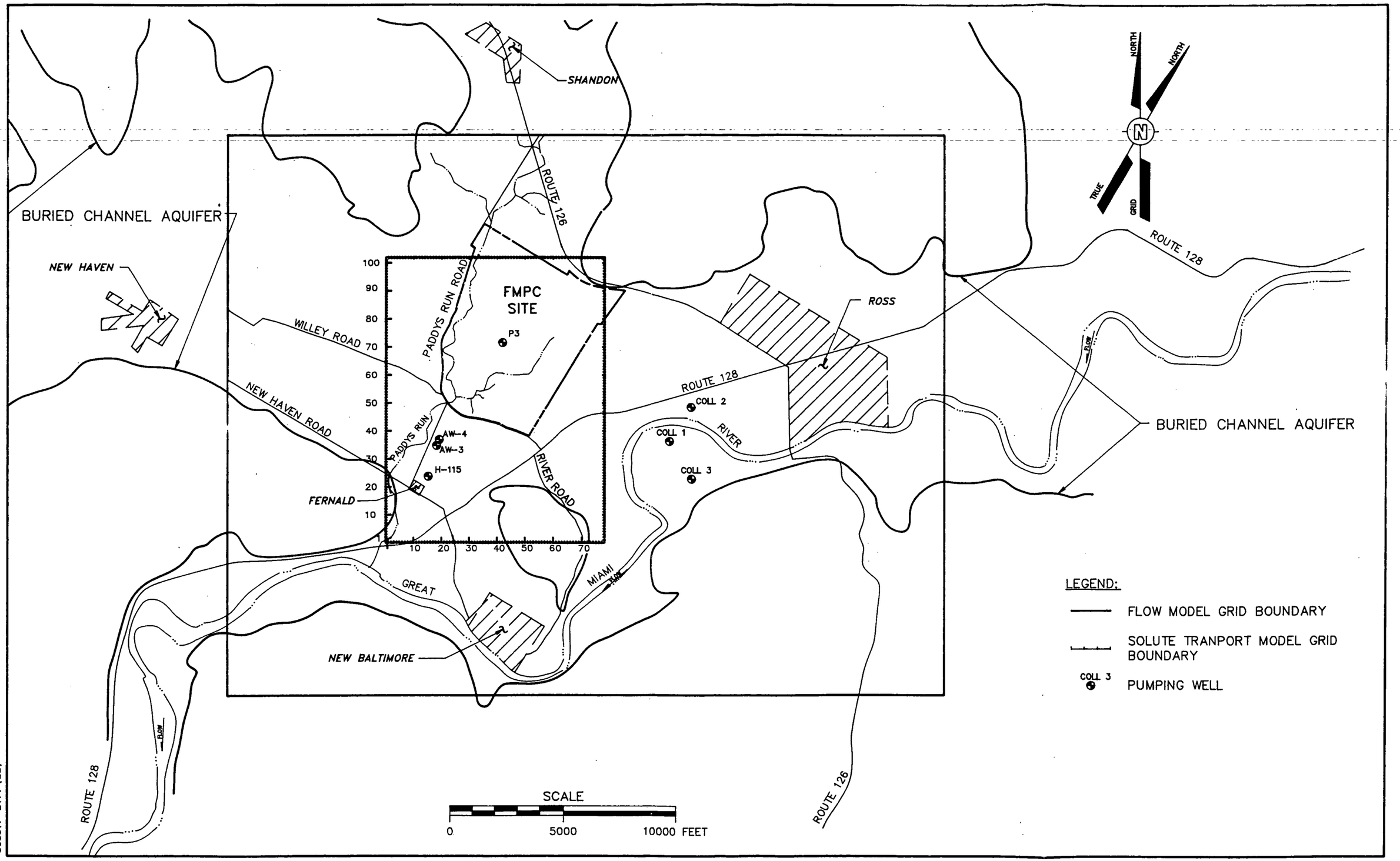

FIGURE A-1
GROUNDWATER MODEL GRID BOUNDARY

A.3.0 MODEL CALIBRATION

The calibration of the groundwater flow model was performed by comparing hydraulic heads calculated by the model against heads measured in numerous monitoring wells throughout the FMPC and surrounding areas.

This calibration was performed using the regional flow model. Reasonable estimates of hydraulic conductivity and recharge were initially input to the model and then varied within an acceptable range to adjust model-computed heads to agree with observed monitoring well heads. The monitoring well heads used for calibration were measured in 1986.

Groundwater flow conditions simulated by the model were successfully made to reproduce the observed flow conditions throughout the study area. Based on water levels from 55 wells, the mean residual (observed head minus calculated head at a monitoring well) for the calibrated flow model was 0.21 feet. The excellent fit portrayed by this residual value is realized when compared to a total change in hydraulic head of approximately 20 feet over the south plume area. The mean of the absolute values of the residuals was 1.08 feet. When the local model was constructed, a computer program was used to check, cell by cell, the correspondence of heads in the local model with heads in the regional model. The correspondence verified that the flow model calibration was preserved in the solute transport model.

The calibration of the solute transport model involved the following steps:

- Based on the current understanding of historic patterns of uranium release, designating appropriate cells as source cells where uranium may enter the groundwater system
- Dividing the model time into source loading periods corresponding to intervals during which source loading was probably significantly different from in other periods

- Introducing reasonable initial estimates of uranium source loading for each source cell

- Establishing the best initial values of longitudinal and transverse dispersivity, as well as a distribution coefficient for uranium

- Adjusting source loading, source loading periods, dispersivities, and the distribution coefficient until concentrations calculated by the model are close to concentrations measured in the field.

The distribution coefficient was set at 0.016 cubic feet per pound, which corresponds to a retardation factor of 9. After attempting calibrations with distribution coefficients corresponding to retardation factors of 1, 6, and 12, a retardation factor of 9 was selected as the most reasonable compromise between two competing goals. These goals were to keep the dispersivities as close to 100 feet as possible and to keep the distribution coefficient as low as possible. The preference for a dispersivity of 100 feet was based on information in the scientific literature. Walton (1985, Figure 2.16) presents a graph of mean travel distance versus longitudinal dispersivity. Assuming a mean travel distance in the south plume of 2500 feet, Walton's graph yields a longitudinal dispersivity of a little over 100 feet. Walton also shows representative longitudinal dispersivities for areal models of alluvial sediments and glacial deposits to be between 39 and 200 feet. The desire to keep the distribution coefficient low was based on preliminary results of the geochemical investigation, which suggest that the uranium is in complexes which have neutral or negative charges. Such charges imply low retardation.

Because the plume is narrow and has high concentration gradients away from the center, the concentration patterns could be matched by having either a sufficiently high retardation factor or a sufficiently low dispersivity. Calibration with a retardation factor of 9 yielded a longitudinal dispersivity of 50 feet and a transverse dispersivity of 1 foot. The model uses transverse dispersivity for vertical dispersivity, so the calibrated transverse dispersivity tends to be low. Although the outcome of the geochemical investigation may result in a different retardation factor, the value of 9 is sufficiently realistic to allow for provisional application of the solute transport model in this study.

Statistics used to characterize the degree of calibration were based on monitoring data from wells that yielded detectable uranium in all samples. The object of the calibration was to produce a representative simulated plume. Calibration was performed by comparing calculated concentrations to the mean values of concentrations measured at the individual wells. Since the mean of observed concentrations at a well where only a few concentrations have been measured is not an accurate estimate of the most representative value for that well, such means were not matched more closely than their accuracy warranted. Instead, the model calibration emphasized (1) avoidance of excessive clumping of positive or negative residuals (observed mean concentration at a well minus the calculated concentration at the well), and (2) keeping the absolute values of the residuals reasonably low.

The first calibration criterion, clumping, was examined by calculating the unit normal deviate from a modification of Moran's I (IT Corporation 1987). A value greater than 1.645 indicates a nonrandom distribution of residuals at the 0.05 level of significance. The optimal value is zero. The value calculated for the calibrated run was 0.144.

The second calibration criterion, reasonably low absolute values of residuals, was examined by using a statistical procedure to determine whether the calculated concentration at an observation well differs from the mean concentration observed there by an improbable amount. The statistical testing procedure used for this purpose followed methods described by Grubbs (1969). This method of testing goodness of fit is more informative than simply measuring deviations from means because it includes uncertainty related to the representativeness of the observed concentrations (sample) at a given well. It allows less deviation from means of large samples and/or samples with little variation in values, but allows greater deviation from means based on only a few samples (only two samples had been collected at some wells) and/or means based on samples with much variation in values. The result of applying this procedure was that no calculated concentration within the plume defined by the 30 microgram per liter contour was significantly different from the observed mean for the well when tested at a level of significance of 2.5 percent. The calculated concentrations were judged to be sufficiently representative of the true mean concentrations in the plume.

Calibration of the solute transport model is provisional. As mentioned above, geochemical work which might supply a better estimate of the distribution coefficient is not complete. A different distribution coefficient would require compensating adjustments in the dispersivity value and the source loading rates to maintain the model calibration.

A.4.0 MODEL APPLICATION

A.4.1 BASELINE CONDITION: NO ACTION ALTERNATIVE

The model results representing the current distribution of uranium in the south plume are shown in Figure A-2. Only the uranium values in the uppermost layer of the aquifer are shown since the highest observed values were from this layer. The maximum concentration in the plume is predicted to be approximately twice the maximum observed value and to lie northeast of the well with the highest observed level. The maximum concentration is also some distance downgradient from the source locations. This result indicates that the plume is affected by source loadings that were greater in the past than they are now. It is also important to note that a steep gradient of uranium concentrations is predicted to exist near several potential receptors and existing monitoring wells along Paddys Run Road.

For purposes of this study, the boundary of the plume has been defined to be the 30 µg/ℓ isoconcentration contour, which approximately corresponds to the area exceeding the derived concentration limit of 33 µg/ℓ for uranium in groundwater. The boundary of the existing plume, as produced by the model, is shown in Figure A-2.

Modeling future concentrations under the no-action alternative was completed by extending the estimates of present source loadings five years into the future. This scenario results in the conditions shown in Figure A-3. The crest of the plume moves south about 1100 feet and the maximum concentration declines about 170 µg/ℓ, or approximately 25 percent, due to plume dispersion.

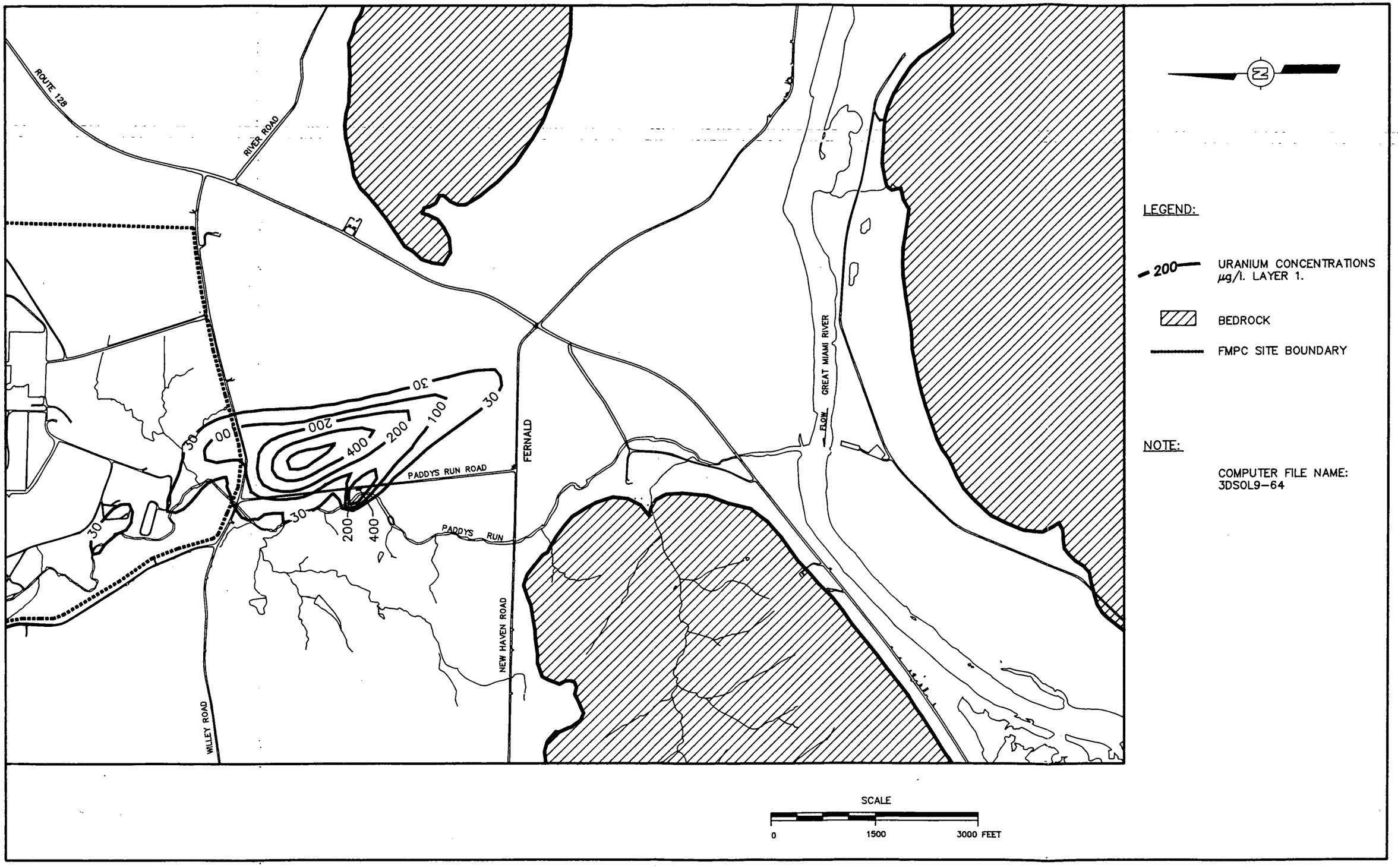

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FIGURE A-2
SIMULATED URANIUM CONCENTRATIONS
PRESENT CONDITIONS

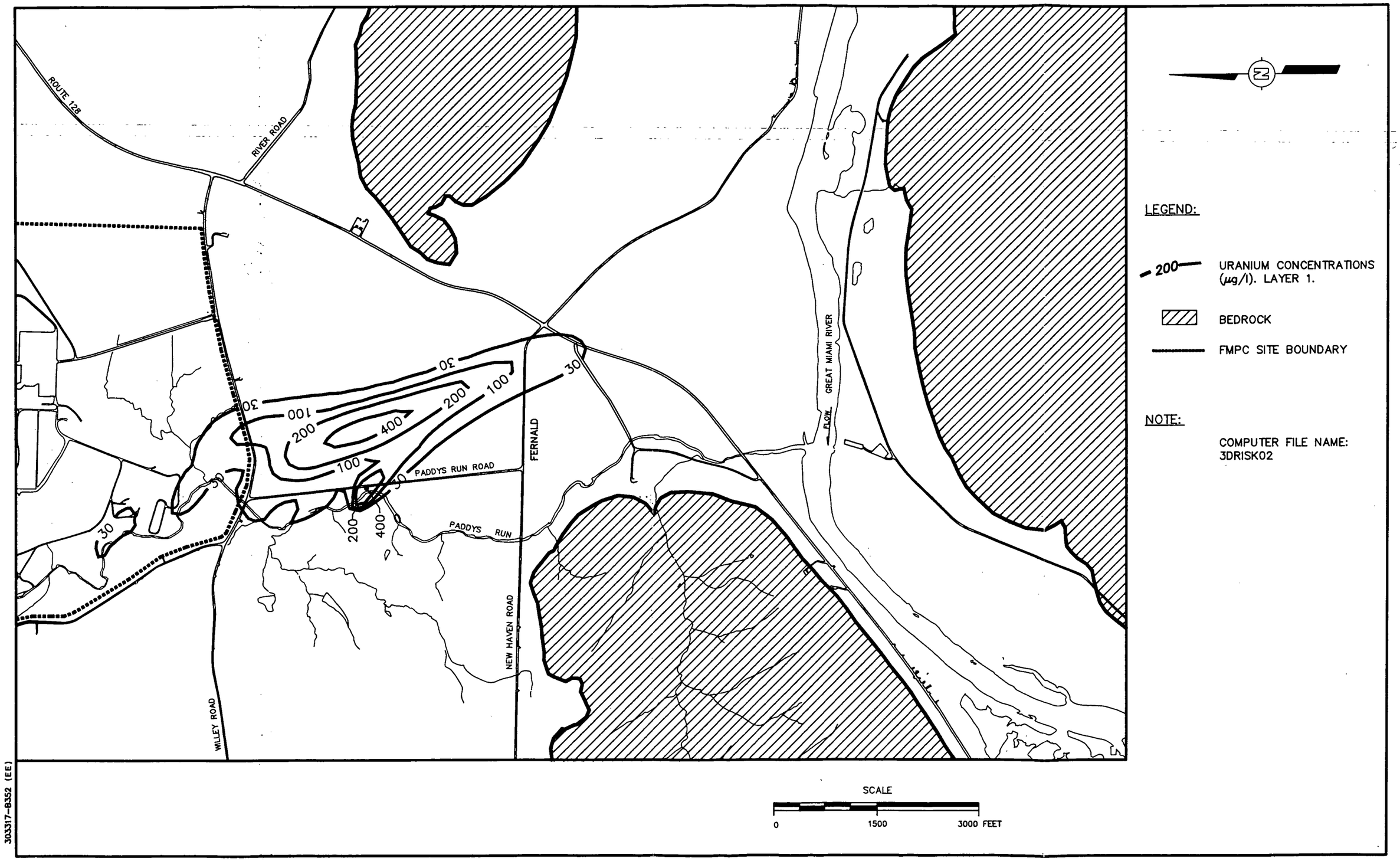

FIGURE A-3
SIMULATED URANIUM CONCENTRATIONS
NO - ACTION CONDITIONS
FIVE YEARS FROM PRESENT

The results presented in Figures A-2 and A-3 were generated by the solute transport model and are thus subject to the uncertainties discussed in previous sections. However, the presentation of existing conditions should not be greatly affected by such uncertainties since it represents the model run that was calibrated against field observations. The overall shape of the plume and the general magnitude of the values for both existing and future conditions are considered to be representative of field conditions.

A.4.2 ALTERNATE WATER SUPPLY ALTERNATIVE

The proposed source of the alternate water supply is a well located near Willey Road, 1750 feet west of the FMPC boundary. Particle tracking was used in conjunction with the groundwater flow model to investigate whether operation of this well at a 500 gpm flow rate would pull water from the plume. The results are presented in Figure A-4. These results show that the particle tracks in the plume are not distorted by the simulated production well; therefore, the well would not draw water from the plume. To verify this, these particle tracks were compared with the no-action scenario, again showing that the simulated production well has little effect on the particle tracks.

A.4.3 PUMPING ALTERNATIVES: PLUME INTERCEPTION

The location and pumping rates for interceptor wells that will produce a hydraulic control to the southward movement of contaminated water in the south plume were selected by introducing a line of wells with various spacings and pumping rates into the model. Particle tracking was used to determine whether water upgradient from the wells and within the lateral and vertical boundaries of the plume would be drawn into them.

Particle tracking is a technique for determining and depicting the three-dimensional movement of groundwater in a finite-difference flow model. In the present investigation it involved processing output from the local SWIFT III model via a computer program named STLINE (GeoTrans 1987). STLINE computes the positions of particles moving in the direction of flow and at the average velocity of water in the porous material. The STLINE program accepts particle initial positions

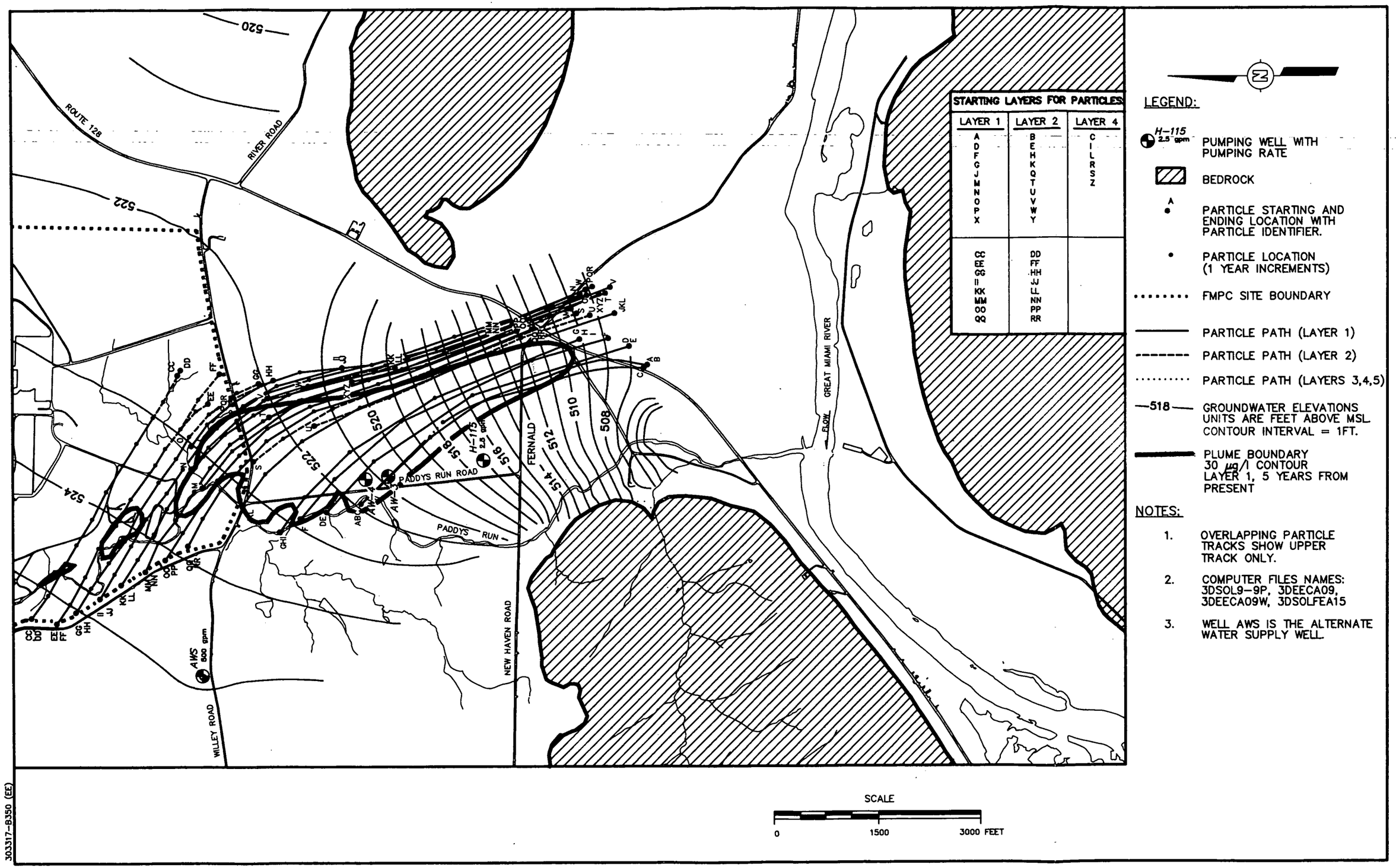

FIGURE A-4
PARTICLE TRACKING
ALTERNATE WATER SUPPLY
ALTERNATIVE

supplied by the user and computes the positions of the particles at the ends of specified time periods. The STLINE output describes the tracks of the particles as they move through the system.

Initial positions of particles were placed within the plume, along the lateral and vertical boundaries of the plume upgradient from the general location of future pumping, and along Paddys Run. Figure A-4 shows the particle tracking if no action is taken (i.e., no pumping). The plume is shown to migrate in a south-southeasterly direction. The focusing of flow lines from all along Paddys Run into the narrow trough of the aquifer is also demonstrated by the particle tracking.

The particles were then strategically placed in a sufficient number of locations to determine whether all water in the plume upgradient from any pumping wells would be intercepted. The results of the particle tracking for the recommended interceptor well system are shown in Figure A-5. The interceptor well system shown in Figure A-5 was selected after trying and rejecting several other possibilities. The rejected well systems included the following:

- Three wells spaced 560 feet apart and pumped at 500 gallons per minute (gpm) each. These wells did not capture all of the particles from the central part of the plume.

- Three wells near the center of the plume spaced 280 feet apart and pumped at 500 gpm each. This option also did not intercept all particles from the eastern part of the plume.

- Five wells spaced 280 feet apart and pumped at 500 gpm each. This option captured all particles from the plume, but involved pumping more water than the selected option described below.

- Three middle wells pumped at 500 gpm each and two end wells pumped at 250 gpm each, with all wells spaced 280 feet apart. This option failed to capture particles from lower layers in the eastern part of the plume.

The system selected used four wells spaced 280 feet apart with each well pumping at 500 gpm. This case was subjected to detailed particle tracking analysis and captured all particles seeded in the plume north of the wells. Drawdown at the wells after five years of pumping was calculated at 8.1, 8.5,

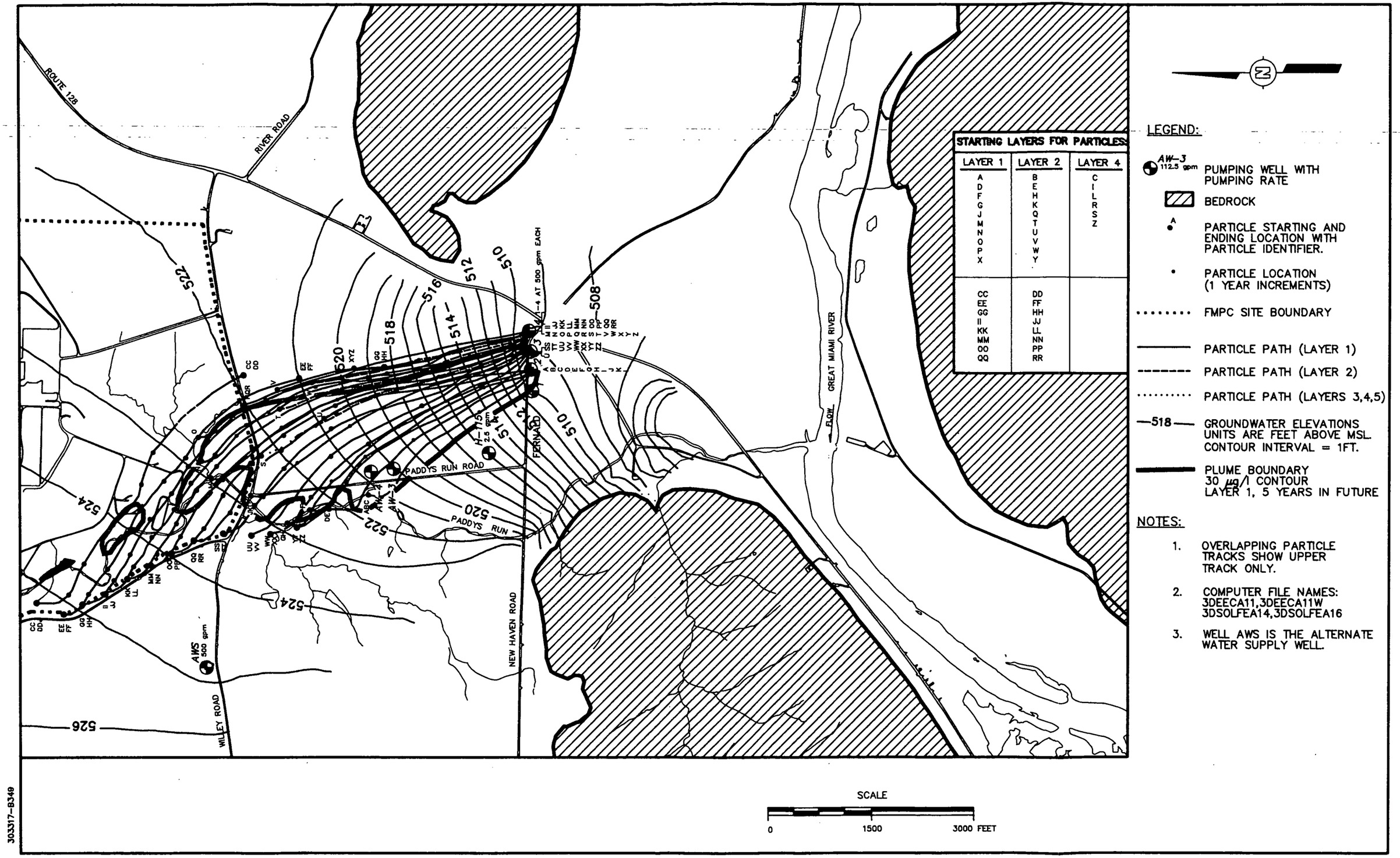

FIGURE A-5
PARTICLE TRACKING
FOR PLUME INTERCEPTION
ALTERNATIVE

8.5, and 8.2 feet from west to east. Well loss was not included in these calculations so the values represent drawdown in the aquifer. Contours of drawdown caused by the interceptor wells are shown in Figure A-6.

The analysis of the location and number of pumping wells utilized only the groundwater flow model, which has been thoroughly calibrated against a considerable data base of field observations. Consequently, there exists a high level of confidence that the recommended system will be effective in capturing the plume north of the pumping wells.

A.4.4 PLUME BEHAVIOR

Simulated uranium concentrations in the plume corresponding to existing conditions were shown in Figure A-2. This distribution of uranium provided the initial condition for the evaluation of the effects of the pumping alternatives on plume behavior. (Note that no other alternative would have a significant effect on the future migration of the plume.) The simulated concentrations in the plume after five years with the selected well system in operation are shown in Figure A-7.

The effect of the interception well system on the concentrations in the plume may be seen by comparing Figure A-7 with Figure A-3, which showed the predicted concentrations after the same time period under a no-action scenario. The plume is shown to be less dispersed as a result of the pumping action, which is important to the eventual selection of a final remedy to supplement the proposed removal action.

The maximum concentration in the plume after five years of operation is predicted to be reduced from 509 micrograms per liter (µg/ℓ) for the case when interceptor wells are not operating (i.e., no action) to 490 µg/ℓ when the wells are in operation. This minor reduction in the maximum concentration is due to the fact that the wells are placed at the leading edge of the plume and high concentrations of uranium are not removed by the wells within the first few years of operation. The placement of the wells near the southern leading edge of the plume was intended to protect groundwater users at downgradient locations.

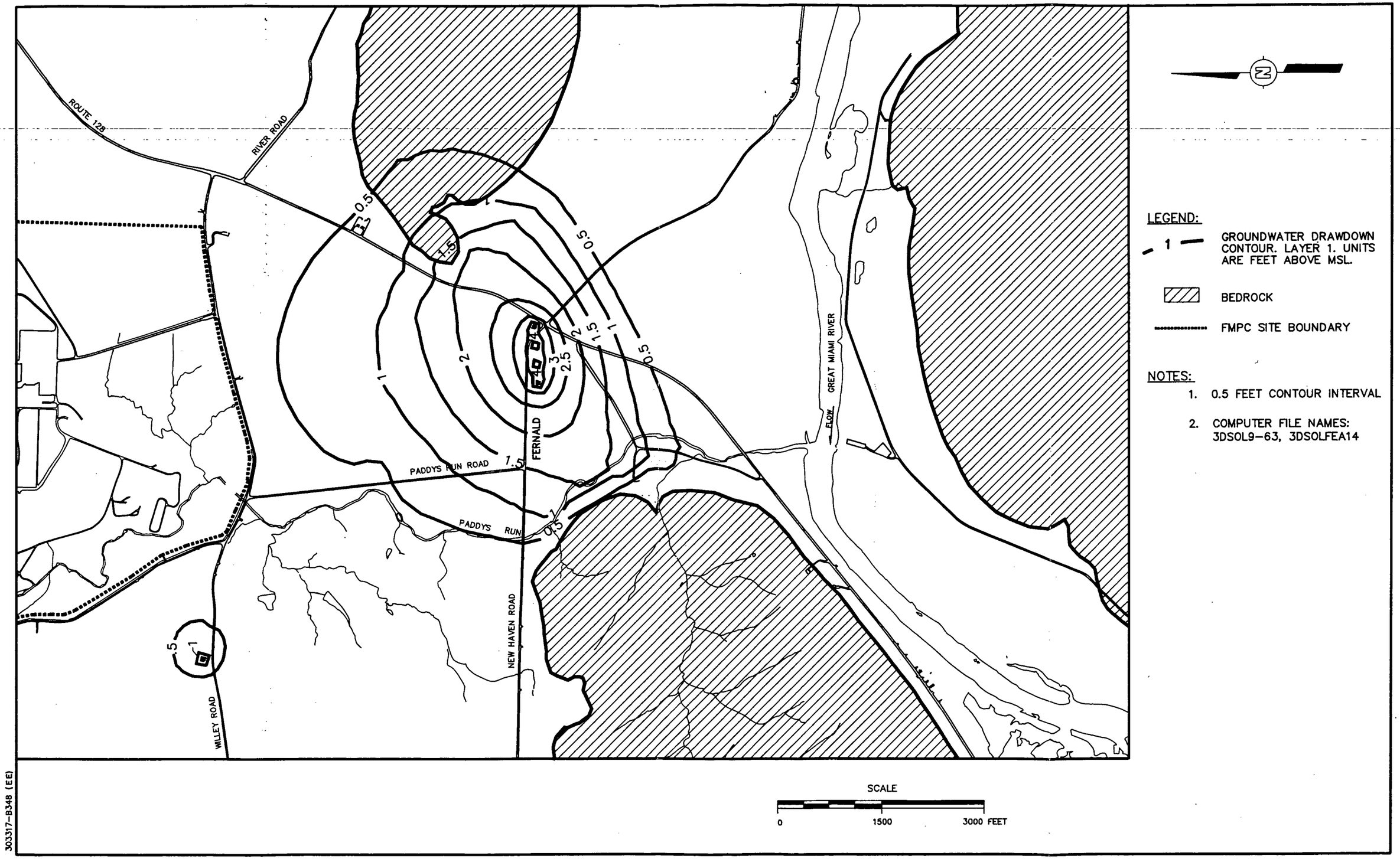

FIGURE A–6
DRAWDOWN DUE TO
GROUNDWATER INTERCEPTOR WELLS

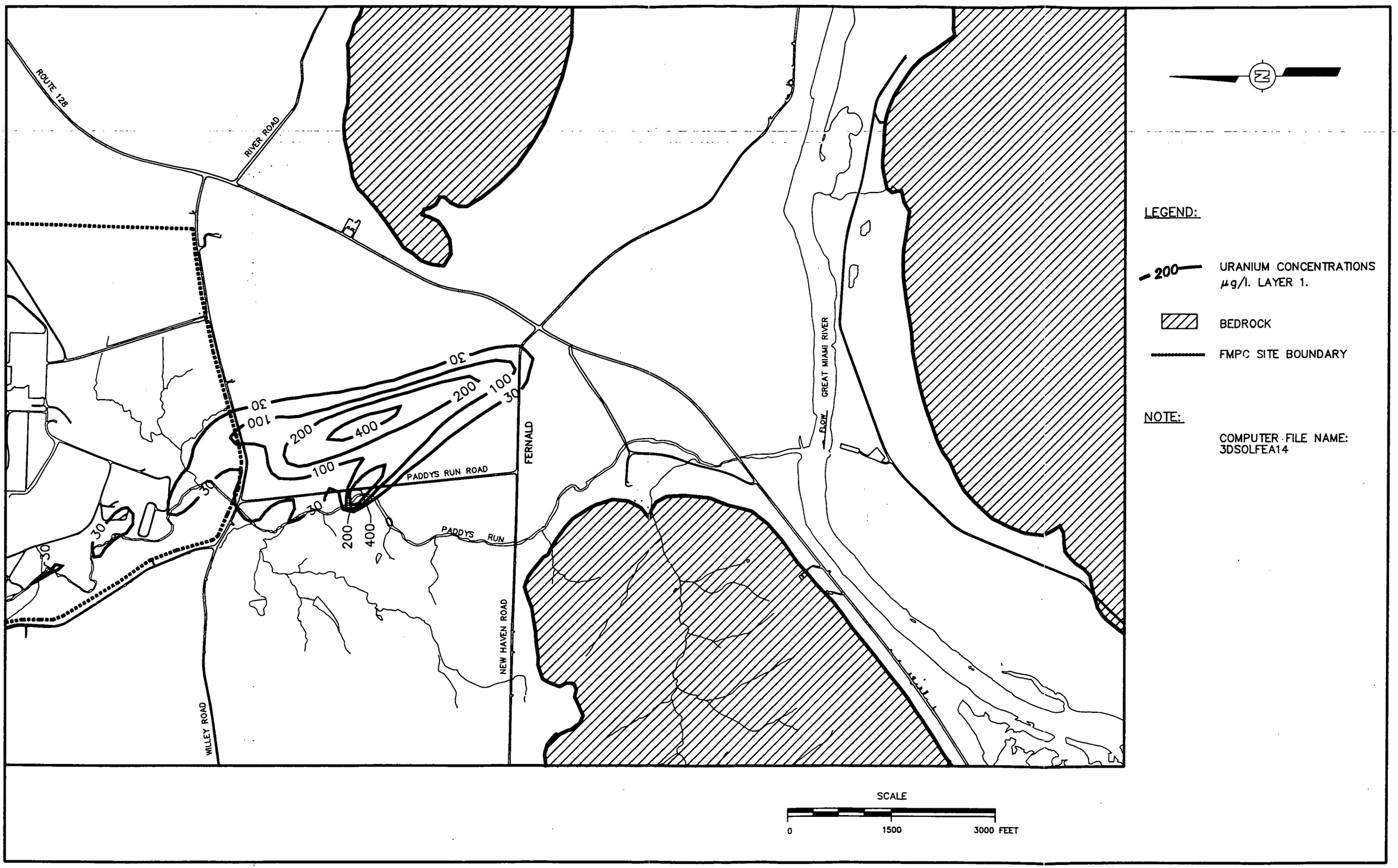

FIGURE A-7
SIMULATED URANIUM CONCENTRATIONS
FIVE YEARS FROM PRESENT WITH
INTERCEPTOR WELLS

The change in uranium concentration over time at the pumping wells is shown in Figure A-8. The calculated amount of uranium removed by the wells during five years of continuous operation is shown in Figure A-9. Although these results are approximations limited by the reliability of the solute transport model, the temporal patterns and the general magnitude of the mass removed are sufficiently accurate to draw two important conclusions. First, the amount of uranium removed increases with each year as the higher concentrations within the plume move southward toward the pumping wells. Second, it is likely that the goal of equivalent mass removal can be met during the later years of pumping when the removal amounts are at a maximum. Future refinement of the model results are not expected to change these general conclusions.

After the removal action has been selected and implemented, field validation of the solute transport model is recommended. Strategically placed monitoring wells could be used to track the response of the real system to the alternative selected, and appropriate action could be taken if the observed uranium concentrations deviate significantly from the expected values.

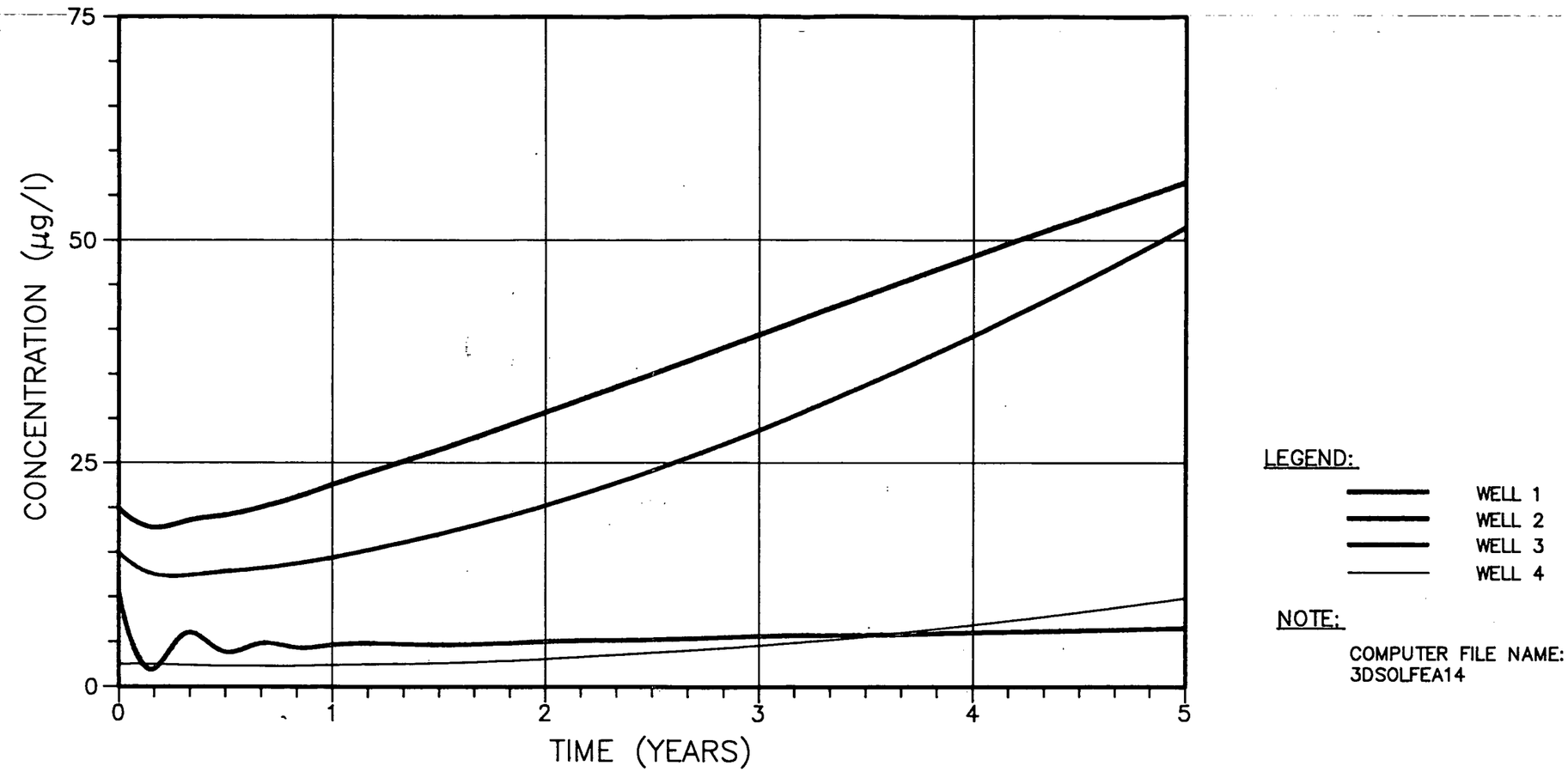

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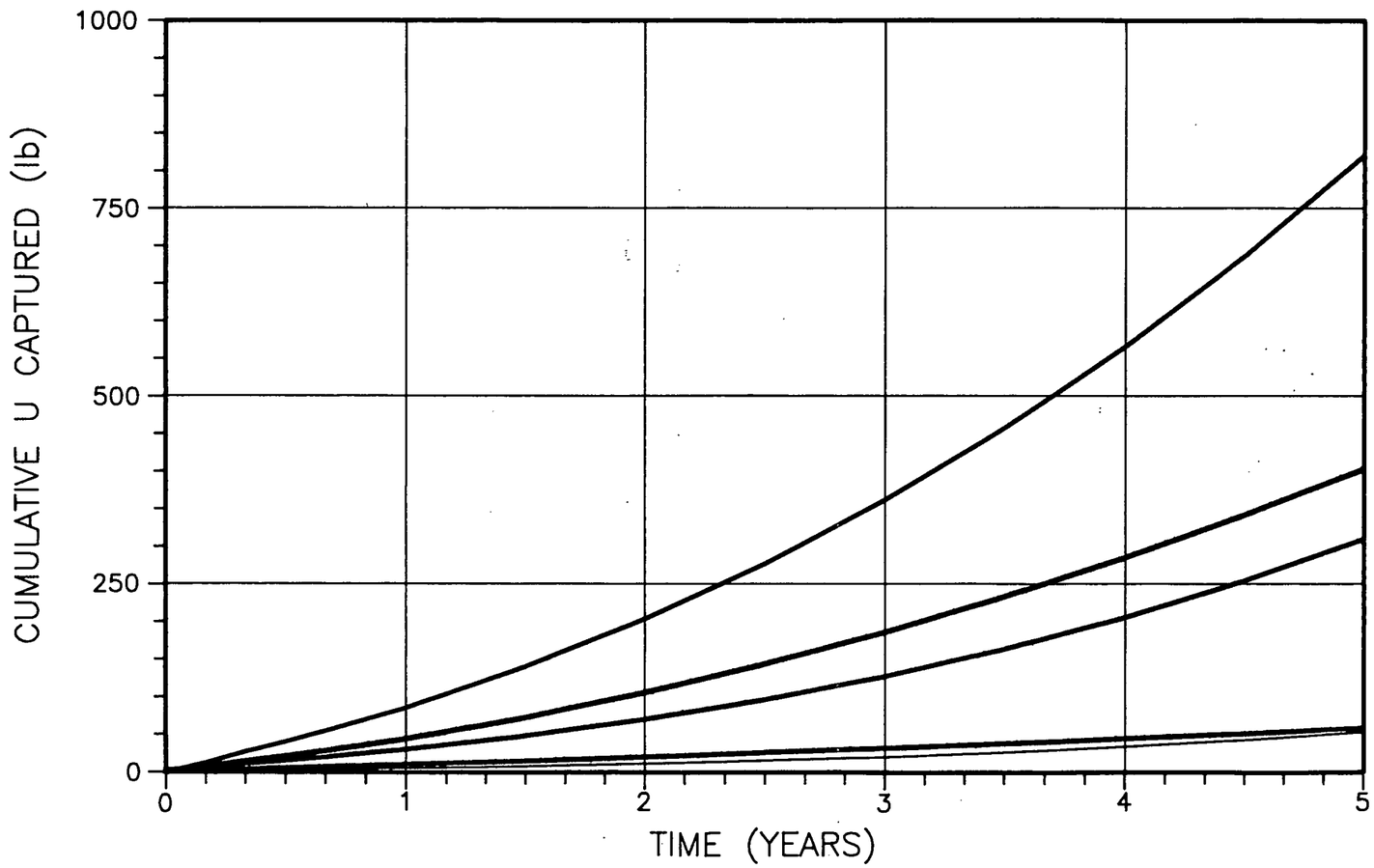
FIGURE A-8
URANIUM CONCENTRATION VS TIME
FOR INTERCEPTOR WELLS



LEGEND:

- WELL 1
- WELL 2
- WELL 3
- WELL 4
- TOTAL

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FIGURE A-9
CUMULATIVE URANIUM CAPTURED
VS TIME
FOR INTERCEPTOR WELLS

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