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TECHNICAL REVIEW OF DAMES AND MOORE'S GROUNDWATER EFFORT THE FEED MATERIALS PRODUCTION CENTER, FERNALD, OHIO, (CHARLENE MORROW - RADIOLOGICAL SITE ASSESSMENT PROGRAM MANPOWER EDUCATION, RESEARCH AND TRAINING DIVISION

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REPORT

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Prepared by
Oak Ridge Associated Universities

Prepared for
Safety and Environmental Control Division:
Oak Ridge Operations Office

U.S. Department of Energy

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CHARLENE MORROW

Radiological Site Assessment Program
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FINAL REPORT

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Prepared for

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Oak Ridge Operations Office
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December 1985

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KEY TO ACRONYMS

(CM)	Charlene Morrow, independent consultant (IC) in environmental engineering
(ORAU)	Oak Ridge Associated Universites
(DM)	Dames and Moore
(NLO)	NLO, Inc.
(GEP)	Good Engineering Practice
(DOE)	Department of Energy
(SSOD)	Storm Sewer Outfall Ditch
(PR)	Paddy's Run
(CWP)	Chemical Waste Pit
(PPA)	Plant Production Area
(FMPC)	Feed Materials Production Center
(I)	Infiltration
(GMR)	Great Miami River
(U)	Uranium
(N)	Nitrate
(Cl)	Chloride
(MG)	Million gallons
(SRP)	Savannah River Plant
(Fe)	Iron
(DO)	Dissolved Oxygen
(ft)	Feet
(gpm)	Gallons per minute
(STP)	Sewage Treatment Plant
(TP)	Test Pit
(GM)	Geometric Mean
(PAM)	Perimeter Air Monitor

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1.0 EXECUTIVE SUMMARY

During 1984 and early 1985, Dames and Moore conducted a groundwater study at the Department of Energy's Feed Materials Production Center in Fernald, Ohio. The objective of this study was to identify the source of above-background uranium concentrations, which have been detected in three offsite wells downgradient of the Feed Materials Production Center. In addition, if it was concluded that the Feed Materials Production Center is the source of the uranium in the offsite wells, the study was to recommend remedial measures. Findings of the Dames and Moore project are presented in three reports-(Task A2), (Task B2), and (Task C2).

At the request of the Safety and Environmental Control Division of the Department of Energy's Oak Ridge Operations Office, Oak Ridge Associated Universities contracted with Ms. Charlene Morrow, an independent consultant, in the fields of hydrology and hazardous waste management, to perform an independent review of the Dames and Moore study. The findings of that review are presented in this report. Included are:

- An evaluation of Dames and Moore's Task A, B, and C Reports;
- Discussions of inconsistencies and inadequacies identified during the evaluation;
- Identification of additional potential sources of groundwater contamination;
- Evaluation of the short- and long-term remediations identified by Dames and Moore; and
- Recommendations for short- and long-term needs/actions required to further assist in identification of sources and remedial alternatives.

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Two sources were identified by the Dames and Moore study. They are, in order of importance:

1. Water flowing into the Storm Sewer Outfall Ditch via the Storm Sewer Outfall.

2. Water flowing into Paddy's Run from the Waste Pit Storage Area.

Evaluation of Dames and Moore's three task reports revealed inconsistencies and inadequacies significant enough to raise doubts whether these two sources are primarily responsible for the above-background concentrations of uranium in the offsite wells. The effectiveness of recommended short- and long-term actions, identified by Dames and Moore as enabling remediation of above-background concentrations of uranium in the offsite wells, is consequently, also questionable.

Based on information obtained during the review, it is the author's opinion that the Dames and Moore study provided insufficient site characterization, including (1) incomplete identification of potential uranium sources; (2) incomplete characterization of potential uranium migration routes; and (3) modification of potential uranium sources to include transport mechanisms. Also, during the project, implementation of the established work plan was modified by alteration of the groundwater zones monitored; alteration in the number and location of groundwater and surface water monitoring stations; and alteration of pathways monitored. These combined events have resulted in an inconsistent and inadequate monitoring program. This, in turn, has resulted in a remedial action selection process, which identified "sources" that are, in actuality, transport mechanisms, while primary sources and other transport mechanisms remain unqualified. Thus, Dames and Moore has identified corrective measures that do not address primary release mechanisms from primary sources and that therefore may be ineffectual. (1)

contradiction!

Dames and Moore did not distinguish between actual onsite sources of uranium and the transport mechanisms responsible for movement of uranium from those sources. As a result, primary sources and other transport mechanisms remain

repetition

contradiction...

unqualified, as do site-specific corrective measures. Although results from the study have allowed identification of a principal transport mechanism, they have not allowed identification of specific sources or corrective measures because Dames and Moore did not collect hard data that would enable quantification of the percentage of uranium originating from each source area. The application of specific corrective measures therefore requires additional data collection. (2)

Recommendations

Completion of three tasks is recommended to fulfill the original scope of work and objectives of this study. These tasks are:

1. Determine direct sources and transport mechanisms responsible for hydrologic release of uranium from the Feed Materials Production Center.

2. Estimate the percent uranium contribution from each of those sources.

3. Select site-specific remedial actions directed at transport mechanisms responsible for uranium release from primary sources. (3) This has been done!

Specific recommendations for the monitoring program during reassessment of potential sources and migration routes include:

1. Restructure the monitoring program to enable assessment of individual sources and pathways.

2. Conduct hydrogeologic characterization of the vadose zone (surficial till).

3. Supplement the monitoring program to enable assessment of all groundwater transport routes.

Specific recommendations for additional studies include: OK, but not under scope of contract S-1094.

1. Conduct a characterization of the CWP Area, specifically, the six Waste Storage Pits, the Clearwell, the two K-65 Storage Silos, and the Metal Oxide Silo.

2. Conduct a characterization of the Flyash Piles. (part of RI/FS)

3. Conduct a bench-scale study examining the leachability of uranium in soil samples taken from selected locations in the Plant Production area, using deionized, ground- and surface waters. This should either serve to refute or add credence to the "runoff from the Plant Production Area" transport pathway. U transport study - D&M recommendation

4. Supplement characterization of the site including development of a water budget.

5. Establish the percent solubility of uranium contained in stream sediment.

6. Conduct a chemical characterization of uranium, surface water, groundwater, and soil. — RI/FS, RCRA sampling

Specific recommendations for remedial actions include:

1. Implement remedial actions for active and inactive Flyash Piles.

2. Cease waste contributions to Chemical Waste Pit 5 and the Clearwell.

3. Implement remedial actions in Chemical Waste Pit Area. D&M

4. Establish effective groundwater controls in the Chemical Waste Pit Area. ?

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2.0 DISCUSSION OF FINDINGS

2.1 Background

The Feed Materials Production Center (FMPC) is operated by NLO, Inc., for the Department of Energy (DOE), to produce purified uranium and uranium compounds. Wastes generated during processing are placed onsite in rubber- and clay-lined pits and in large tanks in the Chemical Waste Pit (CWP) Area, located northwest of the Plant Production Area (PPA). In December 1981, during routine monitoring, NLO noted the occurrence of above-background levels of uranium in three offsite domestic wells. These wells and other wells were sampled by the U.S. Geological Survey (USGS) in August 1982 for uranium and other constituents; the USGS program did not allow for determination of the exact point of origin for the offsite uranium. A groundwater study was initiated by NLO and conducted during 1984 by Dames and Moore (DM). The purpose of the study was to identify the sources for the above-background concentrations of uranium in the three offsite wells. Oak Ridge Associated Universities (ORAU) was requested by DOE's Oak Ridge Operations Office to provide a technical assessment of DM's study.

2.2 Scope of Work

why not look @ the FINAL reports?

An initial overview was made of information contained in DM's most current Task A, B, and C Draft Reports. The contexts of these reports were compared with one another and with DM's charge, for consistency. A technical review session was then held at the FMPC on June 13, 1985. The review was conducted by Charlene Morrow (CM), an independent consultant (IC) in environmental engineering retained by ORAU. Representatives from DOE, NLO, and DM that participated in the review are listed in Appendix A. An approximate transcript of comments made during the review is presented in Appendix B. — DELETE!

Information obtained during the review session was evaluated and compared to information obtained during initial overview, as well as to information obtained during overview of DM's Task C Final Report. A

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discussion of findings was then prepared. Recommendations for further work were made, based on these findings.

2.3 Overview of DM's Remedial Action Selection Process

The purposes of the DM study were to identify the source or sources of the above-background levels of uranium in the offsite wells, and if it was concluded that the FMPC is the source of the uranium well contamination, to recommend remedial meausres. The DM study was divided into three tasks. Task A consisted of a review of existing literature and enabled initial site characterization. Task B consisted of a work plan to be followed during site monitoring. Field work consisted of installation, development, and monitoring of 23 wells. Monitoring of 13 existing NLO wells was also performed by DM, and a modeling study characterizing contaminant movement was conducted. Task C consisted of the final report, which identified two FMPC sources for the offsite uranium and presented recommended remedial measures.

Evaluation of DM's three task reports revealed inconsistencies and inadequacies significant enough to raise doubts concerning (1) the two sources identified by DM as those being primarily responsible for the uranium in the offsite wells and (2) short- and long-term actions recommended by DM for remediation. Based on information obtained during the review, it is the author's opinion that DM has not adequately characterized the site and sources and has not identified appropriate remedial acitons. The inadequate site and source characterization was the result of incomplete identification of potential uranium sources; incomplete characterization of potential uranium migration routes; and modification of potential uranium sources to include transport mechanisms. Also, the established work plan for site monitoring was altered during project implementation by alteration of groundwater zones monitored; alteration in the number and location of groundwater and surface water monitoring stations; and alteration of pathways monitored. These combined events have resulted in an inconsistent and inadequate monitoring program. This, in turn, has resulted in a remedial action selection process, which identified "sources" that are, in actuality, (BEJ)

transport mechanisms, while primary sources and other transport mechanisms remain unqualified. Identified corrective measures may therefore be ineffectual, because they fail to address primary release mechanisms from primary sources.

Specific deficiencies noted in the DM Tasks that support these opinions are outlined in the following sections.

2.3.1 Site Characterization

Introduction: Site characteristics are important criteria for selection of the best remedial approaches. Data should include general site characteristics such as geology, hydrology, meteorology, and more specific characteristics such as waste types, amounts, and methods of disposal. The major objectives of such characterization are the establishment of (1) what has potential to migrate, (2) identification of the sources where it has potential to migrate from, and (3) location of the potential pathways along which such migration can occur.

At the FMPC, it is possible for uranium to be transported to offsite groundwater from an onsite source through air, surface water, or groundwater transport. These transport processes involve an initial transformation to a more mobile phase. Critical pathways for uranium at the FMPC have been demonstrated to be hydrologic, either by surface water or groundwater transport mechanisms. There are many potential hydraulic transport processes by which uranium can be mobilized, dependent upon site characteristics. For example, uranium leachate may travel laterally and emerge as surface seepage, or it may travel downward (vertically) to contaminate groundwater, depending upon localized geology. Generically, hydrologic transport processes can include the following:

1. Leaching; separation of soluble waste constituents by contact with water.

2. Seepage; horizontal movement of leachate, surface water, or groundwater.

3. Runoff; movement of leachate, surface seepage or particulates by surface water.

4. Infiltration; percolation of surface water resulting in leachate movement.

5. Discharge; movement across the water table surface; discharged groundwater may reach surface water.

6. Recharge; recharged surface water may reach groundwater.

It is important to recognize the hydraulic interrelationship between surface water and groundwater and to realize that either can lead to the contamination of the other, via any of these generic processes, given the right conditions.

<u>Findings:</u> Upon examination, DM's site characterization effort was considered to be lacking for the following reasons:

1. Potential sources identified by DM do not include all potential onsite uranium sources.

   Specifically, there are five processes which can lead to initial uranium release from a source by a hydrologic pathway at the FMPC.

   a. Seepage from unlined lagoons and other surface impoundments. Seepage can affect the shallow (perched) groundwater regime or can discharge to the ground surface.

   b. Improper landfilling, resulting in leachate movement to surface or groundwater.

   c. Leaks in pipes, process equipment, and storage tanks.

d. Improper surface and subsurface disposal, resulting in runoff or groundwater recharge.

e. Accidental spills, resulting in runoff or groundwater recharge. No spills of any considerable magnitude have been referred to in observed literature, nor acknowledged by any waste management staff.

The effect of these processes on individual FMPC sources is outlined in Table 2-1. Once uranium is released from a source it can either move into the groundwater system or be discharged to surface water.

Potential source areas initially considered by DM are indicated in Figure 2-1; they are the PPA, the CWP Area, the Scrap Metal Pile (included in the PPA), the active and inactive Flyash Piles, and waters flowing in PR and the SSOD. Those sources contained in the areas defined as potential source areas considered by DM (Figure 1-2, Task C2) are identified in Table 2-1 by having the qualifier "1" placed after them. It is not clear if some of the sources located within the areas designated as sources by DM were considered to be potential contributors, for example, the Clearwell and the Burn Pit. In addition, no distinction is made between the copper and ferrous Scrap Metal Piles.

Sources in Table 2-1 that were not identified by DM include the transfer lines, non-routine liquid discharges, K-65 Tanks, Metal Oxide Silo, and incinerator. A brief discussion of these sources, shown of Figure 2-2, follows:

Transfer Lines: Liquid effluent lines at the FMPC have been in place from 20-30 years, on the average. These lines traverse a major portion of the FMPC site. The line originating at the General Sump goes west to the K-65 Area, north to the CWP Area, and then travels east from the Clearwell to the combined effluent

monitoring wells do not pick this up!

You're ignoring the GW data!

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TABLE 2-1

POTENTIAL PROCESSES LEADING TO RELEASE OF URANIUM FROM FMPC SOURCES

ONSITE SOURCE	PROCESS POTENTIALLY LEADING TO RELEASE
CWP 3[1]	Seepage, Improper Disposal
CWP 5[1]	Seepage, Improper Disposal
Clearwell[1]	Seepage
Transfer Lines	Leakage
Effluent Routinely Discharged to GMR[1]	Improper Disposal
Non-Routine Effluent Discharges	Improper Disposal
K-65 Tanks	Leakage
Metal Oxide Silo	Leakage
CWP 1[1]	Improper Landfilling
CWP 2[1]	Improper Landfilling
CWP 4[1]	Improper Landfilling
CWP 6[1]	Improper Landfilling
Covered Flyash Pile[1]	Improper Landfilling, Improper Disposal
Active Flyash Pile[1]	Improper Disposal
Burn Pit	Improper Disposal
Scrap Metal Pile[1]	Improper Disposal
Stream Sediment[1]	Improper Disposal
Soil[1]	Improper Disposal

Discharge to outfall ditch/Paddy's Run

FSSOD!

to what (GMR/PR?)

Stormwater runoff from CWP's

[1]Sources Contained in Areas Initially Considered by DM

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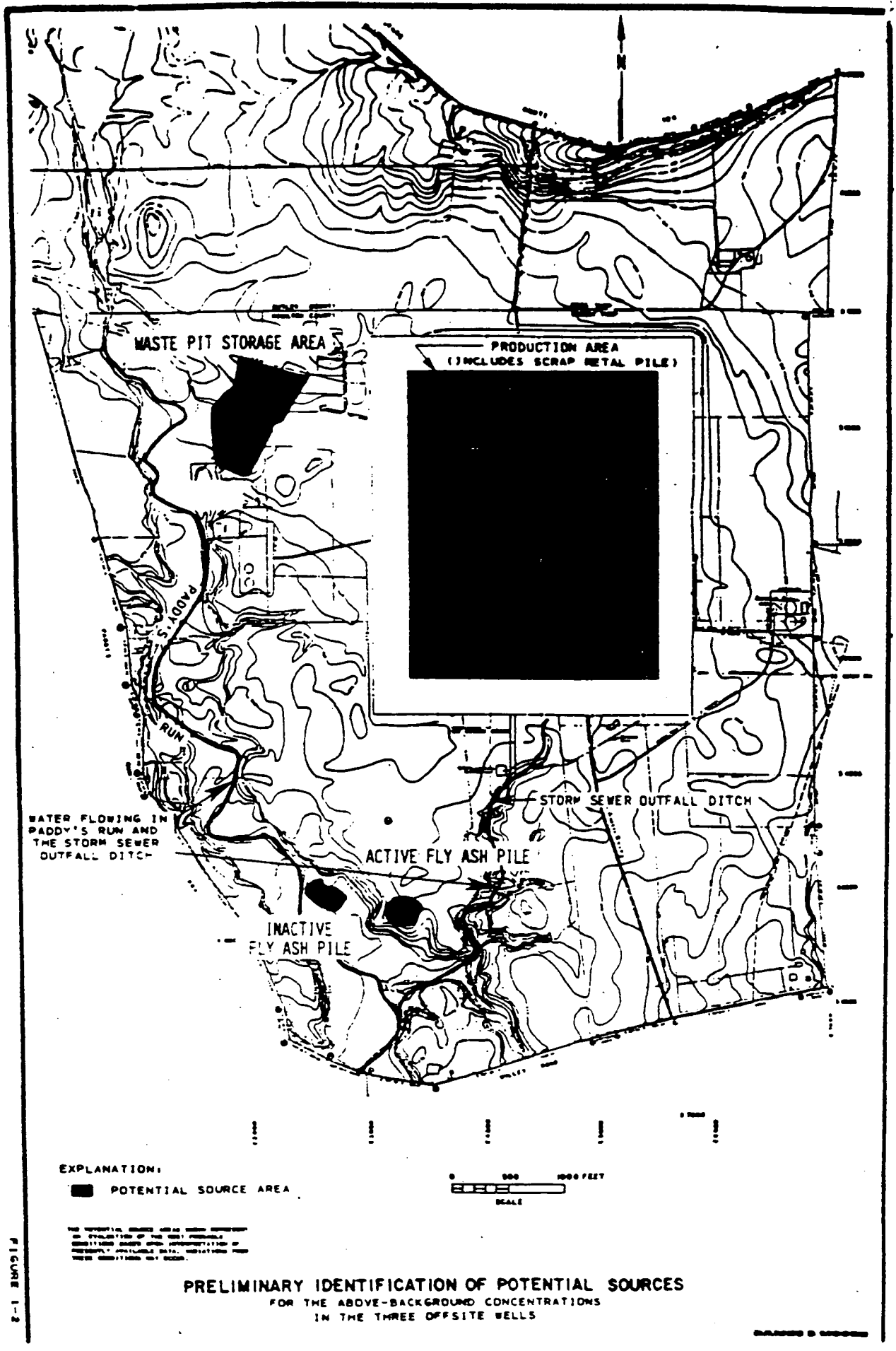

FIGURE 2-1. Potential Source Areas Initially Considered by Dames and Moore.
Source: Task C2)

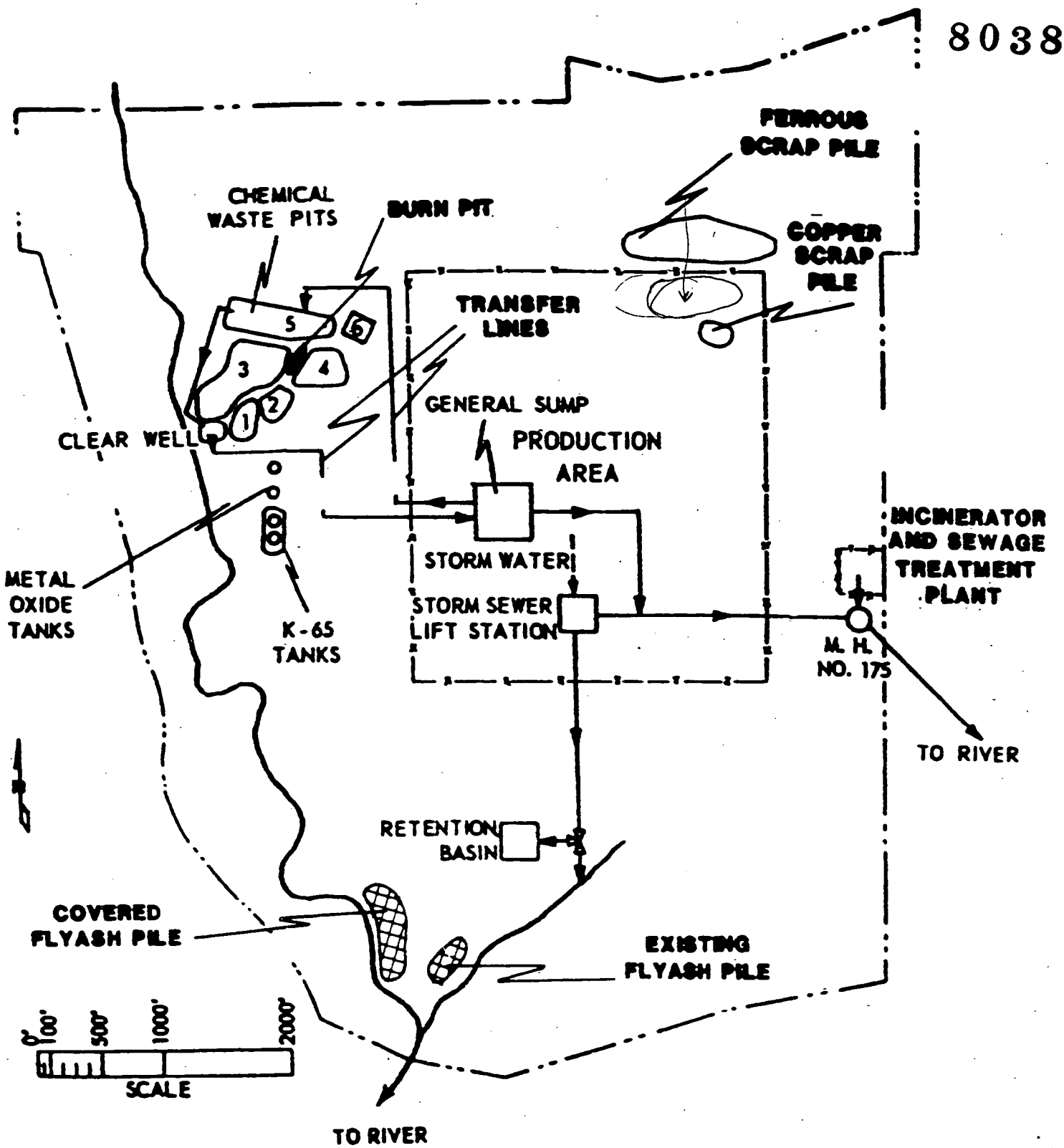

FIGURE 2-2. Location of Potential Uranium Sources.

(Source: FMPC 1984)

The 3 wells are not downgradient to this line !!

line as shown in Figure 2-3. This line then extends some 4,000 ft underground, going to the GMR. It is likely that these lines have developed cracks or have separated in places, allowing for loss of effluent to shallow groundwater or for infiltration of uranium-bearing groundwater into the lines. Portions of the existing transfer line (approximately 2,000 ft) that extend from the General Sump to CWP 5 have been in place (underground) since 1959 a period of 26 years. No flow balance has been established for this system to assess leakage. Another reason supporting this source is that the SSOD has an observable flow which is continuous even in dry periods (ORAU 1985). This may be due to perched groundwater entering fractures in the SSO line. The concentration of uranium in the discharge remains at or above 1 mg/l (refer to Appendix B, p. B-11). Also, the above-ground effluent line, extending from Process Building 4 to the General Sump, has been closed permanently, due to the line's lack of integrity. Waste is now transported to the General Sump via tank truck every three to four days.

1s low U content

Non-Routine Discharges: The occurrence of any direct discharges to PR has not been documented by DM (p. 2-14, Task A2). Pumping of contaminated groundwater from Well 1d directly to PR was carried out in the early 1960's (Eye 1961). The purpose of pumping was interception of contaminated groundwater moving from the CWP Area toward PP wells (P1, P2, P3). Well 1s was installed specifically to allow periods of continuous pumping of the contaminated groundwater at rates of from 50 to 220 gpm over a 23 year period. The location of Wells 1s and 1d is shown in Figure 2-4, relative to the CWP Area and the Plant Production wells.

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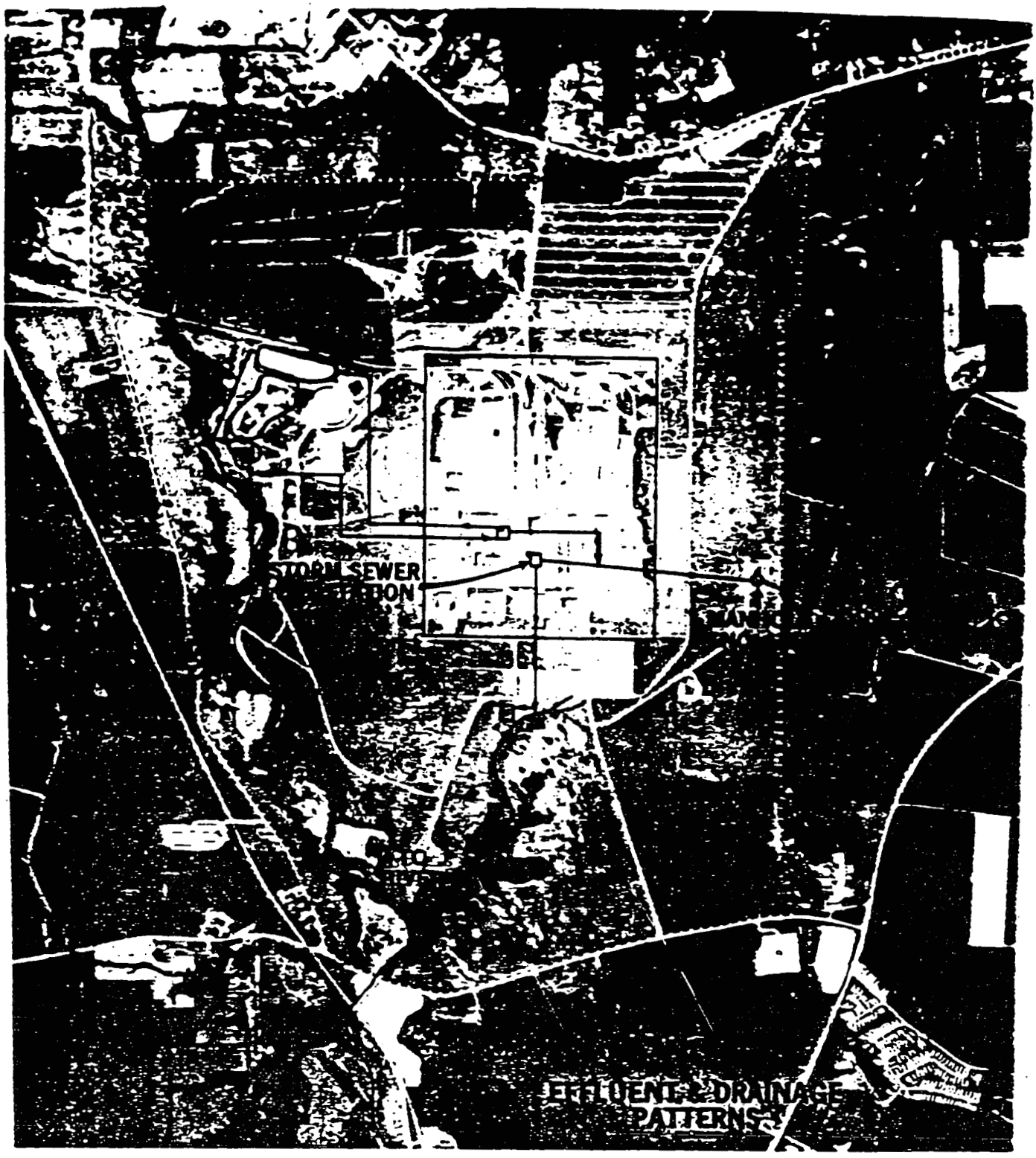

FIGURE 2-3. FMPC Effluent Transfer Lines.

— get serious

(Source: EG&G 1981)

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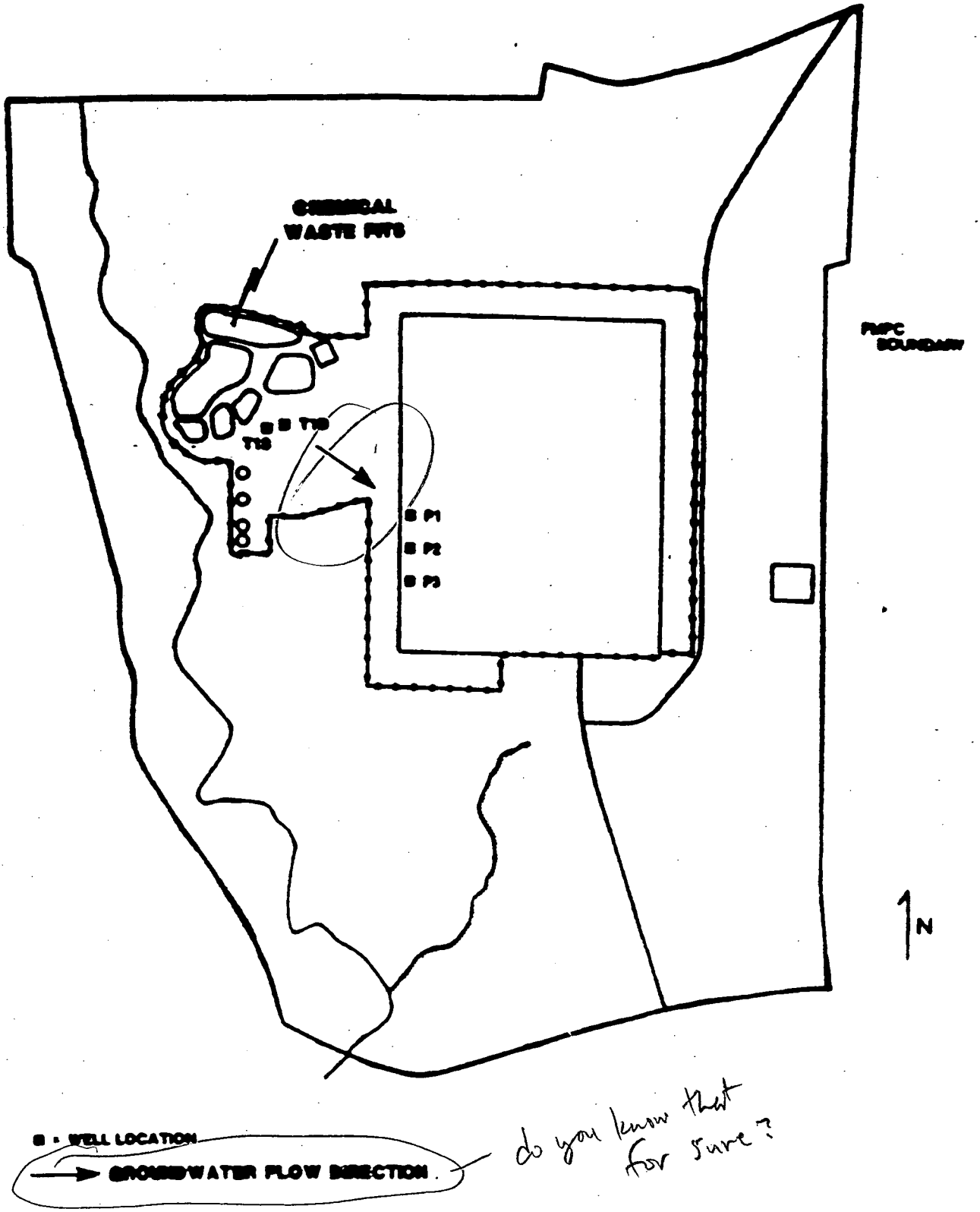

do you know that for sure?

FIGURE 2-4. Location of Test Wells 1s (T1s) and 1d (T1d).

(Source: NLO 1984)

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Although observed levels of uranium were reportedly low, this pumping is considered to be of importance because:

Nitrate (0/4)

a. N and Cl levels approached 2,500 mg/l initially.

b. After prolonged pumping, N and Cl levels failed to fall any lower than 800 mg/l.

c. High N levels are associated with high uranium solubility.

d. Pumping was maintained over an extended time frame (years), during which monitoring for uranium was infrequent.

e. 95 MG of contaminated groundwater may have been discharged via this route in a single year (refer to Appendix C, page C-6).

f. Uranium-data are fragmented; representative uranium data do not exist for most pumping periods.

K-65 Tanks: The composition of the K-65 residues is quite variable. Although the primary radionuclides are Ra-226, Pb-214, Bi-214, and Pb-210, uranium is also present in the waste. These tanks can be considered as potential sources for uranium because (1) the integrity of the tanks is questionable (ORAU 1985); (2) the high-grade (35-60% U_3O_8) of the original uranium ore suggests that non-negligible quantities of U-235 daughters may have accumulated in the ore before it was mined and processed (ORNL 1985); (3) and reported concentrations of four U-235 series radionuclides were 10,000 pCi/g (Anderson 1981).

monitoring wells

Metal Oxide Silo: This silo contains tailings or residues similar to those in the K-65 Tanks, although their origin is refinery operations at the FMPC (Battelle 1981). The concerns are therefore similar in nature to those associated with the K-65 Tanks.

how would this effect the GW in 3 DG wells?

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Incinerator: Some of the highest uranium levels observed in FMPC soil are located in a field just east of the STP near PAM 3 (ORAU 1985). This is the result of deposition from past incineration practices in the STP area.

2. Potential sources identified by DM include transport mechanisms.

DM does not distinguish between actual onsite sources for uranium and the transport mechanisms responsible for movement of uranium from those sources. Sources are points of origin for a contaminant, which in this case is uranium. Sources at the FMPC serve as initial entry points for uranium into the local environment. DM's inclusion of "waters flowing into ... PR and the SSOD" (p. 1-4, Task C2) as the source having the highest potential to currently contribute uranium indicates that transport mechanisms were included when defining sources. Such waters could serve as true sources for uranium, either by liquid effluent coming from a routine/non-routine discharge, or from an accidental spill. Reasons supporting exclusion of these two means are:

a. There have never been any routine discharges of liquid effluent to the SSOD or PR. Effluent from each of the individual production plants is collected and treated at a central facility, the General Sump, then combined with other waste streams and discharged to the GMR (NLO 1984).

b. The only non-routine discharge that has been acknowledged by NLO is the pumping of groundwater from Well 1s directly into PR. This pumping process was permanently halted in 1984.

c. There have been no accidental spills reported by NLO that could have affected either the SSOD or PR (p. 2-34, Task A2).

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Thus, no mechanism exists which would enable the waters themselves to serve as a uranium source. Uranium does not originate in either the SSOD or PR. In concurrence with this observation, both routine/non-routine discharges (p. 2-14, Task A2) and accidental spills (p. 2-34, Task A2) have been dismissed by DM as potential sources for uranium in PR. Accidental spills have also been similarly dismissed as sources for uranium in the SSOD (p. 2-34, Task A2). However, in contradiction to this, DM recognizes a direct discharge of uranium-bearing waters into the SSOD (p. 2-14, Task A2), specifically, untreated surface runoff.

BS This is a routine discharge

Are you suggesting contaminated DSM?

The origin of this runoff is the PPA, although the majority of runoff from this area is collected by storm drains and directed to the Storm Sewer Lift Station, then pumped to the GMR. During periods of intense rainfall, the capacity of the lift station is exceeded and the excess runoff is directed by underground transfer lines to an outfall on the SSOD (p. 4-4, Task C2). Once they have picked up uranium by contacting an onsite source such as contaminated soil, rooftops, asphalt, or an exposed waste pile, the waters entering the SSOD can serve to transport uranium offsite. They are not direct sources, however.

OK, then call the roofs & roadways the direct sources ... what the difference!

The recognition of the SSO discharge as a direct source for uranium may stem from the fact that under National Pollutant Discharge Elimination System (NPDES) rules, this discharge is considered to be a non-point, or secondary source. Permitting of non-point sources was incorporated into NPDES when it was realized that runoff was as significant a contributor to water quality degradation as direct discharge of process effluent, in many instances. Another situation that result be considered is that some portions of the PPA drain to surface ditches which go directly to Paddy's Run.

DEC '88 must be corrected or eliminated

Untreated surface runoff emanating from the SSO pipe should not be considered a direct discharge. The outfall pipe simply serves to concentrate the discharge of runoff from the PPA at a single point on the SSOD. If the outfall pipe and associated collection system did not exist, runoff from the PPA would still drain into the SSOD, just as runoff from the CWP Area presently drains in, part, to PR (p. 4-5, Task C2). During the technical review session, DM concurred with the observation that these waters are transport mechanisms (refer to Appendix B, p. B-2), but that they consider transport mechanisms to be sources.

3. DM does not consider all available transport mechanisms. Consideration of certain transport mechanisms is erratic and inconsistent betwen documents.

   Although not specifically stated, it is implicit that DM focused on two major transport mechanisms: groundwater transport by direct hydrologic interconnection from the source area to the area of the offsite wells, and surface water transport of uranium-bearing runoff water to a point of hydrologic interconnection with groundwater (p. 4-3, Task C2). This approach does not take into account certain transport mechanisms such as seepage of shallow, uranium-bearing groundwater into surface water; an example of indirect groundwater transport through hydrologic connection with surface streams, which are in turn hydrologically connected to offsite groundwater.

   In addition, this approach is inconsistent with Tasks A2 and B2, which both state that the major focus of the investigation will be on the surficial till layer (p. E-2, Task A2; p. 2-1, Task B2). Two of the major supporting reasons given by DM for such a focus are that all waste

Thought processes can change in the field!!!

25

units are contained in the surficial till, and the suspicion that groundwater perched in this zone near the CWP Area may be seeping into PR.

Again, although not specifically stated, it is implicit that DM considered certain transport mechanisms for the release of uranium-bearing water from the source areas. References to these mechanisms are inconsistent between Task A2 and Task C2, as outlined in Table 2-2. Several apparent anomalies which exist are:

BEJ

a. Although one source area is defined as including waters and sediments in Task C2 (p. 4-3), dissolution from sediments is not referred to as a release mechanism at any point in Task C2.

b. Seepage of groundwater is considered as a potential transport mechanism for uranium from all sources in Task A2, but not referred to as a potential mechanism for uranium release from any source in Task C2.

c. Overland flow is not considered as a potential transport mechanism for release of uranium from the CWP Area in Task A2, but is referred to as such in Task C2.

d. No mention of any transport mechanism responsible for release of uranium from the Flyash/Scrap Metal Piles is made in Task C2, except to say that data from downgradient groundwater sampling allow dismissal of the Piles as sources (p. 4-9, Task C2).

In addition to the three deficiencies outlined in the preceeding pages, there are inconsistencies which add confusion to the processes involved in DM's site characterization. The major one is that identified potential sources were modified and were successively assigned new orders of importance in the several DM documents (Task A1, A2, B1, B2, C1, and C2). Table 2-3 illustrates this inconsistency. The final selection of potential sources and the assigned importance of each remain unacknowledged and unsubstantiated.

should draft reports be dismissed & concentrate on FINALS!

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TABLE 2-2

TRANSPORT MECHANISMS BY SOURCE AREA

SOURCE AREA	TRANSPORT MECHANISM	
	Task A2	Task C2
SSOD/PR	- Dissolution from sediment in SSOD and PR (p. 4-4). - Seepage of groundwater into SSOD/PR (p. 4-4). - Direct discharge from outfall to SSOD (p. 4-4). - Local groundwater recharge (p. 4-4) from SSOD/PR.	- Overland flow from CWP Area and PPA (p. 4-7) into PR and SSOD. - Surface seep from CWP Area draining into PR (p. 4-7). - Groundwater entering SSOD line (p. 4-4) and discharging to SSOD. - Groundwater recharge from PR near confluence of PR and SSOD (p. 4-10).
CWP	- Recharge of shallow and deep groundwater zones (p. 4-7).	
Flyash and Scrap Metal Piles	- Overland flow from active pile (p. 4-5). - Infiltration/leaching of inactive pile by surface water (p. 4-5). - Groundwater seepage from active/inactive pile (p. 4-5).	
PPA	- Overland flow from PPA (p. 4-7) - Infiltration/recharge of overland flow (p. 4-7).	

(This is expected ... a reduction in potential sources/mechanisms to a ~~reduce~~ more specific determination!)

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TABLE 2-3

CHANGES IN ORDERS OF IMPORTANCE ASSIGNED TO SOURCES BY DAMES AND MOORE

Note: These are DRAFT reports!

Order of Importance	DAMES AND MOORE REPORT		
	Task A1 and Task B1	Task A2* and Task B2	Task C1 and Task C2
1	CWP Area	Sediment and Wastes in the SSOD and PR	Sediment and Wastes in the SSOD and PR
2	PPA	Flyash Piles	CWP Area
3	Sediments in the SSOD and PR	CWP Area	Flyash Piles
4	Scrap Metal Pile and Flyash Piles	PPA	PPA
5	-------	Scrap Metal Pile	Scrap Metal Pile

* The Task A2 Report Executive Summary (p. E-1) indicates only four potential sources have been identified, although pages E-2 and E-3 list the five potential sources as they are presented here.

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The Task C2 Final Report is based on work planned and performed during Tasks A and B; however, the Task A and B Reports remain in draft form and have not been modified in such a manner so as to be consistent with Task C2 work. The Task A2 discussion (Section 4) which substantiates the assigned importance of each potential source does not correspond to the sources as given in Task C2 (p. 4-3), although the Task A2 Report is referenced on p. 4-3 in Task C2. Also, the Tank C2 Report (p. 1-3; p. 4-3) lists the five potential sources (in order of importance), which were identified prior to performance of field work under Task A. In actuality, the Task A2 Report (p. 4-3) identifies these same potential sources in a slightly different order of importance. These same five potential sources are again identified in the Task B2 Report (p. 1-1). It is not until the Task C1 Report (p. 4-2) that the order becomes that which was stated in Task C2 (p. 4-3) as being the order given in Task A2.

Although DM states in Task C2 (p. 4-3) that potential sources were initially identified in Task A using three criteria, they do not acknowledge that any difference exists between the order of importance assigned to sources in Task A and the order of importance assigned in Task C. They accordingly do not discuss the factors which led to these reassignments, based on those three criteria.

Still another problem area noted is that the potential sources identified by DM possess differing levels of significance. Two of the five potential sources defined by DM (p. 4-3, Task C2), the PPA and the CWP Area, are in reality source areas which contain a number of specific sources within their boundaries. Another two, the Flyash Piles and the Scrap Metal Pile, are specific sources. The final source defined by DM as waters and sediments contained in PR and the SSOD combines a direct source, sediments, with a transport mechanism, waters flowing into PR and the SSOD.

must answer these questions

The incorporation of such inequality when defining sources leads to structural difficulty during the process of determining which sources are actually responsible for uranium release. For example, if sediments and waters flowing into PR and the SSOD determined to be a contributing source, what is the real contributor of uranium? Is it sediments? Is it runoff from the PPA? Is it seepage of leachate waters from the PPA into the SSOD? Is it infiltration from contaminated groundwater in the PPA? Is it runoff from the CWP Area? Is it seepage of leachate waters from the CWP Area into PR?

2.3.2 Site Monitoring

Introduction: A well planned monitoring program allows compilation of site-specific data which will indicate the nature and extent of contamination from sources and migration pathways identified during site characterization. Information must be obtained for groundwater and surface water contamination by selectively monitoring wells, springs, seeps, and surface waters. Soil samples should also be taken. The initial objective of such monitoring is to identify the critical migration routes and sources. After establishing that a contaminant has been released from a particular source via a particular pathway, monitoring should enable determination of the rate and direction of contaminant movement. Since water is generally responsible for the transport of contaminants in soil-groundwater systems, if the rate and direction of water movement are known, they can provide estimates of the rate and direction of contaminant movement, although the rate of movement of most chemicals in groundwater is reduced by either physical, chemical, or biological reactions. Some radionuclides, for example, are adsorbed onto soil surfaces and thus migrate at a much slower rate than the groundwater that carries them. For this reason, a separate study is necessary in order to assess contaminant behavior prior to applying corrective measures.

Hydrogeologic investigations are usually conducted to establish the rate and direction of water movement. These investigations consist of a series of steps, the first of which is a review of existing information. A geophysical survey is then conducted to determine the number and thickness of geologic layers, layer composition and physical properties, and the depth to bedrock or to the water table. Borings are then made to define subsurface geologic formations and groundwater monitoring wells are installed in the borings. Water level measurements are recorded and used to construct water level contour maps, evaluate horizontal gradients, and assess groundwater flow directions. These wells may also be used for water quality monitoring at some later time. Hydraulic conductivity tests are performed and data are used to estimate groundwater flow rates. In certain cases, mathematical models to predict aquifer hydraulics may be used to assist in interpretation of data obtained during the hydrogeologic investigation.

Findings: The major focus of DM's investigation was altered during project implementation. No substantiation or documentation of rationale is provided in the text. Specific deficiencies are as follows:

1. Alteration of groundwater zones monitored during Task B.

   The Task A2 and B2 Reports both state that the major focus of DM's investigation will be on the surficial till layer (p. E-2, Task A2; p. 2-1, Task B2). Supporting reasons given by DM for this focus include:

   a. All source areas occur within or on this unit (p. 2-1, Task B2).

   b. Leachate released from source areas will initially migrate within this layer (p. 2-6, Task B2).

c. This unit can provide local discharge of uranium-bearing groundwater to surface streams (p. 3-9, Task A2).

d. Boring logs indicate that this layer is hydrologically connected to the shallow sand and gravel aquifer, where above-background uranium levels have been observed (p. 2-6, Task A2).

e. This is the groundwater system most likely to be affected by FMPC operations (p. E-2, Task A2).

The Task B2 Report (p. 2-1) outlines a plan which will allow data collection activities necessary to quantify the percentage uranium contribution originating from each source area. The depths of monitoring well clusters to be installed by DM were said to be estimated with the intention that the shallow wells (denoted "s") would monitor the surficial till layer - the uppermost water-bearing zone (p. 2-1, Task B2). The Task C1 report lists data obtained from these monitoring wells, and references the shallow wells (denoted "s") as being located in the upper portion of the sand and gravel aquifer (Table 4-1, Task C1). Although not formally stated in the report text, it is clear from this that DM altered its investigative focus from monitoring of the vadose zone (surficial till) to monitoring of the water table (upper sand and gravel zone).

When questioned during the technical review (refer to Appendix B, p. B-4) as to why the focus had been shifted away from the surficial till, DM explained that their original intention was to monitor the till, but that they were unable to successfully locate water in all but 4 of the wells they dug in the till. (Of the 22 onsite wells actually installed by DM, only four monitor the surficial till: 19 TP, 20 TP, 21 TP, 22 TP; three of these are located within the CWP Area.) They then shifted the focus of the investigation to the upper sand and gravel aquifer. This explanation is not included in the Task C2 Report, which only states that a saturated zone was encountered at 4 to 9 feet below grade in 5 shallow wells, but was not encountered in TP wells

near well clusters 13 and 18 (p. 3-6, Task C2). No further references to this zone are made in the Task C2 Report.

2. Alteration of well sampling locations installed by DM.

The Task C2 Report (Table 4-1) lists all wells DM monitored and their relative locations within the FMPC, but fails to provide rationale as to what source(s) each is intended to monitor.

The Task B2 Report (Table 2-1, p. 2-3 to 2-5), provides a rationale for the location of five well clusters, each of which will monitor a specific source area. Three of the clusters were to be placed in the CWP Area, one in the PPA, and one in the area of the Flyash Piles (p. 3-12, Task A2), for a total of 10 new wells.

The Task C2 Report states that DM installed a total of 22 new wells onsite plus one offsite well, although no reference is made to the fact that only 10 new wells (5 clusters) were originally planned. No rationale is provided for selection of these added sampling locations. Although DM states in Task C2 (p. 1-4, Task C2) that rationale has been provided in Task B2 for installation/location of the 22 wells, that Report provides rationale for 10 wells only.

3. Alteration of overall sampling plan.

The Task B2 Report (Table 3-1) lists a total of 32 well sampling stations and 7 surface water sampling stations. In actuality, DM collected groundwater from 41 stations and surface water from 21 stations (Table 4-2, Task C2). No acknowledgement of, or rationale for these changes is provided in the text.

4. DM's monitoring program does not provide for assessment of all critical migration routes.

   There are three major hydrologic routes by which uranium can first be released from onsite sources at the FMPC:

   a. Shallow, uranium-bearing groundwater seeping into surface streams which then recharge deeper groundwater zones (p. 3-9, Task A2).

   b. Direct runoff of uranium-bearing water to surface streams which then recharge deeper groundwater zones (p. 4-1, Task A2).

   c. Direct hydrologic connection between shallow uranium-bearing groundwater and deeper groundwater zones (p. 2-6, Task B2).

Design of DM's monitoring program included installation and pumping of wells to assess hydrologic interconnection, and collection of stormwater runoff. However, no provisions were made in their program that would allow assessment of shallow groundwater movement, although such an assessment was originally intended by DM (Task B2, P. 2-1). Test pit wells in the CWP Area were capable of providing water level measurements showing a perched groundwater table was present at five to seven feet below grade, but no monitoring wells were capable of assessing the movement of this perched groundwater from the CWP Area toward PR (refer to Appendix B, p. B-7). DM placed no wells directly between the CWP Area and PR, although DM refers to seepage of uranium-bearing groundwater from the CWP Area into PR as a potential source of above-background uranium in the offsite wells (p. 4-3, Task C1).

Only 4 wells installed by DM are capable of monitoring this perched water system. DM did not assess the flow direction or flow velocity of this system, saying they had no hard data - only that it simply makes geologic sense for such shallow groundwater movement (to PR) to be occurring (refer to Appendix B, p. B-7).

This shallow groundwater system has been observed to occur at random throughout the FMPC site (ORAU 1985).

Several additional questionable areas related to DM's hydrogeologic investigation are the assessment of aquifer hydraulics, based only on a predictive model (Target-2DH), rather than on site-specific hydrogeologic data, and the use of limited data to define the extent of the plume of uranium-bearing ground water. Modeling of groundwater flow requires data inputs at each grid point (Figure 5-1, Task C2) for four parameters: hydraulic conductivity, depth to bedrock, infiltration rate, and effective porosity. Values were assumed by DM, in all cases, for depth to bedrock, infiltration rate, and effective porosity. Values were assumed by DM for hydraulic conductivity except in areas where they drilled (primarily the CWP Area). Twelve samples were tested for their hydraulic conductivities. The modeled area included approximately 350 separate grids.

Small changes in hydraulic conductivity were found to produce significant changes in model results (refer to Appendix B, p. B-23). In the area of the offsite wells the hydraulic conductivity values were assumed (refer to Appendix B, p. B-23). In addition, the CWP Area was assumed to be a non-recharge area (refer to Appendix B, p. B-10), and the critical aquifer (surficial till) is not included in the model (refer to Appendix B, p. B-8). The model also assumes that no geochemical processes are occurring, which would affect the migration rate of uranium although the fact that no above-background levels of uranium have been detected in wells near Fernald indicates otherwise (refer to Appendix B, p. B-23).

The approximate extent of groundwater containing above-background concentrations of uranium is defined by a plume (shown in Figure 2-5), the boundaries of which are questionable. The plotted uranium levels are based on one sampling session and monitoring wells do not exist in many areas of the site that would enable full definition of the extent

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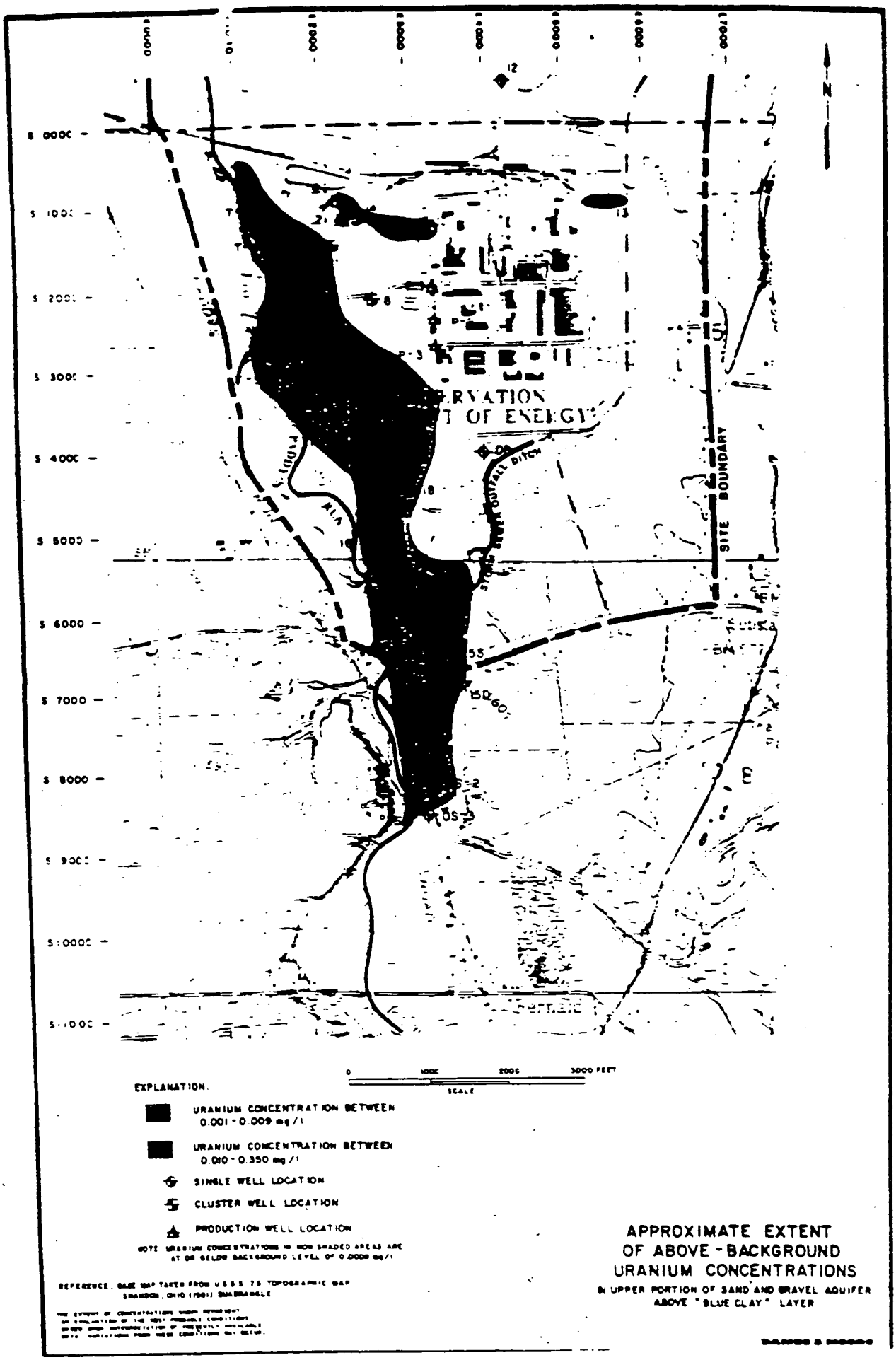

FIGURE 2-5. Uranium Containing Groundwater Plume as Defined by Dames and Moore.
(Source: Task C2)

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of any plume, past any monitoring wells sampled by DM and used as boundary values. Also, a relatively high uranium-level is noted for Monitoring Well 13, located in the northeast part of the site, east of the PPA. A small plume is defined by DM, around this well, although no other wells exist in the immediate vicinity, which would allow assessment of plume boundaries.

The data generated by DM and used to support their conclusions are questionable for the following reasons:

1. DM conducted one sampling session, resulting in analysis of 41 groundwater and 21 surface water samples for the presence of uranium. One sampling cannot be considered representative of the FMPC system due to the highly variable nature of environmental parameters. For most environmental evaluations of parameters required for compliance with EPA standards, for example, quarterly sampling is required to incorporate the effects of seasonal changes. Statistically, samplings can be made more reliable by increasing the number of samples, as well as the frequency of sample procurement.

2. All groundwater samples taken (41) by DM were split with NLO and subsequently analyzed for uranium. Comparison of analytical results by DM revealed an order of magnitude (or more) difference between 9 of those split samples (Table 4-2, Task C2).

   Examination of Table 4-2 values reveal that two more groundwater samples (15d, OB-1) should have been included as having an order of magnitude difference between NLO and DM observations. Therefore, 11 of 41 groundwater samples split between NLO and DM, or 27% of the observations, were found to not agree statistically. The two runoff samples taken from the SSOD were also split with NLO, one of which was found to lack statistical agreement (OD-2), upon examination of Table 4-2. This means that 12 of the 43 samples (28%) split

between NLO and DM were found to be statistically different. Therefore, roughly one-quarter of split samples analyzed indicated that a statistically significant difference existed between NLO and EAL (DM) results.

When such a significant percentage of samples are found to be in disagreement, the validity of the entire data set is in question. A problem exists in sample collection, preservation, or analytical methods. More sampling is required before the data can be used with confidence. However, no further analyses were conducted by DM, nor were the significant differences in uranium results for the split samples discussed in DM's text. A single reference is made to split samples in the text, when DM states that only EAL's data were used during interpretation of the results (p. 4-1, Task C2).

3. Data are reported to the fourth significant figure in Table 4-2 (Task C2) and to the third significant figure in Table 4-3. It is not clear as to which is correct, or which was used in statistical comparisons.

4. The uranium value listed for Well 20 TP in Task C1, Table 4-2 is 0.030 mg/l. This does not agree with the uranium value listed for Well 20 TP in Task C2, Table 4-2, which is 0.0401 mg/l.

5. A seep located near the inactive Flyash Pile is referred to as a DM monitoring point in the Task B work plan Table (3-1). This seep is not referred to again.

6. Analysis and discussion of results for parameters other than uranium are not included in DM's Final Report. Analytical parameters DM intended to quantify for each sample taken (in addition to uranium) are listed in the Task B Work Plan

(Table 3-1): pH, specific conductivity, temperature, dissolved oxygen, and Fe. The only parameter for which results are reported in Task C2 is Fe.

7. Results for runoff samples RO-20 and 21 are presented in Task C1, Table 4-2, but are not included in Task C2, Table 4-2 results. The levels of uranium in these two samples are quite significant: 1.6 and 2.4 mg/l, respectively. The omission of these values from consideration during data analysis is of concern and should be accounted for. DM states that only one offsite sample was collected, so these values must have an origin within the FMPC site. A supposition is that they may correspond in some way to the A, B, and D points noted in Task C1 (Figure 4-3) where drainage from the CWP Area actually enters PR (Figure 4-3). If these values do not correspond to these points, then a question arises as to why samples were not taken at these points, since they would have been more directly comparable to the samples taken at OD-1 and OD-2 points on the SSOD than are other CWP Area sampling points.

2.3.3 Source and Pathway Identification

Introduction: Based on their site characterization, monitoring, and associated hydrogeologic investigations, DM has identified two sources for the above-background concentrations of uranium in the three offsite wells (p. 4-8, Task C2). These are (1) water flowing into the SSOD via the SSO from the PPA and (2) water flowing into PR from CWP Area. The SSOD has been designated as being the most important source (p. 4-9, Task C2). Additional contributions of uranium were identified as coming from runoff water flowing into PR from the CWP Area. The Flyash and Scrap Metal Piles were not found to be sources. DM describes the transport mechanism associated with these two sources in Task Report C2 (p. 4-10). Precipitation-induced runoff water from both the PPA and CWP Area flows via natural and man-made drainage channels into the SSOD and PR. Once in the surface water system, the water mixes with upstream

water and travels via channel flow to an area near the intersection of the SSOD and PR. Within this area, the relatively impervious glacial till grades into more permeable sand and gravel. Surface water thus percolates into the sand and gravel aquifer and follows the natural (and in part, pumping induced) groundwater flow pattern toward the three offsite wells.

Findings: Upon examination, DM's source and pathway identification was considered questionable because identified "sources" are, in actuality, transport mechanisms and primary sources and other potential transport mechanisms remain unqualified.

Identification of "water flowing into the SSOD via the SSO from the PPA" as the primary source is questionable for the following reasons:

1. PPA runoff is not a source, it is a transport mechanism. The potential sources would be pads, roofs, and open ground, as well as the Scrap Metal Pile. No samples were taken by DM, however, that were specific enough to evaluate these sources. Runoff samples taken at random in the PPA would have greatly assisted in evaluating the hypothetical runoff pathway and in tracing back to the actual source. The two runoff samples taken by DM as being representative of PPA runoff were both taken outside the PPA on the SSOD. Soil samples taken at random in the PPA would have greatly assisted in evaluation of the hypothetical runoff pathway. No soil samples were taken by DM. Runoff samples taken in the immediate vicinity of the Scrap Metal Pile would have allowed its assessment as a source. Such samples were not taken.

2. There are other potential mechanisms by which uranium can reach the SSOD from the PPA. They include random seepage of uranium-bearing groundwater into the SSOD (groundwater could become contaminated by uranium-bearing runoff infiltrating the surficial till) and infiltration of uranium-bearing groundwater into transfer lines. These mechanisms were not investigated by DM.

FMPC site history indicates that an existing NLO shallow well, OB-1, located in the immediate vicinity of the SSOD has indicated the presence of a perched system. (Water level 12 12 feet below grade. Groundwater in the surficial till is infiltrating the SSO pipeline. An observed flow of approximately 1 gpm empties continuously from the pipe, even in dry periods (ORAU 1985). Previous analyses by NLO show an average uranium concentration of 1 mg/l during dry periods (refer to Appendix B, p. B-11).

Work was not implemented by DM during their site investigation that would allow assessment of these mechanisms. No wells were installed in the surfical till near the SSOD, or in the PPA. Therefore, no assessment of the perched groundwater system can be made for these areas. The percent uranium-contribution made by actual surface runoff from the PPA to the total amount of uranium being discharged at the SSO is not assessable. This is because DM did not analyze the 1 gpm continuous flow coming from the SSO. Comparison of uranium concentrations contained in this flow and those contained in flow resulting from a rainfall (runoff) event is not possible. Also, the relationship of runoff volume from infiltrating groundwater and runoff volume from the PPA has not been determined. It is likely that the flow of infiltrating groundwater into the pipeline increases during runoff events, rather than remaining a constant 1-2 gpm. This makes evaluation of PPA runoff volume contribution to the pipeline rather difficult, and demonstrates that the uranium-contributing mechanism from the pipeline may not be attributable solely to runoff, and in fact, may be largely due to infiltrating groundwater. In addition, runoff contribution to the SSO is intermittent, and initial runoff from the PPA (that portion containing the most substantial amount of uranium) is directed to the GMR. Only volumes in excess of the lift station's capacity are directed by the SSO to the SSOD.

Identification of "water flowing into PR from the CWP Area" as the secondary source is considered questionable, as well. The CWP Area runoff is a transport mechanism rather than a source.

Additionally, rejection of the CWP Area as the primary source is questionable for the following reasons:

1. DM concludes that the SSOD contributes significantly larger amounts of uranium to offsite wells than does PR, yet DM made no provisions in their sampling program that would allow for direct quantitative comparison between the two pathways. DM collected 19 runoff samples within the CWP Area and no runoff samples within the PPA. Runoff data from these two source areas are not spatially comparable. DM also collected 2 runoff samples directly from the SSOD but no runoff samples directly from PR, although DM noted 3 points on PR where drainage from the CWP Area entered (Figure 4-3, Task C1). Runoff data from these two waters are not spatially comparable, either. There was no assessment of the water budget for the two streams. Such a budget would have allowed assessment of the SSOD's percent contribution to flow on PR. Therefore direct comparison of the two streams is not possible.

2. When qualitatively comparing uranium contributions from the SSOD and PR, DM states (p. 4-4, Task C1) that "Total quantities (of uranium) released via this pathway (CWP runoff/seepage) are greater and more continuous than those in the SSOD. Much higher concentrations (of uranium) are probably released during or shortly after periods of peak flow."

3. A statistical comparison of data obtained by DM for CWP Area and PPA runoff indicates that PR is the more significant pathway. Calculation of GM's for uranium found in the 18 runoff samples taken in the CWP Area and for uranium found in the 2 runoff samples taken in the SSOD produced means of 1.33 mg/l and 0.049 mg/l uranium, respectively (refer to Table C-1, Appendix C). Other related deficiencies are: DM makes no direct reference to statistical analyses of uranium data

in the Task C2 Report. In the Task C1 Report (p. 4-4) DM states that "Average concentration of runoff and seepage water released to PR from the waste pit storage area are (is) approximately an order of magnitude lower than those (that) reported in the off-site wells." DM does not state any specific values, however.

4. DM bases its choice of the SSOD (as the primary source) on the similarity in uranium concentrations between the water released from it (SSOD) and those in the 3 offsite wells (p. 4-9, Task C2). Examination of DM's uranium data (Table 4-2, Task C2) indicates that the concentration of uranium in the SSOD decreased noticeably with increasing distance from the SSO pipe. Uranium is 0.2700 mg/l at the SSOD discharge pipe but decreases to 0.0080 mg/l at OD-2, which is nearest the confluence of PR and the SSOD, and thus nearest the proposed transport mechanism. The only other data DM makes use of are historical NLO data for the SSO pipe and PR (Task C2, Tables 4-4, 4-5). Direct comparison of these data is not appropriate. Sampling points used for PR are not representative of CWP Area input. The upstream sampling point (W5) serves as background only; it is upstream of all FMPC operations. The downstream sampling point (W7) is a total indicator of all FMPC input; it is downstream of all operations. These two sampling locations are shown in Figure 2-6. The downstream point is below the confluence of PR and the SSOD and is representative of both input from the CWP Area and the PPA, as well as other inputs.

5. Examination of data collected by DM indicates that a perched groundwater system exists at 3-7 feet below grade in the surficial till of the CWP Area. Data from these wells located in the surficial till indicate that these wells contain groundwater having the highest uranium levels found in onsite groundwaters sampled by DM: MW 19 TP, 0.29 mg/l; MW 21 TP, 1.50 mg/l; MW 22 TP, 2.10 mg/l. Runoff samples

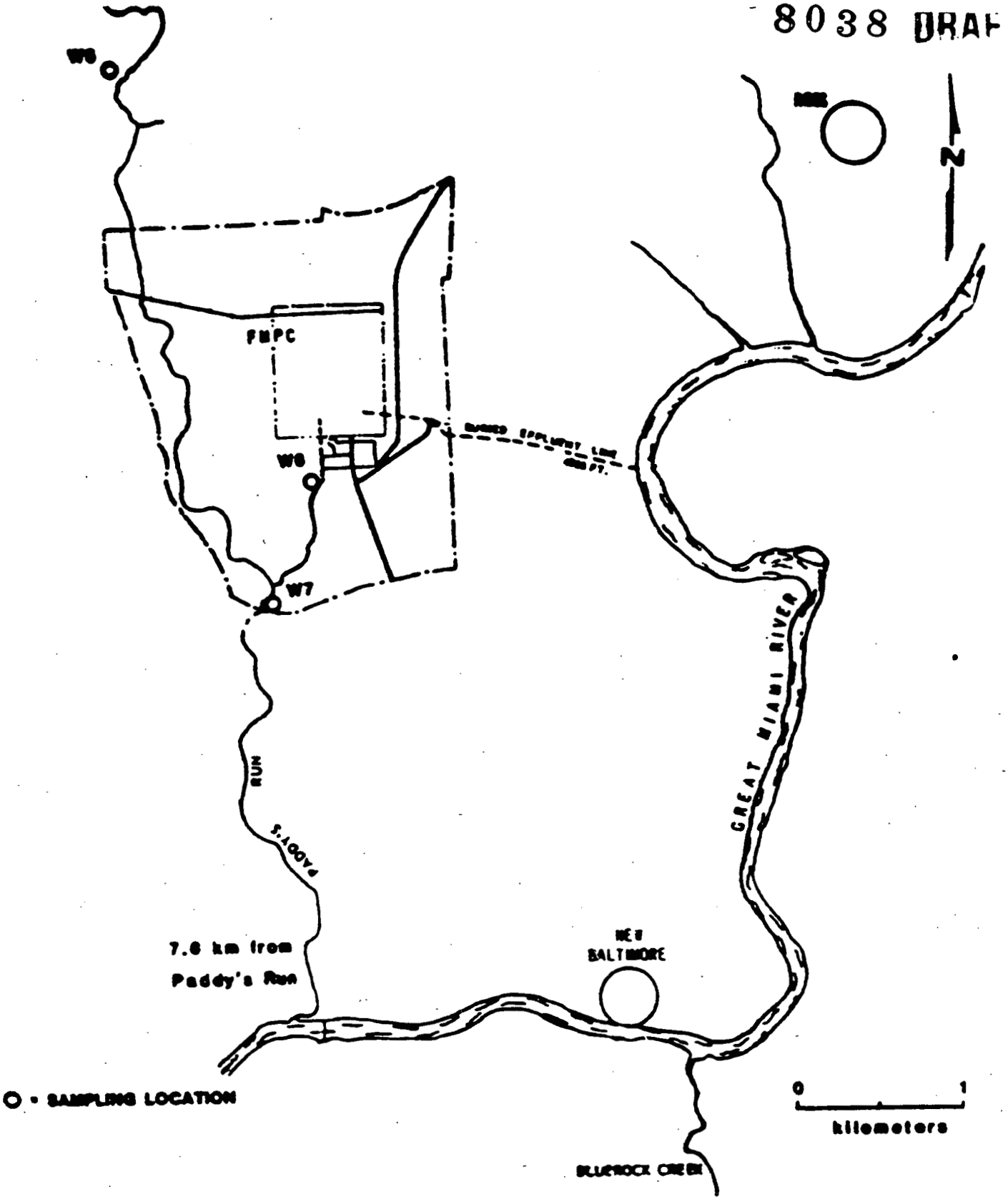

FIGURE 2-6. Surface Water Sampling Locations on Paddy's Run and the Storm Sewer Outfall Ditch.

(Source: NLO 1984)

taken in this area indicate surface transport of uranium ranging from 0.0068 to 34 mg/l. These data indicate that uranium release mechanisms other than surface runoff may be occurring. Such mechanisms include surface seepage of leachate from covered waste pits, due to the bathtub effect; shallow groundwater recharge by seepage from the unlined Clearwell; leakage from waste pits and storage tanks to shallow groundwater; leakage from underground transfer lines to shallow groundwater and; seepage of this uranium-bearing groundwater directly into PR. Work implemented by DM during their site investigation was not sufficient to allow assessment of these mechanisms. In assessing the status of the Waste Pits, DM mistakenly assumed that the closed pits were clay-capped (p. 6-3, Task C1). Thus, DM did not consider the potential these basins have for filling up with infiltrating rainwater (since they are clay or membrane lined) until the water flows out the top. This is more than likely the source of two surface seeps observed during DM's site investigation, and may well be the principal source for U-bearing runoff water in the CWP Area. DM did not establish a flow balance for transfer lines originating at the General Sump, going to CWP 5 and the Clearwell, and from the Clearwell to the outfall at the GMR. NLO stated during the technical review that the underground transfer line installed in 1959 for CWP 3 was not put out of service when CWP 3 was retired, but was simply extended on to CWP 5 (refer to Appendix B, p. B-12). This line may be leaking, having been underground about 26 years.

It is also possible that CWP 5 is leaking. Visible tears and cracks were noted during site inspection (ORAU 1985). The Clearwell is unlined, and undoubtedly loses some of its contents through seepage. Comparison of effluent volume released at the General Sump to effluent volume entering the Clearwell is possible (but was not performed by DM) in order to refute/confirm this pathway for groundwater contamination.

6. DM does not address the potential effect of perched uranium-bearing groundwater on offsite water quality. Although the presence of a localized uranium-bearing system in the CWP Area was noted by DM, the flow direction or velocity of this system were not determined, nor was the system included in DM's modeling effort. The seepage of uranium-bearing groundwater into PR pathway is therefore not considered by DM, although DM does state "we observe that seeps probably do drain into PR, although they were not observed." (Refer to Appendix B, p. B-6).

Other factors relevant to consideration of the CWP Area as a prime source include:

1. Continual pumping of Well 1s over a 20 year period, in order to prevent movement of contaminated groundwater (located in the CWP Area) toward the Production Wells.

2. All wastes disposed of onsite at the FMPC are placed in this area. The approximate total uranium content is 4,730,800 kg (ORAU 1985), as opposed to 2,000 kg of uranium-bearing soil located in the PPA.

DM's conclusion that the Flyash Piles are not sources for offsite uranium is considered questionable for the following reasons:

1. DM based its rejection of the Flyash Piles on results of downgradient groundwater sampling (p. 4-9, Task C2). This approach omits two other potential pathways by which uranium can be transported from the Flyash Piles. These are direct runoff to surface streams and seepage of uranium-bearing groundwater to surface streams.

2. Transport from the inactive (covered) Pile or active Pile is possible by infiltrating surface water contacting the Pile, resulting in seepage of leachate into shallow groundwater,

which can then seep into surface streams or recharge deeper groundwater zones. Buildup of leachate in the covered Pile can also lead to surface seeps. Such a seep was noted by DM in the vicinity of the inactive Pile (Table 3-1, Task B2) but no sampling of this seep was performed. The reason for this is not clear. Also, DM installed no wells in the surficial till near the Flyash Piles; thus assessment of the perched groundwater system can not be made for this area. It is therefore not possible to assess whether shallow uranium-bearing groundwater leached from either of the Flyash Piles seeps directly into the SSOD or PR.

3. Transport from the active Pile is also possible by direct runoff. The Pile is situated near the crest of a steep slope; surface runoff can potentially drain to the SSOD or PR, or recharge the shallow groundwater system. DM took no runoff samples in the immediate vicinity of the Pile, therefore, this route for uranium release cannot be assessed.

4. One of DM's prime supporting reasons for selection of the SSOD as the most important source for offsite uanium was the nearness of the SSOD to the transport mechanism in PR, downstream from its confluence with the SSOD (p. 4-9, Task C2). The Flyash Piles are also very close to this transport mechanism. The distance from the center of the covered Pile to PR is approximately 200 ft. (Task C2, Figure 1-2); distance from the center of the active Pile to either the SSOD or PR is approximately 600 ft (Task C2, Figure 1-2). In addition to this, the active Pile is located in the proximity of a small drainage ditch which empties into the SSOD at the very point where surface water sampling station OD-2 is located. DM took no samples in this ditch. The location of the Flyash Piles in relation to the drainage ditch, PR, SSOD, and sampling station OD-2 is shown in Figure 2-7.

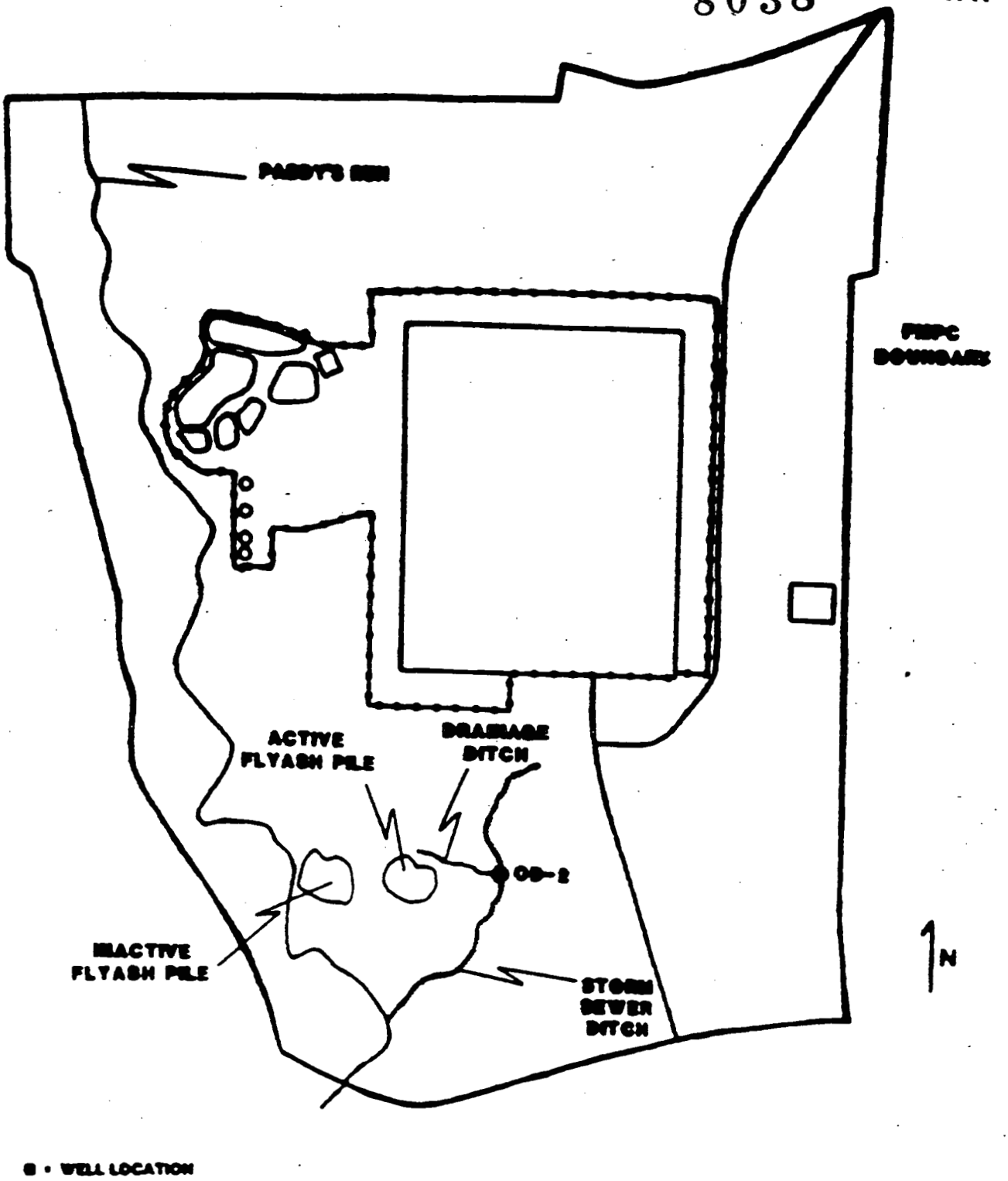

FIGURE 2-7. Surface Drainage in the Vicinity of Flyash Piles.

(Source: Adapted from NLO 1984)

Other factors supporting the Flyash Piles as sources of offsite uranium include:

1. Inactive Pile

   a. There is no seepage control for the inactive Pile; the pile is covered with several feet of lightly compacted (permeable) fill dirt.

   b. The Pile was estimated to contain 612 kg uranium at an average concentration of 10 mg/l (p. 4-6, Task A2). (It is unclear as to the source of this estimate.)

   c. Added small amounts of uranium were dumped into this Pile during a research project (p. 4-5, Task A2).

2. Active Pile

   a. There are no runoff or seepage controls for the active Pile; the Pile is deposited directly onto uncontrolled ground.

   b. Surface runoff from the Pile has resulted in some minor erosion; many rills were present on the sloped area, all of which contained visible flyash residue (ORAU 1985).

   c. The Pile was estimated to contain 408 kg uranium (p. 4-6, Task A2) at an average concentration of 10 mg/l. (It is unclear as to the source of this estimate.)

   d. Fugitive emissions were noted during a site visit at moderate wind speeds of approximately 8 mph (ORAU 1985).

2.3.4 Selection of Remedial Actions

Introduction: Appropriate remedial actions should be selected (based on monitoring results) for those sources and migration pathways having been demonstrated as contributing to offsite U contamination. The establishment of an effective remedial action plan for the FMPC site must take into account all of the sources and pathways involved in the transport of uranium through the environment to the offsite wells, and should be highly site-specific. The most appropriate remedial action can be selected only after a thorough evaluation of the problem, site

characteristics, and available remedial options. Selection should be based on both the technical and the economic feasibility of potential alternatives.

Once release of uranium from a particular source is established, the mechanism or pathway by which release is accomplished must be identified. Selection of the most appropriate remedial action must then address that release mechanism. Applied remedial actions that do not directly address the release mechanism may be ineffectual. For example, if the principal mechanism of release from a waste pit is vertical infiltration by precipitation, then a substantial decrease in release may be accomplished by the placement of a low-permeability cap over the waste pit area. However, if the principal mechanism of release is contact with a high groundwater table, placement of a low-permeability cap over the waste pit area will have little or no effect on release.

Findings: Remedial alternatives selected by DM may be ineffectual due to their failure to address primary release mechanisms from primary sources. Remedial actions suggested by DM are more generic in nature than site-specific. Specific deficiencies noted during the overview are as follows:

Short-Term Remedial Action Recommendations

1. No provision was made for continued monitoring on a frequent basis. Such monitoring is necessary in order to assess the effectiveness of any applied corrective actions.

2. The feasibility of certain recommended actions is questionable from a technical standpoint. Surface water runoff control is suggested as a remedial measure for the CWP Area. Utilization of the Clearwell as a storm water retention basin is included in this measure. Such use is questionable because the Clearwell is unlined and is located in an area of saturation. The Clearwell may be acting as a recharge basin for groundwater in the surficial till, and

thus as a source for uranium release. Also, the Clearwell is currently receiving flow from CWP 5 and thus has a minimized holding capacity, the total holding capacity of the Clearwell (when empty) is estimated at between 0.5 and 1 MG. The calculated volume of runoff water from a hypothetical storm event was found to exceed this capacity (refer to Appendix C, Table C-3).

3. Excavation of uranium-bearing sediment is suggested as a remedial measure. The effectiveness of such excavation is questionable since the percent solubility of the uranium has not been established. If the uranium were soluble to any appreciable degree, attenuation in stream sediment would be minimal. Therefore, it is likely that uranium contained in the sediment is relatively insoluble.

4. The effectiveness of storm water runoff collection and retention in the CWP Area as a remedial measure is questionable. This approach does not address the primary transport mechanism. It is not likely that the primary source of uranium in the CWP Area is contaminated soil, and thus not likely that the primary transport mechanism is storm water runoff. It is more likely that the CWP Area uranium source is seepage coming from the pits after infiltration of rainfall has caused them to fill with water and overflow at the surface. The more appropriate remedial measure would seem to be the placement of a less permeable surface over the CWPs. It is not clear why this was not considered as a short-term measure, since use of an impermeable cover is discussed by DM as a long-term measure. The application of flexible membrane type covers is relatively simple.

5. DM's recommendations for additional studies comprise activities that should have been essential prerequisites to source and pathway identification, as well as to selection of

remedial alternatives. These recommended activities include development of a site water balance in order to provide necessary flow, infiltration and/or recharge data (p. 6-3, Task C2); and a study of the chemistry of the uranium, groundwater and soils in order to determine what geochemical processes are occurring during the groundwater transport of uranium offsite (p. 6-3, Task C2). Both A water balance and a chemical characterization study should both have been completed prior to or during DM's work. Incorporation of these studies into pre-monitoring activities would have greatly assisted in focusing of active monitoring activities. During the technical review session, DM stated that a water balance was necessary for determining corrective actions (refer to Appendix B, p. B-8, B-9).

6. DM recommends collection of supplemental data for hydraulic properties of the surficial till in order to apply effective groundwater control in the CWP Area. Evaluation of hydraulic properties of the till was to be a major goal of DM's groundwater study, initially (p. 2-1, Task B2). It is not clear as to why DM did not perform a more thorough investigation of hydraulic properties of the till, especially in the immediate vicinity of the CWPs, prior to installation of wells. In addition to serving as an early warning of groundwater pollution, if such vadose zone monitoring fails to detect contaminant movement, the requirements for groundwater monitoring may be reduced or largely precluded. The cost savings for constructing monitoring wells could be significant.

Long-Term Remedial Action Recommendations

1. The remedial actions are not final recommended actions, but rather are proposed in order that they might be evaluated for applicability to the FMPC situation (p. 6-4, Task C2). The recommended actions are therefore generic, not site-specific.

2. The recommended remedial actions cannot be made site-specific. Site-specific applications require that the primary source be identified. DM did not collect hard data that would allow assessment of the percent uranium contribution originating from each source area (refer to Appendix B, p. B-3, B-7, B-15).

3. The feasibility of certain recommended actions is questionable from a cost-effective standpoint. Three of the remedial alternatives address specific sources: addition of waste pit covers, a groundwater control system in the CWP Area, and relocation of materials in the PPA and CWP Area. Other alternatives are directed at mitigating the effect of the sources on the environment, rather than at the source itself. Such applications are rarely cost-effective over a long-term period and thus do not follow good engineering practice (GEP). GEP dictates that the source of contamination be identified and evaluated for potential to further contribute. If it is determined that the source still has potential for contaminant release, GEP dictates that the source be isolated from the environment, using engineering applications. GEP does not consider treatment of the effect to be an acceptable approach; such treatment does nothing to halt contaminant release because it is not directed at the source. Treatment of the effect may result in (1) an exponentially enlarged environmental matrix requiring remediation; (2) an associated long-term cost matrix for such required remediation; (3) associated long-term, expanded monitoring requirements; and/or (4) public disapproval.

4. The feasibility of suggested alternative of material relocation is questionable from technical and economical standpoints. All wastes generated at the FMPC since initial startup have been placed in the CWP Area, with the exception of the Scrap Metal and Flyash Piles. Relocation would

involve transferring a substantial volume of relatively hazardous material - approximately 480,000 metric tons (FMPC 1984). Such movement would pose a health risk for those involved. Assessment of risk would be complicated by the fact that certain disposal areas contain unaccountable waste types and volumes. The cost-effectiveness of such an action would be questionable, when compared to in-situ stabilization, since corrective measures would probably still be necessary in the CWP Area after waste relocation. Relocation could, additionaly, increased likelihood for migration/exposure due to potential losses from containerized wastes during excavation.

2.3.5 Fulfillment of Scope of Work

Introduction: DM's groundwater study involved two major objectives:

1. Identify the source or sources of above-background levels of uranium in the offsite wells.

2. Recommend remedial measures if it was concluded that the FMPC facility is the source of the above-background concentrations of uranium in the groundwater in offsite wells (p. 1-2, Task C2).

DM's approach to acheiving these objectives began with field work focused on confirming/refuting the impact of each source area on offsite groundwater quality (p. 4-1, Task A2). Monitoring wells were placed up- and downgradient of each potential source in such a manner as to be capable of detecting uranium release, directly to the groundwater or indirectly by surface water runoff and later recharge (p. 4-1, Task A2). Data would then be gathered to enable tracing above-background levels of offsite uranium-containing groundwater back to its source(s) (p. 4-1, Task A2).

Data gathered from well installation and monitoring would also be used to quantify the percentage of uranium contribution originating from each source area (p. 2-1, Task B2). Potential source areas considered by DM (p. 4-3, Task A2) included: sediments and waters in PR and SSOD, covered (inactive) and Active Flyash Piles, the CWP Area, the PPA, and the Scrap Waste Pile.

Findings: Information obtained during the technical review indicates that sources identified by DM as being primarily responsible for the above-background concentrations of uranium in the offsite wells are questionable. Inadequate site characterization and alteration of the established work plan for site monitoring have led to an inconsistent and inadequate monitoring program. This in turn, has resulted in a remedial action selection process which identified sources that are, in actuality, transport mechanisms and identified corrective measures which may be ineffectual. Primary sources and other transport mechanisms remain unqualified, as do site-specific corrective measures. Although monitoring results have allowed identification of a principal transport mechanism, they have not allowed identification of specific sources or corrective measures since DM collected no hard data that would allow for quantification of the percentage of uranium originating from each source area (refer to Appendix B, p. B-3, B-7, B-15). The application of specific corrective measures therefore requires additional data collection. (refer to Appendix B, p. B-9).

3.0 RECOMMENDATIONS

Completion of three tasks is recommended to fulfill the originial scope of work and objectives of this study. These tasks are:

1. Determine direct sources and transport mechanisms responsible for hydrologic release of uranium from the Feed Materials Production Center.

2. Determine the percent uranium contribution from each of those sources.

3. Select site-specific remedial actions directed at transport mechanisms responsible for uranium release from primary sources.

3.1 Source and Pathway Identification

Specific recommendations for the monitoring program during reassessment of potential sources and migration routes include:

1. Restructure the monitoring program to enable assessment of individual sources and pathways.

   a. Selectively place additional wells in the surficial till to evaluate groundwater quality and movement in the vicinity of specific sources.

   b. Selectively place plug samplers at ground level in order to evaluate the quality of surface runoff in the vicinity of specific sources. (A plug sampler is made of Teflon and is driven into the ground so that the top face of each plug is just below the ground surface. Overland flow enters the plug through a screen in the top that removes large particles but allows entry of smaller suspended particulates. Plug samplers can also be used to collect groundwater seepage through channels around the side surface covering the top face of the plug.)

c. Select additional surface water sampling locations on PR, between existing W5 and W7 locations, and on the SSOD.

d. Sample surface water contained in the drainage ditch that empties into the SSOD near the active Flyash Pile.

2. Conduct hydrogeologic characterization of the vadose zone (surficial till).

a. Establish the extent of the perched groundwater system.

b. Establish hydraulic properties of till, such as hydraulic conductivity, storativity, transmissivity, etc.

c. Assess degree of interconnection between perched groundwater in the surficial till and deeper groundwater systems.

3. Supplement the monitoring program to enable assessment of all groundwater transport routes.

a. Selective placement of additional wells enabling full definition of the extent of uranium-contaminated groundwater.

b. Selectively place additional wells enabling assessment of groundwater flow toward the GMR.

3.2 Additional Studies

Specific recommendations for additional studies include:

RI/FS

1. Conduct a characterization of the CWP Area, specifically, the six Waste Storage Pits, the Clearwell, the two K-65 Storage Silos, and the Metal Oxide Silo. Specific activities can include:

a. Coring of pits and silos.

b. Performing physical and chemical analyses of core samples to determine EP toxicity and major element chemistry.

c. Placing of observation wells in pits where cores were taken.

d. Monitoring leachate levels and water quality in observation wells.

e. Conducting electromagnetic conductivity surveys of the Pits, the Clearwell, and the Silos.

f. Determining the infiltration rate of water from the Clearwell using a seepage meter or equivalent technique.

g. Locating and analyzing surface seeps.

2. Conduct a characterization of the Flyash Piles. Specific activities can include:

RI/FS

a. Coring.

b. Performing physical/chemical analyses of core samples.

c. Placing observation wells where cores were taken.

d. Monitoring leachate levels and water quality in observation wells.

e. Locating and analyzing surface seeps.

3. Conduct a bench-scale study examining the leachability of uranium in soil samples taken from selected locations in the PPA, using deionized, ground-, and surface waters. This should either serve to refute or add credence to the "runoff from PPA" transport pathway.

U transport study

4. Supplement characterization of the site including development of a water budget.

a. Establish annual precipitation; establish percent of precipitation resulting in infiltration, runoff, and evaporation.

b. Establish percent contributed by infiltration to volume of runoff flow from the PPA that enters the SSOD from the SSO during a major runoff event; estimate percent

contribution of uranium. (Such percent contributions allow assignment of principal migration routes.)

c. Establish percent contributed by SSOD to volume of flow in PR during a runoff event; establish percent contribution of uranium.

d. Establish percent of flow PR contributes to the groundwater system at the suspected recharge point identified by DM; establish percent contribution of uranium.

e. Establish a flow balance for effluent discharged from the General Sump and directed to CWP 5 and the Clearwell, prior to being sent to the GMR. This will allow assessment of the degree of integrity associated with the buried portions of transfer line, CWP 5, and the Clearwell.

f. Establish a materials balance for wastes disposed of in each of the Waste Pits, and implement ground- and surface water sampling for the presence of other primary source terms in addition to uranium. Based on observed waste inventories, other source terms could include radioisotopes of Pu, Th, Ra, Cs, Sr, Tc, Ru, Np, and H.

g. Continue to collect and analyze ground- and surface water samples for uranium on a routine basis, as well as for indicator parameters such as pH, specific conductivity, and DO. Indicator parameters should be measured in-situ. Samples collected should be spatially comparable.

5. Conduct a chemical characterization of uranium, surface water groundwater, and soil. Specific activities can include:

a. Establishing the uranium behavior in aqueous solutions representative of FMPC groundwater quality.

b. Evaluating processes that limit the concentration of uranium released to groundwater, such as adsorption onto soil surfaces or precipitation from solution.

c. Establishing the maximum uranium concentration that can occur in groundwater.

d. Establishing the percent solubility of U contained in stream sediment.

3.3 Remedial Actions

Specific recommendations for required remedial actions include:

1. Implement remedial actions for active and inactive Flyash Piles.

   a. The active Flyash Pile has no runoff or seepage control, the inactive Flyash Pile has no seepage control. Temporary covers should be placed over the inactive and active Flyash Piles while more permanent stabilization techniques are evaluated. Many easily-applied and effective cover systems are commercially available. Runoff controls such as berms, dikes, or channels should be considered.

   b. Develop and implement a stabilization and closure plan for the inactive Flyash Pile in accordance with applicable DOE, state, and Federal guidelines. Evaluation of needed surface water and groundwater controls should be made. Provisions should be made to cap the cover of the pile with an impermeable barrier.

   c. Develop and implement a stabilization plan for the active Flyash Pile. Evaluation of needed surface water and groundwater controls should be made. Provisions to cover portions added to the pile at the time of disposal should be made in order to mitigate the effects of runoff, percolation, and fugitive emissions.

2 3. Cease waste contributions to Pit 5 and the Clearwell.

CWP 5 is currently being used as part of the liquid waste treatment system while a new liquid waste treatment plant is under construction. The waste pit was used as a settling basin but is now filled to capacity, and serves only as a wide extension in the transfer line. Settling is accomplished in one of the plant's process buildings prior to release of effluent to CWP 5. The Clearwell currently receives flow from CWP 5, and serves as a portion of an NPDES compliance point. Since the integrity of CWP 5, the

Clearwell, and the transfer lines is questionable, it is desirable to cease waste contributions.

a. Assess the feasibility of routing all effluent released from the General Sump directly to the GMR, allowing bypass of CWP 5, the Clearwell, and transfer lines leading to and from these engineered basins.

b. Develop and implement a stabilization and closure plan consistent with DOE Orders 5820.2 and 5480.2, and applicable state and Federal regulations. The stabilization and closure plan can include (1) dewatering of CWP 5; (2) treatment and disposal of liquids; (3) installation of a rain-excluding cover; (4) removal of wet solids by dredging, transport to a fixation facility, and solidification in cement; (5) disposal of solidified (de-listed) sediment sludge at an approved site (Return to CWP 5 is possible); and (6) closure of CWP 5 by filling with destabilized pit walls and fill earth, capping with an impermeable barrier, coverin with topsoil, and seeding with grass.

The Clearwell should also be dewatered, filled, capped and covered in a similar fashion. The NPDES monitoring point should be removed from the existing permit. Those portions of the transport line lying above-ground should be removed or stabilized in-situ by filling with grout.

3. Implement remedial actions in CWP Area.

When a pit was filled with waste, it was covered with earth, lightly compacted, and reseeded with grass. No attempt was made to cap the pits with impermeable barriers. The pits are lined with clay (Pits 1-4) or synthetic membranes (Pits 5-6) and thus have the capacity to fill with infiltrating water and exhibit the "bathtub" effect.

a. Temporary covers should be placed over Waste Pits 1-4 and 6.

b. More permanent stabilization and closure plans should be developed for the pits consistent with DOE Orders

5480.2 and 5820.2, and applicable state and Federal regulations.

c. Evaluation of needed surface water and groundwater controls should be made.

d. Provisions should be made to cap the cover of each pit with an impermeable barrier after any leachate has been removed and properly disposed of.

4. Establish effective groundwater controls in CWP Area.

Effective groundwater controls should be established for the entire CWP Area. A saturated zone exists within the surficial till layer approximately 4 to 9 feet below grade in the CWP Area. In order to effectively stabilize the waste pits, exclusion of this groundwater is necessary. Engineering methods used to control groundwater movement can include (1) slurry trenches, (2) sheet piling cutoff walls, (3) grout curtains, and (4) french drains. Evaluation of the perched groundwater system may reveal that none of these methods are required, since the presence of the system may be due to infiltration of surface water or recharge from the Clearwell. The control method would then entail use of an impermeable surface barrier only.

3.4 Other

Additional recommendations include:

1. Modification of DM's Task A and B Reports (still in draft form) to allow consistency with the Task C Final Report.

2. Evaluation of existing data in order to address whether offsite elevated uranium-levels are a result of present FMPC operations, or are a result of past practices, such as pumping of contaminated water from Well 1s.

3. Assessment of existing FMPC reports and records for data that will assist in accomplishment of recommended actions.

4. Assessment of the integrity of the 13 original wells, and the necessity to close them, if integrity is questionable.

5. Collection and analysis of additional split samples to resolve the differences noted in previous splits.

6. Establishment of the location of DM runoff samples, RO-20 and RO-21.

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REFERENCES

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APPENDIX A. ATTENDEE LIST

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ATTENDEE LIST

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APPENDIX B. QUESTIONS AND ANSWERS

(CM) The Task A1 Report (p. 4-2) and the Task B1 Report (p. 1-1) both identify in order of likelihood, four potential onsite sources for elevated uranium (U) levels in the offsite wells:

- Chemical Waste Pit (CWP) Area.
- Plant Production Area (PPA).
- Sediments in Storm Sewer Outfall Ditch (SSOD) and Paddy's Run (PR).
- Scrap Metal Pile and Flyash Piles.

The Task A2 Report (p. 4-3) modifies and reassigns other orders of importance to these potential sources as well as making the Scrap Metal Piles and Flyash Piles separate sources:

- Sediments and Waters in the SSOD and PR.
- Flyash Piles.
- CWP Area.
- PPA.
- Scrap Metal Pile.

In addition, the Task A2 Report Executive Summary (p. E-1) says only four potential sources have been identified although pages E-2 and E-3 list the five potential sources as they are listed on p. 4-3. These same five potential sources are identified in the Task B2 Report (p. 1-1).

The Task C1 Report (p. 4-2) again reassigns orders of importance to some of the potential sources:

- Sediments and Waters in SSOD and PR.
- CWP Area.
- Flyash Piles.
- PPA.
- Scrap Metal Pile.

I haven't seen any reference made in these drafts with regard to these changes, ie. each draft simply says Dames and Moore (DM) identified five potential sources based on data collected during the Task A work (example: p. 4-2, Task C1). <u>What were these changes based on?</u>

(DM) Preliminary degrees of importance were assigned based on volumes of waste contained at each source location. This was later modified by discussions with National Lead of Ohio (NLO) staff, with regard to potential sources. (This was substantiated by NLO, who indicated that the SSOD input levels of U were very high and needed to be accounted for as a potential source.)

(CM) Text discussion of well drilling by DM has indicated that drilling was to proceed from the potentially cleanest site to the potentially dirtiest site in order to minimize cross-contamination (example: p. 2-4, Task B1).

note: (----) denotes no answer given or answer not recalled by IC.

Table 2-1 (p. 2-3 to 2-5) in Task B2 lists drilling orders for wells to be installed by DM. The order of drilling indicates the sites from cleanest to dirtiest are considered to be:

- PR near Willey Road.
- Flyash Piles.
- PR downstream of CWP Area.
- Area downgradient of PPA.
- Area downgradient of CWP Area.

Since the order of potential importance or degree of potential contamination has been rearranged in several of the Task Reports, what was the final drilling order and was it directly related to the final order of importance assigned to these five potential sources in the Task C1 Report?

(DM) The drilling order was not clearly recalled by DM, nor was the exact number of wells that were installed, but it was agreed that a table listing the drilling orders for all wells installed by DM would be included in the final Task B Report.

(CM) The five potential sources identified in the Task A1 Report were all direct sources. When in later drafts, modification resulted in one source becoming "waters flowing into and U-bearing sediments in PR and the SSOD" (p. 4-2, Task C1), this resulted in consideration of indirect sources. These indirect sources have now become the prime suspects for elevated U levels in offsite wells.

Do you agree that "waters discharged" are indirect sources when compared with the other potential sources identified, in that these waters are not the ultimate source of the U, but rather a transport mechanism?

(DM) General agreement was indicated that the primary sources identified in Task C1 by DM are transport mechanisms.

(CM) Your report indicates general agreement with this in that the Task C1 Report (p. 4-7) has a Section 4.3 entitled "Transport Mechanisms" which states that U-bearing waters generated from sources identified in the previous Section (4.2) are transported via the runoff to PR and SSOD mechanism. The potential sources of U are actually discussed in Section 4.2, "Identification Methodology":

- Surface runoff from PPA (p. 4-4).
- Infiltration of shallow groundwater to SSOD pipe (p. 4-4).
- Runoff from CWP Area (p. 4-5).
- Seeps coming from CWP Area and going to PR (p. 4-5).

These are the real transport mechanisms and sources areas for offsite U contamination, aren't they?

(DM) General agreement is indicated by DM.

(CM) The Executive Summary for Task C1 (p. E-2) states that two sources have been identified as being responsible for the elevated U levels in offsite wells:

- Water flowing into the SSOD via the SSO.
- Water flowing into PR from the CWP Area.

Aren't these actually just transport mechanisms for the direct-sources identified on the next page (p. E-3), and referred to as factors supporting the above two sources as being responsible for the U contamination?

(DM) General indication is that there is a difference in the way DM defines source as opposed to the independent consultant's (IC) definition. DM indicates that they consider transport mechanisms to be sources.

(CM) Can you assign a percent contribution to each of the direct sources? For example, on page E-3 in the Task C1 Report, what is the percent contribution of elevated U levels in runoff water from the CWP Area as opposed to the percent contribution of elevated U levels in water seeping from the CWP Area via a shallow groundwater route?

(DM) DM indicates that their work did not generate any real hard numbers that could be used in comparison of direct sources and their individual degrees of importance.

(CM) My point here is that your ultimate goal is to identify the principal sources of U in the offsite wells. I assume that this is being done in order to enable corrective measures to be applied at those sources in order to mitigate their effects, if in fact present operating practices are continuing to contribute to the contamination. The more specific the source, the more readily applied the corrective measure. How can you apply corrective measures effectively if you can't prioritize the sources?

(DM) DM indicates that their charge was to identify the sources of elevated U levels in offsite wells and to recommend intermediate and long-term actions to remediate the offsite water quality concerns (p. 1-3, Task A2).

They feel that their characterization of the site was adequate in this regard and that they have identified the primary sources:

- Waters discharged to PR and to the SSOD.

(There was general consensus between DM and NLO staff that collection of runoff waters can be effective in mitigating the effects of offsite U contamination. Therefore, the direct sources need not be identified.)

(CM) Aren't you just treating a transport mechanism if your recommended corrective action is collection of runoff water? From an engineering standpoint, good engineering practice (GEP) dictates that the direct sources should be eliminated rather than attempting to treat their

effects. Isn't collection of runoff waters directed at an effect rather than at specific sources?

(DM) DM repeats their observation that they feel their results and recommendations are adequate to fulfill their charge.

(CM) Did you measure the volume of surface water runoff from the site?

(DM) Not directly, no.

(CM) From your reports, I assume that DM placed 23 wells onsite to supplement the 13 used by NLO, in order to assess the effect of each potential source?

(DM) One well was placed offsite at Henry Knollman's farm. Something like 22 wells were placed onsite.

(CM) I have not seen an effective representation of wells that were placed by DM in any of your reports, either in a figure or a table. Can you provide a figure in your final draft which shows the original 13 wells and then a figure showing the wells placed by DM?

(DM) DM indicated that this had already been requested to be included at some previous meeting. These figures will be included by DM in a final draft.

(CM) Can you include a table which identifies old (NLO) wells and new (DM) wells, and associated characteristics such as the sources each monitors, the depth of the well, observed water levels in each well, and the water zone monitored by the well?

(DM) This table can be added, if desired.

(CM) Also, I have difficulty determining what well is being referred to in some instances, since DM has its own classification system, which differs from the classification system used by NLO. Can the drafts be amended to be consistent with NLO terminology or can a table be provided which gives DM and NLO classifications for each well?

(DM) Yes, if desired.

(CM) The Task A2 Report (p. 3-1) says that there are three groundwater systems or zones present at the NLO site. Can you include a figure that shows the relative locations and extents of these systems?

(DM) Yes, if desired.

(CM) The Task B2 Report (p. 2-1) says that the shallow well clusters (denoted "s") will monitor the surficial till layer, while the deeper well clusters (denoted "d") will monitor the upper sand and gravel aquifer. The Task A2 Report says future monitoring efforts will be focused on the surficial till (p. E-2), and defines "s" and "d" as being the surficial till and upper sand and gravel aquifer, respectively (p. 3-13). However, "s" and "d" are defined as being the the upper sand and gravel aquifer and the lower sand and gravel aquifer, respectively, on p. 2-3 of the Task A2 Report. Which definition is correct?

(DM) The original intention was to monitor the surficial till, but DM was unable to successfully locate water in all of the holes made in this layer. Of 7 to 8 wells dug, only 4 contained water. The focus of the investigation was therefore shifted to the upper sand and gravel aquifer. Thus, "s" denotes the upper sand and gravel aquifer, not the surficial till. Inconsistencies will be rectified in final drafts.

(CM) Do all of the old (NLO) wells monitor the shallow and deep sand and gravel aquifer?

(DM) Yes, except for the three production wells.

(CM) How many of the new (DM) wells monitor this same aquifer system?

(DM) All but four.

(CM) Those four wells monitor the surficial till system?

(DM) Yes. Three are in the CWP Area and one is located further south.

(CM) These are the test pit wells in the CWP Area that had the highest onsite levels of U in groundwater found during the one DM sampling? Wells TP-19, TP-21, TP-22?

(DM) Yes.

(CM) I have a bit of confusion with regard to which of the five sources each well monitors. With the exception of the production wells, the old (NLO) wells all monitor the CWP Area. The Task A2 Report (p. 3-12) lists proposed monitoring well locations, and the areas each will monitor. Nine well clusters are given, five of which are to be installed by DM. The Task B2 Report (p. 2-3 to 2-5) lists monitor well locations for 5 well clusters, all of which are to be installed by DM.

How many wells were actually installed by DM and what sources do they monitor? Could this be placed in a table?

(DM) (DM indicates that wells and sources are not readily recalled but that an appropriate table will be added to the final drafts and all inconsistencies will be resolved.)

(CM) How many NLO wells were sampled by DM?

(DM) DM believes that all NLO wells were sampled.

(CM) Section 3.0 of Task B2 Report (p. 3-2 to 3-3) lists groundwater and surface water sampling points and the analytical tests to be performed. I count 13 NLO wells to be sampled and 19 DM wells--that totals to 32 wells. Your Task C1 Report (Table 4-2) indicates that 37 onsite wells and 4 offsite wells were sampled. Which is correct?

(DM) Table 4-2 is correct.

(CM) Can this be made consistent with the Task B2 Report? Can a figure of all wells sampled be included?

(DM) Yes, if desired.

(CM) Table 4-2 also indicates that 21 runoff and 2 surface water samples were taken. The Task B2 Report (p. 3-2 to 3-3) lists 7 surface water monitoring stations. Which is correct?

(DM) Table 4-2 is correct. Inconsistencies will be resolved in the final drafts.

(CM) Also, your key to the types in the table has no explanation for the "SW" symbol, which I assumed to be surface water.

(DM) Okay.

(CM) I think there's a need for a qualitative explanation of what sampling points were used and also a good descriptive table and a legible figure for these, consistent with the Task C1 Results.

(DM) ----

(CM) Also, with regard to analytical parameters--I have only seen results for U. Can you include results for the other parameters in a table along with the U values, and provide a discussion or interpretation of these data?

(DM) ----

(CM) I see you installed lysimeters but I don't see results for them. Why not?

(DM) We didn't install the lysimeters.

(CM) This needs to be explained in a later draft.

(CM) What about results from your seep stations in PR?

(DM) We were unable to collect any water in any of our seep pans.

(CM) What did you conclude from this? That there were no seeps going to PR?

(DM) We concluded that we failed to observe any seeps going to PR from the CWP Area.

(CM) I've been told by some NLO staff responsible for collection of samples from that area that there are many visible seeps.

(DM) We observed no groundwater seeps going directly into PR during the two months we were onsite. We observe that seeps probably do drain into PR, although they were not observed.

(CM) Okay. That needs to be explained in a final draft as well.

(DM) We did observe two surface seeps in the CWP Area. Those are sampling stations RO-6 and RO-9 in Table 4-2 (Task C1). Seep RO-9 comes out of the northwestern corner of Pit 3 and enters a drainage ditch which flows into PR. The second seep, (RO-6) flows into the north side of the Clearwell.

(CM) You have mentioned that a perched groundwater table is present at five to seven feet below grade in the CWP Area. Were any monitoring wells, either old or new, capable of assessing the movement of perched groundwater from the CWP Area towards PR?

(DM) In what sense?

(CM) Flow direction and flow velocity.

(DM) We can measure gradients in the CWP Area using water levels in the three test pit wells. From those levels, the movement of groundwater in that area is to the East. However, it just makes geologic sense to assume that seepage of groundwater (perched) to PR is occurring.

(CM) But there are no wells placed directly between the CWP Area and PR that can deny/confirm this pathway?

(DM) No.

(NLO) (Some NLO comments were made related to the fact that several old wells exist between the CWP Area and PR that have not shown any U contamination.)

(CM) But these old wells don't monitor the correct aquifer--the surficial till. They monitor the sand and gravel aquifer.

(DM) Yes.

(CM) Section 4.2 of the Task C1 Report refers to this as a potential source of above-background U in the offsite wells (p. 4-3). Did you not feel the need to confirm/deny this possibility with monitoring data?

(DM) We have no hard data, although it makes geologic sense for this seepage to be occurring.

(CM) Your Task A2 and B2 Reports state that the major focus of the investigation will be on the surficial till layer (p. E-2, Task A2; p. 2-1, Task B2). This is based on the following:

- All waste units are contained in the surficial till.
- Suspect the groundwater perched in this zone in the CWP Area may seep into PR.
- Suspect hydrologic interconnection between surficial till and the shallow sand and gravel aquifer.

You have also noted visible surface seeps in the CWP Area; you know the perched water is at 5 to 7 feet below grade; you know the lower portions of the pits sit in this perched water; you know from pumping tests that no interconnection of the till and the shallow sand and gravel zone has been indicated.

Was this area characterized well enough to establish where the perched water does go? I know you don't consider this to be a major source of offsite U.

(DM) In what sense?

(CM) Flow direction and flow velocity. Your Task C1 Report (p. 3-5) says no characterization of flow rate was done. What about flow direction?

(DM) We can estimate from test pit well water levels that the direction of flow is East, but we make no conclusion regarding either flow rate or flow direction for groundwater contained in the surficial till.

(CM) Was any investigation of the pit area carried out aside from noting visible surface seeps?

(DM) No.

(CM) You didn't run any electromagnetic conductivity tests? You didn't measure for levels of stagnant water in the pits?

(DM) No.

(CM) Was a water balance done? Do you know what percent of total rainfall in inches/year results in infiltration, what percent results in runoff, and what percent results in evaporation?

(DM) No. A water balance is appropriate for applying corrective measures, but is not necessary for source identification.

(CM) Your Task C1 Report states that the principal method of groundwater recharge at the site is by direct infiltration (p. 5-5). Is this not the pathway by which site groundwater can pick up U contamination as it percolates to the water table?

(DM) Our computer model indicates that U is not being transported offsite by a groundwater pathway. The principal route is by surface water runoff to PR and the SSOD.

(CM) You estimated an infiltration rate for the CWP Area of 1 inch/year, but that was for the shallow sand and gravel aquifer, not for the surficial till. The perched system was not included in the model, was it?

(DM) No.

(CM) Did you assess the volume of water running off to PR or to the SSOD?

(DM) No.

(CM) Can you assess the volume of water being lost by PR to the groundwater, especially at the point where it is thought that the surface water goes underground and travels to the contaminated offsite wells?

(DM) No. This is important for remedial actions, but not for source identification.

(CM) You basically have no way of assessing the effect of the CWP Area on PR since there are no monitoring wells that lie in between the CWP Area and PR that are located in the surficial till, and since there are no historical data from surface water monitoring stations on PR that apply only to the pit area. There are only two monitoring stations for surface water on PR; one is upstream of all NLO sources, the other is downstream of all sources from NLO. Therefore, individual effects of sources such as the CWP, the Flyash Piles, the K-65 Tanks, and the SSOD cannot be readily evaluated.

(NLO) There's a reason for that. The creek is dry at most points during the year.

(CM) Yes. That is an indication that it is going underground and providing or contributing to groundwater contamination. I see no reference made to this hydrologic characteristic in any DM document. I see no reference made to it in any NLO document either.

(DM) References will be made at appropriate locations in the reports.

(CM) The creek could be sampled--it would just take more effort? You'd just have the wait until flow was present.

(NLO) Yes.

(CM) I note that your Task A2 Report (p. 3-16) does not include the CWP Area as a recharge area. Why?

(DM) Because it was contained in the surficial till and because it was clay-capped.

(CM) The CWP Area is not capped. None of the retired pits are covered with anything but fill dirt.

(DM) (General confusion is indicated.) We were told that the waste pits were clay-capped.

(CM) None of the pits are capped, are they?

(NLO) No. Just earth covered.

(CM) The Task C1 Report (p. 6-3) discussed a remedial option of waste pit reconstruction as follows:

> "The completed waste pits are capped with a layer of clay. If the clay caps and liners are effective,

little or no discharge would be expected. However, some seepage from the waste pit area was observed during site work which indicates that the caps are not totally effective in restricting infiltration."

Following this is discussion of reasons for possible failure of the cap. This information is incorrect and should be removed.

(DM) Yes. We were wrong and will change the wording to read "cover" rather than "cap".

(CM) In considering this new information, do you feel more importance should now be placed on the CWPs as sources for U contamination?

(DM) No. We knew they weren't effective anyway, since there were observed surface seeps.

(CM) Do you still feel that the CWP Area is not a recharge area?

(DM) I don't feel as strongly about that now.

(CM) Were any of the old (NLO) wells considered inadequate for reliable and representative groundwater monitoring?

(DM) No.

(CM) Not even when considering that some wells were installed in the 1950's, and may have corroded well screens; may not have been adequately developed; are all open to the atmosphere; have surface-mounted pumps which drip oil into the wells; and have little or no available well history?

(DM) At first I thought some of the wells might not be useful, but when we pumped them, the waters looked clear and good, and the associated pH and specific conductivity levels were similar to our wells. We decided to use them.

(CM) Would you recommend closing of any old wells?

(DM) No.

(CM) I was told by NLO staff that you had made such a recommendation.

(DM) That was true, before we sampled them and found them to be similar in water quality to our wells. We were unable to confirm a bentonite seal in some old wells and were concerned about aquifer contamination.

(CM) Just supposing hypothetically that the perched water system is seasonal—it is present in wet seasons and absent in dry--is it not possible that some wells are placed in such a manner as to be located where a perched system develops in a wet period?

(DM) Yes.

(CM) Then it is possible for old wells to be acting as drainlines for perched water to enter deeper zones?

(DM) Yes.

(CM) Do you feel now, looking back on the project, that there are any potential sources that you didn't consider that you now feel should have been considered?

(DM) Yes, one. The discontinuous sand layer in the till which results in buried stream channels.

(CM) What about leaking lines as a potential source? The SSOD has an observable flow which is continuous even in dry periods. Oak Ridge Associated Universities (ORAU) noted this during their monitoring review. (ORAU 1985) This is probably the result of perched groundwater entering fractures in the discharge line.

(DM) No. We didn't consider this.

(CM) Was this flow sampled for U by DM?

(DM) No.

(NLO) There is a substantial history of U being discharged into the SSOD. The levels are quite high.

(CM) Yes, but the low flow event was not ever sampled in order to determine the U levels in the infiltration waters?

(NLO) The level of U in the discharge stays at about 1 mg/l during dry spells.

(CM) Also, I am curious as to the source of the U levels presented in the Task A2 Report (p. 2-13). Table 2 gives a summary of NLO data for 1981 to 1983. Uranium discharged is given in kg for both depleted and enriched forms. Isn't the depleted form insoluble?

(NLO) No. Not really.

(CM) How is the amount and type of U discharged determined? Is a sample taken at the outfall and analyzed?

(NLO) No. This is an estimate made by our materials inventory staff, based on what has been produced that year. No analyses were done to enable such a distinction between depleted and enriched U discharged to the SSOD at NLO.

(CM) My reason for asking about the solubility is that only 25 to 35% of the total U released over the three year period was enriched. If the depleted portion was insoluble, that would mean only 50 kg of U, not 87, were discharged over that time period.

(NLO) By sampling some years back, we have found the depleted portion to be 80% soluble, on the average.

(CM) I also see that the total flow of water discharged to the SSOD increased significantly in 1982 and 1983. What was the reason for this?

(NLO) It just rained more, that's all.

(CM) Okay. Back to leaking lines. The line that transfers effluent to the SSOD seems to be receiving some infiltration. I suspect most old lines at the plant are cracked and leaking. Isn't it possible that transfer lines from the General Sump to the CWP Area, and from the Clearwell to the outfall at the GMR are leaking?

(NLO) ----

(CM) These lines can either be receiving infiltration from perched groundwater, or they can be losing effluent to the groundwater. Was a flow balance done on this transfer system to determine if any gross difference existed? A large gain or loss?

(NLO) We know what's pumped out at the General Sump and what's coming into the Clearwell.

(CM) Have these values ever been compared?

(NLO) No. We didn't compare them because of the difference that would be introduced by rain falling into CWP 5.

(CM) Rainfall would be negligible and could be easily accounted for by noting the amount of rainfall and the surface area of the pit.

(NLO) ----

(CM) When CWP 3 was retired, how were the transfer lines to the pit closed off?

(NLO) (Question is not understood.)

(CM) I assume the lines were underground--were they grouted up?

(NLO) The transfer line was not put out of service. It was just extended to CWP 5 from the point just prior to where it had entered CWP 3 previously. The line was above-ground at this point.

(CM) Is it underground at some points?

(NLO) Initially, the transfer line for CWP 3 (coming from the General Sump) is above-ground, lying in a concrete trench. This concrete trench extends in a straight line to near the K-65 Tanks. From this area on, the line is underground until just prior to CWP 3.

(CM) How long has this line been underground?

(NLO) Since CWP 3 was installed in 1959.

(CM) So this line has been underground for 26 years and actually lies submerged in groundwater in some places, particularly in the CWP Area?

(NLO) ----

(CM) I think these lines may be potential sources for U contamination of off-site groundwater. In Oak Ridge, the ORNL facility has a problem with leaking lines. The radioactivity levels in the effluent going to the sewage treatment plant are lower than the levels found in the effluent once it reaches the treatment plant. This is due to infiltration of contaminated groundwater via cracks in the transfer lines.

(NLO) ----

(CM) Another potential source that hasn't been considered is the pumping of contaminated groundwater from NLO Well 1s. I have seen the statement that "There are no direct discharges from the Feed Materials Production Center to PR" in the Task A and B Reports (p. 2-14, Task A2).

I understand that Well 1s had a 200 gallon/minute (gpm) pump installed in 1961 and that well was subsequently pumped continuously for long periods of time in order to intercept contaminated groundwater found between the CWP Area and the PP Wells.

Why was this not considered to be a potential source for U in offsite wells?

(DM) We didn't consider it to be substantial. The amounts of U contained in the groundwater pumped were not very high.

(CM) But the groundwater was pumped directly to PR, and had high levels of nitrates (N) and chloride (Cl), indicating possible movement of leachate from one of the pits?

(NLO) The levels of N and Cl lowered to near normal when CWP 3 was closed.

(CM) What were the levels of N and Cl at initially?

(NLO) The levels of N and Cl were at 2500 mg/l at first.

(CM) Yes, and pumping continuously for 3 months at 200 gpm only resulted in a drop to 800 mg/l. Isn't high N associated with high U solubility?

(NLO) Yes, but the level of U in the groundwater pumped was very low.

(CM) I understand that very little U data are available for years prior to 1980 for Well 1s.

(NLO) The U levels were measured at the time of discharge to PR and they were very low.

(CM) I would like to see these data. The way I understand it, a study was done by Dr. Eye from the University of Cincinnati. The study recommended pumping the contaminated groundwater into the waste pits, in order to mitigate the effects of the high N and Cl on groundwater quality. The concern was directed towards prevention of movement of the contaminated groundwater towards the PP Wells. The origin of the contamination was thought to be CWP 3. At any rate, the two reports I have seen that refer to the pumping of Well 1s seem to indicate that pumping was somewhat continuous from 1961 to 1982 (and perhaps beyond 1982). A USGS study (1982) indicates that at that time, the well was being pumped continuously at less than 100 gpm. Over this time period, the discharge went directly to PR.

(NLO) ----

(CM) Isn't it possible, even if the U levels weren't very high in this pumped groundwater, that the excessive N levels (at or above 800 mg/l) would cause accellerated desorption of U contained in stream sediments?

(NLO) ----

(CM) I did some calculations based on the one U value I had for Well 1s, taken from the USGS report, which was very low--8.2 ug/l (refer to Appendix C, p. C-3). If a 180 gpm pumping rate is assumed, and the 8.2 ug/l U value is used, this results in 95 million gallons (MG) of contaminated groundwater being discharged to PR per year, and 3.6 kg of U.

(DM) That's extremely insignificant in light of the amount of U discharged to the SSOD.

(CM) I agree. But this is a terribly conservative value for U in that well, yet it produced 3.6 kg of U in a year. I have seen no data from the 1961 time period for U, associated with the high N and Cl. Assuming the U level at that time was significantly higher, this source could have been a primary contributor then (1961).

(DM) I see your point.

(CM) If this pumping were assumed to be continuous over a 20 year time period, then the result would be 72 kg of U, based on the 8.2 ug/l U level. If levels were in fact, much higher than this, and I believe they were although I have seen no data for this time period, then the result for total U discharged over a 20 year period would be somewhat exponentiated. This discharge follows the pathway you have proposed as being the primary one--simulating storm water discharge into PR.

(DM) ----

(CM) Would this pumping, if it contained significant U levels, not serve to bias data, in terms of simulating the proposed runoff source effect?

(DM) No. Not in terms of the computer model.

(CM) Why not?

(DM) We did not input U data into the model.

(CM) This source corresponds to the 5 to 10 year transport time estimated by the model for movement to the offsite wells.

(NLO) How did you arrive at that conclusion?

(CM) Pumping began in 1962 and U was first noted in the offsite wells in 1974. That's approximately 10 years.

(NLO) The U was first detected in the offsite wells in November of 1981.

(CM) I was under the wrong assumption, then. I was most impressed by the volume of groundwater that may have been discharged to PR in a single year by this route (95 MG), as opposed to 12 and 14 MG from the SSOD in 1982 and 1983. That's substantial. The question is, how much U did the discharge actually contain?

Are any of the drainage ditches onsite severely eroded?

(DM) Do you mean, are any of them eroded down past the surficial till?

(CM) Yes.

(DM) No. The primary area of erosion occurs right at the SSOD pipe discharge. All ditches onsite have vegetation and still contain surficial till.

(CM) So you wouldn't consider a shortened groundwater flow path as a potential pathway for movement of U?

(DM) No.

(CM) I know at the Savannah River Plant (SRP) this was a primary mechanism for movement of tritium out of their low-level waste burial ground. There was severe erosion of a small creek that drained the area, which led to a 20 year shortening of the groundwater flow path to the creek. The creek was rebuilt in order to prevent this mechanism from continuing to affect water quality.

(DM) ----

(CM) Those are all the questions I have that related to the Task A and B Reports. I'm ready to flip through the Task C1 Report, page by page.

----------LUNCH BREAK----------

(CM) Page E-3. I agree with these six observations, but can you present data to use in assessing which of these is most important?

(DM) No. We have no real hard numbers.

(CM) Also, on p. E-3, number 6. I don't agree with that statement. Uranium is being transported off-site by groundwater pathways, they're just not direct pathways. I would like to see that statement changed to read "via direct groundwater pathways".

(DM) ----

(CM) Do you feel enough wells were placed in order to evaluate potential sources? I noticed that some sources, such as the Flyash Pile, only had one well capable of monitoring their contribution to groundwater (if any). What if a plume was missed by this well?

(DM) Some sources did only have one well capable of monitoring their effect on water quality.

(CM) At NLO there are only 33 onsite wells, the majority of which are located in the CWP Area. At SRP, their 76 acre burial ground has 110 or so monitoring wells placed in a grid pattern inside the fenced area.

(DM) What aquifer is monitored?

(CM) Primarily the uppermost. They also placed wells around the perimeter of the facility, and it was only these wells that detected a plume of tritium leaving the burial ground at the southwest corner. If the wells had not been placed closely on a grid pattern, the plume would not have been detected.

(NLO) Were these cluster wells?

(CM) Yes, but each had a slotted screen that extended the length of the particular zone monitored.

(NLO) What about potential contamination of that zone due to the slotted screen?

(CM) That's a misconception. A slotted screen leads to no more contamination than would occur anyway, since it only extends throughout one single aquifer, which is physically continuous anyway.

The only criticism of slotted screens that I'm aware of is that they are not structurally stable and tend to collapse. Their advantage is that they can readily detect the presence of a plume. Then short-screened wells can be placed more precisely in order to get more specific information. The primary criticism of cluster wells with short screen intervals is that they only monitor the shallow and deep zones and may therefore miss any contaminants moving in between those two points.

Don't you think wells placed on a grid pattern would have been more effective?

(DM) In what sense?

(CM) In determining the flow direction and velocity of any contaminant movement.

(DM) Well, if you have lots and lots of money to spend...

(CM) Page E-5. Five actions are listed which would result in a major reduction in the quantity of U being released from the site. How do "expansion of the groundwater monitoring system," and "water supply substitution" result in a reduction of U being released?

(DM) The lawyers have already caught this. It will be changed.

(CM) Were wells placed in every boring made by DM?

(DM) Yes.

(CM) Page 4-1. The text says that Table 4-1 lists onsite wells which contain statistically significant above-background levels of U. When I look at this table, I only see wells that monitor the sand and gravel aquifer included. Why weren't the three test pit wells included? The test pit wells in the CWP Area had the three highest U levels found in groundwater during your one onsite sampling.

(DM) That's right. We need to add those wells to the table.

(CM) The title of the table will have to be altered, too.

(DM) Okay.

(CM) Looking at Table 4-1, I then can count 25 of 33 wells sampled as being significantly above-background. That's 76% of onsite wells that statistically exceed background.

(DM) ----

(CM) Also, in that table, I think you need to note that these U values are the data from EAL.

Page 4-2. Third paragraph. Were the surface waters sampled during a dry period, or during a runoff event?

(DM) During a runoff event.

(CM) The results presented in Table 4-2 (same paragraph)---you don't explain that samples were split with NLO or just how you interpreted the data.

(DM) ----

(CM) Turning to Table 4-2. Again there are values of U given as EAL U concentrations and NLO U concentrations, but no explanation as to what each of these represents. In your interpretation of data, were these two measurements averaged, or did you just use the EAL results?

(DM) I'm not sure. I think we just used EAL results.

(CM) Also, in that table. The qualifier "1" placed after some of the observations indicates a statistically significant difference between EAL and NLO results. What was this significance based on?

(DM) I believe it was based on an order of magnitude difference between the two observations (NLO and EAL).

(CM) That information needs to be added to the key. Also, when I look at the values in Table 4-2, I wonder why MW 18s was not included as being statistically different? Also observations P-1, P-2, and OB-1?

(DM) We seem to have missed those. They will be added.

(CM) That means that 10 of 41, or 24% of the total number of samples that were split between NLO and EAL for U analyses were not found to agree statistically. I have a problem with roughly one quarter of the samples disagreeing, don't you?

(NLO) Yes.

(CM) What do you attribute this difference to?

(DM) We can only assume our (EAL) data are correct, and that there were laboratory errors in the NLO portions of the splits.

(NLO) General disagreement is indicated by NLO staff.

(CM) Table 4-2 also gives iron (Fe) concentrations. Are these results discussed anywhere?

(DM) ----

(CM) When I looked at the results of the split sampling that were given to me by NLO, there were reported values for OD-1 and OD-2. No values are listed for these observations in Table 4-2. Why?

(DM) Did NLO sample those two points?

(NLO) Yes.

(CM) The values are 0.271 and 0.015 mg/l, respectively.

(DM) We will add those.

(CM) On page 4-2, last paragraph. The text states that two sources of above-background U have been identified and that these sources are shown in Figure 4-1.

Just how useful are these hashed areas in terms of representativeness?

(NLO/DM) General disagreement over hashed source areas in Figure 4-1. Result is that the figure will be deleted from the report.

(CM) I tried to locate the runoff sampling stations denoted "RO" in Table 4-2 on the map in Figure 4-2. I was only able to locate RO-1 through RO-18 on the map. These stations were all located in the CWP Area. Where are RO-19 through RO-21 located? Are they in the SSOD Area?

(DM) Two samples were collected in the SSOD. They are denoted as OD-1 and OD-2 in Table 4-2.

(CM) Where are RO-19 through RO-21? Where is the SW-10 split sample denoted in Table 4-2? NLO reported 2.06 mg/l U for this station, a drainage ditch located south of the Clearwell. This was the highest U value noted in any of the splits.

(DM) ----

(CM) A table is needed that includes all the RO sampling locations.

(DM) That can be added, if desired.

(CM) The legend for Figure 4-2 says water from the Clearwell is treated prior to being discharged to GMR. This is not correct.

(DM) It will be changed.

(CM) I took the average of the CWP RO values in Table 4-2 and compared it to the average of the SSOD OD values. The CWP Area average was 6.12 mg/l as compared to the SSOD average of 0.15 mg/l. How can you conclude from this that the SSOD is the primary source of U offsite?

(DM) Did you take the arithmetic average?

(CM) Yes.

(DM) The data are geometrically distributed. The comparison should be based on a geometric mean.

(CM) Okay.

(DM) You can't directly compare the values for the CWP seeps where U is at 34, 28, 24, and 12 mg/l to values in the SSOD. The CWP Area values are from water that is just sitting. The SSOD values are from water that is flowing.

(CM) Are you saying that these data are not a representative single population?

(DM) No.

(CM) Then you should be able to compare them directly to one another.

(DM) ----

(CM) On page 4-3, you list six factors that substantiate the two identified sources of U. The first one is elevated U levels in runoff water from the PPA which flows into the SSOD. Did you base this on previous data? You only sampled two points on this ditch and those values are 0.300 mg/l (OD-1) and 0.008 mg/l (OD-2). If so, where are these old data presented/discussed in your text?

(DM) Table 4.5.

(CM) What is the percent solubility of this U?

(NLO) It is assumed to be 100%.

(CM) You compare these values to those for PR in Table 4-4, after the flow from the SSOD has entered PR, in order to assess the importance of PR as compared to the SSOD as a source?

(DM) Yes.

(CM) But you don't know the flow rates associated with either?

(DM) No.

(CM) I think you need to present data for these six factors in tabular form, and data for suppositions, in general.

(DM) ----

(CM) This is also true for the statement on p. 4-4 that average concentration of runoff from the CWP Area is an order of magnitude lower than that reported in the offsite wells. The maximum U value reported for the offsite wells was 0.578 mg/l (p. 1-2, Task C1). I don't know what average value you're referring to for the offsite wells. I got an average value (arithmetic) of 6.2 mg/l for the runoff in the CWP Area. The average for the SSOD was 0.15 mg/l. I don't see where you get an average for the CWP Area as being an order of magnitude lower than that for the offsite wells. There are no historical NLO data that measure direct runoff from the CWP Area.

(DM) The data for the runoff from the CWP area are given in Table 4-3.

(CM) You say in the text on page 4-4 that maximum U values for the CWP Area runoff range from 0.052 to 1.8 mg/l. I don't see either of these values in that table.

(DM) Yes. The lawyers have already pointed out that out.

(CM) I object to the use of the term "drainage lines" in that table. To me, that connotates an actual transfer pipe, whereas this is simply referring to an uncontrolled runoff.

(DM) ----

(CM) You give two values for U in that table; the basin concentrations, which are the same as those in Table 4-2; and the concentrations at the discharge points. Where are the discharge points and how were those particular values arrived at?

(DM) That is shown in Figure 4-3.

(CM) But it hasn't been referred to in the text yet, so no reader has been introduced to the terms "A, B, C," or "D". That needs to be corrected.

(DM) Okay.

(CM) Also, on p. 4-4, first paragraph in section 4.2.1. The text says sample points for the SSOD and the CWP Area are shown in Figure 4-2. The SSOD sampling points are not shown in that figure.

(DM) Okay.

(CM) On p. 4-5, first paragraph. You basically conclude that the SSOD is the principal U source. This is based on only two U values. The one which was taken in the SSOD closest to its confluence with PR was 0.008 mg/l. When you examine data from the CWP Area from Table 4-3, the levels of U in PR range from 0.03 to 0.048 mg/l. They are higher than the value for the SSOD.

(DM) You're not considering dilution in PR.

(CM) You're right. But I don't think there are enough data to substantiate the actual importance assigned either mechanism.

(DM) ----

(CM) Page 4-5, section 4.2.3. The text refers to water from the Clearwell as receiving treatment prior to discharge. This is incorrect.

(DM) Okay.

(CMO The last sentence in that paragraph makes no sense. The 0.006 and 1.8 mg/l values are not to be found in Table 4-4.

(DM) The lawyers caught this.

(CM) Also, I can't see where you got an average of 1.6 mg/l for waters draining to the CWP Area.

(DM) ----

(CM) Again, on p. 4-6, treatment of water from the Clearwell is referred to.

(DM) This will be corrected.

(CM) The first paragraph in Section 4.2.5. Shouldn't Table 4-3 be Table 4-4, and the year 1975, not 1979?

(DM) Yes. That's been corrected by the lawyers.

(CM) I also object to the statement on p. 4-6 that U is not being carried offsite via a groundwater pathway. I would prefer that the word "direct" be placed before groundwater, in order for that the read as an accurate statement.

(DM) ----

(CM) Page 4-7, last paragraph. You state that the U levels in the offsite wells were caused by releases in the mid-1970's, based on calculated flow times. Is it not possible that the U levels in these wells were first noted in 1981 not because they had actually increased at that time, but because the monitoring program was not extensive enough to detect the U prior to 1981?

(DM) ----

(CM) Let's talk about the computer modeling. Section 5, p. 5-2. You say documentation of the code is available from DM. Can I get a copy of a document that describes the model?

(DM) Yes. I believe we have one that's not proprietary.

(CM) Can you include the actual differential equations--the partials--used in the text?

(DM) Yes, if desired.

(CM) What were the input parameters for the model?

(DM) Hydraulic conductivity, effective porosity, elevation of the base of the aquifer, infiltration rate, and boundary elevations.

(CM) How many of these parameters were values assumed for, rather than determined by actual testing?

(DM) We had actual data for hydraulic conductivity in the areas where we drilled, which were mostly in the CWP Area. The rest of the grid values for hydraulic conductivity were assumed.

(CM) Effective porosity?

(DM) Those values were all assumed. That's a parameter that no standard test exists for, so its literally impossible to determine.

(CM) Then why is it used?

(DM) Modelers wish it wasn't. Most empirical hydrologic equations use it, however.

(CM) Yes, I know. I had the same problem in determining grouting rates and pressures because they were all based on soil porosity.

What about infiltration rate?

(DM) Those values were all assumed. The elevations of the aquifer base were estimated too, but we had good information to base those on.

(CM) So all of the input parameters to your model, except for hydraulic conductivity in the area DM drilled, were estimated?

(DM) Yes. We used the USGS potentiometric surface map to base our assumptions on. The question exists--is the map itself correct? That's an unanswered question. I do feel there's an anomaly in the data at the Delta Steel Well. A potentiometric high exists there...I personally feel that if another well was drilled there, a perched table would be found.

(CM) Do you feel any lack of confidence in the results of your model since it was mainly based on estimates?

(DM) No. None at all.

(CM) Can you provide a table in your final draft which shows the actual values that were input into the model at each grid point?

(DM) Yes. That's provided in Figure 5-2.

(CM) That figure is hard to read and only gives material types.

(DM) Yes. It needs work.

(CM) Which input parameter was the model most sensitive to?

(DM) Small variations in hydraulic conductivity produced significant changes in the model's results.

(CM) Hydraulic conductivity was assumed in the area of the offsite wells?

(DM) Yes.

(CM) Can you assess the percent contribution of each variable to the model's results?

(DM) I'd say 60 to 80% is due to hydraulic conductivity and 10% to effective porosity. They're the major variables.

(CM) The model also assumed that there were no geochemical processes occurring although the fact that no above-background levels of U have been detected in wells near Fernald indicates otherwise?

(DM) Yes.

(CM) Page 6.1, "Remedial Action Alternatives". The first scenario offered is "Continued Monitoring". This should be done, regardless. Shouldn't this really be called a no action scenario?

(DM) Yes. This section has been rearranged quite a bit. Some options have been combined.

(CM) Page 6-3, "Waste Pit Reconstruction Scenario". Why is this an option if the CWP releases are not considered to be major sources of U offsite?

(DM) ----

(CM) Also, this scenario is not appropriate since the waste pits are not capped.

(DM) Yes. That will be changed.

(CM) Section 6.4, p. 6-5, "Runoff Control Option". You propose to collect and store runoff for the whole site? Do you have any idea of the volume of runoff you're talking about?

(DM) No.

(CM) How do you propose to treat this water? Just let it evaporate?

(DOE) Just pipe it to the GMR and release it.

This was said in jest!

(NLO) That provides for sufficient dilution.

(CM) I thought dilution wasn't the solution to pollution anymore?

(NLO) We won't store the water. It will be released to the GMR.

(CM) Page 7-1, "Action Recommendations". You suggest regrading the CWP Area, although again you don't consider it to be a major source of U. The regrading would serve to divert all runoff from the CWP Area to the Clearwell. What is the volume capacity of the Clearwell?

(DM) ----

(NLO) I think its 1 MG.

(CM) Well, I made some calculations and got about 0.5 MG. I also calculated water runoff from very light rainfall in the CWP Area (refer to p. C-3, Appendix C). The result was 600,000 gallons of runoff in a 30 minute time period. If the Clearwell was totally empty, which it isn't, its about two-thirds full, the holding capacity would be exceeded.

(DM) Okay.

(CM) I don't think you should provide remedial actions without first determining their feasibility.

(DM) ----

(HLO) Page 7-4. I don't think measuring the chemical properties of the U should be listed here. That's something that should have been done a long time ago.

(HLO/CM) (Discussion of how and why U should be characterized--determination of source terms.)

APPENDIX C. CALCULATIONS

TABLE C-1

CALCULATION OF GEOMETRIC MEANS (G.M.Y) FOR SELECTED DATA FROM TABLE 4-2, TASK C-1 REPORT

The Geometric mean can be computed using:

$$G.M.Y. = \text{antilog } {}^{1}/_{n} \text{ E log Y}$$

or

$$G.M.Y. = \sqrt[n]{Y_1 Y_2 Y_3 \ldots Y_n}$$

1. G.M.Y. for runoff samples Ro-1 through Ro-18 for the CWP area.

Value
.03
12
.007
28
24
4.6
.31
34
3
3.6
.83
.34
.54
.48
.71
.62
11
.53

$Y_1 Y_2 Y_3 \ldots Y_n = 166.5$

$n = 18$

$G.M.Y. = \sqrt[18]{166.6} = \boxed{1.33 \text{ mg/l U}}$

2. G.M.Y. for samples from the SSOD, OD-1 and OD-2.

Value
.300
.008

$Y_1 Y_2 = 0.0024$

$n = 2$

$G.M.Y. = \sqrt[2]{0.0024} = \boxed{1.49 \text{ mg/l U}}$

3. G.M.Y. for drainage points* on PR, Ro-20 and Ro-21.

Value
1.6
2.4

$Y_1 Y_2 = 3.84$

$n = 2$

$G.M.Y. = \sqrt[2]{3.84} = \boxed{1.96 \text{ mg/l U}}$

CONCLUSION: Paddy's run is a more significant contributor of U than the SSOD, 1.96 mg/l U vs. 0.049 mg/l U.

* Assumed to be PR drainage points.

TABLE C-2

CALCULATION OF VOLUME OF RUNOFF WATER FROM THE CWP AREA

Using the Rational Method for surface storm runoff,

$Q = CIA$

Where Q = Runoff, ft^3/sec

I = Average Rainfall intensity for the period of maximum rainfall of a given frequency of occurrence having a duration equal to the time required for the entire drainage area to contribute flow, in/hr.

C = Runoff co-efficient based on surface type.

A = Acres drained

Assumptions: Volume of clearwell (Vcw) = 750,000 gallons.

Clearwell contains 495,000 gallons as a result of continuous flow from the general sump.

Available clearwell capacity for retention of storm runoff (Vcc) = 255,000 gallons.

Time for concentration of runoff (tc) = 18 minutes.

A moderate rainfall event occurs, resulting in a I = 4 in/hr, based on tc = 18 minutes, a 5 year storm frequency, and a 30 minute duration.

C = 0.80 (runoff = 80%)

Calculations: Acres drained (A)

$1{,}920{,}000\ ft^2/43{,}560\ ft^2/acre = 44.1$ acres

Runoff volume (Q)

$Q = (0.80)\ (4)\ (44.1) = 141.1$ cfs

Total runoff to clearwell (Vro)

$$\begin{aligned} Vro &= (141\ ft^3/sec)\ (60 Sec/min)\ (30\ min) \\ &= (253{,}800\ ft^3)\ (7.481\ gal/ft^3) \\ &= (1{,}898{,}678\ gallons)\ (MG/1{,}000{,}000\ gallons) \\ &= 1.90\ MG \end{aligned}$$

Comparison with available clearwell capacity (Vcc)

$$\begin{aligned} Vcc - Vro &= 255{,}000\ gallon - 1{,}898{,}678\ gallons \\ &= -1{,}643{,}678\ gallons \end{aligned}$$

Conclusion: Clearwell capacity exceeded by 1,643,678 gallons.

TABLE C-2 (Continued)

Recalculate, using Lower I = 1 in/hr

Q = 35.3 cfs
Vro = 475,073 gallons

Compare with available clearwell capacity

Vcc - Vro = (255,000 - 475,073) gallons
= -220,073 gallons

Conclusion: Clearwell capacity exceeded by 220,073 gallons.

Decision: Clearwell is not capable of holding any amount of rainfall runoff from the CWP area, under current operating conditions.

TABLE C-3

CALCULATION OF VOLUME OF GROUNDWATER DISCHARGED FROM WELL 1s

$$V\ \text{Discharged (gal)} = \text{Pump rate (gpm)} \left(\frac{60\ \text{min}}{\text{hr}}\right) \left(\frac{24\ \text{hr}}{\text{day}}\right) \left(\frac{365\ \text{day}}{\text{yr}}\right)$$

Assumed: Pump rate capacity = 200 gpm
Well 1s pumped at 90% of capacity
Well pumped continuously for 1 year

$$\text{Discharged} = (200\ \text{gpm})\ (0.9) \left(\frac{60\ \text{min}}{\text{hr}}\right) \left(\frac{24\ \text{hr}}{\text{day}}\right) \left(\frac{365\ \text{day}}{\text{yr}}\right) \left(\frac{\text{MG}}{10^6\ \text{gal}}\right)$$

$$= \boxed{94.6\ \text{MG/year}}$$

$$U\ \text{Discharged} = U\ (\text{mg/l})\ (V\ \text{Discharged})_{\text{MG}} \left(\frac{8.34\ \text{lb}}{\text{gal}}\right) \left(\frac{0.454\ \text{kg}}{\text{lb}}\right)$$

[U concentration assumed to be 0.04 mg/l (1962 value)]

$$U\ \text{Discharged} = (0.04)\ (94.6)\ (8.34)\ (0.454) = \boxed{14.3\ \text{kg}}$$