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OHIO EPA'S CONSULTANT'S REVIEW AND COMMENTS ON DOE'S "HYDROGEOLOGIC STUDY OF THE FMPC DISCHARGE TO THE GREAT MIAMI RIVER"

05/10/88

OEPA DOE-FMPC
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COMMENTS

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OhioEPA
State of Ohio Environmental Protection Agency
Southwest District Office
7 East Fourth Street
Dayton, Ohio 45402-2086
(513) 449-6357

Toward A Cleaner Environment
15 Year Anniversary 1972 - 1987

Richard F. Celeste
Governor

May 10, 1988

Mr. James Reafsnyder
Site Manager
DOE-FMPC
P.O. Box 398705
Cincinnati, OH 45239

Dear Mr. Reafsnyder:

Ohio EPA's consultant, Geotrans, Inc., has reviewed DOE's "Hydrogeologic Study of the FMPC Discharge to the Great Miami river". A copy of this review and comments are attached. I would suggest that we meet at the June technical information exchange to discuss issues that need to be addressed. Some issues can be addressed by the August 1, 1988 deadline in the Director's Findings and Orders and some issues may require additional study and may need to be incorporated into the RI report.

If you have any questions about these comments, please contact me.

Sincerely,

Graham E. Mitchell
Unit Supervisor
Division of Water Quality Management and Assessment

GEM/lal

cc: Catherine A. McCord, USEPA-Region V
Jack Van Kley, Ohio Attorney General's Office

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Review of DOE's "Hydrogeologic Study of FMPC Discharge to the Great Miami River"

Prepared for:
Mr. Graham Mitchell
Ohio Environmental Protection Agency
7 East Fourth Street
Dayton, Ohio 45402

Prepared by:
GeoTrans, Inc.
250 Exchange Place, Suite A
Herndon, VA 22070

May 2, 1988

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Environmental Protection Agency
SOUTHWEST DISTRICT

Introduction

GeoTrans has reviewed the "Hydrogeologic Study of FMPC Discharge to the Great Miami River" submitted by DOE to OEPA in fulfillment of Order 14B of the Director's Orders and Findings. The requirements of Order 14B are as follows.

> "The study shall determine whether the discharge from the [FMPC effluent sewer] pipe is located within the zone of influence of the production well field operated by the Southwest Ohio Water Company or any other major production well field. If at any time during the study it is determined that the outfall is located within the zone of influence, the Ohio EPA shall be notified that an investigation shall be initiated to examine the need to and the feasibility of relocating the outfall to a location outside the zone of influence. The report of the investigation shall evaluate the alternatives for relocation and contain schedules for the design and implementation of the alternative should the study establish the need to relocate the outfall. The report shall recommend an alternative to be implemented."

Based on an review of available water-level and chemical (uranium) distribution data and surface water and groundwater modeling results, DOE concludes that: (1) both the FMPC facility and the portion of the river into which sewer flow from FMPC discharges are probably within the capture zone of SOWC production wells (Figures 1, 2, and 3); (2) the increase in uranium concentration of groundwater pumped from the SOWC wells due to FMPC discharges is minor; (3) there is no significant adverse environmental impact, therefore, and (4) remediation is not warranted. DOE also notes that additional studies being conducted during the ongoing remedial investigation at FMPC will facilitate a refinement of their zone-of-influence analyses.

In general, we agree with the findings presented by DOE. Available data do not demonstrate a need to relocate the FMPC effluent sewer line. Data being collected during the ongoing remedial investigation will permit a more detailed and conclusive review of this issue. Specific review comments are provided below.

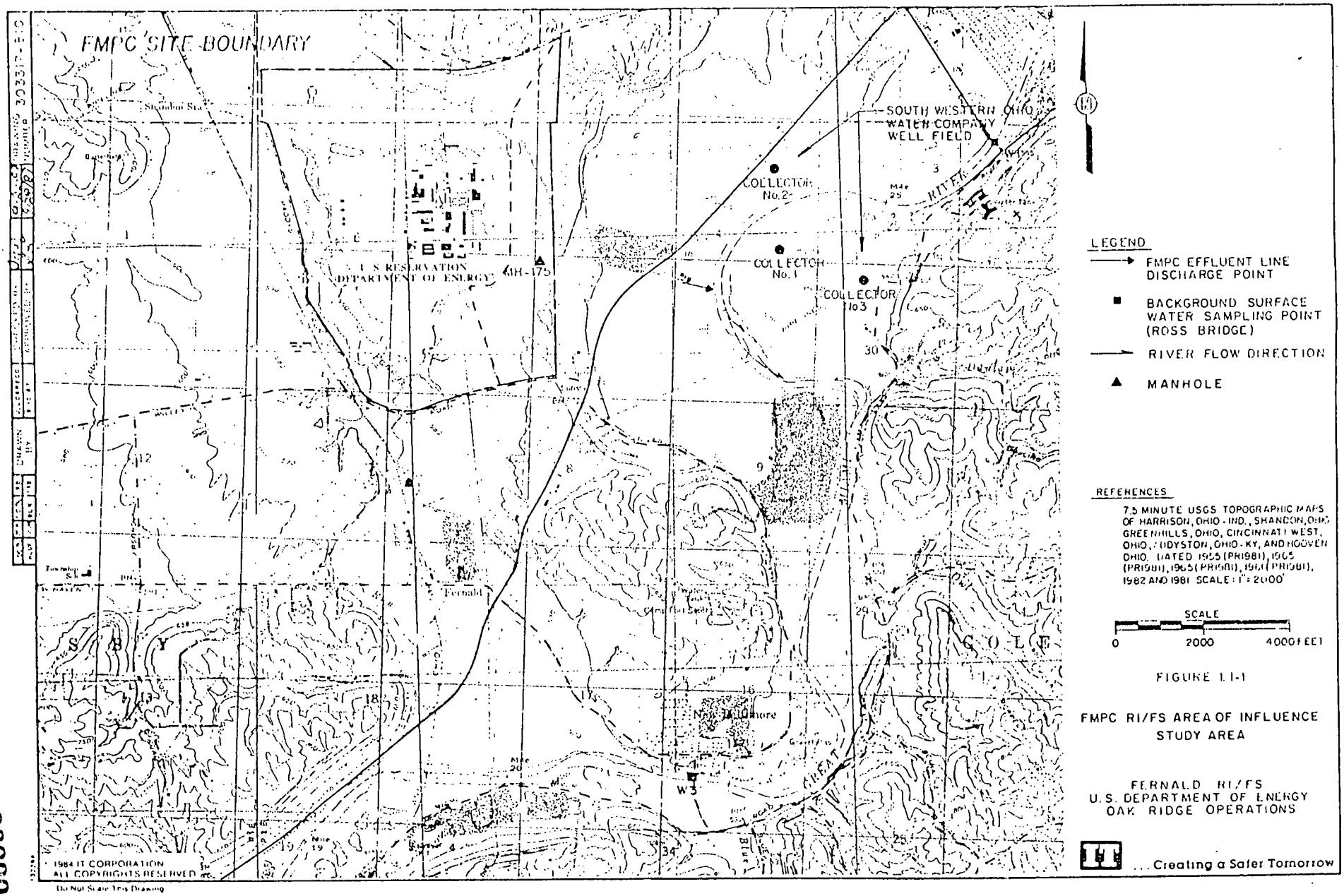

Figure 1. Locations of SOWC collector wells and FMPC effluent discharge line.

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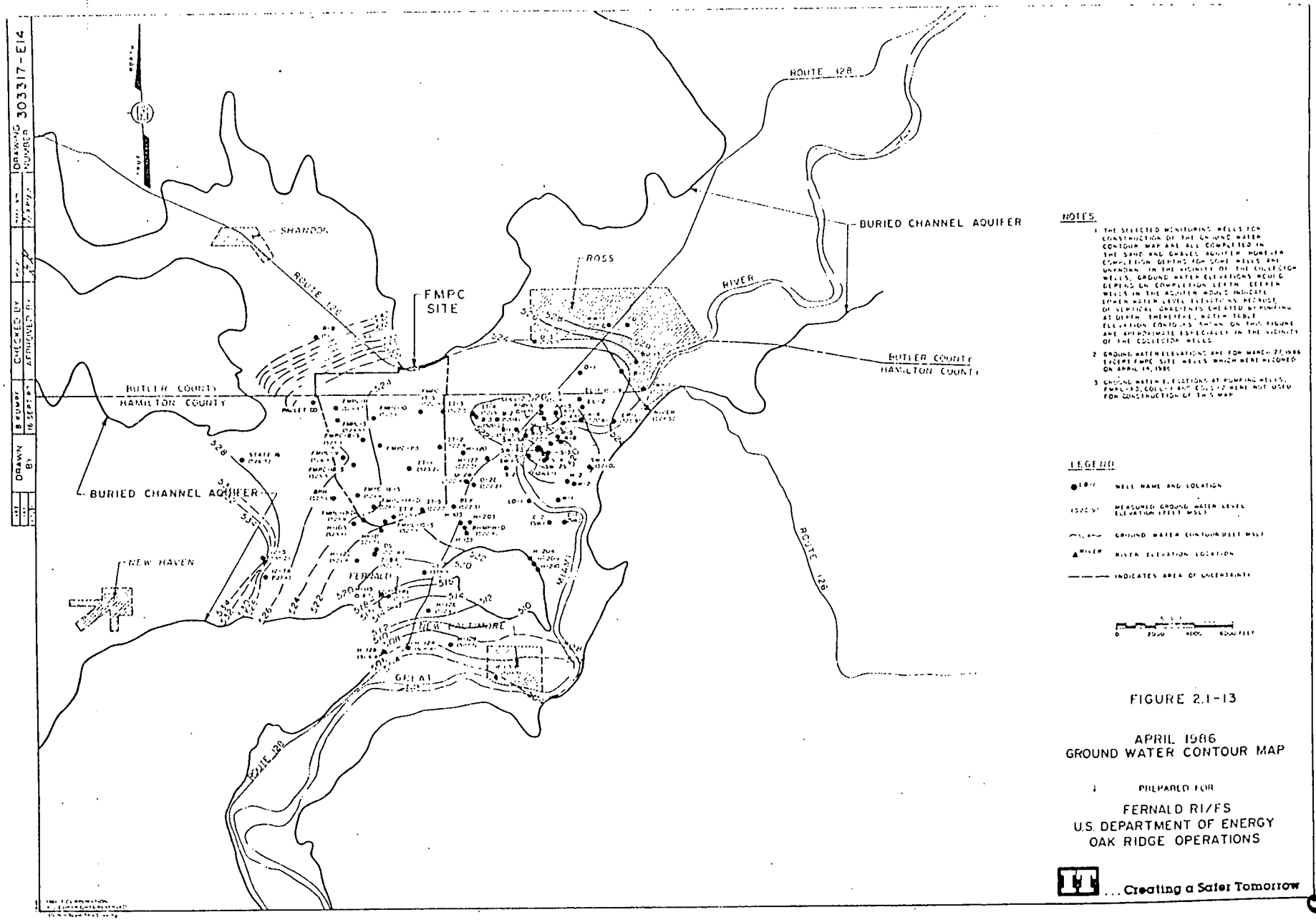

Figure 2. Typical water table contour map showing drawdown cones associated with the SOWC well field.

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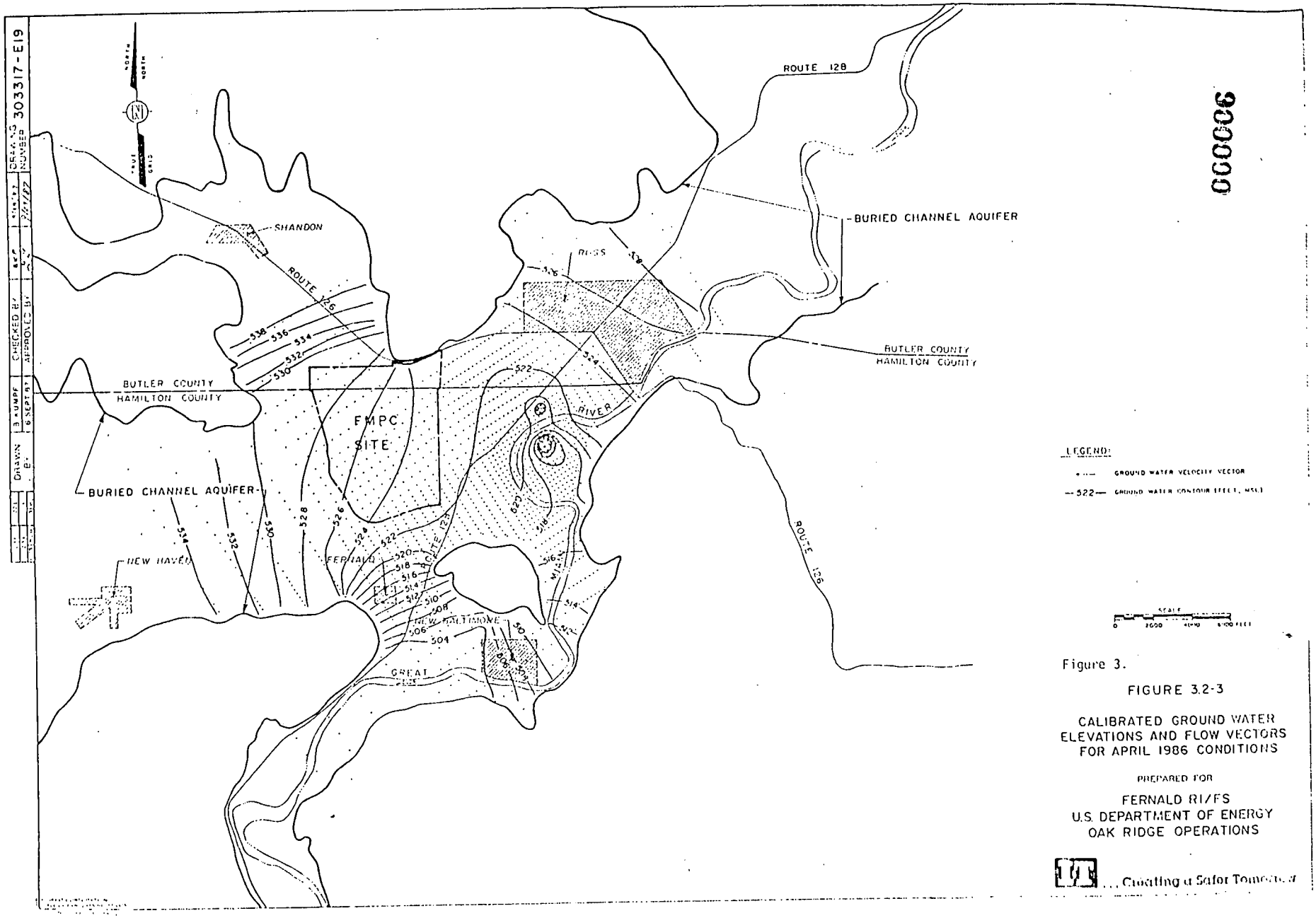

Figure 3.

FIGURE 3.2-3

CALIBRATED GROUND WATER ELEVATIONS AND FLOW VECTORS FOR APRIL 1986 CONDITIONS

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Comments

1. The zone-of-influence (capture zone) of the SOWC production wells in the Big Bend well field along the Great Miami River is well-defined by water-level measurement surveys made on a monthly basis between April 1986 and August 1987. Groundwater flow directions determined from these surveys consistently demonstrate that most of the FMPC facility is within the capture zone of the SOWC wells (Figure 2).

2. Groundwater modeling by DOE also indicates that groundwater beneath most of the FMPC facility is captured by SOWC's Big Bend well field (Figure 3).

3. Water-level measurements and groundwater modeling (Figures 2 and 3) show that the FMPC main effluent line to the Great Miami River which discharges within the 180-degree "Big Bend" is within the SOWC well field capture zone. DOE's conclusion (p.4-1) that "the FMPC [sewer] discharge could actually be outside the capture zone of the SOWC wells if the river infiltration is greater than assumed" is contradicted by the water-level data.

4. DOE combines groundwater modeling and simple mixing calculations to assess the increase in uranium concentration in groundwater pumped at the well field due FMPC discharges. A description of the steps involved with their approach and related comments are given below.

(a) Using observed flow rate and uranium concentration data from an upgradient river station at the Ross Bridge and the effluent sewer pipe, the uranium concentration in the river downgradient from the FMPC effluent discharge is calculated using a complete-mix model as

$$C_r = (Q_p C_{eff} + Q_r C_{back}) / (Q_p + Q_r) \qquad (1)$$

where C_r = Uranium concentration downgradient from the outfall
Q_p = Rate of effluent discharge from the outfall

Q_r = Flow rate in the Great Miami River at the outfall
C_{eff} = Uranium concentration in the sewer effluent, and
C_{back} = Uranium concentration in river water that is upgradient from the outfall.

The range and mean value of these parameters based on measurements and interpretations are shown below.

Table 1. Range and Mean of Complete-Mix Model Input.

Parameter	Low	Mean	High	Basis
C_{eff} (pCi/L)	?	450	?	Weekly measurements in 1986
C_{back} (pCi/L)	0.81	1.2	3.0	Weekly measurements in 1986
Q_p (cfs)	0.31	0.78	1.7	1986 continuous measurement
Q_r (cfs)	267	3,543	108,000	55 year record

The range of uranium concentration in the FMPC sewer effluent is not documented by DOE in the subject report or their "Environmental Monitoring Annual Report for 1986". Therefore, it is only possible to evaluate C_r based on average C_{eff}. This is significant because temporal increases in uranium concentration in the SOWC wells will result from temporal increases in C_{eff} and C_r. In 1985, the value of C_{eff} ranged from 352 pCi/L to 1334 pCi/L around a mean of 663 pCi/L (ORAU, 1985). A proportional C_{eff} range for 1986 would be 239 pCi/L to 905 pCi/L.

Using equation (1), the average value of C_r is 1.3 pCi/L. In evaluating the range of impacts on C_r, DOE assumes that low flows in the sewer pipe do not occur during high flows in the river and vice versa, based on the storm water runoff contribution to sewer effluent. While apparently logical, this assumption should be checked by comparing available sewer flow, river flow, and uranium concentration

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data. The range of C_r values and percent increases in river water uranium concentration impact due to FMPC effluent discharge as calculated by DOE and by making more extreme bounding assumptions are given below.

Table 2. Calculation of C_r Using Several Bounding Assumptions.

Case	in CFS		U in pCi/L		
	Q_r	Q_p	C_{back}	C_{eff}	Calculated C_r
DOE Low (a)	3,534.	0.31	1.2	450.	1.24 (3.3% rise)
DOE Low (b)	108,000.	0.78	1.2	450.	1.203(.25% rise)
DOE Max (a)	3,534.	1.7	1.2	450.	1.42 (18% rise)
DOE Max (b)	267.	0.78	1.2	450.	2.50 (108% rise)
Min Impact	108,000.	0.31	3.0	239.	3.000 (No rise)
Min C_r	108,000.	0.31	0.81	239.	0.811 (.1% rise)
Max C_r & Impact	267.	1.7	0.81	905.	6.53 (706% rise)

River water sampling stations upgradient and downgradient of the FMPC effluent discharge outfall are shown in Figure 4. The range and mean dissolved uranium concentrations in river water based on weekly analyses in 1986 are provided in Table 3. These data show that the U concentration in river water sampled at station W3, approximately 5 km downstream from the sewer outfall, ranged from 0.81 to 2.4 pCi/L, with a mean value, 1.4 pCi/L, that exceeds the value of C_r calculated by DOE. Although the data suggests that the uranium concentration in river water within the SOWC Big Bend well field capture zone could not have exceeded 2.4 pCi/L in 1986, sorption and precipitation probably reduce the mean uranium concentration in river water between the FMPC effluent sewer discharge pipe and station W3.

DOE maintains a constant C_r value of 1.3 pCi/L when assessing impacts of the FMPC sewer discharge on uranium concentration in groundwater pumped by SOWC wells. The effect of varying this parameter on calculated impacts to the SOWC wells is discussed later.

The most accurate way to determine the uranium source term for the groundwater model is to measure uranium in that portion of the river in the SOWC zone-of-influence. Samples of river water downgradient from

Table 3. (from Westinghouse, 1987).

TABLE 13: *Radionuclides in Surface Water, 1986*
page 1 of 2

Radionuclide	Sampling Point[1]	Number of Samples[2]	Concentration[3] pCi/l Minimum	Maximum	Average		95% C.L.[4]	% of Standard[5]	Standard pCi/l[6]
Gross Alpha[7]	W1	52	1	5	3	(0.09)	0.3	8	30
	W3	52	1	5	3	(0.1)	0.3	9	
	W4	52	1	8	3	(0.1)	0.3	9	
	W5	52	1	9	2	(0.07)	0.3	0.6	
	W7	24	1.9	639	33	(1.4)	53	128	
	W8	28	2.2	93	11	(0.40)	6.5	36	
	W9	42	0.81	15	2.8	(0.10)	0.81	9.4	
	W10	40	0.81	82	11	(0.40)	5.7	36	
	W11	32	3.5	416	23	(0.83)	26	75	
Gross Beta[7]	W1	52	3	10	5	(0.2)	0.3	18	30
	W3	52	3.2	14	5.8	(0.21)	0.54	19	
	W4	52	0.81	55	6.6	(0.24)	1.9	22	
	W5	52	2.4	16	5.1	(0.19)	0.54	1.7	
	W7	24	7.6	144	27	(0.98)	13	89	
	W8	28	4.6	68	26	(0.95)	6.5	86	
	W9	42	0.54	12	4.7	(0.18)	0.81	16	
	W10	40	0.81	38	7.7	(0.29)	2.4	26	
	W11	32	4.0	164	13	(0.46)	10	42	
Cs-137	W1	2	<5	<10.0	<8	(<0.3)	NA	<0.3	3000
	W3	2	<5	<8	<7	(<0.2)	NA	<0.2	
	W4	2	<8	<8	<8	(<0.3)	NA	<0.3	
Ra-226	W1	12	<0.5	<0.5	<0.5	(<0.02)	NA[8]	<0.5	100
	W3	12	<0.5	<0.5	<0.5	(<0.02)	NA	<0.5	
	W4	12	<0.5	<0.5	<0.5	(<0.02)	NA	<0.5	
	W5	6	<0.5	<0.5	<0.5	(<0.02)	NA	<0.5	
	W7	10	<0.5	<0.8	<0.5	(<0.02)	NA	<0.5	
	W8	2	<0.5	<0.5	<0.5	(<0.02)	NA	<0.5	
Ra-228	W1	12	<0.5	<0.8	<0.5	(<0.02)	NA	<0.5	100
	W3	12	<0.5	<1	<0.6	(<0.02)	NA	<0.6	
	W4	12	<0.5	<0.8	<0.5	(<0.02)	NA	<0.5	
	W5	6	<0.5	<1	<0.6	(<0.02)	NA	<0.6	
	W7	10	<0.5	<1	<0.7	(<0.03)	NA	<0.7	
	W8	2	<0.5	<0.5	<0.5	(<0.02)	NA	<0.5	
Sr-90	W1	2	<1.1	<1.4	<1.3	(<0.050)	NA	<0.13	1000
	W3	2	1.6	1.9	1.7	(0.060)	0.81	0.17	
	W4	2	2.2	2.4	2.3	(0.080)	0.54	0.23	

TABLE 13: *Radionuclides in Surface Water, 1986*
page 2 of 2

Radionuclide	Sampling Point[1]	Number of Samples[2]	Concentration[3] pCi/l Minimum	Maximum	Average		95% C.L.[4]	% of Standard[5]	Standard pCi/l[6]
Tc-99	W1	2	2	5	3	(0.1)	0.4	0.003	100,000
	W3	2	5	7	6	(0.2)	0.5	0.006	
	W4	2	5	6	6	(0.2)	0.1	0.006	
U-234	W1	2	0.81	0.81	0.74	(0.030)	0.020	0.15	500
	W3	2	0.81	0.81	0.83	(0.030)	0.010	0.17	
	W4	2	0.81	1.1	0.88	(0.030)	0.020	0.18	
U-235	W1	2	0.030	0.030	0.030	(0.0010)	0.00040	0.005	600
	W3	2	0.030	0.030	0.040	(0.0010)	0.000030	0.007	
	W4	2	0.030	0.030	0.040	(0.0010)	0.0010	0.007	
U-236	W1	2	0.0050	0.0050	0.0060	(0.00020)	0.00010	0.001	500
	W3	2	0.0080	0.0080	0.0090	(0.00030)	0.00020	0.002	
	W4	2	0.011	0.027	0.012	(0.00050)	0.0010	0.002	
U-238	W1	2	0.81	0.81	0.75	(0.030)	0.0050	0.13	600
	W3	2	0.81	1.1	0.90	(0.030)	0.010	0.15	
	W4	2	0.81	1.1	1.9	(0.020)	0.040	0.16	
Uranium	W1	52	0.81	3.0	1.2	(0.05)	0.0030	0.030	550
	W3	52	0.81	2.4	1.4	(0.05)	0.0040	0.25	
	W4	52	0.81	4.6	1.4	(0.05)	0.0060	0.26	
	W5	52	0.54	6.8	1.1	(0.04)	0.0090	0.19	
	W7	24	0.54	718	49	(1.8)	2.3	8.8	
	W8	28	1.4	112	9.5	(0.35)	0.29	1.7	
	W9	42	0.81	5.4	1.8	(0.070)	0.010	0.33	
	W10	40	1.1	126	11	(0.42)	0.26	2.0	
	W11	32	5.4	589	29	(1.1)	1.4	5.2	

1. See Figure 19.
2. Samples are composited for radium analyses as follows: one-month composites of daily samples from W1 and W3; one-month composites of weekly samples from W4 two-month composites of weekly samples from W5 and one-month composites of all available weekly samples from W7. Semiannual composites were used for those isotopes where two samples are noted.
3. Bq/l in parentheses.
4. C.L. = Average ± the value shown; = $t(\alpha = 0.05, df)\ S\bar{x}$.
5. Percent of guideline relates to the average value reported.
6. As stated in DOE Memo from W.A. Vaughan, August 5, 1985, to Joe LaGrone.
7. Gross alpha and Gross beta activity values contain activity of uranium and radium in the samples, thus are highly conservative.
8. NA = Not Applicable.

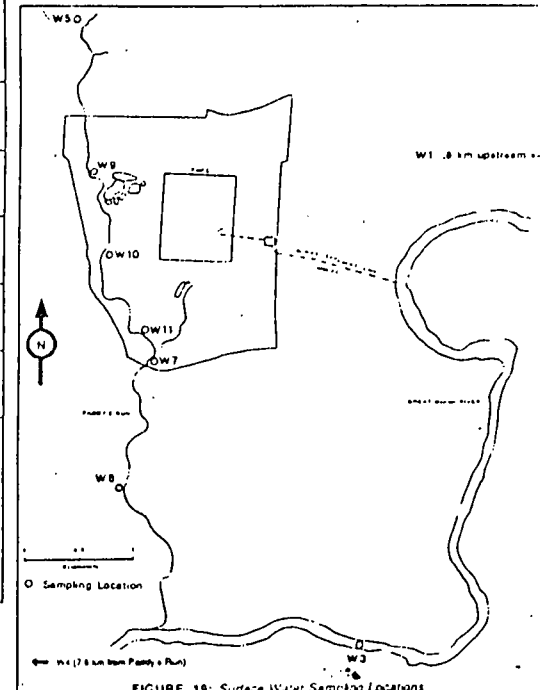

FIGURE 19: *Surface Water Sampling Locations*

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the discharge pipe were taken for analysis as part of this study. Unfortunately, chemical analyses were not complete when the report was prepared. The final assessment of FMPC effluent discharge impacts on the Big Bend well field should rely on actual field data rather than model estimates.

(b) DOE applied a hydrodynamic dispersion model, STRIP1B, to evaluate the appropriateness of using a complete-mix model to determine C_r. Deficiencies of the dispersion model application include: (1) failure to conduct a sensitivity analysis; (2) failure to perform a history match; and (3) incorrect calculation of the transverse hydrodynamic dispersion coefficient by using river depth instead of width (the appropriate value of D_z should have been 31 ft^2/s instead of 0.5 ft^2/s. Although STRIP1B is said to have been verified against another porous media model (p.3-9), what verification has been performed against other surface water models?

Modeling results suggest that complete mixing of FMPC effluent and river water will occur one mile downstream from the discharge pipe, a distance beyond the calculated capture zone of the Big Bend well field. Field observations document conditions which will inhibit complete mixing within the well field capture zone. DOE (p.5-10) reports that "the FMPC outfall may not mix extensively with river water immediately in the vicinity of the source" due to "the presence of an eddy pool immediately downstream from the outfall" on the western side of the river and a gravel bar that "splits the channel into two distinct channels during periods of low flow". The concentration of uranium, therefore, is probably higher in the portion of the river that is on the outside of the Big Bend than that on the inside. Given data constraints and groundwater modeling considerations, DOE decided, nevertheless, to assume complete mixing and a C_r of 1.3 pCi/L for its well field impact assessment.

While we consider this assumption to be justified in lieu of field data at the time of the study, its effect may be to underestimate the increase in uranium due to induced river leakage at the western SOWC collector well and to overestimate the increase at the eastern SOWC collector well.

It is not clear why DOE did not conduct tracer (dye) experiments, rather than modeling, to evaluate dispersion of the FMPC sewer effluent. Tracer experiments conducted under a variety of river stage conditions will better define dispersion at this site than modeling. Additionally, it may be possible to use tracer experiments to measure the rates of induced river leakage and flow to the SOWC collector wells.

(c) Steady-state areal (2-D) groundwater flow modeling was conducted to quantify the sources of water pumped by the SOWC collector wells in the Big Bend well field. Solute transport was not modeled. Rather, results of the groundwater model, the complete-mix river model, and groundwater uranium data were input to simple mixing calculations.

The areal flow model was calibrated by matching simulated and observed hydraulic heads in the study area. Based on the groundwater modeling, DOE estimates that induced river leakage accounts for 76% of the 18.44 MGD groundwater withdrawn at the Big Bend well field. Similarly, based on a limited sensitivity analysis, DOE estimates that the portion of groundwater pumped from the well field that is derived from induced river leakage must range between 72% and 82%.

It may be possible to expand this range if a more extensive sensitivity analysis is performed with the groundwater model. For example, by increasing aquifer transmissivity and recharge rate values, it may be possible to reasonably simulate the observed hydraulic head distribution with a reduced river leakage rate. Conversely, by lowering the aquifer transmissivity and recharge rate, it may be necessary to increase the river leakage rate to adequately match observed hydraulic heads. DOE did not vary aquifer transmissivity and recharge values input in the seven simulations in their sensitivity analysis. This may result in underestimation of the range of uncertainty associated with mixing calculations used to evaluate impacts of uranium in groundwater and sewer discharge from FMPC on SOWC water quality.

DOE (p.3-26) reports that "results of the calibrated model show that only six percent of the total river contribution [to the SOWC collector wells] comes from the river segments downstream from the

[FMPC effluent sewer] discharge point" due "the strong regional gradient south of the collector wells [that] is sufficient to maintain a net southern velocity component." Based on these results, an assessment was made of the uranium increase in pumped groundwater due to induced leakage of FMPC effluent mixed with river water using the input given in Table 4. This uranium concentration increase is calculated as 0.0456 × (1.3 pCi/L - 1.2 pCi/L) = 0.0046 pCi/L (pp.3-27), which is approximately 2% of the estimated background groundwater concentration.

Table 4. DOE Input to Assess Uranium Increase at the SOWC Well Field.

Component to SOWC Well Field	% Flow	U Concentration pCi/L
Induced River Leakage Downriver of Discharge Pipe, Q_d	4.56	1.3
Upriver Induced Leakage, Q_u	71.44	1.2
Groundwater contribution, Q_{gw}	24.00	0.233

Calculated uranium concentrations in groundwater pumped from the SOWC wells (C_w) using a greater range of input values for C_r, Q_d, and Q_u are given in Table 5. As shown, using Q_d and C_r values that are five times greater than the best estimates of DOE increases the value

Table 5. Calculated C_w Using a Greater Range of Parameter Estimates.

Component	Case: #1	#2	#3	#4	#5	#6	#7	#8	#9
Q_d	4.56	4.56	4.56	1.11	1.11	1.11	22.80	22.80	22.80
C_r	1.30	2.50	6.53	1.30	2.50	6.53	1.30	2.50	6.53
Q_u	71.44	71.44	71.44	74.89	74.89	74.89	53.20	53.20	53.20
C_{back}	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Q_{gw}	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
C_{gw}	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
C_w	0.972	1.03	1.22	0.969	0.982	1.02	0.991	1.26	2.18

of C_w from 0.97 to 2.18. The National Academy of Science has proposed a drinking water standard of 35 ppb (23.5 pCi/L) for uranium and USEPA is considering an even higher standard. This sensitivity analysis indicates that it is highly improbable that uranium discharged through the FMPC effluent sewer into the Great Miami River could increase groundwater concentrations at the SOWC collector wells to the proposed standard. Determination of the effect of FMPC effluent discharge into the river on uranium concentrations in groundwater at the Big Bend well field is best made by: (1) sampling and analysis of uranium concentrations in C_r, C_{back}, C_{gw}, and C_w; and (2) better determination of the rate of induced river leakage in the vicinity of the SOWC wells by field measurements (i.e. slug tests as recommended, possibly tracer tests, etc.).

5. Table 3.2.5 gives the appearence that DOE used a transient, three-dimensional model to evaluate the sources of groundwater flowing to the SOWC wells. Why are values for porosity and storage coefficient (used in transient simulations) and K_v (used in layered simulations) included in the table?

6. The main significance of conducting sensitivity analyses with the groundwater model for this application is to determine how the volume of water derived from the difference sources (upgradient groundwater, upgradient and downgradient river water) will change with changing parameter estimates. This result is not given in Table 3.2.6.

7. It is unclear why Figure 3.2-2, titled "Conceptual Design for 'Zone-of-Influence' Groundwater Model" depicts a layered flow domain when only a depth-averaged flow model was used?

8. DOE (p.3-26) reports that the calibrated model indicates that 76% of the water pumped at the Big Bend well field is derived from induced river leakage and that only 6% of the river leakage occurs downgradient of the FMPC effluent sewer discharge. How was this quantitation made?

9. DOE (p.4-4) proposes "that a direct field determination of the leakage factor be completed as part of the sitewide RI/FS." What is the status of this proposal?

10. Although Order 14b mandates determination of the impacts of the FMPC effluent discharge on the SOWC Big Bend well field and other major production well fields, no zone-of-influence assessment was made for the Albright and Wilson withdrawal.

11. Assessment of this and other FMPC issues will be facilitated if we can access (or, preferably, obtain diskette copies) of DOE's environmental data bases (including chemistry, geology, water-levels, well construction, etc.) and groundwater modeling input data set. What arrangements can be made to obtain this information?

References

"Hydrogeologic Study of FMPC Discharge to the Great Miami River", Report dated 10/1/87.

ORAU, 1985, "Environmental Program Review of the Feed Materials Production Center, Fernald, Ohio", Final Report.

Westinghouse Materials Company of Ohio, 1987, "Feed Materials Production Center Environmental Monitoring Annual Report for 1986", USDOE Oak Ridge Operations Contract DE-AC05-86OR21600.