August 23, 1995

PDR per. C. Pollard

Mr. Murray Wade
Oak Ridge National Laboratory
P.O. Box 2008, MS 6206
Oak Ridge, TN 37831-6206

SUBJECT: COMMENTS ON DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES DATED AUGUST 11, 1995, AND FORWARDING OF NRC SOURCE TERM AND CONCEPTUALIZATION DESCRIPTION FOR THE SHIELDALLOY METALLURGICAL CORPORATION, CAMBRIDGE, OHIO SITE

Attached are three documents related to your preparation of the draft Environmental Impact Statement for the Shieldalloy Cambridge, Ohio facility. Enclosure 1 contains our comments on the "Description of Proposed Action and Alternatives" dated August 11, 1995. These comments were faxed to you on August 21. The other documents in Enclosures 2 and 3 are descriptions of the source term and site conceptualization prepared by Mark Thaggard of our staff. This document was faxed to you on August 17, 1995.

For the DOPAA, the schedule called for NRC acceptance of the DOPAA on August 22, 1995. NRC cannot accept the DOPAA until these comments are addressed and appropriate revisions made. As we have recently discussed, we expect to work with you in the next week resolving these comments as quickly as possible.

If you have any questions concerning these documents, please call me at (301)-415-6668.

Sincerely, /S
James E. Kennedy, Senior Project Manager
Low-Level Waste and Regulatory Issues Section
Low-Level Waste and Decommissioning Projects Branch
Division of Waste Management
Office of Nuclear Material Safety and Safeguards

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Enclosure 1

COMMENTS ON REVISED DRAFT
DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES
DATED AUGUST 11, 1995 FOR
SHIELDALLOY METALLURGICAL CORPORATION
CAMBRIDGE, OHIO
ENVIRONMENTAL IMPACT STATEMENT

INTRODUCTION

The U.S. Nuclear Regulatory Commission staff is developing an environmental impact statement (EIS) to evaluate decommissioning alternatives for two slag piles at the Shieldalloy Metallurgical Corporation (SMC) facility in Cambridge, Ohio. These slag piles contain radioactive waste from previous licensed operations and they may also contain hazardous materials. In support of this effort, the Oak Ridge National Laboratory (ORNL) prepared a draft description of proposed action and alternatives (DOPAA) for the EIS, dated June 10, 1995. This draft DOPAA was based, in part, on a preliminary draft Feasibility Study (FS) prepared for the Ohio Environmental Protection Agency (OEPA). A completed draft FS was submitted on June 29, 1995. NRC staff had no written comments on the draft DOPAA. A revised draft DOPAA was submitted to NRC on August 11, 1995. NRC staff comments on this outline follow. All references that follow to the draft FS refer to Volume IV.

A. GENERAL COMMENTS

1. The revised draft Description of Proposed Action and Alternatives (DOPAA) appears to be based, in part, on the preliminary draft FS of April 1995 rather than the draft FS of June 1995. ORNL should verify that the information in the DOPAA is consistent with the draft FS of June 1995. Most of the specific comments which follow can be resolved by using information from the draft FS.

2. The discussions of radiation exposures should be deleted from Section 2. These impacts, along will all other environmental impacts, will be discussed in Section 4.

3. The notes in Sections 2.1, 2.2, and 2.3 concerning PAWG should be deleted. These assumptions will be stated in Section 4.

B. SPECIFIC COMMENTS

1. In Section 2.1, the DOPAA states that it is assumed that there are no chemically hazardous wastes in either pile. Shieldalloy has submitted information that states that there are chemically hazardous wastes, although it is not clear at this point how much will be released from the piles into the environment. This discrepancy will be discussed with you in a conference call. Even if this statement is true, it is characterization information that should be addressed elsewhere in the EIS.

2. In Section 2.1, the volume of soil for the East Pile cap is incorrect based

on the draft FS. According to the draft FS, the correct volume is 12,300 yd^3. This correction will require a corresponding correction to the number of truck loads of material required.

3. Section 2.1 states that the edges of the capped piles will extend 65 feet beyond the current boundaries. The basis for this conclusion is not clear given the cap widths shown in Figures 5 & 6.

4. The cost estimates stated in Section 2.1 are incorrect based on the draft FS.

5. Figure 6 of the DOPAA is not consistent with Figure 4-5 of the draft FS. The soil transition layer has been omitted from Figure 6.

6. The information on the volume of cap material in the second paragraph of Section 2.3 is incorrect based on the draft FS. According to the draft FS, 39,500 yd^3 of combined material will be required for the cap. This compares to 26,900 yd^3 for the onsite-slag-only alternative. The net increase in capping materials is 12,600 yd^3. When added to the off site slag, the increased pile volume is 22,600 yd^3. These corrections will require a corresponding correction to the number of truck loads of material required.

7. Given that the total area of the West Slag Pile without off site slag is 11.4 acres and the estimated area needed for the additional slag is 1.7 acres, the total area for the West Slag Pile with off site slag (14 acres) appears to be incorrect. ORNL should correct or clarify this area estimate.

8. Based on Figure 5-1 of the draft FS, the incremental cost of off site slag alternative appears to be $0.9 M rather the $1M as stated in Section 2.3

9. Section 2.3 should include the reasons for selecting the West Slag Pile over the East Slag Pile for disposal of the off site slag.

10. The activity concentration limits stated in Section 2.4 for natural uranium and natural thorium are correct.

11. The weight of slag in the East Slag Pile, stated in Section 2.4, is incorrect. According to the draft FS, the correct weight is 58,405 tons.

12. Section 2.4 should be expanded to include additional relevant information provided in Sections 4.1.4 and 4.2.3 of the draft FS.

<u>West Slag Pile</u>

- Possible construction of additional railroad spur.
- Additional 500 linear feet of gravel road.
- Phased removal of pile.
- Crushing of the slag.
- Capacity of dump truck.
- Use of small locomotive.
- Topsoil used for restoration.
- Time required (15 rail cars/day,, 5 months/year, 4 years).

East Slag Pile

- Topsoil used for restoration.
- Time required (5 months).

13. Based on the draft FS, the costs stated in Section 2.4 should be $48M for the East Slag Pile and $257M for the West Slag Pile.

14. Figure 8 does not appear to be consistent with Figure 4-6 of the draft FS for the placement of the wetland soil. Figure 4-6 should be revised accordingly or the source of the figure should be validated.

15. In response to the questions on page 17, SMC is examining the feasibility of using the slag in the East Pile as a possible fluxing agent in steel production similar to the planned use of the Newfield slag. However, it is our understanding that supporting analyses have not been completed and are not anticipated to be completed in the near term.

16. The estimated area required for soil and sediment disposal stated in Section 2.5 (75,000 ft^2) appears to be incorrect. Section 4.3.4 of the draft FS states that the estimated disposal area for the wetland soils, alone, is 139,800 ft^2. The estimate in the DOPAA should be corrected or clarified.

17. Given the capping material estimates in Section 4.3.4 in the draft FS, it is not clear how ORNL arrived at the estimates in Section 2.5 of the DOPAA. For example, the DOPAA estimates that 18,400 yd^3 of clay will be required for the entire pile. However, the draft FS estimates that 16,100 yd^3 of clay are required for the wetlands soil area of the pile. A similar apparent discrepancy exists for the amount of silty sand. These estimates should be corrected or clarified.

18. The draft FS estimates the footprint of the West Slag Pile (without added materials) to be 358,800 ft^2. The draft FS estimates that the wetland soil disposal area would be 139,800 ft^2. Therefore, the estimated footprint in Section 2.5 of the DOPAA appears to be incorrect.

19. The reasons for including in Section 2.5 information concerning increased vanadium concentrations and SPLP-extractable metals is not clear. Such information is characterization information which should be addressed elsewhere in the EIS.

20. Given that no other information on the East Slag Pile is included in Section 2.5, the reason for including the cost associated with onsite disposal of the East Slag Pile is not clear. This discussion should be clarified or deleted.

21. Given the cost information in Figures 5-1 through 5-5 and Appendix C of the draft FS, the cost for the alternative discussed in Section 2.5 of the DOPAA appears to be incorrect. The basis for the DOPAA cost estimate should be provided.

22. The source of Figures 10 and 11 should be provided because they are not in the draft FS.

23. The basis for determining the capping material estimates included in Section 2.6 should be provided.

23. The paragraph at the top of page 24 should be deleted. It repeats the listing on page 21.

24. Given that no other information on the East Slag Pile is included in Section 2.6, the reason for including the cost associated with onsite disposal of the East Slag Pile is not clear. This discussion should be clarified or deleted.

25. Given the cost information in Figures 5-1 through 5-5 and Appendix C of the draft FS, the cost for the alternative discussed in Section 2.6 of the DOPAA appears to be incorrect. The basis for the DOPAA cost estimate should be provided.

26. ORNL has consistently questioned the adequacy of the rationale supplied by SMC for not including a detailed analysis of the alternatives addressed in Sections 2.7.1 and 2.7.3 of the DOPAA. Therefore, the reason for the abbreviated discussions in these section is unclear. These sections should be expanded to include all relevant information supplied in response to our requests for additional information and the relevant information contained in Appendix A of the draft FS. Alternatively, the discussion should be expanded to include a more complete summary basis for eliminating these alternatives from further study, and reference made to submittals provided by Shieldalloy that contain the complete background and basis for these eliminating these alternatives.

27. Page 5, Line 6; replace "with treated and" with "and treated with a".

28. For the paragraph on offsite slag, the following insert is provided: "In the early 1980's, Foote Mineral distributed slag as clean fill material for construction uses in the Guernsey County area. Subsequent studies have demonstrated that radionuclide concentrations in some of this slag exceeds NRC's generic release criteria for unrestricted use. It is estimated that approximately 7600 m^3 (10,000 yd^3) of this slag would be returned to the Cambridge facility for decommissioning. Studies for dose assessment and site specific release criteria for this slag are now in progress."

29. Our guesstimate for the worker dose is that each worker would receive less than 50 mrem and the total dose would be less than "24 workers x 50 mrem", or 1.2 person-rem.

30. Section 2.5, Line 7; 0.15m = 0.5 ft, not 1.5 ft.

31. SMC may be able to sell the East Slag Pile for the aluminum content of the slag - that is the benefit.

32. Page 20, Delete first sentence regarding the cost of East Slag Pile disposal. Same for last paragraph of Section 2.6.

33. Section 2.5: what is the decommissioning soil, is that the baghouse dust/soil material used to cap the West Pile?

34. Page 24, line 3; what is 'the key'?

35. Section 2.7.3 - SMC is pursuing sale of the East Slag Pile.

36. Section 2.4 discusses the offsite disposal of the radioactive waste to the Envirocare disposal facility. Because Ohio is responsible under the Low-Level Radioactive Waste Policy Amendments Act of 1985 to provide for disposal capacity for their generators' waste, we suggest adding some language that addresses that responsibility. The following material is provided by us to be added to this section of the DOPAA:

    "Under the provisions of the Low-Level Radioactive Waste Policy Amendments Act of 1985, the State of Ohio is responsible for providing disposal capacity for their generators. Ohio is the host State for the Midwest Compact and is in the process of developing a program for a new disposal facility that is currently planned to go into operation in 2005. The costs for disposal are likely to be well in excess of those at Envirocare, because it will be designed for conventional LLW from generators such as universities and nuclear power reactors, not low specific activity such as is found in the slag at the Shieldalloy site. Thus, Envirocare is considered to be the only viable and realistic offsite disposal option for the Shieldalloy slag piles, considering both the delayed availbility of the Ohio disposal facility and the expected costs for disposal there."

37. Section 1.2, last paragraph, last sentence should read, "...in this environmental impact statement (EIS) will be ~~used~~ **considered** by the Commission..."

38. Section 1.3, Background, fourth paragraph. Has Shieldalloy been decommissioning the site since 1988, or just the slag piles?

39. The May 1994 Summary Report for the Scoping Process, Section 3.2.2, references an Envirocare estimate of approximately \$50 million, rather than the nearly \$300 million in the FS. This lower figure also corresponds generally with the staff's understanding of the costs for disposal at Envirocare.

Source Term

Background

The rate that contaminants are released from an area of contamination is commonly called the source term. The source term is generally a key factor in the assessment of possible consequences to humans and the environment. This is because the rate that contaminants are released into the environment greatly effects their resulting concentrations at points where they may have negative effects. Estimating release rates of contaminants requires knowing their concentrations at the source area and mechanisms for their release from the source material. The purpose of this report is to describe the source term that will be used in assessing the long-term effects from releases of contaminants into the environment, at the Shieldalloy-Cambridge, Ohio site (the Site).

Two principal media through which contaminants are likely to be transported through the environment are air and water. These are the primary transport media that will be considered in assessing impacts associated with the remediation alternatives, for the Site.

The potential chemicals of concern identified for the Shieidalloy-Cambridge, Ohio site are:

> arsenic, barium, beryllium, chromium, copper, lead, selenium, silver, vanadium, zinc, thorium-232 + progenies, uranium-235 + progenies, and uranium-238 + progenies.

Radionuclides

Inventory of Radionuclides

Radionuclides of concern are from the three decay series: thorium-232, uranium-235, and uranium-238. Average concentrations of these radionuclides within the two piles are taken to be a weighted average from samples representing the different types of materials within the piles. Nine distinct materials have been identified as contaminated with radionuclides, including seven different slag types. Concentrations of three parent radionuclides and all of their progenies have been measured or estimated for samples representing each of the nine different materials. A weighted average concentration is determined based upon the weight percent of each material to the total weight within each pile. The radioactivity within the Chemfix® material is essentially the same as background and therefore can be omitted; however, the Chemfix® has only minimal

~~Attachment~~ 2
Enclosure

effect on estimating the weighted average concentrations.
The estimated weighted average concentration of radionuclides within each pile is listed in Table 1.

Release rate of radionuclides into air

The release of radionuclides into the air can occur through either release of gases or particulates from the piles. Based upon the three decay series of concern, the only gases likely to be released are radon (Rn-222) and thoron (Rn-220). Field measurements have shown that radon concentrations are at background levels; therefore, radon is not an immediate problem. Long-term release of radon and thoron, from the piles can be estimated based upon the following functional relationship from Regulatory Guide 3.64 (NRC, 1989):

$$J = 10^4 \cdot R \cdot \rho \cdot E \cdot (\sqrt{\lambda D}) \cdot \tanh(x \sqrt{\frac{\lambda}{D}}) \qquad (1)$$

Where:

J = flux from the slag ($pCi \cdot m^{-2} \cdot s^{-1}$)
R = concentration (pCi/g)
ρ = slag density (g/cm^3)
E = emanation coefficient (dimensionless)
λ = activity decay constant (s^{-1})
D = diffusion coefficient ($cm^2 \cdot s^{-1}$)
x = thickness of the pile (cm)

The long-term activity concentration of radon can be estimated by multiplying the initial radon concentration by a factor 16.7; this is the expected factor of ingrowth of radon during 1000 years from its progenitors (i.e., uranium-238, uranium-234, thorium-230, and radium-226). The long-term activity concentration of thoron (i.e., radon-220) can be assumed to be equal to the concentration of thorium-232. Based upon current concentrations of radionuclides within the piles, these progenitors will most likely control the radon concentration. A diffusion coefficient of 7.5×10^{-5} $cm^2 \cdot s^{-1}$ and an emanation coefficient of 0.01 can be assumed. These numbers were derived by calibrating the RESRAD computer code (Yu et al., 1993) with measured diffusion rates from slag and background soil samples (Kelly, 1995). The emanation coefficient for slag material has been estimated to be an order of magnitude lower than the value being used here; therefore, the 0.01 value may be considered conservative, in terms of over-estimating releases (United Nations, 1988). The slag is believed to have a bulk density close to 2.65 g/cm^3, based upon the estimated tonnage and volume of materials within the two piles. Using these assumed parameters and the weighted average concentrations of thorium-230 and thorium-232 within the piles, the long-term

estimated flux of radon and thoron is presented in Table 2. These estimated release rates are based upon a situation of the piles being either fully or partially uncovered (e.g., the "no-action" alternatives). The alternatives for in-situ stabilization of waste within the West Pile, include having a multi-layered cover with a clay barrier to inhibit water from reaching the waste. It is expected that while this clay barrier is functioning as designed, releases of radon will be nominal. For alternatives involving in-situ stabilization, the proposed cover for the East Pile does not include a low-permeability barrier; therefore, releases of radon for this alternative should be similar to the "no-action" alternative.

Release of particulates when the piles are covered (i.e., for the alternatives involving in-situ stabilization) is expected to be negligible. For the case of when the piles are partially or completely uncovered (i.e., for the "no-action" alternative), the estimated release concentrations of contaminated particulates can be made through the following relationship (Kozak et al., 1990):

$$C_a = C_m \cdot C_p \tag{2}$$

Where:

C_a = Concentration of radionuclides in the air (pCi/m^3)
C_m = Concentration of radionuclides in the soils (pCi/g)
C_p = Concentration of particulates in the air (g/m^3)

Measured values of C_p for the United States range between 9E-06 to 7.9E-5 g/m^3 (Kozak et al., 1990). Using the upper value, an upper-end estimate of particulate concentrations are provided in Table 3. These estimates are considered conservative because most of the contaminated material, on the site, is largely sand size (i.e., 0.5 to 2.0 mm) or larger. The average wind speed in the region is 8.4 mph; this speed is generally only sufficient for lifting very small particles (i.e., < 1 mm) [Hasserlriis, 1984].

Conservative calculations have been also made which show that slightly over 9 m^3 of radioactive particulates are needed to give someone immediately down-gradient from the West Pile, a dose of 1 mrem/year. This translates into an erosion rate of 0.005% per year. The weathering rate of corundum, which is a hard rock, high in aluminum, is less than 1E-10% per year. If the slag weathers at a comparable rate, it is very unlikely that the slag would release a large enough volume of particulates to be of much concern. Since the bulk (by weight and volume) of the radiologically contaminated material is the slag, particulate transport should not be of much concern from a radiological standpoint.

Release rate of radionuclides into water

Estimates of the rate of release of radionuclides into water can be made by assuming equilibrium partitioning between the radionuclides within water flowing through the pile and radionuclides on the solid material; this is represented by the distribution coefficient (K_d). Implicit in the assumption of equilibrium partitioning is the assumption that the radionuclides are on the solid surface. For the slag material, which is again the bulk of the material contaminated with radionuclides, this assumption should greatly overestimate the release rate. Radionuclides within the slag are tightly bound as part of the slag matrix; therefore, their releases are expected to be either through diffusion through the outer rind of the slag and/or dissolution of the slag itself. Release of radionuclides through either diffusion or dissolution should be at a much lower rate than simple wash-off from the slag surface. The slag has been described as being chemically similar to unhydrated cement clinker. As with cement, the slag is expected to develop a crust or weathering rind, on its outer surface, that will reduce the rate at which water can contact fresh, weatherable surfaces. Therefore, the rate of weathering is expected to diminish with time. Release of radionuclides would likely be through diffusion through this outer rind surface. For the soils, assuming the releases are controlled by equilibrium partioning may be a more realistic representation, but is still considered conservative because of the manner in which the distribution coefficients are estimated (see below).

Estimates of the distribution coefficients for radionuclides can be made based upon the ratio of the weighted average concentration (mg/kg) within the solid material and the average concentration (mg/L) within leachate derived from the solid. Experimental leachate concentrations were estimated using an extraction test, the synthetic precipitation leaching procedure (SPLP), on samples of slag and soil. Use of the SPLP method is expected to provide an overestimation of leachate concentrations, and thus an overestimation of release rates. The SPLP method requires grinding up the material so that it can pass through a 9.5 mm standard sieve; this is expected to create a larger surface area, which exposes more of the material to the liquid. Further, the material is bathed in an acid solution that has a pH of 4.2. Since the distribution coefficients for a particular chemical species is expected to be independent of the isotopic form, estimated distributions for a given chemical species can be averaged. For example, estimated distribution coefficients for uranium-234, uranium-235, and uranium-238 are averaged to come up with the estimated distribution coefficient for uranium. Estimated distribution coefficients are listed in Table 4. These distribution coefficients should not be viewed as real values in terms of representing the behavior of contaminants within the source area, but only as a means of conservatively bounding releases; that is, the actual releases are not expected to be greater than those estimated using these puesdo-distribution coefficients.

Using the estimated distribution coefficient (K_d), the rate of release can be estimated

from the following functional relationship (Rood, 1994):

$$Q(t) = \lambda_L \cdot Q_o \cdot e^{-(\lambda_L+\lambda_d)t} \qquad (3)$$

Where:

$Q(t)$ = release rate (Ci/yr)
Q_o = inventory of radionuclide (Ci)
λ_L = leach rate constant (yr^{-1})
λ_d = activity decay constant (yr^{-1})
t = time (yr)

$$\lambda_L = \frac{P}{(\theta \cdot R_d \cdot T)} \qquad (4)$$

Where:

P = percolation rate ($m \cdot yr^{-1}$)
θ = volumetric moisture content (dimensionless)
R_d = retardation factor
T = thickness of the source area (m)

$$R_d = 1 + \frac{K_d \cdot \rho}{\theta} \qquad (5)$$

Where:

K_d = distribution coefficient (mL/g)
ρ = bulk density (g/cm^3)

Release from the source area is modeled in this manner as a first-order leaching process that accounts for decay and sorption. This model assumes that releases are not solubility controlled and that the mass-transfer rate between solids and liquids is rapid. Further, the ingrowth of daughters at the source is not accounted for. Because of its characteristics, it is believed that estimating releases from the slag, in this manner, should be quite conservative (i.e., provide overestimates of releases). In fact, estimated releases for the slag may be overestimated by several orders of magnitude. Although estimating releases in this manner is acknowledged to provide overestimates, this method will be used because it is considered to provide a defensible means of determining impacts. Because releases are believed to be overestimated, no adjustments are made to account for daughter ingrowth at the source. Estimates made to look at the rate of ingrowth of daughters for several radionuclides tend to indicate

that this asumption should not greatly affect calculated impacts.

Parameters that can be used to estimate release rates, using the above formulation, are provided in Table 5. The percolation rate listed in Table 5 assumes that the piles are uncovered, or that the existing cover over the West Pile is degraded. The existing cover over the West Pile is believed to reduce percolation into the pile from 0.72 ft/y (0.22 m/y) to 0.1 ft/y (0.03 m/y); therefore, as long as the cover is assumed to function as designed, the estimated releases should be estimated by assuming a percolation rate of 0.1 ft/y. As previously noted, the proposed cover for the East Pile, for in-situ stabilization, is not designed to limit water from reaching the waste; therefore, releases from the East Pile should be the same for both the "no-action" and "in-situ stabilization" alternatives.

Chemicals

Inventory of Chemicals

The nonradiological chemicals of concern are metals. Given the nature of operations at the site, this is expected. Average concentrations of these chemicals, for the various alternatives to be considered, are listed in Table 6. The average concentrations within the West and East Piles are weighted based upon the weight percent of the materials within a given pile.

Release of chemicals into air

None of the chemicals of concern are expected to generate gases. Therefore, the principal release of chemicals into the air will be through entrainment with particulates. As with the radionuclides, releases of particulates when the piles are covered are expected to be minimal. When the piles are partially or completely uncovered, an upper-end estimate of release concentrations can be made using the same functional relationship (2) used for the radionuclides. Estimated release concentrations are provided in Table 7. These estimates are considered conservative because of the particle size of the contaminated material.

Release rate of chemicals into water

As with the radionuclides, estimates of the rate of release of chemicals into water can be made using equations (3) through (5). Given the chemicals of concern, the decay constant term, in equation (3), can be omitted, or arbitrarily set to zero. Again, conservative estimates of the distribution coefficients can be made based upon the ratio the concentration of chemicals within the solids to the concentration within leachate derived from the solid medium. Leachate concentrations were measured by the SPLP method, which is expected to provide an overestimation of leachate

concentrations. Estimated distribution coefficients for the various media are listed in Table 8. These distribution coefficients and the parameter values listed in Table 5 can be used in equations (3) to (5) to estimate releases of contaminants into water. The thickness (T) of the contaminated sediments is expected to be 12 ft (3.7 m). The density of the contaminated sediments can be assumed to be 1.7 g/cm^3, and the moisture content 0.375. Releases of chemicals from the contaminated sediment and the slag should be evaluated separately, since the contaminated sediments will not be mixed with the slag. Estimated releases from both the slag and sediment can be added together to get the total release for a particular chemical.

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Table 1. Inventory and concentration of radionuclides within the West and East Piles.

Radionuclide	West Pile Conc. (pCi/g)	West Pile Inventory (Ci)	East Pile Conc. (pCi/g)	East Pile Inventory (Ci)
Ac-227	5.48	2.16	26.10	1.43
Ac-228	2.08	0.82	21.60	1.18
Bi-210	7.61	3.01	12.40	0.68
Bi-211	12.40	4.90	32.50	1.78
Bi-212	1.67	0.66	15.90	0.87
Bi-214	6.39	2.52	38.50	2.11
Pa-231	10.30	4.07	39.00	2.13
Pa-234m	4.38	1.73	41.10	2.25
Pb-210	90.40	35.71	32.40	1.77
Pb-211	12.40	4.90	32.50	1.78
Pb-212	2.06	0.81	23.70	1.30
Pb-214	6.70	2.65	39.10	2.14
Po-210	3.75	1.48	9.87	0.54
Po-212	1.07	0.42	10.20	0.56
Po-214	6.39	2.52	38.50	2.11
Po-215	12.40	4.90	32.50	1.78
Po-216	19.80	7.82	99.80	5.46
Po-218	6.39	2.52	38.50	2.11
Ra-223	12.40	4.90	32.50	1.78
Ra-224	19.80	7.82	99.80	5.46
Ra-226	6.39	2.52	38.50	2.11
Ra-228	2.08	0.82	21.60	1.18
Rn-219	12.40	4.90	32.50	1.78
Rn-220	19.80	7.82	99.80	5.46
Rn-222	6.39	2.52	38.50	2.11
Th-227	5.48	2.16	26.10	1.43
Th-228	2.02	0.80	15.60	0.85
Th-230	285.00	112.58	980.00	53.61

Th-231	0.92	0.36	4.68	0.26
Th-232	3.74	1.48	21.30	1.17
Th-234	3.89	1.54	26.20	1.43
Tl-207	12.40	4.90	32.50	1.78
Tl-208	0.68	0.27	7.55	0.41
U-234	4.20	1.66	41.30	2.26
U-235	0.92	0.36	4.68	0.26
U-238	4.04	1.60	40.40	2.21

Table 2. Estimated radon fluxes.

	West Pile ($pCi \cdot m^{-2} \cdot s^{-1}$)	**East Pile ($pCi \cdot m^{-2} \cdot s^{-1}$)**
Radon-222	1.3e-03	3.9e-03
Radon-220	9.6e-01	4.5e+00

Table 3. Estimated radionuclide concentration in air-borne particulates.

Radionuclide	Particulate Concentration for West Pile (pCi/m^3)	Particulate Concentration for East Pile (pCi/m^3)
Ac-227	4.33e-04	2.06e-03
Ac-228	1.64e-04	1.71e-03
Bi-210	6.01e-04	9.80e-04
Bi-211	9.80e-04	2.57e-03
Bi-212	1.32e-04	1.26e-03
Bi-214	5.05e-04	3.04e-03
Pa-231	8.14e-04	3.08e-03
Pa-234m	3.46e-04	3.25e-03
Pb-210	7.14e-03	2.56e-03
Pb-211	9.80e-04	2.57e-03
Pb-212	1.63e-04	1.87e-03
Pb-214	5.29e-04	3.09e-03
Po-210	2.96e-04	7.80e-04
Po-212	8.45e-05	8.06e-04
Po-214	5.05e-04	3.04e-03
Po-215	9.80e-04	2.57e-03
Po-216	1.56e-03	7.88e-03
Po-218	5.05e-04	3.04e-03
Ra-223	9.80e-04	2.57e-03
Ra-224	1.56e-03	7.88e-03
Ra-226	5.05e-04	3.04e-03
Ra-228	1.64e-04	1.71e-03
Rn-219	9.80e-04	2.57e-03
Rn-220	1.56e-03	7.88e-03
Rn-222	5.05e-04	3.04e-03
Th-227	4.33e-04	2.06e-03

Th-228	1.60e-04	1.23e-03
Th-230	2.25e-02	7.74e-02
Th-231	7.27e-05	3.70e-04
Th-232	2.95e-04	1.68e-03
Th-234	3.07e-04	2.07e-03
Tl-207	9.80e-04	2.57e-03
Tl-208	5.40e-05	5.96e-04
U-234	3.32e-04	3.26e-03
U-235	7.27e-05	3.70e-04
U-238	3.19e-04	3.19e-03

Table 4. Estimated distribution coefficients for radionuclides within the source area.

Radionuclide	Distribution Coefficient (K_d) (mL/g)
Actinium	4191
Bismuth	980
Protactinium	4553
Lead	1045
Polonium	595
Radium	180
Thorium	66,755
Thallium	557
Uranium	23,812

Table 5. Parameters used in estimating release rates.

Parameter	West Pile	East Pile
P (percolation)	0.22 m/y	0.22 m/y
θ (moisture content)	0.032	0.032
T (thickness)	5.06 m	2.59 m
ρ (waste density)	2.65 (g/cm^3)	2.15 (g/cm^3)

Table 6. Inventory of chemicals of concern.

Chemical	West Pile (g/kg)	East Pile (g/kg)	On-site Sediments (g/kg)	Off-site Sediments (g/kg)	Wetland Sediments (g/kg)	Volume weighted average sediments (g/kg)
Arsenic	1.19e-03	2.89e-04	1.73e-02	9.46e-03	2.55e-02	2.07e-02
Barium	5.67e-02	1.51e-01	8.88e-02	9.77e-02	8.66e-02	8.94e-02
Beryllium	2.20e-04	1.69e-04	7.40e-03	2.64e-03	1.42e-03	2.59e-03
Chromium	5.30e-02	9.80e-03	2.22e-01	5.94e-02	9.68e-02	1.08e-01
Copper	7.71e-03	2.38e-03	2.71e-02	2.51e-02	1.51e-02	1.91e-02
Lead	2.27e-02	3.36e-04	6.17e-02	3.94e-02	2.16e-02	3.16e-02
Selenium	2.15e-04	3.89e-04	1.23e-02	3.30e-03	6.79e-03	6.87e-03
Silver	9.88e-05	5.87e-05	7.40e-03	2.02e-02	3.40e-03	7.69e-03
Uranium	9.60e-03	9.76e-02	Bckgrd	Bckgrd	Bckgrd	Bckgrd
Vanadium	5.81e-01	2.98e-01	5.01e+00	9.45e-01	2.45e+00	2.51e+00
Zinc	9.87e-02	8.42e-03	2.54e-01	1.62e-01	8.04e-02	1.25e-01

Table 7. Estimate of particulate concentration of metals.

Chemical	Particulates from the West Pile (w/o sediments) ($\mu g/m^3$)	Particulates from the West Pile (w/sediments) ($\mu g/m^3$)	Particulates from the East Pile ($\mu g/m^3$)
Arsenic	9.42e-02	4.22e+00	2.28e-02
Barium	4.48e+00	2.60e+01	1.19e+01
Beryllium	1.74e-02	9.22e-01	1.34e-02
Chromium	4.19e+00	3.41e+01	7.74e-01
Copper	6.09e-01	5.93e+00	1.88e-01
Lead	1.80e+00	1.15e+01	2.66e-02
Selenium	1.70e-02	1.79e+00	3.08e-02
Silver	7.81e-03	2.46e+00	4.64e-03
Vanadium	4.59e+01	7.10e+02	2.35e+01
Zinc	7.79e+00	4.70e+01	6.65e-01

Table 8. Estimated distribution coefficients for chemicals of concern, within the sediments.

Chemical	On-site Sediment (ml /g)	Off-site Sediment (ml /g)	Wetland Sediment (ml /g)
Arsenic	664	364	981
Barium	178	195	173
Beryllium	740	264	142
Chromium	2774	743	1210
Copper	904	836	503
Lead	30825	19692	10801
Selenium	1233	330	679
Silver	740	2024	340
Vanadium	269	51	132
Zinc	508	324	161

Conceptual Model

Background

The basic goal of contaminant transport modeling is to compute contaminant concentrations at locations where impacts can occur, such as where someone can come into contact with the contaminants. The first step in modeling contaminant transport is the development of a conceptual model of the transport pathway. This involves making an abstraction of site characterization data into a form that is capable of being modeled. This generally requires making a number of simplifying assumptions about geometries within the pathway, and spatial and temporal variability of parameters (Kozak et al., 1989).

The Shieldalloy - Cambridge, Ohio site has been characterized to the extent that possible environmental transport pathways for contaminants can be identified and described. Site characterization information suggests that air, ground water, and surface water are the key pathways through which contaminants can be transported. For purposes of analyzing possible impacts away from the disposal areas (i.e., for the no-action and stabilization-in-place alternatives), these are the primary pathways that will be considered. As contaminants are released from source area, they may move through any or all of these pathways. Predicting how the total concentration of a given contaminant will be partitioned between the various pathways is highly uncertain. Therefore, for the purposes of assessing impacts associated with a particular pathway, it will be assumed that all of the contaminants are transported through that particular pathway.

Transport of contaminants through the Air

Meteorological data for Columbus, Ohio (roughly 75 miles {121 Km} west of the site) show that the predominant wind direction is to the north and northeast, at roughly 8.4 mph (3.8 m/s). Therefore, for purposes of assessing impacts from contaminants transported through the air, an appropriate assumption is for someone to be located north of the site.

Transport of contaminants through Ground Water

The bedrock beneath the site is predominantly shale intermingled with thin sandstone units. The average depth to the bedrock is around 40 feet (12 m), with a prominent bedrock high (roughly 10-20 feet {3.05-6.1 m} below land surface) in the area south of the Mill Building and the East Slag Pile. Above the bedrock is valley-fill alluvial, lacustrine, and palustrine deposits consisting of clays, sandy-silty clays, and silty-clayey sands.

~~Attachment~~ 3
Enclosure

The uppermost aquifer, at the site, is a semi-confined aquifer in the valley-fill alluvium. This aquifer ranges in thickness from 25 to 60 feet (7.6 to 18.3 m), with an avarage of around 40 feet. The sequence of alluvial deposits, from the surface down, is as follows: roughly 15 feet (4.6 m) of silty clay; 15-20 feet (4.6-6.1 m) of silty, clayey sand; and 15-20 feet of silty clay and sandy clay. The upper clay unit is consistent across the site. Water is contained and transported primarily in the lower two units; however, the lower half of the upper clay is saturated. The average depth to the water table is seven feet (2.1 m).

The bedrock zone also contains an aquifer. The degree of interconnection between the shallow, alluvium aquifer and the bedrock aquifer is currently unknown.

Recharge to the shallow, alluvium aquifer is estimated to be 0.5 ft/yr (0.15 m/y). Chapman Run is believed to be a local ground-water discharge area, for the shallow, alluvium aquifer. Ground water within the alluvium aquifer is estimated to flow to the west, at a rate of 8.4E-02 ft/d (2.6E-02 m/d). This is based upon a mean hydraulic conductivity of 2.4 ft/d, a hydraulic gradient of 7.0E-3 ft/ft, and an effective porosity of 0.2.

For purposes of assessing impacts associated with ground water transport of contaminants, the following conceptual model is assumed:

- Contaminants are released from the slag piles (see source term description) and migrate into the underlying clays. Flow through the seven foot unsaturated zone occurs at a rate of 1.2 ft/y (0.37 m/y); this is based upon an assumed percolation rate of 0.5 ft/y (0.14 m/y), a unit hydraulic gradient, and a moisture content of 0.4. When the cover over the West Pile is assumed to function as designed, flow through the unsaturated zone will be assumed to be 0.25 ft/y (0.08 m/y); this is based upon an assumed percolation rate of 0.1 ft/y (0.03 m/y), a unit hydraulic gradient, and a moisture content of 0.4.

- Contaminants entering the saturated zone are assumed to flow laterally to the west. All contamination is assumed to be transported within the shallow, alluvium aquifer (i.e., no contaminant transport is assumed to occur in the bedrock aquifer); this assumption should be conservative, since contaminants reaching the bedrock aquifer should be much more diluted than in the shallow aquifer.

- If control over site access is maintained, the closest possible receptor locations are 383 feet (117 m) west of the West Pile and 293 feet (89 m) west of the East Pile. These are the closest, down-gradient locations that future wells could be installed, if site access is limited.

Based upon site characteristics and the current geometrical shape of the piles, it is estimated that a plume emanating from the West Pile will disperse vertically over an distance anywhere from 25 to 100% of the thickness of the shallow aquifer. The smaller percent represents what would happen if contaminants are released while the pile is covered and the cover functions as designed. A plume emanating from the East Pile is expected to disperse over a vertical distance equivalent to 75% of the thickness of the aquifer. Analyses to look at the aerial capture zone of a well located immediately off site, and supplying water to a family of four (i.e., 630 gpd) show that a plume emanating from the West Pile would be roughly fours times as wide as the capture zone for the well, and for the East Pile, the plume would be roughly twice as wide as the capture zone. These analyses are instructive for understanding the potential dilution of contaminants as they are transported to a receptor location off site.

The surface clays and clayey substrate within the silty, clayey sands are expected to provide some attenuation of contaminants of concern. Table 1 lists distribution coefficients (K_ds) that will be assumed for analyzing contaminant transport through the unsaturated and saturated zones. Values derived for the unsaturated zone are estimated based upon the ratio of leachate concentrations (mg/L) from the SPLP tests to sediment concentrations (mg/kg) [see the source term description for further detail]. Values for the saturated zone are taken from Strenge and Peterson (1989). These values are based on soils with a pH between 5 and 9, and a clay content less than 10%. Values for saturated zones are generally toward the lower end of the range for the respective soil types, as reported by Thibault and Sheppard (1990). Values cited in Strenge and Peterson (1989) were used because it provides a more complete dataset.

A schematic of the ground-water conceptual model is shown in figure 1. Values in parentheses are for the East Pile, the corresponding other value is for the West Pile. The italicized flow rates represent flow conditions when the cover over the West Pile is assumed to be functioning as designed.

Transport of contaminants through Surface Water

The site is located in the Wills Creek valley, on the west flank of the drainage divide between Chapman Run and Wills Creek. The two creeks join approximately 0.5 mile (0.8 Km) north of the site. Flow in Chapman Run, immediately south of the confluence, has been estimated to be around 90 ft^3/s (cfs) {2.6 m^3/s}. Flow in Wills Creek, immediately south of the confluence is estimated to be a little over 400 cfs (11 m^3/s).

Surface water flow on the site is controlled by tributaries of Chapman Run, drainage ditches, and wetlands. All surface water flow ultimately ends in Chapman Run, which flows into Will Creek. Chapman Run runs parallel (north to south) with the western site boundary. It crosses the northwestern corner of the site. Flow is to the north, at

roughly 20 cfs (0.6 m^3/s), near the site.

Three distinct watersheds have been delineated for the site. The northern and northeastern third of the site is drained by ditches that flow into a wetland located north of the West Pile. This wetland drains through a tributary into Chapman Run, north of the site. Discharge from this watershed has been estimated to be around 0.002 cfs (6E-05 m^3/s).

Most surface drainage on the site occurs through a series of ditches and tributaries which flow through a large wetland system immediately west of the West Pile. Discharge from this watershed occurs through a tributary, which enters Chapman Run approximately 200 feet (61 m) west of the site. The estimated discharge rate for the watershed is roughly 2 cfs (0.06 m^3/s).

The smallest drainage area, on the site, drains a small portion of the northwestern quarter of the West Pile. Drainage from this area occurs through a tributary which flows into Chapman Run, northwest of the site. No discharge estimates have been made for this watershed area.

For purposes of assessing impacts associated with surface water transport of contaminants, the following conceptual model is assumed:

- Only transport of dissolved contaminants will be considered. Analyses of existing contamination, on the site, have suggested that most contaminant transport through surface water is in the dissolved phase. Since sediment transport will not be considered, no consideration will be given to attenuation of contaminants through partitioning between water and sediments.

- Contaminants released within a given watershed (see the source term description for information on release rates) will be assumed to reach off-site locations where discharge first enters Chapman Run. Contaminants will be assumed to enter surface water directly from the source area (i.e., no consideration will be given to overland transport). Further, no consideration will be given to contaminants within the shallow aquifer discharging into Chapman Run. Analyses to assess impacts to well users (under the ground-water assessment) should provide an upper-bounds of effects to surface water users.

  Contaminants released from the East Pile will be assumed to travel a distance of 2100 feet (640 m) to the northwest at a rate of 2 cfs, and discharge into Chapman Run. Flow in Chapman Run, at this point, will be assumed to be 20 cfs.

  Contaminants released from the southern half of the West Pile (this will include

contaminated sediments and off-site slag added to the pile) will be assumed to travel a distance of 700 feet (213 m) to the west at a rate of 2 cfs, and discharge into Chapman Run at the same location where contaminants from the East Pile enter.

Contaminants released from the northeastern part of the West Pile (roughly 30% of the current pile area) will be assumed to travel a distance of 350 feet (107 m) to the north at a rate of 0.002 cfs. Flow in Chapman Run will be assumed to be 20 cfs.

Contaminants released from the northwestern part of the West Pile (roughly 20% of the current pile area) will be assumed to travel a distance of 350 feet to the northwest at a rate of 0.002 cfs, and discharge into Chapman Run. Again, flow in Chapman Run will be assumed to be 20 cfs.

A schematic of the surface-water conceptual model is shown in figure 2.

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Table 1. Distribution coefficients for the unsaturated and saturated zones.

Chemical	Unsaturated Zone (ml/g)	Saturated Zone (ml/g)
Actinium	5 616	228
Arsenic	670	6
Barium	182	530
Beryllium	382	70
Bismuth	734	6
Chromium	1576	17
Copper	750	336
Lead	20439	234
Polonium	4944	6
Protactinium	450	0
Radium	3190	24
Selenium	747	6
Silver	1035	0
Thallium	23	0
Thorium	6178	100
Uranium	3443	0
Vanadium	151	50
Zinc	331	13

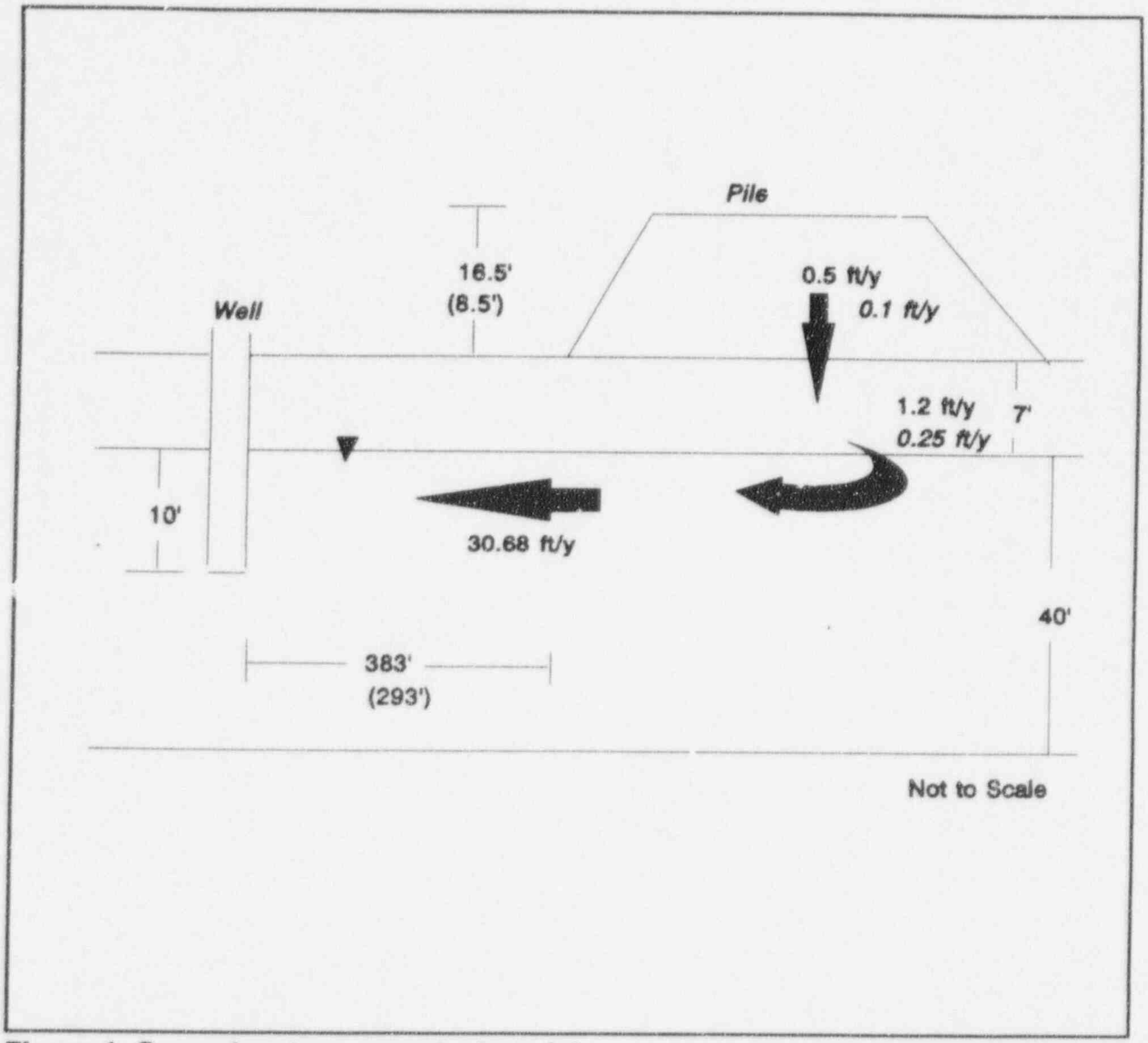

Figure 1. Ground-water conceptual model.

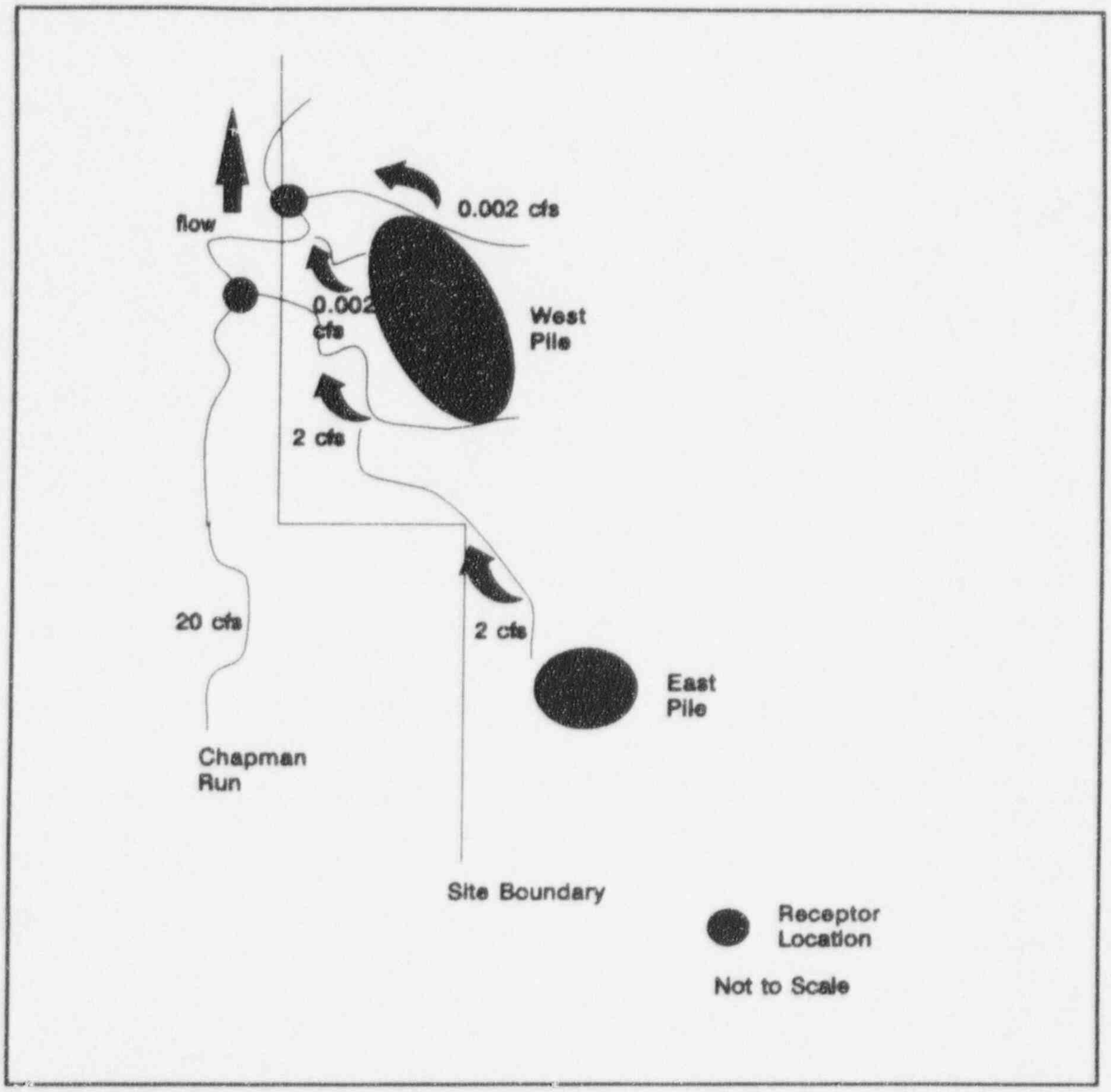

Figure 2. Surface-water conceptual model.