CABOT

June 14, 2005

Theodore Smith
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Cabot Reading Site, Reading, Pennsylvania (License No. SMC-1562)
Radiological Assessment and Decommissioning Plan
Rip-Rap Cover Design Modifications

Reference: 1. May 6, 2005 Decommissioning Plan and Radiological Assessment

Dear Mr. Smith:

As discussed in our telephone conversation on June 8, 2005, Cabot Corporation proposes to modify the design of the rip-rap cover described in reference 1. The changes resulted from a meeting with parties involved in redevelopment of the former American Chain and Cable (ACC) property and the former Dana Oley Yard (Dana) north of the subject site. The meeting reviewed the proposed rip-rap cover in the context of the current redevelopment plans.

The participants in the meeting concluded that the planned extension of River Road to provide improved access to the Dana property would benefit from a thinner and smaller area of rip-rap in the River Road right-of-way (ROW). To evaluate the feasibility of changing the rip-rap design, Cabot inspected the ACC property. The inspection found that the upper portion of the ACC property drains to the south and east, away from the top of the slope containing the slag. The rip-rap design calculations provided in reference 1 conservatively assumed that the area within 500 feet of the slope drained on to the slag pile. Revised calculations, using the actual topography, resulted in a reduction of the required rip-rap rock size, thickness and width of the rip-rap base extending into the ROW. In addition, the calculations indicated that the rip-rap only needs to extend to the top of the topographic bench in the southern portion of the slope. The revised design, consistent with the calculations, remains compliant with NUREG-1623.

The proposed design modifications do not affect the dose estimates presented in the Radiological Assessment submitted by reference 1. The modifications affect only areas below or beyond the radiological slag deposit on the pile, and do not modify the effective density of rip-rap on the slag pile used for the Radiological Assessment. Consequently, the radiological assessment assumptions related to rip-rap on the slag pile are not affected. Since the radiological assessment related to slag in the area of the ROW conservatively disregarded the presence of any rip-rap over that material, the proposed modification to the rip-rap design also does not affect that aspect of the assessment.

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Enclosed you will find three packages of replacement pages with instructions for the Decommissioning Plan and Radiological Assessment Reports.

Please call me at 617-342-6023 if you have any questions.

Sincerely,

Wayne M. Reiber
Manager, Environmental Assessment and Remediation

CABOT
Reading, Pennsylvania Slag Pile Site
Revision 3 Replacement Pages Instructions

REVISION 2 Pages to be REMOVED	REVISION 3 Pages to be INSERTED
DECOMMISSIONING PLAN	
Front Cover	Front Cover
Cover Page	Cover Page
iv	iv
1-8	1-8
1-24	1-24
1-26	1-26
Figure 1-12	Figure 1-12
Figure 1-13	Figures 1-13A and 1-13B
Appendix E	Appendix E
RADIOLOGICAL ASSESSMENT	
Front Cover	Front Cover
Cover Page	Cover Page
iii	iii
1-2	1-2
1-6	1-6
1-7	1-7
Figure 1-3	Figure 1-3
2-2	2-2
3-2	3-2
3-10	3-10
3-14	3-14
3-16	3-16
3-20	3-20
Figure 3-2	Figure 3-2

DECOMMISSIONING PLAN

FOR

READING SLAG PILE SITE

Prepared for:

Cabot Corporation
Two Seaport Lane
Boston, MA 02210

Prepared by:

ST Environmental Professionals, Inc.
114 Lutz Road
Boyertown, PA 19512

Revision 3
June 2005

ST Environmental Professionals, Inc.

DECOMMISSIONING PLAN

FOR

READING, PENNSYLVANIA SLAG PILE SITE

Prepared for:

Cabot Corporation
Two Seaport Lane
Boston, MA 02210

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Revision 3, June, 2005

TABLES

FIGURES

top of the embankment and a clay material at a depth of approximately 38 feet below the top of the embankment. The approximate locations of 1996 borings and other sampling locations are shown on Figure 1-6.

The on-site soils are well drained. It is apparent based on the characterization results and visual observations that there are no wetlands within the Site boundaries. The only observed potential wetlands in the vicinity of the Site appear to be immediately adjacent to the Schuylkill River and within portions of the former Schuylkill Canal.

1.3.5 Surface Water Hydrology

No water courses other than the Schuylkill River were identified in the immediate vicinity of the Site. As would be expected for granular fill material, the surface of the Site and adjacent areas are well drained. The United States Geological Survey (USGS) has maintained a stream gauging station approximately 2,000 feet downstream from the Site. The average daily flow rate was 1,532 cubic feet per second (cfs). The minimum reported daily flow was 98 cfs and the maximum reported daily flow was 26,800 cfs (USGS, 1997)

The flood profile for the June 1972 flood (Tropical Storm Agnes) in Pennsylvania indicates that the maximum water level was at elevation 219.2 feet above mean sea level (MSL) 450 feet upstream from the Reading Railroad bridge (approximately 500 feet upstream from the Site) and at elevation 218.6 feet MSL at the Buttonwood Street Bridge (approximately 600 feet downstream from the Site) (Miller, 1974). Therefore, the flood level at the Site was at approximately elevation 219 feet MSL. Because the 1972 flood was reported to far exceed any previously recorded flood levels on the Schuylkill River, these elevations represent the maximum reported flood levels. The 100-year flood elevation at this location is mapped as 211 feet MSL.

Based on the above information, the Norfolk ROW and the River Road ROW are within the flood plain of the Schuylkill River. The majority of the slag pile, which ranges in elevation from approximately elevation 210 feet to 260 feet above MSL, is above the 100 year and the maximum reported flood level.

Following installation of the rip-rap cover the surface elevations of the slag pile will range from approximately 212 feet to 261 feet above MSL, entirely above the 100-year flood level.

1.3.6 Groundwater Hydrology

The information evaluated for this report was sufficient to develop a comprehensive conceptual model of the Site geologic and hydrogeologic conditions. All the Site-specific and background information supports the model. The conceptual model is depicted in Figure 1-7, a cross section showing the subsurface conditions beneath the Site. Figure 1-8 depicts a cross section across the entire industrial property. As shown in Figure 1-7, a

restrictions. In addition, some of the material will be beneath a 2.3-foor thick rip-rap cover eliminating potential exposure and any reasonable probability of movement.

Reviewers Comments

Reviewer comments on a draft Safety Evaluation Report prepared by the NRC Staff expressed concern regarding the characterization of the slag. Cabot understands that the concern was based on speculation that the auger drilling and split-spoon sampling performed by NES may have underestimated the amount of slag present as large hard glassy blocks. A complete response to this concern, provided in 2002 (Cabot 2002), showed that the results of characterization are confirmed by a variety of methods and the potential range of uncertainty is small. The installation of a rip-rap cover provides additional assurance that the limited uncertainty regarding the amount of slag is not significant to the potential dose to the public.

Some reviewers have expressed concern that in the current condition of the Slag Pile, future erosion could lead to exposure of concentrated slag on the slope, essentially recreating the conditions that existed when the slag was initially placed on the slope. This scenario is not credible because it requires all the material that has been placed on the slag to be selectively removed by erosion.

The current covering consists of rock placed by Kawecki to cover the slag and debris placed by the property owners following Kawecki operations. That material contains numerous large bodies of reinforced concrete aggregate, rocks, and metallic scrap. The past 30 to 40 year history of the Site provides assurance that the slope is stable and significant erosion has not been observed. If it is assumed that somehow erosion occurs, only the smaller fragments of materials could be removed. The larger pieces of concrete, rock and debris would remain and provide for a durable cover. In addition, material would remain filling the interstitial spaces between the large blocks of slag, reducing the potential exposure.

Based on Site observations, period documents, and characterization results, with the possible exception of a small area near the southwest border of the pile there are sufficient large pieces of durable material covering the pile to ensure a continuous cover following erosion of finer materials.

The potential future dose due to postulated exposure of a limited area of slag can be estimated from the dose assessment calculations performed for the Radiological Assessment (RARV2, STEP 2005). Those results indicate that the potential exposure depends primarily on the area and concentration. In the unlikely event of significant erosion, the small area of slag that could potentially be exposed by erosion would be similar to the assumption in the limited excavation scenario presented in the RARV2. The calculated potential dose for that scenario is well below the 25 mrem/year limit for release without restrictions.

1.5.3 Proposed Rip-Rap Cover

The physical characteristics of the slag and the Site ensure that potential doses are less than the NRC limits for unrestricted release. The proposed rip-rap cover, which is designed to remain stable from down slope movement and erosion for 1,000 years without active maintenance, provides additional assurance that the limits will be met.

The rip-rap cover design was performed by an experienced geotechnical engineering firm using the guidelines in NUREG-1623. The detailed calculations and procedures for installation are contained in Appendix E. On the slope and top edge of the pile, the cover will consist of a 1.0 foot thick layer of durable rock with an average size of approximately 6" (D_{50}=6"). At the base of the slope, a 2.3-foot thick layer of D_{50}=9" durable rock will extend 11 feet from the slope to form a base to anchor the slope. The rip-rap cover is depicted in plan view on Figure 1-12 and cross section in Figures 1-13A and 1-13B.

The rip-rap cover is an engineered barrier that eliminates any concern regarding possible erosion. The continuous cover of large durable pieces of rock also will ensure a stable and continuous cover over the slag that will prevent exposure to the slag, even without considering the presence of the finer materials in the cover.

1.5.4 Radiological Assessment

A detailed discussion of the methods and assumptions used to perform the radiological assessment can be found in the Radiological Assessment for Reading, Pennsylvania Slag Pile Site (STEP, 2005). They are summarized in the following section.

The NRC radiological criteria for license termination are expressed in terms of radiation dose that might reasonably be expected from residual radioactive material after decommissioning. As used here, the term "dose" is intended to be interpreted as total effective dose equivalent (TEDE), which is the quantity expressed in the NRC regulation. At the Reading Site this dose would depend upon concentrations of residual radioactive materials in soils and other remaining materials. The dose would also depend on Site-specific factors that might control potential resource use, potential migration of radioactive materials, and potential access to radioactive materials. Finally, this dose would also depend on potential activities of future users of the Site.

The radiation dose assessment process, as applied herein, includes the estimation of the radiation dose (TEDE) that might be received by a typical member of a small group of people that could be expected to receive the highest doses from use of the Site as far as 1,000 years into the future, as required in the radiological criteria for license termination. Thus, the assessment considers not only the expected conditions at the Site, soon after remediation, but conditions projected for the distant future, as well. The assessment evaluates potential uses of the Site and potential migration of radioactive materials through the environment over time, taking account of both natural processes and human activities that could be expected to alter the patterns or rates of constituent movement.

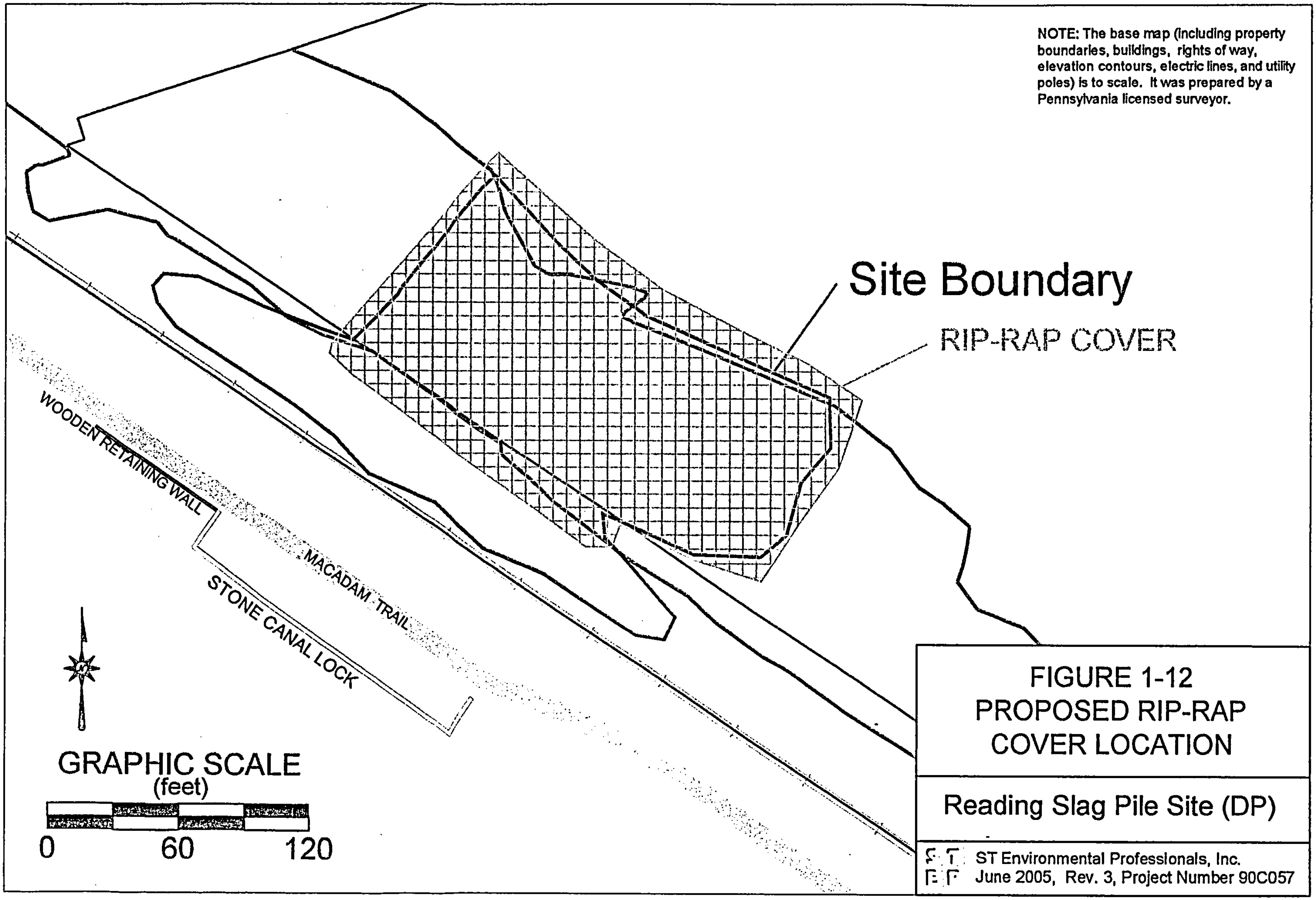

FIGURE 1-12
PROPOSED RIP-RAP
COVER LOCATION

Reading Slag Pile Site (DP)

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June 2005, Rev. 3, Project Number 90C057

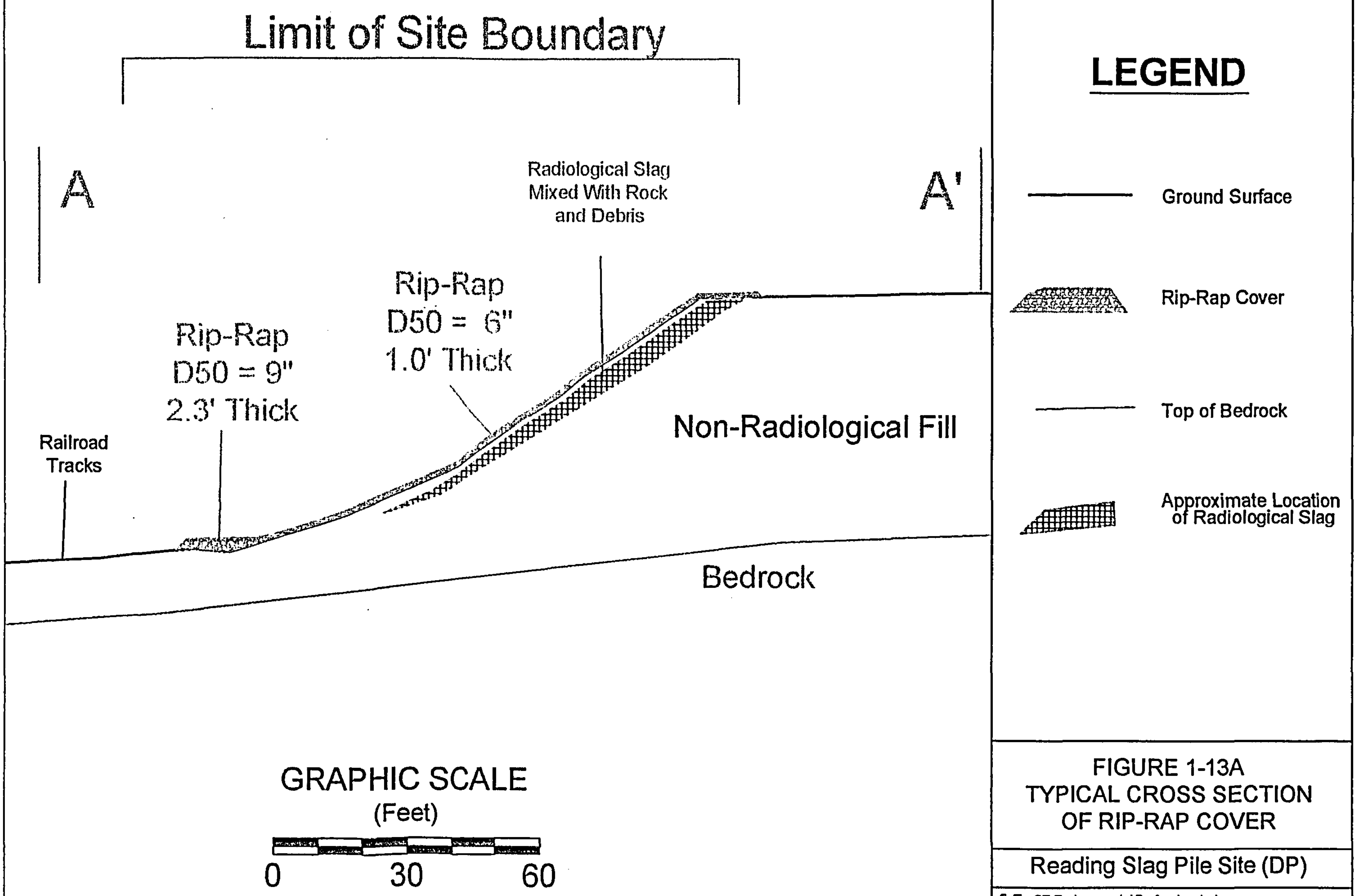

FIGURE 1-13A
TYPICAL CROSS SECTION
OF RIP-RAP COVER

Reading Slag Pile Site (DP)

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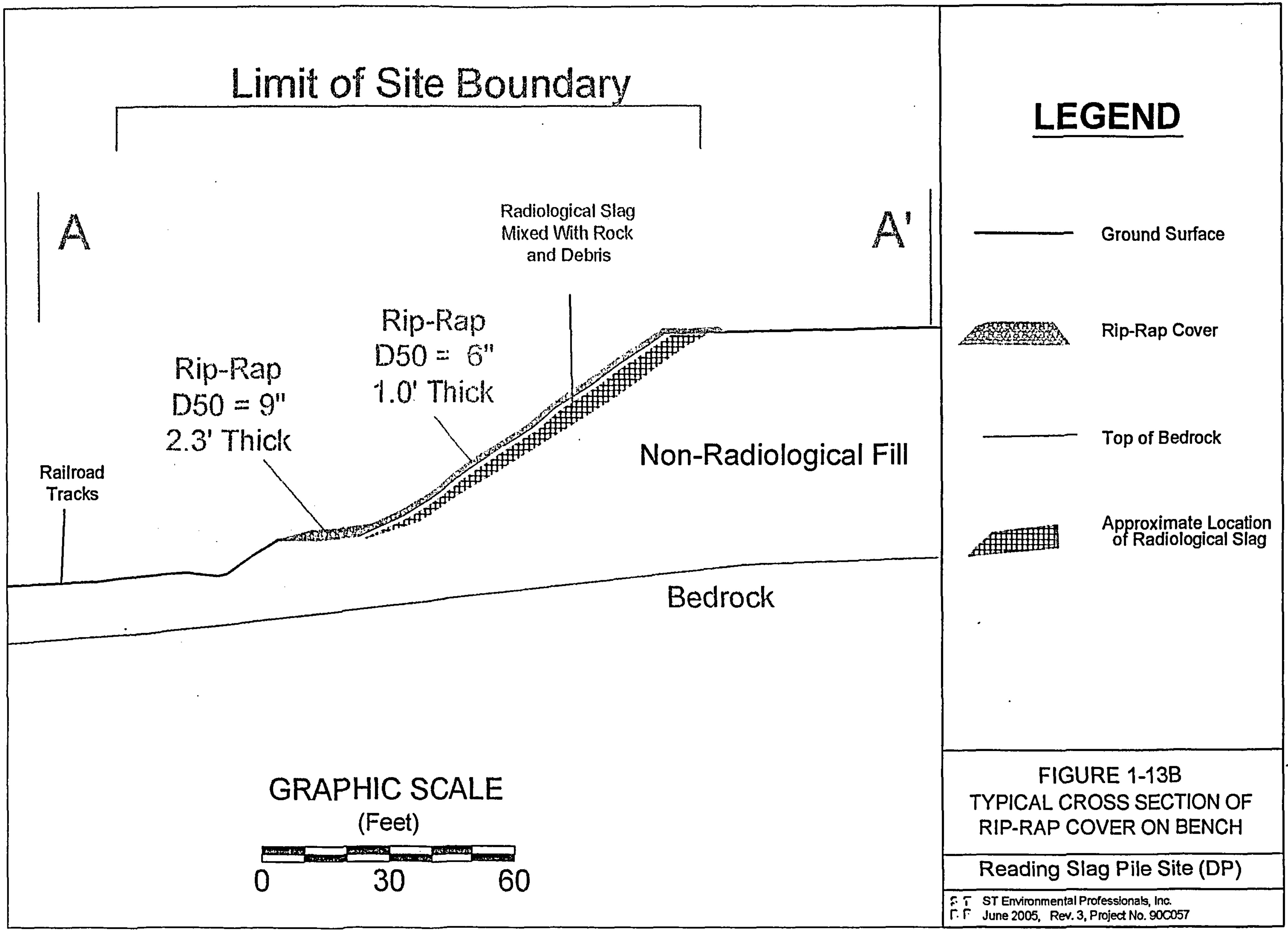

FIGURE 1-13B
TYPICAL CROSS SECTION OF RIP-RAP COVER ON BENCH

Reading Slag Pile Site (DP)

ST Environmental Professionals, Inc.
June 2005, Rev. 3, Project No. 90C057

APPENDIX E

RIP-RAP COVER DESGN

DESIGN CALCULATIONS

GeoSystems Consultants, Inc.		CALCULATION SHEET		Project No.	03G324
CLIENT	STEP, Inc.	SUBJECT	Riprap Design Calculation	Prepared by:	DMH 6/7/2005
PROJECT	Cabot Reading Slag Pile			Reviewed by:	

Reference

TASK:

Complete calculations for the design of the riprap protection at the Cabot site in Reading, Pa

REFERENCES:

1 NUREG-1623 "Design of Erosion Protection for Long-Term Stabilization", prepared by U.S. Nuclear Regulatory Commision, dated September 2002

2 Drawing entitled "Topographical Plan, Reading Slag Pile", prepared by ST Environmental Professionals, dated 12/16/98

3 Hydrometeorological Report No. 52, prepared by National Weather Service

4 "Erosion and Sediment Pollution Control Program Manual", prepared by the Commonwealth of Pennsylvania, Department of Environmental Protection, Office of Water Management, dated April 15, 2000

CALCULATIONS:

Calculations are based on steps outlined in Appendix D of Reference 1

1. Determine the drainage area on a unit width basis.

Slope: a = 82 ft / 43560 ft^2/acre — 0.002 acres [2]

2. Determine time of concentration (t_c)

$t_c = (11.9\ L^3/H)^{.385}$ [1]

where:			
	$L_{(slope)}$	= slope length (miles) = 82 ft / (5280 ft/mi)	0.016 mi
	$H_{(slope)}$	= slope height (ft)	50 ft
	$t_{c\ (slope)}$	= (11.9 (0.016)^3/50) .385	0.005 hrs
	Total t_c		0.005 hrs
			0.3 minutes

3. Determine the Rainfall Intensity

1 hr, 1 mi^2 probable maximum precipitation for Reading, PA — 17.75 in [3]

Rainfall Duration Minutes	of 1 hr PMP
0	0
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

Interpolate % of PMP for 0.3 minute — 12.1 %

Adjusted Rainfall Depth
17.75 x 12.1% — 2.15 inches in t_c minutes

Rainfall estimate (i)
2.15 in / 0.3 minutes (60 min/hr — 458.34 in/hr

CLIENT	STEP, Inc.	SUBJECT	Riprap Design Calculation	Prepared by:	DMH 6/7/2005
PROJECT	Cabot			Reviewed by:	
	Reading Slag Pile			Project No.	03G324

Reference

4. Calculate Peak Flow Rate

$q = C\,i\,a$ [1]

where: q = flow (cfs)/ft
C = runoff coefficient 0.35

Slope: Q = (0.80) (458.34) (0.002) 0.30 cfs

5. Determine Rock Size, D_{50}

Using Stephenson's Equation: [1]

$$D_{50} = \frac{q\,K\,(\tan\theta)^{7/6}\,\eta_p^{\,1/6}}{C\,(32.2)^{0.5}\,[(1-\eta_p)(G_s-1)\cos\theta\,(\tan\Phi - \tan\theta)]^{5/3}}$$

where:				
θ	= slope angle		31 °
η_p	= rock fill porosity	assume:	0.35
C	= Empirical factor	assume:	0.22
G_s	= specific gravity of rock	assume:	2.95
Φ	= rock angle of repose	assume:	42 °
K	= Oliver's constant	assume:	1.8

Slope: D_{50} = 1.3 in
use: 6 in

Use NSA No. R-4 Riprap placed 12" thick
A 4-inch thick filter blanket of NSA No. FS-2 should be placed below the riprap. [4]

6. Calculate Riprap size at Toe of Embankment

$D_{50} = 10.46\,S^{0.43}\,(C_f\,q_d)^{0.56}$ [1]

where:			
S	= embankment side slope		0.61 ft/ft
C_f	= flow concentration factor (assume)		2.5
q_d	= design unit discharge		0.30 cfs
D_{50} =			7.2 in
		use:	9 in
			Use NSA No. R-5

Apron length = D_{50} (1/12) * 15 11 ft [1]

Thickness = D_{50} (1/12) * 3 2.3 ft [1]

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC
ADMINISTRATION

U.S. DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS

HYDROMETEOROLOGICAL REPORT NO. 52

Application of Probable Maximum Precipitation Estimates -
United States East of the 105th Meridian

**Click on the Contents button on the Toolbelt
to see the Table of Contents**

Prepared by

E.M. Hansen, L.C. Schreiner & J.F. Miller

Hydrometeorological Branch

Office of Hydrology

National Weather Service

WASHINGTON, D.C.

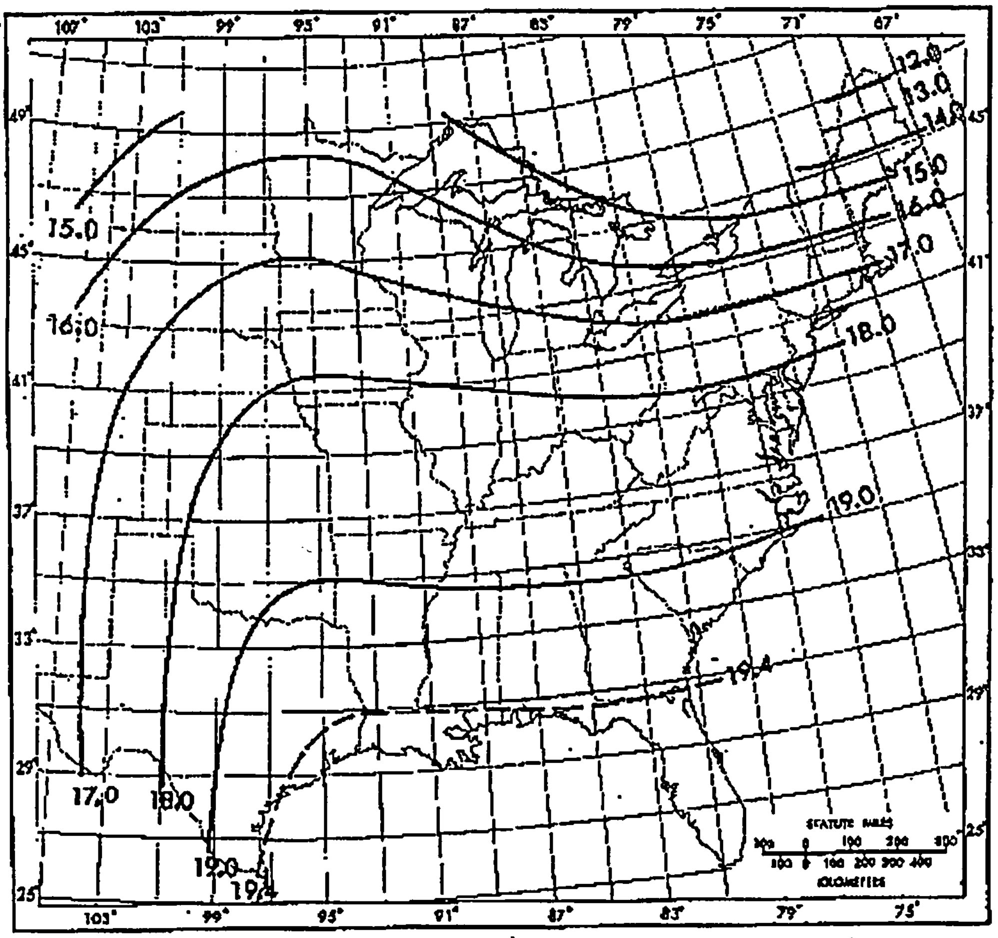

Figure 24.-l-hr l-mi2 precipitation from HMR go. 51.

transposition limits.. Comparison of this 18.3-in. value with the 1-hr 1-mi2 PMP from figure 24 shows a difference of 0.6 in. We consider this a reasonable envelopment of a moisture maximized transposed amount.

6.3.3 Depth-area ratios

Preparation of 1-hr PMP values over the range of area sizes of interest required development of depth-area reduction ratios. A primary basis for such reduction ratios is the list in table 19 of 12 extreme storms (those noted by asterisks) for which point or l-mi2 data are available at 1 hr. A problem with the data from these 12 storms is the limited area of most storms. Nearly 60 percent have an areal extent of less than 240 while one fourth of them

Table 21.-Extreme 1-hr amounts used as support for 1-hr l-mi2 PMP Location of storm center

CONSTRUCTION SEQUENCE

CONSTRUCTION SEQUENCE

The construction sequence will consist of and riprap placement

Clearing

Clearing will begin with the removal of the trees. This is usually accomplished by cutting down large trees with chain saws and letting them fall or dragging them down the slope with the use of chains and machines such as bulldozers, backhoes and/or hydraulic excavators.

Riprap Placement

Placement of the rip rap begins at the bottom of the slope and works toward the top. Hydraulic excavators can place the first several feet of riprap on the slope. Once the placement front is beyond the reach of the excavators, a small crane outfitted with a clamshell type bucket is used to place the riprap. The crane is initially located at the bottom of the slope and is then relocated to the top of the slope once the riprap is approximately half way up the slope. Riprap placement can be resumed by hydraulic excavators at the top of the slope once the placement front is within reach.

Generally a geotextile is place between the riprap and the slope to separate the subgrade from the riprap. Due to the lifetime requirements of this project a filter blanket should be used between the riprap and the subgrade. For the R-4 riprap used for this slope, the Pennsylvania Department of Environmental Protection (PADEP) Erosion and Sedimentation Control Program Manual recommends the 4-inch thick filter rock having a gradation meeting the requirements of NSA size FS-2.

The quarries in the vicinity of the site are generally limestone quarries. Limestone generally meets or exceeds the requirements however quality assurance testing should be completed prior to placement of the material. It may be advantageous to use diabase form the Dyer quarry in nearby Birdsboro, PA. Because it is not a limestone, it would be expected to be resistance to dissolution.

RADIOLOGICAL ASSESSMENT

FOR

READING SLAG PILE SITE

Prepared for:

Cabot Corporation
Two Seaport Lane
Boston, MA 02210

Prepared by:

ST Environmental Professionals, Inc.
114 Lutz Road
Boyertown, PA 19512

Revision 3
June 2005

ST Environmental Professionals, Inc.

RADIOLOGICAL ASSESSMENT

FOR

READING, PENNSYLVANIA SLAG PILE SITE

Prepared for:

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Two Seaport Lane
Boston, MA 02210

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Revision 3, June, 2005

TABLES

FIGURES

APPENDICES

The property containing the Site has been used for industrial purposes for over 100 years and is designated for industrial/commercial and related uses in redevelopment plans for the Site. Future residential use is highly unlikely.

The Decommissioning Plan incorporates emplacement of 1.0-foot thick layer of rip-rap, on the slag pile slope face and along the top edge. A 2.3-foot thick rip-rap apron will extend 11 feet from the bottom of the slope into the River Road ROW to anchor the slope. The rip-rap is intended primarily for added assurance that erosion will not occur over the period of interest. Given this limited purpose and the self-armoring properties of such measures, this feature constitutes a passive engineered barrier, as described in NRC guidance (USNRC, 2003b, Section 3.5). The rip-rap cover is designed to remain effective for erosion control for 1,000 years without maintenance. Consequently, no institutional controls will be required after license termination.

Three basic exposure scenarios were developed and evaluated as a base or primary analysis for the slag pile:

- A worker preparing the Site and constructing the rip-rap layer (WRR-P)
- A trespasser who walks on the slag pile slope face after license termination (TRR)
- A worker on the Site after license termination who spends part of his work day in a facility assumed to be located on the flat surface at the top of the slag pile and a portion of his work time in activities involving walking on the slag pile slope face. (WRR)

A separate analysis was performed for the River Road ROW Area under the current conditions. Development of scenarios for analysis recognizes the limited potential uses of the ROW segment. The most severe exposure scenarios would likely involve some kind of occasional recreational use or occupational use involving excavation. Even in those scenarios, exposure time would be small. Two basic exposure scenarios were developed for purposes of analysis:

- A recreational walker who routinely walks on the ROW segment for exercise or pleasure (RWWLK)
- A worker who participates in excavation in the ROW segment (RWWRK)

The maximum calculated dose for each scenario is presented below in both tabular and graphic form and is compared to the 25 mrem/y limit (10 CFR 20 Subpart E) for unrestricted release. As shown, the maximum calculated doses are all substantially less than the limit for unrestricted release. Some of the material in the ROW will be covered with a 2.3-foot thick layer of 9" rip rap. The rip-rap cover will eliminate some of the potential exposure and further reduce the modeled dose.

Based on the difference in elevations in 1904 and 1997, total volume of radiological slag, non-radiological slag, fill and debris on the property was calculated to be approximately 3,000,000 ft^3. Therefore, the pure radiological slag represents approximately 0.22 % of the total volume of the slag, fill, and debris at the property.

Although the original Site characterization indicated the presence of some slag beyond the toe of the slag pile, the extent of those depositions appeared to be limited and the concentrations of radionuclides within the depositions were in the range of the concentrations of naturally occurring radionuclides. Consequently, at that time, explicit radiological assessment for these materials was considered unnecessary.

Supplementary characterization work was performed after submittal of the original Radiological Assessment and Decommissioning Plan (Revision 0, August 1998). This work included a topographic survey of the slag pile and additional radiological characterization of materials beyond the base of the slag pile (STEP, 1999 and STEP, 2000). This work indicated that the volume of the slag/soil mix in the River Road ROW was approximately 10,000 ft^3 to 20,000 ft^3. This assessment includes an explicit radiological assessment for materials in the River Road ROW under current conditions without the rip-rap cover in place.

The Site topography, climate, physiography and geology, soils, surface water hydrology, and groundwater hydrology are described in detail in the Decommissioning Plan (STEP, 2005), the Hydrologic and Geologic Assessment Report (STEP, 1997), and the Report on Topographic and Radiological Surveys (STEP, 1999).

The thickness and rock size for the proposed rip-rap cover design were calculated using NRC guidance document NUREG-1623. It should be noted that passive engineered barriers are typically constructed to inhibit water contacting the waste, limit releases, or mitigate doses for inadvertent intruders. The physical characteristics of the slag and Site already eliminate water pathways and release of radionuclides from the slag and limit exposure to an inadvertent intruder. The barrier is being proposed as a method to provide additional assurance that the characteristic Site features are robust.

Even without the addition of the rip-rap cover, it would be unlikely that erosion would expose a significant amount of slag. The Site characterization efforts and historical documents indicated that the material covering the slag contains large pieces of rock, reinforced concrete, and metal scrap. Some of the rock was intentionally placed by the licensee following operations. These large pieces of durable material provide for long-term protection from erosion through the natural process of self-armoring. If any erosion did occur, the fine materials would be preferentially removed leaving the large pieces as a cover preventing further erosion. A radiological survey performed by Cabot in 2003 indicated that the existing cover was nearly but not entirely covering the radiological slag. The potential exposure of a small area of slag would not result in modeled exposures above the regulatory limit for release without restrictions. However, the exact amount and disposition of large durable pieces of material within the cover was not known.

Therefore, the exact area of slag that could potentially be exposed, although likely to be small, was uncertain. The installation of the rip-rap cover ensures that the entire slag pile is covered by durable material that will provide additional assurance of long-term erosion protection.

The rip-rap cover on the slope and top edge will consist of a 1.0 foot thick layer of durable rock sized D_{50}=6" (USA number R-4 rip-rap). This exceeds the size criteria calculated using NUREG-1623 methods of D_{50} = 1.3 for the slope. An apron of rip-rap will be placed extending 11 feet out from the toe of the slope to anchor the rip-rap cover. This will eliminate the need to excavate slag at the toe of the slope. The apron will consist of USA number R-5 rip-rap (D_{50} = 9"). This exceeds the design calculation of D_{50} = 7.2". The apron will be 2.3-feet thick to facilitate proper placement of the large size rip-rap. Additional design details are provided in the Decommissioning Plan (STEP, 2005). Figure 1-3 depicts the location and extent of the proposed rip-rap cover. Figure 3-2 depicts the typical cross section.

Installation of the rip-rap cover will consist of three primary tasks.

- Clearing will consist of cutting the trees and brush
- Surface preparation will consist of minimizing irregularities of the slope and installation of a four-inch thick filter blanket (NSA number FS-2) to separate the rip-rap from underlying materials
- Placement of the rip-rap will be performed by using excavators from the top and bottom of the slope with workers making final adjustments by hand

Total work time for all three tasks is expected to be approximately one month or 160 hours. It is likely that different workers will be performing the three tasks.

Radiological Assessment

The NRC radiological criteria for license termination are expressed in terms of radiation dose that might reasonably be expected from residual radioactive material after decommissioning. As used in this report, the term "dose" means total effective dose equivalent (TEDE), which is the quantity expressed in the NRC regulation. At the Reading Site this dose would depend upon concentrations of residual radioactive materials in soils and other remaining materials. The dose would also depend on Site-specific factors that might control potential resource use, potential migration of radioactive materials, and potential access to radioactive materials. Finally, this dose would also depend on potential activities of future users of the Site.

The radiation dose assessment process, as applied herein, includes the estimation of the maximum radiation dose (TEDE) that might be received by a typical member of a small

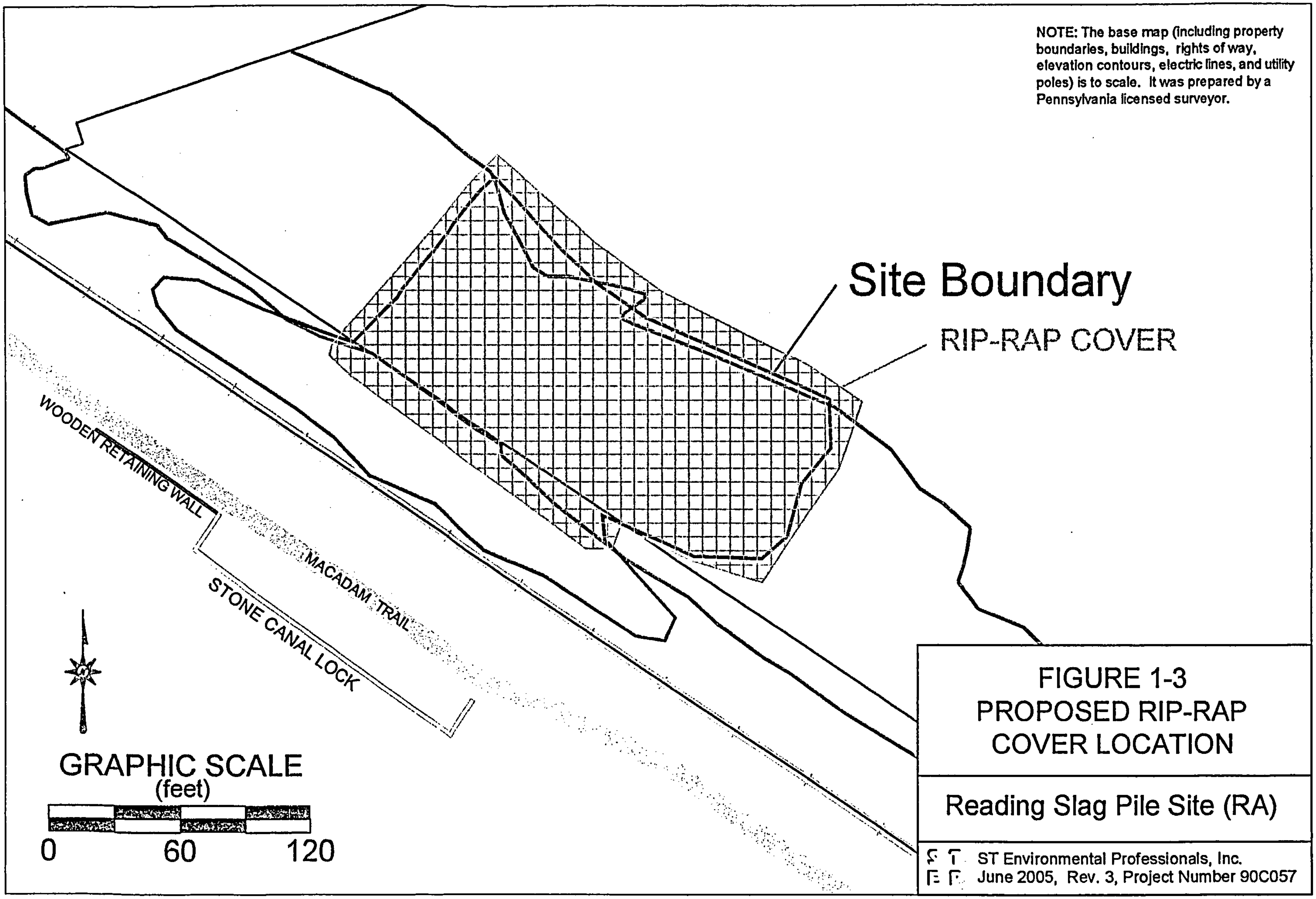


FIGURE 1-3
PROPOSED RIP-RAP COVER LOCATION

Reading Slag Pile Site (RA)

ST Environmental Professionals, Inc.
June 2005, Rev. 3, Project Number 90C057

radionuclides in this mix vary, depending largely on the concentration of radionuclide-bearing slag in the mix.

Radionuclide concentrations are highest in waste slag, discrete pieces of which range widely in size in the material mix. Concentrations of thorium and uranium, the sources of the radionuclides of interest have been measured in a number of slag samples by different organizations including analyses by the radiological health physics consultant during the operations, the NES site characterization, and the Johns Hopkins report. Those results are summarized in previous Cabot-NRC correspondence (Cabot, 2002) Concentrations of thorium in this slag are quite uniform at about 0.31 weight percent (wt %). The maximum measured concentration was only about 50% higher than the average. Measurements of uranium concentrations in slag are not as numerous as the measurements of thorium and the results indicate more variability in uranium concentration. (However, as will be shown, the thorium radionuclides are more important contributors to dose, so the variability in uranium concentration does not significantly affect uncertainty in calculated doses.) The arithmetic average uranium concentration in waste slag is 0.05 weight percent (wt %). However, uranium measurements were more frequent among samples containing relatively low concentrations of thorium, which could bias uranium concentration results to the low side. For this reason, these thorium and uranium results from each measurement were used to calculate a uranium/thorium mass ratio. The average uranium/thorium mass ratio, 0.41, was then applied to the average thorium mass concentration to derive a uranium mass concentration of 0.13 wt %. The average measured thorium concentration of 0.31 wt % and the derived average uranium concentration of 0.13 wt % were used to calculate radionuclide concentrations in undiluted waste slag—670 pCi/g total thorium (Th-232 + Th-228) and 871 pCi/g total uranium (U-238 + U-234).

Average radionuclide concentrations in the material mix on the slag pile can be calculated from average nuclide concentrations measured in slag and soil material bearing licensed radionuclides. Direct radiation measurements of radiation exposure rate at 1-m above the surface can also be used to estimate nuclide concentrations in soils near the surface. Results of direct radiation measurements and measurements of nuclide concentrations in surface and subsurface soil samples from the slag pile are provided in the characterization report for the Reading slag pile (Cabot, 1996a and NES, 1996a and 1996b).

Average net activity concentrations may be calculated from data in the Characterization Report (NES, 1996a). The average net (background subtracted) activity concentration in the slag/soil/debris mix is approximately 75 pCi/g of combined thorium (Th-232 and Th-228) and uranium (U-238 and U-234). (This net activity concentration is the result of subtraction of 2.6 pCi/g total uranium and 2.5 pCi/g total thorium from gross measurements, as explained in the Characterization Report.) Of the 75 pCi/g total uranium and thorium, about 22.5 pCi/g is thorium-232 and 15 pCi/g is uranium-238. Progeny from these two nuclides can be assumed to be present at equilibrium concentrations. This estimate is based on the average measured concentrations from the surface to a depth of 16 feet in Boreholes 1, 3, 4, 5, 15, and 16 at the top of the pile. The

of exposure pathways and exposure scenarios, based on the foregoing consideration of Site-specific features.

3.2 SITE-SPECIFIC CONSIDERATIONS

For the Reading Site, there are important Site-specific considerations that shape potential exposure scenarios. These have been considered, as described below, in the development of scenarios for potential radiation exposure to residual radioactive materials at the Reading Site.

Based on review of Sanborne maps, the property containing the Site has been used for industrial purposes for at least 100 years. The historical zoning designation for the property was HM (Heavy Manufacturing). The City of Reading and Berks County have designated the area containing the Site as an urban redevelopment area. As part of that process, the area containing the Site has been designated for industrial/commercial and related uses. The Reading Redevelopment Authority has razed the former buildings and is currently in the process of preparing the property for construction. Discussions with potential industrial tenants are in progress.

Development of the former Dana property north of the Site has been partially completed with the construction of roads and other infrastructure. Plans by a committed tenant of that property include the use of the River Road ROW as an access route in the near future.

Considering the likely schedule for completion of plans and development of the property (1 to 3 years) and the typical longevity of commercial or industrial facilities (50 to over 100 years), the use of the property is not expected to change in the foreseeable future. In accordance with NRC guidelines, the planned near-term use of a site is appropriate for dose modeling assumptions. The combined past and planned tenure of industrial/commercial use is approximately 200 years or 20% of the 1,000 year period of interest. This provides a good deal of confidence that the scenarios modeled are representative of both the long-term as well as short-term uses of the site.

Ground surface elevation data from the 1904 Sanborne map showed an approximately uniform slope from the Schuylkill Canal to Tulpehocken Street. Over the past 101 years, fill, consisting of slag and other materials, has been used to improve the topographic profile of the industrial property. The improvements have created a large level area extending from Tulpehocken Street to near the southwestern property boundary. As shown in cross section BB' (Figure 3-1), the current profile provides the maximum area of level ground suitable for industrial use within the property boundaries. The following features of the current configuration represent the optimal profile for industrial or commercial use.

- The maximum possible area of continuous level ground is available for buildings or parking areas

embankment, the radiological slag would likely be buried beneath non-radiological slag. Any development of the areas containing radiological slag would result in a cover of soil or pavement. Either scenario greatly reduces the already low calculated potential dose.

If, as concluded in NUREG-1703, the radiological component is preferentially contained in the large hard glassy blocks of waste slag, then the probability of significant activity being available for exposure is extremely low. The large blocks of slag that do not leach uranium and thorium would not contribute to water-born or air-born pathways. Direct dose would be unlikely because the blocks would not be left exposed in any setting normally occupied for any but short time periods.

The RA calculated potential doses from the thin (1-foot to 2-foot thick) limited area of dilute radiological slag in the River Road ROW. Those results demonstrated that potential dose was below 1 mrem/yr for all scenarios considered. The limited extent and concentration of the ROW material ensures that any movement or change would likely reduce the dose. It is highly unlikely that the material could inadvertently be placed in a configuration that would lead to a dose above the 25 mrem/yr limit for release without restrictions. In addition, some of the material will be beneath a 2.3-foor thick rip-rap cover eliminating potential exposure and any reasonable probability of movement

Conclusions Regarding Movement of Slag

The above considerations lead to the following conclusions regarding the potential for relocation of slag materials:

- Offsite relocation of the slag is very unlikely and would result in reduced exposure, concentration, and potential dose.

- On-site redistribution of slag would result in reduced exposure, concentration, and potential dose.

Consequently, exposure scenarios appropriate for evaluation of this Site against regulatory criteria in 10 CFR Part 20, Subpart E, are confined to those that assume the material remains in place. However, hypothetical scenarios involving potential exposure associated with the process of relocation of this material to some unspecified and uncontrolled surface location and potential exposure of a worker who spends a portion of his work time on the relocated material have been included for evaluation as alternate scenarios.

3.5 EXPOSURE SCENARIO AND PATHWAY DEFINITION

License termination decisions can sometimes be based on analysis using simplified generic screening exposure scenarios. Screening exposure scenarios are based on conservative exposure assumptions that typically cause doses to be overestimated. While they may be useful for screening purposes, they are not suitable representations of

slag pile solid to the concentration in water percolating through it) were set at 1,000 mL/g to simulate this effect.

Compliance Scenarios

Three exposure scenarios were judged to be sufficiently realistic for determination of compliance with regulatory limits. Each is described in turn below:

WRR-P—Worker placing rip-rap on slope, including clearing and grubbing—Worker conservatively assumed to work full time on the slope for the duration of the job, one month

Source: 25 pCi/g U+Th (current near-surface)
Cover: none
Time: 160 h/y on slope (0.0183 y)
Inhalation rate: 1.74E4 m^3/y (heavy)
Dust in air: 7.0E-4 g/m^3 (heavy)
Soil ingestion rate: 36.5 g/y

TRR—Trespasser on rip-rap after license termination—Trespasser walks on slope with rip-rap 3 hours per week, 6 months per year

Source: 25 pCi/g U+Th (current near-surface)
Cover: 1.0 ft rip-rap (0.8 ft solid equiv, 2.2 g/cm^3) (dose reduction from soil blanket is ignored)
Time: 72 h/y on slope (0.0082 y)
Inhalation rate: 1.24E4 m^3/y
Dust in air: 2.0E-4 g/m^3
Soil ingestion rate: 36.5 g/y

WRR—Worker on top of slope and on rip-rap on the slope after license termination—Worker works on radiologically affected area 10% of his work time, or 200 h/y, of which 20 h/y is walking on slope with rip-rap and 180 h/y is in building with 6" concrete floor on the flat surface at the top of the slag pile.

Source: 25 pCi/g U+Th (current near-surface)
Cover: 1.0 ft rip-rap (0.8 ft solid equiv) on slope (dose reduction from soil blanket is ignored); 6 in concrete on top (no rip-rap assumed)
Time: 180 h/y indoor at top (0.021 y) and 20 h/y outdoor on slope (0.0023 y)
Direct dose reduction factor: indoor—0.19; outdoor—1
Inhalation dose reduction factor: indoor—0.4; outdoor—1
Inhalation rate: 1.24E4 m^3/y
Dust in air: 2.0E-4 g/m^3
Soil ingestion rate: 36.5 g/y

condition, 180 h/y is in building with 6" concrete floor on the flat surface at the top of the slag pile.

Source: 25 pCi/g U+Th (current near-surface)
Cover: No cover on slope; 6 in concrete on top (no rip-rap assumed)
Time: 180 h/y indoor at top (0.021 y) and 20 h/y outdoor on slope (0.0023 y)
Direct dose reduction factor: indoor—0.19; outdoor—1
Inhalation dose reduction factor: indoor—0.4; outdoor—1
Inhalation rate: 1.24E4 m^3/y
Dust in air: 2.0E-4 g/m^3
Soil ingestion rate: 36.5 g/y

Alternate Scenarios—Hypothetical Limited Excavation

WRR-LE (RIS-2004-08 alternate scenario)—Worker conducting limited excavation on slope covered by rip-rap (e.g., laying pipe or cable across slope), exposed to radionuclides in excavated slag and soil for 10 hours in one year

Source: 10 m^2 by 6 ft deep mix of 1.0 ft rip-rap (0.8 ft solid equivalent), 1.0 ft soil containing 15 pCi/g total Th and 10 pCi/g total U, and 4.2 ft of undiluted waste slag. (The dose reduction from the soil blanket is ignored.) Waste slag is assumed to contain 0.307 weight % Th (based on analysis of samples) and 0.128 weight % U (based of the average measured ratio of U/Th in samples analyzed for both. These concentrations correspond to 670 pCi/g total Th and 871 pCi/g total U for undiluted slag. The excavation mix average is 472 pCi/g total Th and 670 pCi/g total U.
Cover: none
Time: 10 h/y on slope (0.0011 y)
Inhalation rate: 1.74E4 m^3/y (heavy)
Dust in air: 7.0E-4 g/m^3 (heavy)
Soil ingestion rate: 36.5 g/y

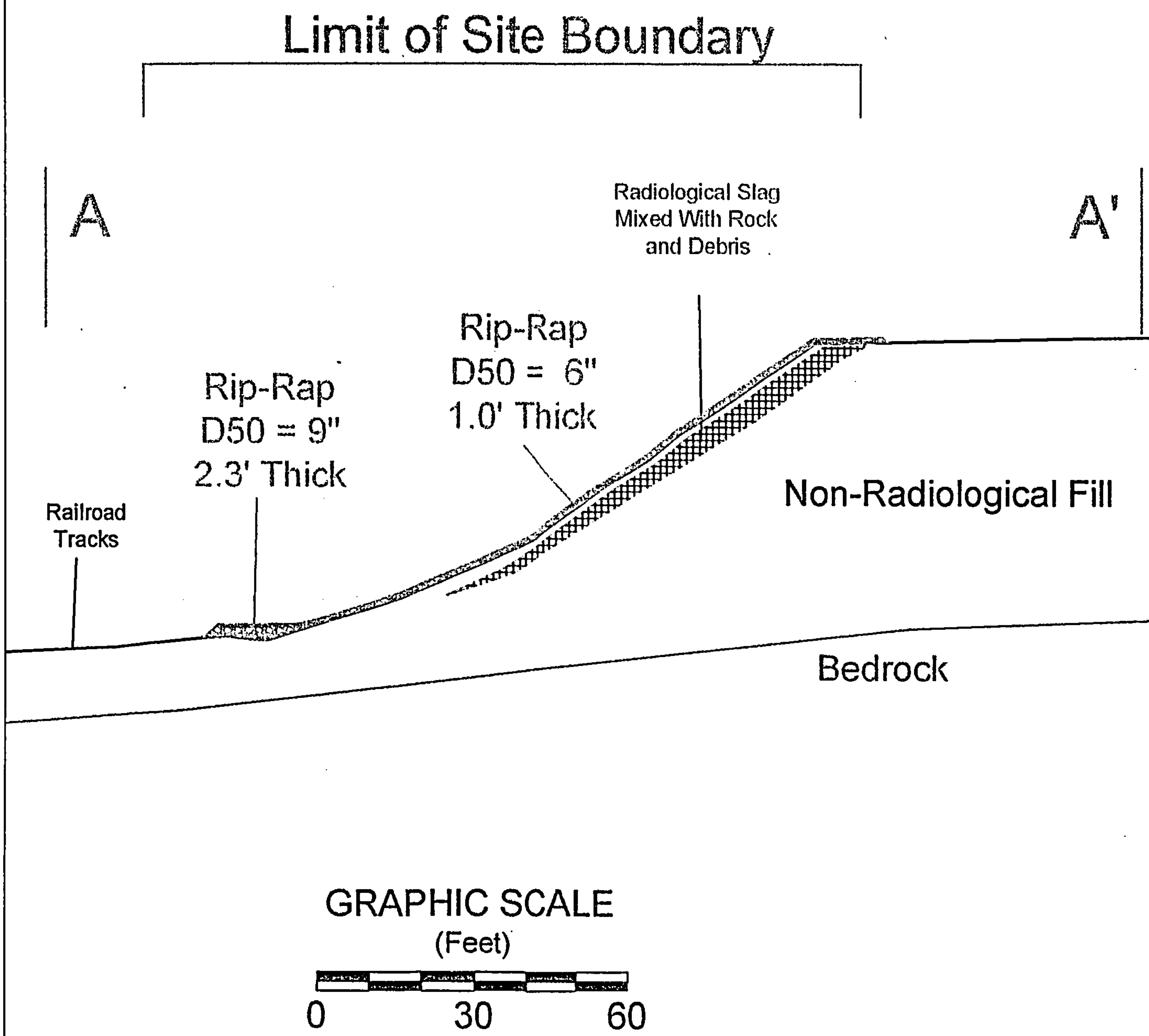
TRR-ALE (RIS-2004-08 alternate scenario)—Trespasser on slope covered by rip-rap after limited excavation redistributes some excavated slag radionuclides to the surface—Trespasser walks randomly on slope 3 hours per week, 6 months per year

Source: Excavated material in a strip 3 ft wide by 170 ft long contains 472 pCi/g total Th and 670 pCi/g total U, as described in Scenario WRR-LE. For walking randomly on the slope of approximately 19,600 ft2, this is equivalent to slope area average concentrations of 12.3 pCi/g total Th and 17.4 pCi/g total U.
Cover: none
Time: 72 h/y on slope (0.0082 y)
Inhalation rate: 1.24E4 m^3/y
Dust in air: 2.0E-4 g/m^3
Soil ingestion rate: 36.5 g/y

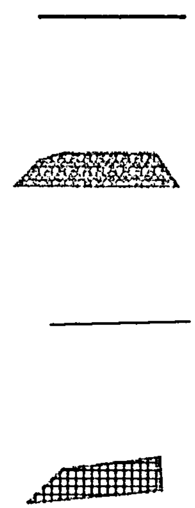
RWWRK—ROW worker—Worker exposed along the River Road ROW below the slope during excavation for 40 h/y of soils bearing low concentrations of slag radionuclides.

Source: 25 pCi/g U+Th (current)
Cover: none
Time: 40 h/y on slope (0.0046 y)
Inhalation rate: 1.74E4 m^3/y (heavy)
Dust in air: 7.0E-4 g/m^3 (heavy)
Soil ingestion rate: 36.5 g/y

Because radionuclide concentrations in River Road ROW materials are well characterized and because scenario and parameter value uncertainties are small, analysis of alternate scenarios for exposure to radionuclides in River Road right-of-way materials is unnecessary. In addition, the assessment does not take into account the reduction of dose due to the 2.3-foot thick rip-rap that will cover some of the radiological slag in the ROW.



LEGEND



- Ground Surface
- Rip-Rap Cover
- Top of Bedrock
- Approximate Location of Radiological Slag

FIGURE 3-2
TYPICAL CROSS SECTION
OF RIP-RAP COVER

Reading Slag Pile Site (RA)

ST Environmental Professionals, Inc.
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