August 7, 2006

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Boyertown, PA 19512

U.S. Nuclear Regulatory Commission
ATTN: DOCUMENT CONTROL DESK
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11555 Rockville Pike
Rockville, MD 20852-2738

Subject: Addendum 1 to Reading Slag Pile Site Decommissioning Plan
Design of Riprap Cover
License No. SMC-1562
Docket Number 40-9027

Document Control,

Please find enclosed one copy of the subject report submitted on behalf of Cabot Corporation.

Please contact Mr. Theodore Smith of the NRC if you have any questions.

Yours truly,

Steffan R. Helbig

Steffan R. Helbig, President

cc: Theodore Smith, NRC (5 copies)
Wayne Reiber, Cabot (4 copies)

Enclosure

NMSS01

ADDENDUM 1

TO

READING SLAG PILE SITE DECOMMISSIONING PLAN (Revision 4) Design of Riprap Cover

Prepared for:

Cabot Corporation
Two Seaport Lane
Boston, MA 02210

Prepared by:

ST Environmental Professionals Inc.
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Boyertown, PA 19512

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STEP

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1.0 INTRODUCTION

In March 2000, Cabot submitted Revision 1 of the Reading Slag Pile Site Radiological Assessment (RA-1) and Decommissioning Plan (DP-1) that to the U. S. Nuclear Regulatory Commission (NRC). Those documents concluded that the site-specific conditions indicated that release without restrictions was appropriate. The pertinent site-specific conditions included:

- Characteristics of the slag -
    - Large hard glassy chunks that will not weather significantly
    - No leaching
    - No appreciable inhalation or ingestion pathway, primarily direct dose
    - No realistic scenario where large areas of pure slag are exposed and human presence is common
    - Not suitable for agriculture or turf
- Configuration of the slag
    - Buried beneath steep slope
- Past and expected future land use
    - Industrial/Commercial 100 + years and planned for 50+ years
    - Transportation corridor
- Physical setting
    - Steep inaccessible slope
    - No groundwater pathway
    - Optimal grading for maximum utilization

Based in part on a draft report by Johns Hopkins University, the NRC had concerns regarding the characterization of the radiological inventory at the site and potential future erosion of the existing cover.

The characterization issue was addressed in the Report on Johns Hopkins Progress Report and Related Items (Cabot 2002). The response demonstrated that the quantity of slag present was unlikely to be significantly different from the reported 600 tons and that the maximum activity was very well characterized.

On March 21, 2003, the NRC issued a request for additional information. Cabot was confident in the Revision 1 conclusions. However, Cabot was concerned that the inherent difficulty of predicting specific erosion scenarios and uncertainty regarding the composition of the existing cover would delay the decommissioning process. On February 3, 2004, Cabot proposed the addition of a riprap cover to address the issues and expedite the license termination process. The NRC responded on August 27, 2004 that the concept was acceptable and provided suggestions regarding necessary information for their review.

In May 2005, Cabot submitted Revision 2 of the Reading Slag Pile Site Radiological Assessment (RA-2) and Decommissioning Plan (DP-2) that included the addition of a riprap cover to the U. S. Nuclear Regulatory Commission (NRC).

In June 2005 Cabot submitted Revision 3 of the Reading Slag Pile Site Radiological Assessment (RA-3) and Decommissioning Plan (DP-3) that included additional details and analyses. The revisions were a response to ongoing redevelopment activities at the property that contained the Reading Slag Pile Site.

All dose scenarios in the RA-3 considered, except for major excavation, essentially assumed an infinite thickness and quantity of buried slag. The calculated dose for the alternative scenario of major excavation was less than 1/10 of the 25 mrem/year criterion and, therefore, the RA-3 conclusions are not sensitive to even very large uncertainties in characterization. Cabot is confident that there is no more than a fractional uncertainty in the slag characterization. There was not enough physical space available to have allowed for the placement of a sufficient volume of slag to result in the dose calculations exceeding the release criteria.

A letter from the NRC to Cabot (Sept 9, 2005) indicated that they would proceed with the review of the Revision 3 submissions and indicated general areas where more detailed design information would likely be requested. To expedite the process, a series of conference calls were implemented to interactively discuss the technical details that would be applicable.

This addendum provides the technical design details of the riprap cover Cabot believes will satisfy the NRC reviewers. The cover design provides an additional level of assurance and eliminates the issue of future erosion.

This addendum is incorporated into the Radiological Dose Assessment and Decommissioning Plan by reference provided in revision pages being submitted under separate cover.

2.0 USE OF RIPRAP COVER

A riprap cover is being considered only to eliminate the possibility of future erosion resulting in complete removal of the current cover material and exposure of a large area of pure slag. To result in a projected dose greater than the 25 mrem/year criterion, requires the unreasonable assumption that all current cover material is completely removed while pure slag remains completely in place and people spend unreasonably long periods of time on a steep hillside of pure slag. Cabot has decided that a riprap cover may present a quicker and simpler path to decommissioning as opposed to a protracted debate on the composition of the existing cover and potential erosion and exposure scenarios.

The cover is designed with the objective of remaining intact for the 1,000 year period of interest without reliance upon maintenance. To achieve this objective, a robust design approach was used that is consistent with NRC's erosion control guidance in NUREG-1623 However, to satisfy the decommissioning criteria it only needs to ensure that the slag pile remains partially covered. Simple bounding calculations provide an indication of the robustness of the Decommissioning Plan.

Historical measurements and scaling of information in RA-3 indicated that exposure to an infinite area of pure slag would result in a direct dose of approximately 1 mrem/hour. Some perspective is provided by comparison of this estimated dose to decommissioning 25 mrem/year dose criterion for unrestricted use that is applicable to the site, as well as the 100 mrem/year public limit for operating facilities. Any exposure time less than 25 hours/year on pure slag would result in a dose lower than 25 mrem/year. The potential slag area comprises approximately 25% of an identical steep slope area. Based on characterization data, the area where pure slag is actually present is considerably less. The time spent on the slope that would lead to exceeding 25 mrem/year can be estimated based on the percentage of pure slag exposed and the overall time spent on the entire slope. Table 2-1 provides those numbers for various scenarios

It is difficult to imagine any realistic scenario where an individual worker would spend 24 minutes (5% of their work day) on a steep slope of pure slag. Therefore, even the unrealistic scenario of complete exposure of the entire slag pile does not result in a realistic probability of exceeding the criteria. Any coverage provided by the riprap in the future increases the confidence that the decommissioning will be successful. Because the cover is designed to remain intact for the 1,000 year period of interest, the probability of exceeding 25 mrem/year is essentially zero.

The review and acceptance of this addendum and Decommissioning Plan should be based on the criteria that the riprap cover provides additional assurance of some coverage throughout the 1,000 year period of interest. Even fractional coverage ensures that the dose criteria will be met.

Table 2-1 - Estimated Dose on Pure Slag
Reading Slag Pile Site Decommissioning Plan Addendum

Percent of Pure Slag Area Exposed	Hours Required on Pure Slag Area to Exceed 25 mrem/year Dose	Hours Required on Overall Slope to Exceed 25 mrem/year Dose	Hours/Minutes per Working Day (250d/year) Required on Overall Slope to Exceed 25 mrem/year Dose
100	25	100	0.4/24
75	25	135	0.55/33
50	25	200	1.25/75
25	25	410	1.65/99

3.0 SELECTION OF DURABLE RIPRAP MATERIAL

The cover design process and process for selecting a durable material for the Reading Slag Pile Site was based on NRC's criteria and procedures in NUREG-1623.

Purpose of Durable Rock

The acceptance criteria for the riprap material include both the current properties of size, strength, and density sufficient to resist erosion and also the ability to maintain those properties during the 1,000 year period of interest (durability). The material must be sufficiently durable to resist weathering and maintain its size throughout the 1,000 year period of interest.

Approach for Selecting Durable Rock Using NRC Guidance

Cabot utilized the NRC guidelines in NUREG-1623 and NUREG-1757, Supplement 1 to select and analyze available durable rock for use as a cover. The NRC guidance in NUREG-1623 has been used successfully for over 10 years by NRC and DOE to select durable rock for construction of erosion covers at numerous uranium mill tailings sites that are designed to remain stable for up to 1,000 years (NUREG-1623, p. 14) without reliance upon active ongoing maintenance. The primary potential failure mechanisms for riprap involve processes that would reduce the effective size of the riprap and its ability to resist erosion. Those processes include:

- Weathering of the riprap converting some or all of individual pieces into "soil"
- Weathering of the riprap reducing the size, density, and strength
- Dissolution of carbonate riprap
- Dissolution of carbonate veins
- Breakage along joints, bedding planes, clay seams, or other zones of weakness in the riprap
- Disaggregation of the riprap due to presence of expanding lattice clay minerals

The NUREG guidance provides an approach to evaluate the riprap for properties that would lead to failure.

The NUREG guidance was developed primarily to address uranium mill tailings in the western United States but was intended by NRC for use at other sites, including decommissioning sites. Due to the steep slope, and proximity to the Schuylkill River, and potential of a major flood to affect the slope, Cabot decided to follow the NUREG-1623 guidance and use a rock cover instead of a vegetative cover, provide a cover design that would not rely on maintenance, and to facilitate regulatory review.

The ability of various rock types to resist weathering can be inferred by the relative topographic relationships prevalent throughout the United States. Basic geologic observations provide an indication that rock types can be placed in a general order of durability ranging from the least durable; evaporates through shale, sandstone, carbonates, and crystalline metamorphic and igneous rocks. The degree of fracturing, lithification, calcite veins, and mineralogical composition also have a significant influence on rock durability. The guidance focuses on the presence of clay minerals or minerals that could rapidly weather to clay minerals.

The ubiquitous association of western uranium deposits with sedimentary formations often results in a lack of a nearby source of obviously durable riprap. Often the best available material consists of sandstone. NUREG-1623 deals extensively with methods to determine if a particular sandstone is suitable and what amount of over sizing is needed to ensure performance over a 200 to 1,000 year period.

In the general vicinity of the Reading site there are numerous sources of various types of rock available including limestone, dolomite, granitic gneiss, diabase, sandstone, and shale. Cabot eliminated consideration of the carbonate rocks (limestone and dolomite) because of potential dissolution over the 1,000 year period of the rock or calcite veins. Shale and sandstone were eliminated because of potential weathering and frost wedging effects that might reduce the size. Of the two remaining rock types, diabase was believed to be more resistant to weathering. It was also denser than other available rock types providing a greater resistance to erosion for a given size and thickness. Due to its density, hardness, and general lack of extensive fractures the diabase is more difficult to quarry and handle and therefore more expensive. The additional expense is partially offset by lower shipping cost because the diabase quarries were closer to the site. Cabot decided that the additional cost was justified because of the superior properties of the diabase rock.

The early Mesozoic intrusive rocks in southeastern Pennsylvania have been described in general references and commercially using the somewhat generic term of diabase. More specific classifications have been provided by various authors studying specific intrusives. The term diabase is used in this report as a general term for consistency with some references and general terminology used in the area.

In southeast Pennsylvania, the durability of diabase is obvious based on direct general observations. In addition to the test results and references cited, this author (Steffan R. Helbig, P.G.) has extensive personal experience relating to diabase exposed at the surface and in excavations. The evaluation process described in NUREG-1623 and NUREG-1757 is presented below.

Description of the Rock Source

Cabot's review resulted in the selection of the Dyer Quarry in Birdsboro, PA as the source for the riprap cover material. The Dyer Quarry is located approximately 7 miles southeast of the site and is shown on Figure 3-1.

The quarry was inspected by representatives of Cabot and the NRC. The diabase was observed to be generally massive and uniform with moderate to slight jointing (greater than 1 foot and up to several 10's of feet spacing). There was one area that displayed closer parallel jointing (less than 1 foot) apparently due to either flow structure or a fracture zone. The contacts with the country rock consist of a finer grained chill zone.

In the uppermost bench, remnant residual soil and weathered diabase boulders were present. Some boulders displayed spheroidal weathering features. A few small pieces of weathered diabase were observed. However, nearly all the spheroidal boulders observed had only a thin (mm scale) weathering rind beneath which the rock was unweathered and hard. A few rock fragments that had been quarried in the upper zone had an occasional very thin weathering rind on preexisting fractures. Nearly all the quarried pieces displayed clean unweathered surfaces. Lower benches displayed less indications of weathering.

The quarry operator reported that the country rock consisted of baked sandstone that will not be quarried for the riprap. Inclusions of country rock were not observed or noted during the inspection.

During the site visit, the larger boulders were being broken by a hydraulic jackhammer attached to a tracked excavator. The quarry operator indicated that due to its strength, hardness, and general lack of fractures, the diabase was difficulty and expensive to quarry. The additional cost, as compared to other available rock types in the area, was offset by the favorable physical properties of the product. The operator stated that the Norfolk Southern Railroad shipped the Dyer Quarry material as far as Illinois for use as ballast. The additional cost to purchase and ship was justified by the ability of the diabase to hold up under the constant impact from railroad operations.

Description of Rock Type

Regional Distribution and Descriptions of Pennsylvania Diabase

Diabase is a massive, phaneritic, mafic, intrusive, igneous rock. It lacks bedding planes or foliation. Some anisotropy may be present due to chilled margins and occasional flow structure. Joints, induced by cooling or post emplacement stress, may also be present. The characteristics of early Mesozoic (late Triassic to early Jurassic age) diabase sheets in southeast Pennsylvania in general and the intrusive body mined at the Dyer Quarry in particular are described in various references.

Froelich, in Shultz, 1999 and others have identified three distinct types of early Mesozoic intrusives in southeast Pennsylvania; York Haven, Rossville, and Quarryville. These types are characterized as high Ti quartz-normative, low Ti quartz-normative and olivine-normative tholeiite, respectively. Figure 3-2 (from Shultz 1999) depicts the outcrop areas of early Mesozoic intrusive rocks in southeastern Pennsylvania. The Dyer quarry is located in the northern portion of the Birdsboro sheet (8a in the figure). As described in that reference, the Birdsboro sheet containing the Dyer Quarry is of the York Haven type (high Ti quartz-normative). The York Haven type is not reported as containing significant olivine.

The location of the quarry is depicted on the local geologic map in Figure 3-3.

Local Description of Dyer Quarry Diabase

The intrusive body (Birdsboro sheet) mined at the Dyer Quarry consists of a nearly vertical mass over 1,000 feet thick. The interpretive cross section (Figure 3-4) depicts the sheet extending vertically downward for several thousand feet before becoming nearly horizontal.

The description of diabase in Pennsylvania by Geyer, 1982 provides insight into the durability.

> **DIABASE (Trd)**
>
> **DESCRIPTION:** Diabase occurs in Pennsylvania primarily as dikes and sheets; the dikes are generally 5 to 100 feet thick and the sheets much thicker; in most places, the rock is dark gray to black, dense, and very fine grained, and consists of 90 to 95 percent labradorite and augite; reference section is at devils den in Gettysburg National Park, Adams County.
>
> **BEDDING:** None.

FRACTURING: Joints have a blocky pattern; well developed; moderate distance between fractures; open and steeply dipping.

WEATHERING: Highly resistant; slightly weathered to a shallow depth; weathering produces large rounded boulders mixed with thin mantle.

TOPOGRAPHY: Undulating hills of medium relief; natural slopes are moderately steep and stable; dikes form ridges.

CONSTRUCTION MATERIALS: Good source of road material, riprap, embankment facing, fill, and building stone.

The characteristics of diabase in the area containing the Dyer Quarry are also described by MacLachlan, 1983.

All diabase is dark gray, fine grained in dikes, and medium grained to locally pegmatitic in major bodies. Fresh rock is predominantly plagioclase and greenish-black pyroxene.

York Haven Type (Jdyh) is chemically a normal continental tholeiite and forms the major sheets and some dikes. Slices of metamorphosed sediment are encountered in the main sheet, and metamorphic effects may be observed extending several hundred feet into invaded sediments near the major bodies. Chill zones are characteristically uniformly microcrystalline. Maximum thickness of main sheet is probably in excess of 300 m (1,000 ft).

Excellent source of road material, riprap, railway ballast, building stone, embankment facing, and fill.

Mineralogy and Chemical Composition

The mineralogical composition of samples from the Dyer Quarry were provided by the quarry (Attachment 1) and petrographic analyses performed on additional samples for Cabot (Attachment 2). The quarry results indicated that the diabase consisted of 51% - 56% plagioclase feldspar, 17% - 36% pyroxene, 3% - 10% hornblende, 2% - 6% graphic quartz, 4% - 7% quartz, and 4% magnetite. The Cabot samples were analyzed by Construction Petrographics, Inc. (Attachment 2). The rock was reported to consist primarily of plagioclase feldspar and hornblende with lesser amounts of graphic quartz and feldspar. The analyst classified the samples as a quartz-diorite. Several grains of opaque minerals were also present.

Both results are consistent with the classification of the rock as a diorite. The composition of diorite is classified as intermediate between mafic rock types (gabbro, diabase) and felsic rock types (granite). Being more felsic than diabase, diorites are more likely to contain quartz and less likely to contain olivine.

Three sources of chemical composition results were compared:

- Analyses of samples from the Dyer Quarry (Attachment 1)

- Analyses of five samples from the same diabase sheet near the quarry (Gottfried, 1991). The sample locations were provided by Gottfried and the portion of the map showing the selected samples is depicted in Figure 3-5. Only the five samples from within 2 miles of the quarry were considered in the comparison (Attachment 2)

- The median for analyses of York Haven type diabase sheets (Froelich, 1999)

Table 3-1 provides those analytical results. Comparison of the results indicated that the results for the Dyer Quarry samples and the samples from Gottfried are fairly uniform. In addition, those results are similar to the median values for the York Haven type sheet. The chemical composition results confirm the York Haven type diabase classification of the Dyer Quarry as indicated in Shultz, 1999.

Review of the chemical analyses indicated that the diabase is also low in natural uranium and thorium. Based on the average results in Table 3-1, the total uranium and thorium activity in the diabase is approximately 1.2 pCi/g which is considerably lower than the Reading site average of 5.1 pCi/g. Placement of the cover will reduce the exposure at the site both through shielding of the slag and by lowering the average near surface background activity.

Physical Characteristics

The physical properties of the diabase were provided by the quarry and independent tests performed for Cabot. The properties reported by the quarry (Attachment 1) included an average specific gravity of 2.97 and a compressive strength of 30,000 lb/in^2. The independent tests results performed for Cabot (Attachment 2) reported a specific gravity of 2.977. The independent test report stated:

> The rock was hard. The specimen had to be struck several times with a geology hammer to break it. The rock fractured randomly. No shear fracturing occurred.

Additional physical property results are provided in later sections.

Weathering Characteristics

The weathering process of crystalline rocks, including diabase, is complex in the intermediate steps and details. However, the overall process can be characterized as the interaction of the original rock forming minerals with water and the atmosphere resulting in minerals that are stable at the earth's surface. Through dissolution, hydrolysis, oxidation, and precipitation some elements are selectively removed and new minerals are formed. The typical result is a soil containing the original insoluble minerals (such as quartz), clay minerals, and oxides.

The progression of weathering into rock varies depending on the specific rock type, climate, and location in the soil profile. In the humid temperate climate of southeast Pennsylvania, the weathering results in a residual soil or saprolite. The topography and soil thickness are a reflection of the durability of the bedrock. Greater durability results in topographic highlands. Over time, an equilibrium is established between the rate of weathering of underlying bedrock relative to the rate of soil removal by erosion, resulting in a thinner soil profile over more resistant rocks. Diabase and the igneous/metamorphic rocks of the Reading Prong underlay the highest topography in the Reading area. Based on observations and literature, the Reading Prong rocks have a well developed saprolite mantle typically 10 to over 20 feet thick. The diabase rocks have a thin mantle of residual soil as described by Geyer, 1982.

> **WEATHERING:** Highly resistant; slightly weathered to a shallow depth; weathering produces large rounded boulders mixed with thin mantle.

Based on the information available, the diabase appears to be the most durable rock in the Reading area.

The characteristics of diabase weathering observed in the quarry upper level and throughout the area by S. Helbig include the following.

- Thin soil over bedrock with numerous outcrops.
- Many areas lack any significant soil cover and consist entirely of bedrock outcrops and large boulders
- Subsurface bedrock and boulders consist of fresh rock with a thin weathering rind
- Bedrock and boulders exposed at the surface consist of fresh rock with no apparent weathering rind
- Where soil is present there is a concentration of boulders on the surface relative to the soil profile
- Saprolite is uncommon

Based on the literature and observations, the weathering of diabase in the subsurface consists of a thin zone with a fairly distinct front that progresses into the rock. This thin zone separates the residual soil from fresh unweathered rock. Thick zones of evenly weathered saprolite are rare. The weathering fronts progress inward from the bedrock surface and from fractures. As these fronts converge they result in a spheroidal shape of the remaining boulders. Weathering of diabase exposed at the surface appears to be extremely slow.

Evaluation of Acceptable Rock Quality for Long-Term Durability

Rock Durability Analysis and Score

The diabase rock has been well characterized by physical testing, inspection, and current uses. Based on the properties reported by the quarry and independent laboratory tests, the diabase easily exceed the criteria in NUREG-1623 of 85% as shown in Table 3-2

Absence of Adverse Minerals

The mineral composition of a rock has a bearing on the susceptibility to weathering that would lead to a reduction in the size of the riprap within the 1,000 year period of interest. The primary adverse minerals of concern include:

- The existence (interstitial or in veins) of expanding lattice clay minerals such as smectite
- Minerals that would rapidly weather to clay minerals such as olivine
- Carbonate mineral veins that could dissolve

Based on published literature, the York haven type diabase contains little or no olivine as would be expected for a quartz-normative tholeiite or a diorite. Olivine was not identified in the petrographic analysis of the Dyer Quarry samples (Attachment 1). That report also noted the absence of clay minerals, shale seams, or mica grains and very little weathering of the feldspar grains. No carbonate minerals or veins were reported by the quarry analyses, the independent Cabot analyses, or noted during the site visit.

Absence of Adverse Rock Heterogeneities

Heterogeneities in the rock can be planes of weakness or develop into planes of weakness. Potential adverse heterogeneities in the diabase include joints, fractures, flow zones, chilled margins, alteration zones, zones of higher porosity, and xenoliths. Nearly all of these features have been noted in the literature or observed during the site visit. However, these features comprise only an insignificant fraction of the overall rock mass and are easily recognizable and not all will actually be detrimental. For example, only joints that remain within individual pieces after the quarrying and placement operations will have a potential impact on the durability of the riprap cover.

At the Dyer Quarry the diabase consists of a massive dike approximately 1,000 feet thick. Observations during the site visit indicated that the typical joint spacing ranged from several feet to10 feet. The extreme joint spacing ranged form less than a foot in one apparent flow zone up to 30 or more feet. Other than in the upper bench, nearly all joints and fractures appeared to be unweathered. It did not appear that joints remained in individual pieces of rock after being quarried. The generally large joint spacing and lack of incipient joints is indicated by the difficulties experienced by the quarrying operations. Even after blasting and removal from the face, large impact hammers mounted on hydraulic excavators are needed to break the very large boulders into pieces small enough to be managed by conventional equipment. The excellent performance of the Dyer diabase as railroad ballast exposed to constant impact also indicates a lack of incipient joints or unexpressed planes of weakness. The size requirements for the riprap will preclude material from zones of closer joint spacing.

Chill zones are restricted to the margins of the diabase dike and can be avoided during quarrying operations for the riprap. Xenoliths were not observed during the site visit and are not believed to be common. If present, xenoliths can be identified and avoided or rejected for use as riprap. Alteration zones occur only in the surrounding country rock that will not be quarried for the riprap.

The diabase has essentially no primary porosity and a very low secondary porosity due to widely spaced joints and fractures. It is homogenous lacking bedding planes or foliation. These characteristics result in a low hydraulic conductivity. The diabase formations in southeast Pennsylvania are notorious for their poor aquifer characteristics. It is often inadequate for an individual domestic supply. The hydraulic properties of the diabase limit the rate and volume of groundwater flow through diabase and limit the rate of weathering. Fracture of flow zones with higher hydraulic conductivity are uncommon and only one was observed in the quarry. That zone did not exhibit noticeable weathering indicating that even the closer spaced joints may not be sufficiently open to allow significant groundwater flow.

General Evidence of Resistance to Weathering

The slow weathering of diabase has been described in detail above and is based on the observations of thin soils, rounded boulders, thin weathering rind, and forming topographic ridges. There are several natural analogs that provide additional assurance of the durability of diabase. Long-term investigations of the Coweeta basin in North Carolina have determined the rate of weathering of crystalline rocks composed of primarily quartz, biotite and muscovite micas, plagioclase feldspar, and almandine garnet to be approximately 3.8 cm/1,000 years (Swank, 1988). The average temperature and rainfall in the Coweeta basin is greater than in the Reading, PA area. Weathering in the Reading area would be expected to be slower than in North Carolina.

Graveyards located in the same diabase dike as the Dyer Quarry (Figure 3-1) were surveyed. Several graveyards within 2 miles of the quarry contained gravestones made from the local diabase. Representative pictures of these gravestones (Figure 3-6 and 3-7) demonstrate the slow rate of weathering of diabase. After 115 years of exposure the lettering and edges of the gravestone are sharp and only a slight staining is visible.

An additional natural analog was also obtained as an example of the general durability of mafic crystalline rocks. The following two pictures from Chebeague Island, Maine (Figure 3-8 and 3-9) show glacial striations. The bedrock consists of metavolcanics with a mafic composition. The rock has foliation and planes of weakness along micaceous partings. The glaciation that caused the striations occurred approximately 10,000 years ago. Despite aggressive frost wedging affects and foliation the striations are still evident after 10,000 years.

Conclusions

The diabase rock chosen for the cover material was selected due to its favorable physical properties, long-term durability, inherent resistance to weathering and its ability to protect the underlying materials if properly designed. Rock covers require little to no maintenance and the relatively high density of the material provides attenuation of radioactive releases.

Continued performance through the 1,000 year period of interest requires that the riprap material maintains its favorable characteristics, primarily its strength and size gradation. Degradation of the riprap performance would occur if the diabase weathered and formed a soil or if the individual pieces of rock break down into smaller fragments. Geologic references, physical testing, and direct observations provide confirmation that the diabase will remain stable and continue to meet the design criteria for the 1,000 year period of interest.

TABLE 3-1
Chemical Analyses - Diabase
Reading Slag Pile Site Decommissioning Plan Addendum

UNITS	CONSTITUENT	Dyer Quarry Analysis	Average of Five Gottfried Samples (Pbl-1, Pbl-2A, Pbl-2B, Pbl-3, Pbl-4)	Froelich - York Haven Diabase Median
%	SiO_2	52.10	53.02	51.84
	TiO_2	1.50	1.45	1.09
	Al_2O_3	14.70	15.60	14.34
	Fe_2O_3	13.10	2.78	1.18
	FeO		8.54	8.75
	MnO	0.19	0.17	0.20
	MgO	4.83	4.26	7.72
	CaO	9.60	9.46	10.73
	Na_2O	2.52	2.93	1.96
	K_2O	0.87	1.05	0.60
	P_2O_5	0.18	0.22	0.12
	H_2O^+		1.17	0.23
	H_2O-		0.31	
	CO_2		0.05	0.08
	LOI	0.32		
	Cr_2O2	0.01		
	S		0.03	
	F		0.03	
	Cl		0.09	
	Total %	99.92	101.18	98.84
ppm	Sc		31.20	
	Crt		36.34	
	Co		40.40	
	Ni		43.40	
	Zn		82.00	
	Ga		21.80	
	As		2.03	
	Rb		39.60	
	Sr		214.00	
	Sb		0.23	
	Cs		1.14	
	Ba		250.00	
	Y		27.20	
	La		16.14	
	Ce		33.68	
	Nd		17.80	
	Sm		4.80	
	Eu		1.44	
	Tb		0.85	
	Yb		2.80	
	Lu		0.40	
	Hf		3.60	
	Nb		10.82	
	Ta		0.83	
	Th		3.36	
	U		0.69	
ppb	Pd		11.32	
	Pt		7.42	
	Rh		0.50	
	Ru		<0.50	
	Ir		<0.50	
	Au		10.00	

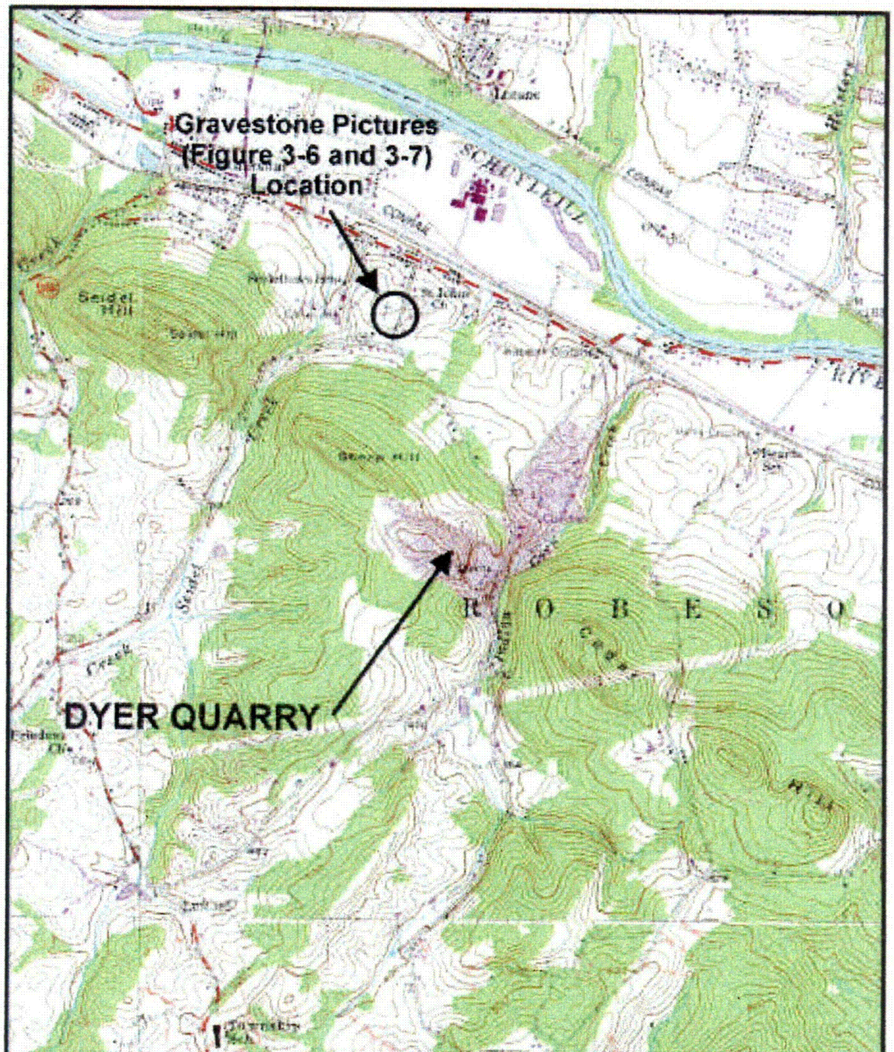
Gottfried Gottfried, David, Froelich, Albert J., and Grossman, J. N., 1991, "Geochemical Data for Jurassic Diabase Associated with Early Mesozoic Basins in the Easter United States: Western Newark Basin, Pennsylvania and New Jersey", USGS Open File Report 91-322-D
These samples were located within 1 mile of the Dyer Quarry and from the same diabase sheet.

Froelich Froelich, A. J., and Gottfried, David, 1999, "Early Mesozoic - Igneous and Contact Metamorphic Rocks", in "The Geology of Pennsylvania "Edited by Charles H. Shultz

Table 3-2 Rock Quality Score
Reading Slag Pile Site Decommissioning Plan Addendum

Laboratory Test	Weighting Factor Igneous	Test Results Provided by Quarry	NUREG 1623 Table F-2 Score	Maximum	Weighted Score Total	Maximum
Sp. Gravity	9.0	2.97	10.0	10.0	90.0	90
Absorption (%)	2.0	0.40	8.5	10.0	17.0	20
Sodium Sulfate (%)	11.0	1.95	9.5	10.0	104.5	110
L/A Abrasion (%)	1.0	17.00	2.5	10.0	2.5	10
TOTAL					214	230
Percentage						**93.0%**

Laboratory Test	Weighting Factor Igneous	Test Re-sults Provided by Lab	NUREG 1623 Table F-2 Score	Maximum	Weighted Score Total	Maximum
Sp. Gravity	9.0	3.00	10.0	10.0	90.0	90
Absorption (%)	2.0	0.22	9.5	10.0	19.0	20
Sodium Sulfate (%)	11.0	0.18	10.0	10.0	110.0	110
L/A Abrasion (%)	1.0	12.80	4.0	10.0	4.0	10
TOTAL					223	230
Percentage						**97.0%**



SCALE FEET

0 4,000 8,000

NORTH

SOURCE: USGS, Birdsboro, PA, 7.5 Minute Quadrangle

FIGURE 3-1
Dyer Quarry
Location Map

READING SLAG PILE SITE

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FIGURE 3-2
From Shultz, 1999

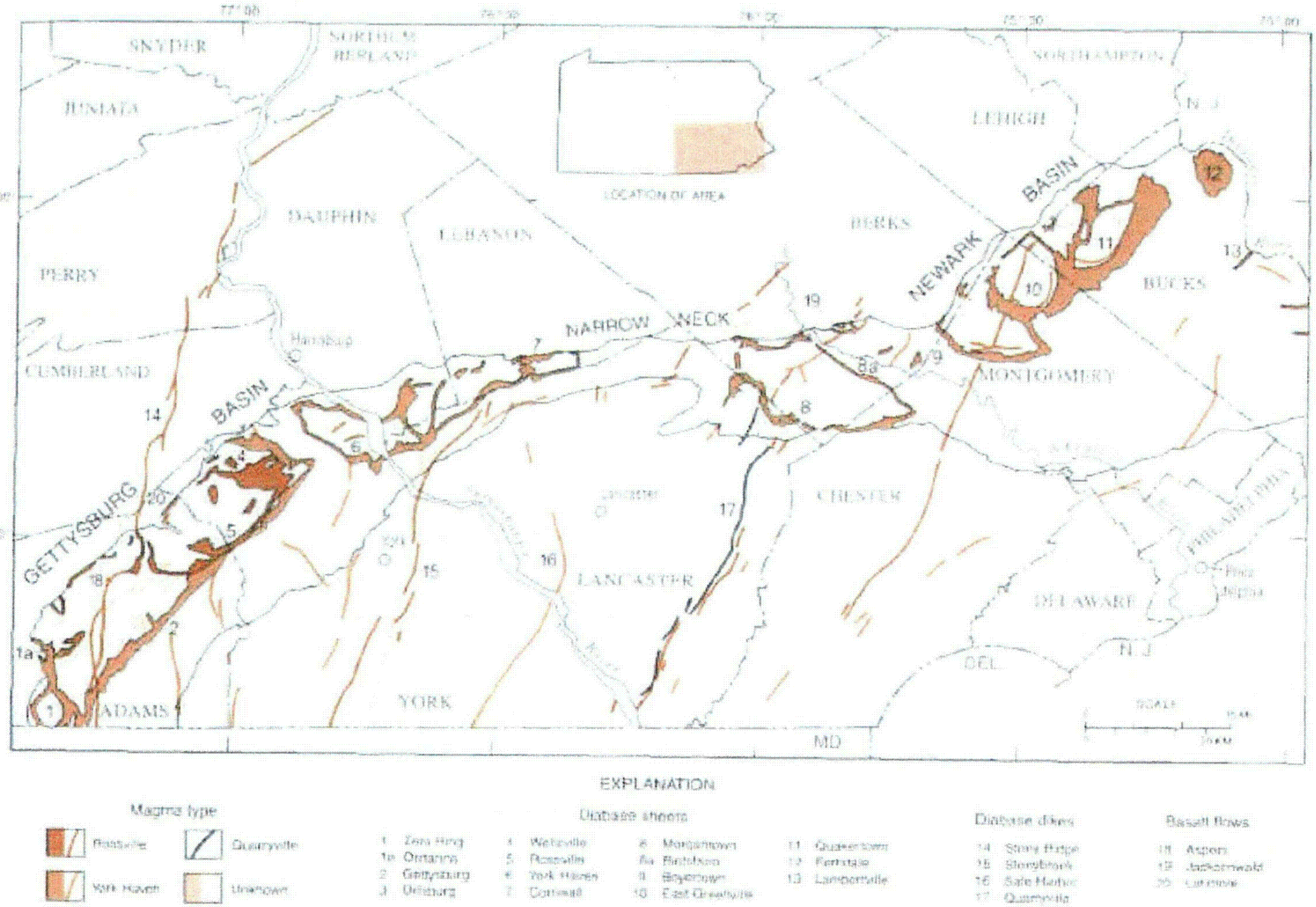

Figure 12B-1. Distribution of early Mesozoic igneous rocks in eastern Pennsylvania (modified from Lanning, 1972, Plate 1; Smith, R. C., II, and others, 1975, *Geology and geochemistry of Triassic diabase in Pennsylvania*, Geological Society of America Bulletin, v. 86, Figure 1, p. 944 [modified with permission of the publisher, the Geological Society of America, Boulder, Colorado USA; copyright © 1975 Geological Society of America]; Berg and others, 1980; and R. C. Smith, II, personal communication, 1996). Principal named diabase sheets, diabase dikes, and basalt flows are indicated by numbers.

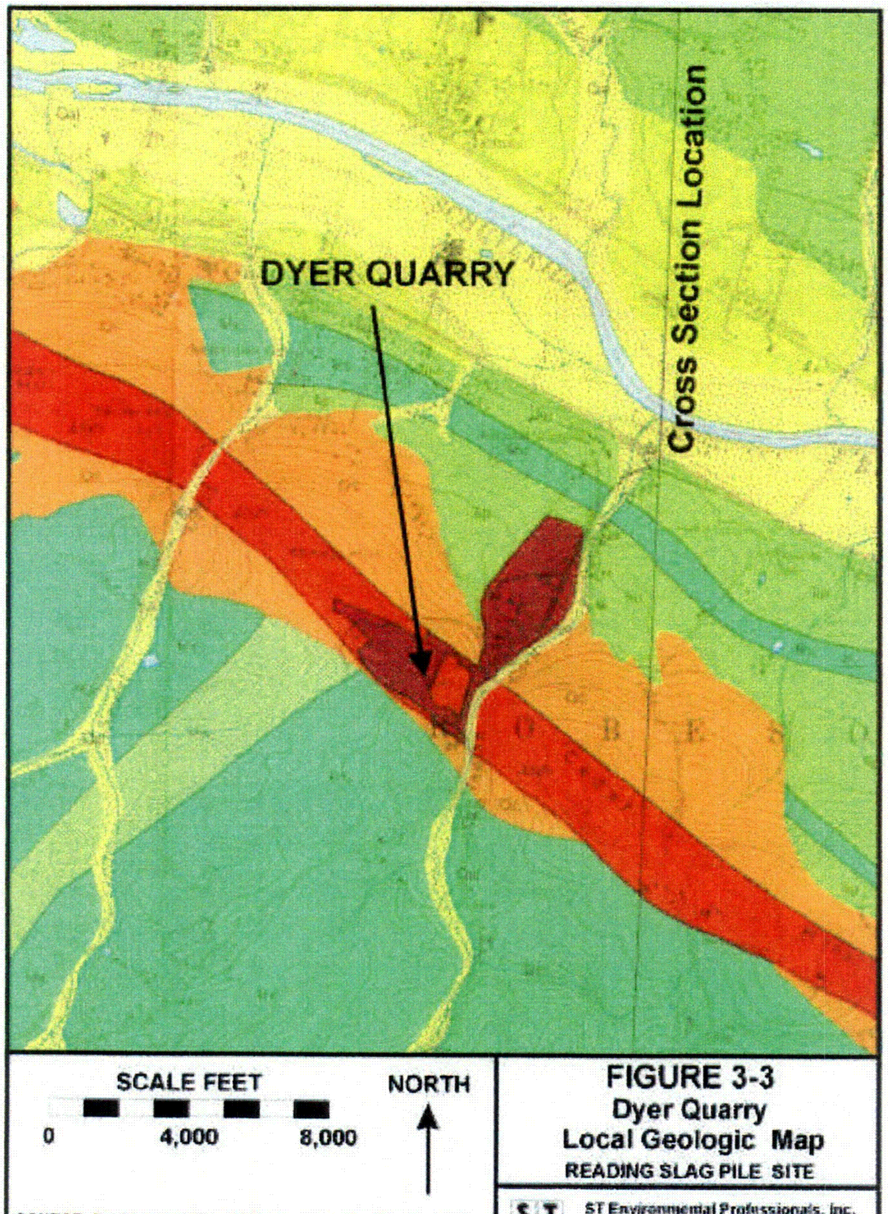

FIGURE 3-3
Dyer Quarry
Local Geologic Map
READING SLAG PILE SITE

SOURCE: Geology and Mineral Resources o the Reading and Birdsboro Quadrangles, Berks County, PA, MacLachlan, 1983

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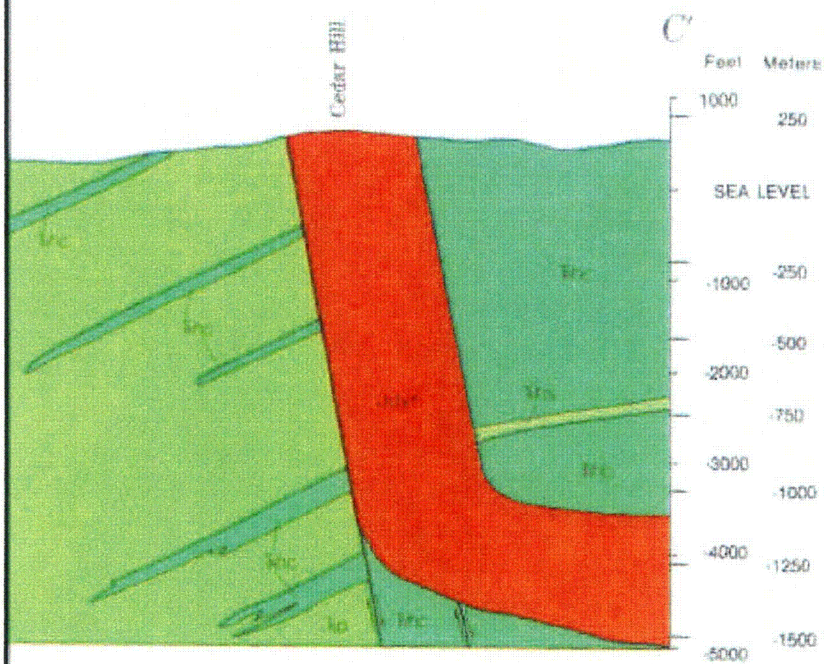
July, 2006



SCALE FEET

0 1,200 2,400

NORTH

SOURCE: Geology and Mineral Resources o the Reading and Birdsboro Quadrangles, Berks County, PA, MacLachlan, 1983

FIGURE 3-4
Dyer Quarry
Geologic Cross Section
READING SLAG PILE SITE

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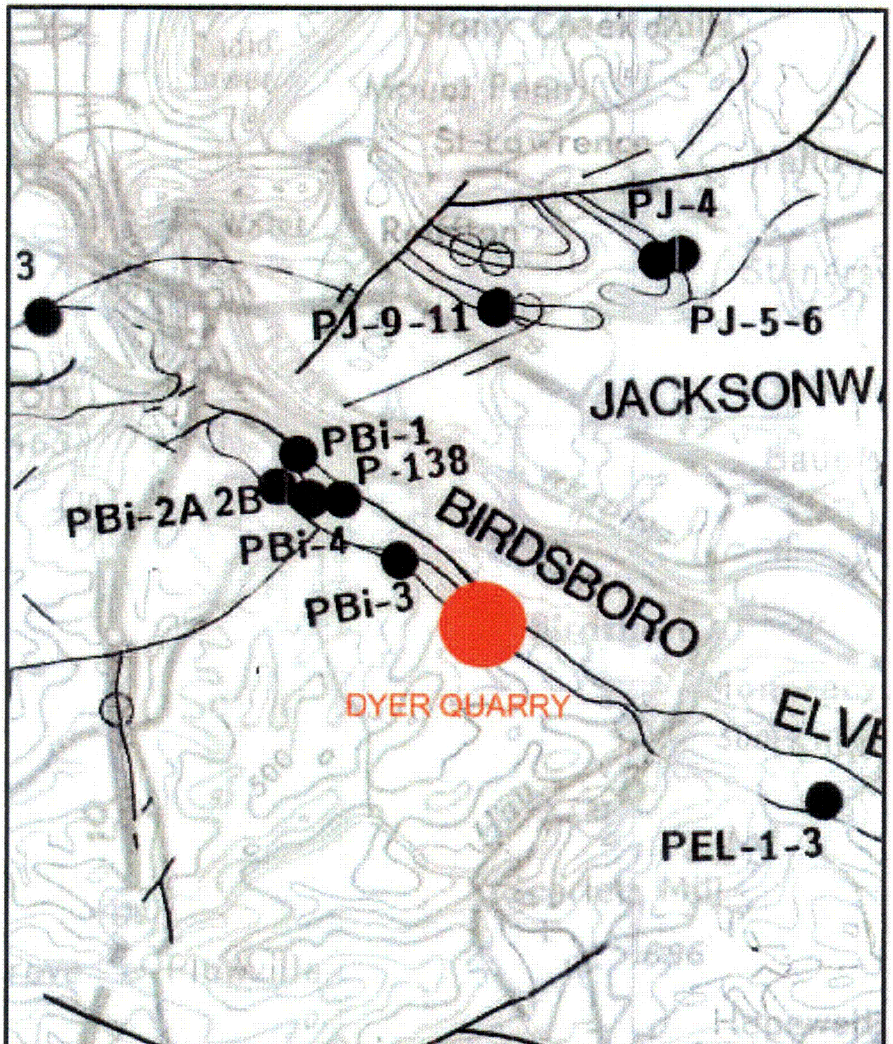

NORTH

APPROXIMATE SCALE FEET

0 5,000 10,000

SOURCE: USGS Open File Report 81-322-A, Gottfried, et al, 1981

FIGURE 3-5
Gottfried Sample Locations

READING SLAG PILE SITE

STEP

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STEP Project Number 97C057
July, 2006

FIGURE 3-6
Diabase Gravestone

FIGURE 3-7
Diabase Gravestone

FIGURE 3-8
Glacial Striations (front to back) on metavolcanics
Chebeague Island, Maine

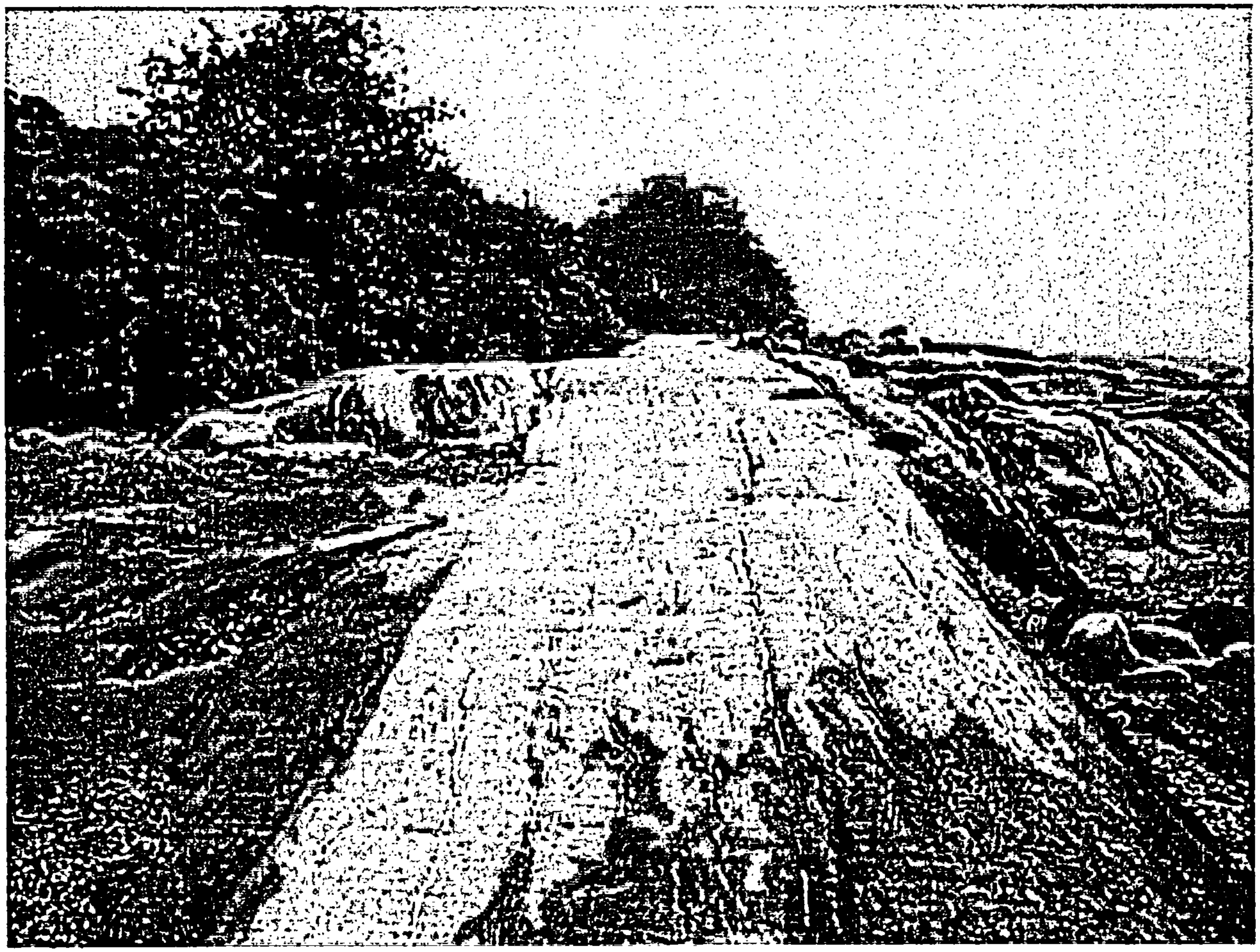


FIGURE 3-9
Glacial Striations (left to right) on metavolcanics
Chebeague Island, Maine

4.0 COVER DESIGN

4.1 Probable Maximum Precipitation/Probable Maximum Flood Calculations

The Probable Maximum Precipitation (PMP) was calculated for the drainage area contributing to the slope using Hydrometeorological Report No. 52, prepared by National Weather Service. The calculations are included in Appendix A.

The Probable Maximum Flood (PMF) flow for the Schuylkill River at the Cabot site was estimated from the drainage area using a straight line interpolation on a log-log scale of 21 PMF flow calculations completed by others and accepted by the NRC for locations on the Delaware and Susquehanna River Watersheds in Pennsylvania. See Figure 4-1. This data was obtained from Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants" and the Limerick Generating Station USFAR. Drainage areas ranged from 6.2 to 27,000 square miles and flows ranged from 13,700 to 1,750,000 cubic feet per second (cfs).

A drainage area of 880 square miles was used for the Cabot site. This is the drainage area for U.S.G.S. stream flow gauge 01471510 which is located approximately 1.25 miles downstream of the site and therefore a conservative estimate. The corresponding flow from Figure 2 for 880 square miles is 300,000 cfs.

4.2 Cover Design Details

The cover design, though not required to, generally follows the procedures outlined in NUREG-1623.

4.2.1 Surface Preparation

Clearing will begin with the removal of the trees. This will usually be 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.

Removal of stumps will be accomplished starting at the top of the slope and working down. Equipment will typically consist of small bulldozers and back hoes. In the case of the removal of large stumps on steep slopes, a chain may be attached from the rear of the bulldozer on the slope to a larger piece of equipment, such as a hydraulic excavator, on the top of the slope to prevent the bulldozer from sliding on the slope.

Removal of the stumps is desirable to provide a stable base for the riprap and to prevent regrowth of forestation through the riprap after completion of the project.

4.2.2 Filter Layer

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 will be used between the riprap and the subgrade. For the PennDOT R-4, R-6 and R-7 riprap used for this project, the Pennsylvania Department of Environmental Protection (PADEP) Erosion and Sedimentation Control Program Manual recommends a 4 , 8, and 12-inch thick layers of filter rock, respectively, having a gradation meeting the requirements of NSA sizes FS-2 for R-4 and FS-3 for the others. See Table 4-1.

4.2.3 Riprap Size and Gradation

Riprap from the Dyer Quarry of Birdsboro, Pennsylvania of gradation R-4 and R-6, as shown in Table 4-1, will be used to protect the sideslope from erosion due to the drainage of the PMP on the slope. The shear forces associated with the rising of the Schuylkill River due to the PMF will be resisted at the toe of the slope by R-7 graded riprap. The riprap will also provide attenuation of the radiation from the slag below.

The design of the riprap for the PMP drainage is included in Appendix A.

The local height and velocity profile of the Schuylkill River PMF at the site was calculated using the HEC-RAS River Analysis System software version 4.1.3 from the Hydraulic Engineering Center of the U.S. Army Corps of Engineers. Cross sections of the Schuylkill River at the site were developed from Maptech Terrain Navigator Pro software using Enhanced Digital Elevation Data from U.S.G.S. Digital Elevation Model for the 7.5 minute Topographic Quadrangle for Reading, Pennsylvania, and a detailed survey of the site prepared by Kent Surveyors of Wyomissing, Pennsylvania. These cross sections, located as shown in Figure 4-2, were adjusted to match with the Schuylkill River profile obtained from the Flood Insurance Study (FIS) for Berks County, Pennsylvania. The site and the cross sections are located between stations 397,700 and 398,100 on the river profile which is shown in Figure 4-3.

Steady flow analysis was used in HEC-RAS with the upstream and downstream boundary conditions set to normal depth for the slope of the energy gradient reported in the FIS study. Manning's "n" values of 0.03 and 0.10 were selected for the channel and overbank areas, respectively. These values were selected from HEC-RAS for the conditions present at the site and were within the range reported by the FIS for the Schuylkill River.

The HEC-RAS model was validated using stage/flow data for the 100 year flood reported by the FIS for the site and by observed highwater marks near the site for June 1972 Flood caused by Tropical Storm Agnes from Water Resources Bulletin No. 9.

For the PMF analysis, Manning's "n" for the left overbank was revised to 0.045 for the riprap cover, 0.015 for the asphalt roadway and 0.10 for the overbank below the roadway. Cross-section 2 is shown in Figure 4-4.

The HEC-RAS model provided local velocities along each hydraulic cross section, as shown in Figures 4-4. The velocities from the four hydraulic cross sections were averaged for the slope and the toe of the slope along the proposed roadway. The averages were used to design the riprap to resist the shear forces of the PMF using the Abt/Johnson Equation corrected for the angle of the side slope and the heavier density of the diabase riprap.

At the toe of the slope, riprap of gradation R-7, D_{50}=18 inches will provide adequate resistance to forces associated with the transition from the steeper slope above and shear forces from the PMF of the Schuylkill River. On the side slope, riprap of gradation R-6, D_{50}=12 inches will provide adequate resistance to forces associated with the shear forces from the PMF of the Schuylkill River. Finally, on the side slope above elevation 230, which is above the projected crest of the PMF, riprap of gradation R-4, D_{50}=6 inches will provide adequate protection against runoff associated with a PMP event.

4.2.4 Area Coverage

The riprap will completely cover the slope and top section containing slag and a portion of the material in the River road ROW. The extent of the riprap cover is depicted on Figure 4-5.

4.2.5 Thickness of Cover

The cover thickness on the slope will be a minimum of twice the D_{50} of the riprap to provide proper protection and promote proper placement of the material plus the appropriate thickness of the filter layer.

The riprap at the toe of the slope will be a minimum thickness of 4.5 feet (3 x D_{50} of the R-7 gradation) and with a maximum extent of 23 feet to resist forces associated with the transition from the steeper slope above and the higher velocities of the PMF over the proposed road at the toe of the slope. The thickness may be greater at some points where the apron length is limited by the proposed road corridor in order to keep an effective cross section of 103.5 square feet (4.5 ft x 23 ft).

4.2.6 Cross Sections

Drawings 1 and 2 (attached) show details of the riprap cover on the slope. The locations of cross sections are shown in plan view in Drawing 1 and the cross sections are depicted in Drawing 2.

Table 4-1
Rock Size Gradation
Reading Slag Pile Site Decommissioning Plan Addendum

NSA No.	Graded Rock Size (in)		
	Maximum	d_{50}	Minimum
R-4	12	6	3
R-6	24	12	6
R-7	30	18	12
FS-2	2	#4	#100
FS-3	6.5	2.5	#16

Adapted from Table 9, Reference B and Section 850, Reference U

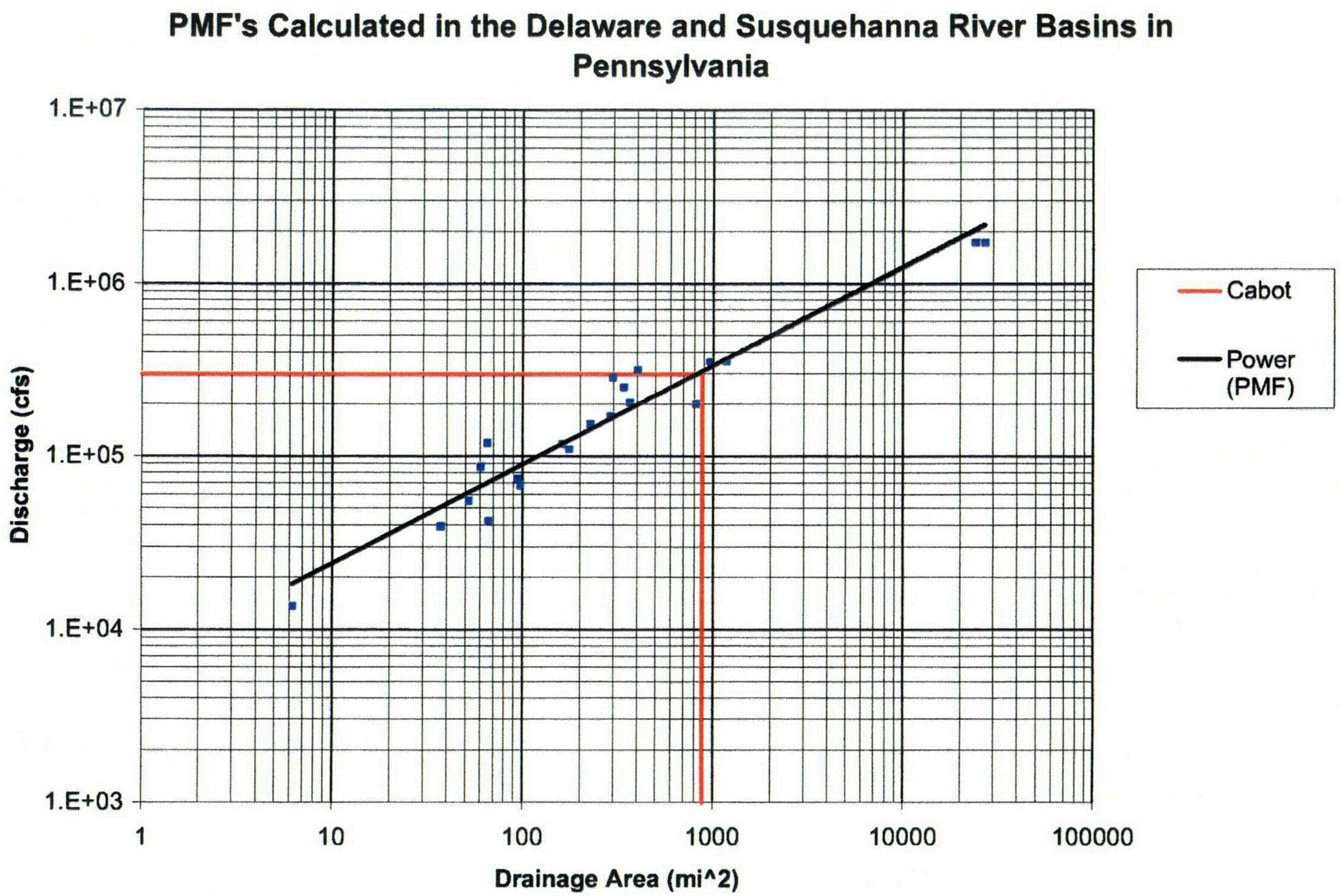


Figure 4-1 Interpolation of PMF from accepted studies

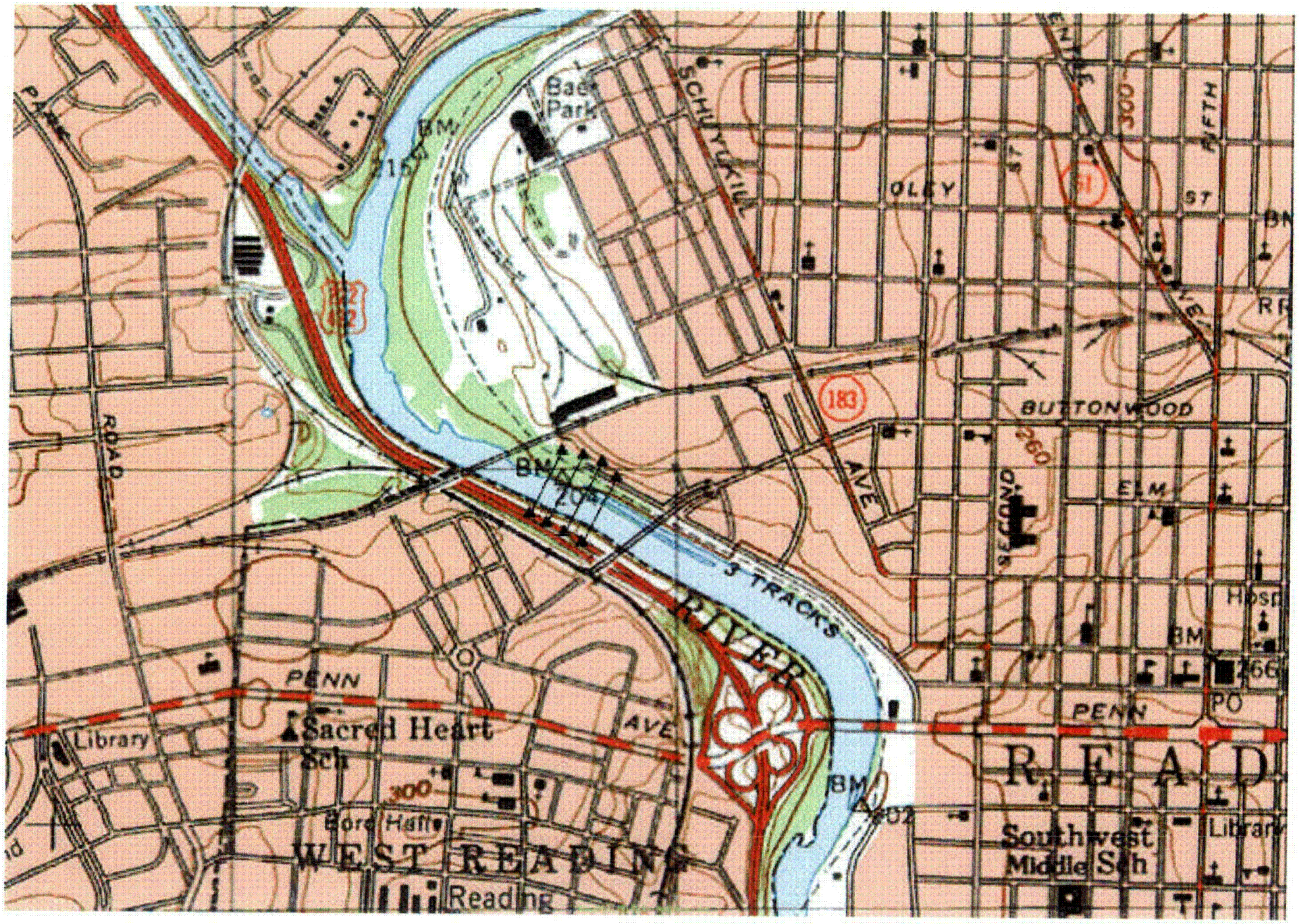


Figure 4-2 HECRAS Cross Section Locations

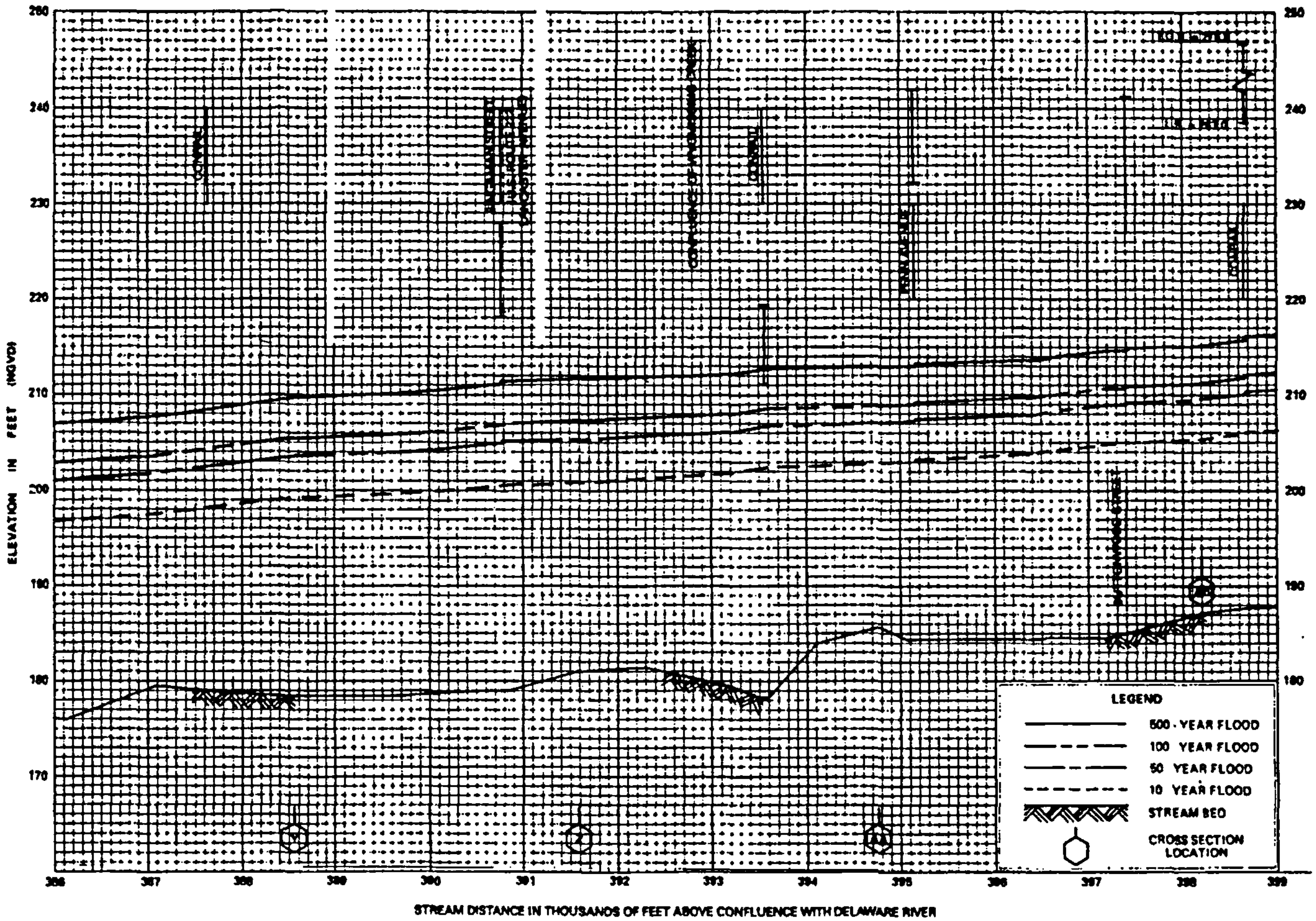


Figure 4-3 Schuylkill River Profile, Reference

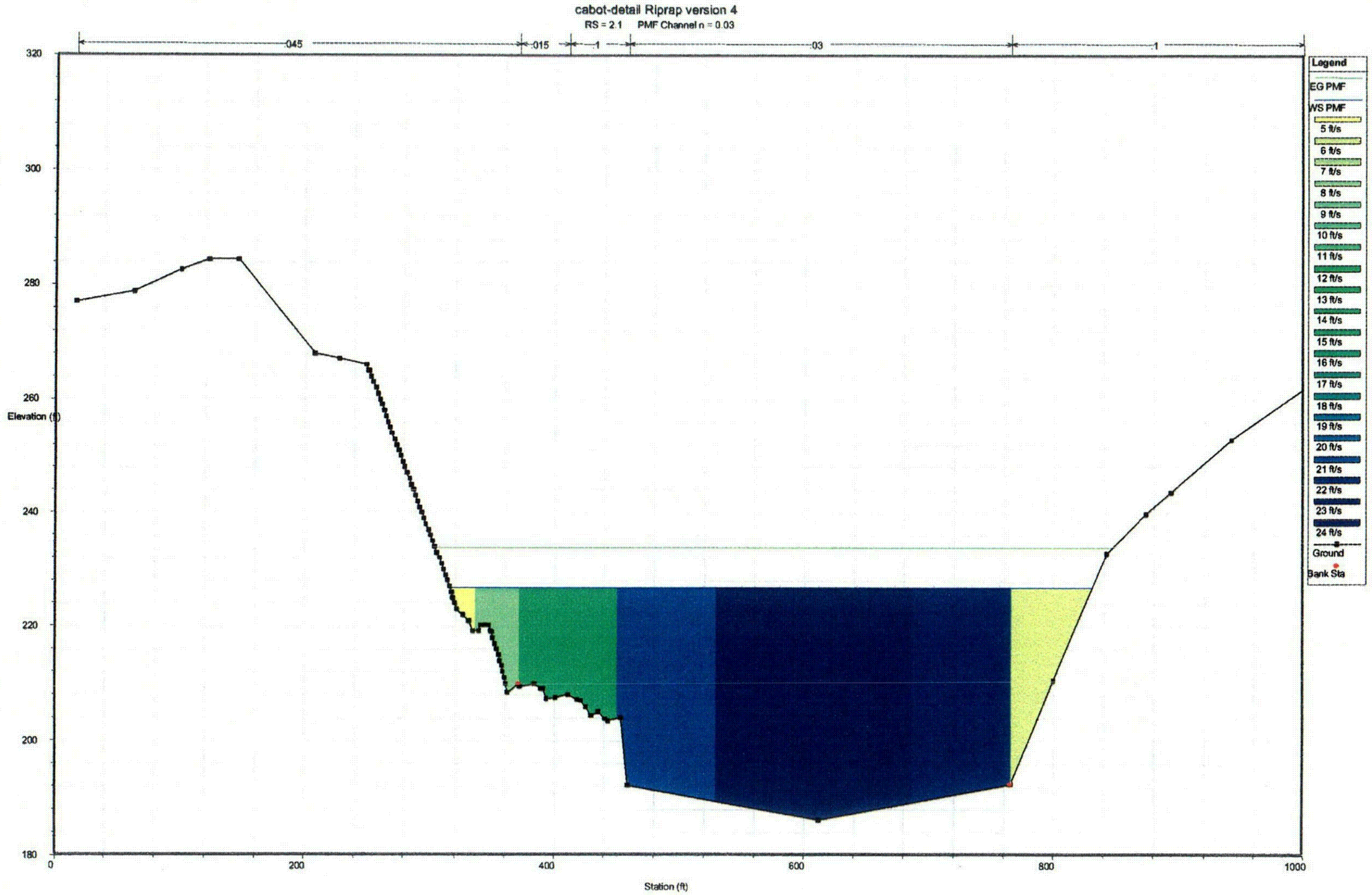


Figure 4-4 Cross Section 2 Geometry, "n" Values and Velocity Distribution

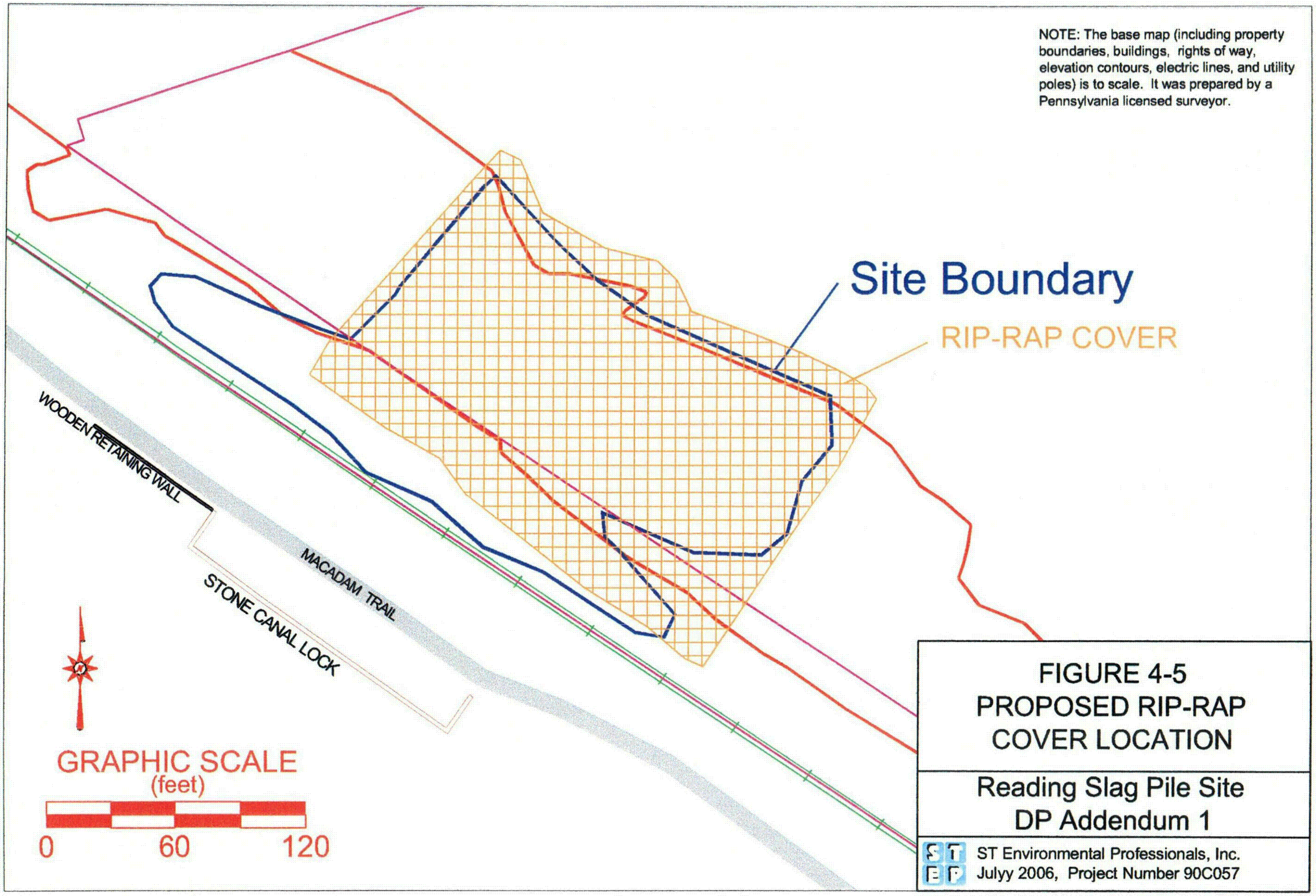


FIGURE 4-5
PROPOSED RIP-RAP COVER LOCATION

Reading Slag Pile Site
DP Addendum 1

ST Environmental Professionals, Inc.
Julyy 2006, Project Number 90C057

5.0 Quality Assurance/Quality Control

Following approval of the Decommissioning Plan, Cabot will prepare detailed design and construction plans for placement of the riprap. Those plans will be part of the license inspection process. A quality assurance/quality control (QA/QC) will be incorporated in those plans describing the procedures to ensure that the riprap has the physical properties and is placed consistent with this addendum. The QA/QC will consist of regular inspections at the quarry, physical testing of the riprap after completion of each third of the project, inspection of the riprap at the site, inspection of the placement, and compliance testing of the placement. These procedures will be intended to ensure that the rock used is homogenous and absent heterogeneities or other features that would cause weathering.

5.1 Thickness of Cover

Cover thickness will be monitored continuously during placement by a quality control representative using grade stakes placed on a minimum 25 foot grid. Cover thickness will be measured perpendicular to the slope. Additionally a Professional Licensed Surveyor will survey the top of subgrade after clearing, top of filter layer and top of riprap after completion in a specified area to be determined in a staging plan provided by the contractor prior to construction.

The material layers shall be placed generally to the limits and thicknesses shown on the Drawings within the following tolerances:

1. The top of the bedding subgrade shall be within ±0.1 foot of the design elevations.

2. Top of bedding material shall be within ±0.1 foot of the design elevations.

3. The in-place thickness of riprap material shall be between 90 percent and 125 percent of the thickness shown.

4. Local irregularities not exceeding the thickness limits above will be permitted provided that such irregularities do not form noticeable mounds, ridges, swales or depressions that in the opinion of the Engineer could cause concentrations of surface runoff or form ponds or gullies.

5.2 Rock Testing

Quality Control testing of the riprap cover will be completed 4 times during the project, at the beginning, 33%, 67%, and 95% completion.

Quality control testing will consist of:

Gradation	ASTM C117, C136
Specific Gravity	ASTM C127
Absorption	ASTM C127
Sodium Sulfate Soundness	ASTM C88 (5 cycles)
LA Abrasion	ASTM C131 (100 revolutions)

The results of the tests will be submitted to the geotechnical engineer to be evaluated against Table F-2, of NUREG-1623. A minimum score of 80% is required for the riprap to be acceptable. A score of 93% has been verified using test results provided by the Dyer Quarry and a score of 97% has been verified using independent laboratory testing as discussed previously.

In-place gradation tests will be conducted by determining a specific area on top of the riprap layer. The rock within the area will be removed to the top of the bedding layer. A measurement device (i.e., tape measure) will be used to determine the distance from the top of the bedding to the top of the riprap layer and stone sizes. Materials segregated or not placed according to the requirements shall be regraded or adjusted, or removed and replaced using appropriate equipment, to conform with the tolerances and limits given above. Materials not meeting the requirements shall be removed and replaced with specified materials. Rejected materials shall be disposed of at designated disposal sites. Materials not meeting the grading requirements shall be reprocessed or discarded. The Contractor may require modification of the processing and grading operations to ensure that the specified grading requirements are met.

5.3 Riprap Placement

Prior to riprap placement test sections of the proper thickness, gradation and interlock will be assembled. The sections will be visibly examined by the contractor, quality assurance personnel and geotechnical engineer and will serve as a guide for the acceptance of future riprap placement. The test section will also be tested for gradation and rock weight per unit volume to set and quantify the standard that future placement can be compared to.

Placement of the rip rap will begin at the bottom of the slope and work 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 will be used to place the riprap. The crane will initially be located at the bottom of the slope and then relocated to the top of the slope once the riprap is approximately half way up the slope. Riprap placement will be resumed by hydraulic excavators at the top of the slope once the placement front is within reach. End-dumping and spreading of the riprap will not be allowed. One or more spotters will be assigned to each piece of equipment placing the riprap to guide the operator in achieving uniform placement. The spotters will we equipped with crowbars or other hand tools to adjust the rock to achieve a solid interlocking layer.

6.0 SITE-SPECIFIC RADIATION SAFETY PROGRAM

Cabot Corporation (Cabot) has conducted monitoring and oversight at the Reading Project site in Reading, Pennsylvania under its possession-only license SMC-1562. Cabot has also conducted operations at its Boyertown, Pennsylvania facility, in the vicinity of the Reading site, under license SMB-920 for more than 20 years, and has successfully completed renewals and amendments to that license on several occasions.

As described in the Decommissioning Plan and Radiological Assessment for the Reading Project, the inventory of radioactive materials at the site is limited. Consequently, the nature, scope, and duration of the planned decommissioning operations and the radiation safety program required to support the project are also limited. Evaluation of radiation doses expected for project workers is included in the Radiological Assessment supporting the Decommissioning Plan. This evaluation resulted in projected doses for workers that are small fractions of 10 CFR Part 20 radiation dose limits applicable for members of the public. This evaluation demonstrates that both workers and the public will be suitably protected.

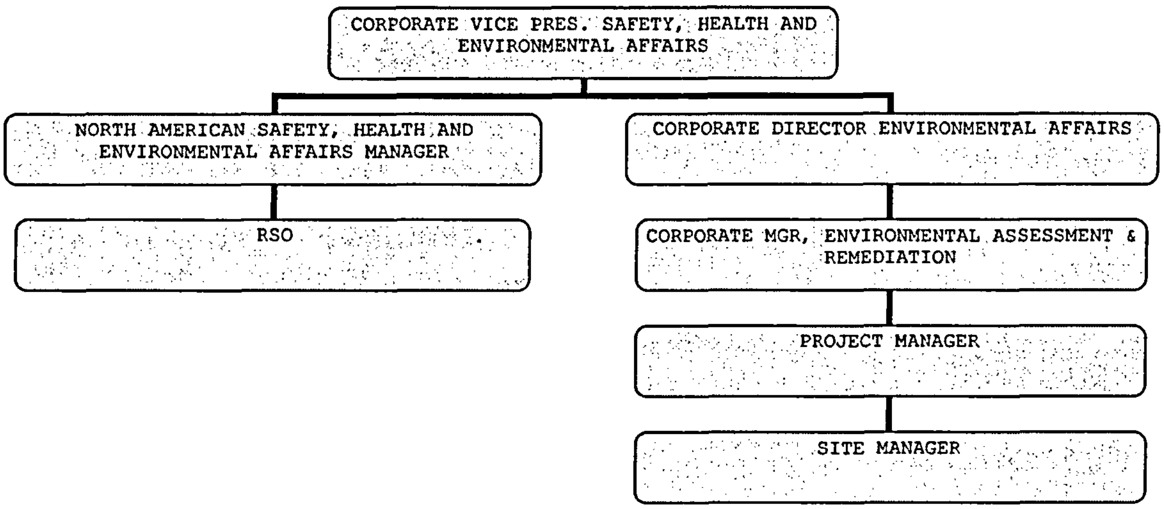
A description of the Reading Project Radiation Safety Program is provided here. This program will be designed and operated independent of other Cabot radiation safety programs, but will draw upon Cabot Boyertown radiation safety resources for operational support. The program described here presumes that all work will be performed under license SMB-920. Work performed by licensed site remediation contractors may be performed under the contractor's NRC license in accordance with conditions in NUREG-1757 Vol. 1, Rev. 1, Appendix K (Policy and Guidance Directive 94-02).

6.1 Commitment to Radiation Safety Program Implementation

Cabot is committed to establishing, implementing, and maintaining a Radiation Safety Program that meets or exceeds the regulatory requirements, including 10 CFR 20 Subpart B, and complies with accepted industry practices. It shall be the objective of the program to ensure that exposures to employees and members of the general public from radioactive materials used by Cabot are kept as low as reasonably achievable (ALARA). The Radiation Safety Program will be maintained by Cabot at the Reading site in accordance with the conditions defined in source material license SMB-1562.

6.2 Organization and Personnel Qualifications

This section describes the organizational structure of the Reading project and the roles and responsibilities of managers and staff that are relevant to the radiation safety programs at the site. An organizational chart showing the individuals whose responsibilities may directly impact the success of the radiation safety programs is presented below.



Reading Project Organizational Structure

Cabot may revise its management structure in order to address the changing needs of its operations. A license revision or notification to the NRC is required only for changes that negatively impact the independent reporting path for the RSO, the authorities of the RSO, or the involvement of the RSO in the operational management of the project.

The overall direction of Cabot operations related to the Reading project provided through intermediate-level management by the Corporate Vice President, Safety, Health, and Environmental Affairs. He has overall responsibility for development and implementation of corporate policy and the ultimate management of all corporate personnel and activities.

The overall management of the Reading project is provided by the Reading Project Manager. He has overall responsibility for all project operations, and is ultimately responsible for the health and safety of the project workers and protection of the environment and members of the general public from project activities.

The day-to-day direct management of the Reading project site activities is provided by the Reading Project Site Manager. He has direct responsibility for ensuring that the Reading project site activities comply with the company's policies and procedures, including the site radiation safety programs.

The Radiation Safety Officer is responsible for the development and implementation of a program for monitoring project and site activities and conditions to determine status of compliance with the conditions of the radioactive materials license and relevant local, state and federal regulations. The RSO reporting chain is separated from the project and site management reporting chain. In this independent role, the RSO provides a mechanism by which any employee or contractor can report potentially unsafe conditions or safety concerns. The RSO promptly assess and resolves any reported concerns.

All managers and the RSO have the authority to halt operations that appear to be unsafe, and may be called upon to approve the restart of operations after such a shutdown. In his independent role, the RSO provides a mechanism by which any employee or contractor can report potentially unsafe conditions or safety concerns. The RSO promptly assess and resolves any reported concerns.

The RSO has access to all levels of operational management as necessary for the execution of his/her duties. The RSO has the authority to immediately terminate any activity that is found to be an imminent threat to health, safety, or property, or that is likely to violate the license conditions or radiation safety program requirements, and this authority cannot be revoked. A fulltime employee fills the RSO position. Specific duties of the RSO include, but are not limited to the following:

- Approving written operating procedures, radiation work permits, etc., including assuring ALARA principles are appropriately included.
- Monitoring activities involving radioactive material, including conducting routine measurements and special surveys of areas where radioactive material is used.
- Determining compliance with rules and regulations and license conditions.
- Providing guidance on the proper shipping of all radioactive material from the CSM facility and ensuring compliance with applicable regulations of the U.S. Department of Transportation (DOT) and other appropriate agencies.
- Performing and arranging for calibration of instruments.
- Coordinating the radiation safety training of personnel before they are allowed to work independently in restricted areas, and ensuring that class information is current, correct, and appropriate.
- Training and supervising radiological technicians who conduct radiation monitoring program activities to ensure that procedures are followed and results are correct.
- Offering timely feedback on aspects of radiation safety to employees, management, and to the Director of Safety, Health, and Environment.
- Maintaining files of information relevant to future site decommissioning and managing radiological decontamination efforts.

The RSO will have the following training and experience as a minimum:

- BS degree in biology or a physical science

- Completion of a basic radiation safety course
- At least two years experience in the safe use and handling of radioactive material

The Radiation Safety Officer also attends a professional society meeting, seminar, or radiation safety training session at least once every two years for professional development.

6.4 Written Procedures

Cabot establishes and maintains written procedures to address the routine activities of its radiation safety program. The current list of written procedures includes, but is not limited to, the following topics:

- Personal dosimetry
- Air sampling
- Contamination surveys using wipe samples
- Instrument calibration and use
- Radiation safety orientation
- Control of release of materials and equipment from restricted areas

If project duration extends longer than anticipated, existing procedures will be reviewed during the annual radiation safety program reviews and revised as necessary to keep them current and accurate. New procedures are developed, reviewed, authorized, and implemented as necessary to document new processes. Procedures are tracked and maintained in compliance with ISO-9000 requirements. Official copies of procedures are maintained in electronic format and the RSO keeps a current set of procedures for the radiation safety programs available for review during on-site inspections by the NRC.

6.5 Training in the Use of Radioactive Material

Cabot has developed and implemented a radiation protection-training program for its employees and visitors to the facility. This program was designed to meet the requirements of Parts 19 and 20 of Title 10 of the Code of Federal Regulations. Training classes serve as part of the indoctrination for new workers and incorporate topics such as the following:

- Basic principles of radioactivity and characteristics of radioactive material
- Radiation hazards and potential health impacts from overexposure / prenatal exposure
- Proper methods for safely working with radioactive materials
- Methods for reducing radiation doses and controlling contamination
- Regulatory limits and ALARA philosophy
- Monitoring methods and instruments
- Employees' rights and access to records
- Personal protective equipment

- Cabot's radiation safety programs, roles and responsibilities

New workers complete a written test as part of their indoctrination. The information imparted during radiation safety training is reviewed and revised during the annual review of the radiation safety programs conducted by the ALARA Committee. Cabot includes reviews of radiation safety topics and training on new or revised radiation safety procedures and protocols on an on-going, as needed basis as part of its continuing safety training and employee meetings. In addition to this continuous retraining, restricted area workers are required to attend a refresher course at least once every three years. Cabot retains written documentation of participation in all of these retraining sessions. Training requirements are established for three categories of individuals, as indicated below.

Restricted Area Workers – All employees whose work activities are expected to require access to restricted areas will complete general radiation worker training prior to working without supervision in those areas. Class agendas and sign-up sheets are maintained as records of training. Agendas and materials used for this training are subject to minor changes in content without prior notification of the regulatory agencies. Topics that are typically covered in the class are listed below:

- Fundamentals of radiation safety, including
    - Characteristics of radiation and contamination;
    - Units of radiation dose and quantity of radioactivity;
    - Hazards of exposure to radiation, including internal, external, and acute, and chronic exposures, and stochastic and non-stochastic effects;
    - Levels of radiation from licensed material;
    - Methods of controlling radiation dose (hygiene and administrative controls such as controlled area procedures, engineering controls such as ventilation, protective equipment such as respirators, and general concepts for reducing doses such as time, distance, and shielding); and
    - Reporting responsibilities and procedures, and proper responses to incidents, accidents, emergencies, and releases;
- Locations and physical forms of licensed material;
- Locations and markings of restricted areas and airborne radioactivity areas;
- Radiation detection instruments including use of personnel monitoring equipment;
- Operation, and limitations of radiation survey instruments
- Storage, control, and disposal of licensed material; and
- Requirements of pertinent Federal regulations.

Ancillary Personnel – Ancillary personnel such as clerical, security, and administrative staff whose routine work activities at the Boyertown plant do not require their presence in restricted areas will not normally have access to the areas where radioactive materials are stored and handled. However, they will be provided basic hazard recognition and emergency notification training that addresses the radiological hazards at the site. Topics that are typically covered in the class include hazard recognition, locations of radioactive materials, and procedures to follow in case a radiological release is encountered.

Non-employees – Appropriately trained Cabot employees will accompany non-employees such as visitors and subcontracted workers who are expected to require access to restricted areas while on-site. The site is enclosed by a locked security fence. The Cabot escort provides basic hazard recognition information, determines if the visitor will need to access restricted areas, and is responsible for the safety of the non-employee while on-site. If non-employees need to access restricted areas of the site without a Cabot escort they will first receive the Restricted Area Worker training required for Cabot employees.

6.6 Methods of Exposure Control

Cabot has established routine work practices and procedures designed to minimize exposures to radioactive materials for employees and members of the general public. Work is performed in accordance with approved detailed procedures, as described in Section 6.4. These procedures are available for regulatory review. A general description of methods used at the site is provided in the following subsections.

Administrative Controls

Cabot employs administrative controls such as a locked fence, postings and frequent inspections. Workers are informed of restrictions during training sessions. Work areas are posted with signs and informational postings as required by the regulations and consistent with their conditions. Work is performed in accordance with approved written procedures under supervision and monitoring of site management.

Engineering Controls

Cabot incorporates engineering controls to limit access to the areas containing radioactive materials Control of excavation activities and dust management during rip-rap placement will be sufficient to assure that no additional engineering controls will be required to assure that exposure of workers or the public to airborne radioactive material do not exceed limits specified in 10 CFR Part 20.

6.7 Radiation Monitoring Instruments

The RSO maintains various radiation-monitoring instruments for conducting surveys and measurements and analyzing samples. A qualified, licensed contractor calibrates the instruments on at least an annual frequency. The following types of instruments, or their functional equivalents, are maintained at the site, at a minimum.

TYPE	PURPOSE
Micro-R meter (NaI)	Dose assessment, area monitoring
Geiger-Mueller tube	Dose assessment, area monitoring
Geiger – Mueller pancake probe	Contamination surveys, fixed and removable
Dual scaler (alpha – beta)	Sample counting (air particulates, smears)
Alpha/beta surface probe	Contamination surveys (100 sq. cm.)

Instruments used to show compliance with applicable regulations are calibrated before first use and after repair. Each instrument that is available for use is calibrated at least annually thereafter. Calibration records are retained for each instrument for at least the two most recent periods to establish documentation that the annual frequency is being maintained. Hand-held survey instruments used for the estimation of contamination will be calibrated by determining the detection efficiency of the system using a reference source appropriate to the use of the instrument. The efficiency and reference radionuclide will be noted on the calibration label. The RSO maintains on-site laboratory and office facilities to the extent necessary to support the radiation safety programs in a timely way. Cabot facilities in Boyertown, Pennsylvania will also be used to the extent they can be in a practical and timely way. These facilities are used to maintain and source-check the radiation-monitoring instruments, count samples such as airborne particulate filters that are analyzed on-site, provide office space for the RSO and his staff, and maintain files for the records that document compliance with the conditions of the radioactive materials license. The RSO's office is located in an area that is not significantly affected by elevated levels of radiation from site operations and is separate from other work areas associated with daily site operations. Records are kept in lockable file cabinets. The sample counting area is cleaned and monitored at least monthly to ensure that contaminated material does not accumulate and negatively impact the work environment or the sample counting statistics.

6.8 Radiation Surveys and Monitoring Programs

Occupational Monitoring

Occupational monitoring programs are designed in compliance with the requirements of 10 CFR 20 to measure concentrations of radioactive material and radiation levels in the work environment, and evaluate personnel dose equivalents when those concentrations or levels exceed administrative limits. The RSO is responsible for the technical oversight and implementation of the monitoring programs. He oversees activities performed by technicians, reviews the data, evaluates potential changes in the programs or procedures, determines if follow-up actions are required, and maintains files of the results. The following subsections describe, in general, the types of measurements that are performed. Monitoring program details are provided in site-specific procedures and documents that are maintained by the RSO. Monitoring program details will be similar to Boyertown program details, which have been reviewed by NRC personnel during past inspections.

Exposure to External Radiation

Personal or area dosimeters and exposure rate instrument surveys are used to track levels of radiation exposure in the work areas where radioactive materials are present. Area dosimeters may be considered an acceptable alternative to personal dosimeters in some areas of the site because of the low levels of radioactivity in the materials, the small quantities of materials that are present, and the short periods of time that workers are close to the material. Radiation levels are measured in locations where highest dose rates are found as determined by the RSO, and at locations of particular interest, such as restricted area boundaries.

Monitoring Airborne Radionuclides

The potential airborne radiological contaminant of concern at the Reading site is resuspended soil bearing naturally occurring uranium, thorium, and progeny nuclides. Based on technical evaluations in the Radiological Assessment, radionuclide concentrations in air are expected to be low and highly localized in areas of active work. Work area air monitoring is conducted to meet monitoring requirements of 10 CFR Part 20.

Miscellaneous Radiological Surveys

Quarterly surveys and inspections are performed at the facility fenceline to ensure that that site conditions have not changed, the fence is intact and the postings are in place.

Environmental Programs

The operations to be conducted in the Reading Project are limited to installation of rip-rap on the portion of the site slope bearing radioactive material and associated clearing and grubbing. The limited nature and scope of these activities assures minimal impact on cultural, historical, land use, and environmental values. Radiological monitoring designed to protect workers will also monitor protection of the general public. Consequently, no radiation safety programs specifically focused on environmental impacts are planned.

7.0 Financial Assurance

An engineering estimate of the cost to install the riprap cover was performed by GeoSystems Consultants, Inc. Those calculations are contained in Attachment 3. *The total estimated cost, including contingencies, is $450,000 to $500,000.* This is greater than the current financial assurance amount being maintained by Cabot for the Reading site. Cabot will increase the financial insurance to cover the new estimate and provide that documentation under separate cover.

8.0 References

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STEP, 2005c. "Decommissioning Plan for the Reading, Pennsylvania Site", Revision 3, for Cabot Corporation, ST Environmental Professionals, Inc., June 2005.

STEP, 2005d. "Radiological Assessment for the Reading, Pennsylvania Site, Revision 3" for Cabot Corporation, ST Environmental Professionals, Inc., June 2005.

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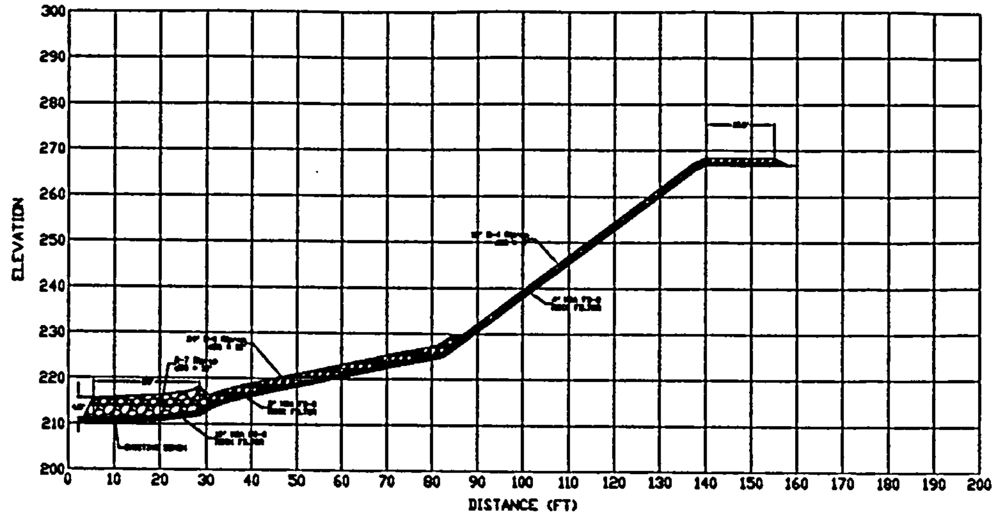
DRAWINGS

REFERENCE:

TOPOGRAPHY PROVIDED BY ST ENVIROMENTAL PROFESSIONALS, INC

CROSS SECTION LOCATION PLAN RIP RAP COVER DESIGN CABOT CORPORATION READING, PENNSYLVANIA	
GeoSystems Consultants, Inc.	
PROJECT NO.: 03G324	DRAWING 1
JULY 2006	

CROSS SECTION A



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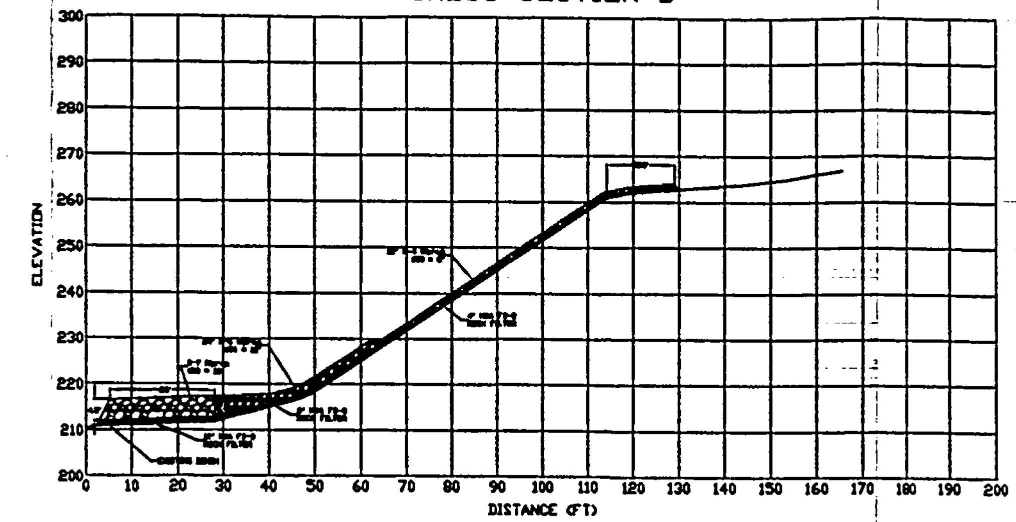

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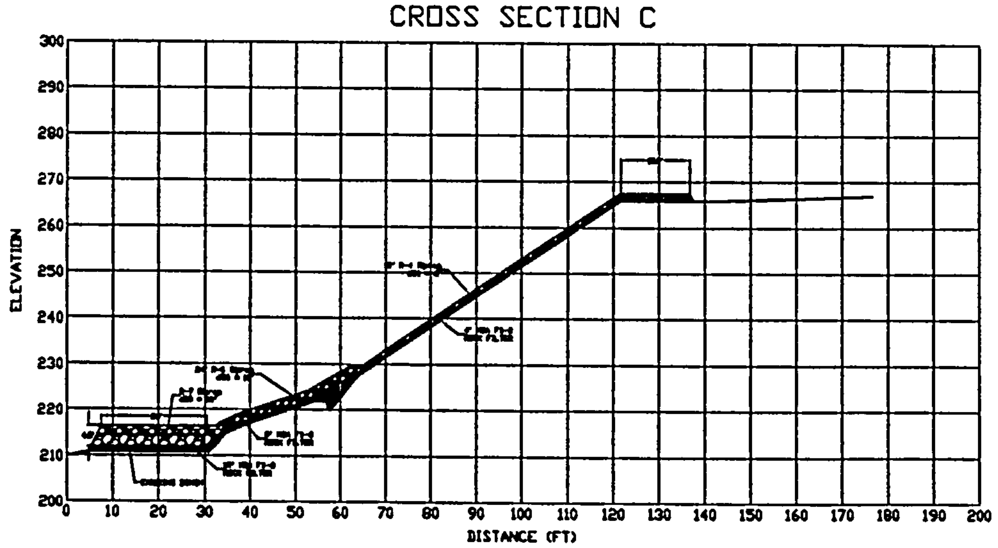

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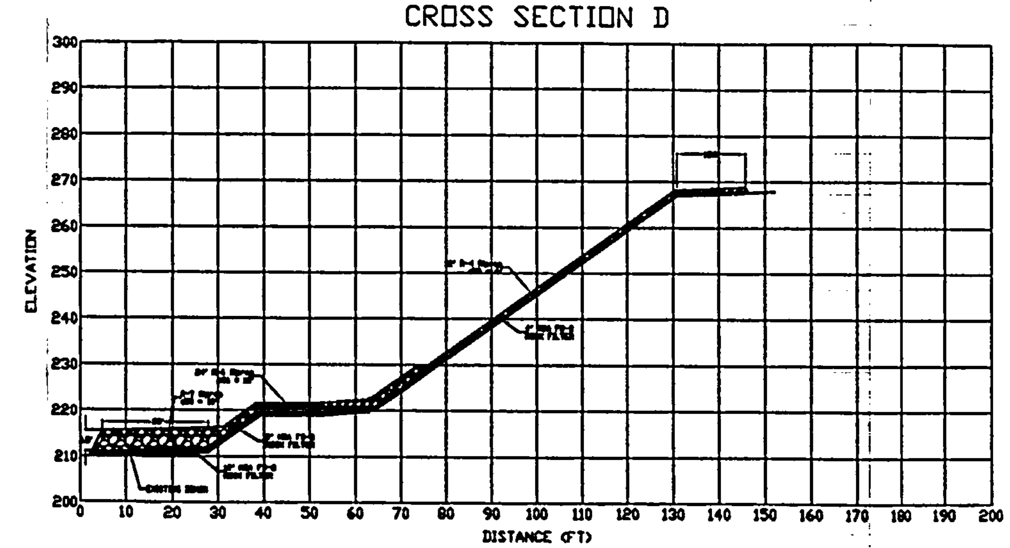
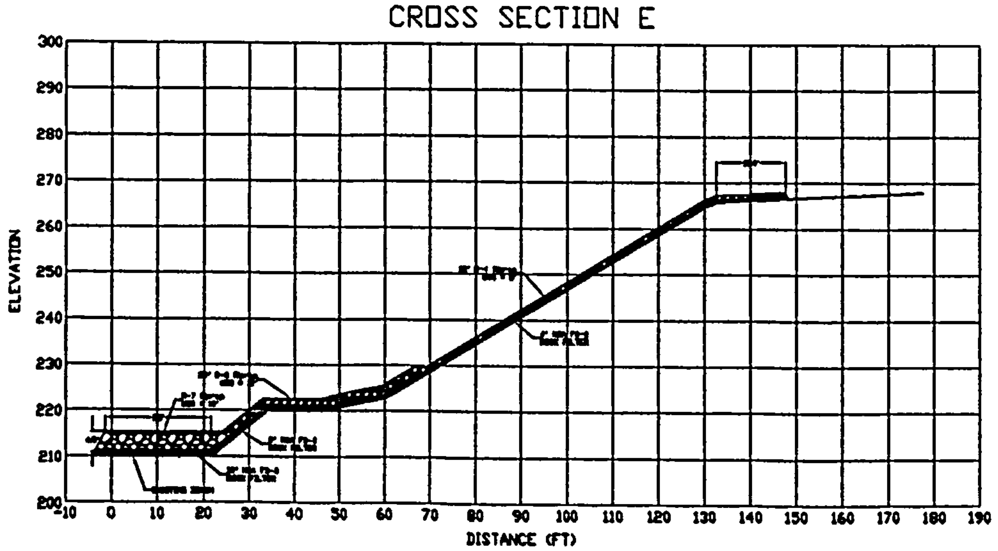


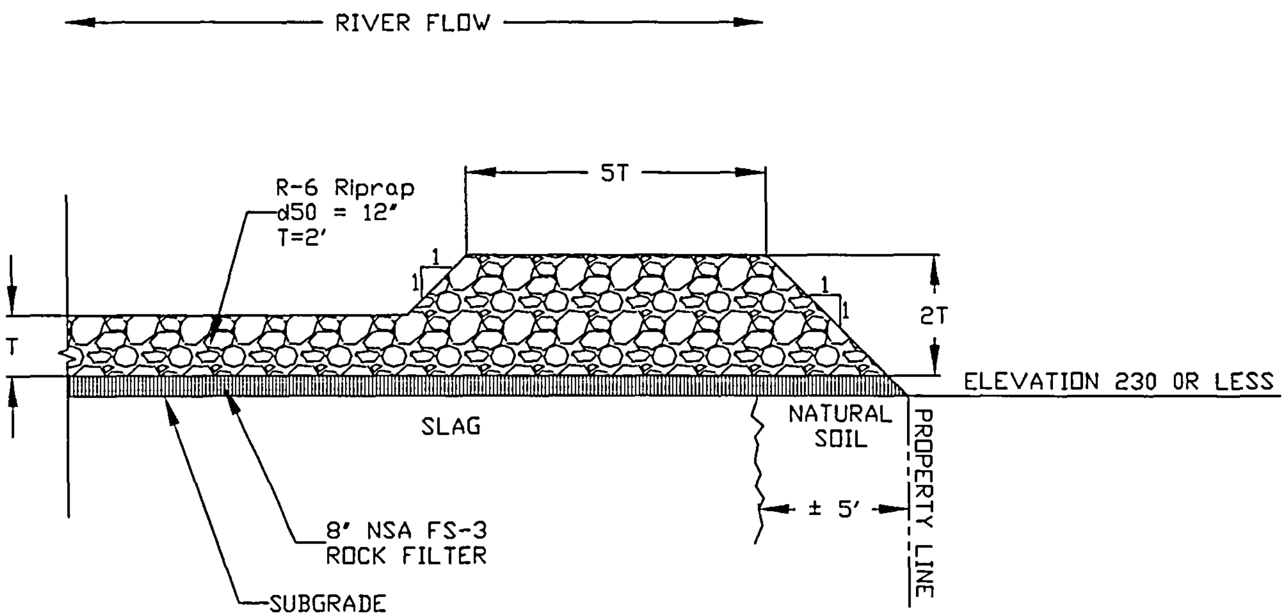
CROSS SECTION E



DETAILED CROSS SECTIONS
RIP RAP COVER DESIGN
CABOT CORPORATION
READING, PENNSYLVANIA

GeoSystems Consultants, Inc.

PROJECT NO.: 03G324	DRAWING 2
JULY 2006	



REFERENCE:

DETAIL BASED ON PLATE B-41, EM
1110-2-1601, CHANGE 1, DATED 30 JUNE 94

END PROTECTION DETAIL RIP RAP COVER DESIGN CABOT CORPORATION READING, PENNSYLVANIA	
GeoSystems Consultants, Inc.	
PROJECT NO.: 03G324	DRAWING 3
JULY 2006	

ATTACHMENT 1

DYER QUARRY TEST RESULTS

DYER QUARRY INC.
1275 ROCK HOLLOW ROAD
BIRDSBORO PA, 19508
PHONE: 1.610.582.6010
FAX: 1.610.582.2304

DIABASE PROPERTIES

		LOWER	UPPER	
1.	LABRADORITE	51%	56%	PLAGIOCLASE FELDSPAR
2.	AUGITE	36%	17%	MINERAL OF THE PYROXENE GRP.
3.	HORNBLENDE	3%	10%	SILICATE MINERAL
4.	QUARTZ (GRAPHIC)	2%	6%	CRYSTALLINE MINERAL CONTAINING CRYSTALS LIKE LETTERS
5.	QUARTZ	4%	7%	A HARD CRYSTALLINE MINERAL
6.	MAGNETITE	4%	4%	BLACK MINERAL ORE OF IRON

PHYSICAL PROPERTIES

1.	ANTI SKID RATING	H
2.	COMPRESSIVE STRENGTH	30,000 LBS SQ/INCH
3.	L.A. ABRASION LOSS	17 AVG
4.	DEVAL ABRASION LOSS	2.0 AVG
5.	SODIUM SULFATE LOSS	1.95 AVG
6.	SPECIFIC GRAVITY	2.97
7.	ABSORPTION	0.4% AVG
8.	CEMENTING VALUE	170 AVG
9.	SOLID VOLUME - LBS/CU.FT.	185.3
10.	SOLID VOLUME - LBS/CU.YD.	5,003.90

CHEMICAL WHOLE ROCK ANALYSIS

1.	SILICON DIOXIDE	SiO_2	52.10%
2.	TITANIUM DIOXIDE	TiO_2	1.50%
3.	ALUMINUM HYDROXIDE	Al_2O_3	14.70%
4.	IRON OXIDE	Fe_2O_3	13.10%
5.	MANGANATE	MnO	0.19%
6.	MAGNESIUM OXIDE	MgO	4.83%
7.	CALCIUM OXIDE	CaO	9.60%
8.	SODIUM OXIDE	Na_2O	2.52%
9.	POTASSIUM OXIDE	K_2O	0.87%
10.	PHOSPHORUS PENTOXIDE	P_2O_5	0.18%
11.	CHROMIUM DIOXIDE	Cr_2O_2	0.01%
12	LOSS ON IGNITION	LOI	0.32%

Received Time Oct.17. 3:51PM

PROGRAM: S4?85100 PENNDOT CAMMS TESTING REPORT 4/08/200?
REPORT : CA?LR510 AGGREGATE ENGLISH 1:58:3?
FINAL REPORT Ref#: A288403 Lab#: 02030178 Pass/Fail: P CAMSPRO?

Cont #:0000?0	QA Rtng:	Cntrctr:
St # N:0050?109QRY 0510 711 9998	Smp Cls:RS	Suplier:DYR06A14
Pr #:	Orgnztn:0510	Lctn Cd:DYR06A14
Mtl Cd:203 ?57	State R:	JMF #/Y: /
Mtl Ds:AGGR?T,COARSE	Section: 0000	L/C XRf:
408Y/S:2000 703	Station:	Prt Tkt:
Supl #:	Colcted: 2/12/2002	Lot Nbr:1
Plc Cl: STO?KPILE	Receivd: 2/22/2002	# Incrm: 1
Smp By:C.PA?IS	Released: 4/08/2002	447 XRf:

TR-447 Remarks: REQUALIFICATION SAMPLES

SCREEN	LIMITS		RL	-1-
2"				100
1 1/2"	100	100	0	100
1"	95	100	5	100
5/8"				98
1/2"	25	60	35	57
#4	0	10	10	2
#8	0	5	5	1

PERCENT ABSORPTION
-1-
0.50

SSD SPECIFIC GRAVITY
-1-
2.98

BULK SPECIFIC GRAVITY
-1-
2.963

APPARENT SPECIFIC GRAVITY
-1-
3.008

LA ABRASION LOSS %
-1-
15.98

LIMITS: 0 - 45 R(L): 45

THIN & ELONGATED PIECES %
-1-
3.48

LIMITS: 0 - 15 R(L): 15

SODIUM SULFATE - TOTAL % LOSS
-1-
0.25

LIMITS: 0 - 10 R(L): 10

ATTACHMENT 2

PENNONI TEST RESULTS

Pennoni

PENNONI ASSOCIATES INC.
CONSULTING ENGINEERS

3602 Horizon Drive
Suite 160
King of Prussia, PA 19406
Tel 610•277•2402
Fax 610•277•7449

February 7, 2006

GETS 0601

Mr. Dave Hamas
GeoSystems
514 Pennsylvania Avenue
Ft. Washington, PA 19034

Re: Dyer Quarry

Dear Mr. Hamas:-

The following is a report of our laboratory tests of a sample of stone submitted by you recently.

Lab No: LV-16826

STONE TESTS – ASTM C88, C127, C535

Test	Result
Sulfate soundness	0.18% loss
Bulk SSD specific gravity	2977
Absorption	0.22%
LA abrasion	12.8% loss

Attached are our petrographer's microscopic examination of the stone.

Should you have any questions, please do not hesitate to contact us.

Very truly yours,

PENNONI ASSOCIATES INC.

John A. Jasczak
Inspection Supervisor
Inspection & Testing Technology

Michel Hatem, P.E.
Senior Engineer
Inspection & Testing Technology

JAJ/MH/lwf

Enclosure

I:\Reports\Reports 2006\GETS 0601 Dyer Quarry LV16826 2-7-06 doc

CONSTRUCTION PETROGRAPHICS, INC.
Petrographic Laboratory Services
36642 Quakertown, Farmington Hills, MI 48331 · (248) 880-8601 · Fax: Coming soon

REPORT ON PETROGRAPHIC EVALUATION OF ROCK FROM DYER QUARRY

PAI Job No. GETS 0601/CPI Project No. 06-413

January 31, 2006

INTRODUCTION

One rock specimen, represented by six small chunks (Photo 1), was received January 17, 2006, from Pennoni Associates, Inc., King of Prussia, Pennsylvania. Reportedly, the specimen is from the Dyer Quarry. Petrographic evaluation of the specimen was requested, to identify the material, as well as identify any potentially detrimental structural features.

This report presents the details and results of the petrographic evaluation of the rock specimen.

FINDINGS AND CONCLUSIONS

1. The rock is petrographically identified as a diorite. It is a coarse-grained, dark, igneous rock. It consists primarily of plagioclase feldspar and hornblende amphibole; with lesser amounts of intergrown quartz and feldspar grains, which may classify this rock as a quartz-diorite. Several grains of an opaque mineral are also present. Photos 2 through 5 illustrate the texture and mineral composition of the rock.

2. No clay minerals, shale seams, or mica grains were observed.

3. The feldspar grains exhibit very little weathering.

4. The rock is hard. The specimen had to be struck several times with a geology hammer to break it. The rock fractured randomly. No shear fracturing occurred.

LABORATORY TESTING

Two of the rock chunks were saw-cut in half, and one resultant saw-cut surface from each chunk was lapped and polished. The polished rock surfaces, as well as existing and freshly fractured surfaces of the rock, were examined macroscopically and using a stereomicroscope at magnifications up to 40X. A thin section of the rock, approximately 20 to 30 microns thick and mounted on a 1- by 1-1/2-inch glass microscope slide, was prepared from two separate rock chunks. The thin sections were examined using a polarizing-light microscope at magnifications up to 200X.

Respectfully submitted,

Jean L. Randolph
Petrographer
President of Construction Petrographics, Inc.

Attachments

Your sample will be retained in our laboratory storage facility for a period of three months. At that time it will be automatically discarded, unless we hear otherwise from you.

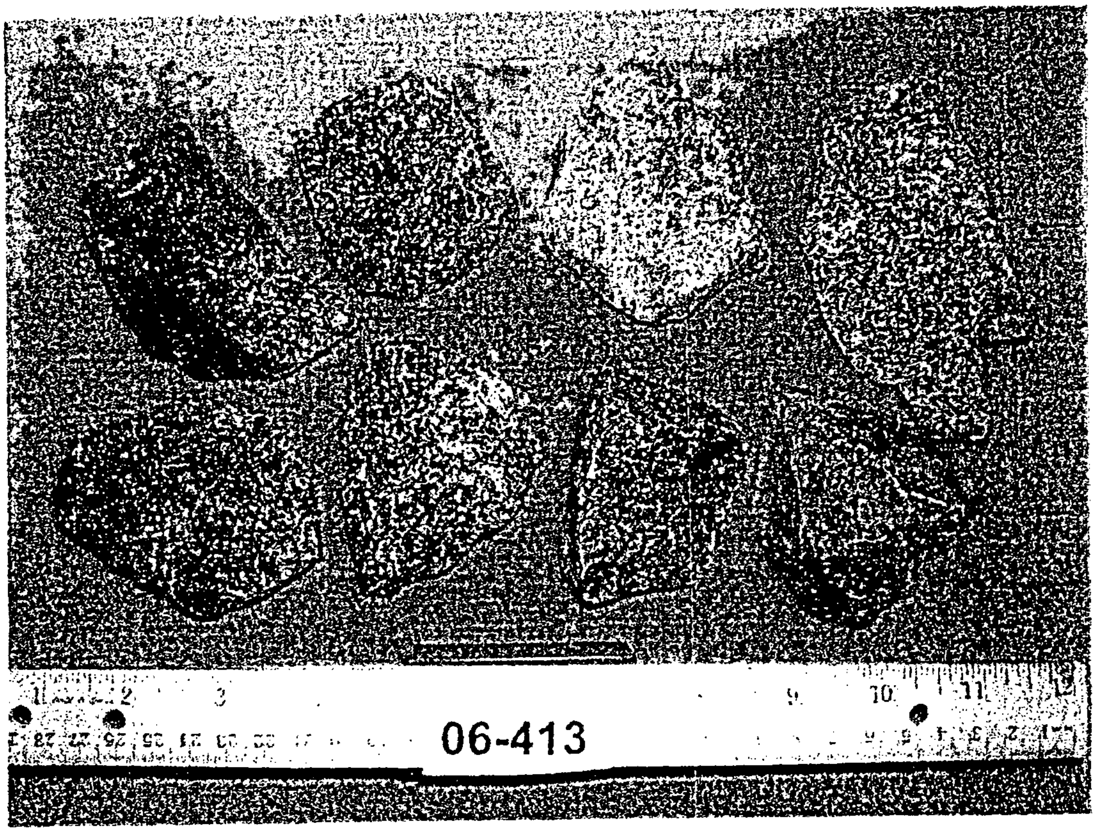
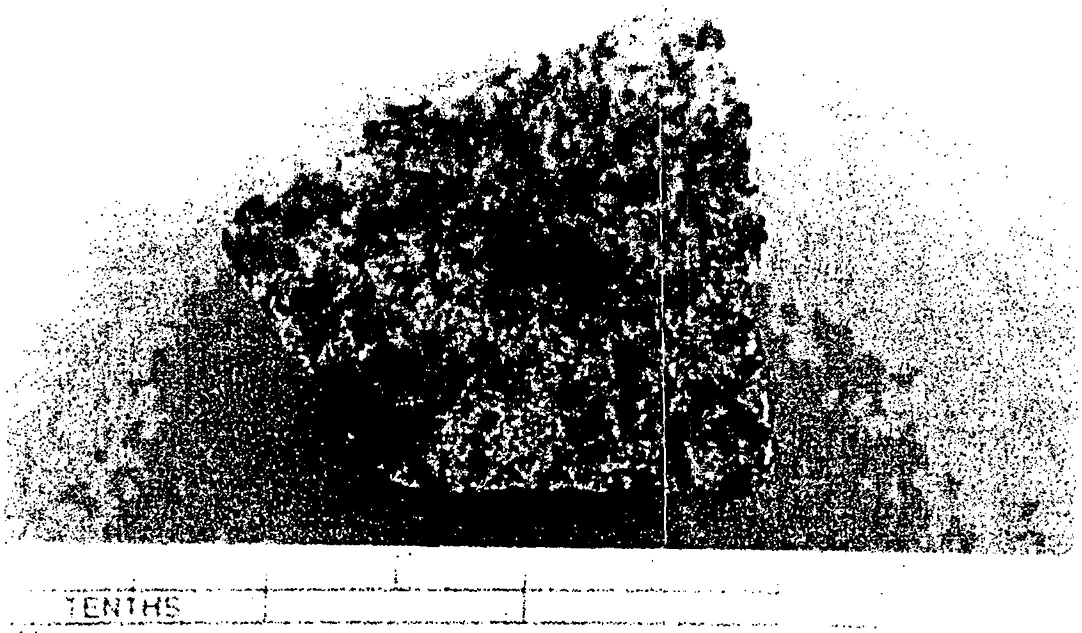
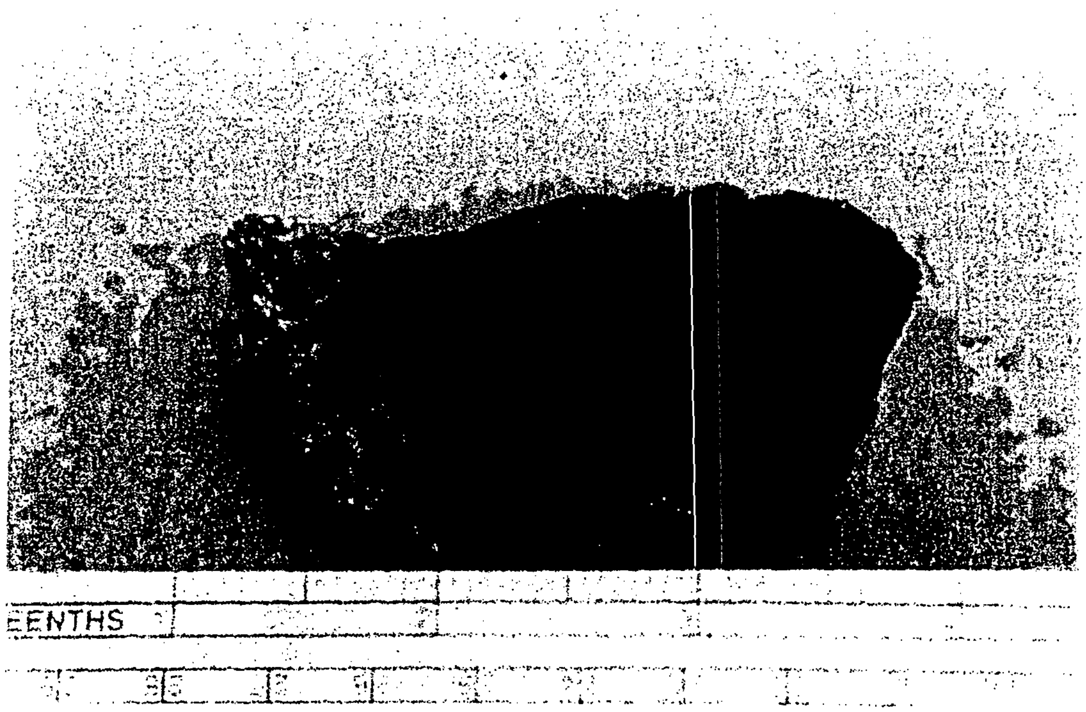


Photo 1. Eight pieces of one rock specimen, as received for testing.



(2)



(3)

Photos 2 and 3. Cut and polished surfaces of two of the rock chunks. The rock is coarse-grained and somewhat equigranular. The amount of hornblende amphibole varies between specimens; the darker the rock, the more amphibole is present.

(4)

(5)

Photos 4 and 5. Photomicrographs taken from a thin section of the diorite, representing a "typical" section of the rock and illustrating its mineralogy. They are the same photograph, but taken in different lighting.
Length of field = ~ 4-1/3 mm. Description follows on next page.

Photo 4, taken in plane-polarized light, illustrates the lack of any soft minerals or materials, such as micas or clays. It also illustrates the lack of weathering to the feldspar grains (white area of photo). The grains in brown on the left side of the photo are hornblende amphibole.

Photo 5, taken in crossed-polarized light, illustrates the coarseness of the mineral grains. The feldspar particles (gray- and black-striped grains) are well-defined. The orange-brown mineral on the left side of the photo is amphibole. The swirly, "blob-like" gray and white material located in the bottom right of the photo is the intergrown quartz and feldspar. It is also located around the adjacent large feldspar grain.

ATTACHMENT 3

ENGINEERING COST ESTIMATE

				Project No.	03G324
CLIENT	STEP, Inc.	SUBJECT	Riprap Construction Cost Estimate	Prepared by: DMH	7/7/2006
PROJECT	Cabot			Reviewed by: RDS	7/29/2006
	Reading Slag Pile				

TASK: Estimate the construction cost for the riprap placement at the Cabot Site in Reading, PA

REFERENCE: 2005 RSMEANS Building Construction Cost Data 63rd Annual Edition

QUANTITY ESTIMATE:

Slope 1.5H:1V tan-1(1/1.5)	α =	33.7	°
Plan Width parralel to river	W =	250	ft
Plan length of slope	L =	108	ft
Effective Length =W/cos(α)	L' =	130	ft
Plan Area	A =	27,000	sf
		3,000	sy
		0.62	acre
Effective Area =W x L'	A' =	32,450	sf
		3,606	sy
		0.74	acre
Slope toe	elevation	210	ft
Slope crest	elevation	282	ft
Slope height		72	ft

Material Size and Gradation

	Graded Rock Size (in)		
NSA No.	Max	d50	Min
R-4	12	6	3
R-6	24	12	6
R-7	30	18	12
FS-2	2	#4	#100
FS-3	6.5	2.5	#16

R-4 (to be placed above elevation 230

Length of Slope above 230	=(282-230)/SIN(33.7*PI()/180)=	94 ft
Upper apron length		15 ft
Thickness = 2 x d50		1 ft
Volume =	=(94+15)*1*250/27	**1,007 cy**
Total Weight	=1007*27cf/cy*185lbs/cf / 2000lbs/ton * (1-0.35) =	**1635 tons***

R-6 (to be placed below elevation 230

Length of Slope above 230	=(230-210)/SIN(33.7*PI()/180)=	36 ft
Thickness = 2 x d50		2 ft
Volume =	=36*2*250/27	**668 cy**
Total Weight	=668*27cf/cy*185lbs/cf / 2000lbs/ton * (1-0.35) =	**1084 tons***

R-7

Apron Length		25 ft
Thickness		4.5 ft
Volume =	=25*4.5*250/27	**1,042 cy**
Total Weight	=1042*27cf/cy*185lbs/cf / 2000lbs/ton * (1-0.35) =	**1691 tons***

GeoSystems Consultants, Inc.	CALCULATION SHEET		Page 2 of 6
		Project No.	03G324
CLIENT STEP, Inc.	SUBJECT Riprap Construction Cost Estimate	Prepared by: DMH	7/7/2006
PROJECT Cabot		Reviewed by: RDS	7/29/2006
Reading Slag Pile			

FS-2	Underlying R-4		
	Thickness		0.5 ft
	Volume =	=(94+15)*0.5*250/27	**503 cy**
	Total Weight	=503*27cf/cy*185lbs/cf / 2000lbs/ton * (1-0.35) =	**817 tons***
FS-3	Underlying R-6 &R-7		
	Thickness under R-6		0.67 ft
	Thickness under R-7		1 ft
	Volume under R-6	=36*0.67*250/27	224 cy
	Volume under R-7	=25*1*250/27	231 cy
	Total Volume		**455 cy**
	Total Weight	=455*27cf/cy*185lbs/cf / 2000lbs/ton * (1-0.35) =	**739 tons***
TOTAL OF ALL ROCK			**3,675 cy**
	*Weight based on porosity of 0.35 and rock density of 185 lbs/cf		**5,966 tons***

SCHEDULE

Section	Description	Unit	Quantity	Output	Extended	Subtotal
02370-450-0100						
	Machine placed	cy	3,675	62.00	59.27	
OR						
02370-450-0200						
	18" Min thickness (mat.)	sy	3,606	53.00	58.15	

MATERIAL COST (Delivered)

Section/Descriptoion	Description	Unit	Quantity*	Unit Cost	Extended	Subtotal
	R-4	ton	1,635	15.75	25,744.37	
	R-6	ton	1,084	18.85	20,431.87	
	R-7	ton	1,691	19.60	33,143.91	
	FS-2	ton	817	12.00	9,807.38	
	FS-3	ton	739	12.00	8,866.73	97,994.26

CONSTRUCTION COST (2005 dollars)

Site Clearing						
02230-100-0300						
	Cut & Chip heavy trees 24"	acre	0.74	10,800.00	8,045.44	
02230-100-0350						
	Grub and remove stumps	acre	0.74	5,850.00	4,357.95	
Erosion and Sedimentaion Control, RIPRAP						
02370-450-0100						
	Machine placed (lab,O&P)	cy	959	24.50	23,485.83	
02370-450-0200						
	18" Min thickness (lab,O&P)	sy	3,606	61.45	221,561.13	
INFLATION						
CPI increase form June 2005 to June 2006				4.30%	11,070.36	268,520.71

CLIENT	STEP, Inc.	SUBJECT	Riprap Construction Cost Estimate	Project No.	03G324
PROJECT	Cabot			Prepared by:	DMH 7/7/2006
	Reading Slag Pile			Reviewed by:	RDS 7/29/2006

ENGINEERING						
QA/QC	Quarry	day	15	450	6,750.00	
	Slope	day	60	450	27,000.00	
Consultation		hours	75	120	9,000.00	42,750.00
SUBTOTAL					302,270.71	366,514.97
CONTINGENCY					20%	73,302.99
TOTAL						439,817.96
RANGE						450,000 to 500,000

APPENDIX A

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				

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.

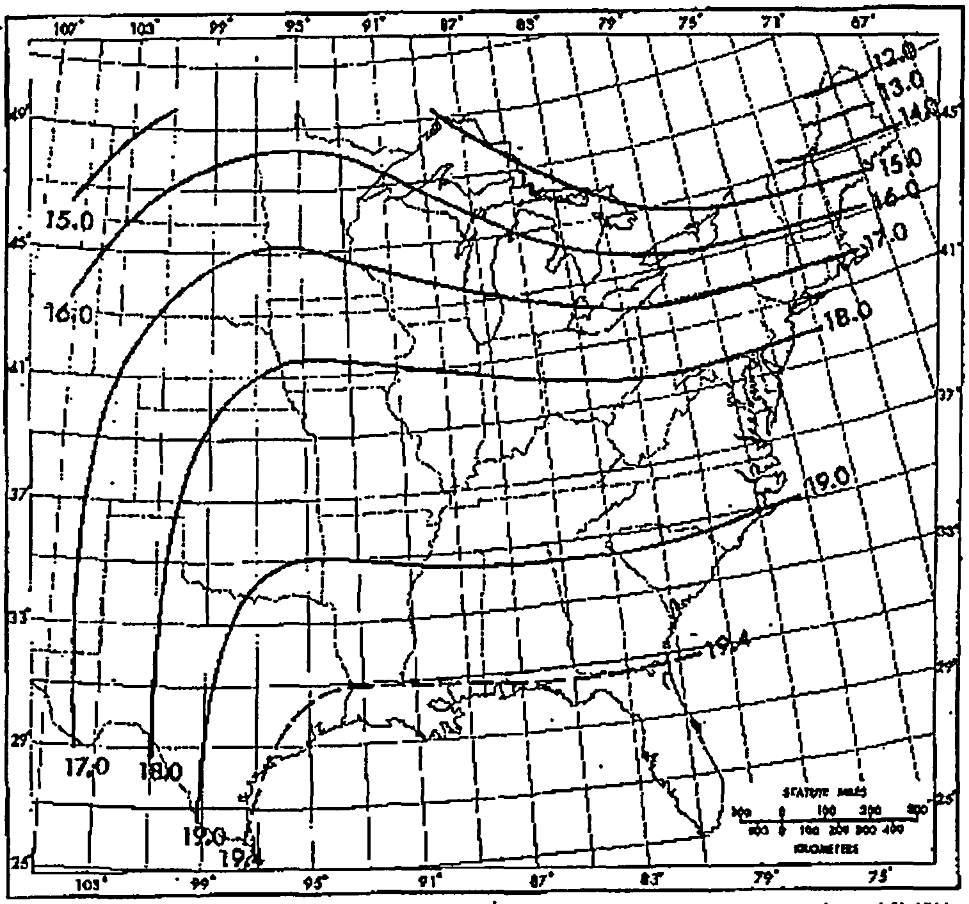


Figure 24.-l-hr l-mi2 precipitation from HMR go. 51.

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

GeoSystems Consultants, Inc.		CALCULATION SHEET		Project No.	03G324
CLIENT	STEP, Inc.	SUBJECT	Riprap Design Calculation for Schuykill River	Prepared by:	DMH 5/11/2006
PROJECT	Cabot		Probable Maximum Flood	Reviewed by:	
	Reading Slag Pile				

TASK:

Complete calculations to the design the riprap protection at the Cabot site in Reading, Pa to resist the Probable Maximum Flood (PMF) from the adjacent Schuykill River.

PROCEDURE:

1 Determine PMF flow for the Schuykill River at the site by plotting drainage area vs. PMF for sites located in the Susquehanna and Delaware Watersheds in Pennsylvania and interpolate for the drainage area contributing to the PMF at the Cabot site.

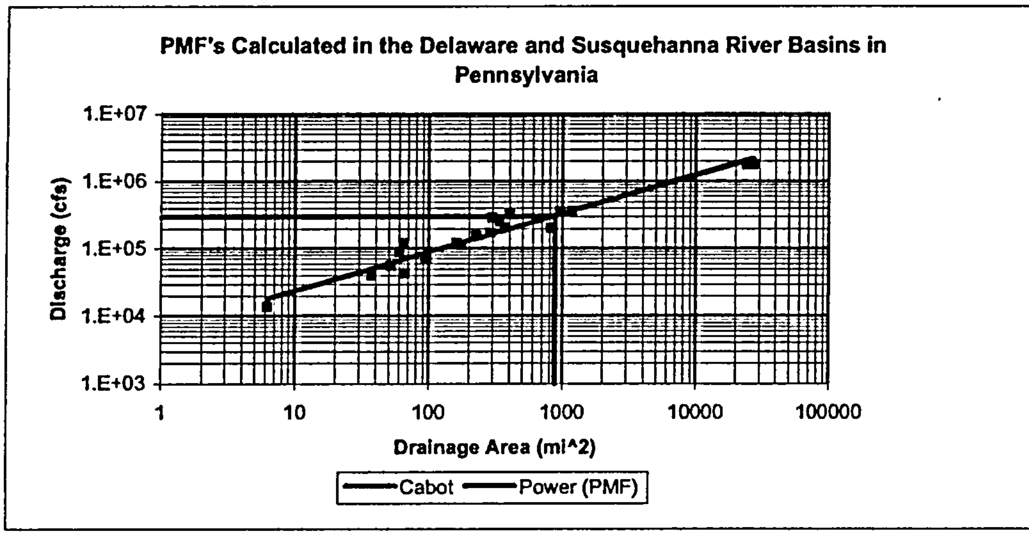
2 Complete HEC-RAS model for the Schuykill River at the Cabot Site to determine the river elevation and water velocities for the PMF, 3/4 PMF and 1/2 PMF. Calibrate model using data for the 100 year flood and the June 1972 Flood caused by Hurricane Agnes.

3 Calculate Riprap size based on velocities from HEC-RAS model using Unites Stated Army Corp of Engineers Engineering Manual No. 1110-2-1601, "Hydraulic Design of Flood Control Channels".

CALCULATIONS:

1 PMF's for sites located in the Delaware and Susquehanna Watersheds from U.S. Nuclear Regulatory Commission Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants" and Limerick Generating Station UFSAR are Plotted on a log-log scale. For the Cabot Site a drainage area of 880 square miles was used which is taken from U.S.G.S. Flood Gauging Station 01471510 located 1.25 miles down stream of the site.

Site	Drainage Area (square miles)	PMF (cfs)
Aylesworth	6.2	13,700
Stillwater	37	39,600
Trexler	52	55,500
Prompton	60	87,190
Gen Edgar Jadwin	65	119,700
Aquashicola	66	42,500
York Indian Rock	94	74,300
Beltzville	97	68,000
Maiden Creek	161	118,000
Blue Marsh	175	110,600
Alvin R. Bush	226	154,000
Francis E. Walter	288	170,000
Cowanesque	298	285,000
Foster Joseph Sayers	339	251,000
Curwensville	365	205,000
Tioga-Hammond	402	318,000
Hawk Mountain	812	202,000
Raystown	960	353,400
Limerick	1170	356,000
Fulton (Harrisburg)	24100	1,750,000
Peach Bottom	27000	1,750,000



From the fit, an 880 square mile drainage area corelates to a PMF discharge of 300,000 cfs.

2 HEC-RAS Model

The HEC-RAS model was compiled using topographic cross sections from the Reading USGS 7.5 minute topographic quadrangle and associated digital elevation model. The river bottom profile was obtained from the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for Berks County Pennsylvania. The datum for all references is NGVD 1929.

Manning's "n" values for the HEC-RAS model were choosen based on observed conditions and were within the ranges specified for the channel (0.025-0.050) and overbank (0.025-0.120) areas of the Schuylkill River by the FIS.

Location	Description	"n"
Channel	Clean, straight, full, no rifts or deep pools	0.030
Channel	Same as above but with stones and some weeds	0.050
Overbank	Medium to dense brush, in summer	0.100
Overbank	Gravel	0.030
Overbank	Riprap	0.045
Overbank	Asphalt	0.015

This model was verified against flow/stage data at the site for the 100 year flood from the FIS (55,800 cfs at elevation 211.3) and from data from Water Resources Bulletin No. 9, "Hydrological Data of the June 1972 Flood in Pennsylvania" prepared by the Pennsylvania Department of Environmental Resources in correlation with the USGS stage/discharge rating table for Station 01471510 (77,900 cfs at elevation 214.8 near the gauge and elevation 219 at the site).

The cross sections were then augmented using data from the site survey completed by Kent

Surveyors using NGVD 1929. This detailed survey shows that the site is up to 40 feet lower and the river and is between 110 and 170 feet wider at the selected cross sections than indicated by the USGS data. Since USGS data was used in the FIS it is reasonable that the flood elevation is lower in the detailed model for the 100 year flood due to the resulting larger cross section.

Velocities and water depths for the were taken from the river profiles and cross sections provided by the HEC-RAS model for at the steep slope section and at the bottom of the slope near the proposed road.

HEC-RAS Results Summary					
Section	1.1	2.1	3.1	4.1	Average
Flood elevation	226.7	226.9	227.4	228.4	
Roadway Elevation	208.1	210.0	210.9	211.0	
Side slope velocity	7.8	8.7	7.1	9.0	8.2
Roadway velocity	16.3	15.5	22.1	20.6	18.6
Flow depth at slope bottom	18.6	16.9	16.5	17.4	17.3

3 Calculate Riprap Size for side slope

Above elevation 230, the sideslope will not be affected by the PMF, therefore, the sideslope runoff design using R-4 (D_{50}=6") controls.

Use the Abt/Johnson equation to calculate the sideslop riprap size below elevation 230.

$D_{50} = 5.23\, S^{0.43}\, q^{0.56}\, C_\gamma / K_1$

where:

S	= slope of the channel	=	0.003
q	= flow per unit width		
	= Vd		
	= 8.2 x 17.3	q =	141.6 cfs/ft
K_1	= side slope correction factor		
	$= (1-\sin^2\theta/\sin^2\phi)^{0.5}$		
	θ = max of 1V:1.5H	=	34 °
	ϕ = angle of repose of riprap	=	40 °
		K_1 =	0.49
C_γ	= unit weight correction factor		
	$= (\gamma_{S1} - \gamma_w)/(\gamma_{S2} - \gamma_w)$		
γ_w	= unit weight of water	=	62.4 pcf
γ_{S1}	= unit weight of theoretical stone	=	165.0 pcf
γ_{S2}	= unit weight of actaul stone	=	185.8 pcf
		C_γ =	0.83

D_{50} = 5.23 (0.003)^0.43 (141.6)^0.56 (0.83) /(0.49) = 11.6 in

Use R-6 for slope protection D_{50} = 12.0 in

Thickness = D_{50} x 2 24.0 in

A 8-inch thick filter blanket of NSA No. FS-3 should be placed below the riprap.

				Project No.	03G324
CLIENT	STEP, Inc.	SUBJECT	Riprap Design Calculation for Schuylkill River	Prepared by:	DMH 5/11/2006
PROJECT	Cabot		Probable Maximum Flood	Reviewed by:	
	Reading Slag Pile				

3 Calculate Riprap Size for toe of slope

$D_{50} = 5.23\ S^{0.43}\ q^{0.56}\ C_\gamma / K_1$

where:				
	S	= slope of the channel	=	0.003
	q	= flow per unit width		
		= Vd		
		#VALUE!	q =	322.7 cfs/ft
	K_1	= side slope correction factor		
		$= (1-\sin^2\theta/\sin^2\phi)^{0.5}$		
		θ = max of 1V:1.5H	=	34 °
		ϕ = angle of repose of riprap	=	40 °
			K_1 =	0.49
	C_γ	= unit weight correction factor		
		$= (\gamma_{S1} - \gamma_w)/(\gamma_{S2} - \gamma_w)$		
	γ_w	= unit weight of water	=	62.4 pcf
	γ_{S1}	= unit weight of theoretical stone	=	165.0 pcf
	γ_{S2}	= unit weight of actaul stone	=	185.8 pcf
			C_γ =	0.83

D_{50} = 5.23 (0.003)^0.43 (322.7)^0.56 (0.83) /(0.49) = 18.4 in

Use R-7 for slope protection D_{50} = 18.0 in

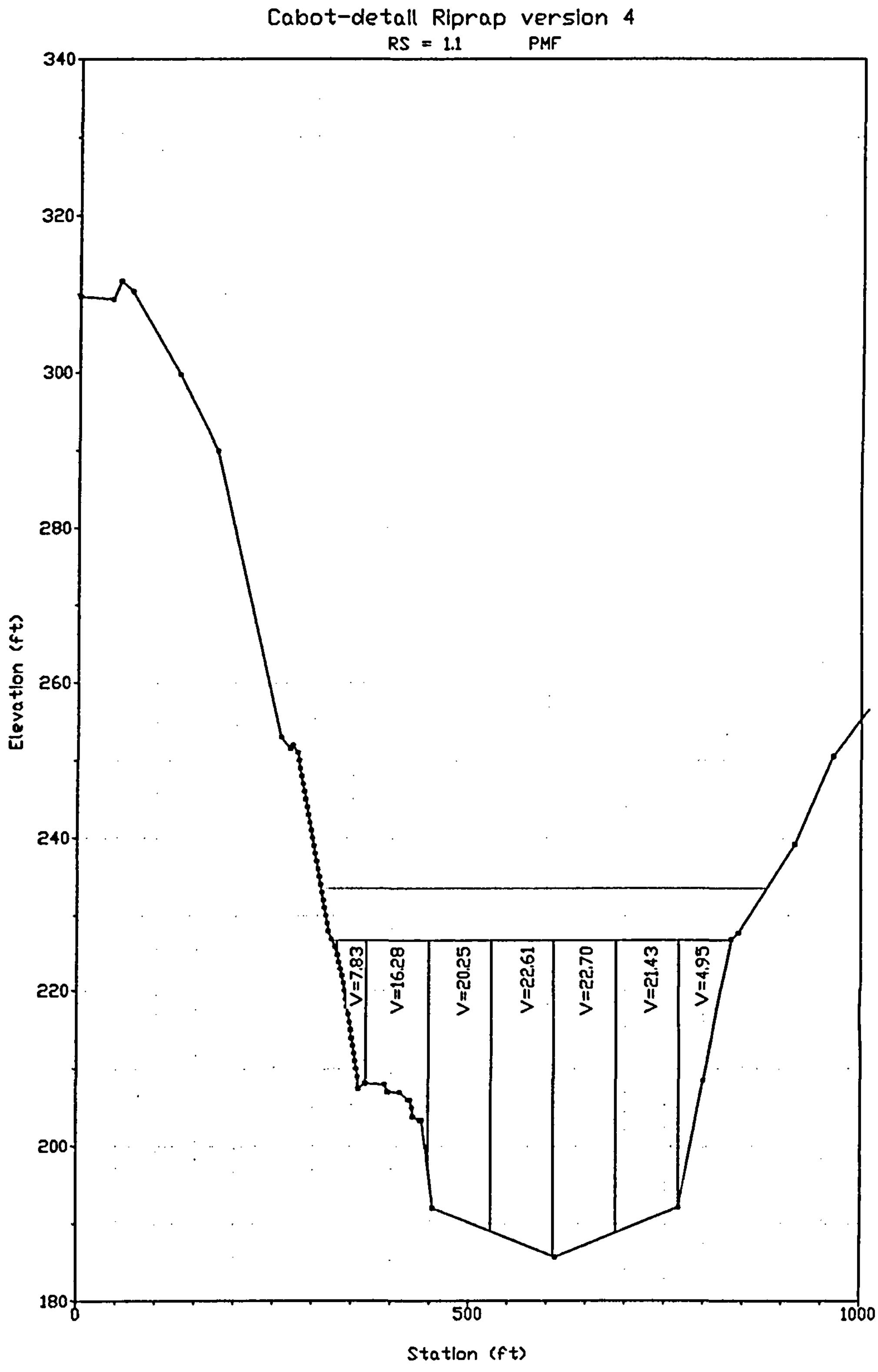
Thickness = D_{50} x 2 36.0 in

A 8-inch thick filter blanket of NSA No. FS-3 should be placed below the riprap.

Apron length = D_{50} (1/12) * 15 23 ft

Thickness = D_{50} (1/12) * 3 4.5 ft

A 12-inch thick filter blanket of NSA No. FS-3 should be placed below the riprap.



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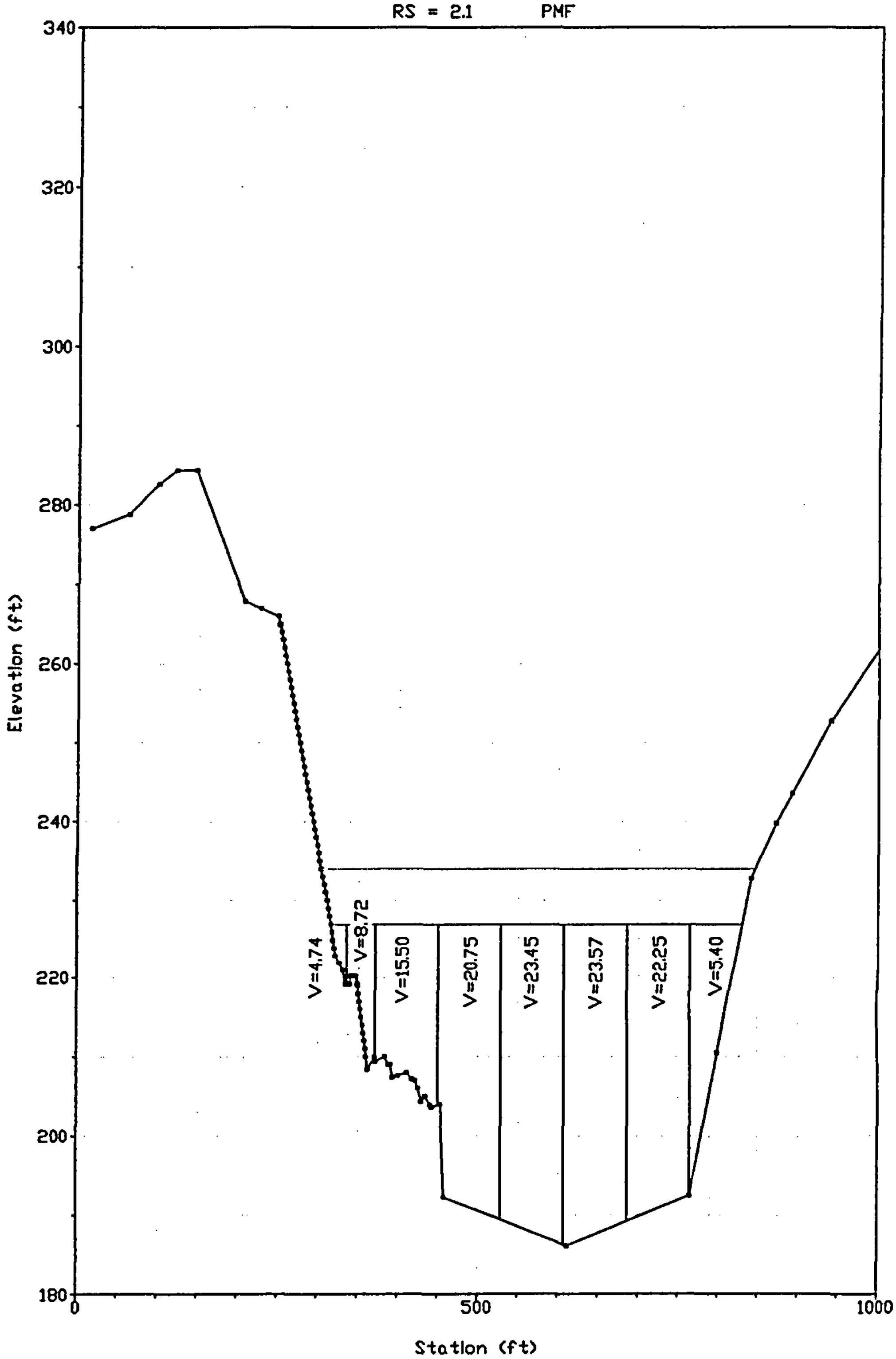
Cabot-detail Riprap version 4

RS = 2.1 PMF



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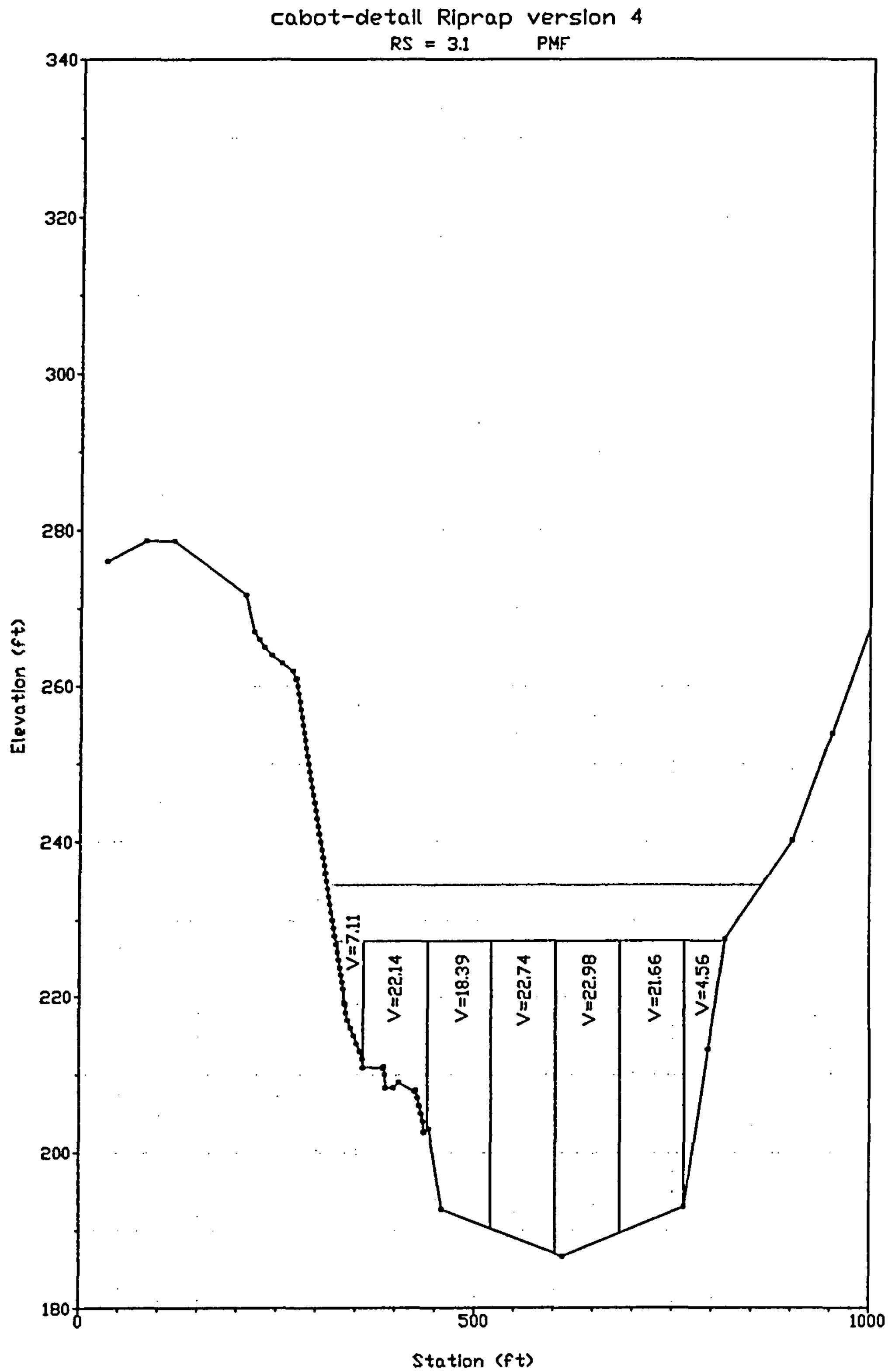

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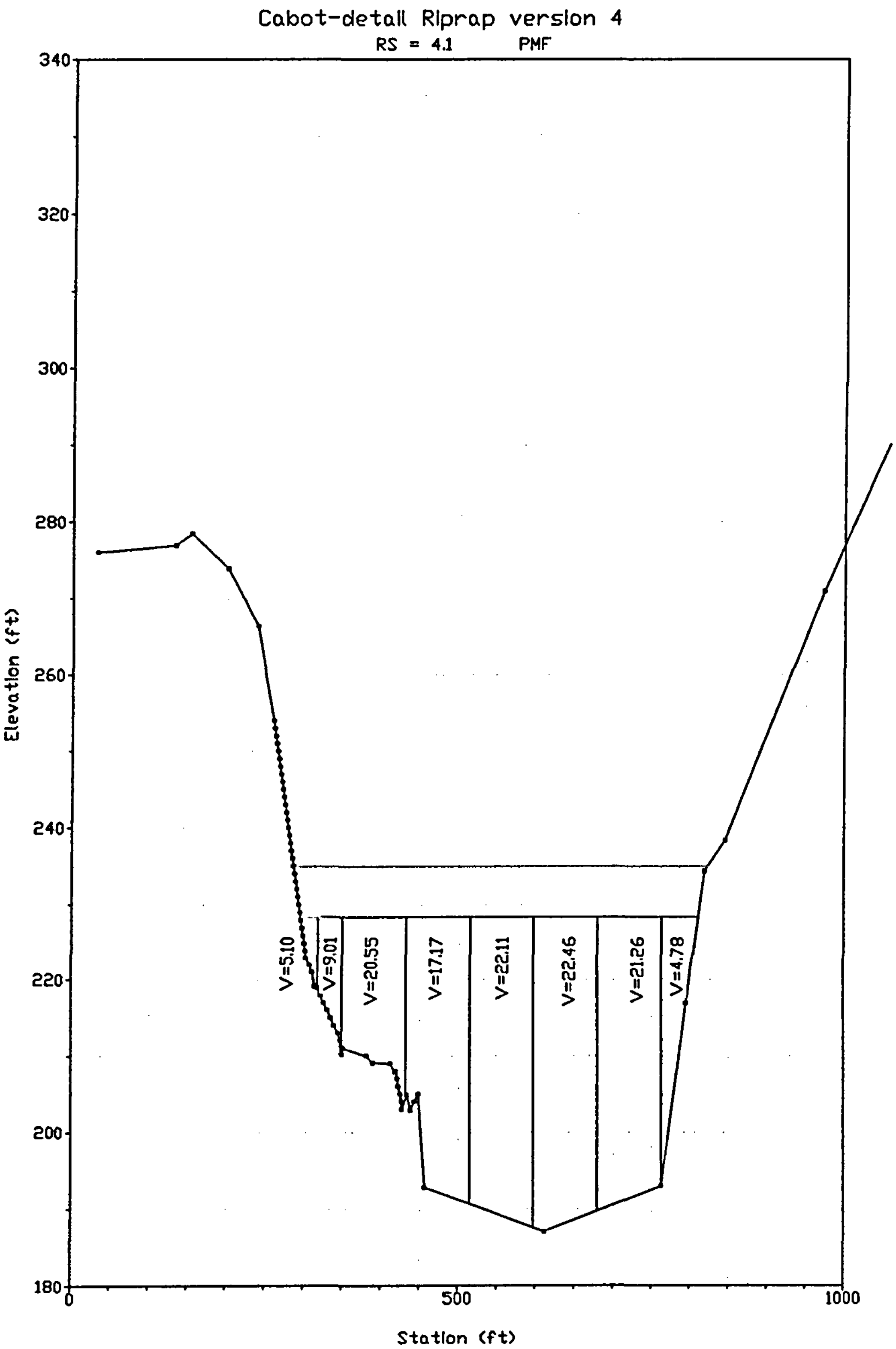

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HEC-RAS Version 3.1.3 May 2005
U.S. Army Corp of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX   XXXX        XXXX      XX      XXXX
X     X  X       X    X       X   X    X  X    X
X     X  X       X            X   X   X    X   X
XXXXXXX  XXXX    X      XXX   XXXX    XXXXXX    XXXX
X     X  X       X            X X     X    X        X
X     X  X       X    X       X  X    X    X        X
X     X  XXXXXX   XXXX        X   X   X    X   XXXXX
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PROJECT DATA
Project Title: cabot-detail Riprap version 4
Project File : cdRRv4.prj
Run Date and Time: 6/22/2006 10:51:23 AM

Project in English units

PLAN DATA

Plan Title: Plan 05
Plan File : m:\Projects\2003\2003G324 Reading Slag\hec\cdRRv4.p05

Geometry Title: cabot
Geometry File : m:\Projects\2003\2003G324 Reading Slag\hec\cdRRv4.g01

Flow Title : Flow 01
Flow File : m:\Projects\2003\2003G324 Reading Slag\hec\cdRRv4.f01

Plan Summary Information:

Number of:					
Cross Sections	=	4	Multiple Openings	=	0
Culverts	=	0	Inline Structures	=	0
Bridges	=	0	Lateral Structures	=	0

Computational Information
- Water surface calculation tolerance = 0.01
- Critical depth calculation tolerance = 0.01
- Maximum number of iterations = 20
- Maximum difference tolerance = 0.3
- Flow tolerance factor = 0.001

Computation Options
- Critical depth computed only where necessary
- Conveyance Calculation Method: At breaks in n values only
- Friction Slope Method: Average Conveyance
- Computational Flow Regime: Mixed Flow

FLOW DATA

Flow Title: Flow 01
Flow File : m:\Projects\2003\2003G324 Reading Slag\hec\cdRRv4.f01

Flow Data (cfs)

River	Reach	RS	100 yr	Agnes	0.5 PMF	0.75 PMF	PMF
Scuylkill River	Reading	4.1	55792	77900	150000	225000	300000

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
Scuylkill River	Reading	100 yr	Normal S = 0.0001	Normal S = 0.0029
Scuylkill River	Reading	Agnes	Normal S = 0.0001	Normal S = 0.0029
Scuylkill River	Reading	0.5 PMF	Normal S = 0.0001	Normal S = 0.0029
Scuylkill River	Reading	0.75 PMF	Normal S = 0.0001	Normal S = 0.0029
Scuylkill River	Reading	PMF	Normal S = 0.0001	Normal S = 0.0029

GEOMETRY DATA

Geometry Title: cabot
Geometry File : m:\Projects\2003\2003G324 Reading Slag\hec\cdRRv4.g01

CROSS SECTION

RIVER: Scuylkill River
REACH: Reading RS: 4.1

INPUT
Description:
Station Elevation Data num= 90

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
32	276	132.51	276.9	154.02	278.39	201.18	273.9	239.9	266.36
261.26	254	262.6	253	263.95	252	265.34	251	266.7	250
268.05	249	269.41	248	270.71	247	272.07	246	273.42	245
274.78	244	275.97	243	277.31	242	278.65	241	279.99	240
281.33	239	282.67	238	284.08	237	285.42	236	286.77	235
288.11	234	289.38	233	290.72	232	292.07	231	293.41	230
294.82	229	296.16	228	297.5	227	298.85	226	300.11	225
301.53	224	302.8	223	307.9	222	310.82	221	314.28	219.2
318.38	219	322.3	218	326.42	217	330.82	216	335.17	215
339.78	214	345.07	213	347.76	212	349.81	210.22	350.84	211
381.49	210	390.27	209.1	412.6	209	418.66	207.91	420	208
421.81	207	423.45	206	425.49	205	427.24	204	427.87	202.97
434.33	204.91	438.96	202.8	443.91	204	449.29	205	457.27	192.83
612	187	762.93	193	795.46	216.91	819.16	234.33	845.62	238.35
973.02	270.91	1057.4	289.99	1078.91	293.74	1118.61	293.74	1177.35	287.75
1224.51	282.14	1260.08	282.14	1289.86	279.89	1313.02	281.39	1421.4	299.35
1446.21	299.72	1581.06	295.23	1629.04	295.61	1654.68	297.48	1760.36	323.03
1807.51	330.14	1844.74	332.38	1881.96	330.51	1934.08	323.03	1961	317

Manning's n Values num= 5

Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
32	.045	349.81	.015	412.6	.1	457.27	.03	762.93	.1

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
349.81	762.93	150	150	150	.1	.1

CROSS SECTION OUTPUT Profile #PMF

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	234.93	Element	Left OB	Channel	Right OB
Vel Head (ft)	6.58	Wt. n-Val.	0.045	0.040	0.100
W.S. Elev (ft)	228.35	Reach Len. (ft)	150.00	150.00	150.00
Crit W.S. (ft)	219.92	Flow Area (sq ft)	546.98	13979.89	850.06
E.G. Slope (ft/ft)	0.003003	Area (sq ft)	546.98	13979.89	850.06
Q Total (cfs)	300000.00	Flow (cfs)	4410.94	291522.30	4066.74

Top Width (ft)	515.33	Top Width (ft)	54.12	413.12	48.09
Vel Total (ft/s)	19.51	Avg. Vel. (ft/s)	8.06	20.85	4.78
Max Chl Dpth (ft)	41.35	Hydr. Depth (ft)	10.11	33.84	17.68
Conv. Total (cfs)	5474750.0	Conv. (cfs)	80496.0	5320039.0	74214.7
Length Wtd. (ft)	150.00	Wetted Per. (ft)	58.13	422.94	59.69
Min Ch El (ft)	187.00	Shear (lb/sq ft)	1.76	6.20	2.67
Alpha	1.11	Stream Power (lb/ft s)	14.22	129.21	12.77
Frctn Loss (ft)	0.43	Cum Volume (acre-ft)	4.62	140.48	10.45
C & E Loss (ft)	0.05	Cum SA (acres)	0.48	4.16	0.60

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
additional cross sections.
Note: Manning's n values were composited to a single value in the main channel.

Profile #PMF

Hydr Depth(ft)	Pos	Velocity (ft/s)	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv
5.91	1 LOB	5.10	286.25	318.03	673.21	131.96	24.84	0.22
13.06	2 LOB	9.01	318.03	349.81	3737.73	415.01	33.30	1.25
19.36	3 Chan	20.55	349.81	432.43	32876.87	1599.59	84.86	10.96
33.41	4 Chan	17.17	432.43	515.06	47392.48	2760.64	90.02	15.80
39.25	5 Chan	22.11	515.06	597.68	71723.07	3243.31	82.68	23.91
[illegible].18	6 Chan	22.46	597.68	680.31	74564.48	3319.90	82.69	24.85
36.99	7 Chan	21.26	680.31	762.93	64965.41	3056.45	82.69	21.66
17.68	8 ROB	4.78	762.93	882.74	4066.74	850.06	59.69	1.36

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
additional cross sections.
Note: Manning's n values were composited to a single value in the main channel.

CROSS SECTION

RIVER: Scuylkill River
REACH: Reading RS: 3.1

INPUT
Description:
Station Elevation Data num= 104

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
33	276	82.34	278.64	117.37	278.64	208.11	271.73	219.64	267
226.07	266	232.35	265	241.82	264	254.57	263	268.16	262
271.94	260.86	272.96	261	274.25	260	275.79	259	277.25	258
278.53	257	279.96	256	281.38	255	282.86	254	284.38	253
285.89	252	287.48	251	289	250	290.52	249	292.04	248
293.56	247	295.09	246	296.61	245	298.13	244	299.65	243
301.17	242	302.69	241	304.21	240	305.73	239	307.25	238
308.89	237	310.42	236	311.94	235	313.46	234	315.01	233
316.54	232	318.07	231	319.69	230	321.21	229	322.74	228
324.26	227	325.79	226	327.31	225	328.79	224	330.32	223
331.86	222	333.31	221	334.59	219.2	336.16	219	337.52	218
339.86	217	343.42	216	347.1	215	350.8	214	355.18	213
358.38	212	358.95	210.86	384.04	210.8	385.13	211	386.54	210
387.43	208.28	397.51	208.3	404.54	209	424.61	207.85	426.03	208

428.22	207	430.49	206	432.71	205	434.85	204	436.12	202.61
442.55	202.99	458.94	192.66	612	186.6	765.06	192.98	796.04	213.282
817.92	227.62	902.18	240.1	952.32	253.91	1015.2	271.73	1078.88	285.18
1124.25	292.45	1173.6	288.09	1235.68	281.91	1315.28	278.27	1364.63	280.09
1416.37	278.27	1519.84	278.27	1551.68	275.73	1574.76	273.91	1594.66	276.09
1628.89	278.64	1655.15	280.45	1762.61	300.09	1798.42	305.54	1824.69	308.81
1868.47	309.54	1919.41	309.18	1944.08	307.72	1972.6	306		

Manning's n Values num= 5

Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
33	.045	358.95	.015	426.03	.1	458.94	.03	765.06	.1

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
358.95	765.06	150	150	150	.1	.1

CROSS SECTION OUTPUT Profile #PMF

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	234.45	Wt. n-Val.	0.045	0.037	0.100
Vel Head (ft)	7.10	Reach Len. (ft)	150.00	150.00	150.00
W.S. Elev (ft)	227.35	Flow Area (sq ft)	334.54	13585.35	901.19
Crit W.S. (ft)		Area (sq ft)	334.54	13585.35	901.19
E.G. Slope (ft/ft)	0.002697	Flow (cfs)	2364.67	293524.10	4111.19
Q Total (cfs)	300000.00				
Top Width (ft)	493.77	Top Width (ft)	35.22	406.11	52.44
Vel Total (ft/s)	20.24	Avg. Vel. (ft/s)	7.07	21.61	4.56
Max Chl Dpth (ft)	40.75	Hydr. Depth (ft)	9.50	33.45	17.18
Conv. Total (cfs)	5776390.0	Conv. (cfs)	45530.9	5651700.0	79159.5
Length Wtd. (ft)	150.00	Wetted Per. (ft)	39.98	412.29	62.70
Min Ch El (ft)	186.60	Shear (lb/sq ft)	1.41	5.55	2.42
Alpha	1.12	Stream Power (lb/ft s)	9.96	119.88	11.04
Frctn Loss (ft)	0.46	Cum Volume (acre-ft)	3.11	93.02	7.43
C & E Loss (ft)	0.00	Cum SA (acres)	0.32	2.75	0.43

te: Manning's n values were composited to a single value in the main channel.

Profile #PMF

Hydr Depth(ft)	Pos Velocity (ft/s)	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv
1	LOB	293.76	326.36	2.97	2.26	3.14	0.00
0.86	1.32						
2	LOB	326.36	358.95	2361.70	332.29	36.84	0.79
10.19	7.11						
3	Chan	358.95	440.17	33695.88	1521.70	84.17	11.23
18.74	22.14						
4	Chan	440.17	521.39	51237.89	2785.57	84.26	17.08
34.30	18.39						
5	Chan	521.39	602.62	71591.66	3148.85	81.29	23.86
38.77	22.74						
6	Chan	602.62	683.84	73548.98	3200.32	81.29	24.52
39.40	22.98						
7	Chan	683.84	765.06	63449.70	2928.91	81.29	21.15
36.06	21.66						
8	ROB	765.06	885.81	4111.19	901.19	62.70	1.37
17.18	4.56						

Note: Manning's n values were composited to a single value in the main channel.

CROSS SECTION

VER: Scuylkill River
REACH: Reading RS: 2.1

INPUT

Description:

Station Elevation Data num= 116

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
17	277	63.13	278.73	100.33	282.58	122.65	284.3	147	284.3
207.79	267.9	227.79	267	249.79	266	250.9	264.91	252.08	265
253.65	264	255.31	263	257.02	262	258.71	261	260.51	260
262.1	259	263.88	258	265.44	257	267.13	256	268.82	255
270.51	254	272.2	253	273.89	252	275.67	251	277.35	250
279.04	249	280.72	248	282.41	247	284.09	246	285.78	245
287.46	244	289.15	243	290.83	242	292.52	241	294.2	240
295.89	239	297.58	238	299.4	237	301.08	236	302.75	235
304.51	234	306.33	233	308.05	232	309.81	231	311.62	230
313.31	229	314.89	228	316.43	227	317.83	226	319.06	225
320.48	224	321.94	223	326.69	222	331.16	221	334.53	219.2
339.78	219.2	341.11	220.2	343.47	220.2	347.09	220.17	348.98	219.2
349.62	219	350.98	218	352.34	217	353.7	216	355.04	215
356.36	214	357.54	213	358.96	212	360.37	211	360.79	210
362.88	208.4	371.53	210	372.42	209.36	384.18	210	388.86	209
391.37	209	393.89	207.38	400.9	207.58	411.49	208	418.05	207.18
421.81	207	425.75	206	429.82	204.32	434.89	205	440.82	203.89
442.68	203.59	453.65	204	458.58	192.27	612	186.1	765.42	192.45
799.81	210.48	842.35	232.79	873.33	239.75	892.96	243.56	941.77	252.75
1051.85	269.65	1067.24	271.22	1100.13	273.23	1140.45	275.25	1163.27	277.49
1197.75	280.41	1246.03	286.01	1283.43	286.01	1380.52	282.42	1400.15	280.85
1448.42	271.22	1463.28	269.43	1491.93	267.63	1513.68	267.63	1576.88	275.27
1645.95	284.05	1681.6	288.13	1732.85	293.15	1788.56	298.8	1849.52	304.99
1935.77	304.99								

Manning's n Values num= 5

Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
17	.045	371.53	.015	411.49	.1	458.58	.03	765.42	.1

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
371.53	765.42	150	150	150	.1	.1

CROSS SECTION OUTPUT Profile #PMF

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	233.99	Wt. n-Val.	0.045	0.042	0.100
Vel Head (ft)	7.11	Reach Len. (ft)	150.00	150.00	150.00
W.S. Elev (ft)	226.88	Flow Area (sq ft)	511.28	13335.32	1130.51
Crit W.S. (ft)		Area (sq ft)	511.28	13335.32	1130.51
E.G. Slope (ft/ft)	0.003496	Flow (cfs)	4097.94	289794.50	6107.58
Q Total (cfs)	300000.00				
Top Width (ft)	514.49	Top Width (ft)	54.93	393.89	65.66
Vel Total (ft/s)	20.03	Avg. Vel. (ft/s)	8.02	21.73	5.40
Max Chl Dpth (ft)	40.78	Hydr. Depth (ft)	9.31	33.86	17.22
Conv. Total (cfs)	5073721.0	Conv. (cfs)	69306.0	4901121.0	103293.9
Length Wtd. (ft)	150.00	Wetted Per. (ft)	61.47	403.45	74.14
Min Ch El (ft)	186.10	Shear (lb/sq ft)	1.82	7.21	3.33
Alpha	1.14	Stream Power (lb/ft s)	14.55	156.78	17.98
Frctn Loss (ft)	0.48	Cum Volume (acre-ft)	1.65	46.67	3.93
C & E Loss (ft)	0.04	Cum SA (acres)	0.17	1.37	0.23

Note: Manning's n values were composited to a single value in the main channel.

Profile #PMF

Hydr Depth(ft)	Pos Velocity (ft/s)	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv
1 / 4.63	LOB / 4.74	300.62	336.08	427.06	90.16	21.41	0.14
2 / 1.88	LOB / 8.72	336.08	371.53	3670.88	421.12	40.06	1.22
3 / 19.85	Chan / 15.50	371.53	450.31	24240.73	1564.09	80.29	8.08
4 / 35.02	Chan / 20.75	450.31	529.09	57245.77	2758.64	86.63	19.08

5	Chan	529.09	607.86	72116.77	3074.75	78.84	24.04	39.03	23.45
6	Chan	607.86	686.64	72986.42	3097.00	78.85	24.33	39.31	23.57
7	Chan	686.64	765.42	63204.77	2840.84	78.85	21.07	6.06	22.25
8	ROB	765.42	882.46	6107.58	1130.51	74.14	2.04	17.22	5.40

Note: Manning's n values were composited to a single value in the main channel.

CROSS SECTION

RIVER: Scuylkill River
REACH: Reading RS: 1.1

INPUT
Description:
Station Elevation Data num= 99

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	309.66	42.09	309.33	52.55	311.6	67.07	310.34	127.49	299.73
176.29	289.88	258.52	253	270.44	251.5	273.07	252	279.78	251
281.67	250	283.3	249	285.22	248	286.99	247	288.76	246
290.53	245	292.3	244	294.06	243	295.83	242	297.59	241
299.35	240	301.11	239	302.87	238	304.65	237	306.34	236
308	235	309.68	234	311.34	233	312.99	232	314.65	231
316.3	230	318.2	229	319.88	228	323.7	227	328.8	226
331.61	225	333.45	224	335.48	223	337.39	222	339.19	221
340.87	220	342.49	219	344.1	218	345.63	217	347.17	216
348.8	215	349.25	213.94	350.46	214	351.95	213	353.38	212
354.89	211	356.26	210	357.99	209	359.94	207.48	368.26	208.12
392.91	208	396.8	207.04	412.16	207	423.12	206.01	425.38	206
427.83	205	428.92	203.83	438.27	203.32	440.61	203.36	454.76	192.04
612	185.7	769.24	192.11	800.7	208.47	836.1	226.87	845.56	227.73
917.02	239.1	964.66	250.47	1009.39	256.53	1039.6	260.32	1068.65	261.33
1088.4	261.83	1113.96	260	1157.54	260	1195.3	262.09	1258.62	269.67
1310.33	275.22	1323.11	274.97	1348.09	273.2	1386.43	271.43	1414.32	269.16
1455.57	269.41	1466.61	271.69	1486.94	269.41	1539.23	269.41	1597.32	277.5
1655.42	284.57	1690.86	290.63	1733.85	294.42	1785.55	301.5	1820.41	305.54
1867.47	307.81	1903.49	309.58	1930.79	311.85	1950.64	313.57		

Manning's n Values num= 5

Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
0	.045	368.26	.015	412.16	.1	454.76	.03	769.24	.1

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
368.26	769.24	450	450	450	.1	.1

CROSS SECTION OUTPUT Profile #PMF

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	233.47	Wt. n-Val.	0.045	0.040	0.100
Vel Head (ft)	6.73	Reach Len. (ft)			
W.S. Elev (ft)	226.74	Flow Area (sq ft)	446.59	13768.98	1153.17
Crit W.S. (ft)	218.19	Area (sq ft)	446.59	13768.98	1153.17
E.G. Slope (ft/ft)	0.002903	Flow (cfs)	3469.04	290826.00	5704.93
Q Total (cfs)	300000.00				
Top Width (ft)	510.82	Top Width (ft)	43.23	400.98	66.61
Vel Total (ft/s)	19.52	Avg. Vel. (ft/s)	7.77	21.12	4.95
Max Chl Dpth (ft)	41.04	Hydr. Depth (ft)	10.33	34.34	17.31
Conv. Total (cfs)	5567984.0	Conv. (cfs)	64385.1	5397715.0	105883.2
Length Wtd. (ft)		Wetted Per. (ft)	48.95	406.09	75.07
Min Ch El (ft)	185.70	Shear (lb/sq ft)	1.65	6.14	2.78
Alpha	1.14	Stream Power (lb/ft s)	12.84	129.79	13.77
Frctn Loss (ft)		Cum Volume (acre-ft)			
C & E Loss (ft)		Cum SA (acres)			

Note: Manning's n values were composited to a single value in the main channel.

Profile #PMF

Hydr Depth(ft)	Pos Velocity (ft/s)	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv
1 0.71	LOB 1.28	294.61	331.43	5.85	4.58	6.64	0.00
2 12.00	LOB 7.83	331.43	368.26	3463.18	442.02	42.31	1.15
3 20.73	Chan 16.28	368.26	448.46	27073.34	1662.49	83.28	9.02
4 35.87	Chan 20.25	448.46	528.65	58245.04	2876.92	82.03	19.42
5 39.30	Chan 22.61	528.65	608.85	71242.46	3151.34	80.26	23.75
6 39.53	Chan 22.70	608.85	689.04	71946.13	3170.00	80.26	23.98
7 36.26	Chan 21.43	689.04	769.24	62319.08	2908.22	80.26	20.77
8 17.31	ROB 4.95	769.24	887.38	5704.93	1153.17	75.07	1.90

Note: Manning's n values were composited to a single value in the main channel.

SUMMARY OF MANNING'S N VALUES

River:Scuylkill River

Reach	River Sta.	n1	n2	n3	n4	n5
Reading	4.1	.045	.015	.1	.03	.1
Reading	3.1	.045	.015	.1	.03	.1
Reading	2.1	.045	.015	.1	.03	.1
Reading	1.1	.045	.015	.1	.03	.1

SUMMARY OF REACH LENGTHS

River: Scuylkill River

Reach	River Sta.	Left	Channel	Right
Reading	4.1	150	150	150
Reading	3.1	150	150	150
Reading	2.1	150	150	150
Reading	1.1	450	450	450

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: Scuylkill River

Reach	River Sta.	Contr.	Expan.
Reading	4.1	.1	.1
Reading	3.1	.1	.1
Reading	2.1	.1	.1
Reading	1.1	.1	.1

ERRORS WARNINGS AND NOTES
Errors Warnings and Notes for Plan : Plan 03

River: Scuylkill River Reach: Reading   RS: 4.1   Profile: PMF
     Warning:The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
     Note: Manning's n values were composited to a single value in the main channel.
River: Scuylkill River Reach: Reading   RS: 3.1   Profile: PMF
     Note: Manning's n values were composited to a single value in the main channel.
River: Scuylkill River Reach: Reading   RS: 2.1   Profile: PMF
     Note: Manning's n values were composited to a single value in the main channel.
River: Scuylkill River Reach: Reading   RS: 1.1   Profile: PMF
     Note: Manning's n values were composited to a single value in the main channel.