REPORT
BLASLAND & BOUCK ENGINEERS, P.C.

Supplemental Hydrogeologic Investigation Plan

WINSTON THOMAS FACILITY & BENNETT'S DUMP

Westinghouse Electric Corporation
Waste Technology Services Division
Waltz Mill Site, Pennsylvania

August 1986
SUPPLEMENTAL HYDROGEOLOGIC INVESTIGATION PLAN

WINSTON THOMAS FACILITY

AND

BENNETT'S DUMP

WESTINGHOUSE ELECTRIC CORPORATION
WASTE TECHNOLOGY SERVICES DIVISION
WALTZ MILL SITE, PENNSYLVANIA

AUGUST 1986

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WINSTON THOMAS FACILITY

I. Introduction

A. Purpose

The Consent Decree requires Westinghouse to perform a Supplemental Hydrogeologic Investigation of the Winston Thomas Facility with the resulting data used for selection of on-site monitoring locations for future ground-water monitoring at the site (Paragraphs 74(a) and 75).

In accordance with Paragraph 74 of the Consent Decree, a Supplemental Hydrogeologic Investigation Plan for the Winston Thomas Facility was submitted to the parties of the Consent Decree within 60 days of the signing of the Consent Decree. This Plan was submitted in combination with the Supplemental Hydrogeologic Investigation Plan for Bennett's Dump in October 1985. In December of 1985, Westinghouse met with the parties of the Consent Decree to review this submittal. After the December meeting, the Environmental Protection Agency (EPA) submitted a formal review to Westinghouse (letter to Mr. Carl Anderson from M.V. Pearce, December 3, 1985). On the basis of comments received at the meeting and in the letter, Westinghouse agreed to resubmit the Plan and incorporate changes that would address the issues raised by the EPA and other parties of the Consent Decree.

A revised Winston Thomas Facility Supplemental Hydrogeologic Investigation Plan was submitted in February, 1986 to the parties of the Consent Decree. The revised Plan was reviewed by the parties of the Consent Decree and comments were submitted to Westinghouse by the EPA (April 14, 1986) and the City of Bloomington (May 13, 1986). In addition,
the parties of the Consent Decree met on May 20th, 1986 to review their comments to this Plan and to reach agreement on the necessary revisions to be included in this final submittal of the Supplemental Hydrogeologic Investigation Plan for the Winston Thomas Facility.

B. Location and History

The Winston Thomas Sewage Treatment Plant is located in the central portion of Monroe County, Indiana, about 2.5 miles south of Bloomington in the west half of the southwest quarter of Section 16, Range 1W, Township 8N. The site, approximately 26 acres, is situated in a topographically level, north-south trending valley adjacent to Clear Creek as shown on Figure WT-1.

The Winston Thomas Facility operated from 1933 to 1982, coinciding with the period of Westinghouse use, 1958 to 1982. During the period that the plant was in service, it handled the sewage waste from the City of Bloomington. Plant operations were discontinued in 1982 because of the obsolescence of certain facilities. During the period of Westinghouse use, certain facilities of the treatment plant, including the tertiary lagoon, trickling filter, digesters, drying beds and old lagoons, became contaminated with low levels of polychlorinated biphenyls (PCBs).

A review of the available hydrogeologic data indicated that the regional ground-water flow is from north to south. Further field work is needed to confirm this. Soils, while expected to be shallow, may locally be as great as ten feet thick. Their composition may vary from silt or clay-rich residual soils to coarser-grained stream deposits. Also, as a task of the 1982 investigation, a review of residential well logs yielded information such as depth to water, depth to bedrock and well yield. The local bedrock and
water-bearing formation is described as the Harrodsburg Limestone. This unit is described to vary in thickness between 60 to 80 feet (1, 2) and 30 to 100 feet in Monroe County, Indiana (3). Field Investigations performed under Task 2.1 will delineate the thickness of Harrodsburg Limestone beneath the Winston Thomas Facility Site.

Westinghouse performed studies that include a preliminary fracture trace analysis and review of hydrogeologic information prepared for Environ in December of 1982 (4), and soil test borings, lagoon cores and analytical work performed in conjunction with ongoing discussions with the City of Bloomington, the EPA and the Department of Justice in 1983 and 1984.

C. Investigation Overview

The purpose of the Winston Thomas Facility Supplemental Hydrogeologic Investigation is to review and evaluate the development of the site and the hydrogeologic conditions, and to define the locations of on-site and off-site monitoring wells for future ground-water monitoring, as specified in the Consent Decree.

The Investigation will focus on work activities that contribute to the understanding of the interrelationship between the site’s history and hydrogeologic setting with respect to the needs for developing the necessary ground-water monitoring plans for this site.

The Consent Decree requires that a total of eight wells be drilled at the Winston Thomas Facility as part of the Supplemental Hydrogeologic Investigation. The proposed locations for these wells are shown on Figure WT-1.
The selection of these locations is based on previous studies completed by Westinghouse, and discussions with the U.S. Department of Justice and other parties of the Consent Decree negotiation in 1984.

In addition, seven of the eight locations selected are identical to those presented by Phillip E. LaMoreaux & Associates (PELA) (5) to the U.S. Department of Justice during the development of the Consent Decree in 1984. At this time, we have chosen to locate the eighth well on what we believe to be a fracture trace that exists between the tertiary lagoon and Clear Creek; the eighth location selected by PELA was nearer to the sludge drying beds.

The monitoring points selected provide for:

1. areal coverage to acquire upgradient and downgradient water-level elevations and water quality data,
2. monitoring locations adjacent to the major source areas of existing contamination, and
3. sufficient characterization of subsurface conditions to describe lithology and bedrock structure.

The Supplemental Hydrogeologic Investigation described in the following sections is a comprehensive three phase study. The proposed monitoring well locations may be modified based on the Phase 1 and Phase 2 work efforts. The number and permanent location for the On-Site Monitoring Wells will be selected on the basis of the work performed in the Supplemental Hydrogeologic Investigation and as presented in the final work product of Phase 3. The work schedule for the Supplemental Hydrogeologic Investigation is set forth in Table WT-1 and a detailed description of the work tasks for each of the three phases is presented within the following text.
II. Scope of Work for Supplemental Hydrogeologic Investigation

A. Phase 1 - Data Collection and Review

Phase 1 will begin within 14 days of approval, by the parties of the Consent Decree, of the Supplemental Hydrogeologic Investigation Plan. Phase 1 will include: a review of the site history including construction of the tertiary lagoon and rerouting of Clear Creek; a geology and hydrogeology review; an evaluation of past investigations including the tertiary lagoon coring program, berm stability evaluation, soil borings and previous analytical results; and an aerial photography review coupled with a topographic map study. Following these activities, a site inspection will be completed.

The goals of Phase 1 are to review the general geology and hydrogeology of both the unconsolidated and consolidated units beneath the Winston Thomas Facility Site, to evaluate the nature and extent of geomorphic and land use changes that have occurred, and to assess the surface expressions of karst features. The purpose of the review is to establish a foundation level of understanding on-site conditions, to uncover data needs that should be addressed in later work tasks, and to establish a framework to begin the detailed look at the hydrogeology and ground-water quality characteristics of the site.

At the conclusion of Phase 1, Westinghouse will also submit to the parties of the Consent Decree, a Progress Report of the Phase 1 findings which will also include a description of any changes/additions in the Scope of Work or in the locations of proposed borings/corings and monitoring wells to be completed in Phase 2.
Task 1.1 Geology and Hydrogeology Review

Information regarding the geology/hydrogeology near the Winston Thomas Facility, gathered from sources such as Indiana Geological Survey Reports, Indiana University theses and publications and Department of Agriculture Soil Survey, will be reviewed to refine our knowledge of the type of soils and rock units that will be encountered during drilling activities, and pertinent characteristics of these soil and rock units including marker beds, water bearing zones and karst development in these units. The geology and hydrogeology will be discussed with the technical representatives of the Consent Decree parties and other hydrogeologists and geologists knowledgeable in local conditions.

This task will define how to identify bedrock formation units by marker beds or changes in lithology, and reconfirm the approximate drilling and monitoring depths necessary for future drilling activities and well installation. In addition, the identification of karst features such as sinkholes, caverns and springs at or around the Winston Thomas Facility may aid in the delineation of ground-water flow directions and solution feature trends which may affect flow directions and, therefore, may be an additional consideration in the placement of Phase 2 borings/corings and monitoring wells.

In addition, Westinghouse has completed a well user survey that includes the area around the Winston Thomas Facility. This summary identifies the location, by street address, of active or inactive water wells in the area. The well logs gathered in support of the survey will be reviewed and may be useful in determining additional information about ground-water characteristics around the site.
Task 1.2 Review of Previous Subsurface and Analytical Investigations

Both Westinghouse and the EPA have conducted prior studies at the Winston Thomas Facility. Westinghouse has performed studies to determine the contamination in the trickling filter by sampling and analyzing the trickling filter rocks. In addition, a total of 15 cores were taken in the tertiary lagoon to verify the existence of the clay liner and estimate the extent of PCB migration into this liner by molecular diffusion. Also, ten borings were drilled by Westinghouse to determine the location and size of the former sludge lagoons and their PCB content. Primarily these early studies were performed to quantify the waste areas in size and PCB content for future remediation activities.

Other soil investigations have addressed the stability of the berm surrounding the tertiary lagoon (6). This study included eight borings, cross sections and evaluations. A review of these past soil borings/lagoon corings and any resultant analytical efforts may provide a data base for the characteristics of the unconsolidated units and for the potential for contaminant migration into these units.

Data from this review that is determined to be relevant to the investigation will be included in the Phase 1 Progress Report.

Task 1.3 Aerial Photograph Analysis, Review of Construction Drawings and Topographic Maps

Aerial photographs, construction drawings and topographic maps will be reviewed to delineate any geomorphic features such as
pre-tertiary lagoon construction drainage patterns of Clear Creek and any karst features, especially fracture traces, sinkholes, springs and seepage areas.

This aerial photograph analysis will include and incorporate past studies completed by Westinghouse (4) and the EPA (7).

In conjunction with the aerial photography analysis, the topographic review will demarcate areas of both natural and man-made landform changes. Engineers' construction drawings developed for constructing the plant and its modifications, including the construction of the tertiary lagoon, will be reviewed and evaluated in this work task.

This work task will be utilized to establish an historical perspective of the Winston Thomas Facility Site, to add to our data base for site characterization, and to re-affirm the placement of Phase 2 borings/corings and monitoring wells.

Task 1.3 Site Reconnaissance

A field reconnaissance of the Winston Thomas Facility Site and immediate surroundings will be performed to identify physical features and access limitations that may influence drilling locations. Also the verification of features delineated in the aerial photography review, topographic map review and literature review will be completed in this work task. The emphasis of the site reconnaissance will be to identify drilling access limitations and karst features such as springs, sinkholes, swallow holes and seeps which may influence boring/coring or monitoring well placement.

The area to be covered by this site inspection is outlined on Figure WT-1.
Task 1.5 Phase 1 Progress Report

A Progress Report summarizing the results of Phase 1 will be generated and sent to the parties of the Consent Decree within 15 days upon completion of the Phase 1 work tasks. The Report will also include any modifications to the Scope of Work described herein for Phase 2. Additionally, the Report will include the following:

a. A description of any changes in the proposed boring/coring and monitoring well locations, and rationale for these changes.

b. A section on background geology and hydrogeology.

c. A section on past work and applicability to the Supplemental Hydrogeologic Investigation Plan.

d. A section on the aerial photography, construction drawing review and the topography study.

e. A complete reference list of items b. through d. above. The documents/data cited in this reference list will be made available if requested by any of the parties of the Consent Decree.

f. A discussion of the approach to the selection of which sites will be cored in the Phase 2 work program and how the coring data will be utilized to locate monitoring wells or additional coring locations will be supplied.

If requested, Westinghouse will be available to meet to review or discuss the findings of the Progress Report with selected representatives of the Consent Decree parties prior to beginning Phase 2.

Within seven days of receiving comments from the parties of the Consent Decree on the Phase 1 Progress Report, Westinghouse will begin the Phase 2 Work Program.
B. Phase 2 - Site Investigations

1. General

Phase 2 is primarily a field program of drilling and sampling in both the soil and the rock units located at the Winston Thomas Facility. The rock core holes will be utilized as temporary wells to initiate the measurement of site-specific hydrogeologic data and to confirm future monitoring well sites.

The primary goals of Phase 2 are: to evaluate the stratigraphy in the immediate vicinity of the Winston Thomas Facility; to evaluate the hydrogeologic characteristics including ground-water flow direction, ground-water gradients, water bearing zones, and permeability characteristics; and to assess and confirm the Phase 1 and Phase 2 task results for installing monitoring wells at their described locations.

Ground water will be sampled and analyzed as described below in Task 2.4 after all the monitoring wells are installed in Task 2.3 of Phase 2.

2. Field Investigations

Task 2.1 Continuous Soil Test Boring/Rock Coring

A continuous profile of soil and bedrock will be sampled from ground surface to an approximate depth of 60 feet; or to the base of the Harrodsburg Limestone at each boring/coring location. The work completed in Task 1.1 should define how to identify the base of the Harrodsburg Limestone.

The borings/corings will be located at no less than five of the eight proposed monitoring well locations.
This work will be completed in steps such that information from these borings/corings will be utilized to assess whether additional borings/corings are necessary to define the site's stratigraphy or the relocation of any monitoring wells.

In the unconsolidated deposits, continuous split-spoon sampling will be employed according to ASTM Standards and Procedures outlined in Appendix A, *Drilling/Sampling Protocol for Soil Borings*. In the consolidated rock units, continuous coring will be employed following ASTM Standards and Procedures outlined in Appendix B, *Drilling/Sampling Protocol for Rock Coring*. A geologist will be on site to ensure these protocols are being followed and to describe, in detail, the soil and rock units encountered. The unconsolidated unit description will include the following: soil type, grain size, color and water content. The rock core will be inspected by the geologist and logs prepared to include the following: rock type, color, grain size, fossils, density, solution features, fractures, joints, weathering features, clay infilling and core loss. Cores will be stored in plastic sleeves in core boxes until they are no longer needed.

At each coring location, the core hole will be utilized as a temporary observation well. Therefore, to ensure the integrity of this temporary system for the collection of hydrogeologic data, it may be necessary to install a temporary surface casing.

Each core hole will be gamma ray logged according to methods found in Appendix C, *Gamma Ray Logging Protocol*. The gamma ray logs will be compared to the detailed lithologic coring logs and a correlation of gamma ray readings with lithology will be prepared. Future holes that are not cored will be gamma ray logged and the core hole/gamma ray
correlation data will be used to extend the understanding of site wide lithology. Gamma ray results will be presented in the Phase 3 Report.

Also, at one interval in each corehole, a Packer Test or other applicable test will be performed to assess the permeability characteristics of the rock formations. If more than one productive flow system is encountered during the coring operation, additional tests may be required. The Packer Test will follow procedures outlined in Appendix D, Packer Test Protocol.

In addition, it is our intent to collect at least three rounds of water levels over a 30 day interval to assess ground-water flow directions and gradients, and assist in confirming the placement of monitoring wells.

**Task 2.2-A Monitoring Well Installation/Rock**

This task will include the installation of at least eight monitoring wells in the proposed locations as shown on Figure WT-1. These monitoring wells may include the construction of one or more of the temporary observation wells installed at the coring locations if these temporary wells are at the necessary depths and the cored hole is suitable to be a proper and durable monitoring well. The installation of additional monitoring wells will follow procedures outlined in Appendix E, Drilling Protocol for Open Hole Monitoring Well Completion. At each additional well installation that is not at the location of a core hole drilled during Phase 2, a gamma ray log and/or caliper log will be performed according to Appendix C, Gamma Ray Logging Protocol, and Appendix F, Caliper Logging Protocol.
Task 2.2-B Monitoring Well Installation/Soils

If water bearing units are encountered within the unconsolidated deposits during the course of drilling the soil borings, Westinghouse may recommend the installation of monitoring wells in these units. These monitoring wells will be installed by methods outlined in Appendix G, Drilling Protocol for Monitoring Well Completion In Soils.

Task 2.3 Data Transmittal

Upon completion of monitoring well installations, Westinghouse will provide to the parties of the Consent Decree a plot plan showing the locations of core holes and monitoring wells, coring and drilling logs, geophysical logs, water level elevations, a ground-water quality sampling schedule and a written description of any changes made to the Supplemental Hydrogeologic Investigation Plan.

If requested, Westinghouse will be available to meet to review or discuss the information described above with selected representatives of the Consent Decree.

Task 2.4 Ground-Water Sampling

After all monitoring wells are installed, they will be sampled according to the schedules stated in Table 3, Exhibit 13 of the Consent Decree. Westinghouse will sample and analyze the ground water on a quarterly basis over one hydrologic cycle. The water quality analytical results will be forwarded to the parties of the Consent Decree on a timely basis.
The intervals between sampling will be no less than 88 days and no more than 92 days. Upon the completion of the required year of monitoring (four rounds), Westinghouse will evaluate which of the monitoring wells will be On-Site Monitoring Wells and submit a Plan supporting these selections.

Ground water will be sampled according to the Ground-Water Sampling Protocol, found in Appendix H. All ground water will be analyzed for PCBs in accordance with the requirements of "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW846, 2d, ed, July 1982" as specified in the Consent Decree (Paragraph 71a).

At each of the four rounds of sampling, within 60 days, Westinghouse will submit to the parties of the Consent Decree the following data for each well sampled:

a. water level  
b. temperature  
c. pH  
d. specific conductance  
e. PCB analytical results  
f. water table elevation contour map.

The field measurements, water level, temperature, pH and specific conductance will be recorded on a data sheet similar to Attachment 3 of the Ground-Water Sampling Protocol, in Appendix H. The analytical results will be presented in table form. The water table elevation contour map will be constructed and submitted on the Winston Thomas base map.
C. Phase 3 - Evaluation of Data and Submission of the On-Site Monitoring Well Plan

1. Evaluation of Data

Task 3.1 Evaluation of Data

At the conclusion of Phase 2 work efforts, including the one year of ground-water data collection, an evaluation will be made to determine if there has been a sufficient characterization of the hydrogeology to proceed with the On-Site Monitoring Well Plan. In this evaluation, comments received from the parties of the Consent Decree at the end of Phase 1 and Task 2.3 will be incorporated.

If upon completion of this evaluation, Westinghouse determines that additional information is required, Westinghouse will notify the parties of the Consent Decree and inform them of the Scope of Work that will be required and a time schedule for its completion. If, however, sufficient data is available to select the on-site monitoring wells then the Plan will be submitted as described in Task 3.2.

2. Submittal of On-Site Monitoring Well Plan

Task 3.2 On-Site Monitoring Well Plan

Within 90 days of completion of the Winston Thomas Facility Supplemental Hydrogeologic Investigation, Westinghouse will submit a Plan for approval by the parties of the Consent Decree designating the location of on-site monitoring wells.
The On-Site Monitoring Well Plan will include:

a. A presentation of the work efforts performed during the Supplemental Hydrogeologic Investigation.
b. Detailed well logs of Phase 2 wells, borings and corings.
c. Geophysical logs.
d. The results of the permeability testing.
e. Ground-water analytical results.
f. Ground-water elevation contour maps.
g. Geologic cross sections.
h. A map locating the monitoring wells to be utilized as the On-Site Monitoring Wells and the justification for locating the wells as recommended.
i. Procedures for well abandonment and well replacement.
j. The selection of dedicated sampling devices.
III. References


SUPPLEMENTAL HYDROGEOLOGIC INVESTIGATION PLAN
BENNETT'S DUMP

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### C. Phase 3 Evaluation of Data and Submission of the On-Site Monitoring Well Plan

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I. Introduction

A. Purpose

The Consent Decree requires Westinghouse to perform a Supplemental Hydrogeologic Investigation of Bennett's Dump with the resulting data used for selection of on-site monitoring locations for future ground-water monitoring at the site (Paragraphs 74(a) and 75).

In accordance with Paragraph 74 of the Consent Decree, a Supplemental Hydrogeologic Investigation Plan for Bennett's Dump was submitted to the parties of the Consent Decree within 60 days of the signing of the Consent Decree. This Plan was submitted in combination with the Supplemental Hydrogeologic Investigation Plan for the Winston Thomas Facility in October 1985. In December of 1985, Westinghouse met with the parties of the Consent Decree to review this submittal. After the December meeting, the Environmental Protection Agency (EPA) submitted a formal review to Westinghouse (letter to Mr. Carl Anderson from M.V. Pearce, December 3, 1985). On the basis of comments received at the meeting and in the letter, Westinghouse agreed to resubmit the Plan and incorporate changes that would address the issues raised by the EPA and other parties of the Consent Decree.

A revised Bennett's Dump Supplemental Hydrogeologic Investigation Plan was submitted in February, 1986 to the parties of the Consent Decree. The revised Plan was reviewed by the parties of the Consent Decree and comments were submitted to Westinghouse by the EPA (April 14, 1986) and the City of Bloomington (May 13, 1986). In addition, the parties of the Consent Decree
met on May 20, 1986 to review their comments to this Plan and to reach an agreement on the necessary revisions to be included in this final submittal of the Supplemental Hydrogeologic investigation Plan for Bennett's Dump.

B. Location and History

Bennett's Dump is located in the central portion of Monroe County, Indiana, about 2.5 miles northwest of the town of Bloomington in all four quarters of the northeast quarter of Section 30, Range 1W, Township 9N. Bennett's Dump is located on a gentle hillside that slopes east to west and terminates on the west side of the site at Stout's Creek.

The Dump is adjacent to Bennett's Quarry, an active limestone quarry, and consists of a 3.5 acre main site, an adjacent smaller 0.5 acre site and a very small area to the north of the two main fill areas as shown on Figure BD-1. Previous studies have identified that waste materials containing polychlorinated biphenyls (PCBs) were deposited at the site.

This ground-water flow direction is assumed to be to the north based on surface flow conditions. The Investigation will establish ground-water flow and the Phase 1 Progress Report will describe flow directions based on these investigations. Soil thickness varies from 2 to 15 feet. Their composition varies from silt or clay-rich residual soils to coarse grained weathered bedrock deposits. Also, a portion of this review yielded information such as bedrock type and depth to water. The local bedrock is described as the Salem and Harrodsburg Limestone. The local water table elevation is expected to be near the base of the Salem Limestone or the top of the Harrodsburg Limestone (1, 2, 3).
The Westinghouse studies include an aerial photography analysis, a review of hydrogeologic information and soil test borings in conjunction with ongoing discussions with the State of Indiana, the EPA and the Department of Justice in 1984.

C. Investigation Overview

The purpose of the Bennett's Dump Supplemental Hydrogeologic Investigation is to review and evaluate the development of the site and the hydrogeologic conditions and to define the location of on-site and off-site monitoring wells for future ground-water monitoring, as specified in the Consent Decree.

The Investigation will focus on work activities that contribute to the understanding of the interrelationship between the site's history and the hydrogeologic setting with respect to the need for developing the necessary ground-water monitoring plans for this site.

The Consent Decree requires that a total of four wells be drilled at Bennett's Dump as part of the Supplemental Hydrogeologic Investigation. The proposed locations for these wells are shown on Figure BD-1. The selection of these locations is based on previous studies completed by Westinghouse, and discussions with the U.S. Department of Justice and other parties of the Consent Decree negotiation in 1984. In addition, these four locations selected are similar to those presented by Phillip E. LaMoreaux & Associates (PELA) (4) to the U.S. Department of Justice during the development of the Consent Decree in 1984.
The four monitoring points selected provide for:

1. areal coverage to acquire upgradient and downgradient water-level elevations and water quality data,
2. placement adjacent to the major source areas of existing contamination, and
3. sufficient characterization of subsurface conditions to describe lithology and bedrock structure.

The Supplemental Hydrogeologic Investigation described in the following sections is a comprehensive three phase study. The proposed monitoring well locations may be modified based on the Phase 1 and Phase 2 work efforts. The number and permanent location for the On-Site Monitoring Wells will be selected on the basis of the work performed in the Supplemental Hydrogeologic Investigation and as presented in the final work product of Phase 3. The work schedule for the Supplemental Hydrogeologic Investigation is set forth in Table BD-1 and a detailed description of the work tasks for each of the three phases is presented within the following text.

II. Scope of Work for Supplemental Hydrogeologic Investigation

A. Phase 1 - Data Collection and Review

Phase 1 will begin within 14 days of approval, by the parties of the Consent Decree, of the Supplemental Hydrogeologic Investigation Plan. Phase 1 includes: a review of the site history including quarry operations; a geology and hydrogeology review; an evaluation of past investigations including the shallow soil boring program, geophysical surveys, previous analytical results, and preliminary aerial photograph evaluations; and an aerial photography review coupled with a topographic map study. Following these activities, a site inspection will be completed.
The goals of Phase 1 are to review the general geology and hydrogeology of both the unconsolidated and consolidated units beneath the Bennett's Dump Site, to evaluate the nature and extent of geomorphic and land use changes that have occurred and to assess the surface expressions of karst features.

The purpose of the review is to establish a foundation level of understanding of site conditions, to uncover data needs that should be addressed in later work tasks and to establish a framework to begin the detailed look at the hydrogeology and ground-water quality characteristics of the site.

At the conclusion of Phase 1, Westinghouse will also submit to the parties of the Consent Decree a Progress Report of the Phase 1 findings which will also include a description of any changes/additions in the Scope of Work or in the locations of proposed borings/corings and monitoring wells to be completed in Phase 2.

Task 1.1 Geology and Hydrogeology Review

Information regarding the geology/hydrogeology near Bennett's Dump, gathered from sources such as Indiana Geological Survey Reports, Indiana University theses and publications, and Department of Agriculture Soil Survey, will be reviewed to refine our knowledge of the type of soils and rock units that will be encountered during drilling activities, pertinent characteristics of these soil and rock units including marker beds, water bearing zones and karst development in these units. The geology and hydrogeology will be discussed with the technical representatives of the Consent Decree parties and other hydrogeologists and geologists knowledgeable in local conditions.
This task will define how to identify the different bedrock formation units by marker beds or changes in lithology, and reconfirm the approximate drilling and monitoring depths necessary for future drilling activities and well installation. In addition, the examination of rock outcrops, quarry walls and the identification of karst features such as sinkholes, caverns and springs at or around Bennett's Dump may aid in the delineation of geologic structures, ground-water flow directions and solution feature trends which may affect flow directions and, therefore, may be an additional consideration in the placement of Phase 2 borings/corings and monitoring wells.

In addition, Westinghouse has completed a homeowner well user survey that includes the area around the Bennett's Dump Site. This summary identifies the location, by street address, of active or inactive water wells in this area. The well logs gathered in support of the survey will be reviewed and may be useful in determining additional information about ground-water characteristics around the site.

Task 1.2 Review of Previous Subsurface, Analytical and Geophysical Investigations

Both Westinghouse and the EPA have conducted prior studies at the Bennett's Dump Site. The EPA has drilled 60 shallow borings in the unconsolidated units (5). Westinghouse also has drilled 27 borings in the soils around Bennett's Dump. These borings were drilled to delineate the nature of the soil, to assess the limits of the fill areas and to assess the nature of the waste material. Some soil samples were laboratory tested for Atterberg limits, density and laboratory permeability (6). A review of all the boring work will define the
geologic nature of the soil and will be presented in Task 1.5, Phase 1 Progress Report.

Some samples from the soil borings have also been analyzed for PCB content. These analytical concentrations have been contoured by the EPA (7) and the resultant patterns may delineate fill areas and therefore may be useful in determining the potential for PCB movement from the unconsolidated deposits into the bedrock at Bennett's Dump.

The EPA performed several geophysical surveys including: a proton magnetometer geophysical survey, primarily to delineate buried metallic material at the site; resistivity soundings to determine the electrical stratification of the soil; and electromagnetic induction to add to the magnetometer's delineation of the buried metallic material (8). A review of the geophysical work may be used in conjunction with the aerial photography study to confirm that soil borings, rock corings and monitoring wells will be located on the periphery of fill areas.

The work efforts conducted by the EPA and Westinghouse may provide a data base for the characterization of the unconsolidated units and for determining contaminant migration in these units.

Task 1.3 Aerial Photograph Analysis and Review of Topographic Maps

Stereoscopic aerial photographs will be reviewed to reconfirm the limits of the Bennett's Dump waste site(s) and subsequent changes in these waste areas through time and other site changes which may be the result of quarrying activity. Aerial photographs will also be reviewed to evaluate pre-existing surface water drainage patterns, and to delineate karst features, especially fracture traces, sinkholes, springs and seepage areas.
This aerial photograph analysis will incorporate past studies completed by Westinghouse (9) and the EPA (10).

In conjunction with the aerial photography analysis, the topographic review will demarcate areas of both natural and man-made landform changes. A 1984 topographic map, completed by Westinghouse of the Bennett's Dump Site, coupled with the City of Bloomington Planning Map developed by Abrams Aerial Survey Corporation in 1976, will be compared to a 1908 topographic map of the Bloomington area obtained from the National Archives, Washington D.C.

The aerial photograph analysis and the topography review will be utilized to confirm boring/coring and monitoring well locations of Phase 2, and to ensure that all soil borings, rock corings and monitoring wells will be placed outside the waste areas.

Task 1.4 Site Reconnaissance

A field reconnaissance of the Bennett's Dump Site and immediate surroundings will be performed to identify physical features and access limitations that may influence drilling locations. Also, the verification of features delineated in the aerial photograph review, topographic map review and literature review will be completed in this work task. The emphasis of the site reconnaissance will be to note recent changes at the Bennett's Dump Site including quarry activities and to identify karst features such as springs, sinkholes, swallow holes and seeps which may influence boring/coring or monitoring well locations by their presence and/or trends. The area to be covered by this site inspection is outlined on Figure BD-1.
In addition, at the Bennett's Dump Site, the quarry walls will be examined and, if possible, the orientation and number of fractures and joints will be delineated as well as the strike and dip of the rock units. These data will be combined with the detailed coring results to generate an overall concept of bedrock stratigraphy and secondary porosity characteristics. The quarries that will be studied are within the limits of the site inspection as indicated on Figure BD-1. If these quarries are not suitable for inspection, adjacent quarries may be examined.

Task 1.5 Phase 1 Progress Report

A Progress Report summarizing the results of Phase 1 will be generated and sent to the parties of the Consent Decree within 15 days following completion of the Phase 1 work tasks. The Report will include any modifications to the Scope of Work described herein for Phase 2. Additionally, the Report will include the following:

a. A description of any changes in the proposed boring/coring and monitoring well locations and rationale for these changes.

b. A section on background geology and hydrogeology.

c. A section on past work and applicability to the Supplemental Hydrogeologic Investigation Plan.

d. A section on the aerial photography and topographic map study.

e. A section on karst and structural features/trends identified in the quarry mapping.
f. A complete reference list for items b. through e. above. The documents/data cited in this reference list will be made available if requested by any of the parties of the Consent Decree.

g. A discussion of the approach to the selection of which sites will be cored in the Phase 2 work program and how the coring data will be utilized to locate monitoring wells or additional coring locations will be supplied.

If requested, Westinghouse will be available to meet to review or discuss the findings of the Progress Report with selected representatives of the Consent Decree parties prior to beginning Phase 2.

Within seven days of receiving comments from the parties of the Consent Decree on the Phase 1 Progress Report, Westinghouse will begin the Phase 2 Work Program.

B. Phase 2 - Site Investigations

1. General

Phase 2 is primarily a field program of drilling and sampling in both the soil and the rock units located at Bennett's Dump. The rock core holes will be utilized as temporary wells to initiate the measurement of site-specific hydrogeologic data and to identify future on-site monitoring well sites.

The primary goals of Phase 2 are: to evaluate the stratigraphy of the Bennett's Dump Site; to evaluate the hydrogeologic characteristics including
ground-water flow direction, ground-water gradients, water bearing zones, and permeability characteristics; and to assess Phase 1 and Phase 2 task results to confirm the locations of subsequent Phase 2 monitoring wells.

Ground water will be sampled and analyzed after all the monitoring wells are installed in Task 2.2 of Phase 2.

2. Field Investigation

2.1 Continuous Soil Test Boring/Rock Coring

A continuous profile of soil and bedrock will be sampled from ground surface to an approximate depth of 80 feet below the ground surface; or to the base of Harrodsburg Limestone at each boring/coring location. The work completed in Task 1.1 should define how to identify the base of the Harrodsburg Limestone.

The borings/corings will be located at the four proposed monitoring well locations. This work will be completed in steps such that information from these boring/coring locations will be utilized to assess whether additional borings/corings are necessary to define the site's stratigraphy or the relocation of any monitoring well(s).

In the unconsolidated deposits, continuous split-spoon sampling will be employed according to ASTM Standards and Procedures outlined in Appendix A, Drilling/Sampling Protocol for Soil Borings. In the consolidated rock units, continuous coring will be employed following ASTM Standards and Procedures outlined in Appendix B, Drilling/Sampling Protocol for Rock Coring. A geologist will be on site to ensure these protocols are being followed and to describe in detail the soil and rock units encountered. The unconsolidated unit description
will include the following: soil type, color, grain size and water content. The rock coring logs will include, where possible, the following in their description: rock type, color, grain size, fossils, density, solution features, fractures, joints, weathering features, clay infilling and core loss.

At each coring location, the resultant core hole will be utilized as a temporary observation well. Therefore, to ensure the integrity of this temporary system to collect hydrogeologic data, it may be necessary to install a temporary surface casing.

Each core hole will be gamma ray logged upon completion of the coring according to methods found in Appendix C, Gamma Ray Logging Protocol. These gamma ray logs will be compared to the detailed lithologic coring logs and a correlation of gamma ray readings with lithology will be prepared. Future holes that are not cored will be gamma ray logged and the core hole/gamma ray correlation data will be used to extend the understanding of site-wide lithology. Gamma ray results will be presented in the Phase 3 Report.

Also, at one interval in each corehole, a Packer Test or other applicable test will be performed to assess the permeability characteristics of the rock formations. If more than one productive fracture system is encountered at a coring location, more Packer Tests or permeability tests may be required. The Packer Test will follow procedures outlined in Appendix D, Packer Test Protocol.

In addition, it is our intent to collect at least three rounds of water levels over a 30 day interval to assess ground-water flow directions and gradients and assist in confirming the placement of monitoring wells.
Task 2.2-A Monitoring Well Installation/Rock

This task will include the installation of at least four monitoring wells in the proposed locations as shown on Figure BD-1. These monitoring wells may include the construction of one or more of the temporary observation wells installed at the coring locations, if these temporary wells are at the necessary depths and the cored hole is suitable to be a proper and durable monitoring well. The installation of additional monitoring wells will follow procedures outlined in Appendix E, Drilling Protocol for Open Hole Monitoring Well Completion. At each additional well installation that is not at a location of a rock core drilled during Phase 2, a gamma ray log and/or caliper log will be performed according to Appendix C, Gamma Ray Logging Protocol and Appendix F, Caliper Logging Protocol.

Task 2.2-B Monitoring Well Installation/Soils

If water bearing units are encountered within the unconsolidated deposits during the course of drilling soil test borings, Westinghouse may recommend the installation of monitoring wells in these units. These monitoring wells will be installed by methods outlined in Appendix G, Drilling Protocol for Monitoring Well Completion In Soils.

Task 2.3 Data Transmittal

Upon completion of monitoring well installations, Westinghouse will provide to the parties of the Consent Decree a plot plan showing the locations of core holes and monitoring wells, coring and drilling logs, gamma ray logs, water level elevations, a ground-water quality sampling schedule and written description of any changes made to the Supplemental Hydrogeologic Investigation Plan.
If requested, Westinghouse will be available to meet to review or discuss the information described above with selected representatives of the Consent Decree.

Task 2.4 Ground-Water Sampling

After all monitoring wells are installed, they will be sampled according to the schedules stated in Table 3, Exhibit 13 of the Consent Decree. Westinghouse will sample and analyze the ground water on a quarterly basis over one hydrologic cycle. The water quality analytical results will be forwarded to the parties of the Consent Decree on a timely basis.

The intervals between sampling will be no less than 88 days and no more than 92 days. Upon completion of the required year of monitoring (four rounds), Westinghouse will evaluate which of the monitoring wells will be the On-Site Monitoring Wells and submit a Plan supporting these selections.

Ground water will be sampled according to the Ground-Water Sampling Protocol found in Appendix H. All ground water will be analyzed for PCBs in accordance with the requirements of "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, 2d ed., July 1982."

At each of the four rounds of sampling, within 60 days, Westinghouse will submit to the parties of the Consent Decree the following data for each well sampled:

a. water level
b. temperature
c. pH
d. specific conductance
e. PCB analytical results
f. water table elevation contour map

The field measurements, water level, temperature, pH and specific conductance, will be recorded on a data sheet similar to Attachment 3 of the Ground-Water Sampling Protocol, in Appendix H. The analytical results will be presented in table form. The water table elevation contour map will be constructed and submitted on the Bennett's Dump base map.

C. Phase 3 - Evaluation of Data and Submission of the On-Site Monitoring Well Plan

1. Data Evaluation

Task 3.1 Evaluation of Data

At the conclusion of Phase 2 work efforts, including the one year of ground-water data collection, an evaluation will be made to determine if there has been a sufficient characterization of the hydrogeology to proceed with the On-Site Monitoring Well Plan. In this evaluation, comments received from the parties of the Consent Decree at the end of Phase 1 and Task 2.3 will be incorporated.

If upon completion of this evaluation, Westinghouse determines that additional information is required, Westinghouse will notify the parties of the Consent Decree and inform them of the Scope of Work that will be required and a time schedule for its completion. If, however, sufficient data is available to select the on-site monitoring wells then the Plan will be submitted as described below in Task 3.2.
2. Submittal of On-Site Monitoring Well Plan

Task 3.2 On-Site Monitoring Well Plan

Within 90 days of completion of the Bennett's Dump Supplemental Hydrogeologic Investigation, Westinghouse will submit a Plan for approval by the parties of the Consent Decree designating the location of on-site monitoring wells.

The On-Site Monitoring Well Plan will include:

a. A presentation of the work efforts performed during the Supplemental Hydrogeological Investigation.

b. Detailed well logs of Phase 2 boring/coring logs and monitoring well logs.

c. Geophysical logs.

d. The results of the permeability testing.

e. Ground-water analytical results.

f. Ground-water elevation contour maps.

g. Geologic cross sections.

h. A map locating the monitoring wells to be utilized as the On-Site Monitoring Wells and the justification for locating the wells as recommended.

i. Procedures for well abandonment and well replacement.

j. The selection of dedicated sampling devices.
III. References


6. STS Consultants Ltd. Laboratory Testing with Regard to the Bennett's Quarry Project near Bloomington, Indiana, August 19, 1983.


### Project Schedule

**Bennett's Dump**

**Supplemental Hydrogeologic Investigation Plan**

#### Phases

**Phase 1**
- Task 1.1 - Geology and Hydrogeology Review
- Task 1.2 - Review of Previous Investigation(s)
- Task 1.3 - Air Photos, Drawings, Topographic Map Review
- Task 1.4 - Site Reconnaissance
- Task 1.5 - Phase I Report

**Phase 2**
- Task 2.1 - Soil Boring / Rock Coring
- Task 2.2 - Monitoring Well Installation / Rock & Soils
- Task 2.3 - Data Transmittal
- Task 2.4 - Ground-Water Sampling

**Phase 3**
- Task 3.1 - Evaluation of Data
- Task 3.2 - On-Site Monitoring Well Plan
PROJECT SCHEDULE
WINSTON THOMAS FACILITY
SUPPLEMENTAL HYDROGEOLOGIC INVESTIGATION PLAN

PHASE 1
TASK 1 - GEOLOGY AND HYDROGEOLOGY REVIEW
TASK 1.2 - REVIEW OF PREVIOUS INVESTIGATION(S)
TASK 1.3 - AIR PHOTOS, DRAWINGS, TOPOGRAPHIC MAP REVIEW
TASK 1.4 - SITE RECONNAISSANCE
TASK 1.5 - PHASE 1 REPORT

PHASE 2
TASK 2.1 - SOIL BORING / ROCK CORING
TASK 2.2 - A & B MONITORING WELL INSTALLATION / ROCK & SOILS
TASK 2.3 - DATA TRANSMITTAL
TASK 2.4 - GROUND-WATER SAMPLING

PHASE 3
TASK 3.1 - EVALUATION OF DATA
TASK 3.2 - ON-SITE MONITORING WELL PLAN

WEEKS
APPENDICES

A. DRILLING/SAMPLING PROTOCOL FOR SOIL BORINGS
   Attachment 1 Standard Method for Penetration Test and Split- 
   Barrel Sampling of Soils
   Attachment 2 Subsurface Log

B. DRILLING/SAMPLING PROTOCOL FOR ROCK CORING
   Attachment 1 Standard Practice for Diamond Core Drilling for Site 
   Investigation
   Attachment 2 Sample Core Box Layout
   Attachment 3 Subsurface Log
   Attachment 4 Key to Subsurface Logs
   Attachment 5 Daily Field Report

C. GAMMA RAY LOGGING PROTOCOL
   Attachment 1 Gamma Ray Logging
   Attachment 2 Gamma Ray Log

D. PACKER TEST PROTOCOL
   Figure 1 General Water System Layout
   Figure 2 Double Packer Test
   Figure 3 Single Packer Test
   Attachment 1 Packer Test Log

E. DRILLING PROTOCOL FOR OPEN HOLE MONITORING WELL COMPLETION
   Figure 1 Typical Open Hole Monitoring Well Completion Detail

F. CALIPER LOGGING PROTOCOL

G. DRILLING PROTOCOL FOR MONITORING WELL COMPLETION IN SOILS
   Figure 1 Typical Ground-Water Well

H. GROUND-WATER SAMPLING PROTOCOL
   Attachment 1 Ground-Water Sampling Procedures
   Attachment 2 Materials
   Attachment 3 Ground-Water Sampling Field Log
   Attachment 4 Chain-of-Custody
APPENDIX A
DRILLING/SAMPLING PROTOCOL FOR SOIL BORINGS
DRILLING/SAMPLING PROTOCOL FOR SOIL BORINGS

I. Drilling/Sampling Procedures

Test borings shall be completed using the hollow-stem auger drilling method or driven casing drilling method to a depth specified by the supervising geologist/engineer.

Samples of the encountered subsurface materials shall be collected continuously. The sampling method employed shall be ASTM D-1586/Split-Barrel Sampling (Attachment 1). Upon retrieval sample shall be placed in glass jars and labeled, stored on site and transmitted to the appropriate testing laboratory or storage facility. PCB analysis and/or permeability of soils may be required if water saturated coarse grain materials are found. A geologist will be on site during the drilling operations to fully describe each soil sample including 1) soil type, 2) color, 3) percent recovery, 4) moisture content, 5) texture, 6) grain size and shape, 7) consistency, 8) miscellaneous observations. The supervising geologist will be responsible for retaining a representative portion of each sample in a one pint glass jar labeled with 1) site, 2) boring number, 3) interval sample/interval period, 4) date, 5) time of sample collection, and 6) sampling personnel. A standard log form is found in Attachment 2.

The Drilling Contractor will be responsible for obtaining accurate and representative samples, informing the supervising geologist of changes in drilling pressure and loss of circulation, and keeping a separate general log of soils encountered including blow counts (i.e., the number of blows from a soil sampling drive weight (140 pounds) required to drive the split spoon sampler in 6-inch increments).

A field survey control program will be conducted using standard instrument survey techniques to document boring location and elevation.
II. Equipment Decontamination

Equipment decontamination will occur between each separate work site. All drilling equipment and associated tools including augers, drill rods, sampling equipment, wrenches and any other equipment or tools that may have come in contact with contaminated materials shall be decontaminated using high pressure steam cleaning equipment using a controlled water source followed by a dilute solvent rinse and controlled water rinse. We propose that the control water source will be from the City of Bloomington Municipal Water Supply acquired at the Westinghouse Plant on Curry Pike in Bloomington. The water will be sampled and analyzed for PCBs prior to use as a control water source.

The drilling equipment will be decontaminated for each boring in an area designated by the supervising geologist. No equipment will leave a drilling site at any time without first being decontaminated as described above unless otherwise specified in the field by the geologist.
ATTACHMENT 1
OF
APPENDIX A
1. Scope

1.1 This method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For a specific precautionary statement, see 5.4.1.

1.3 The values stated in inch-pound units are to be regarded as the standard.

2. Applicable Documents

2.1 ASTM Standards:
   D2487 Test Method for Classification of Soils for Engineering Purposes
   D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
   D4220 Practices for Preserving and Transporting Soil Samples

3. Descriptions of Terms Specific to This Standard

3.1 anvil—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods

3.2 cathead—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.3 drill rods—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.4 drive-weight assembly—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.5 hammer—that portion of the drive-weight assembly consisting of the 140 ± 2 lb (63.5 ± 1 kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.6 hammer drop system—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.7 hammer fall guide—that part of the drive-weight assembly used to guide the fall of the hammer.

3.8 N-value—the blowcount representation of the penetration resistance of the soil. The N-value, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.9 ∆N—the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.10 number of rope turns—the total contact angle between the rope and the cathead at the...
beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.11 **sampling rods**—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

3.12 **SPT**—abbreviation for Standard Penetration Test, a term by which engineers commonly refer to this method.

4. **Significance and Use**

4.1 This method provides a soil sample for identification purposes and for laboratory tests appropriate for soil obtained from a sampler that may produce large shear strain disturbance in the sample.

4.2 This method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate SPT blowcount, or N-value, and the engineering behavior of earthworks and foundations are available.

5. **Apparatus**

5.1 **Drilling Equipment**—Any drilling equipment that provides at the time of sampling a suitably clean open hole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions.

5.1.1 **Drag, Chopping, and Fishtail Bits.** Less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advance
drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 **Roller-Cone Bits.** Less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advance
drilling methods if the drilling fluid discharge is deflected.

5.1.3 **Hollow-Stem Continuous Flight Augers.** With or without a center bit assembly, may be used to drill the boring. The inside diameter of the hollow-stem augers shall be less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm).

5.1.4 **Solid, Continuous Flight, Bucket and Hand Augers.** Less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used if the soil on the side of the boring does not cave onto the sampler or sampling rods during sampling.

5.2 **Sampling Rods**—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod which has an outside diameter of 1¾ in. (41.2 mm) and an inside diameter of 1¾ in. (28.5 mm).

**Note 1**—Recent research and comparative testing indicates the type rod used, with stiffness ranging from "A" size rod to "N" size rod, will usually have a negligible effect on the N-values to depths of at least 100 ft (30 m).

5.3 **Split-Barrel Sampler**—The sampler shall be constructed with the dimensions indicated in Fig. 2. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The use of liners to produce a constant inside diameter of 1¾ in. (35 mm) is permitted, but shall be noted on the penetration record if used. The use of a sample retainer basket is permitted, and should also be noted on the penetration record if used.

**Note 2**—Both theory and available test data suggest that N-values may increase between 10 to 30% when liners are used.

5.4 **Drive-Weight Assembly**:

5.4.1 **Hammer and Anvil**—The hammer shall weigh 140 ± 2 lb (63.5 ± 1 kg) and shall be a solid rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting a free fall shall be used. Hammers used with the cathead and rope method shall have an unimpeded overfill capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged.

**Note 3**—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 **Hammer Drop System**—Rope-cathead, trip, semi-automatic, or automatic hammer drop systems may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 **Accessory Equipment**—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.
6. Drilling Procedure

6.1 The boring shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 mm) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance", or the "N-value". If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb
The 63.5-kg hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used, the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than 2¼ rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

Note 4—The operator should generally use either 1¾ or 2¼ rope turns, depending upon whether or not the rope comes off the top (1¾ turns) or the bottom (2¼ turns) of the cathead. It is generally known and accepted that 2¼ or more rope turns considerably impede the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unfrayed condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into scalable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 6-in. (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel.

8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

8.1.1 Name and location of job,
8.1.2 Names of crew,
8.1.3 Type and make of drilling machine,
8.1.4 Weather conditions,
8.1.5 Date and time of start and finish of boring,
8.1.6 Boring number and location (station and coordinates, if available and applicable),
8.1.7 Surface elevation, if available,
8.1.8 Method of advancing and cleaning the boring,
8.1.9 Method of keeping boring open,
8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,
8.1.11 Location of strata changes,
8.1.12 Size of casing, depth of cased portion of boring,
8.1.13 Equipment and method of driving sampler,
8.1.14 Type sampler and length and inside diameter of barrel (note use of liners),
8.1.15 Size, type, and section length of the sampling rods, and
8.1.16 Remarks.

8.2 Data obtained for each sample shall be recorded in the field and shall include the following:

8.2.1 Sample depth and, if utilized, the sample number,
8.2.2 Description of soil,
8.2.3 Strata changes within sample,
8.2.4 Sampler penetration and recovery lengths, and
8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

9. Precision and Bias

9.1 Variations in N-values of 100% or more have been observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, N-values in the same soil can be reproduced with a coefficient of variation of about 10%.

9.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in N-values.
obtained between operator-drill rig systems.

9.3 The variability in N-values produced by different drill rigs and operators may be reduced by measuring that part of the hammer energy delivered into the drill rods from the sampler and adjusting N on the basis of comparative energies. A method for energy measurement and N-value adjustment is currently under development.

FIG. 1 Definitions of the Number of Rope Turns and the Angle for (a) Counter-clockwise Rotation and (b) Clockwise Rotation of the Cathead
A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 - 0.00 in. (38.1 ± 1.3 - 0.0 mm)
E = 0.00 ± 0.02 in. (0.25 ± 0.25 mm)
F = 2.00 ± 0.05 - 0.00 in. (50.8 ± 1.3 - 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retaining may be used to retain soil samples.

**FIG. 2 Split-Barrel Sampler**

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.
## SUBSURFACE LOG

<table>
<thead>
<tr>
<th>SAMPLE No.</th>
<th>TIME</th>
<th>DEPTH From</th>
<th>To</th>
<th>No. OF BLOWS</th>
<th>SOIL DESCRIPTION AND BORING LOG</th>
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### REMARKS

Wiley-Fisk Form B-10
APPENDIX B

DRILLING/SAMPLING PROTOCOL FOR ROCK CORING
DRILLING/SAMPLING PROTOCOL FOR ROCK CORING

Bedrock test borings will be completed using a wire line or a double tubed core barrel with an NX size core diameter in accordance with ASTM D2113, "Standard Practice for Diamond Core Drilling for Site Investigation", Attachment 1.

Continuous bedrock core samples will be obtained, labeled, preserved, and classified as outlined below. These tasks will be documented upon completion in the field.

Obtaining Rock Core Samples

Prior to core barrel introduction into the hole, circulation of water will be maintained for a short time to remove any cuttings that may clog barrel. Drilling rods will be carefully centered to prevent core breakage. Drilling bit pressure and water pressure will be maintained at a level consistent throughout borings and runs will be completed without interruption so penetration rates can be determined.

Labeling and Preserving Rock Core Samples

Core samples will be rinsed with clean water, stored in plastic sleeves and placed within plastic sleeves in wood boxes with increasing depths aligned left to right and core runs separated by wood blocks. Man-made breaks will be marked with a pen across the break. Wood blocks will be labeled and placed at the end of each core run to indicate run. A wooden spacer will be inserted if no sample is recovered and labeled "L.C." (lost core) with corresponding depth. The core box will be labeled on the outside top and inside
lid for 1) client, 2) date, 3) job number, 4) boring number, 5) run number, 6) run interval, and 7) box number/total box number. A diagram of core box labeling is included in Attachment 2.

The supervising geologist will be responsible for recording rock core mechanical and geological characteristics. The mechanical characteristics will include 1) penetration rates, 2) RQD (rock quality degree), 3) percent recovery, 4) water loss, 5) bit type and size.

A geological classification will include the following parameters, 1) lithology, 2) color, 3) grain size and shape, 4) estimated percent porosity, 5) presence of interstitial water, 6) bedding planes or foliation, 7) mineralogy and, 8) degree of crystallinity, 9) properties of joints, 10) nature of voids, vugs, cavities, 11) hardness, 12) degree of weathering. A rock core subsurface log is shown in Attachment 3 and a key to the subsurface log is shown in Attachment 4.

Documenting Field Events

A supervising geologist will be responsible for documenting drilling events using the daily field log provided in Attachment 5. A documentation of drilling events will include 1) start and finish dates of drilling, 2) name and location of job, 3) job number and client and site location, 4) sample number and depths, 5) type and size of samples, 6) depth to water, 7) type of drilling machine, 8) size of casing, 9) names of contractors drillers, inspectors or people on site and 10) weather conditions.
**Equipment Decontamination**

Equipment decontamination will occur between each separate work site. All drilling equipment and associated tools including augers, drill rods, sampling equipment, wrenches and any other equipment or tools that may have come in contact with contaminated materials shall be decontaminated using high pressure steam cleaning equipment using a controlled water source followed by a dilute solvent rinse and controlled water rinse. We propose that the control water source will be from the City of Bloomington Municipal Water Supply acquired at the Westinghouse Plant on Curry Pike in Bloomington. The water will be sampled and analyzed for PCBs prior to use as a control water source.

The drilling equipment will be decontaminated for each boring in an area designated by the supervising geologist. No equipment will leave a drilling site at any time without first being decontaminated as described above unless otherwise specified in the field by the geologist.
Standard Practice for
DIAMOND CORE DRILLING FOR SITE INVESTIGATION

This standard is issued under the fixed designation D 2113; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes equipment and procedures for diamond core drilling to secure core samples of rock and some soils that are too hard to sample by soil-sampling methods. This method is described in the context of obtaining data for foundation design and geotechnical engineering purposes rather than for mineral and mining exploration.

2. Applicable Documents

2.1 ASTM Standards:

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils
D 1587 Practice for Thin-Walled Tube Sampling of Soils
D 3550 Practice for Ring-Lined Barrel Sampling of Soils

3. Significance and Use

3.1 This practice is used to obtain core specimens of superior quality that reflect the in-situ conditions of the material and structure and which are suitable for standard physical-properties tests and structural-integrity determination.

4. Apparatus

4.1 Drilling Machine, capable of providing rotation, feed, and retraction by hydraulic or mechanical means to the drill rods.

4.2 Fluid Pump or Air Compressor, capable of delivering sufficient volume and pressure for the diameter and depth of hole to be drilled.

4.3 Core barrels as required:

4.3.1 Single Tube Type, WG Design, consisting of a hollow steel tube, with a head at one end threaded for drill rod, and a threaded connection for a reaming shell and core bit at the other end.

A core lifter, or retainer located within the core bit is normal, but may be omitted at the discretion of the geologist or engineer.

4.3.2 Double Tube, Swivel-Type, WG Design—An assembly of two concentric steel tubes joined and supported at the upper end by means of a ball or roller-bearing swivel arranged to permit rotation of the outer tube without causing rotation of the inner tube. The upper end of the outer tube, or removable head, is threaded for drill rod. A threaded connection is provided on the lower end of the outer tube for a reaming shell and core bit. A core lifter located within the core bit is normal but may be omitted at the discretion of the geologist or engineer.

4.3.3 Double Tube, Swivel-Type, WT Design, is essentially the same as the double tube, swivel-type, WG design, except that the WT design has thinner tube walls, a reduced annular area between the tubes, and takes a larger core from the same diameter bore hole. The core lifter is located within the core bit.

4.3.4 Double Tube, Swivel Type, WM Design, is similar to the double tube, swivel-type, WG design, except that the inner tube is threaded at its lower end to receive a core lifter case that effectively extends the inner tube well into the core bit, thus minimizing exposure of the core to the drilling fluid. A core lifter is contained within the core lifter case on the inner tube.

4.3.5 Double Tube Swivel-Type, Large-Diameter Design, is similar to the double tube, swivel-type, WM design, with the addition of a

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1 This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.


3 Annual Book of ASTM Standards, Vol 04.06
ball valve, to control fluid flow, in all three available sizes and the addition of a sledge barrel, to catch heavy cuttings, on the two larger sizes. The large-diameter design double tube, swivel-type, core barrels are available in three core per hole sizes as follows: 2½ in. (69.85 mm) by 3 in. (76.2 mm), 4½ in. (114.3 mm) by 5½ in. (139.7 mm), and 6 in. (152.4 mm) by 7½ in. (190.5 mm). Their use is generally reserved for very detailed investigative work or where other methods do not yield adequate recovery.

4.3.6 Double Tube, Swivel-Type, Retrievable Inner-Tube Method, in which the core-laden inner-tube assembly is retrieved to the surface and an empty inner-tube assembly returned to the face of the borehole through the matching, large-bore drill rods without axes for withdrawal and replacement of the drill rods in the borehole. The inner-tube assembly consists of an inner tube with removable core liner case and core liner at one end and a removable inner-tube head, swivel bearing, suspension adjustment, and latching device with release mechanism on the opposite end. The inner-tube latching device locks into a complementary recess in the wall of the outer tube such that the outer tube may be rotated without causing rotation of the inner tube and such that the latch may be actuated and the inner-tube assembly transported by appropriate surface control. The outer tube is threaded for the matching, large-bore drill rod and internally configured to receive the inner-tube latching device at one end and threaded for a reaming shell and bit, or bit only, at the other end.

4.4 Longitudinall Split Inner Tubes—As opposed to conventional cylindrical inner tubes, allow inspection of, and access to, the core by simply removing one of the two halves. They are not standardized but are available for most core barrels including some of the retrievable inner-tube types.

4.5 Core Bits—Core bits shall be surface set with diamonds, impregnated with small diamond particles, inserted with tungsten carbide slugs, or strips, hard-faced with various hard surfacing materials or furnished in saw-tooth form, as all appropriate to the formation being cored and with concurrence of the geologist or engineer. Bit matrix material, crown shape, water-way type, location and number of water ways, diamond size and cut weight, and bit facing materials shall be for general purpose use unless otherwise approved by the geologist or engineer. Nominal size of some bits are shown in Table 1.

Note 1—Size designation (letter symbols) used throughout the text and in Tables 1, 2, and 3 are those standardized by the Diamond Core Drill Manufacturers’ Assoc. (DCDMA). Inch dimensions in the tables have been rounded to the nearest hundredth of an inch.

4.6 Reaming Shells, shall be surface set with diamonds, impregnated with small diamond particles, inserted with tungsten carbide strips or slugs, hard faced with various types of hard surfacing materials, or furnished blank, all as appropriate to the formation being cored.

4.7 Core Lifters—Core lifters of the split-ring type, either plain or hard-faced, shall be furnished and maintained, along with core-lifter cases or inner-tube extensions or inner-tube shoes, in good condition. Basket or finger-type lifters, together with any necessary adapters, shall be on the job and available for use with each core barrel if so directed by the geologist or engineer.

4.8 Casings:

4.8.1 Drive Pipe or Drive Casing, shall be standard weight (schedule 40), extra-heavy (schedule 80), double-extra-heavy (schedule 160) pipe or W-design flash-joint casing as required by the nature of the overburden or the placement method. Drive pipe or W-design casing shall be of sufficient diameter to pass the largest core barrel to be used, and it shall be driven to bed rock or to firm seating at an elevation below water-sensitive formation. A hardened drive shoe is to be used as a cutting edge and thread protection device on the bottom of the drive pipe or casing. The drive shoe inside diameter shall be large enough to pass the tools intended for use, and the shoe and pipe or casing shall be free from burrs or obstructions.

4.8.2 Casing—When necessary to case through formations already penetrated by the borehole or when no drive casing has been set, auxiliary casing shall be provided to fit inside the borehole to allow use of the next smaller core barrel. Standard sizes of telescoping casing are shown in Table 2. Casing bits have an obstruction in their interior and will not pass the next smaller casing size. Use a casing shoe if additional telescoping is anticipated.

4.8.3 Casing Liners—Plastic pipe or sheet-metal pipe may be used to line an existing large-diameter casing. Liners, so used, should not be driven, and care should be taken to maintain true
alignment throughout the length of the liner.

4.8.4 Hollow Stem Auger—Hollow stem auger may be used as casing for coring.

4.9 Drill Rods:

4.9.1 Drill Rods of Tubular Steel Construction are normally used to transmit feed, rotation, and retraction forces from the drilling machine to the core barrel. Drill-rod sizes that are presently standardized are shown in Table 3.

4.9.2 Large bore drill rods used with retrievable inner-tube core barrels are not standardized. Drill rods used with retrievable inner-tube core barrels should be those manufactured by the core-barrel manufacturer specifically for the core barrel.

4.9.3 Composite Drill Rods are specifically constructed from two or more materials intended to provide specific properties such as light weight or electrical nonconductivity.

4.9.4 Nonmagnetic Drill Rods are manufactured of nonferrous materials such as aluminum or brass and are used primarily for hole survey work. Some nonmagnetic rods have left-hand threads in order to further their value in survey work. No standard exists for nonmagnetic rods.

4.10 Auxiliary Equipment, shall be furnished as required by the work and shall include: roller rock bits, drag bits, chopping bits, boulder busters, fishtail bits, pipe wrenches, core barrel wrenches, lubrication equipment, core boxes, and marking devices. Other recommended equipment includes: core splitter, rod wicking, pump-out tools or extruders, and hand sieve or strainer.

5. Transportation and Storage of Core Containers

5.1 Core Boxes, shall be constructed of wood or other durable material for the protection and storage of cores while enroute from the drill site to the laboratory or other processing point. All core boxes shall be provided with longitudinal separators and recovered cores shall be laid out as a book would read, from left to right and top to bottom, within the longitudinal separators. Spacer blocks or plugs shall be inserted into the core column within the separators to indicate the beginning of each coring run. The beginning point of storage in each core box is the upper left-hand corner. The upper left-hand corner of a hinged core box is the left corner when the hinge is on the far side of the box and the box is right-side up. All hinged core boxes must be permanently marked on the outside to indicate the top and the bottom. All other core boxes must be permanently marked on the outside to indicate the top and the bottom and additionally, must be permanently marked internally to indicate the upper-left corner of the bottom with the letters UL or a splotch of red paint not less than 1 in.². Lid or cover fitting(s) for core boxes must be of such quality as to ensure against mix up of the core in the event of impact or upsetting of the core box during transportation.

5.2 Transportation of cores from the drill site to the laboratory or other processing point shall be in durable core boxes so padded or suspended as to be isolated from shock or impact transmitted to the transporter by rough terrain or careless operation.

5.3 Storage of cores, after initial testing or inspection at the laboratory or other processing point, may be in cardboard or similar less costly boxes provided all layout and marking requirements as specified in 5.1 are followed. Additional spacer blocks or plugs shall be added if necessary at time of storage to explain missing core. Cores shall be stored for a period of time specified by the engineer but should not normally be discarded prior to completion of the project for which they were taken.

6. Procedure

6.1 Use core-drilling procedures when formations are encountered that are too hard to be sampled by soil-sampling methods. A 1-in. (25.4-mm) or less penetration for 30 blows is accordance with Method D 1586 or other criteria established by the geologist or engineer, shall indicate that soil-sampling methods are not applicable.

6.1.1 Seat the casing on bedrock or in a firm formation to prevent raveling of the borehole and to prevent loss of drilling fluid. Level the surface of the rock or hard formation at the bottom of the casing when necessary using the appropriate bits. Casing may be omitted if the borehole will stand open without the casing.

6.1.2 Begin the core drilling using an N-size double-tube swivel-type core barrel or other size or type approved by the engineer. Continue core drilling until core blockage occurs or until the net length of the core barrel has been drilled in. Remove the core barrel from the hole and disassemble it as necessary to remove the core. Reassemble the core barrel and return it to the hole. Resume coring.
6.1.3 Place the recovered core in the core box with the upper (surface) end of the core at the upper-left corner of the core box as described in 5.1. Continue boxing core with appropriate markings, spacers, and blocks as described in 5.1. Wrap soft or friable cores or those which change materially upon drying in plastic film or seal in wax, or both, when such treatment is required by the engineer. Use spacer blocks or spools properly marked to indicate any noticeable gap in recovered core which might indicate a change or void in the formation. Fit fracture, bedded, or jointed pieces of core together as they naturally occurred.

6.1.4 Stop the core drilling when soft materials are encountered that produce less than 50% recovery. If necessary, secure samples of soft materials in accordance with the procedures described in Method D 1586, Practice D 1587, or Practice D 3550, or by any other method acceptable to the geologist or engineer. Resume diamond core drilling when refusal materials as described in 6.1 are again encountered.

6.2 Subsurface structure, including the dip of strata, the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described. Take special care to obtain and record information about these features. If conditions prevent the continued advance of the core drilling, the hole should be cemented and redrilled, or reamed and cased, or cased and advanced with the next smaller-size core barrel, as required by the geologist or engineer.

6.3 Drilling mud or grouting techniques must be approved by the geologist or engineer prior to their use in the borehole.

6.4 Compatibility of Equipment.
6.4.1 Whenever possible, core barrels and drill rods should be selected from the same letter-size designation to ensure maximum efficiency. See Tables 1 and 3.
6.4.2 Never use a combination of pump, drill rod, and core barrel that yields a clear-water up-hole velocity of less than 120 ft/min.
6.4.3 Never use a combination of air compressor, drill rod, and core barrel that yields a clear-air up-hole velocity of less than 3000 ft/min.

7. Boring Log
7.1 The boring log shall include the following:
7.1.1 Project identification, boring number, location, date boring began, date boring completed, and driller's name.
7.1.2 Elevation of the ground surface.
7.1.3 Elevation of or depth to ground water and raising or lowering of level including the dates and the times measured.
7.1.4 Elevations or depths at which drilling fluid return was lost.
7.1.5 Size, type, and design of core barrel used.
Size, type, and set of core bit and reaming shell used. Size, type, and length of all casing used.
Description of any movements of the casing.
7.1.6 Length of each core run and the length or percentage, or both, of the core recovered.
7.1.7 Geologist's or engineer's description of the formation recovered in each run.
7.1.8 Driller's description, if no engineer or geologist is present, of the formation recovered in each run.
7.1.9 Subsurface structure description, including dip of strata and jointing, cavities, fissures, and any other observations made by the geologist or engineer that could yield information regarding the formation.
7.1.10 Depth, thickness, and apparent nature of the filling of each cavity or soft seam encountered, including opinions gained from the feel or appearance of the inside of the inner tube when core is lost. Record opinions as such.
7.1.11 Any change in the character of the drilling fluid or drilling fluid return.
7.1.12 Tidal and current information when the borehole is sufficiently close to a body of water to be affected.
7.1.13 Drilling time in minutes per foot and bit pressure in pound-force per square inch gage when applicable.
7.1.14 Notations of character of drilling, that is, soft, slow, easy, smooth, etc.

8. Precision and Accuracy
8.1 This practice does not produce numerical data; therefore, a precision and accuracy statement is not applicable.

Note 2—Inclusion of the following tables and use of letter symbols in the foregoing text is not intended to limit the practice to use of DCDMA tools. The table and text references are included as a convenience to the user under the vast majority of tools in use do meet DCDMA dimensional standards. Similar equipment of approximately equal size on the metric standard system is acceptable unless otherwise stipulated by the engineer or geologist.
### TABLE 1 Core Bit Sizes

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<tr>
<th>Size Designation</th>
<th>Outside Diameter</th>
<th>Inside Diameter</th>
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<td>in.</td>
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### TABLE 2 Casing Sizes

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<th>Threads per in.</th>
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### TABLE 3 Drill Rods

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<td>2.13</td>
<td>53.9</td>
<td>1.75</td>
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<td>NW</td>
<td>2.63</td>
<td>66.6</td>
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<tr>
<td>HW</td>
<td>3.50</td>
<td>88.9</td>
<td>3.06</td>
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The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.
SAMPLE CORE BOX LAYOUT

NOT TO SCALE
<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>STRATIGRAPHIC COLUMN</th>
<th>RANGE</th>
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Packer Tests are used to investigate the water bearing properties of discrete zones within rock core holes or open rock wells. Packer tests are performed by tightly sealing off selected intervals in the rock hole, pumping water into that interval, and measuring the amount of water lost with time. The test is performed in the portion of the drill hole below surface casing, either above or below the static water level.

The equipment needed for the test includes:

1. The rubber packer(s) and a length of perforated pipe,
2. The water system, which includes a water meter, pressure gauge, and various valves to adjust and maintain the water pressure and flow as shown in Figure 1.

Either single or double packers may be used for permeability tests. The double packer test shown in Figure 2 will be utilized when the hole is drilled to its final depth, filled with water, surged and bailed out. Two packers will then be set and inflated with the perforated portion of the pipe between the packers. The test will be performed by starting from the bottom of the hole and working upwards at intervals selected by the supervising geologist/engineer.

A single packer may be used as the boring is advanced. A single packer test is shown in Figure 3. After removing each core run, a packer will be seated to test the top of interval of rock core just removed. This procedure may be repeated after each additional core run.

The water system will be assembled in the general scheme shown on Figure 1. A bypass line is connected to the main water line with a simple gate valve, which will be placed between the pump and the water meter valve.
(also a gate valve). Next in line from the water meter valve is the water meter itself, followed in direct sequence by a check valve, another gate valve for the relief line, and lastly, the pressure gauge. The pressure gauge will be the last instrument before the packers themselves.

After the packer(s) have been seated at the desired interval, the remainder of the test will be conducted in the following manner:

1. Open the bypass valve completely with the water meter valve closed.
2. Start the pump or open other water supply.
3. Open the meter valve slowly to allow water to flow and pressure to build. If this valve is completely opened and additional pressure is still needed, it may be obtained by slowly closing off the bypass valve, thus forcing more water through the one meter valve. A completely open meter valve and a completely closed bypass valve will produce the maximum water pressure for a particular pumping rate.

The purpose of the bypass valve is to dampen the surge of water produced by the action of the pump. With this surge minimized, the water pressure can be maintained or changed. Thus, both valves will have to be used simultaneously to arrive at the desired pressure; however, the bypass valve should be used as much as possible to make greater use of its damping effect.

After the desired pressure has been obtained, the system will be run for 5-10 minutes to ensure, as much as possible, that all fractures, voids, etc. in the material being tested are filled. This time will also afford an opportunity for the operator to make sure the water pressure is relatively stable at the desired level.
After the system has run for 5-10 minutes, the operator will begin the test by first recording the time and gallon amount from the water meter. At 5-minute intervals, a second meter reading will be taken, the difference between the two readings is recorded and a gallons per minute (G.P.M.) rate computed. These G.P.M. computations will be repeated every 5 minutes for 10-15 minutes, or until the amount of the "take" in G.P.M. is relatively stabilized.

A general procedure of testing each interval of rock for 10 minutes at increasing pressures of 10, 20, 30 psi should give valid determinations of rock permeability. Should particular field conditions require, the procedure will be modified at the discretion of the supervising geologist/engineer. This may require changing testing times, pressure, and/or intervals.

After each interval has been tested, a measure of the interval's back-pressure will be conducted. This is accomplished by quickly closing off both the meter and bypass valves. This will hold the water in the line and the check valve will maintain the pressure in the line by preventing any flow of water back away from the packer(s).

The drop in pressure will be recorded against time; for example, 20-19 psi in 1 second, 19-18 psi in 3 seconds, 18-17 psi in 10 seconds, etc. This should be done for each tested interval before the packer(s) are removed and reseated or the next test.

The data will be recorded in a form similar to that of the attached Attachment 1.
**DOUBLE PACKER TEST**

- **Height of Casing**
- **Depth to Water Table**
- **Depth to Packer**
- **Height of Gauge**
- **Perforated Pipe**
- **Test Interval**
- **Bedrock**
<table>
<thead>
<tr>
<th>Run No.</th>
<th>From</th>
<th>To</th>
<th>% Recov.</th>
<th>RQD</th>
<th>Rate (ft/min)</th>
<th>Lithological Column</th>
<th>Rock Classification</th>
<th>Definitive</th>
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</table>

**NOTES:** Gradational contacts are dashed.

**METHOD OF INVESTIGATION**

**CLASSIFICATION**

**FRACTURES**
KEY TO SUBSURFACE LOGS

Core Conditions

% Recovery - length of core recovered divided by length of core run.

RQP - Rock Quality Degree, a percent, the sum of the length of pieces four inches long or greater divided by the length of the core run.

Rock Hardness Scale

VERY HARD - surface cannot be scratched by a knife.

HARD - difficult to scratch with a knife.

MODERATELY HARD - surface is easily scratched by a knife. Difficult to scratch with a fingernail.

SOFT - surface is easily scratched by a fingernail.

Fracture Descriptions

Orientation

$N^\circ$ - angle of fracture surface from horizontal.

H - horizontal fracture (perpendicular to core run)

V - vertical fracture (parallel to core run)

$JxF$ - joint (fracture) crosses foliation

$JIIF$ - joint is parallel to foliation

U - joint in unfoliated rock

MB - mechanical break

Morphology

S - straight

C - curved

! - irregular

Surface Condition

1 - slick

2 - smooth

3 - rough

Example: J $30^\circ$ x F, C-2 (Joint $30^\circ$ from horizontal crossed foliation, joint is curved and surface is smooth)
## DAILY FIELD REPORT

**DATE**

**WEATHER**

<table>
<thead>
<tr>
<th>Day</th>
<th>Clear</th>
<th>Overcast</th>
<th>Rain</th>
<th>Snow</th>
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<td>37</td>
<td>50</td>
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</tr>
<tr>
<td>Mon</td>
<td>50</td>
<td>70</td>
<td>85</td>
<td>85</td>
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</tbody>
</table>

**TEMP.**

- To 37
- 50-70
- 70-85
- 85 up

**WIND**

- Light
- Moderate
- High

**HUMIDITY**

- Dry
- Moderate
- Humid

### AVERAGE FIELD FORCE

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<tr>
<th>Name</th>
<th>Screening</th>
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### VISITORS

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### EQUIPMENT AT THE SITE

- [Blank]

### FIELD ACTIVITIES

- [Blank]

### DISTRIBUTION

1. Proj Mgr
2. Field Office
3. File
4. Client

PAGE 1 OF [__] PAGES

BY ___________________ TITLE ___________________
APPENDIX C
GAMMA RAY LOGGING PROTOCOL
GAMMA RAY LOGGING PROTOCOL

All test borings specified by the supervising geologist will be gamma ray logged using a Johnson-Keck Gr-81 Gamma-Ray Logging System or the equivalent in accordance with the operating instructions.

Initially, the time constant and range will be set based on the gamma radiation variation for the borehole and recorded on the data sheet together with the date, well or boring number, water level, and type of drilling fluid. A background reading (counts per unit time) shall be recorded by holding the probe in the open air in the vicinity of the well to be tested. Then the probe will be lowered to the bottom of the well or borehole and the depth and counts per unit time will be recorded on the data sheet (Attachment 1). The probe will be raised in increments predetermined by the supervising geologist. Gamma ray readings will be measured at least every one foot or every three inches in areas where fractures, voids and core loss were noted during the drilling. The depth and counts per minute will be recorded at each increment until the top of the borehole or well is reached. After the gamma ray logging is completed, an additional background reading shall be recorded.

The data will be plotted on a standard form (Attachment 2) adjacent to the stratigraphic column for that borehole.

The probe and cable shall be decontaminated using a control water rinse followed by a dilute solvent swabbing and distilled water rinse upon completion of gamma ray logging of each borehole or well.
ATTACHMENT 1
OF
APPENDIX C
# GAMMA RAY LOGGING

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</table>
ATTACHMENT 2
OF
APPENDIX C
SINGLE PACKER TEST

HEIGHT OF CASING
STICK UP

DEPTH TO WATER TABLE

HEIGHT OF GAUGE

DEPTH TO PACKER

BEDROCK

TEST INTERVAL

PERFORATED PIPE
ATTACHMENT 1
OF
APPENDIX D
## PACKER TEST LOG

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<th>Time</th>
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<td>To(ft)</td>
<td>From(ft)</td>
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**Project Title**

**Test Date**

**Project No.**

**Boring Diameter(2r)**

**Location**

**Casing Height**

**Boring No.**

**Gauge Height**

**Personnel**

**Start**

**Finish**

**Start**

**Finish**
APPENDIX E
DRILLING PROTOCOL FOR OPEN HOLE MONITORING WELL COMPLETION
DRILLING PROTOCOL FOR OPEN HOLE MONITORING WELL COMPLETION

I. Drilling Procedures

Test borings shall be completed using the air rotary method to a depth specified by the supervising geologist/engineer.

The air rotary drilling method will be utilized for 4"-diameter monitoring well completion. An air filter system will be implemented on the air system to prevent any introduction of foreign oil substances into the well. A plastic tarp will be placed around the well to deviate water from the well to a collection pit. No mineral oil will be used as drilling lubricants and only a low volume of water from a control source will be introduced to cool the drilling bit, if necessary.

A geologist will be on site during the drilling operations to fully describe each soil sample including 1) soil type, 2) color, 3) moisture content, 4) texture, 5) odor and 6) miscellaneous observations.

The Drilling Contractor will be responsible for informing the supervising geologist of changes in drilling pressure, keeping a separate general log of soils encountered, and completing monitoring wells to levels directed by the supervising geologist following specifications further outlined in this protocol.

II. Open Hole Monitoring Well Completion

All open hole monitoring wells shall be constructed using a 6" steel casing installed a minimum of 5 feet into bedrock. The annulus will be tremie grouted with a neat Portland Cement and 2-5 percent bentonite mixture to 2 feet above bedrock. After cement is allowed to set for 24 hours, the monitoring well will then be drilled to desired depth below bedrock with a
4"-diameter air rotary bit. When drilling is complete, the annular space around the surface casing will be grouted to ground surface.

A vented steel cap will be fitted on the protective surface casing and a steel hasp shall be welded on one side of each steel casing so the cap may be secured with a brass lock. The cement seal shall extend laterally at least one foot (11") in all directions from the protective casing and shall slope gently outward to drain water away from the well.

A typical monitoring well detail is shown in Figure 1. The supervising geologist shall specify the monitoring well design to the Drilling Contractor before installation.

The supervising geologist is responsible for recording the exact well details as relayed by the drilling contractor and actual measurement. Both the supervising geologist and drilling contractor are responsible for tabulating all well materials used such as footage of casing and bags of grout or cement.

A field survey control program will be conducted using standard instrument survey techniques to document well location and ground, inner and outer casing elevations.

III. Well Development

All open hole monitoring wells will be developed or cleared of all fine-grained materials and sediments that have settled in or around the well during installation. The development will be by air surging, pumping or bailing ground water from the well until it yields relatively sediment-free water.
IV. Equipment Decontamination

All drilling equipment and associated tools including augers, drill rods, sampling equipment, wrenches and any other equipment or tools that may have come in contact with contaminated materials shall be decontaminated using high pressure steam cleaning equipment using a controlled water source followed by a dilute solvent rinse and controlled water rinse. We propose that the control water source will be from the City of Bloomington Municipal Water Supply acquired at the Westinghouse Plant on Curry Pike in Bloomington. The water will be sampled and analyzed for PCBs prior to use as a control water source.

All well materials and well development materials will be washed with soapy water, swabbed with a solvent and rinsed with controlled water before emplacement in the borehole or well.

The drilling equipment will be decontaminated for each well in an area designated by the supervising geologist. No equipment will leave a drilling site at any time without first being decontaminated as described above unless otherwise specified in the field by the geologist.
SUPPLEMENTAL HYDROGEOLOGIC INVESTIGATION
WINSTON THOMAS FACILITY AND BENNETTS DUMP

TYPICAL OPEN HOLE MONITORING WELL
COMPLETION DETAIL

BIASLANO & BOUCK
ENGINEERS, P.C.
APPENDIX F
CALIPER LOGGING PROTOCOL
CALIPER LOGGING PROTOCOL

A down hole caliper log will be obtained for each open hole monitoring well after completion. A caliper log simply measures the diameter of an open hole well. It consists of four spring-activated arms which, when opened, contact the sides of the borehole as it is pulled through from the bottom of the hole to the top. The arms are electronically sensitive to variations in hole diameter with the continuously recorded electric potential being proportional to the diameter of the hole.

Variations in hole diameter indicate relative rock densities, porous zones and fracture zones. Caliper logs will be used with drilling logs to correlate major water bearing zones or lithologies within and between boreholes.

The caliper logging instrument shall be decontaminated between wells as specified in Equipment Decontamination of Drilling Protocol for Open Hole Monitoring Well Completion.
APPENDIX G
DRILLING PROTOCOL FOR MONITORING WELL COMPLETION IN SOILS
DRILLING PROTOCOL FOR MONITORING WELL COMPLETION IN SOILS

I. Drilling/Sampling Procedures

Test borings shall be completed using the hollow-stem auger drilling method or driven casing drilling method to a depth specified by the supervising geologist/engineer. Further details regarding drilling/sampling procedures can be found in Appendix A.

II. Monitoring Well Completion

All monitoring wells installed in unconsolidated deposits will be constructed of TIMCO or equivalent P.V.C. flush joint threaded well screen (between 5 to 10 feet in length) and riser casing (Schedule 40 or 80) that will extend from the screened interval to 2'-3' above existing grade. Well screen slot size will be determined from appropriate grain size. Other materials utilized for completion will be washed silica sand, bentonite grout, Portland Cement, and a locking protective steel well casing and cap.

The installation method for 2" monitoring wells shall be to place the screen and casing assembly into the auger string once the screen interval has been selected. At that time a washed silica sand pack will be placed if required to prevent screen plugging to at least two (2) feet above the well screen. If a sand pack is not warranted, the auger string will be pulled back to allow the native aquifer material to collapse 2'-3' above the top of the screen. Bentonite grout will then be added to the annulus between the casing and the inside auger wall via a tremie pipe to insure proper sealing. Grout will continue to be added during the extraction of the augers until the entire aquifer thickness has been sufficiently sealed off from the horizontal and/or vertical flow above the screened interval. During placement of sand and bentonite, frequent measurements will be made to check the height of the
sand pack and thickness of bentonite-layers by a weighted tape measure.

A vented protective steel casing shall be located over the P.V.C. standpipe extending two (2) feet below grade and 2'-3' above grade and secured by a Portland Cement seal. The cement seal shall extend laterally at least one foot (1') in all directions from the protective casing and shall slope gently away to drain water away from the well. A vented steel cap will be fitted on the protective casing and a steel hasp shall be welded on one side of each steel casing so the cap may be secured with a brass lock.

A typical monitoring well detail is shown in Figure 1. The supervising geologist shall specify the monitoring well design to the Drilling Contractor before installation.

The supervising geologist is responsible for recording the exact well details as relayed by the drilling contractor and actual measurement. Both the supervising geologist and drilling contractor are responsible for tabulating all well materials used such as footage of casing and screen or bags of grout, cement or sand.

A field survey control program will be conducted using standard instrument survey techniques to document well location, and ground, inner and outer casing elevations.

III. Equipment Decontamination

All drilling equipment and associated tools, including augers, drill rods, sampling equipment, wrenches and any other equipment or tools that may have come in contact with contaminated materials shall be decontaminated using a high pressure steam cleaning equipment using a controlled water source followed by a solvent rinse and controlled water rinse. The control
water shall be obtained from a source approved by the supervising geologist. The primary choice of a controlled water source will be a municipal supply. A sample will be collected for analytical testing prior to its use.

All well materials and well development materials will be washed with soapy water, swabbed with a solvent, and rinsed with controlled water before emplacement in the borehole or well.

The drilling equipment will be decontaminated for each well in an area designated by the supervising geologist. No equipment will leave a drilling site at any time without first being decontaminated as described above unless otherwise specified in the field by the geologist.
TYPICAL GROUNDWATER WELL

FIGURE 1

APPENDIX Q
APPENDIX H
GROUND-WATER SAMPLING PROTOCOL
GROUND-WATER SAMPLING PROTOCOL

I. General

No wells will be sampled prior to well development as described below in Section 2.

During precipitation events, sampling of wells will be discontinued until precipitation ceases.

For the first two sampling periods the On-Site Monitoring Wells will be sampled by either a pump or bailer according to the procedure described in Section H.III below and as presented in Attachment 1. Following the second round of sampling, an assessment will be made as to the suitability of each sampling method alternative based on the wells' response to pumping. If it goes dry during pumping, a bailer will be utilized; if it continues to yield water, a pump will be used.

Attachment 1 details the decision-making process involved in determining the number of purge volumes required and in selecting the suitable sampling method.

Each well will be fitted with a designated sampling device and the end of the second round of sampling.

II. Well Development

All monitoring wells will be developed; cleared of fine-grained materials and sediments that have settled in or around the well during installation, to ensure the screen is transmitting representative portions of the ground water. The development may be by one of three methods, air surging, pumping or bailing ground water from the well until it yields relatively sediment-free water.
When developing a well using the air surging method, a clean polypropylene tubing is extended to the screened portion of the well, attached to an air compressor and allowed to surge until the ground water clears. New polypropylene tubing will be used for each well developed by this method.

In pumping or bailing, a clean pump or bailer will be used and subsequently decontaminated after each use. Decontamination will consist of a dilute solvent rinse, followed by a distilled water rinse. Ground water will be pumped from the bottom of the well up using a Keck model stainless steel submersible pump or equivalent, or bailed using a stainless steel or teflon bailer. Clean plastic will be placed on the ground around the well to avoid surface contamination transfer into the well and new polypropylene rope will be used on the bailer for each well.

III. Ground-Water Sampling Procedures (See Attachment 1)

To ensure a representative sample of the ground water is acquired, a volume of water (i.e., purge volume), as determined by the sampling methodology presented in Attachment 1, will be evacuated from each well by a Keck-type submersible pump, teflon bladder pump or the equivalent, or a stainless steel bailer dependent on the method used to evacuate the well. Care will be taken not to over pump the wells during evacuation, such that an unnatural migration of contaminants to the well would occur.

The sampling procedure is outlined below: (See Attachments 1 and 2)

1) Identify well to be sampled in field notebook or sampling log sheet (Attachment 3).

2) Put on disposable overalls, disposable rubber boots and a new pair of disposable gloves.
3) Place plastic sheeting near well to use as a clean work area.

4) Set out clean or new materials for each well, such as stainless steel bailer or other appropriate sampling device, gloves and polypropylene rope.

5) Remove well cap, obtain a water level elevation and bottom of well depth using an electric well probe and record in field notebook or on sampling log sheet.

6) Calculate the number of gallons of water in the well using the length of water column (in feet) times .163 for a 2" diameter well or .653 for a 4" diameter well. Record this in the field notebook or on a sampling log sheet.

7) Remove a ground-water sample from the top of the well via a stainless steel bailer, place in one (1) quart glass container, observe and note appearance and retain on ice in a cooler.

8) Remove required purge water from the well. (Depends on the aquifer characteristics and well behavior determined in the first two sample rounds. See H.1).

9) After the sufficient volume of ground water in the well has been removed or if the well has been pumped or bailed dry, obtain the ground-water samples with the pump or bailer in one (1) quart containers.

10) Label all sample containers with date, time, well number, site, sampling personnel and store on ice in a cooler.

11) After all sampling containers have been filled, remove one (1) more bailer of ground water, place in a glass quart jar, measure and record physical appearance, temperature, conductivity and pH.

12) Replace well cap and lock well.
13) Place all disposable sampling materials (rope, gloves, plastic sheeting and plastics suits) in a plastic bag for disposal.

14) Clean pump and/or bailer with a dilute-solvent rinse followed with a distilled water rinse (unless well is fitted with dedicated sampling device).

15) Initiate Chain of Custody following guidelines from SW-846, Test Methods for Evaluating Solid Waste. (Attachment 4)

16) Deliver samples to laboratory.

17) Purge water will be drummed and treated on-site to a level of less than 1 ppb PCB at the conclusion of each sampling event by a method approved by the parties of the Consent Decree. The treated water will be disposed of on-site.
ATTACHMENT 1
OF
APPENDIX H
GROUND-WATER SAMPLING PROCEDURES
BENNETT'S DUMP
BLOOMINGTON, INDIANA

Perform initial evaluation
Measure water level
Start evacuation of well
Measure pH, temp., and op. cond. to calculate purge volume
Measurements stabilize
Measurements do not stabilize
Recommended # of purge volumes
Establish sampling procedure
If evacuation procedure takes longer than usual
Run slug test to check well and formation. Compare with round 1 results
If comparisons unfavorable
Replace
End
Go to initial evaluation
Perform slug test round 1 only
Well goes dry
Evaluate pump in well
Recommended bailer or dedicated sampling device
Well does not go dry
Recommended pump or dedicated sampling device
Step evacuation of the well at the recommended purge volume
Measure pH, temp., op. cond.
Obtain sample
Store properly & ship to laboratory. Establish Chain of Custody
Analyze water for PCB's
Evaluate and submit results to parties of the Consent Decree
Treat purge water on-site to obtain a concentration of less than 1 ppb PCB
Dispose of treated purge water on-site.

BLASLAND & BOUCK
ENGINES, P.C.
ATTACHMENT 2
OF
APPENDIX H
The following materials, as required, shall be available during ground-water sampling:
- Disposable gloves
- Disposable overalls
- Rubber boots
- Plastic sheeting
- Bailer 1-1/2 inch I.D. stainless steel or teflon
- Polypropylene rope
- Distilled water
- Cleaning solvent, acetone (pesticide grade)
- Clean disposable towels
- Actat Olympic well probe or equivalent
- 6' rule with gradation in tenths or hundredths of a foot
- Keck-type submersible pump with accessories, teflon bladder pump or equivalent
- 3 Metal containers lined with plastic bags
- 5-gallon graduated pail
- Conductivity/Temperature meter, YSI or equivalent
- pH meter
- Appropriate containers:
  1-quart glass containers with teflon lined screw caps for PCBs
  1-pint plastic bottle for inorganics
  2-40 ml hypovials for gases and volatile organics
- 200 ml beaker
- Insulated transport containers/with blue ice
ATTACHMENT 3
OF
APPENDIX H
## Ground-Water Sampling Field Log

<table>
<thead>
<tr>
<th>Site</th>
<th>Well No.</th>
<th>Sampling Personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Date</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
</tr>
</tbody>
</table>

### I. Well Information

- Well depth
- Water table depth
- Length of water column
- Ground Elevation
- Top of Casing
- Elevation (I/O)
- Water table elevation

### II. Well Water Information

- Volume of water in well
- Pumping rate of pump
- Volume of bailer
- Minutes of pumping
- Number of bails

### III. Physical Appearance/Top of Water Column

- Color
- Turbidity
- Film

### IV. Evacuation Information

- Volume of water removed from well
- Did well go dry? Y N

### V. Well Sampling

- Container
- Analysis

### VI. Ground-Water Characteristics

- Physical appearance/after well evacuation
  - Color
  - Temperature
  - Conductivity
  - pH
- Turbidity
- Film
- **Film**
ATTACHMENT 4
OF
APPENDIX H
Example of chain-of-custody record.