# Appendix D: PJM Feasibility Studies

# *PJM Generator Interconnection Request Queue AB2-067 Kammer-Vassell 765 kV Feasibility Study Report*

**August 2016**

## Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the feasibility study, but the actual allocation will be deferred until the impact study is performed.

The Feasibility Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

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## General

The Interconnection Customer (IC) proposes to install an 1100.0 MW (1100.0 MW Capacity) 2x1 Combined Cycle Natural Gas generating facility in Guernsey County, OH (see Figure 2). The generating facility will interconnect to a newly proposed three (3) circuit breaker 765 kV switching station connecting to AEP's Kammer – Vassell 765 kV line (See Figure 1).

The requested Backfeed date is September 1, 2019.
The requested in-service date is September 1, 2020.

## Attachment Facilities

**Point of Interconnection (Kammer – Vassell 765 kV Line)**

To accommodate the interconnection on the Kammer – Vassell 765 kV line a new three (3) circuit breaker 765 kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus will be constructed 40 miles east of the Kammer 765 kV substation (see Figure 1). Installation of associated protection and control equipment, 765 kV line risers, SCADA, and 765 kV revenue metering will also be required. The new interconnection switching station will be expandable to accommodate future projects in the area.

## New Switching Station Work and Cost:

- Construct a new three (3) breaker 765 kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus. Installation of associated protection and control equipment, 765 kV line risers, SCADA, and 765 kV revenue metering will also be required.
- **Estimated Station Cost: $30,000,000**

## Protection and Relay Work and Cost:

- Install line protection and controls at the new 765 kV switching station.
- **Estimated Cost: $2,000,000**
- Upgrade line protection and controls at the Kammer 765 kV substation to coordinate with the new 765 kV switching station.
- **Estimated Cost: $1,000,000**
- Upgrade line protection and controls at the Vassell 765 kV substation to coordinate with the new 765 kV switching station.
- **Estimated Cost: $1,000,000**

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IC is expected to obtain, at its cost, a 1200' x 500' station site for the new 765 kV switching station and all necessary permits. Ownership of the new 765 kV switching station and associated equipment shall be transferred from IC to AEP upon successful completion of the required work.

A 765 kV line extension is required to loop through the proposed 765 kV switching station. The proposed 765 kV switching station is assumed to be located immediately adjacent to the existing transmission lines. A supplemental line easement for the tap structures will be required. It is expected that IC will obtain the supplemental easement when the station property is purchased.

It is understood that IC is responsible for all costs associated with this interconnection. The costs above are reimbursable to AEP. The cost of IC's generating plant and the costs for the line connecting the generating plant to IC's switching station are not included in this report; these are assumed to be IC's responsibility.

The Generation Interconnection Agreement does not in or by itself establish a requirement for American Electric Power to provide power for consumption at the developer's facilities. A separate agreement may be reached with the local utility that provides service in the area to ensure that infrastructure is in place to meet this demand and proper metering equipment is installed. It is the responsibility of the developer to contact the local service provider to determine if a local service agreement is required.

**Local and Network Impacts**

The impact of the proposed generating facility on the AEP System was assessed for adherence with applicable reliability criteria. AEP planning criteria require that the transmission system meet performance parameters prescribed in the AEP FERC Form 715[1] and Connection Requirements for AEP Transmission System[2]. Therefore, these criteria were used to assess the impact of the proposed facility on the AEP System. The Queue Project AB2-067 was evaluated as an 1100.0 MW (Capacity 1100.0 MW) injection on Kammer – Vassell 765 kV line in the AEP area. Project AB2-067 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB2-067 was studied with a commercial probability of 53%.

# Potential network impacts were as follows:

## Summer Peak Analysis - 2020

1 https://www.aep.com/about/codeofconduct/OASIS/TransmissionStudies/GuideLines/AEP_East_FERC_715_2016_Final_Part_4.pdf

2 https://www.aep.com/about/codeofconduct/OASIS/TransmissionStudies/Requirements/AEP_Interconnection_Requirements_rev1.pdf

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**Generator Deliverability**
*(Single or N-1 contingencies for the Capacity portion only of the interconnection)*

None

**Multiple Facility Contingency**
*(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)*

None

**Contribution to Previously Identified Overloads**
*(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)*

None

**Short Circuit**
*(Summary of impacted circuit breakers)*

- The 138 kV Circuit Breaker J1 at the South Canton 138 kV substation was found to be over-duty. Duty percent without AB2-067 is 99.90%, duty percent with AB2-067 is 100.07%.

**Stability Analysis**

To be determined in the System Impact Study

**Voltage Variations**

None

**Delivery of Energy Portion of Interconnection Request**
PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.
Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed, which will study all overload conditions associated with the overloaded element(s) identified.

Not Applicable
**Additional Limitations of Concern**

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None

**Local/Network Upgrades**

- Replace circuit breaker J1 at the South Canton 138 kV substation with an 80kA breaker.
- **Estimated Cost: $800,000**

**Schedule**

It is anticipated that the time between receipt of executed agreements and Commercial Operation may range from 18 to 24 months if no line work is required. If line work is required, construction time would be between 36 to 48 months after signing an interconnection agreement.

**Conclusion**

Based upon the results of this Feasibility Study, the construction of the 1100.0 MW (1100.0 MW Capacity) natural gas generating facility of IC (PJM Project #AB2-067) will require the following additional interconnection charges. This plan of service will interconnect the proposed generating facility in a manner that will provide operational reliability and flexibility to both the AEP system and the IC generating facility.

**Estimated Cost for the new 765 kV Switching Station: 30,000,000**
**Estimated Protection and Relay Cost: $4,000,000**
**Estimated Local/Network Upgrade Cost: $800,000**

**Total Estimated Cost for Project AB2-067: $34,800,000**

The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements.

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**Additional Interconnection Customer Responsibilities:**

1. An Interconnection Customer entering the New Services Queue on or after October 1, 2012 with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.

3. The Interconnection Customer seeking to interconnect a wind generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per item 5.iv. of Schedule H to the Interconnection Service Agreement.

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# *Generation Interconnection Feasibility Study Report*

# *For*

# *PJM Generation Interconnection Request Queue Position AC1-044*

# *Kammer-Vassell 765 kV*

**March 2017**

# Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the feasibility study, but the actual allocation will be deferred until the impact study is performed.

The Feasibility Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

PJM utilizes manufacturer models to ensure the performance of turbines is properly captured during the simulations performed for stability verification. Turbine manufacturers provide such models to their customers. The list of manufacturer models PJM has already validated is contained in Attachment G-2 of Manual 14A. Manufacturer models may be updated from time to time, for various reasons such as to reflect changes to the control systems or to more accurately represent the capabilities turbines and controls which are currently available in the field. Additionally, as new turbine models are developed, turbine manufacturers provide such new models which must be used in the conduct of these studies. PJM needs adequate time to evaluate the new models in order to reduce delays to the System Impact Study process timeline for the Interconnection Customer as well as other Interconnection Customers in the study group. Therefore, PJM will require that any Interconnection Customer with a new manufacturer model must supply that model to PJM, along with a $10,000 fully refundable deposit, no later than three (3) months prior to the starting date of the System Impact Study (See Section 2.2.2. of Manual 14A for starting dates) for the Interconnection Request which shall specify the use of the new model. The Interconnection Customer will be required to submit a completed dynamic model study request form (Attachment G-1 of Manual 14A) in order to document the request for the study.

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# General

The Interconnection Customer (IC) proposes to increase the generation of its previous PJM Project #AB2-067, an 1100.0 MW (1100.0 MW Capacity) natural gas generating facility by 550.0 MW (550.0 MW Capacity) in The IC, Ohio (see Figure 2). The primary point of interconnection is to AEP's Kammer – Vassell 765 kV line (see Figure 1). Both projects will be known as the "The IC Power Station" and are summarized in the table below:

| | **AB2-067** | **AC1-044** |
|---|---|---|
| **Plant Configuration** | 1 x 1 CC | 1 x 1 CC |
| **Maximum Facility Output (MW)** | 1,100 | 550 |
| **Capacity (MW)** | 1,100 | 550 |
| **Planned Backfeed** | September 1, 2019 | September 1, 2019 |
| **Planned In-Service** | September 1, 2020 | September 1, 2020 |

**Table 1**

# Attachment Facilities

### Primary Point of Interconnection (Kammer – Vassell 765 kV Line)

PJM Project AB2-067 will pay for the necessary direct connection work required. Project AC1-044 will share the same Generator lead to the new 765 kV interconnection switching station being constructed by Project AB2-067.

It is understood that the IC is responsible for all costs associated with this interconnection. The cost of The IC's generating plant and the costs for the line connecting the generating plant to the IC Power Station's switching station are not included in this report; these are assumed to be the IC Power Station's responsibility.

The Generation Interconnection Agreement does not in or by itself establish a requirement for American Electric Power to provide power for consumption at the developer's facilities. A separate agreement may be reached with the local utility that provides service in the area to ensure that infrastructure is in place to meet this demand and proper metering equipment is installed. It is the responsibility of the developer to contact the local service provider to determine if a local service agreement is required.

# Interconnection Customer Requirements

Requirement from the PJM Open Access Transmission Tariff:

1. An Interconnection Customer entering the New Services Queue on or after October 1, 2012 with a proposed new Customer Facility that has a Maximum Facility Output equal

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to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.

# Revenue Metering and SCADA Requirements

## PJM Requirements

The Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

## AEP Requirements

The Interconnection Customer will be required to comply with all AEP Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "Requirements for Connection of New Facilities or Changes to Existing Facilities Connected to the AEP Transmission System" document located at the following link:

http://www.pjm.com/~/media/planning/plan-standards/private-aep/aep-interconnection-requirements.ashx

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**Network Impacts**

The Queue Project AC1-044 was evaluated as a 550.0 MW (Capacity 550.0 MW) injection tapping the Kammer-Vassell 765kV line (AB2-067 Tap) substation in the AEP area. Project AC1-044 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC1-044 was studied with a commercial probability of 53%. Potential network impacts were as follows:

## Base Case Used

Summer Peak Analysis – 2020 Case

## Contingency Descriptions

The following contingencies resulted in overloads:

None

## Generator Deliverability

*(Single or N-1 contingencies for the Capacity portion only of the interconnection)*

None

## Multiple Facility Contingency

*(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)*

None

## Contribution to Previously Identified Overloads

*(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)*

None

## Steady-State Voltage Requirements

*(Results of the steady-state voltage studies should be inserted here)*

None

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## Short Circuit

*(Summary of impacted circuit breakers)*

New circuit breakers found to be over-duty:

| # | Over-Duty Circuit Breaker | Duty Percent with AC1-044 | Duty Percent without AC1-044 | Duty Percent Difference |
|---|---|---|---|---|
| #1 | South Canton 138 kV Circuit Breaker L | 100.07% | 99.98% | **0.09%** |
| #2 | South Canton 138 kV Circuit Breaker L2 | 100.07% | 99.98% | **0.09%** |

**Table 2**

## Affected System Analysis & Mitigation

### LGEE Impacts:

LGEE Impacts to be determined during later study phases (as applicable).

### MISO Impacts:

MISO Impacts to be determined during later study phases (as applicable).

### Duke, Progress & TVA Impacts:

Duke Carolina, Progress, & TVA Impacts to be determined during later study phases (as applicable).

### OVEC Impacts:

OVEC Impacts to be determined during later study phases (as applicable).

## Delivery of Energy Portion of Interconnection Request

*PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.*

*Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which shall study all overload conditions associated with the overloaded element(s) identified.*

Not Applicable

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## New System Reinforcements

| # | Over-Duty Circuit Breaker | Upgrade Description | Schedule | Estimated Cost |
|---|---|---|---|---|
| #1 | South Canton 138 kV Circuit Breaker L | Replace 63kA Circuit Breaker with 80kA Circuit Breaker | An approximate construction time would be 12 to 18 months after signing an interconnection agreement. | **$800,000** |
| #2 | South Canton 138 kV Circuit Breaker L2 | Replace 63kA Circuit Breaker with 80kA Circuit Breaker | An approximate construction time would be 12 to 18 months after signing an interconnection agreement. | **$800,000** |
| | | | **Total New Network Upgrades** | **$1,600,000** |

**Table 3**

### Schedule

It is anticipated that the time between receipt of executed agreements and Commercial Operation may range from 12 to 18 months if no line work is required. If line work is required, construction time would be between 24 to 36 months after signing an interconnection agreement.

### Conclusion

Based upon the results of this Feasibility Study, the increase of 550.0 MW (PJM Project #AC1-044) generation to The IC Power Station's previous request (PJM Project #AB2-067) will require the following additional interconnection charges.

| **Cost Breakdown for Primary Point of Interconnection (Kammer-Vassell 765 kV Line)** | | |
|---|---|---|
| **Attachment Cost** | PJM Project AB2-067 will pay for the necessary direct connection work required. Project AC1-044 will share the same Generator lead to the new 765 kV interconnection switching station being constructed for Project AB2-067. | |
| **Non-Direct Connection Cost Estimate** | 765 kV Revenue Metering may need to be upgraded for the additional generation | **$100,000** |
| | Replace the South Canton 138 kV Circuit Breaker L | **$800,000** |
| | Replace the South Canton 138 kV Circuit Breaker L2 | **$800,000** |
| | **Total Estimated Cost for Project AC1-044** | **$1,700,000** |

**Table 4**

The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements.

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**Figure 1: Primary Point of Interconnection (Kammer - Vassell 765 kV Line)**

**Single-Line Diagram**

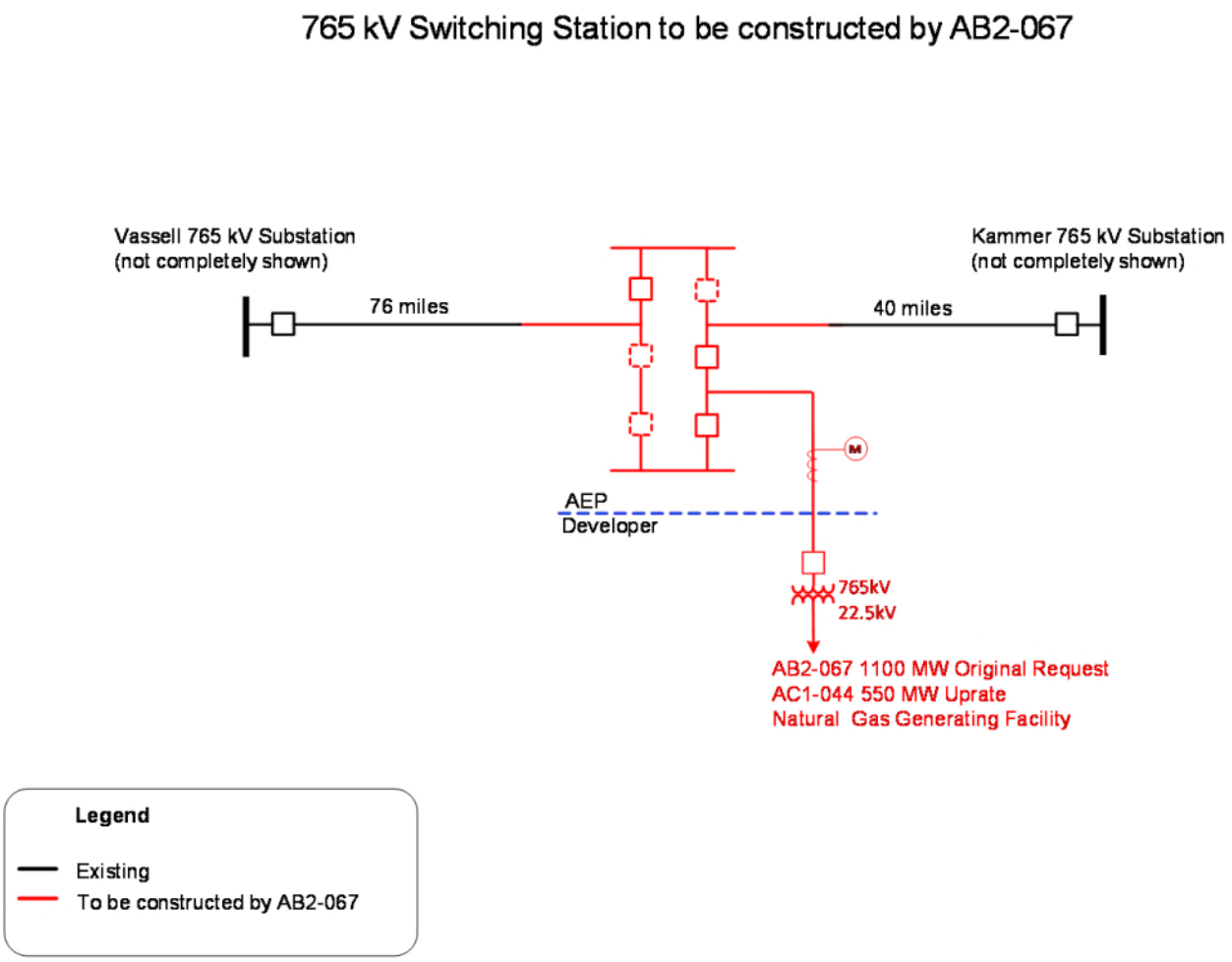


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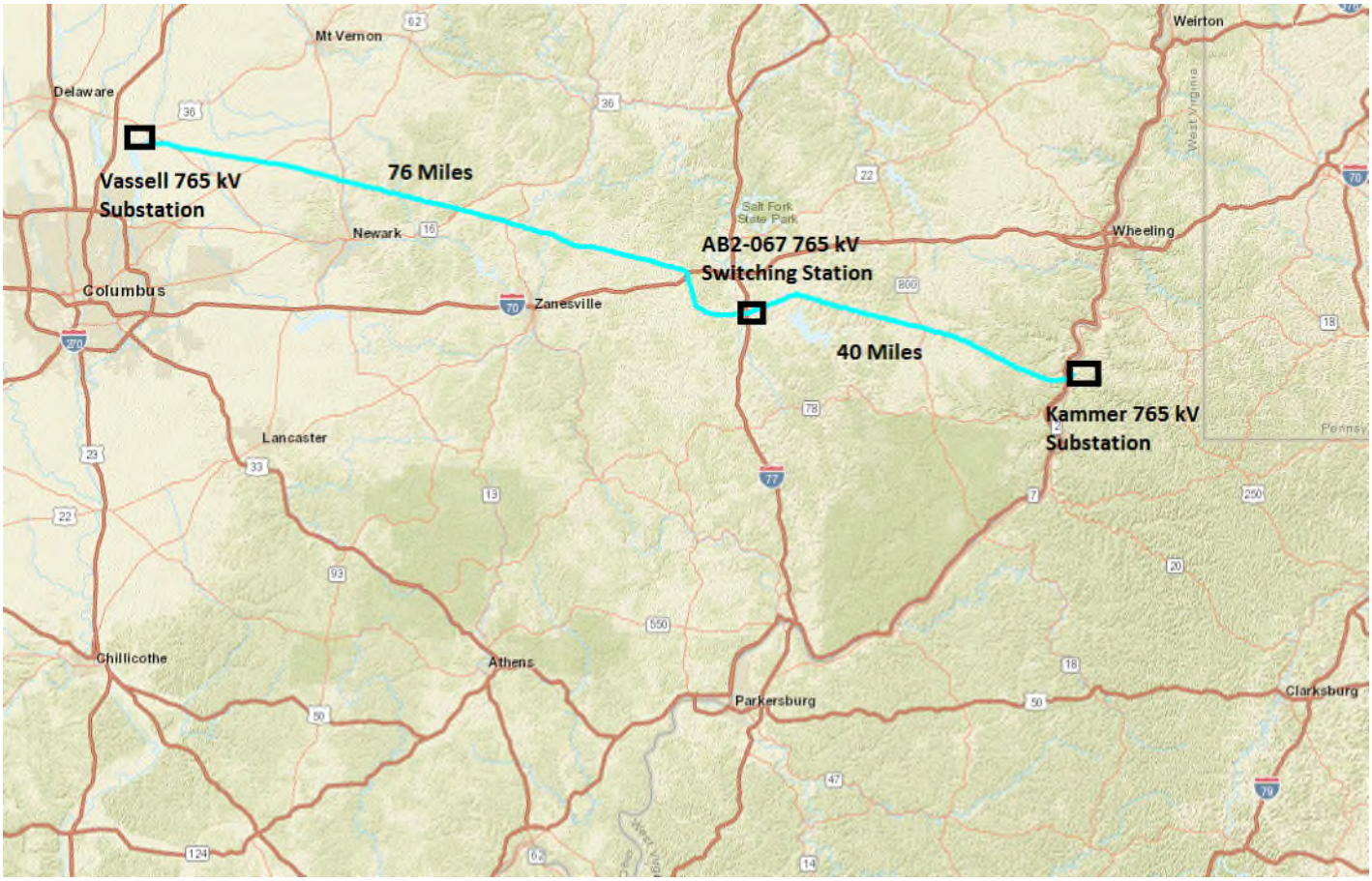
**Figure 2: Primary Point of Interconnection (Kammer – Vassell 765 kV Line)**

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# Appendix E: Economic Assessment

Economic Development RESEARCH GROUP

# Economic Assessment of the Proposed Natural Gas-Fired Guernsey Power Station in Guernsey County, Ohio

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February 2017

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# The Firm

Economic Development Research Group Inc. (EDR Group) is a consulting firm focusing specifically on applying state-of-the-art tools and techniques for evaluating economic development performance, impacts, and opportunities. The firm was started in 1996 by a core group of economists and planners who are specialists in models and tools for evaluating impacts of infrastructure, technologies, and natural resources on economic development opportunities. EDR Group provides both consulting advisory services and full-scale research projects for public and private agencies throughout North America and in Europe, Asia, and Africa. Our work focuses on three issues:

- Economic Impact Analysis – How will my project/program affect economic growth and attraction? …How can I best target my efforts?
- Market/Strategy Analysis – How will I be affected by changes in the economy? …What should I do to respond to them?
- Benefit/Cost Analysis – What will the economic benefits and costs of my project/program be? …What should I do to maximize net value?

The economic development work of EDR Group is organized in terms of five areas: (1) forecasting economic change; (2) opportunities assessment; (3) strategy development; (4) benefit-cost analysis; and (5) program evaluation.

# Executive Summary

The construction and operation of the proposed Guernsey Power Station will create significant economic impacts for Eastern Ohio and the rest of the state. Total economic impacts include direct local transactions associated with the construction budget and operations budget; subsequent indirect impacts from businesses making purchases of local supplies and services; and induced impacts from workers spending wages locally in the area where they live.

Economic and tax revenue impacts over the 33 months of construction are as follows (2016 dollars):

**Eastern Ohio**

- 6,880 job-years (or 2,500 average annual jobs)
- $353.7 million in associated labor income
- $427.4 million in value added (gross regional product)
- $610.9 million in output (business sales)
- $16.3 million in state and local tax revenue

**State of Ohio (including Eastern Ohio)**

- 8,540 job-years (or 3,110 average annual jobs)
- $450.1 million in associated labor income
- $586.2 million in value added (gross state product)
- $952.8 million in output (business sales)
- $33.7 million in state and local tax revenue

Economic and tax revenue impacts during a typical year of operations are as follows (2016 dollars):

**Eastern Ohio**

- 140 annual jobs (25 are plant personnel)
- $9.8 million in associated annual labor income
- $40.1 million in annual value added (gross regional product)
- $77.2 million in annual output (business sales)
- $915,700 in annual state and local tax revenue

**State of Ohio (including Eastern Ohio)**

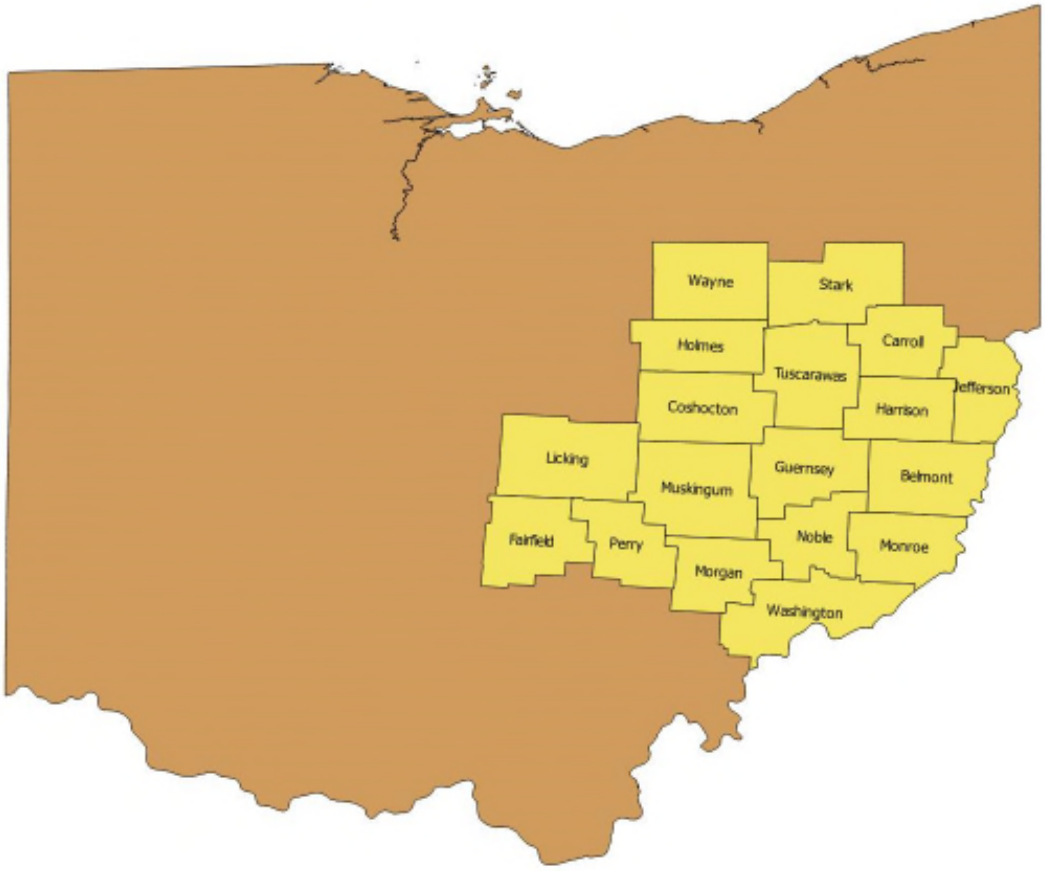
- 180 annual jobs
- $11.7 million in associated annual labor income
- $43.1 million in annual value added (gross state product)
- $82.8 million in annual output (business sales)
- $1.1 million in annual state and local tax revenue

# 1 Introduction

Economic Development Research Group maintained full independence and impartiality in conducting the following analysis. The organization takes no institutional position on matters of policy and holds no conflicts of interest that impeded it from providing objective analysis to Tetra Tech, Inc. or the citizens of Ohio.

Guernsey Power Station (GPS) is a proposed 1,650-megawatt, natural gas-fired energy generating facility located in southern Guernsey County, Ohio.[1] The study region ("Eastern Ohio") includes 18 counties that surround Guernsey County (see Figure 1). Eastern Ohio is primarily rural except for Fairfield, Licking, and Perry counties, which are part of the U.S. Census Bureau-defined Columbus Metropolitan Statistical Area.[2]

**Figure 1: Eastern Ohio Study Region**



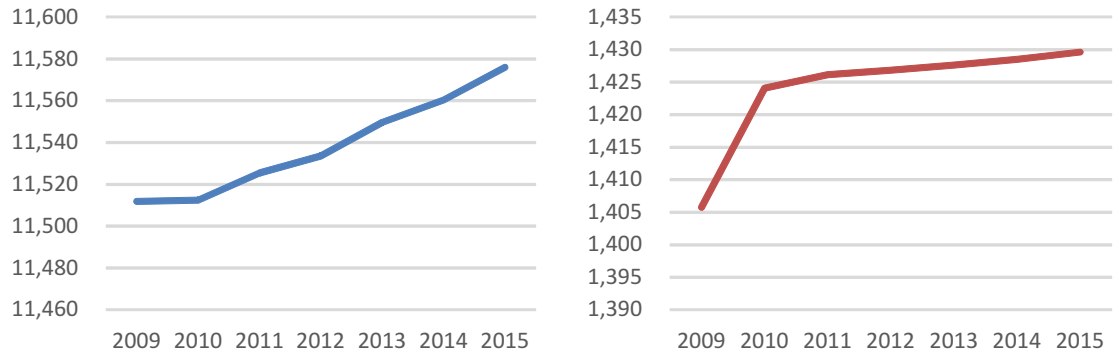

[1] See http://guernseypowerstation.com/guernsey-power-station/.
[2] The U.S. Census Bureau defines an Urbanized Area as having at least 50,000 people and an Urban Cluster as having between 2,500-50,000 people. Rural areas encompass people living outside these urban areas.

# 2 Existing Conditions

## 2.1 Population Trends

The population of Ohio has grown steadily over the last several years, increasing 0.6 percent from 2009-2015. Eastern Ohio grew 1.7 percent during this period, with the strongest growth occurring between 2009-2010, just after the Great Recession officially ended. Eastern Ohio comprises about 12 percent of the state's total population.

**Figure 2: Population of Ohio (left) and Eastern Ohio (right), 2009-2015 (in thousands)**




**Source:** American Community Survey 5-Year Estimates

## 2.2 Educational Attainment

The share of the state's population that has a high school education or greater is approximately 89.3 percent while the share in Eastern Ohio is 87.7 percent (see Table 1). These levels are compared with 86.7 percent nationally. The share of the Ohio population that has a college degree is approximately 26.2 percent while the share in Eastern Ohio 18.7 percent. Nationally, the share of the population with a college degree is 29.8 percent.

**Table 1: Educational Attainment in Ohio, Eastern Ohio & the U.S., 2015**

| | Ohio | Eastern Ohio | U.S. |
|---|---|---|---|
| Population 25 Years and Over | 7,817,508 | 975,181 | 211,462,522 |
| **Level of Education** | | | |
| Less than high school | 10.9% | 12.3% | 13.4% |
| High school graduate (includes equivalency) | 34.2% | 40.6% | 27.8% |
| Some college | 28.9% | 28.4% | 29.1% |
| Bachelor's degree | 16.4% | 12.2% | 18.5% |
| Master's degree | 7.1% | 5.0% | 8.0% |
| Professional school degree | 1.6% | 0.9% | 2.0% |
| Doctorate degree | 1.1% | 0.6% | 1.3% |
| **Source:** 2011-2015 American Community Survey 5-Year Estimates | | | |

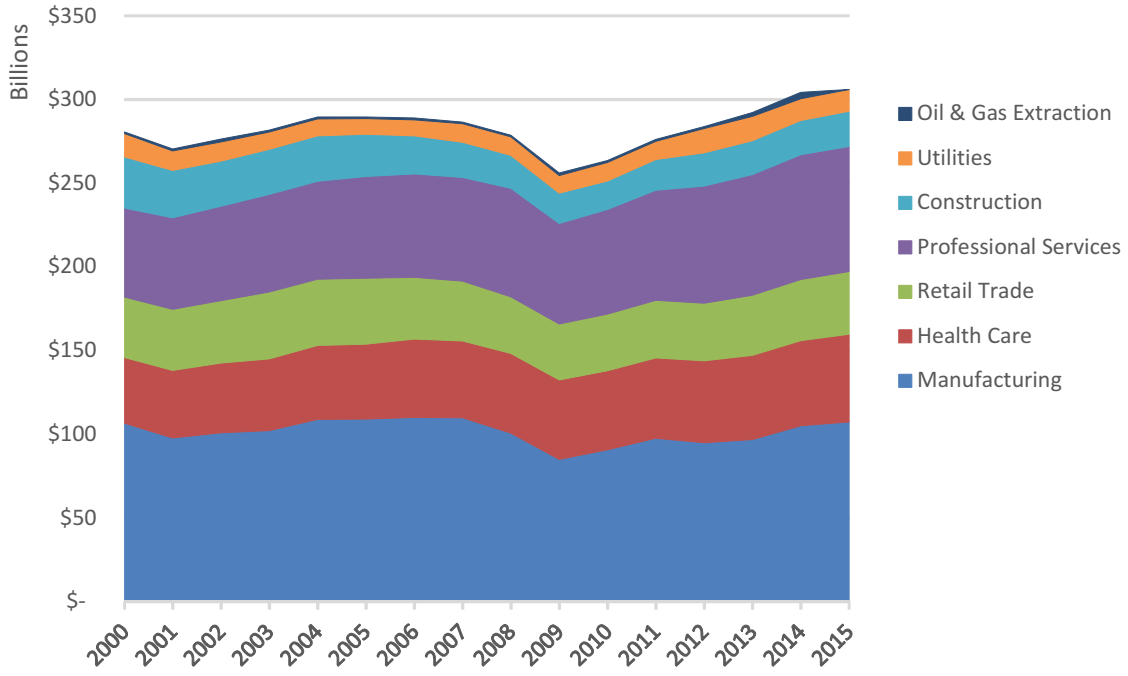
# 2.3 Economic Profile & Trends

## 2.3.1 Gross State Product

From 2000-2015, Ohio's gross state product (GSP) grew by 13 percent, a trend that was driven by high GSP growth in several industries (see Figure 2). Healthcare GSP grew by 33 percent during this period and professional services grew by 41 percent. Oil and gas extraction grew by over 300 percent during this period, reflecting the widespread use of hydraulic fracturing. Figure 2 shows how the growth of Ohio's economy was interrupted by the Great Recession, which lasted from December 2007 through June 2009.[3]

[3] According to the National Bureau of Economic Research (NBER), the official arbiter of U.S. recessions (see http://www.nber.org/cycles.html for a list of business cycle contractions, with the latest describing the Great Recession, and http://www.bls.gov/spotlight/2012/recession/pdf/recession_bls_spotlight.pdf for U.S. Bureau of Labor Statistics commentary on the Great Recession)

**Figure 2: Gross State Product by Select Industry in Ohio, 2000-2015 (billions of 2016 dollars)**




**Source:** U.S. Bureau of Economic Analysis

## 2.3.2 Employment and Unemployment

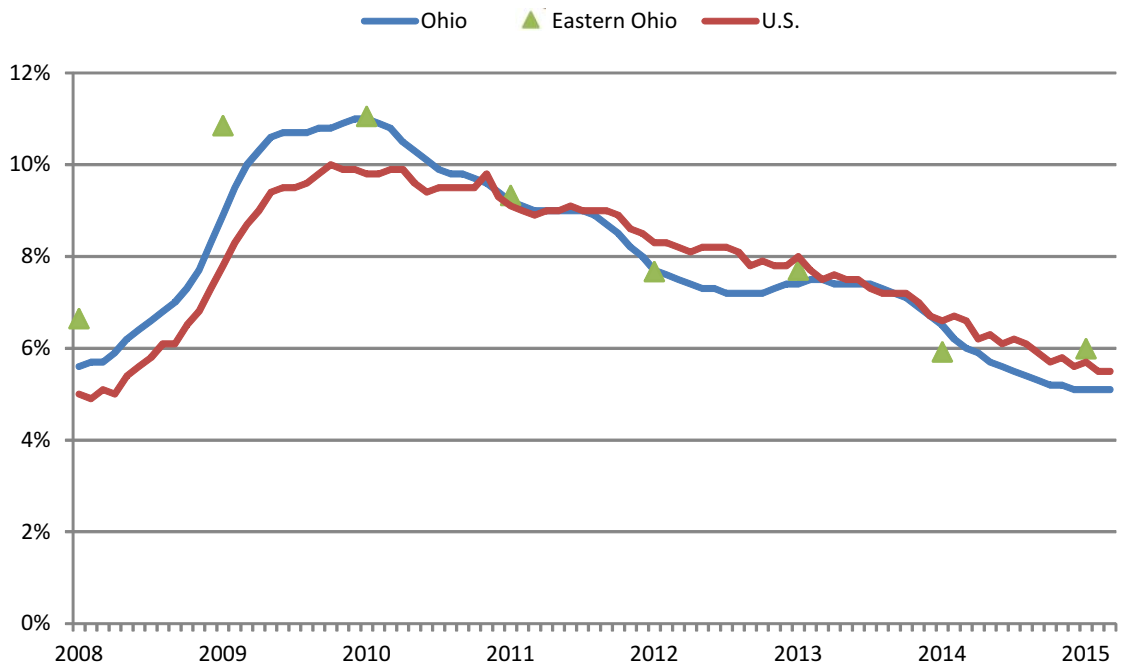
In 2015, major employers in Eastern Ohio included restaurants, retailers and wholesalers, hospitals and other healthcare facilities, real estate companies, and truck companies (see Figure 3). Regarding the supply of workers for GPS construction, in 2015 there were an estimated 5,770 construction laborers in the Columbus metro area, part of which is outside Eastern Ohio. Because the project site is within driving distance of the Columbus metro area, the analysis assumes that the region's labor supply will be able to meet the facility's construction demand.

**Figure 3: Top Ten Private-Sector Industries by Employment in Eastern Ohio, 2015**

| Rank | Description | Employment |
|---|---|---|
| 1 | Limited-service restaurants | 24,120 |
| 2 | Full-service restaurants | 21,720 |
| 3 | Wholesale trade | 21,630 |
| 4 | Hospitals | 21,490 |
| 5 | Real estate | 20,010 |
| 6 | Nursing and community care facilities | 17,400 |
| 7 | Retail – general merchandise stores | 14,750 |
| 8 | Retail – food and beverage stores | 11,790 |
| 9 | Truck transportation | 11,530 |
| 10 | Offices of physicians | 11,430 |
| **Source:** IMPLAN 2015 based on U.S. Bureau of Economic Analysis data | | |

During the Great Recession, the unemployment rate in Eastern Ohio exceeded state and national levels, ultimately peaking at a rate of over 11 percent in 2010 (see Figure 4). By 2012, Eastern Ohio's unemployment rate fell to 7.6 percent, a rate equal to Ohio's and below that of the U.S. As of 2015, the unemployment rate in Eastern Ohio was 6.0 percent, 5.1 percentage points below its 2010 peak and 0.6 percentage points below its pre-recession level.

**Figure 4: Unemployment Rate in Ohio, Eastern Ohio & the U.S., 2008-2015**




**Note:** Ohio and U.S. unemployment rates reflect a seasonally adjusted monthly value. The Eastern Ohio rate reflects an annual average, as monthly, seasonally adjusted values are not available by county.
**Source:** U.S. Bureau of Labor Statistics

# 3 Economic Impacts

This section estimates the economic impacts associated with GPS, and is based on the facility's preliminary budget estimates for construction and subsequent operations. Construction of GPS, scheduled to begin in early 2018, will influence economic activity in Eastern Ohio and the rest of state over a period of 33 months by hiring local construction trade labor and sourcing some construction-phase inputs (capital goods, materials, and supplies) locally. With plant operations beginning in late 2020, economic impacts will transition from construction-related to operations-related. GPS will operate with Eastern Ohio (resident) employees and be supplied/maintained by purchasing some percentage of local parts, supplies, and services. All project spending and impact figures are in 2016 dollars.

## 3.1 Economic Impact Methodology

The following economic impact results portray the direct effects associated with the project's phase-specific spending, and the "multiplier" effects. During the construction phase, the direct effects pertain to hiring members of the local resident work force, and the local share of the non-labor-related spending to build the facility. Construction impacts also include the subsequent rounds of local purchasing of supplies (indirect) and the spending by those working at the facility and at suppliers (induced). During the operations phase, the local disposition of the annual operating budget is necessary to capture the indirect and induced effects, but the set of direct effects should describe the annual production of GPS—namely its gross revenues,[4] employment, and payroll. Total economic impacts represent the combination of direct, indirect, and induced effects, stated in terms dollars of output, dollars of labor income, and employment.

Initial spending effects are identified from preliminary construction and annual operating budgets for the proposed facility. These budgets provide estimated labor and materials expenditures to support construction and estimates of what is sourced locally (within the Eastern Ohio 18-county region or elsewhere in the Ohio economy).

The indirect and induced effects are estimated using an IMPLAN multi-region input-output (MRIO) model for Eastern Ohio and the state of Ohio.[5] These multipliers trace indirect and induced impacts generated from industry relationships in Eastern Ohio and the state. Implied trade flows also influence the multiplier response. The models are calibrated to depict region-specific industry-by-industry purchasing patterns (for the

[4] We estimate this value using payroll data along with region-specific data from the IMPLAN model on fossil fuel-fired electric generators.

[5] IMPLAN is a proprietary economic impact model that uses data from multiple publicly-available datasets published by the U.S. Bureau of Economic Analysis and Bureau of Labor Statistics, among others. For more information on IMPLAN, visit http://implan.com/.

indirect effects) and consumer purchasing patterns (for the induced effects). The indirect and induced multipliers for each industry estimate how much additional activity results when a project stimulates local business.

The size of the affected area is critical for impact analysis as a larger economic region will capture more multiplier transactions than a single county alone. Therefore, it is crucial to this assessment that supplies and labor are distinguished by those that would come directly from Eastern Ohio, those that would come from the rest of Ohio, and those that leak away beyond the state boundary. Impacts for Eastern Ohio are derived from local purchases in the 18 counties and the multiplier effects in that regional economy, while impacts for the state of Ohio are derived from the sum of impacts in Eastern Ohio and the impacts resulting from purchases with businesses in the rest of Ohio. Results stemming from the construction and operations phases are presented for both geographies.

Key to gauging the overall impact of GPS is the identification of how much of the initial spending will be local content. To reflect construction and operations inputs for the facility and the multiplier responses that would ensue, EDR Group follows a bill-of-goods approach that uses budget information.

## 3.2 Impacts of Construction

Construction is expected to begin in 2018 and last 33 months, with 48 percent of spending occurring in the first 12 months, 36 percent occurring between months 13-24, and 16 percent occurring through months 25-33. The total capital outlay (gross project cost) to develop and construct GPS will be an estimated $1.4 billion, $250 million of which will be spent on labor with the rest spent on equipment and materials.[6] During construction of GPS, local construction workers will be enlisted who spend wages at local businesses. Also, locally sourced supplies will generate activity for contractors, service providers, and manufacturers.

The impacts presented in this section are derived from construction budget estimates provided by the developer. Direct impacts represent local production requirements of the budget, indirect impacts come from supply purchases, and induced impacts come from disposable income spent within the region or state.

### 3.2.1 Regional and Statewide Supply of Labor and Inputs

Of the total construction supplies and labor outlay of $1.4 billion, approximately 25 percent reflects contracting and labor expenditures within Eastern Ohio. This share increases to approximately 38 percent when the entire state of Ohio defines the market (inclusive of Eastern Ohio) (see Table 2). The project developer has assumed that 90

[6] The impact analysis excludes the cost of land acquisition because it represents a transfer of wealth rather than new wealth creation.

percent of the construction labor will come from Eastern Ohio with the rest coming from elsewhere in the state. This assumption is supported by the fact that there is an ample-sized construction labor force in the region (as discussed in Section 2.3.2). The remaining construction dollars represent supplies that are purchased outside of the state of Ohio.

**Table 2: Estimated Construction Budget (33-month total) (millions of 2016 dollars)**

| Spending Category | Total Spend | Eastern Ohio Share | Eastern Ohio Spend | Rest-of-Ohio Share | Rest-of-Ohio Spend | Total Ohio Spend |
|---|---|---|---|---|---|---|
| **Engineering and procurement** | | | | | | |
| Engineering/design | $20,000,000 | 5% | $1,000,000 | 5% | $1,000,000 | $2,000,000 |
| Site preparation | $25,000,000 | 100% | $25,000,000 | 0% | $0 | $25,000,000 |
| Permitting fees | $2,000,000 | 50% | $1,000,000 | 50% | $1,000,000 | $2,000,000 |
| Insurance | $7,000,000 | 30% | $2,100,000 | 0% | $0 | $2,100,000 |
| Project management | $10,000,000 | 15% | $1,500,000 | 5% | $500,000 | $2,000,000 |
| **Building equipment (capital) costs** | | | | | | |
| Pre-engineered buildings | $150,000,000 | 40% | $60,000,000 | 50% | $75,000,000 | $135,000,000 |
| Power generation equipment (turbines) | $450,000,000 | 0% | $0 | 0% | $0 | $0 |
| Bulk metal materials (e.g., pipes, electrical) | $200,000,000 | 10% | $20,000,000 | 20% | $40,000,000 | $60,000,000 |
| Other bulk materials (e.g., insulation, wood) | $69,000,000 | 10% | $6,900,000 | 15% | $10,350,000 | $17,250,000 |
| Transformers, generators, breakers, controls | $80,000,000 | 0% | $0 | 0% | $0 | $0 |
| Continuous emission systems | $3,000,000 | 0% | $0 | 0% | $0 | $0 |
| Waste and water treatment systems | $50,000,000 | 5% | $2,500,000 | 5% | $2,500,000 | $5,000,000 |
| Fuel compressors, diesel & nat. gas handling | $10,000,000 | 5% | $500,000 | 5% | $500,000 | $1,000,000 |
| Instrumentation | $20,000,000 | 5% | $1,000,000 | 5% | $1,000,000 | $2,000,000 |
| Other (equipment leasing, local subs) | $50,000,000 | 40% | $20,000,000 | 50% | $25,000,000 | $45,000,000 |
| **Distribution equipment (capital) costs** | | | | | | |
| Poles | $2,000,000 | 0% | $0 | 0% | $0 | $0 |
| Wires | $8,000,000 | 0% | $0 | 0% | $0 | $0 |
| Transformers | $30,000,000 | 0% | $0 | 0% | $0 | $0 |
| Other controls and equipment | $2,000,000 | 10% | $200,000 | 10% | $200,000 | $400,000 |
| Substation structures, fences, etc. | $8,000,000 | 25% | $2,000,000 | 10% | $800,000 | $2,800,000 |
| **Labor cost** | **$250,000,000** | **90%** | **$225,000,000** | **10%** | **$25,000,000** | **$250,000,000** |
| **Total construction cost, including labor** | **$1,446,000,000** | **25%** | **$368,700,000** | **13%** | **$182,850,000** | **$551,550,000** |
| **Source:** Guernsey Power Station, LLC | | | | | | |
| **Note:** Totals may not sum exactly due to rounding. | | | | | | |

Construction of GPS translates into direct, non-labor-related spending totaling $302 million for businesses within the state of Ohio, with $144 million occurring within Eastern Ohio (see Table 3). There will be impacts on orders for parts and materials from Ohio manufacturers, as well as orders for services from local engineering, design, and site preparation industries.

**Table 3: Locally Procured Construction Spending by Industry (33-month total) (2016 dollars)**

| Industry | Industry Sector Description | Eastern Ohio Procurement | Rest-of-Ohio Procurement | Total Ohio Procurement |
|---|---|---|---|---|
| 51 | Water, sewage, and other systems | $2,500,000 | $2,500,000 | $5,000,000 |
| 54 | Construction of other new power and communication structures | $25,000,000 | $0 | $25,000,000 |
| 215 | Mineral wool manufacturing | $6,900,000 | $10,350,000 | $17,250,000 |
| 217 | Iron and steel mills and ferroalloy manufacturing | $20,000,000 | $40,000,000 | $60,000,000 |
| 239 | Plate work manufacturing | $60,000,000 | $75,000,000 | $135,000,000 |
| 242 | Ornamental and architectural metal work manufacturing | $2,000,000 | $800,000 | $2,800,000 |
| 283 | Gas turbine generator set units manufacturing | $0 | $0 | $0 |
| 288 | Air and gas compressor manufacturing | $500,000 | $500,000 | $1,000,000 |
| 317 | Industrial process variable instruments manufacturing | $1,200,000 | $1,200,000 | $2,400,000 |
| 332 | Power, distribution, and specialty transformer manufacturing | $0 | $0 | $0 |
| 437 | Industrial process variable instruments manufacturing | $2,100,000 | $0 | $2,100,000 |
| 445 | Commercial and industrial machinery and equipment rental and leasing | $20,000,000 | $25,000,000 | $45,000,000 |
| 449 | Architectural, engineering, and related services | $2,500,000 | $1,500,000 | $4,000,000 |
| 526 | Other local government enterprises | $1,000,000 | $1,000,000 | $2,000,000 |
| **Total non-labor-related cost** | | **$143,700,000** | **$157,850,000** | **$301,550,000** |
| **Source:** Guernsey Power Station, LLC | | | | |
| **Note:** Totals may not sum exactly due to rounding. | | | | |

### 3.2.2 Economic Impacts of Construction

The total economic impact of the construction of GPS is a sum of the direct, indirect, and induced effects from construction spending. The direct impact is the portion of the budget that local businesses are fulfilling. Indirect and induced effects are based on the amount of additional business sales (from supplier purchases and worker spending) that would be generated within Eastern Ohio or the state for the industries listed in Table 3.

The 33-month economic impact of construction of the facility in Eastern Ohio is an estimated $610.9 million in business sales, $427.4 million of which is a contribution to gross regional product (see Table 4). Construction of GPS is also expected to support 6,880 job-years and approximately $353.7 million in related labor income in Eastern Ohio.[7] When impacts in the rest of the state are included, the total statewide impact of construction of the facility is estimated to be $952.8 million, approximately $586.2 million

[7] A job-year is equal to one job for one year.

of which is a contribution to gross state product. Construction of GPS is also expected to support an estimated 8,540 job-years and $450.1 million in related labor income in the state of Ohio.

**Table 4: Total 33-Month Economic Impacts of Construction (2016 dollars)**

| Impact Measure | Job-Years | Labor Income | Contribution to Gross Regional/State Product | Output |
|---|---|---|---|---|
| **Impacts in Eastern Ohio** | | | | |
| Direct effect[8] | 4,540 | $250,000,000 | $250,000,000 | $250,000,000 |
| Indirect effect | 840 | $50,584,000 | $75,655,200 | $176,780,100 |
| Induced effect | 1,500 | $53,082,100 | $101,761,900 | $184,104,400 |
| Total impact | 6,880 | $353,666,200 | $427,417,100 | $610,884,500 |
| **Impacts in Ohio (statewide total)** | | | | |
| Direct effect[8] | 4,540 | $250,000,000 | $250,000,000 | $250,000,000 |
| Indirect effect | 1,790 | $114,426,400 | $175,413,700 | $416,371,100 |
| Induced effect | 2,220 | $85,631,100 | $160,740,700 | $286,474,900 |
| Total impact | 8,540 | $450,057,500 | $586,154,400 | $952,846,000 |
| **Source:** Guernsey Power Station LLC and IMPLAN model; calculations by EDR Group | | | | |
| **Note:** Totals may not sum exactly due to rounding. | | | | |

The average annual economic impact of construction of GPS in Eastern Ohio is an estimated $222.1 million of business sales, $155.4 million of which is a contribution to annual gross regional product (see Table 5). Construction of the facility is also expected to support an estimated average of 2,500 jobs at any one time during the construction period and $128.6 million in related annual labor income in Eastern Ohio. When impacts from the rest of Ohio are included, the annual statewide economic impact of the construction of GPS is estimated to be $346.5 million, $213.1 million of which is a contribution to annual gross state product. Construction of the facility is also expected to support an estimated average of 3,110 jobs at any one time during the construction period and $163.7 million in related annual labor income in the state of Ohio.

[8] For the construction phase, the direct effects are representative of the construction labor expense as provided by the developer, hence the value added and output values are equal to the direct labor expense. All other materials, supplies, and equipment for the project site are reported among the indirect effects to the extent they are procured within the region.

**Table 5: Average Annual Economic Impacts of Construction (2016 dollars)**

| Impact Measure | Average Annual Jobs | Average Annual Labor Income | Average Annual Contribution to Gross Regional/State Product | Average Annual Output |
|---|---|---|---|---|
| **Impacts in Eastern Ohio** | | | | |
| Direct effect | 1,650 | $90,909,100 | $90,909,100 | $90,909,100 |
| Indirect effect | 300 | $18,394,200 | $27,511,000 | $64,283,700 |
| Induced effect | 550 | $19,302,600 | $37,004,300 | $66,947,100 |
| Total impact | 2,500 | $128,605,900 | $155,424,400 | $222,139,800 |
| **Impacts in Ohio (statewide total)** | | | | |
| Direct effect | 1,650 | $90,909,100 | $90,909,100 | $90,909,100 |
| Indirect effect | 650 | $41,609,600 | $63,786,800 | $151,407,700 |
| Induced effect | 800 | $31,138,600 | $58,451,200 | $104,172,700 |
| Total impact | 3,110 | $163,657,300 | $213,147,100 | $346,489,500 |
| **Source:** Guernsey Power Station, LLC and IMPLAN model; calculations by EDR Group | | | | |
| **Note:** Totals may not sum exactly due to rounding. | | | | |

### 3.2.3 Tax Revenue Impacts of Construction

Construction of GPS will also generate state and local tax revenue. Over the 33-month construction phase, the facility will generate an estimated $16.3 million in annual tax revenue in Eastern Ohio, mostly through taxes on production and imports (see Table 7). Statewide, when considering the project's requirements from the rest of Ohio's economy, annual tax revenue impacts from construction will increase to an estimated $33.7 million.

**Table 6: Total 33-Month Tax Revenue from Facility Construction (2016 dollars)**

| Revenue Source | State and Local Revenue |
|---|---|
| **Impacts in Eastern Ohio** | |
| Employee compensation | $534,300 |
| Proprietor income | $0 |
| Production and imports | $13,331,700 |
| Households | $2,370,300 |
| Corporations | $65,000 |
| Total impact | $16,301,300 |
| **Impacts in Ohio (statewide total)** | |
| Employee compensation | $862,400 |
| Proprietor income | $0 |
| Production and imports | $26,945,500 |
| Households | $5,728,200 |
| Corporations | $192,900 |
| Total impact | $33,729,000 |
| **Source:** Guernsey Power Station, LLC and IMPLAN model; calculations by EDR Group | |
| **Note:** Totals may not sum exactly due to rounding. | |

## 3.3 Impacts of Operations and Maintenance

In 2021, the first year of operations and maintenance for GPS, the annual spend will be $35 million (in nominal dollars), including $30 million on supplies and $5 million on payroll for 25 staff. The impacts presented in this section are derived from the operations budget and hiring expectations at the facility. Direct impacts represent the annual production from GPS. Indirect impacts are generated from supply purchases that have local vendors and induced impacts are generated with increases in local disposable income being used to make local consumer purchases.

### 3.3.1 Regional and Statewide Supply of Labor and Inputs

Of an annual operations and maintenance (O&M) outlay of $33.6 million (in 2016 dollars), approximately 40 percent will be purchased in Eastern Ohio with another 6 percent captured elsewhere in the state.

**Table 7: Estimated Annual Operations and Maintenance Budget (2016 dollars)**

| Spending Category | Annual Spend | Eastern Ohio Share | Eastern Ohio Spend | Rest-of-Ohio Share | Rest-of-Ohio Spend | Total Ohio Spend |
|---|---|---|---|---|---|---|
| Maintenance equipment and tools | $492,600 | 50% | $246,400 | 40% | $197,100 | $443,600 |
| Balance of plant spares | $489,900 | 30% | $147,000 | 0% | $0 | $147,000 |
| Water services (including chemicals) | $4,766,700 | 100% | $4,766,700 | 0% | $0 | $4,766,700 |
| Major maintenance | $17,165,400 | 10% | $1,716,500 | 10% | $1,716,500 | $3,433,000 |
| Building and grounds maintenance | $483,500 | 100% | $483,500 | 0% | $0 | $483,500 |
| Utilities | $495,600 | 100% | $495,600 | 0% | $0 | $495,600 |
| Other (insurance and management) | $4,830,100 | 15% | $724,500 | 5% | $241,500 | $966,000 |
| **Annual labor cost** | $4,854,900 | 100% | $4,854,900 | 0% | $0 | $4,854,900 |
| **Annual O&M cost, including labor** | **$33,578,900** | **40%** | **$13,435,100** | **6%** | **$2,155,200** | **$15,590,300** |
| **Source:** Guernsey Power Station, LLC | | | | | | |
| **Note:** Totals may not sum exactly due to rounding. | | | | | | |

GPS's operations and maintenance budget translates into direct, non-labor-related spending totaling $10.7 million for businesses within the state of Ohio, with $8.6 million occurring within Eastern Ohio (see Table 8). There will be purchases from retailers and wholesalers, and spending on various services necessary to operate and maintain the facility.

**Table 8: Estimated Annual Operations and Maintenance Spending by Industry (2016 dollars)**

| Industry | Industry Sector Description | Eastern Ohio Procurement | Rest-of-Ohio Procurement | Total Ohio Procurement |
|---|---|---|---|---|
| 51 | Water, sewage, and other systems | $4,766,700 | $0 | $4,766,700 |
| 62 | Maintenance and repair of nonresidential structures | $1,716,500 | $1,716,500 | $3,433,000 |
| 395 | Wholesale trade | $147,000 | $0 | $147,000 |
| 406 | Retail - Miscellaneous store retailers | $246,400 | $197,100 | $443,600 |
| 427 | Wired telecommunications carriers | $495,600 | $0 | $495,600 |
| 461 | Management of companies and enterprises | $724,500 | $241,500 | $966,000 |
| 468 | Services to buildings | $483,500 | $0 | $483,500 |
| **Total non-labor-related cost** | | **$8,580,300** | **$2,155,200** | **$10,735,400** |
| **Source:** Guernsey Power Station LLC | | | | |
| **Note:** Totals may not sum exactly due to rounding. | | | | |

### 3.3.2 Economic Impacts of Operations and Maintenance

The total economic impact from the operations and maintenance of the Facility is a sum of direct, indirect, and induced impacts. The direct impact is the dollar value of economic activity occurring at the facility. The local portion of this first spending by GPS will lead to indirect and induced effects within Eastern Ohio and elsewhere in the state of Ohio.

The annual impact of O&M in Eastern Ohio is an estimated $77.2 million, $40.1 million of which will be a contribution to gross regional product (see Table 9). Operations and maintenance will support an estimated 140 jobs annually and generate $9.8 million in related annual labor income in Eastern Ohio during the operational life of the facility. The estimated statewide impact of O&M is $82.8 million, $43 million of which will be a contribution to gross state product. Operations and maintenance will support an estimated 180 jobs annually and generate approximately $11.7 million in related annual labor income in the state of Ohio during the operational life of the facility.

**Table 9: Annual Economic Impacts from Facility O&M (2016 dollars)**

| Impact Measure | Jobs | Labor Income | Contribution to Gross Regional/State Product | Output |
|---|---|---|---|---|
| **Impacts in Eastern Ohio** | | | | |
| Direct effect | 25 | $4,938,400 | $31,172,500 | $60,411,800 |
| Indirect effect | 70 | $3,236,400 | $5,906,500 | $11,269,800 |
| Induced effect | 45 | $1,581,200 | $3,031,200 | $5,478,400 |
| Total impact | 140 | $9,756,000 | $40,110,200 | $77,160,000 |
| **Impacts in Ohio (statewide total)** | | | | |
| Direct effect | 25 | $4,938,400 | $31,172,500 | $60,411,800 |
| Indirect effect | 94 | $4,554,700 | $7,806,100 | $15,039,500 |
| Induced effect | 57 | $2,163,300 | $4,080,300 | $7,304,500 |
| Total impact | 180 | $11,656,400 | $43,058,900 | $82,755,800 |
| **Source:** Guernsey Power Station LLC and IMPLAN model; calculations by EDR Group | | | | |
| **Note:** Totals may not sum exactly due to rounding. | | | | |

### 3.3.3 Tax Revenue Impacts of Operations and Maintenance

Operation and maintenance of GPS will also generate state and local tax revenue. The facility will generate an estimated $915,700 in annual tax revenue in Eastern Ohio, mostly through taxes on productions and imports and taxes that households pay (see Table 10). When impacts in the rest of the state are included, O&M will generate an estimated $1.1 million in annual tax revenue statewide, again mostly from taxes on production and imports and households.

**Table 10: Annual Tax Revenue from Facility O&M (2016 dollars)**

| Revenue Source | State and Local Revenue |
|---|---|
| **Impacts in Eastern Ohio** | |
| Employee compensation | $18,000 |
| Proprietor income | $0 |
| Production and imports | $784,000 |
| Households | $110,000 |
| Corporations | $3,600 |
| Total impact | $915,700 |
| **Impacts in Ohio (statewide total)** | |
| Employee compensation | $22,600 |
| Proprietor income | $0 |
| Production and imports | $940,600 |
| Households | $163,080 |
| Corporations | $5,470 |
| Total impact | $1,131,700 |
| **Source:** Guernsey Power Station, LLC and IMPLAN model; calculations by EDR Group | |
| **Note:** Totals may not sum exactly due to rounding. | |

# 4 Conclusion

Construction of Guernsey Power Station represents an investment of $1.4 billion (gross project cost), of which 25 percent is captured within Eastern Ohio and an additional 13 percent within the rest of the state. This investment will result in significant economic impacts in Eastern Ohio and elsewhere in the state. The total economic impact of the construction of GPS in Eastern Ohio is an estimated $610.9 million, $427.4 million of which is a contribution to gross regional product. Construction will support 2,500 jobs annually, on average, and $128.6 million in annual labor income in Eastern Ohio over the 33-month construction period. The statewide impact (Eastern Ohio included) is an estimated $952.8 million, $586.2 million of which is a contribution to gross state product. Construction will support an estimated 3,110 jobs annually and $163.7 million in annual labor income in the state of Ohio over the 33-month construction period.

The economic impact from the operations and maintenance of GPS in Eastern Ohio is an estimated $77.2 million annually, $40.1 million of which represents a contribution to annual gross regional product. Operations and maintenance will support an estimated 140 jobs annually and generate $9.8 million in annual labor income in Eastern Ohio during the operational life of the facility. Statewide, the economic impact of O&M is an estimated $82.8 million annually, $43.1 million of which is an annual contribution to gross state product. Operations and maintenance will also support 180 jobs and generate $11.7 million in annual labor income in the state of Ohio.

Construction, operations, and maintenance of GPS will also generate state and local tax revenue. During construction, the facility will generate an estimated $16.3 million in annual tax revenue in Eastern Ohio which, when combined with impacts in the rest of the state, will be $33.7 million. Once operating, GPS will generate an estimated $1.1 million in annual tax revenue in the state of Ohio, $915,700 of which will occur in Eastern Ohio.

# Appendix F: Complaint Resolution Program

# Complaint Resolution Procedure

## Guernsey Power Station

**February 2017**

**Guernsey Power Station LLC**
c/o Caithness Corporation
565 Fifth Avenue, 29th Floor
New York, NY 10017

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# 1.0 INTRODUCTION

This procedure provides a framework for management of complaints received during the construction, startup, commissioning, and operation of the Guernsey Power Station (the Facility). In all cases, Facility representatives will work to resolve or mitigate any issues with those who submit a complaint. This includes working closely with the Engineering, Procurement and Construction (EPC) contractor during the construction, start-up and commissioning period.

Facility representatives prefer to take a proactive approach and strive to maintain on-going, open communications with the Guernsey County Commissioners, Valley Township Trustees and the local community. Many different forms of communication can be used to establish dialog with the local community and the regulating agencies. Following are different communication methods that may be employed:

- Participate in the Chamber of Commerce;
- Update Guernsey County Commissioners and Valley Township Trustees of upcoming construction activities;
- Hold an open house for the community to share project information;
- Maintain a Facility website which covers project benefits, employment opportunities, and points of contact; and
- Issue press releases updating the community about the Facility.

## 2.0 COMPLAINT PROCESS

Facility representatives will document, investigate, evaluate, and attempt to resolve all Facility-related complaints. Complaints by community residents or others may be made through the following channels:

- By calling the local or 800 telephone numbers which Facility representatives will set up and share with the community;
- By submitting a written complaint on the Facility website or to its local address; or
- By making the complaint in person at the Facility's construction or operations building.

The Facility will work with the complainant to investigate the issue in a timely manner. The investigation may include obtaining the following information directly from the complainant:

- Nature/details of the complaint;
- When the issue began;
- Is the issue intermittent or on-going;
- Has the complainant contacted the Facility before about the issue and if so, when, and what actions were taken to address the complaint; and
- Has the complainant contacted anyone else about this issue, and if so, who was contacted and what was the date and time of the contact.

## 3.0 RESOLUTION PROCESS

Facility personnel will make reasonable efforts to resolve the issue to the satisfaction of both parties in a timely manner. Internal investigation and identification of corrective action(s) may include:

- Performing a root cause analysis;
- Identifying who will be involved in developing and implementing the solution;
- Specifying how much time will a solution take (time frame);
- Assembling what is needed to implement a solution; and
- When appropriate, review procedures and make modifications to prevent reoccurrence.

Facility representatives will discuss with the complainant the corrective actions taken/planned to resolve or mitigate the issue. Follow-up with the complainant or other groups (Valley Township Trustees, Guernsey County Commissioners, others) will be conducted as needed.

A log will be kept locally of the name and contact details of the complainant and the actions taken to resolve the complaint.

# Appendix G: Traffic Management Plan

# TRAFFIC MANAGEMENT PLAN

## Guernsey Power Station

## Guernsey County, Ohio

**February 2017**

*Prepared for:*

**Guernsey Power Station, LLC**

*Prepared by:*

**Tetra Tech, Inc.**

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TETRA TECH

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# ACRONYMS/ABBREVIATIONS

| Acronyms/Abbreviations | Definition |
|---|---|
| GPS | Guernsey Power Station, LLC |
| the Facility | Guernsey Power Station |
| the Facility Site | a property that is the proposed location of the Guernsey Power Station, located entirely within Valley Township, Guernsey County, Ohio |
| Laydown and Parking Area | a property that is the proposed location of construction laydown and parking for the Guernsey Power Station, located just north of the Facility Site within Jackson Township, Guernsey County, Ohio |
| I-77 | Interstate 77 |
| I-70 | Interstate 70 |
| OPSB | Ohio Power Siting Board |
| EPC | Engineering, Procurement, and Construction |
| RUMA | Road Use and Maintenance Agreement |

# 1.0 PROJECT BACKGROUND

Guernsey Power Station, LLC (GPS) is developing the Guernsey Power Station (the Facility) in Guernsey County, Ohio. The Facility is a state-of-the-art combined cycle natural gas-fired electric generating facility designed in three 1x1x1 single shaft power train configurations with a net generating capacity of 1,650 megawatts. The proposed Facility, which includes combustion turbine generators, heat recovery steam generators, steam turbine generators, transformers, a Facility switchyard, and other ancillary equipment, will be located within a property that is located entirely within Valley Township, Guernsey County, Ohio (the Facility Site) (Figure 1).

The Facility Site is adjacent to Interstate 77 (I-77) to the east, and approximately 4.5 miles south of Interstate 70 (I-70). Wills Creek, a tributary of the Muskingum River, forms the southern boundary of the Facility Site. The Facility Site is bordered to the west by a privately-owned parcel and a privately-owned railroad spur. The Facility Site is bordered to the north by Seneca Lane, although the area to the north of Seneca Lane will be used for construction laydown and parking.

An Engineering, Procurement, and Construction (EPC) contractor will be retained by GPS for building the Facility. Construction on the Facility is anticipated to begin in early 2018.

Beginning with the initial site work and continuing throughout construction of the Facility, traffic will increase in the area and will occasionally include oversized loads. This Traffic Management Plan was prepared to meet the requirements of the Ohio Power Siting Board (OPSB), and to be used for information for Valley Township, Jackson Township and for Guernsey County. Revisions to the Traffic Management Plan may result following selection of the EPC contractor and prior to construction, but similar assessments will be completed to verify appropriate routing for equipment deliveries and other construction-related traffic.

# 2.0 TRAFFIC EXPECTATIONS

## 2.1 CONSTRUCTION TRAFFIC

Most of the traffic entering and exiting the Facility Site during construction will be typical vehicular traffic associated with construction activities, including personal vehicles, commercial vehicles, and semi-trailers providing material and supplies. The initial construction traffic will include equipment and materials for site preparation of the Facility Site and Laydown and Parking Area. Once the Facility Site is graded, equipment related to pouring foundations and construction of the buildings and power generation and associated facilities will be brought to the Facility Site. Once foundations have commenced, delivery of heavy loads would include equipment related to the generation facility, such as turbines/generators, stack sections or other oversized/overweight equipment.

The construction period is anticipated to occur over 33 months, beginning in early 2018. It is anticipated that the peak construction work force will include approximately 500 construction workers. Construction parking will be located to the north of the Facility Site in the designated Laydown and Parking Area (Figure 1).

## 2.2 OPERATIONAL TRAFFIC

During operations, beginning in late 2020, vehicle traffic will consist primarily of employee vehicles and occasional deliveries by truck. The Facility will operate during three shifts over a 24-hour day with a peak of approximately 25 full-time employees during the normal work day.

# 3.0 PERMITS AND SITE ACCESS

Due to the proximity of two major interstates (I-77 and I-70), the majority of construction traffic – particularly oversized and heavy loads – will utilize these roadways, minimizing traffic on local roadways. The Facility Site location with respect to state roads is shown in Figure 2. After exiting the interstates, access to the Facility will be via state and local roads.

## 3.1 LOCAL COORDINATION

Coordination efforts will occur with the Guernsey County Engineer's office and Township Trustees prior to initiation of construction. This will include a review of anticipated delivery routing, a discussion of any measures necessary to improve delivery routes, and a commitment for restoration of inadvertently damaged transportation infrastructure.

## 3.2 SPECIAL HAULING PERMITS

Heavy haul or wide loads on state and interstate highways will require a state permit and coordination with the County Engineer for potential county or local permits. Per Ohio Revised Code, Sections 5577.04 and 5577.05, vehicles may not exceed 80,000 pounds gross weight or height in excess of 13 feet, 6 inches. Vehicles in excess of these weight and dimensional restrictions will require an Ohio Special Hauling Permit. As shown on Figure 3, the primary route will utilize interstate highway I-77. Special Hauling Permits require surety bonding. Special Hauling Permits for the roads in the Township/County may be covered under a Road Use and Maintenance Agreement (RUMA) described in Section 5.0. Applicable Ohio Special Hauling Permits (and Guernsey County, if applicable) will be obtained prior to the need for such deliveries.

## 3.3 CONSTRUCTION ACCESS

Construction access for non-local workers and deliveries to the Facility Site and Laydown and Parking Area will predominantly be off I-77. Vehicles approaching from the north and south are expected to exit I-77 at Exit 37 to State Road (OH-) 313 (Clay Pike Road). Vehicles will travel west on OH-313 (Clay Pike Road), turn northward onto OH-821 (Marietta Road), and turn eastward onto local roadway Seneca Lane to the proposed construction entrance off Puritan Street for Facility Site access. Vehicles accessing the Laydown and Parking Area will turn left off Seneca Lane directly onto the Laydown and Parking Area. The construction entrance will be installed off Puritan Street at the northern end of the Facility Site, and will be converted into a permanent entrance once construction activities are completed.

Alternative access routes from I-70 and alternative exits along I-77 were considered and are available; however, the proposed route maximizes use of interstate highways and minimizes use of local roadways.

## 3.4 EMPLOYEE PARKING

### 3.4.1 Construction Employee Parking

Construction employee parking will be provided for workers at the Laydown and Parking Area, just north of the Facility Site. The parking area will provide sufficient parking for each phase of construction, as needed. Access to the Laydown and Parking Area will be via Seneca Lane.

### 3.4.2 Operational Employee Parking

Operational employee parking will be provided for workers at the Facility Site. The parking area will provide parking for a sufficient number of employee and visitor spaces. Access to the Facility Site will be via the Facility entrance off Puritan Street.

## 3.5 PROPOSED ROAD ROUTES

Due to the proximity of the Facility Site to a major interstate highway (I-77), one road route was identified for both southbound and northbound traffic. This route minimizes vehicle traffic on local roadways.

I-77 Southbound: Vehicles will exit I-77 at Exit 37 for OH-313 toward Pleasant City/Senecaville, and turn right onto OH-313 West (Clay Pike Road) for 1.35 miles, turn right onto OH-821 North (Marietta Road) for 1.1 miles, and turn right (east) onto Seneca Lane. Vehicles will travel approximately 0.75 miles on Seneca Lane, and turn right onto Puritan Street or left onto the Laydown and Parking Area. The Facility Site entrance will be on Puritan Street, approximately 200 feet south of Seneca Lane.

Traffic returning to I-77 southbound will reverse the same route: exit Puritan Street, turn left on to Seneca Lane (or turn right on Seneca Lane if leaving the Laydown and Parking Area), turn left onto OH-821 South (Marietta Road), turn left on to OH-313 East (Clay Pike Road), and turn right to merge onto I-77 South.

I-77 Northbound: Vehicles will exit I-77 at Exit 37 for OH-313 toward Pleasant City/Senecaville, and turn left onto OH-313 West (Clay Pike Road) for 1.35 miles, turn right onto OH-821 North (Marietta Road) for 1.1 miles, and turn right (east) onto Seneca Lane. Vehicles will travel approximately 0.75 miles on Seneca Lane, and turn right onto Puritan Street. The Facility Site entrance will be on Puritan Street, approximately 200 feet south of Seneca Lane.

Traffic returning to I-77 northbound will reverse the same route: exit Puritan Street, turn left on to Seneca Lane (or turn right on Seneca Lane if leaving the Laydown and Parking Area), turn left onto OH-821 South (Marietta Road), turn left onto OH-313 East (Clay Pike Road), and turn left to merge onto I-77 North.

As previously noted in Section 3.3, Construction Access, the proposed route maximizes the use of interstate highways, and minimizes use to local roads. Alternative routes originating from I-70 or alternatives exits along I-77 will be considered as necessary (e.g., in the event of road or exit closure).

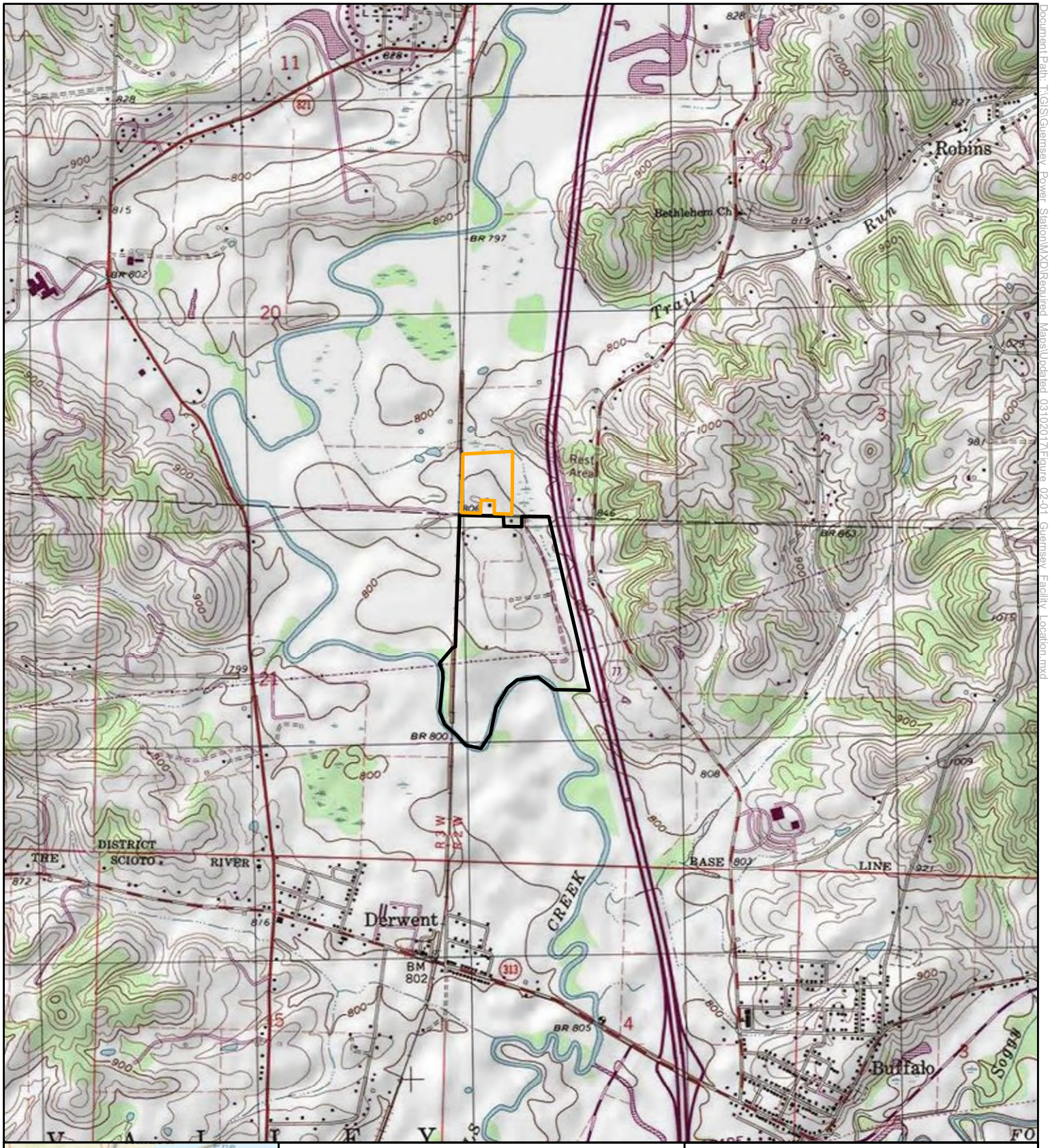
Figure 3 presents the proposed road route.

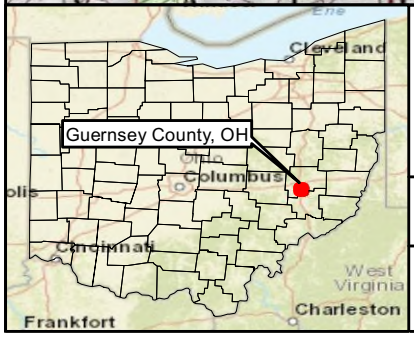
# 4.0 RAIL ACCESS

Activities associated with the above-ground construction of the Facility has the potential to utilize rail transportation for larger equipment, as considered appropriate by the selected EPC contractor. A private railroad spur, formerly owned by the Cleveland and Marietta Railroad/Pennsylvania Railroad, extends west of the Facility Site between Byesville and Derwent. Should the use of rail delivery be determined to be feasible, it would eliminate heavy load deliveries on several local roads but would involve negotiation with the private owner of the rail line and consideration of appropriate unloading facilities. Should this be contemplated, additional information would be provided prior to any modifications required for implementation of rail use.

# 5.0 ROAD USE AND MAINTENANCE AGREEMENT

It is expected that a Memorandum of Understanding will be developed and executed between GPS and Guernsey County/Township officials for use of the County and Township roads. A copy of the executed agreement will be provided to the OPSB and to all contractors and subcontractors that will be working at the Facility.




**Legend**

Facility Site

Proposed Laydown/Parking

0 500 1,000 2,000 Feet

USGS 7.5 Minute Topogrpahic Quad: Byesville, OH (1975)
Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
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Figure 1
Guernsey Power Station

Facility Location

Guernsey County, Ohio

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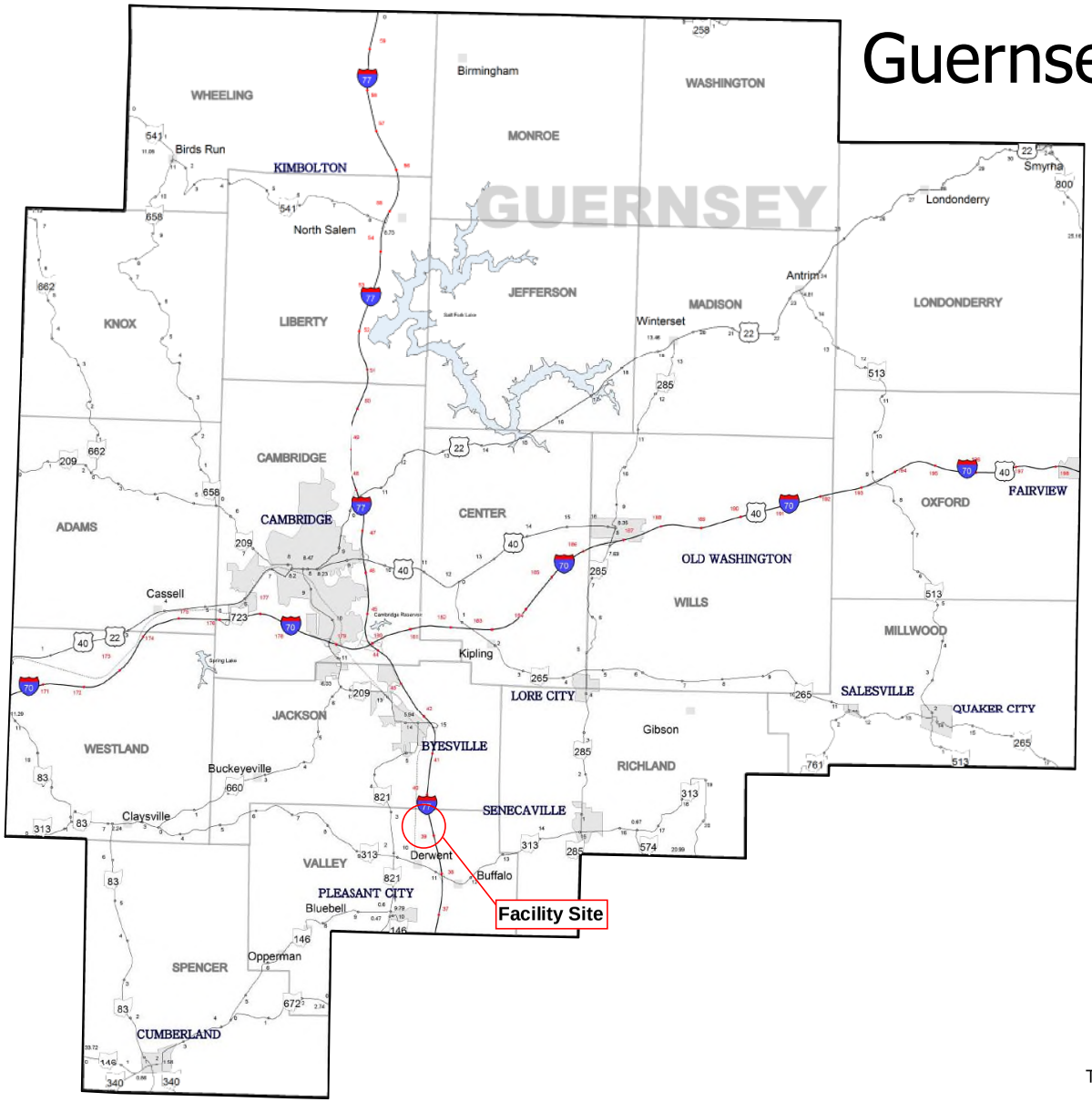
# Guernsey County




Prepared by:
The Ohio Department of Transportation
District 5 GIS/Mapping Section
February, 2012

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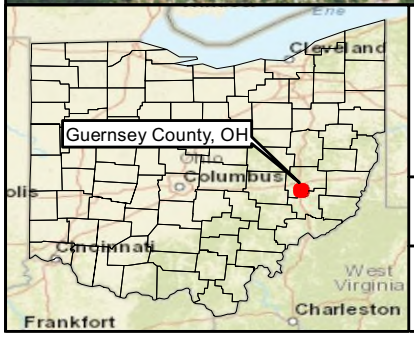
Figure modified from Ohio Department of Transportation District 5 Map

Figure 2
Guernsey Power Station

Location of Facility Site and Major Roadways

Guernsey County, Ohio




**Legend**

- Facility Site
- Proposed Laydown/Parking
- Proposed Access Route

0 500 1,000 2,000 Feet

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Figure 3
Guernsey Power Station

Proposed Access Route

Guernsey County, Ohio

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# Appendix H: Sound Survey and Analysis Report

# Sound Survey and Analysis Report

## Guernsey Power Station
## Guernsey County, Ohio

**March 2017**

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TETRA TECH

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Appendix A: Equipment Calibration Certificate

# ACRONYMS/ABBREVIATIONS

| Acronyms/Abbreviations | Definition |
|---|---|
| $^{o}F$ | degrees Fahrenheit |
| µPa | microPascal |
| dB | decibel |
| dBA | A-weighted decibel |
| dBL | linear decibel |
| Facility | Guernsey Power Station |
| Facility Site | a 118-acre property, located off Seneca Lane in Valley Township, Guernsey County, Ohio, on which the Guernsey Power Station is proposed |
| CTG | combustion turbine generator |
| GPS | Guernsey Power Station |
| HRSG | heat recovery steam generator |
| Hz | Hertz |
| I-77 | Interstate 77 |
| ISO | International Organization for Standardization |
| kHz | kiloHertz |
| $L_{eq}$ | equivalent sound level |
| $L_w$ | sound power level |
| $L_P$ | sound pressure level |
| $L_{i(c)}$ | interior sound pressure level |
| m | meters |
| mi | miles |
| ML | monitoring location |
| OPSB | Ohio Power Siting Board |
| OSHA | Occupational Safety and Health Administration |
| pW | picowatt |
| STC | Sound Transmission Class |
| STG | steam turbine generator |
| Tetra Tech | Tetra Tech, Inc. |
| USEPA | United States Environmental Protection Agency |
| UTM | Universal Transverse Mercator |

# 1.0 INTRODUCTION

Tetra Tech, Inc. (Tetra Tech) has prepared this noise impact assessment for the proposed Guernsey Power Station (GPS or the Facility) to support an application to the Ohio Power Siting Board (OPSB). The Facility is proposed on approximately 118 acres located off Seneca Lane and Puritan Street in Valley Township, in Guernsey County Ohio (the Facility Site). The Facility will have a nominal net capacity of 1,650 megawatts (MW), utilizing three General Electric (GE) 7HA.02 combustion turbine generators (CTGs). As a combined cycle power plant, the exhaust heat of each CTG is used in its heat recovery steam generators (HRSG) to produce steam to generate additional energy in a steam turbine generator (STG). An air-cooled condenser (ACC) will be located south of each of the three steam turbine buildings (which each house a CTG and an STG).

The balance of this section of the report provides background information, including a discussion of the Facility setting, descriptions of the noise metrics used throughout the report, and applicable noise standards and regulations. Section 2 provides the results of the ambient sound measurement program. Predicted noise levels associated with Facility construction are provided in Section 3, with predicted noise levels from full-load operation of Facility equipment discussed in Section 4. Mitigation measures are identified that demonstrate the Facility is capable of meeting the reflected sound levels; however, final design may incorporate different mitigation measures in order to achieve the same objectives. References are provided in Section 5.

## 1.1 FACILITY SETTING

The approximately 118-acre Facility Site is located south of Seneca Lane and west of Interstate 77 (I-77) in Valley Township, Guernsey County, Ohio. The majority of the Facility Site is used, or was formerly used, for agricultural purposes. Several structures, including three residences, are located within the Facility Site and will be demolished.

The Facility Site is bounded by an active, privately-owned railway to the west, I-77 to the east, Wills Creek to the south, and Seneca Lane to the north. Existing noise sources in the area include: traffic along I-77; railway operations; traffic associated with local roadways; and industrial and other activities in the surroundings. Proximate industrial uses include the Shelly Company (a sand and gravel operation located approximately 0.3 miles from the Facility that utilizes the adjacent railroad line and includes an unloading station, conveyors, and truck loading operations); and Basic Systems Inc. and BSI Group/Bi-Con Services (pipe and pressure vessel fabrication businesses located approximately 0.5 miles south of the Facility).

Two residences and several garages are located on Puritan Street, located within the Facility Site boundaries and will be demolished as part of construction. One residence and associated trailer along Seneca Lane within the northwestern corner of the Facility Site will also be demolished.

The closest residence outside of the Facility Site is located within approximately 100 feet from the Facility Site boundary at the corner of Seneca Lane and Puritan Street. The next nearest occupied residence outside of the Facility Site is located approximately 100 feet north of the Facility Site boundary across Seneca Lane. Both are expected to remain in residential use throughout Facility construction and operation.

Three additional residences on Seneca Lane west of the railroad tracks, are located between 130 and 240 feet from the nearest Facility Site property boundary. Other structures are located further west along Seneca Lane. More distant scattered residences are located along Marietta Road approximately 0.6 miles from the Facility Site's western property boundary.

To the south, open land and industrial uses (Shelly Company, Basic Systems, Inc. and BSI Group/Bi-Con Services, as discussed above) separate other residential areas from the Facility Site. Residential areas within one mile to the south include two neighborhoods along Clay Pike Road (south and southwest of the Facility Site) that are of relatively higher density. The two neighborhoods are separated from each other by industrial uses. The nearest residence to the Facility Site within these two neighborhoods is on Walnut Street, approximately 0.5 miles southwest

of the Facility Site property boundary. A third residential neighborhood is located southeast of the Facility Site, east of I-77, with only a small portion of the neighborhood within one mile of the Facility Site.

To the east, several residences are located on the eastern side of I-77, along Vocational Road, approximately 0.10 mile from the Facility Site's eastern property boundary, with additional residences located along Buffalo Mine Road.

Other potentially noise-sensitive locations are further from the Facility Site. The Guernsey-Noble Vocational School is located across I-77 approximately 0.6 miles southeast of the Facility site. The property boundary of the Meadowbrook Middle School and High School is located just over one mile northwest of the Facility Site. No additional schools, hospitals, places of worship, or cemeteries were identified within one mile of the Facility Site. The nearest place of worship and cemetery is Bethlehem Church and the abutting Bethel Methodist Protestant Cemetery, which are just over one mile northwest of the Facility Site. The nearest hospital is Southeastern Ohio Regional Medical Center, approximately 7.2 miles north-northwest of the Facility Site in the City of Cambridge.

Figure 1 provides an overview of the Facility Site as well as the immediately surrounding area.

## 1.2 ACOUSTIC METRICS AND TERMINOLOGY

All sounds originate with a source, whether it is a human voice, motor vehicles on a roadway, or a combustion turbine. Energy is required to produce sound and this sound energy is transmitted through the air in the form of sound waves – tiny, quick oscillations of pressure just above and just below atmospheric pressure. These oscillations, or sound pressures, impinge on the ear, creating the sound we hear. A sound source is defined by a sound power level (abbreviated "$L_W$"), which is independent of any external factors. By definition, sound power is the rate at which acoustical energy is radiated outward and is expressed in units of watts.

A source sound power level cannot be measured directly. It is calculated from measurements of sound intensity or sound pressure at a given distance from the source outside the acoustic and geometric near-field. A sound pressure level (abbreviated "$L_P$") is a measure of the sound wave fluctuation at a given receiver location, and can be obtained through the use of a microphone or calculated from information about the source sound power level and the surrounding environment. The sound pressure level in decibels (dB) is the logarithm of the ratio of the sound pressure of the source to the reference sound pressure of 20 microPascals (µPa), multiplied by 20.[1] The range of sound pressures that can be detected by a person with normal hearing is very wide, ranging from about 20 µPa for very faint sounds at the threshold of hearing, to nearly 10 million µPa for extremely loud sounds such as a jet during take-off at a distance of 300 feet.

Broadband sound includes sound energy summed across the entire audible frequency spectrum. In addition to broadband sound pressure levels, analysis of the various frequency components of the sound spectrum can be completed to determine tonal characteristics. The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves. Typically the frequency analysis examines 11 octave bands ranging from 16 Hz (low) to 16,000 Hz (high). Since the human ear does not perceive every frequency with equal loudness, spectrally-varying sounds are often adjusted with a weighting filter. The A-weighted filter is applied to compensate for the frequency response of the human auditory system, and is represented in dBA.

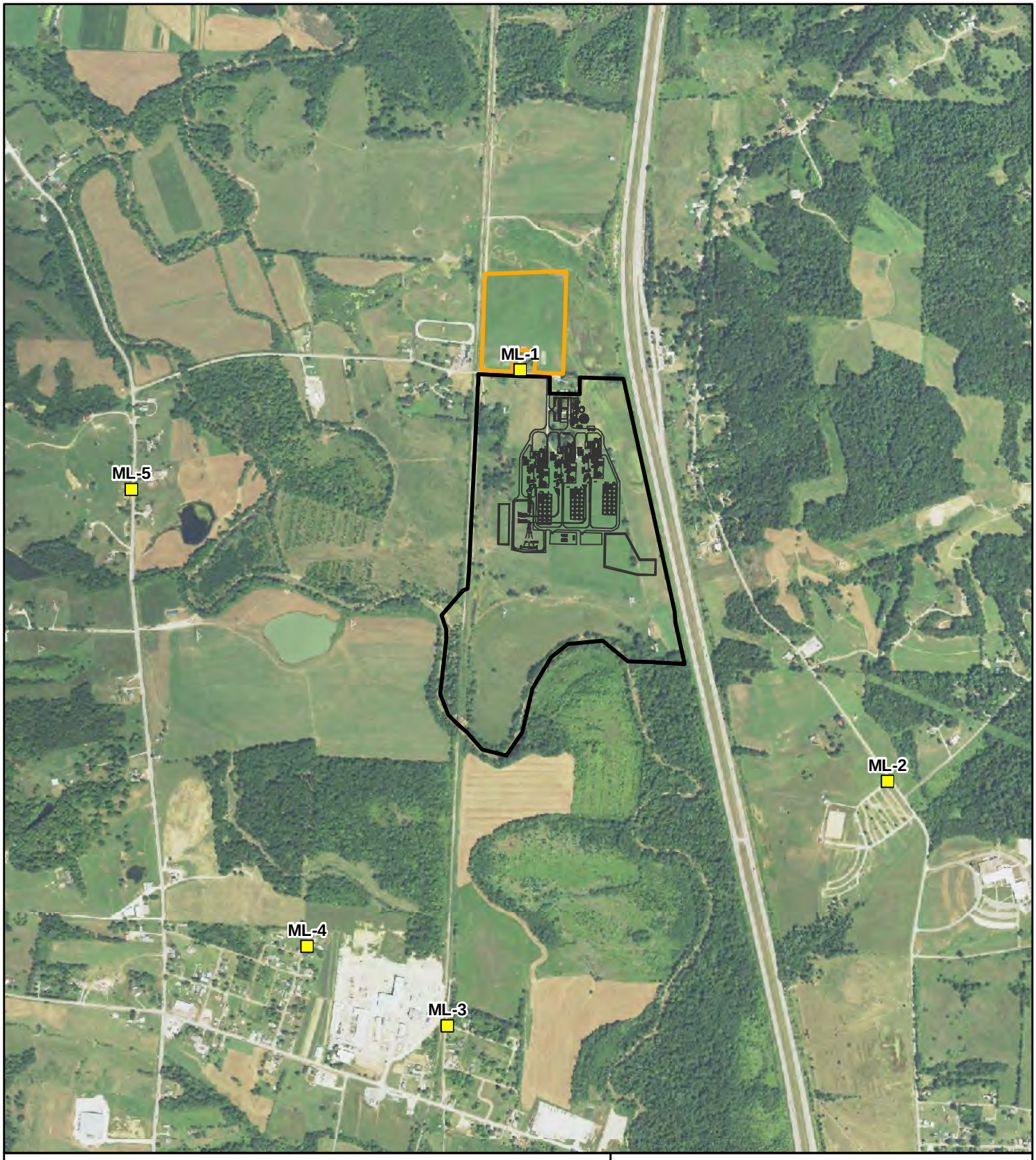
[1] The sound pressure level ($L_p$) in dB corresponding to a sound pressure (p) is given by the following equation:

$$Lp = 20 \log10 ( p / pref);$$

Where:

p = the sound pressure in µPa; and

pref = the reference sound pressure of 20 µPa.




Legend

Short-term Baseline Sound Monitoring Locations

Facility Site

Proposed Laydown/Parking

N

0 0.1 0.2 Miles

**Figure 1**
**Baseline Sound Monitoring Locations**

Guernsey Power Station
Guernsey County, Ohio

Guernsey Power Station

R:\PROJECTS\GUERNSEY_5732\NOISE\MAPS\Figure_1_Monitoring_Locations.mxd

Sound can be measured, modeled, and presented in various formats, with the most common metric being the equivalent sound level ($L_{eq}$). The equivalent sound level has been shown to provide both an effective and uniform method for comparing time-varying sound levels and is widely used in acoustic assessments in the State of Ohio. Estimates of noise sources and outdoor acoustic environments, and the comparison of relative loudness are presented in Table 1. Table 2 presents additional reference information on terminology used in the report.

**Table 1. Sound Pressure Levels ($L_P$) and Relative Loudness of Typical Noise Sources and Acoustic Environments**

| Noise Source or Activity | Sound Level (dBA) | Subjective Impression |
|---|---|---|
| Vacuum cleaner (10 feet) | 70 | Moderate |
| Passenger car at 65 miles per hour (25 feet) | 65 | |
| Large store air-conditioning unit (20 feet) | 60 | |
| Light auto traffic (100 feet) | 50 | Quiet |
| Quiet rural residential area with no activity | 45 | |
| Bedroom or quiet living room; Bird calls | 40 | Faint |
| Typical wilderness area | 35 | |
| Quiet library, soft whisper (15 feet) | 30 | Very quiet |
| Wilderness with no wind or animal activity | 25 | Extremely quiet |
| High-quality recording studio | 20 | |
| Acoustic test chamber | 10 | Just audible |
| | 0 | Threshold of hearing |

Adapted from: Kurze and Beranek (1988) and United States Environmental Protection Agency (USEPA) (1971)

**Table 2. Acoustic Terms and Definitions**

| Term | Definition |
|---|---|
| Noise | Typically defined as unwanted sound. This word adds the subjective response of humans to the physical phenomenon of sound. It is commonly used when negative effects on people are known to occur. |
| Sound Pressure Level ($L_P$) | Pressure fluctuations in a medium. Sound pressure is measured in dB referenced to 20 microPascals, the approximate threshold of human perception to sound at 1,000 Hz. |
| Sound Power Level ($L_W$) | The total acoustic power of a noise source measured in dB referenced to picowatts (one trillionth of a watt). Noise specifications are provided by equipment manufacturers as sound power as it is independent of the environment in which it is located. A sound level meter does not directly measure sound power. |
| Equivalent Sound Level ($L_{eq}$) | The $L_{eq}$ is the continuous equivalent sound level, defined as the single sound pressure level that, if constant over the stated measurement period, would contain the same sound energy as the actual monitored sound that is fluctuating in level over the measurement period. |

| | |
|---|---|
| A-Weighted Decibel (dBA) | Environmental sound is typically composed of acoustic energy across all frequencies. To compensate for the auditory frequency response of the human ear, an A-weighting filter is commonly used for describing environmental sound levels. Sound levels that are A-weighted are presented as dBA in this report. |
| Unweighted Decibels (dBL) | Unweighted sound levels are referred to as linear. Linear decibels are used to determine a sound's tonality and to engineer solutions to reduce or control noise as techniques are different for low and high frequency noise. Sound levels that are linear are presented as dBL in this report. |
| Propagation and Attenuation | Propagation is the decrease in amplitude of an acoustic signal due to geometric spreading losses with increased distance from the source. Additional sound attenuation factors include air absorption, terrain effects, sound interaction with the ground, diffraction of sound around objects and topographical features, foliage, and meteorological conditions including wind velocity, temperature, humidity, and atmospheric conditions. |
| Octave Bands | The audible range of humans spans from 20 to 20,000 Hz and is typically divided into center frequencies ranging from 31 to 8,000 Hz. |
| Broadband Noise | Noise which covers a wide range of frequencies within the audible spectrum, i.e., 200 to 2,000 Hz. |
| Frequency (Hz) | The rate of oscillation of a sound, measured in units of Hz or kilohertz (kHz). One hundred Hz is a rate of one hundred times (or cycles) per second. The frequency of a sound is the property perceived as pitch: a low-frequency sound (such as a bass note) oscillates at a relatively slow rate, and a high-frequency sound (such as a treble note) oscillates at a relatively high rate. For comparative purposes, the lowest note on a full range piano is approximately 32 Hz and middle C is 261 Hz. |

## 1.3 NOISE LEVEL REQUIREMENTS AND GUIDELINES

No specific federal, state or local numerical sound level limits are applicable to the Facility. However, OPSB §4906-4-08(A)(3)(a) through (e) define requirements for the assessment of noise that must be addressed during the permitting process for electric power generating facilities. This includes preconstruction background noise measurements taken under both day and nighttime conditions (provided in Section 2); construction noise levels (provided in Section 3); operational noise levels (provided in Section 4); the location of noise-sensitive areas within one mile (provided in Section 1.1); and a description of equipment and procedures to mitigate the effects of noise emissions during both construction and operation (provided in Sections 3 and 4, respectively). The OPSB does not define quantifiable sound limits either absolute or relative to existing conditions, but utilizes information regarding a facility's setting and sound generation to evaluate the acceptability of projected sound levels.

# 2.0 EXISTING SOUND ENVIRONMENT

Tetra Tech conducted a series of ambient sound level measurements to characterize the existing acoustic environment in the vicinity of the Facility during both daytime and nighttime periods. This section summarizes the methodology used by Tetra Tech to conduct the sound survey and describes the measurement locations.

## 2.1 FIELD METHODOLOGY

To document the existing conditions, baseline sound level measurements were performed on December 13 and 14, 2016. Weather conditions were conducive for the collection of accurate sound data. The measurement locations were selected to be representative of the surroundings of potential receptors nearest to the proposed Facility Site in the principal geographical directions. The ambient sound survey consisted of short-term measurements with an acoustics expert present that were completed for a minimum duration of 30 minutes at locations representative of the closest potentially noise sensitive areas in each geographical direction relative to the Facility Site. The short-term measurements were made during both daytime (10:00 a.m. to 4:00 p.m.) and nighttime (11:00 p.m. to 3:00 a.m.) periods.

All of the measurements were conducted using a Larson Davis Model 831 precision integrating sound-level meter that meets the requirements of American National Standards Institute (ANSI) Standards for Type 1 precision instrumentation. This sound analyzer has an operating range of 5 dB to 140 dB, and an overall frequency range of 8 to 20,000 Hz. During the measurement program, microphones were fitted with a windscreen, set upon a tripod at a height of approximately 1.5 meters (5 feet) above the ground and located out of the influence of any vertical reflecting surfaces. The sound analyzer was calibrated at the beginning and end of the measurement period using a Larson Davis Model CAL200 acoustic calibrator following procedures that are traceable to the National Institute of Standards and Technology (NIST). Table 3 lists the measurement equipment employed during the survey. The sound level meters were programmed to sample and store A-weighted and octave band sound level data, including $L_{eq}$ and the percentile sound levels.

**Table 3. Measurement Equipment**

| Description | Manufacturer | Type |
|---|---|---|
| Signal Analyzer | Larson Davis | 831 |
| Preamplifier | Larson Davis | PRM902 |
| Microphone | PCB | 377B02 |
| Windscreen | ACO Pacific | 7-inch |
| Calibrator | Larson Davis | CAL200 |

During the survey there was some snowfall. Usage levels of surrounding roadways may or may not have been affected by the snow. Temperatures ranged from 19 to 32 degrees Fahrenheit (°F) during the day, and 26 to 31°F during the nighttime. Wind speeds were variable, averaging from calm to 6 miles per hour (mph) during the daytime, and 7 to 10 mph during the nighttime. Atmospheric conditions during the survey period were acceptable for the collection of accurate sound measurements.

## 2.2 FIELD METHODOLOGY

Five short-term, attended sound measurements were performed at public locations near residential properties proximate to the Facility Site. The monitoring locations (ML-1 through ML-5) were selected to represent ambient conditions at land uses in the vicinity of the Facility Site.

The short-term monitoring locations are described in Table 4 and mapped on Figure 1. Additional descriptions of the monitoring locations and field observations are provided below.

**Table 4. Sound Level Monitoring Locations**

| Monitoring Location | Coordinates (Universal Transvese Mercastor Zone 19N) | | Distance and Direction from Facility Site Boundary |
|---|---|---|---|
| | Easting (m) | Northing (m) | |
| ML-1 | 454118 | 4421278 | 0.02 mile N |
| ML-2 | 455166 | 4420105 | 0.42 mile ESE |
| ML-3 | 453909 | 4419407 | 0.49 mile S |
| ML-4 | 453510 | 4419635 | 0.50 mile SSW |
| ML-5 | 453008 | 4420937 | 0.60 mile W |

### 2.2.1 Location ML-1

This monitoring location is located immediately north of the Facility Site on Seneca Lane in an unincorporated portion of Guernsey County. Landowner access was granted to deploy the monitor adjacent to 11111 Seneca Lane. This location was selected to represent the residences located along Seneca Lane. Seneca Lane is a two-lane paved road bordered mostly by open fields with some scattered trees and dead-ends just past the proposed Facility entrance at Puritan Street.

During the daytime measurements, the dominant sound source was from distance traffic along I-77 although there was a dog barking for a short period of time. There was little to no traffic along Seneca Lane, nor any other noticeable sound sources. Nighttime measurements were fairly consistent with the daytime measurements; however, traffic along I-77 appeared to be decreased.

### 2.2.2 Location ML-2

This monitoring location is located across I-77 approximately 0.4 miles southeast of the southeastern Facility Site property line, along Vocational Road in the Village of Senecaville. This location was next to an open field with line-of-sight to I-77.

During the daytime measurement period, noise generated by traffic on I-77 was dominant; however, there was also traffic occurring on Vocational Road. During the nighttime measurement period, which occurred approximately between 1:45 am to 2:15 am, traffic was still frequent and audible from I-77. There was little to no traffic along Vocational Road during the nighttime measurement period.

### 2.2.3 Location ML-3

This monitoring location is located approximately 0.5 mile south of the southern Facility Site property line. This location was representative of one of the closest more densely developed neighborhoods south of the Facility Site in the community of Derwent. There is a small privately-owned active railway located to the west of the neighborhood. The railway is used for loading and unloading activities associated with the Shelly Company sand and gravel operations. The Bi-Con facility is also located to the west of the neighborhood.

During the daytime measurement period, there was background sound reflected activity at Bi-Con including backhoe movement, as well as barking dogs. There was minimal traffic along Nixon and 3rd Streets. There was no railway traffic at the time of the measurement. During the nighttime measurements, sound could be heard from traffic on I-77, although other industrial and residential activities had quieted; some minimal sound was created by interaction of wind with a nearby electric transmission line.

### 2.2.4 Location ML-4

This monitoring location is located approximately 0.5 miles southwest of the southwestern Facility Site property line along Walnut Street in the community of Derwent. This location was representative of the residential and industrial development in its general vicinity, which consists of a number of houses and the Bi-Con facility to the east.

During the daytime measurement period, there were a number of contributing sound sources including activity at the Bi-Con facility. In addition, birds and a rooster could be heard, as well as music in the distance. Minimal traffic occurred along Walnut Street. During the nighttime measurement period, some operations were still audible at Bi-Con. Sound was also generated by traffic on I-77 and on nearby roads, including motorcycle traffic, and by wind chimes.

### 2.2.5 Location ML-5

This monitoring location is located near several residences along Marietta Road, north of Derwent. The location is approximately 0.6 miles west of the western Facility Site boundary. Clusters of trees and open space lie between this monitoring location and the Facility Site.

During the daytime measurements, traffic along Marietta Road was frequent and the primary source of noise. Noise from traffic on I-77 could also be heard in the distance. During the nighttime period there was still some traffic along Marietta Road; however, the volume decreased substantially from daytime conditions.

## 2.3 MEASUREMENT RESULTS

Table 5 provides a summary of the measured ambient sound levels observed at each of the monitoring locations for both the daytime and nighttime $L_{eq}$. Results of the ambient sound survey show that sound levels surrounding the proposed Facility Site vary during daytime and nighttime conditions.

During the day, higher ambient sound levels reflected industrial and highway traffic, in addition to other land use activites. Daytime $L_{eq}$ sound levels at the measurement locations ranged from a low of 46 dBA at ML-3 to a high of 63 dBA at ML-5. The lower levels of daytime sound are consistent with what would be expected within a relatively quiet rural residential area. The higher sound levels reflect traffic from I-77, which is a characteristic background condition, as well as sound from Bi-Con and other local roads and activity.

Nighttime sound levels were considerably quieter, ranging from a low of 32 dBA at ML-5 to 46 dBA at ML-2. Traffic decreased during nighttime, reducing its effect as a dominant sound source and ultimately reducing the average nighttime $L_{eq}$ sound level, which may differ during non-winter weather conditions.

**Table 5. Sound Measurement Results – $L_{eq}$ Sound Levels**

| Monitoring Location | Time Period | Leq (dBA) |
|---|---|---|
| ML-1 | Day | 48 |
| | Night | 37 |
| ML-2 | Day | 57 |
| | Night | 46 |
| ML-3 | Day | 46 |
| | Night | 35 |
| ML-4 | Day | 49 |
| | Night | 36 |
| ML-5 | Day | 63 |
| | Night | 32 |

# 3.0 FACILITY CONSTRUCTION

Construction of the Facility is expected to be typical of other power generating facilities in terms of schedule, equipment, and activities. Construction is anticipated to require approximately 33 months. Nighttime construction will be limited; however, activities may occur 6 days per week, 10 hours per day. Certain activities, such as foundation pours, cannot be stopped until the task is completed, which may continue into the nighttime period. As required, a night shift may be implemented to maintain schedule or complete a continuous task. The last 3 to 4 months of construction would include commissioning and start-up activities, which may occur up to 24 hours a day, 7 days a week.

## 3.1 NOISE CALCULATION METHODOLOGY

Acoustic emission levels for activities associated with Facility construction were based upon typical ranges of energy equivalent noise levels at construction sites, as documented by the USEPA (USEPA 1971) and the USEPA's "Construction Noise Control Technology Initiatives" (USEPA 1980). The USEPA methodology distinguishes between type of construction and construction phase.

Using those energy equivalent noise levels as input to a basic propagation model, construction noise levels were calculated at the nearest Facility Site boundary and the five MLs.

The basic model assumed spherical wave divergence from a point source located at the acoustic center of the Facility Site. Furthermore, the model conservatively assumed that all pieces of construction equipment associated with an activity would operate simultaneously for the duration of that activity. An additional level of conservatism was built into the construction noise model by excluding potential shielding effects due to intervening structures and buildings along the propagation path from the site to receiver locations.

## 3.2 PROJECTED NOISE LEVELS DURING CONSTRUCTION

Table 6 summarizes the projected noise levels due to Facility construction, organized into the following five broad work activities:

1. Site clearing and grading;
2. Placement of major structural concrete foundations;
3. Erection of building structural steel;
4. Installation of mechanical and electrical equipment; and
5. Commissioning and testing of equipment.

Based on sound propagation calculations, construction sound levels are predicted to range from 43 to 65 dBA at the MLs. Periodically, sound levels may be higher or lower than those presented in Table 6; however, the overall sound levels should generally be lower due to excess attenuation and the trend toward quieter construction equipment in the intervening decades since these data were developed. As shown in Table 6, the highest projected sound level from construction-related activity is expected to occur at ML-1, during activities associated with excavation and Facility commissioning.

**Table 6. Projected Construction Noise Levels by Phase (dBA)**

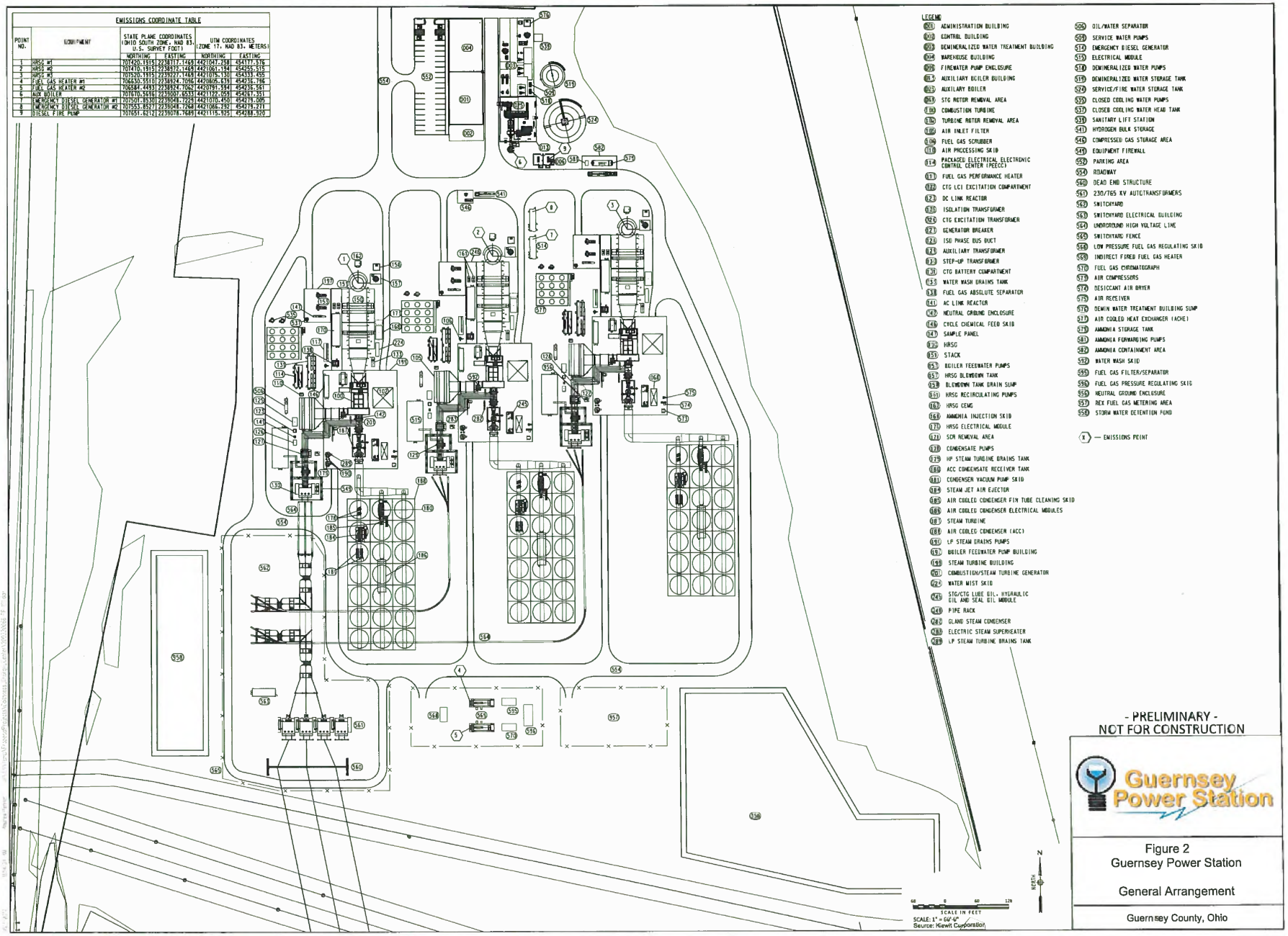
| Construction Phase | USEPA Construction Noise Level 50 feet | Facility Property Line | ML-1 | ML-2 | ML-3 | ML-4 | ML-5 |
|---|---|---|---|---|---|---|---|
| Phase 1: Site clearing and grading | 86 | 66 | 61 | 47 | 44 | 45 | 47 |
| Phase 2: Excavation and placement of major structural concrete foundations | 89 | 69 | 64 | 50 | 48 | 49 | 51 |
| Phase 3: Erection of building structural steel | 85 | 65 | 60 | 46 | 44 | 44 | 46 |
| Phase 4: Installation of mechanical and electrical equipment | 83 | 63 | 59 | 45 | 43 | 43 | 45 |
| Phase 5: Equipment installation, commissioning and testing | 89 | 69 | 65 | 51 | 49 | 49 | 51 |

Reasonable efforts will be made to minimize the impact of noise resulting from construction activities at proximate noise sensitive areas through the use of noise mitigation. Because of the temporary nature of the construction noise, no adverse or long-term effects are expected.

## 3.3 CONSTRUCTION NOISE MITIGATION

Since construction machines operate intermittently, and the types of machines in use at the Facility Site change with the phase of construction, noise emitted during construction will be mobile and highly variable, making it challenging to control. The construction management protocols will include the following noise mitigation measures to minimize noise impacts:

- Maintain all construction tools and equipment in good operating order according to manufacturers' specifications;
- Limit use of major excavating and earth moving machinery to daytime hours;
- To the extent practicable, schedule construction activity during normal working hours on weekdays when higher sound levels are typically present, and are found acceptable. Some limited activities, such as concrete pours, will be required to occur continuously until completion;
- Equip any internal combustion engine used for any purpose on the job or related to the job with a properly operating muffler that is free from rust, holes, and leaks;
- For construction devices that utilize internal combustion engines, ensure the engine's housing doors are kept closed, and install noise-insulating material mounted on the engine housing consistent with manufacturers' guidelines, if possible;
- Utilize the Complaint Resolution Procedure to address any noise complaints received from residents; and
- Communicate with neighbors prior to conducting specific loud noise activities such as steam blows.




EMISSIONS COORDINATE TABLE

| POINT NO. | EQUIPMENT | STATE PLANE COORDINATES (OHIO SOUTH ZONE, NAD 83, U.S. SURVEY FOOT) NORTHING | EASTING | UTM COORDINATES (ZONE 17, NAD 83, METERS) NORTHING | EASTING |
|---|---|---|---|---|---|
| 1 | HRSG #1 | 707420.1915 | 2238717.7469 | 4421047.258 | 454177.576 |
| 2 | HRSG #2 | 707410.1915 | 2238872.7469 | 4421061.194 | 454255.515 |
| 3 | HRSG #3 | 707520.1915 | 2239227.7469 | 4421095.130 | 454433.495 |
| 4 | FUEL GAS HEATER #1 | 706630.5510 | 2238924.7096 | 4420805.619 | 454236.786 |
| 5 | FUEL GAS HEATER #2 | 706584.4493 | 2238924.7062 | 4420791.564 | 454236.561 |
| 6 | AUX BOILER | 707610.5696 | 2239007.6533 | 4421122.059 | 454267.351 |
| 7 | EMERGENCY DIESEL GENERATOR #1 | 707501.8530 | 2239048.7225 | 4421010.450 | 454279.005 |
| 8 | EMERGENCY DIESEL GENERATOR #2 | 707553.8527 | 2239048.7268 | 4421086.287 | 454279.211 |
| 9 | DIESEL FIRE PUMP | 707651.6212 | 2239078.7685 | 4421115.925 | 454288.920 |

**Table 7. Modeled Octave Band Sound Power Level ($L_P$) for Major Pieces of Facility Equipment**

| Sound Source | Sound Power Level ($L_P$) by Octave Band Frequency dBL | | | | | | | | | Broadband Level |
|---|---|---|---|---|---|---|---|---|---|---|
| | 31.5 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | dBA |
| Air Cooled Condenser[1] | --- | 110 | 107 | 103 | 98 | 98 | 94 | 90 | 83 | 103 |
| Steam Jet Air Injector | | 96 | 93 | 89 | 84 | 83 | 79 | 76 | 68 | 88 |
| Turbine Compartment[2] | 107 | 104 | 101 | 96 | 97 | 98 | 101 | 106 | 94 | 109 |
| Lube Oil Module[2] | 101 | 102 | 99 | 98 | 97 | 96 | 96 | 97 | 88 | 103 |
| Inlet Plenum[2] | 102 | 99 | 98 | 93 | 94 | 97 | 97 | 94 | 89 | 102 |
| Load Compartment[2] | 87 | 93 | 93 | 87 | 87 | 93 | 94 | 88 | 79 | 98 |
| Generator[2] | 109 | 114 | 107 | 98 | 98 | 94 | 91 | 90 | 80 | 101 |
| Steam Turbine[2] | --- | 108 | 112 | 111 | 109 | 107 | 107 | 103 | 97 | 113 |
| Ammonia Injection Skid | 96 | 103 | 99 | 96 | 97 | 97 | 95 | 92 | 87 | 102 |
| HRSG Recirculating Pump | 90 | 90 | 87 | 85 | 86 | 90 | 81 | 78 | 69 | 92 |
| HRSG Transition Duct | 115 | 119 | 118 | 108 | 94 | 92 | 58 | 68 | 51 | 105 |
| Turbine Diffuser | 106 | 113 | 97 | 93 | 87 | 84 | 86 | 88 | 75 | 94 |
| HRSG Body | 115 | 119 | 118 | 108 | 94 | 92 | 58 | 68 | 51 | 105 |
| Inlet Filter Face (acoustically Lined Hood) | 121 | 115 | 105 | 89 | 72 | 75 | 81 | 89 | 90 | 96 |
| Boiler Feed Pump[2] | --- | 99 | 95 | 97 | 100 | 103 | 102 | 98 | 95 | 109 |
| Closed Cooling Water Pump | 86 | 86 | 83 | 81 | 82 | 86 | 77 | 74 | 65 | 88 |
| Fuel Gas Performance Heater | 90 | 96 | 98 | 90 | 80 | 82 | 86 | 87 | 84 | 93 |
| Air Processing Skid | 103 | 102 | 102 | 93 | 84 | 79 | 83 | 69 | 59 | 91 |
| Inlet Ducting | 117 | 112 | 102 | 92 | 77 | 70 | 82 | 78 | 69 | 91 |

**Table 7. Modeled Octave Band Sound Power Level ($L_P$) for Major Pieces of Facility Equipment**

| Sound Source | Sound Power Level ($L_P$) by Octave Band Frequency dBL | | | | | | | | | Broadband Level |
|---|---|---|---|---|---|---|---|---|---|---|
| | 31.5 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | dBA |
| CTG Excitation Transformer | 79 | 79 | 83 | 80 | 86 | 78 | 68 | 63 | 57 | 84 |
| Step-Up Transformer | 92 | 98 | 100 | 95 | 95 | 89 | 84 | 79 | 72 | 95 |
| Condensate Pump | --- | 83 | 84 | 85 | 86 | 83 | 79 | 75 | 71 | 88 |
| Turbine Compartment Vent | 102 | 102 | 110 | 101 | 98 | 95 | 94 | 98 | 95 | 104 |
| HRSG Stack with Silencer | 101 | 108 | 107 | 98 | 83 | 80 | 65 | 56 | 49 | 94 |
| Air Cooled Heat Exchanger[3] | --- | 103 | 102 | 99 | 94 | 92 | 86 | 80 | 74 | 97 |
| Fuel Gas Heater and Stack | 87 | 83 | 88 | 87 | 85 | 88 | 88 | 86 | 81 | 94 |
| Fuel Gas Separator | 86 | 82 | 87 | 86 | 84 | 87 | 87 | 85 | 80 | 93 |
| Fuel Gas Metering and Regulating | 86 | 82 | 87 | 86 | 84 | 87 | 87 | 85 | 80 | 93 |
| Autotransformer | 92 | 92 | 96 | 93 | 99 | 91 | 81 | 76 | 70 | 97 |
| Ammonia Forwarding Pump | 82 | 89 | 85 | 82 | 83 | 83 | 81 | 78 | 73 | 88 |
| Air Compressor and Dryer[2] | 103 | 102 | 102 | 93 | 84 | 79 | 83 | 69 | 59 | 91 |
| Service Water Pumps[2] | 84 | 85 | 86 | 87 | 84 | 80 | 76 | 72 | 88 | 89 |
| Demineralized Water Pumps[2] | 76 | 70 | 70 | 73 | 80 | 83 | 84 | 80 | 72 | 89 |

[1]Equalivalent to a sound pressure level of 50.5 dBA at 400 feet.

[2]Equipment located within a Building

[3]Equalivalent to a sound pressure level of 44 dBA at 400 feet

**Table 8. Noise Level Reductions for Different Types of Construction and Acoustical Treatments**

| Type of Construction or Acoustical Treatment | Modeled Noise Level Reductions by Octave Band Center Frequency (dBL) | | | | | | | | | STC Rating |
|---|---|---|---|---|---|---|---|---|---|---|
| | 31.5 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | |
| Roof and Wall Construction | 13 | 19 | 19 | 27 | 30 | 26 | 26 | 37 | 38 | 27 |

## 4.3 NOISE CONTROL MEASURES

The Facility will incorporate design features to minimize potential noise impacts on the surrounding community. Sound resulting from normal operation of the Facility will be minimized through the design measures inherent in the equipment specifications noted above, with the following additional mitigation measures included in this analysis:

- **Unit 3 Step-up Transformer**: The Unit 3 step-up transformer will incorporate noise mitigation that will reduce the overall sound power level to 90 dBA.
- **Autotransformers:** All autotransformers will incorporate noise mitigation that will reduce the overall sound power level to 95 dBA.
- **Unit 3 Condensate Pumps**: The Unit 3 condensate pumps will incorporate noise mitigation that will reduce the overall sound power level to 85 dBA.
- **Unit 3 Ammonia Injection Skid**: The Unit 3 ammonia injection skid will incorporate noise mitigation that will reduce the overall sound power level to 80 dBA.
- **Unit 3 Turbine Compartment Vents**: The Unit 3 turbine compartment vents will incorporate noise mitigation that will reduce the overall sound power level to 96 dBA.
- **Unit 2 Turbine Compartment Vents**: The Unit 2 turbine compartment vents will incorporate noise mitigation that will reduce the overall sound power level to 100 dBA.

In addition, all equipment will include sound attenuation to meet the Occupational Safety and Health Administration (OSHA) nearfield sound levels whenever feasible. Hearing protection will be mandatory in any areas where this is not practical. The treatments with the acoustic performance as outlined above relate to the dominant noise sources. The specific mitigation measures were incorporated into inputs reflected in Tables 7 and 8; however, final design may incorporate different mitigation measures in order to achieve the same objective as demonstrated in this assessment.

## 4.4 NOISE PREDICTION MODEL RESULTS

Broadband (dBA) sound pressure levels were calculated (as shown in Table 9) for expected normal Facility operation assuming that all components identified previously are operating continuously and concurrently at the representative manufacturer-rated sound levels as well as incorporating noise reduction measures identified in Section 4.3. The sound energy was then summed to determine the equivalent continuous A-weighted downwind sound pressure level at a point of reception. Sound contour plots displaying broadband (dBA) sound levels presented as color-coded isopleths are provided in Figure 3. The noise contours are graphical representations of the cumulative noise associated with full operation of the equipment and show how operational noise would be distributed over the surrounding area within a 1-mile radius of the Facility Site. The contour lines shown are analogous to elevation contours on a topographic map, i.e., the noise contours are continuous lines of equal noise level around some source, or sources, of noise. Figure 3 also shows the ambient sound monitoring locations, representative of proximate noise sensitive land uses, which were used to assess potential noise impacts on a cumulative basis.

Table 9 shows the projected exterior sound levels resulting from full, normal operation of the Facility at the MLs under the mitigated design.

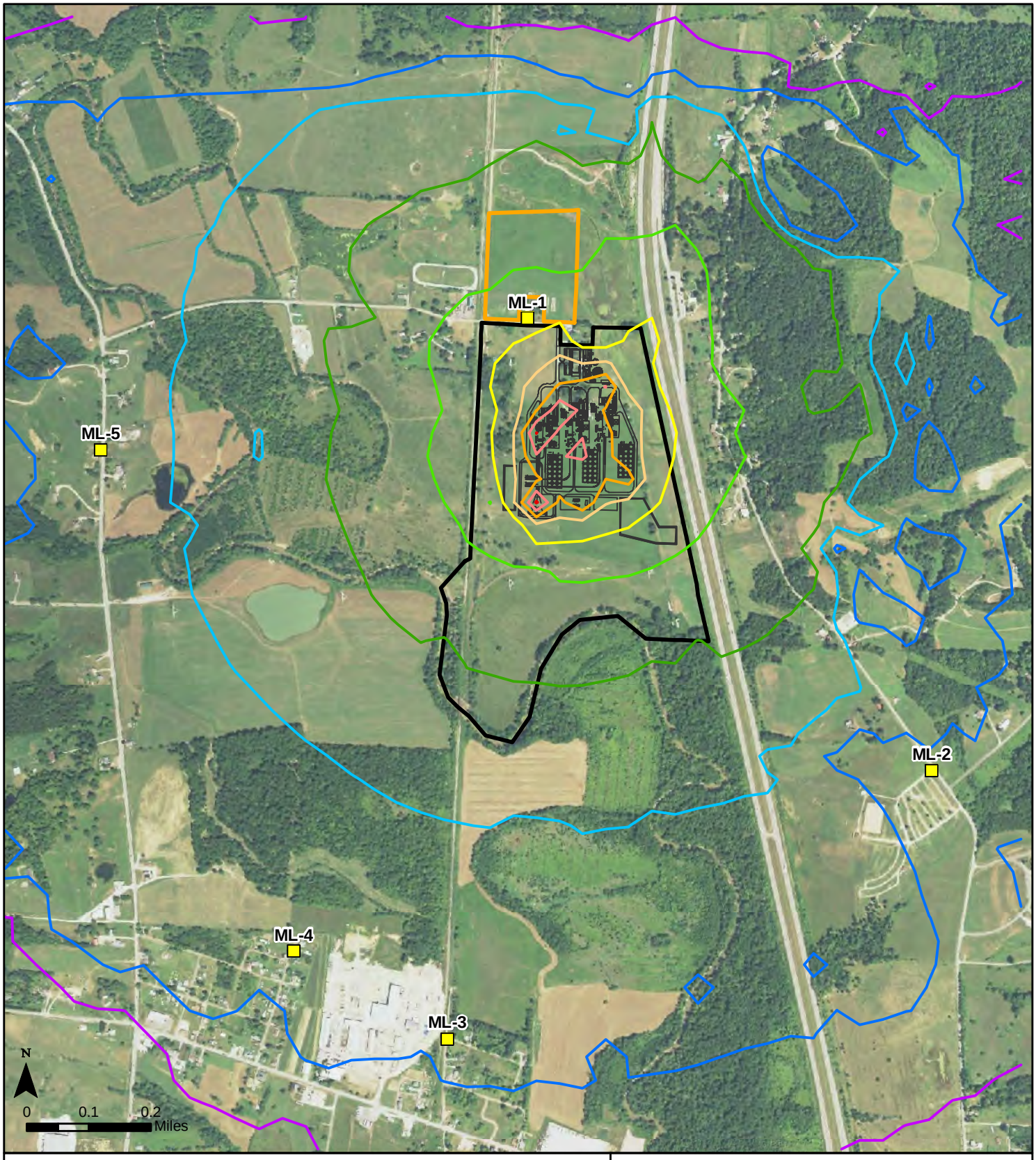
**Table 9. Acoustic Modeling Results Summary – Mitigated Design**

| Monitoring Location | Nighttime Ambient $L_{eq}$, dBA | Facility Sound Level, dBA | Total Sound Level (Ambient + Project), dBA |
|---|---|---|---|
| ML-1 | 37 | 54 | 54 |
| ML-2 | 46 | 34 | 46 |
| ML-3 | 35 | 36 | 38 |
| ML-4 | 36 | 37 | 39 |
| ML-5 | 32 | 38 | 39 |

As shown in Figure 3, the majority of surrounding residences will experience Facility sound levels less than 50 dBA, which is reflective of a quiet noise setting, as identified in Table 1. Approximately four residences west of I-77 (represented by ambient conditions at ML-1) and approximately five residences east of I-77 (represented by ambient conditions at ML-2) are located within the area that would experience Facility sound levels greater than 50 dBA, but less than 55 dBA.

Daytime ambient levels at both locations (48 dBA for ML-1 and 57 dBA for ML-2) are such that Facility sound levels are not anticipated to result in a significant change in existing conditions. In fact, ambient conditions for the homes east of I-77 have the potential to be even higher than the 57 dBA recorded, as ML-2 is located approximately 1,350 feet from I-77 while some of the homes are within 200 feet of the highway.

Overall, the Facility setting continues to be strongly influenced by I-77 traffic at night, although measured levels are somewhat quieter. During nighttime hours, when ambient levels are somewhat quieter, residents are likely to be indoors. Typical residential construction provides approximately 15 dB of additional noise reduction (Harris 1998). Noise levels from the Facility would, therefore, result in interior noise levels of approximately 33 dBA to 39 dBA at the nearest residences (generally represented by ML-1 and ML-2); beyond the immediate area and outside of the 55 dBA sound contour shown in Figure 3, potential effect would be even less. Therefore, nighttime sound levels are expected to be well within the range of typical interior noise levels in bedrooms where people are sleeping, which is 30 dBA to 40 dBA (Harris 1998).




Legend

Short-term Baseline Sound Monitoring Locations

Facility Site

Proposed Laydown/Parking

Sound Level Contours (dBA):

30
35
40
45
50
55
60
65
70
75

**Figure 3**
**Sound Level Contours**

Guernsey Power Station
Guernsey County, Ohio

R:\PROJECTS\GUERNSEY_5732\NOISE\MAPS\Figure_3_Noise_Contours.mxd

# 5.0 REFERENCES

Harris, C. M. 1998. Handbook of Acoustical Measurements and Noise Control, 3rd Edition. Acoustical Society of America.

ISO. 1996. Acoustics – Attenuation of Sound during Propagation Outdoors. Part 2: General Method of Calculation. ISO Standard 9613-2. Geneva, Switzerland.

Kurze, U. and L. Beranek. 1988. Noise and Vibration Control. Institute of Noise Control Engineering, Washington, DC.

USEPA. 1971. Technical Document NTID300.1, Noise from Construction Equipment and Operations, US Building Equipment, and Home Appliances. Prepared by Bolt Beranek and Newman for USEPA Office of Noise Abatement and Control, Washington, DC. December 1971.

# APPENDIX A: EQUIPMENT CALIBRATION CERTIFICATE

# Calibration Certificate

***Certificate Number 2015001438***

***Customer:***
**Hilton Garden Inn Covington/Mandeville**
**350 Holiday Square Boulevard**
**Covington, LA 70433, United States**

| | | | | |
|---|---|---|---|---|
| ***Model Number*** | 831 | ***Procedure Number*** | D0001.8384 | |
| ***Serial Number*** | 0003848 | ***Technician*** | Ron Harris | |
| ***Test Results*** | **Pass** | ***Calibration Date*** | 16 Feb 2015 | |
| ***Initial Condition*** | As Manufactured | ***Calibration Due*** | | |
| | | ***Temperature*** | 23.3 °C | ± 0.01 °C |
| ***Description*** | Larson Davis Model 831 | ***Humidity*** | 50.6 %RH | ± 0.5 %RH |
| | | ***Static Pressure*** | 86.43 kPa | ± 0.03 kPa |

***Evaluation Method***

***Tested with:***
PRM831, S/N 036755
377B02, S/N 150728

***Data reported in dB re 20 µPa.***

***Compliance Standards***

Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8378:

| | |
|---|---|
| IEC 60651:2001 Type 1 | ANSI S1.4-2014 Class 1 |
| IEC 60804:2000 Type 1 | ANSI S1.4 (R2006) Type 1 |
| IEC 61252:2002 | ANSI S1.11 (R2009) Class 1 |
| IEC 61260:2001 Class 1 | ANSI S1.25 (R2007) |
| IEC 61672:2013 Class 1 | ANSI S1.43 (R2007) Type 1 |

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the SI through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005. **Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.**

The quality system is registered to ISO 9001:2008.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

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**Standards Used**

| Description | Cal Date | Cal Due | Cal Standard |
|---|---|---|---|
| SRS DS360 Ultra Low Distortion Generator | 07/08/2014 | 07/08/2015 | 006311 |
| Hart Scientific 2626-S Humidity/Temperature Sensor | 05/16/2014 | 05/16/2015 | 006943 |
| Larson Davis CAL200 Acoustic Calibrator | 08/06/2014 | 08/06/2015 | 007027 |
| Larson Davis Model 831 | 03/05/2014 | 03/05/2015 | 007182 |
| 1/2 inch Microphone - P - 0V | 03/11/2014 | 03/11/2015 | 007185 |
| Larson Davis CAL291 Residual Intensity Calibrator | 09/26/2014 | 09/26/2015 | 007287 |

Larson Davis, a division of PCB Piezotronics, Inc
1681 West 820 North
Provo, UT 84601, United States
716-684-0001

ilac-MRA ACCREDITED Cert. #3622.01

LARSON DAVIS
A PCB PIEZOTRONICS DIV.

## Acoustic Calibration

Measured according to IEC 61672-3:2013 10 and ANSI S1.4-2014 Part 3: 10

| Measurement | Test Result [dB] | Lower Limit [dB] | Upper Limit [dB] | Expanded Uncertainty [dB] | Result |
|---|---|---|---|---|---|
| 1000 Hz | 114.00 | 113.80 | 114.20 | 0.14 | Pass |

## Acoustic Signal Tests, C-weighting

Measured according to IEC 61672-3:2013 12 and ANSI S1.4-2014 Part 3: 12 using a comparison coupler with Unit Under Test (UUT) and reference SLM using S-time-weighted sound level

| Frequency [Hz] | Test Result [dB] | Expected [dB] | Lower Limit [dB] | Upper Limit [dB] | Expanded Uncertainty [dB] | Result |
|---|---|---|---|---|---|---|
| 125 | -0.20 | -0.20 | -1.20 | 0.80 | 0.21 | Pass |
| 1000 | 0.14 | 0.00 | -0.70 | 0.70 | 0.21 | Pass |
| 8000 | -2.15 | -3.00 | -5.50 | -1.50 | 0.21 | Pass |

**-- End of measurement results--**

## Self-generated Noise

Measured according to IEC 61672-3:2013 11.1 and ANSI S1.4-2014 Part 3: 11.1

| Measurement | Test Result [dB] |
|---|---|
| Low Range, 20 dB gain | 64.05 |

**-- End of measurement results--**

**-- End of Report--**

Signatory: *Ron Harris*

# Appendix I: Preliminary Geotechnical Report

# PRELIMINARY GEOTECHNICAL DATA REPORT

## Guernsey Power Station
## Byesville, Ohio

Schnabel Reference 16C15039.00
December 6, 2016

**PRELIMINARY - TO BE SUPERCEDED**

Schnabel ENGINEERING

December 6, 2016

Mr. Jerold Bishop, PE
Kiewit Engineering and Design Co.
9401 Renner Boulevard
Lenexa, KS 66219

**PRELIMINARY**

**Subject:** **Preliminary Geotechnical Data Report, Guernsey Power Station, Byesville, Ohio (Schnabel Reference 16C15039.00)**

Dear Mr. Bishop:

**SCHNABEL ENGINEERING, LLC** (Schnabel) is pleased to submit our preliminary geotechnical data report for this project. This submission is the first of a series of submissions as outlined in our Scope of Services described below. This study was performed in accordance with our agreement dated October 24, 2016, authorized by Mr. John Burns.

## PROJECT DESCRIPTION

This project involves a proposed power station to be located in the southern portion of Guernsey County, Ohio, near the town of Byesville. Figure 1 – Site Vicinity Map shows the project location. We understand that Kiewit is providing preliminary engineering for the power plant developer so that a contract can be advertised to solicit Engineering, Procurement, and Construction (EPC) contractors.

### Proposed Construction

The Guernsey Power Station will consist of a gas-fired power plant, along with heat recovery steam generators. The configuration, which has not yet been finalized, is to include three separate (1x1) combined cycle shafts. The primary power island will have a footprint of roughly 1,200 ft x 1,000 ft. This will include combustion turbine-generators, heat recovery steam generators, steam turbine generators, transformers, water tanks, and other miscellaneous structures and equipment.

### Site Description

The project site is currently used for agricultural purposes, and there is a series of residential and agricultural structures in the northern portion of the site. It is known that the site is underlain by extensive underground workings from coal mining operations, which are no longer active. Wills Creek runs through and divides the site into northern and southern areas. For the purposes of this report, the northern and southern areas of the site will be referred to as the Primary Area and Secondary Area, respectively. The relative location of these two areas is described below.

The Primary Area will include the proposed primary power island. This area is bounded on the east by Interstate 77, to the south by overhead transmission lines, to the west by railroad tracks (currently used for tourist tours related to coal mining history in the region), and to the north by Seneca Lane.

The Secondary Area includes the proposed switchyard and other transmission line structures and facilities. This area is bounded on the north and east by Wills Creek, to the south by Clay Pike Road, and to the west by railroad tracks.

## SCHNABEL SCOPE OF SERVICES

Exhibit A in our above-referenced agreement, titled "Specifications for Geotechnical Investigations," defines the scope of services for this project. A brief summary of our scope of services is as follows:

- Conduct a preliminary geotechnical subsurface investigation program, including test borings, Cone Penetration Testing (CPT), and laboratory testing.
- Conduct an abandoned mine works study that includes a desk study and analysis, field reconnaissance, seismic reflection investigation, and a video inspection of the open mine through boreholes.
- Prepare a Preliminary Geotechnical Data Report (this submission).
- Prepare a Draft Final Geotechnical Engineering Recommendations Report.
- Prepare a Final Geotechnical Engineering Recommendations Report.
- Prepare an Abandoned Mine Works Report.

It should be noted that the current scope of our studies on this project is intended to be preliminary in nature, with an emphasis on the abandoned underground mine workings. Recommendations provided in the reports described above are preliminary and shall be supplemented by more detailed investigations as deemed necessary by the selected EPC contractor for their use in design of the proposed facilities.

## GEOTECHNICAL SUBSURFACE EXPLORATION PROGRAM

We performed a subsurface exploration and field testing program to identify the subsurface stratigraphy underlying the site and to evaluate the geotechnical properties of the materials encountered. This program included test borings and Cone Penetration Testing (CPT), which are described below. It should be noted that the geotechnical laboratory testing is currently in progress, and therefore the test boring logs are still in draft form. The appendices contain the draft results of our exploration.

### Subsurface Exploration Methods

#### *Test Borings*

Schnabel's subcontractor, Armstrong Drilling, Inc., drilled six test borings under our observation between November 8 and 28, 2016. The test borings in the Primary Area (B-1 to B-5) were drilled to a minimum of 150 ft below existing ground surface. Test Boring B-6, drilled in the Secondary Area, was drilled to a depth of 133 ft below existing ground surface. All six borings were extended to below the abandoned mine workings. Figure 2, provided by Kiewit and modified by Schnabel, indicates the approximate test boring locations. The Standard Penetration Test (SPT) and split-spoon sampling were performed at selected depths in the borings. Appendix A includes specific observations, remarks, and draft logs for


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the borings; classification criteria; drilling methods; and sampling protocols. The logs will be updated based on the results of geotechnical laboratory testing and submitted as final in a subsequent submission.

The SPT samples were obtained using a hydraulically driven automatic trip hammer (ATH). Most correlations with SPT data are based on N-values collected with a safety hammer. The energy applied to the split-spoon sampler using the ATH is about 33 percent greater than that applied using the safety hammer, resulting in lower N-values. The hammer blows shown on the boring logs are uncorrected for the higher energy; however, we correct SPT N-values for the higher energy when using N-values in our analyses.

### *Cone Penetration Testing (CPT)*

Schnabel's subcontractor, ConeTec, Inc., pushed 16 Cone Penetration Test (CPT) probes under our observation on November 2 and 3, 2016. Figure 2 indicates the approximate location of each CPT probe. The cones were pushed to the depths specified to us in the "Specifications for Geotechnical Investigation" or to cone refusal, whichever occurred first. Shear wave velocity tests were conducted at 5-ft intervals at CPT-2 and CPT-9. Pore Pressure Dissipation (PPD) tests were performed at various intervals at CPT-1, CPT-9, CPT-11, and CPT-B3. Appendix B includes the data report prepared by ConeTec for the CPT program. Note that the ConeTec data report indicates an assumed water surface of 9.5 ft below ground surface, which, after completion of the test boring program, was deemed to be a perched water surface with the base water table located below top of rock surface. The ConeTec report will be revised in a future submission.

## PRELIMINARY DESCRIPTION OF SUBSURFACE CONDITIONS ENCOUNTERED

Below is a preliminary description of subsurface conditions encountered in the test borings. Note that the subsurface conditions are described separately for the Primary and Secondary Areas, since the borings encountered significantly different conditions. Upon further examination of the boring logs, core box photos, and results of laboratory testing, updated and more comprehensive strata descriptions will be included in a subsequent submission.

### Primary Area – North Side of Creek (Test Borings B-1 to B-5)

The test borings in the Primary Area (B-1 to B-5) encountered three primary strata below the ground cover: residual soil, disintegrated rock, and bedrock. An abbreviated description of these strata follows:

#### *Ground Cover*

The borings encountered 2 to 8 inches of ground cover, which was described as rootmat and topsoil.

#### *Residual Soil*

Residual soils are derived through the in-place physical and chemical weathering of the underlying rock. The residual soil stratum was encountered from below the groundcover to a depth of 5 to 16 ft below ground surface. This layer was visually classified as brown silt and


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PRELIMINARY

yellowish-brown to grayish-brown lean clay, and, based on SPT N-values, generally exhibits stiff to very stiff consistency.

***Disintegrated Rock***

Below the residual layer, the borings encountered a 0- to 10-ft thick layer of disintegrated rock above intact bedrock. Disintegrated rock is defined as residual material with SPT N-values between 60 blows per foot and refusal. Refusal is defined as an N-value of 50 blows for a penetration of one inch or less.

***Bedrock***

Top of bedrock was encountered at depths ranging from 9 to 26 ft below ground surface. The borings encountered beds of sedimentary rock, including: sandstone, shale, siltstone, limestone, and coal. All borings were extended to below the abandoned coal mine elevation and into the mine floor rock.

***Groundwater***

At the completion of drilling, 3-inch ID solid PVC casing was installed up to 130 ft below ground surface in select borings for the purposes of lowering video camera equipment into the borehole. Long-term water readings taken from inside these PVC casings indicate the depth to water is 20 to 49 ft below the ground surface.

In the Primary Area, there was no evidence of base groundwater levels present above top of rock surface during drilling (i.e., wet cuttings or split spoon samples). In some instances, prior to introducing water for rock coring, water was detected above top of rock after returning to the borehole after an extended break in drilling operations (i.e., after returning on a Monday morning). This could represent a perched water surface above rock that is susceptible to seasonal fluctuations.

The groundwater levels on the logs indicate our estimate of the hydrostatic water table at the time of our subsurface exploration. The final design should anticipate the fluctuation of the hydrostatic water table depending on variations in precipitation, surface runoff, pumping, tidal action, evaporation, leaking utilities, stream levels, and similar factors.

**Secondary Area – South Side of Creek (Test Boring B-6)**

Test Boring B-6 encountered four primary strata below the ground cover: fill, alluvial/lacustrine, disintegrated rock, and bedrock. An abbreviated description of these strata follows:

***Ground Cover***

The borings encountered approximately 1 inch of ground cover, which was described as rootmat and topsoil.


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PRELIMINARY

***Fill***

The fill stratum was encountered from below the ground cover to a depth of 7 ft below the ground surface. This layer was visually classified as light brown lean clay, and, based on SPT N-values, generally exhibits soft to medium stiff consistency.

***Alluvial and Lacustrine Deposits***

The alluvial and lacustrine soil deposits were encountered from below the fill stratum to a depth of 68 ft below ground surface, which corresponds to a thickness of slightly over 60 ft. Most of this layer was visually classified as brown to gray, lean clay and sandy lean clay, and, based on SPT N-values, generally exhibits soft to stiff consistency. The bottom 4 ft of this layer was visually classified as gray silty sand, and, based on SPT N-values, exhibits a loose density.

***Disintegrated Rock***

Below the alluvial and lacustrine layers, and above intact bedrock, the borings encountered a 3-ft thick layer of disintegrated rock. Disintegrated rock is defined as residual material with SPT N-values between 60 blows per foot and refusal. Refusal is defined as an N-value of 50 blows for a penetration of one inch or less.

***Bedrock***

Top of bedrock was encountered at 70 ft below ground surface. Boring B-6 encountered beds of sedimentary rock, including: sandstone, shale, and coal. The boring was extended to below the abandoned coal mine elevation and into the mine floor rock.

***Groundwater***

Groundwater was encountered approximately 14 ft below ground surface in Boring B-6.

The groundwater levels on the logs indicate our estimate of the hydrostatic water table at the time of our subsurface exploration. The final design should anticipate the fluctuation of the hydrostatic water table depending on variations in precipitation, surface runoff, pumping, tidal action, evaporation, leaking utilities, stream levels, and similar factors.

## LIMITATIONS

This data report is provided for informational purposes only. Due to the preliminary nature of this report, we reserve the right to modify any and all soil, rock, and water level descriptions contained herein based on further examination of boring logs, rock core photographs, and laboratory testing results. Our subsequent submissions will address our preliminary geotechnical recommendations and will supersede this report in its entirety.

We have endeavored to complete the services identified herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions as this project. No other representation, express or implied, is included or


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intended, and no warranty or guarantee is included or intended in this report, or other instrument of service.

We appreciate the opportunity to be of service for this project. Please call us if you have any questions regarding this report.

Sincerely,

**SCHNABEL ENGINEERING, LLC**

Jeremy J. Brown, PE
Project Engineer

William K. Petersen, PE
Senior Associate

JJB:WKP:vm

Attachments:

Figures
Appendix A: Subsurface Exploration Data
Appendix B: Cone Penetration Test (CPT) Data


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# FIGURES

Figure 1: Site Vicinity Map
Figure 2: Boring and CPT Location Plan


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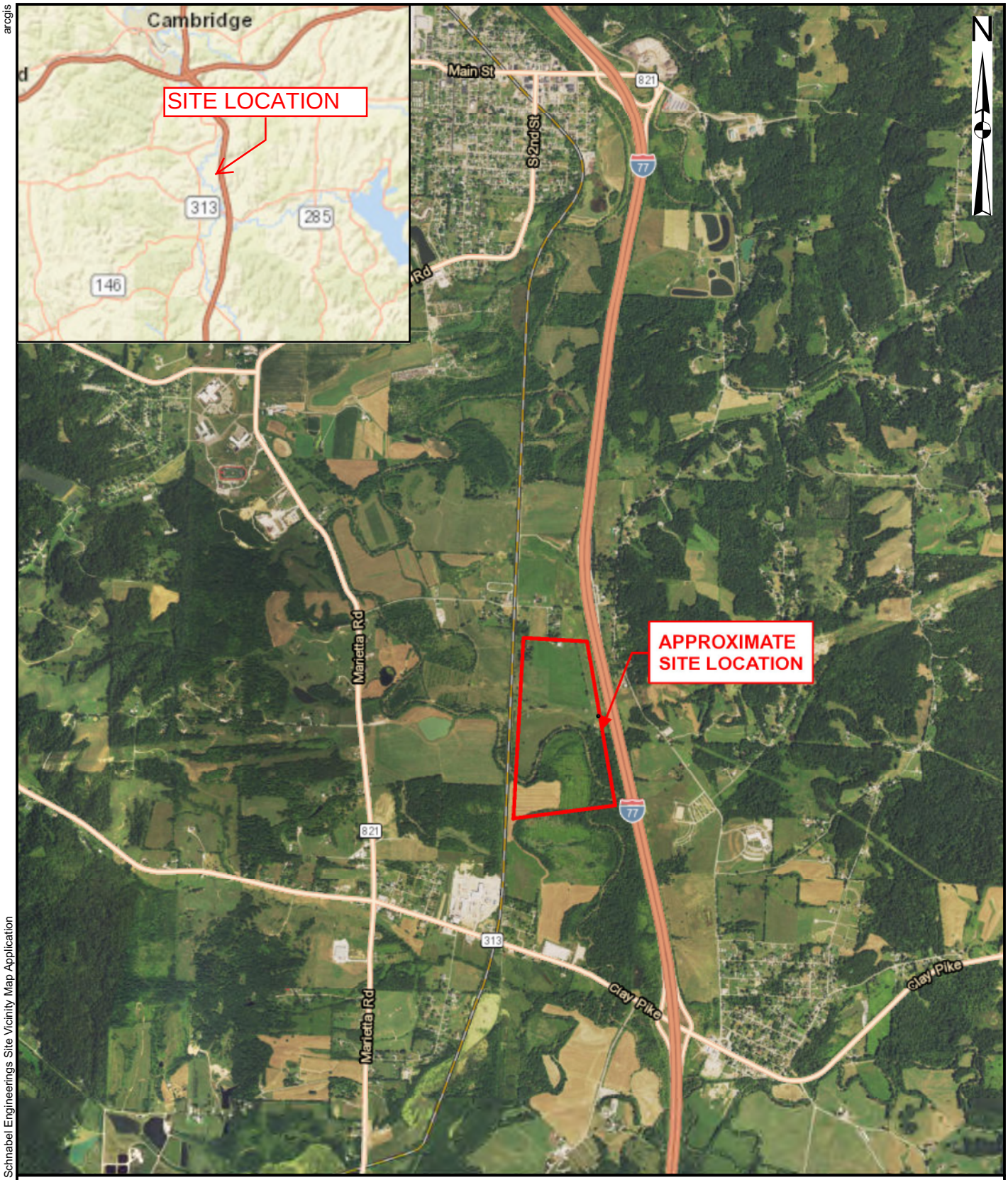


Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors

NOT TO SCALE

Schnabel ENGINEERING

GUERNSEY POWER STATION
BYESVILLE, OHIO

PROJECT NO. 16C15039.00

SITE VICINITY MAP

FIGURE 1

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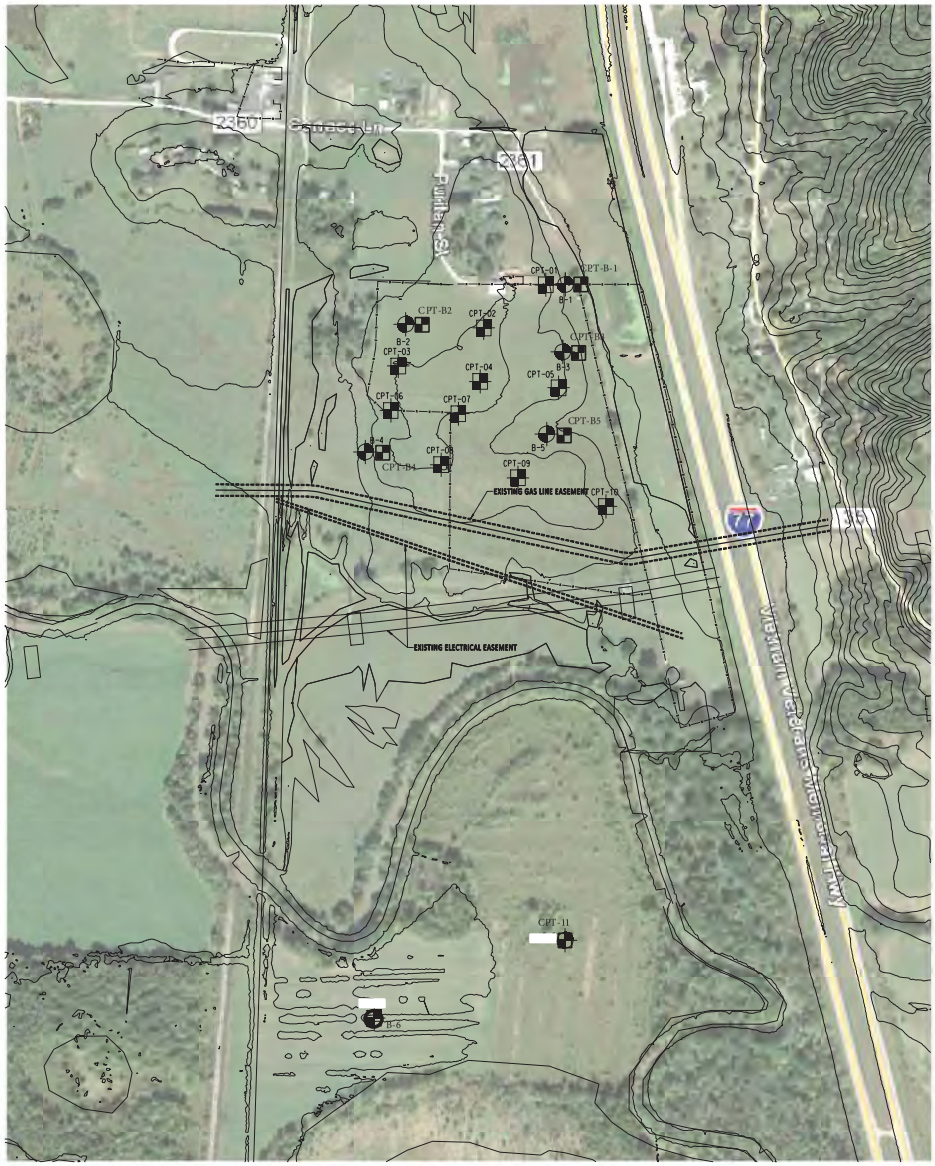
arcgis
12/5/2016 This Map was Created In Schnabel Engineerings Site Vicinity Map Application

#

# FIGURE 2




LEGEND

B-1 SOIL BORING

CPT-01 CONE PENETROMETER TEST (CPT)

WETLAND AREA

PLANT NORTH

200 0 200 400

SCALE IN FEET

SCALE: 1" = 200'-0"

**- PRELIMINARY -**
**NOT FOR CONSTRUCTION**

| REV | DESIGN BY | DRAWN BY | CHECKED BY | DATE |
|---|---|---|---|---|
| C | ISSUED FOR CONTRACT | | | |
| | A. PENNER | A. PENNER | S. GARRETT | 10-24-16 |
| B | ISSUED FOR INFORMATION | | | |
| | A. PENNER | A. PENNER | S. GARRETT | 09-22-16 |
| A | ISSUED FOR INFORMATION | | | |
| | A. PENNER | A. PENNER | S. GARRETT | 09-08-16 |

GUERNSEY POWER STATION, LLC

GUERNSEY POWER STATION

Kiewit

Kiewit Engineering & Design Co.
9401 Renner Boulevard
Lenexa, Kansas 66219

SOIL BORING
LOCATION PLAN

| ENGINEER/DESIGN | |
|---|---|
| ORIGINATOR | S. GARRETT |
| LEAD ENG | S. GARRETT |
| ENG MGR | S. GARRETT |
| PROJ MGR | S. GARRETT |

DRAWING NUMBER

20022066-SB-101

10/24/2016 1:27:03 PM Andrew.Penner J:\JES\Temp\ProposalProjects\Coltness_Energy_Center\20022066-SB-101.dgn

# APPENDIX A

# SUBSURFACE EXPLORATION DATA

Subsurface Exploration Procedures
General Notes for Subsurface Exploration Logs
Identification of Soil
Descriptive Criteria for Rock Core Logging
Supplemental Rock Descriptive Terms
Boring Logs, B-1 through B-6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# SUBSURFACE EXPLORATION PROCEDURES

**Test Borings – Hollow Stem Augers**

The borings are advanced by turning a continuous flight auger with a center opening of 2¼, 3¼, or 4¼ inches. A plug device blocks off the center opening while augers are advanced. Cuttings are brought to the surface by the auger flights. Sampling is performed through the center opening in the hollow stem auger, by standard methods, after removal of the plug. Usually, no water is introduced into the boring using this procedure.

**Standard Penetration Test Results**

The numbers in the Sampling Data column of the boring logs represent Standard Penetration Test (SPT) results. Each number represents the blows needed to drive a 2-inch O.D., 1⅜-inch I.D. split-spoon sampler 6 inches, using a 140-pound hammer falling 30 inches. The sampler is typically driven a total of 18 or 24 inches. The first 6 inches are considered a seating interval. The total of the number of blows for the second and third 6-inch intervals is the SPT "N value." The SPT is performed according to ASTM D1586.

The SPT samples were obtained using a hydraulically driven automatic trip hammer (ATH). Most correlations with SPT data are based on N-values collected with a safety hammer. The energy applied to the split-spoon sampler using the ATH is about 33 percent greater than that applied using the safety hammer, resulting in lower N-values. The hammer blows shown on the boring logs are uncorrected for the higher energy; however, we correct SPT N values for the higher energy when using N values in our analyses.

**Soil Classification Criteria**

The group symbols on the logs represent the Unified Soil Classification System Group Symbols (ASTM D2487) based on visual observation and limited laboratory testing of the samples. Criteria for visual identification of soil samples are included in this appendix. Some variation can be expected between samples visually classified and samples classified in the laboratory.

Residual soils are derived through the in-place physical and chemical weathering of the underlying rock. Disintegrated rock is defined as residual material with SPT N values between 60 blows per foot and refusal. Refusal is defined as an N value of 50 blows for a penetration of one inch or less.

**Pocket Penetrometer Results**

The values following "PP=" in the sampling data column of the logs represent pocket penetrometer readings. Pocket penetrometer readings provide an estimate of the unconfined compressive strength of fine-grained soils.


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**Rock Core Drilling**

The drillers core drilled rock using special core bits set with carbide steel or diamond, depending upon the rock texture. The bit was fitted onto a double-tube, swivel-type core barrel in which an exterior tube and bit rotate, and an interior barrel remains stationary to receive the rock core. Drillers circulated water between the barrels and across the bit face to provide cooling and to flush away cuttings. The size of bits is indicated on individual boring logs.

The length of rock core recovered expressed as a percentage of the total length cored is shown on the logs. Rock Quality Designation (RQD) is also given for rock cores drilled with NX-size core drilling equipment. RQD is defined as the total length of NX-size rock fragments recovered that are greater than 4 inches in length, discounting drilling breaks, expressed as a percentage of the total length cored. RQD is preferred to core recovery as a measure of engineering characteristics of rock.

**Volatile Organic Vapor Screening**

The headspaces of soil samples collected during our subsurface exploration were screened for the presence of volatile organic vapors with a Photoionization Detector (PID). The PID provides an indication of the concentration of organic vapors in the headspace in parts per million (ppm). The PID detects a variety of organic vapors, but does not detect the presence of methane. PID readings are presented in the sampling data column of the test boring logs.

**Boring and CPT Elevations**

Boring and CPT locations were staked by a Kiewit surveying subcontractor. Approximate boring and CPT locations are shown on Figure 2. Ground surface elevations at the boring locations were provided by the surveyor and are indicated on the boring logs. Locations and elevations should be considered no more accurate than the methods used to determine them.


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# GENERAL NOTES FOR SUBSURFACE EXPLORATION LOGS

1. Numbers in sampling data column next to Standard Penetration Test (SPT) symbols indicate blows required to drive a 2-inch O.D., 1⅜-inch I.D. sampling spoon 6 inches using a 140 pound hammer falling 30 inches. The Standard Penetration Test (SPT) N value is the number of blows required to drive the sampler 12 inches, after a 6 inch seating interval. The Standard Penetration Test is performed in general accordance with ASTM D1586.
2. Visual classification of soil is in accordance with terminology set forth in "Identification of Soil." The ASTM D2487 group symbols (e.g., CL) shown in the classification column are based on visual observations.
3. Estimated water levels indicated on the logs are only estimates from available data and may vary with precipitation, porosity of the soil, site topography, and other factors.
4. Refusal at the surface of rock, boulder, or other obstruction is defined as an SPT resistance of 50 blows for 1 inch or less of penetration.
5. The logs and related information depict subsurface conditions only at the specific locations and at the particular time when drilled or excavated. Soil conditions at other locations may differ from conditions occurring at these locations. Also, the passage of time may result in a change in the subsurface soil and water level conditions at the subsurface exploration location.
6. The stratification lines represent the approximate boundary between soil and rock types as obtained from the subsurface exploration. Some variation may also be expected vertically between samples taken. The soil profile, water level observations and penetration resistances presented on these logs have been made with reasonable care and accuracy and must be considered only an approximate representation of subsurface conditions to be encountered at the particular location.
7. Key to symbols and abbreviations:

| | |
|---|---|
| S-1, SPT | Sample No., Standard Penetration Test |
| 5+10+1 | Number of blows in each 6-inch increment |

| | |
|---|---|
| UD-1, UNDIST | Sample No., 2" or 3" Undisturbed Tube Sample |
| Rec=24", 100% | Recovery in inches, Percent Recovery |

| | |
|---|---|
| Run #1, CORE | Core No., Rock Core |
| Run = 5.0 ft | Run length in feet |
| REC = 60", 100% | Recovery in inches, Percent Recovery |
| RQD = 60", 100% | RQD in inches, Percent RQD |

| | |
|---|---|
| S-1, SAMPLE | Sample No., Hand Auger or Test Pit sample |

| | |
|---|---|
| LL | Liquid Limit |
| MC | Moisture Content (percent) |
| PID | Photoionization Detector Reading (ppm) |
| PL | Plastic Limit |
| PP | Pocket Penetrometer Reading (tsf) |
| %Passing#200 | Percent by weight passing a No. 200 Sieve |


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# IDENTIFICATION OF SOIL

## I. DEFINITION OF SOIL GROUP NAMES (ASTM D2487)

| | | | SYMBOL | GROUP NAME |
|---|---|---|---|---|
| Coarse-Grained Soils<br>More than 50% retained on No. 200 sieve | Gravels –<br>More than 50% of coarse fraction<br>retained on No. 4 sieve<br>Coarse, ¾" to 3"<br>Fine, No. 4 to ¾" | Clean Gravels<br>Less than 5% fines | GW | WELL GRADED GRAVEL |
| | | | GP | POORLY GRADED GRAVEL |
| | | Gravels with fines<br>More than 12% fines | GM | SILTY GRAVEL |
| | | | GC | CLAYEY GRAVEL |
| | Sands – 50% or more of coarse Fraction passes No. 4 sieve<br>Coarse, No. 10 to No. 4<br>Medium, No. 40 to No. 10<br>Fine, No. 200 to No. 40 | Clean Sands<br>Less than 5% fines | SW | WELL GRADED SAND |
| | | | SP | POORLY GRADED SAND |
| | | Sands with fines<br>More than 12% fines | SM | SILTY SAND |
| | | | SC | CLAYEY SAND |
| Fine-Grained Soils<br>50% or more passes the No. 200 sieve | Silts and Clays –<br>Liquid Limit less than 50<br>Low to medium plasticity | Inorganic | CL | LEAN CLAY |
| | | | ML | SILT |
| | | Organic | OL | ORGANIC CLAY |
| | | | | ORGANIC SILT |
| | Silts and Clays –<br>Liquid Limit 50 or more<br>Medium to high plasticity | Inorganic | CH | FAT CLAY |
| | | | MH | ELASTIC SILT |
| | | Organic | OH | ORGANIC CLAY |
| | | | | ORGANIC SILT |
| Highly Organic Soils | Primarily organic matter, dark in color and organic odor | | PT | PEAT |

## II. DEFINITION OF SOIL COMPONENT PROPORTIONS (ASTM D2487)

| | | | Examples |
|---|---|---|---|
| Adjective Form | GRAVELLY<br>SANDY | >30% to <50% coarse grained component in a fine-grained soil | GRAVELLY LEAN CLAY |
| | CLAYEY<br>SILTY | >12% to <50% fine grained component in a coarse-grained soil | SILTY SAND |
| "With" | WITH GRAVEL<br>WITH SAND | >15% to <30% coarse grained component in a fine-grained soil | FAT CLAY WITH GRAVEL |
| | WITH GRAVEL<br>WITH SAND | >15% to <50% coarse grained component in a coarse-grained soil | POORLY GRADED GRAVEL WITH SAND |
| | WITH SILT<br>WITH CLAY | >5% to <12% fine grained component in a coarse-grained soil | POORLY GRADED SAND WITH SILT |

## III. GLOSSARY OF MISCELLANEOUS TERMS

**SYMBOLS** ..... Unified Soil Classification Symbols are shown above as group symbols. A dual symbol "-" indicates the soil belongs to two groups. A borderline symbol "/" indicates the soil belongs to two possible groups.

**FILL** ..... Man-made deposit containing soil, rock and often foreign matter.

**PROBABLE FILL** ..... Soils which contain no visually detected foreign matter but which are suspect with regard to origin.

**DISINTEGRATED ROCK (DR)** ..... Residual materials with a standard penetration resistance (SPT) between 60 blows per foot and refusal. Refusal is defined as an SPT of 100 blows for 2 inches or less penetration.

**PARTIALLY WEATHERED ROCK (PWR)**..... Residual materials with a standard penetration resistance (SPT) between 100 blows per foot and refusal. Refusal is defined as an SPT of 100 blows for 2inches or less penetration.

**BOULDERS & COBBLES**..... Boulders are considered rounded pieces of rock larger than 12 inches, while cobbles range from 3- to 12-inch size.

**LENSES**..... 0- to ½-inch seam within a material in a test pit.

**LAYERS** ..... ½- to 12-inch seam within a material in a test pit.

**POCKET** ..... Discontinuous body within a material in a test pit.

**MOISTURE CONDITIONS**..... Wet, moist or dry to indicate visual appearance of specimen.

**COLOR** ..... Overall color, with modifiers such as light to dark or variation in coloration.


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# DESCRIPTIVE CRITERIA FOR ROCK CORE LOGGING

Rock is defined as natural subsurface material yielding SPT blow counts of N ≥ 100/2 inches (Martin, 1977). Rock descriptions may include the following descriptive elements, as applicable, generally in the order indicated. Supplemental descriptors may also be used, depending on project performance objectives and available information.

ROCK TYPE, strength, weathering, fracturing, color, recovery, RQD

**Rock Type** General terms are used following the NRCS (2001) rock type classification chart based on visual identification. Some of the NRCS rock types common to our geographic area of practice are listed below. Mineralogical modifiers may be added where they help define distinct units (e.g., Garnet-Muscovite Schist).

| | |
|---|---|
| Sedimentary: | Conglomerate, Sandstone, Mudstone, Siltstone, Claystone, Shale, Limestone, Dolomite, Coal, Chert |
| Igneous: | Pegmatite, Granite, Diorite, Gabbro, Diabase, Rhyolite, Monzonite, Andesite, Basalt |
| Metamorphic: | Gneiss, Schist, Phyllite, Slate, Quartzite, Marble, Amphibolite, Hornfels |

**Strength** (modified from Hoek, 2001) The estimated Uniaxial Compressive Strength associated with each rock strength term is based on the field strength index test for intact rock samples as follows.

| | | |
|---|---|---|
| • Extremely Strong | >36,000 psi | Specimen can only be chipped with a geological hammer. |
| • Very Strong | 15,000 - 36,000 psi | Specimen requires many blows of a geological hammer to fracture it. |
| • Strong | 7,500 - 15,000 psi | Specimen requires more than one blow of a geological hammer to fracture it. |
| • Medium Strong | 3,500 - 7,500 psi | Specimen cannot be peeled with a pocket knife; can be fractured with one blow from a geological hammer. |
| • Weak | 700 - 3,500 psi | Specimen can be peeled with a pocket knife with difficulty; shallow indentation made by firm blow with point of a geological hammer. |
| • Very Weak | 150 - 700 psi | Material crumbles under firm blows with point of a geological hammer; can be peeled with a pocket knife. |

**Weathering** (modified from ACOE, 1994; and USBR, 2001)

- Fresh Mineral crystals appear bright and show no discoloration. Fractures show little or no staining on their surfaces. Discoloration does not extend into intact rock.
- Slightly Weathered Rock is generally fresh except along fractures. Some fractures are stained and discoloration may extend up to 0.5 inches into rock.
- Moderately Weathered Significant portions of rock appear dull and discolored. Rock may be significantly weaker than in its fresh state near fractures. Soil zones of limited extent may occur along some fractures.
- Highly Weathered Rock appears dull and discolored throughout. Majority of rock mass is significantly weaker than in its fresh state. Isolated zones of stronger rock and/or soil may occur throughout.
- Severely Weathered Significant portions of rock mass essentially weathered to soil. Rock fabric may still be discernable (i.e., saprolite). Isolated zones of stronger rock may occur locally. Quartz may be present as hard, fractured dikes or veins.

**Fracturing** (from ACOE, 1994)

| | |
|---|---|
| Very Slightly Fractured | > 6.5 ft |
| Slightly Fractured | 2 ft - 6.5 ft |
| Moderately Fractured | 8 in - 2 ft |
| Highly Fractured | 2.5 in - 8 in |
| Intensely Fractured | < 2.5 in |

**Color** (from Munsell Color System; and GSA, 1995) Color descriptions include a primary color and up to two shade or secondary color modifiers, and may also include a color pattern term to define the relationship between multiple colors.

Shade: Light, Dark

Secondary: Blackish, Brownish, Grayish, Greenish, Reddish, Yellowish, Orangeish

Primary: Black, Brown, Gray, Green, Red, Yellow, Orange, White

Pattern: and, to, with mottles of, with speckles of, with streaks of, with bands of

- **Recovery** is defined as the total length of recovered core in a core run divided by the total length of the core run, times 100 percent. A core run may be any depth interval of concern. Only natural fractures are considered for determining the length of core pieces. Mechanical breaks formed during or after coring do not count against the length determination. The length of recovered core pieces is measured along the core axis, between fracture midpoints.
- **RQD** (ASTM D6032, Deere & Deere, 1988, 1989) is defined as the total length of core pieces at least four inches long recovered from a core run divided by the total length of the core run, times 100 percent. A core run may be any depth interval of concern. Only natural fractures are considered for determining the length of core pieces. Mechanical breaks formed during or after coring do not count against the length determination. The length of recovered core pieces should be measured along the core axis, between fracture midpoints. Core pieces that are highly to severely weathered, very weak, or contain numerous pores should not count toward RQD.


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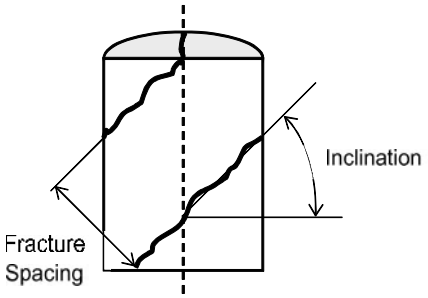
# SUPPLEMENTAL ROCK DESCRIPTIVE TERMS

In addition to the basic rock descriptive elements provided on the preceding Descriptive Criteria for Rock Core Logging sheet, rock descriptions may include the following supplemental descriptive elements depending on project performance objectives and available information.

**Bedding Thickness & Inclination** Bedding is defined as the layered arrangement of sediment deposits in sedimentary rock. Bedding thickness is the average perpendicular distance between bedding surfaces. Bedding thickness intervals follow Bieniawski (1989). Inclination is measured in degrees from a plane perpendicular to the core axis (see Inclination Measurement Figure shown below).

| | |
|---|---|
| Very Thickly Bedded | > 6.5 ft |
| Thickly Bedded | 2 ft - 6.5 ft |
| Medium Bedded | 8 in - 2 ft |
| Thinly Bedded | 2.5 in - 8 in |
| Very Thinly Bedded | < 2.5 in |




**Inclination Measurement Figure**

**Foliation Character & Inclination** Foliation is defined as the planar arrangement of textural features in metamorphic rock. Inclination is measured in degrees from a plane perpendicular to the core axis (see Inclination Measurement Figure).

| | |
|---|---|
| Strongly Foliated | Foliation is easily discernable throughout. |
| Moderately Foliated | Foliation is discernable with some difficulty. |
| Poorly Foliated | Foliation is generally not discernable. |

**Fracture Set Data** Individual fractures or fracture sets may be characterized by the following descriptive elements, when applicable and discernable: fracture type, inclination (as per Inclination Measurement Figure above), average spacing, roughness and infilling condition. An example fracture set data description for an individual stratum is: *4 joints at 80-90°, moderately spaced, slightly rough, with spotty iron staining and partially filled with pyrite*. If fractures are rare, they can be described individually by listing the depth, followed by the descriptive terms in this section.

## FRACTURE TYPE

| | |
|---|---|
| Fracture | Any natural break in rock; 'Fracture' is the general term used for individual breaks that do not fall into any of the following fracture-type categories |
| Joint | A relatively planar fracture without shear displacement; occurs with other similarly oriented joints generally at regularly spaced intervals |
| Shear | A fracture along which differential movement has taken place parallel to the surface (i.e., shear displacement) sufficient to produce slickensides or polishing |
| Fault | A major fracture along which there has been appreciable shear displacement accompanied by gouge and/or a severely fractured zone |
| Bedding Fracture | A fracture along a bedding plane |
| Foliation Fracture | A fracture along a foliation plane |
| Vein Fracture | A fracture along the contact of an intrusive vein |

## Average Spacing (NRCS, 2001)

| | |
|---|---|
| Very Widely Spaced | > 6.5 ft |
| Widely Spaced | 2 ft - 6.5 ft |
| Moderately Spaced | 8 in - 2 ft |
| Closely Spaced | 2.5 in - 8 in |
| Very Closely Spaced | < 2.5 in |

***Infilling Condition***

| *Coverage* | *Type* |
|---|---|
| Spotty Filling of (≤ 50% coverage) | Calcite |
| Partially Filled with (50 to 100% coverage) | Chlorite |
| Filled with (100% coverage) | Clay |
| | Gypsum |
| | Iron Staining |
| | Manganese |
| | Mica |
| | Pyrite |
| | Quartz |
| | Talc |

**Roughness** (Bieniawski, 1989)

| | |
|---|---|
| Very Rough | - Most surface asperities extend > 2 mm from the average planar surface. |
| Rough | - Most surface asperities extend 0.5 to 2 mm from the average planar surface. |
| Slightly rough | - Most surface asperities extend < 0.5 mm from the average planar surface. |
| Smooth | - Generally smooth to touch with few surface asperities. |
| Slickensided | - Infilling material contains slickensides. |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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-1**<br>Contract Number: 16C15039.00<br>Sheet: 1 of 4 |
|---|---|---|---|

**Contractor:** Armstrong Drilling
Murraysville, Pennsylvania

**Contractor Foreman:** T. Armstrong

**Schnabel Representative:** Robin Reed

**Equipment:** HM D-50

**Method:** 4-1/4" ID Hollow Stem Auger,
HQ Double Barrel

**Hammer Type:** Auto Hammer (140 lb)

**Dates Started:** 11/23/16 **Finished:** 11/28/16

**X:** 2239304.454 ft **Y:** 707460.5169 ft

**Plunge:** -90 **Bearing:**

**Ground Surface Elevation:** 810± (ft) **Total Depth:** 150.9 ft

**Water Level Observations**

| Date | Time | Depth | Casing | Caved |
|---|---|---|---|---|
| | | | | |

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 0.1 | Rootmat and topsoil | | 809.7 | | | | | |
| | SILT; moist, brown, contains root fragments, medium stiff to stiff, probable RESIDUAL material | ML | | | | S-1, SPT 3+3+5+7 REC=24", 100% | PP = 3.50 tsf | |
| 2.0 | | | 807.8 | | | S-2, SPT 4+7+8+10 REC=24", 100% | PP = 4.50 tsf | |
| | SILT; moist, brown, medium stiff to hard, probable RESIDUAL material | ML | | | | | | |
| 5.0 | DISINTEGRATED ROCK, sampled as poorly graded sand with gravel, fine to coarse; dry, brown, very dense, disintegrated sandstone rock | DR | 804.8 | | 5 | S-3, SPT 4+16+36+56 REC=24", 100%<br>S-4, SPT 26+48+10/0" REC=12", 100% | | |
| 9.0 | SANDSTONE, medium strong, moderately weathered, highly fractured to moderately fractured, brown and gray | | 800.8 | | 10 | S-5, SPT 50/4" REC=3", 75%<br>R-1, CORE Run = 3.2 ft REC=14", 37%<br>R-2, CORE Run = 10.0 ft REC=118", 98% RQD=118", 98% | | Sampler bouncing last 25 blows<br>Bedding dips generally shallow (0 - 5 degrees), some crossbedding in sandstone lithologies |
| 13.2 | SANDSTONE, strong, slightly weathered, slightly fractured, gray | | 796.6 | | 15 | | | |
| | | | | | 20 | | | |
| 20.7 | SHALE, weak, fresh, very slightly fractured, gray, laminated SHALE, SILTSTONE, SILTY SHALE; contains thin clay seams | | 789.1 | | | | | |
| 22.8 | SANDSTONE, medium strong, fresh, slightly fractured to very slightly fractured, gray, contains shaley laminations | | 787.0 | | 25 | R-3, CORE Run = 10.0 ft REC=118", 98% RQD=118", 98% | | |
| 29.2 | SHALE, weak, fresh, slightly fractured to very slightly fractured, dark gray with streaks of brown | | 780.6 | | 30 | | | |
| 30.8 | SHALE, weak, fresh, slightly fractured to very slightly fractured, dark gray, contains siltstone and sandstone laminations | | 779.0 | | | R-4, CORE Run = 10.0 ft REC=117", 98% RQD=117", 98% | | |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-1**<br>Contract Number: 16C15039.00<br>Sheet: 2 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | SHALE, weak, fresh, slightly fractured to very slightly fractured, dark gray, contains siltstone and sandstone laminations *(continued)* | | | | 40<br>45 | R-5, CORE<br>Run = 10.0 ft<br>REC=112", 93%<br>RQD=84", 70% | | |
| 49.4 | SHALE, very weak, fresh, highly fractured, gray, BRECCIATED SHALE/GOUGE | | 760.4 | | 50 | | | |
| 52.5 | SANDSTONE, medium strong to strong, fresh, very slightly fractured, light gray, mechanical breaks occur on micaceous partings, few very thin clayey partings; SILTSTONE layer from about 100.3 -100.5 ft. | | 757.3 | | 55<br>60<br>65<br>70<br>75<br>80 | R-6, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=120", 100%<br>R-7, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=120", 100%<br>R-8, CORE<br>Run = 10.0 ft<br>REC=119", 99%<br>RQD=119", 99% | | |

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*(continued)*

| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-1**<br>Contract Number: 16C15039.00<br>Sheet: 3 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | SANDSTONE, medium strong to strong, fresh, very slightly fractured, light gray, mechanical breaks occur on micaceous partings, few very thin clayey partings; SILTSTONE layer from about 100.3 -100.5 ft. *(continued)* | | | | 85<br>90<br>95<br>100 | R-9, CORE<br>Run = 10.0 ft<br>REC=119", 99%<br>RQD=119", 99%<br>R-10, CORE<br>Run = 10.0 ft<br>REC=119", 99%<br>RQD=119", 99% | | |
| 103.3 | SHALE, weak, fresh, very slightly fractured, dark gray and gray, dry, interlaminated SHALE, SILTSTONE and SANDSTONE | | 706.5 | | 105 | R-11, CORE<br>Run = 10.0 ft<br>REC=118", 98%<br>RQD=118", 98% | | End drilling for day/week at 102.4 ft at 15:00<br>Resume drilling 11-28-16 at 08:03 |
| 105.8 | | | 704.0 | | | | | |
| 106.5 | SANDSTONE, medium strong to strong, fresh, very slightly fractured, gray | | 703.3 | | | | | |
| | SHALE, weak, fresh, very slightly fractured, dark gray and gray, interlaminated SHALE, SILTSTONE and SANDSTONE | | | | 110 | | | |
| 111.5 | SHALE, weak, fresh, very slightly fractured, dark gray to black, CARBONACEOUS SHALE, few siltstone and sandstone laminations | | 698.3 | | | R-12, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=89", 74% | | |
| 115.2 | SHALE, weak, fresh, very slightly fractured, dark gray and gray, interlaminated SHALE, SILTSTONE and SANDSTONE | | 694.6 | | 115 | | | |
| 119.8 | COAL, very weak to weak, fresh, intensely fractured, black | | 690.0 | | 120 | R-13, CORE<br>Run = 10.0 ft<br>REC=94", 78%<br>RQD=38", 32% | | |
| | | | | | 125 | | | |
| 126.3 | | | 683.5 | | | | | Likely lost clayey/soft material in interval from 126.3 - 129 ft; |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-1**<br>Contract Number: 16C15039.00<br>Sheet: 4 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 130.2 | SILTSTONE, very weak, fresh, intensely fractured to highly fractured, light greenish gray, fractured SILTSTONE/CLAY SHALE, likely lost core in this interval *(continued)* | | 679.6 | | 130 | | | high water pressure, core barrel blocked off at 129 ft. Recovered siltstone/clay shale appears highly to intensely fractured |
| | SANDSTONE, medium strong to strong, fresh, very slightly fractured, gray, contains siltstone/shale laminations | | | | | R-14, CORE<br>Run = 10.0 ft<br>REC=118", 98%<br>RQD=118", 98% | | |
| | | | | | 135 | | | |
| | | | | | 140 | | | |
| | | | | | | R-15, CORE<br>Run = 8.5 ft<br>REC=102", 100%<br>RQD=102", 100% | | |
| | | | | | 145 | | | |
| | | | | | 150 | | | |
| 150.9 | | | 658.9 | | | | | |

Bottom of Boring at 150.9 ft.
Auger refusal at 9.0 ft.
Boring terminated at selected depth.

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-2**<br>Contract Number: 16C15039.00<br>Sheet: 1 of 4 |
|---|---|---|---|

**Contractor:** Armstrong Drilling
Murraysville, Pennsylvania

**Contractor Foreman:** T. Armstrong

**Schnabel Representative:** Robin Reed

**Equipment:** HM D-50

**Method:** 4-1/4" ID Hollow Stem Auger,
HQ Double Barrel

**Hammer Type:** Auto Hammer (140 lb)

**Dates Started:** 11/11/16 **Finished:** 11/14/16

**X:** 2238602.272 ft **Y:** 707269.847 ft

**Plunge:** -90 **Bearing:**

**Ground Surface Elevation:** 825± (ft) **Total Depth:** 150.5 ft

**Water Level Observations**

| | Date | Time | Depth | Casing | Caved |
|---|---|---|---|---|---|
| After Drilling | 11/22 | 3:10 PM | 48.7' | --- | --- |

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 0.7 | Rootmat and topsoil | | 823.9 | | | | | |
| 2.0 | LEAN CLAY; moist, light brown, contains root fragments, stiff to very stiff, probable RESIDUAL material | CL | 822.6 | | | S-1, SPT 3+5+6+8 REC=20", 83%<br>S-2, SPT 6+10+12+14 REC=24", 100% | | |
| | LEAN CLAY; moist, yellowish brown with mottles of gray, stiff to very stiff, probable RESIDUAL material | CL | | | 5 | S-3, SPT 6+7+11+13 REC=24", 100%<br>S-4, SPT 3+6+10+12 REC=24", 100% | | |
| | Change: orangish brown | | | | 10 | UD UNDIST REC=20", 83%<br>S-5, SPT 4+4+6+9 REC=24", 100% | | Shelby Tube Down pressure 100, 100, 200, 500 psi |
| 11.5 | LEAN CLAY; moist, light greenish gray with mottles of orangish brown, contains weathered rock fragments, stiff to very hard | CL | 813.1 | | | | | |
| 16.0 | DISINTEGRATED ROCK, sampled as; moist, gray and orangish brown, very dense, SHALE | | 808.6 | | 15 | S-6, SPT 12+24+50/3" REC=14", 93% | PP = 4.50 tsf | Relict rock structure observed |
| | Change: dark gray, CARBONACEOUS SHALE | DR | | | 20 | S-7, SPT 36+50+50/2" REC=12", 86% | | |
| 25.7<br>25.8 | DISINTEGRATED ROCK, sampled as; moist, gray, SANDSTONE | DR | 798.9<br>798.8 | | 25 | S-8, SPT 48+50/4" REC=5", 50%<br>R-1, CORE Run = 1.6 ft REC=8", 42% RQD=22", 115%<br>R-2, CORE Run = 10.0 ft REC=112", 93% RQD=102", 85% | | End drilling for day at 14:55, 11-11-2016<br>Resume drilling 11-14-2016, 10:50 |
| | SANDSTONE, medium strong, slightly weathered to fresh, slightly fractured to very slightly fractured, gray, moderately micaceous, contains coal fragments and carbonaceous laminations, thin coal layer at 31 - 31.2 ft | | | | 30 | | | Light gray return |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-2**<br>Contract Number: 16C15039.00<br>Sheet: 2 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | ELEV (ft) | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|
| 38.2 | Change: weak to medium strong | 786.4 | | R-3, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=94", 78% | | |
| 40.3 | SHALE, very weak to weak, slightly weathered, slightly fractured to very slightly fractured, dark gray, decomposed from 38.2 - 38.4 ft and 40.2 - 40.3 ft. | 784.3 | 40 | | | |
| | SANDSTONE, medium strong, fresh, slightly fractured to very slightly fractured, gray, contains carbonaceous laminations | | | | | |
| 45.4 | SILTSTONE, weak to medium strong, fresh, slightly fractured to very slightly fractured, gray with streaks of dark gray, interlaminated SILTSTONE and SHALE<br>Change: few plant fossils | 779.2 | 45 | R-4, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=120", 100% | | Dark gray return at 47.5 ft. |
| | | | 50 | | | |
| | | | 55 | | | |
| 57.4 | SHALE, very weak to weak, fresh, very slightly fractured, dark gray to black, carbonaceous | 767.2 | | R-5, CORE<br>Run = 10.0 ft<br>REC=115", 96%<br>RQD=115", 96% | | |
| | | | 60 | | | |
| | | | 65 | | | |
| 68.7 | CLAYEY SHALE, very weak, slightly weathered, highly fractured, gray, POSSIBLE FAULT GOUGE, slickensided shale at 68.7 and 69.7 ft. Very weak to decomposed, slickensides dip approximately 55 - 60 degrees | 755.9 | | R-6, CORE<br>Run = 10.0 ft<br>REC=107", 89%<br>RQD=51", 43% | | Grayish brown to gray return at 67 to 68 ft. |
| | | | 70 | | | |
| 74.8 | SILTSTONE, medium strong, fresh, slightly fractured, greenish gray, contains small blebs and narrow stringers of light brown limestone, few conglomerate pebbles from 80 - 80.4 ft, sandstone laminations | 749.8 | 75 | R-7, CORE<br>Run = 10.0 ft<br>REC=119", 99%<br>RQD=119", 99% | | |
| 80.4 | | 744.2 | 80 | | | Return greenish gray at 80 ft. |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-2**<br>Contract Number: 16C15039.00<br>Sheet: 3 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 82.5 | SILTSTONE, medium strong, fresh, slightly fractured, gray, laminated SILTSTONE and SANDSTONE *(continued)* | | 742.1 | | | | | |
| | SANDSTONE, medium strong, fresh, slightly fractured to very slightly fractured, light gray, crossbedded with carbonaceous laminations and micaceous partings, fine grained | | | | 85 | | | |
| | | | | | | R-8, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=120", 100% | | |
| | | | | | 90 | | | |
| | | | | | 95 | | | |
| | | | | | | R-9, CORE<br>Run = 10.0 ft<br>REC=119", 99%<br>RQD=119", 99% | | Core breaks under tension along micaceous bedding planes/partings, some partially clay coated. |
| | | | | | 100 | | | |
| | | | | | 105 | | | |
| | Change: Fine to medium grained | | | | | R-10, CORE<br>Run = 10.0 ft<br>REC=118", 98%<br>RQD=118", 98% | | |
| | | | | | 110 | | | |
| | Change: Fine grained, silty laminations | | | | | | | |
| 113.2 | SHALE, medium strong, fresh, slightly fractured to very slightly fractured, gray, contains silt and fine sand laminations | | 711.4 | | 115 | | | |
| | | | | | | R-11, CORE<br>Run = 5.0 ft<br>REC=42", 70%<br>RQD=42", 70% | | |
| | | | | | 120 | | | No return water. |
| 122.3 | Puritan mine, open from 122.3 to 125.4 ft, gob from 125.4 ft to mine floor at 130.6 ft. | | 702.3 | | | R-12, CORE<br>Run = 10.0 ft<br>REC=24", 20%<br>RQD=0", 0% | | Broke through mine roof at 122.3 ft, open from 122.3 - 125.4 ft, gob from 125.4 - 130.6 ft |
| | | | | | 125 | | | |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-2**<br>Contract Number: 16C15039.00<br>Sheet: 4 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 130.6 | SHALE, very weak, severely weathered, gray, decomposed shale/claystone/underclay | | 694.0 | | 130 | | | End drilling for day at 130.6 ft at 17:45.<br>Resume drilling 11-15-2016, 06:58 |
| 133.5 | SHALE, very weak, moderately weathered, slightly fractured, gray, contains clay seams | | 691.1 | | 135 | R-13, CORE<br>Run = 5.0 ft<br>REC=53", 88%<br>RQD=0", 0% | | |
| 138.2 | SANDSTONE, weak to medium strong, fresh, very slightly fractured, gray, fine grained sandstone with silty/shaley laminations, few decomposed shale and/or clay seams from 143.6 - 144.2 ft. | | 686.4 | | 140 | R-14, CORE<br>Run = 5.0 ft<br>REC=59", 98%<br>RQD=51", 85% | | Bedding dips generally shallow (0 - 5 degrees), some crossbedding in sandstone lithologies |
| | | | | | 145 | R-15, CORE<br>Run = 8.1 ft<br>REC=97", 100%<br>RQD=88", 91% | | |
| 150.5 | | | 674.1 | | 150 | | | |

Bottom of Boring at 150.5 ft.
Boring terminated at selected depth.

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-3**<br>Contract Number: 16C15039.00<br>Sheet: 1 of 4 |
|---|---|---|---|

**Contractor:** Armstrong Drilling
Murraysville, Pennsylvania

**Contractor Foreman:** T. Armstrong

**Schnabel Representative:** Robin Reed

**Equipment:** HM D-50

**Method:** 4-1/4" ID Hollow Stem Auger,
HQ Double Barrel

**Hammer Type:** Auto Hammer (140 lb)

**Dates Started:** 11/15/16 **Finished:** 11/16/16

**X:** 2239298.407 ft **Y:** 707151.796 ft

**Plunge:** -90 **Bearing:**

**Ground Surface Elevation:** 822± (ft) **Total Depth:** 150.5 ft

**Water Level Observations**

| | Date | Time | Depth | Casing | Caved |
|---|---|---|---|---|---|
| Completion | 11/17 | 7:00 AM | 42.5' | 20.0' | --- |
| After Drilling | 11/22 | 3:18 PM | 42.2' | --- | --- |

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 0.2 | Topsoil | | 822.0 | | | S-1, SPT 6+5+5+4 REC=24", 100% | | |
| | LEAN CLAY; moist, light brown, stiff to very stiff, probable RESIDUAL material | | | | | | | |
| | Change: orangish brown | | | | | S-2, SPT 7+6+11+12 REC=24", 100% | PP = 4.50 tsf | |
| | Change: orangish brown with mottles of gray | CL | | | 5 | S-3, SPT 4+6+8+11 REC=24", 100% | PP = 4.00 tsf | |
| | | | | | | UNDIST REC=23", 96% | | |
| | | | | | 10 | S-4, SPT 4+7+19+50 REC=24", 100% | PP = 4.00 tsf | |
| 10.5 | DISINTEGRATED ROCK, sampled as; moist, brown, medium dense to very dense, siltstone | | 811.7 | | | | | |
| | | DR | | | 15 | S-5, SPT 30+50/4" | | |
| 20.0 | DISINTEGRATED ROCK, sampled as; dry, gray, very dense, silty shale | DR | 802.2 | | 20 | S-6, SPT 32+48+50/1" REC=6", 46% | | Light gray drill return |
| 20.8 | SANDSTONE, medium strong, slightly weathered to moderately weathered, slightly fractured to very slightly fractured, gray and brown | | 801.4 | | | R-1, CORE Run = 1.7 ft REC=32", 157% RQD=34", 167% R-2, CORE Run = 10.0 ft REC=119", 99% | | Bedding dips generally shallow (0 - 5 degrees), some crossbedding in sandstone lithologies |
| | | | | | 25 | | | |
| | | | | | 30 | | | |
| 34.2 | | | 788.0 | | | R-3, CORE Run = 10.0 ft REC=109", 91% RQD=64", 53% | | |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-3**<br>Contract Number: 16C15039.00<br>Sheet: 2 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 36.7 | SHALE, very weak, slightly weathered, moderately fractured, gray, contains clay seams, carbonaceous material and fine grained sandstone laminations *(continued)* | | 785.5 | | | | | Brownish gray drill return<br>Gray drill return |
| | SANDSTONE, medium strong, slightly weathered to fresh, slightly fractured, gray, dirty sandstone with clay partings, moderately micaceous, fracturing from 39.5 - 40.5 is mechanical | | | | 40 | | | |
| 42.8 | | | 779.4 | | | | | |
| 43.6 | SHALE, very weak, slightly weathered, slightly fractured, gray with mottles of brown, SILTY SHALE | | 778.6 | | | R-4, CORE<br>Run = 10.0 ft<br>REC=116", 97%<br>RQD=106", 88% | | Groundwater at 42.5 ft on completion, pulled augers and could hear water running into hole. Stabilized at 10 ft, recheck 11/21/2016 |
| | SHALE, weak, fresh, very slightly fractured, dark gray with streaks of gray, contains sandstone and siltstone laminations | | | | 45<br>50 | | | Dark gray drill return |
| 52.8 | | | 769.4 | | | | | |
| | SHALE, weak, fresh, very slightly fractured, dark gray, contains carbonaceous plant fossils | | | | 55 | R-5, CORE<br>Run = 10.0 ft<br>REC=117", 98%<br>RQD=109", 91% | | |
| | | | | | 60 | | | |
| | Change: CARBONACEOUS SHALE layer from 61 - 61.2 ft. | | | | | | | Black drill return |
| 62.8 | | | 759.4 | | | | | |
| | SHALE, very weak to weak, fresh to slightly weathered, moderately fractured, dark gray, contains clay seams | | | | 65 | R-6, CORE<br>Run = 10.0 ft<br>REC=116", 97%<br>RQD=111", 93% | | |
| 65.6 | | | 756.6 | | | | | |
| | SILTSTONE, medium strong, fresh, slightly fractured, gray, fine grained sandstone laminations, healed joint dipping 60 degrees at 77.5 ft. | | | | | | | |
| 69.5 | | | 752.7 | | | | | |
| | SANDSTONE, medium strong to strong, fresh, very slightly fractured, gray, contains siltstone laminations, mechanical breaks occur along micaceous partings | | | | 70 | | | |
| | | | | | 75 | R-7, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=120", 100% | | |
| | | | | | 80 | | | |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-3**<br>Contract Number: 16C15039.00<br>Sheet: 3 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | SANDSTONE, medium strong to strong, fresh, very slightly fractured, gray, contains siltstone laminations, mechanical breaks occur along micaceous partings *(continued)* | | | | 85 | R-8, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=120", 100% | | |
| | | | | | 90 | | | |
| | | | | | 95 | R-9, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=120", 100% | | |
| | | | | | 100 | | | |
| | | | | | 105 | R-10, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=120", 100% | | |
| | | | | | 110 | | | |
| | | | | | 115 | R-11, CORE<br>Run = 10.0 ft<br>REC=111", 93%<br>RQD=92", 77% | | |
| 116.1 | SILTSTONE, medium strong, fresh, slightly fractured, gray, mechanical breaks occur along partially intact joints dipping 60 - 80 degrees | | 706.1 | | | | | |
| 118.9 | SHALE, weak, fresh, moderately fractured to highly fractured, dark gray to black, mechanical breaks occur along partially intact irregular fractured | | 703.3 | | 120 | | | |
| 122.0 | SHALE, weak to medium strong, fresh, slightly fractured, dark gray to black, interlaminated shale, silty shale and carbonaceous shake, few partially intact joints | | 700.2 | | 125 | R-12, CORE<br>Run = 10.0 ft<br>REC=100", 83%<br>RQD=46", 38% | | |
| 126.8 | COAL, weak, fresh, intensely fractured, black, boney coal with clay/shale seams | | 695.4 | | | | | Black drill return |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-3**<br>Contract Number: 16C15039.00<br>Sheet: 4 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | COAL, weak, fresh, intensely fractured, black, boney coal with clay/shale seams *(continued)* | | | | 130 | | | |
| 131.7 | | | 690.5 | | | | | |
| 132.5 | SHALE, very weak to weak, fresh, highly fractured, dark gray to black, contains coal fragments and thin coal stringers, few partially intact fractures | | 689.7 | | | R-13, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=90", 75% | | |
| 135.2 | CLAYSTONE, very weak, severely weathered, intensely fractured, gray, contains clay seams, slightly vuggy | | 687.0 | | 135 | | | |
| | SILTSTONE, weak to medium strong, fresh, very slightly fractured, gray, interlaminated siltstone, shale and sandstone with minor conglomerate | | | | 140 | | | |
| 143.5 | SANDSTONE, medium strong, fresh, very slightly fractured, gray, contains carbonaceous/shaley laminations | | 678.7 | | 145 | R-14, CORE<br>Run = 7.7 ft<br>REC=92", 100%<br>RQD=92", 100% | | |
| 150.5 | | | 671.7 | | 150 | | | |

Bottom of Boring at 150.5 ft.
Boring terminated at selected depth.

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-4**<br>Contract Number: 16C15039.00<br>Sheet: 1 of 4 |
|---|---|---|---|

**Contractor:** Armstrong Drilling
Murraysville, Pennsylvania

**Contractor Foreman:** T. Armstrong

**Schnabel Representative:** Robin Reed

**Equipment:** HM D-50

**Method:** 4-1/4" ID Hollow Stem Auger,
HQ Double Barrel

**Hammer Type:** Auto Hammer (140 lb)

**Dates Started:** 11/17/16 **Finished:** 11/17/16

**X:** 2238432.504 ft **Y:** 706680.0717 ft

**Plunge:** -90 **Bearing:**

**Ground Surface Elevation:** 812± (ft) **Total Depth:** 150.1 ft

**Water Level Observations**

| | Date | Time | Depth | Casing | Caved |
|---|---|---|---|---|---|
| After Drilling | 11/22 | 3:02 PM | 20.0' | --- | --- |

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 0.1 | Topsoil | | 812.2 | | | | | |
| | SILT; moist, light brown, estimated <5% sand, contains root fragments, stiff to very stiff, probable RESIDUAL material | ML | | | | S-1, SPT 3+4+5+6 REC=18", 75%<br>S-2, SPT 4+8+11+14 REC=18", 75% | PP = 4.50 tsf | Collected bulk sample from 0 - 5 ft. |
| 3.5 | | | 808.8 | | | | | |
| | SILT; moist, orangish brown with mottles of gray, estimated <5% sand, contains severely weathered rock fragments, very stiff to very hard, probable TERRACE material | | | | 5 | S-3, SPT 5+8+10+14 REC=24", 100%<br>UNDIST REC=24", 100% | PP = 4.50 tsf | Relict rock texture observed<br>U/D push force 100, 300, 300, 600 psi |
| | Change: light brown with mottles of gray | ML | | | 10 | S-4, SPT 5+7+13+16 REC=24", 100%<br>S-5, SPT 4+10+13+16 REC=24", 100% | | |
| 14.5 | | | 797.8 | | | | | |
| 14.6 | DISINTEGRATED ROCK, sampled as; moist, grayish brown with mottles of gray, very dense | DR | 797.7 | | 15 | S-6, SPT 50/1" REC=1", 100%<br>R-1, CORE Run = 3.3 ft REC=39", 100% RQD=0", 0%<br>R-2, CORE Run = 10.0 ft REC=88", 73% RQD=32", 27% | | Bedding dips generally shallow (0 - 5 degrees), some crossbedding in sandstone lithologies |
| | SANDSTONE, very weak to weak, highly weathered, highly fractured, brown and gray, thin 2 - 8 in, iron stained joint dipping 60 degrees at about 17 ft, planar, slightly rough | | | | 20 | | | |
| | Change: moderately weathered | | | | 25 | | | Fractured/broken rock from 23.5 to 25.5 ft., lost drill return at 24.5 ft. |
| 27.8 | SANDSTONE, weak to medium strong, slightly weathered, moderately fractured to slightly fractured, gray pinkish, very fine grained sandstone/silty sandstone, few clay and/or shaley partings on bedding planes; | | 784.5 | | 30 | R-3, CORE Run = 10.0 ft REC=98", 82% RQD=57", 48% | | |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-4**<br>Contract Number: 16C15039.00<br>Sheet: 2 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 36.5 | Change: Siltstone laminations from 35.5 to 36.5 ft. | | 775.8 | | | | | Regained drill return at 35 ft.<br><br>Drill return gray |
| | SHALE, very weak to weak, fresh, slightly fractured to very slightly fractured, dark gray, clay seams from 36.5 - 37 ft and 40.3 - 40.5 ft. | | | | 40 | R-4, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=116", 97% | | |
| | | | | | 45 | | | |
| | Change: contains red beds | | | | 50 | R-5, CORE<br>Run = 10.0 ft<br>REC=106", 88%<br>RQD=104", 87% | | |
| | | | | | 55 | | | |
| 57.7 | BRECCIA, very weak, slightly weathered, intensely fractured, gray, contains limestone clasts and limey clay | | 754.6 | | 60 | R-6, CORE<br>Run = 10.0 ft<br>REC=117", 98%<br>RQD=73", 61% | | |
| | | | | | 65 | | | |
| 67.2 | SANDSTONE, medium strong to strong, fresh, very slightly fractured, gray, some sandstone calcareous, micaceous with siltstone laminations; mechanical breaks occur along micaceous partings | | 745.1 | | 70 | R-7, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=120", 100% | | |
| | | | | | 75 | | | |
| | | | | | 80 | R-8, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=120", 100% | | |

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*(continued)*

| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-4**<br>Contract Number: 16C15039.00<br>Sheet: 3 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | SANDSTONE, medium strong to strong, fresh, very slightly fractured, gray, some sandstone calcareous, micaceous with siltstone laminations; mechanical breaks occur along micaceous partings *(continued)* | | | | 85<br>90<br>95 | R-9, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=120", 100%<br>R-10, CORE<br>Run = 10.0 ft<br>REC=118", 98%<br>RQD=118", 98% | | |
| 99.6 | SHALE, weak, fresh, very slightly fractured, gray and dark gray, abrupt transition from sandstone to shale/silty shale; carbobaceous lamibations from 106 -106.5 ft. | | 712.7 | | 100<br>105 | | | |
| 106.5 | SHALE, weak, fresh, very slightly fractured, dark gray to black, carbonaceous shale with coal laminations | | 705.8 | | | | | |
| 107.8 | SHALE, medium strong, fresh, slightly fractured, gray to dark gray, 80Â°, contains fine grained sandstone laminations | | 704.5 | | 110 | R-11, CORE<br>Run = 10.0 ft<br>REC=116", 97%<br>RQD=38", 32% | | Drill return black |
| 110.9 | COAL, very weak to weak, fresh, highly fractured to intensely fractured, black | | 701.4 | | 115 | | | |
| 117.2 | SHALE, very weak to weak, fresh, highly fractured, gray purplish, contains slickensides | | 695.1 | | | | | |
| 119.0 | LIMESTONE, medium strong, fresh, slightly fractured, gray bluish, limestone, shale | | 693.3 | | 120<br>125 | R-12, CORE<br>Run = 10.0 ft<br>REC=118", 98%<br>RQD=118", 98%<br>R-13, CORE<br>Run = 10.0 ft | | |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-4**<br>Contract Number: 16C15039.00<br>Sheet: 4 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | LIMESTONE, medium strong, fresh, slightly fractured, gray bluish, limestone, shale *(continued)* | | | | 130 | REC=119", 99%<br>RQD=119", 99% | | |
| | | | | | 135 | | | |
| 137.8 | SANDSTONE, medium strong to strong, fresh, very slightly fractured, gray | | 674.5 | | | R-14, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=120", 100% | | |
| | | | | | 140 | | | |
| | | | | | 145 | | | |
| | | | | | | R-15, CORE<br>Run = 2.3 ft<br>REC=27", 98%<br>RQD=27", 98% | | |
| 150.1 | | | 662.2 | | 150 | | | |

Bottom of Boring at 150.1 ft.
Auger refusal at 14.5 ft.
Boring terminated at selected depth.

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-5**<br>Contract Number: 16C15039.00<br>Sheet: 1 of 4 |
|---|---|---|---|

**Contractor:** Armstrong Drilling
Murraysville, Pennsylvania

**Contractor Foreman:** T. Armstrong

**Schnabel Representative:** Robin Reed

**Equipment:** HM D-50

**Method:** 4-1/4" ID Hollow Stem Auger,
HQ Double Barrel

**Hammer Type:** Auto Hammer (140 lb)

**Dates Started:** 11/21/16 **Finished:** 11/22/16

**X:** 2239230.793 ft **Y:** 706772.5904 ft

**Plunge:** -90 **Bearing:**

**Ground Surface Elevation:** 813± (ft) **Total Depth:** 152.2 ft

**Water Level Observations**

| | Date | Time | Depth | Casing | Caved |
|---|---|---|---|---|---|
| After Drilling | 11/28 | 3:30 PM | 36.2' | 85.0' | --- |

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 0.2 | Rootmat and topsoil | | 812.5 | | | S-1, SPT 3+5+5+7 REC=24", 100% | | |
| 2.0 | FILL, sampled as silt; moist, brown, contains root fragments, stiff to very stiff | FILL | 810.7 | | | S-2, SPT 4+7+9+11 REC=24", 100% | PP = 4.50 tsf | |
| | LEAN CLAY; moist, brown with mottles of gray, stiff to very hard, probable RESIDUAL material | | | | 5 | S-3, SPT 4+7+8+10 REC=24", 100% | PP = 4.50 tsf | |
| | | | | | | UNDIST REC=23", 96% | PP = 4.50 tsf | |
| | Change: gray with mottles of brown | CL | | | 10 | S-4, SPT 4+7+7+10 REC=24", 100% | PP = 4.50 tsf | |
| 15.5 | | | 797.2 | | 15 | S-5, SPT 10+50/0" REC=1", 17% | | Bedding dips generally shallow (0 - 5 degrees), some crossbedding in sandstone lithologies Lost drill return |
| 15.6 | DISINTEGRATED ROCK, sampled as; gray with mottles of brown, very dense, shale | DR | 797.1 | | | R-1, CORE Run = 2.3 ft REC=23", 85% RQD=35", 130% | | |
| | SANDSTONE, medium strong, moderately weathered, highly fractured to moderately fractured, gray and brown, fine to medium grained, micaceous; weathered/iron stained bedding planes and joints, joints dip 30 - 45 degrees | | | | 20 | R-2, CORE Run = 10.0 ft REC=116", 97% RQD=91", 76% | | |
| | | | | | 25 | | | |
| 28.0 | SANDSTONE, medium strong, slightly weathered to fresh, slightly fractured, gray, shale with clay seams from 30 - 30.5 ft, clay partings on some bedding planes | | 784.7 | | 30 | R-3, CORE Run = 10.0 ft REC=110", 92% RQD=101", 84% | | Sand locked twice from 27.9 - 37.9 ft, likely due to low pump pressure |

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TEST BORING LOG 16C15039.00 OHIO.GPJ SCHNABEL DATA TEMPLATE 2008_07_06.GDT 12/5/16

*(continued)*

| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-5**<br>Contract Number: 16C15039.00<br>Sheet: 2 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | SANDSTONE, medium strong, slightly weathered to fresh, slightly fractured, gray, shale with clay seams from 30 - 30.5 ft, clay partings on some bedding planes *(continued)* | | | | | | | |
| 38.7 | Change: Clay seam from 38.5 - 38.7 ft | | 774.0 | | | | | |
| | SILTSTONE, weak, fresh, slightly fractured, dark gray and gray, siltstone/silty shale with sandy laminations | | | | 40 | R-4, CORE<br>Run = 10.0 ft<br>REC=118", 98%<br>RQD=116", 97% | | |
| | | | | | 45 | | | |
| | | | | | | R-5, CORE<br>Run = 10.0 ft<br>REC=112", 93%<br>RQD=88", 73% | | |
| 50.0 | SHALE, very weak to weak, fresh, slightly fractured, dark gray with streaks of red, laminated shale/silty shale; clay seam 57.7 - 57.8, red beds/laminations about 55 ft. | | 762.7 | | 50 | | | |
| | | | | | 55 | | | |
| | | | | | | R-6, CORE<br>Run = 10.0 ft<br>REC=110", 92%<br>RQD=93", 78% | | |
| 59.0 | SILTSTONE, weak, fresh, slightly fractured, gray, siltstone/silty shale | | 753.7 | | 60 | | | |
| 63.3 | SANDSTONE, medium strong, slightly weathered to fresh, slightly fractured, gray, micaceous; mechanical breaks occur on micaceous partings | | 749.4 | | 65 | | | |
| | | | | | | R-7, CORE<br>Run = 10.0 ft<br>REC=104", 87%<br>RQD=104", 87% | | |
| | | | | | 70 | | | |
| | | | | | 75 | | | |
| | | | | | | R-8, CORE<br>Run = 10.0 ft<br>REC=113", 94%<br>RQD=110", 92% | | |
| | | | | | 80 | | | |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-5**<br>Contract Number: 16C15039.00<br>Sheet: 3 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | SANDSTONE, medium strong, slightly weathered to fresh, slightly fractured, gray, micaceous; mechanical breaks occur on micaceous partings *(continued)* | | | | 85 | | | Installed 3-inch PVC casing to 85 ft. |
| | | | | | | R-9, CORE<br>Run = 10.0 ft<br>REC=117", 98%<br>RQD=108", 90% | | |
| | | | | | 90 | | | Rods dropped from 91.3 - 91.5 ft. |
| | | | | | 95 | | | |
| | | | | | | R-10, CORE<br>Run = 10.0 ft<br>REC=116", 97%<br>RQD=116", 97% | | |
| | | | | | 100 | | | |
| | | | | | 105 | | | |
| 108.3 | SHALE, weak to medium strong, fresh, slightly fractured, dark gray, silty shale; very weak shale with clay seams from 108.3 108.4 ft | | 704.4 | | | R-11, CORE<br>Run = 10.0 ft<br>REC=110", 92%<br>RQD=108", 90% | | |
| | | | | | 110 | | | |
| 115.1 | SHALE, weak, fresh, slightly fractured, dark gray to black, CARBONACEOUS SHALE | | 697.6 | | 115 | | | |
| 117.9 | SHALE/GOB, roof shale in direct contact with gob. No obvious drops/openings between mine roof and gob. | | 694.8 | | | R-12, CORE<br>Run = 10.0 ft<br>REC=52", 43%<br>RQD=0", 0% | | Hole caving in, likely gob |
| | | | | | 120 | | | |
| | | | | | 125 | | | |
| 126.0 | SHALE, very weak to weak, fresh, gray, contains calcareous clasts and stringers | | 686.7 | | | | | |
| 128.4 | | | 684.3 | | | R-13, CORE<br>Run = 5.0 ft | | |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-5**<br>Contract Number: 16C15039.00<br>Sheet: 4 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | SILTSTONE, weak to medium strong, fresh, slightly fractured, gray to greenish gray *(continued)* | | | | 130 | REC=60", 100%<br>RQD=60", 100% | | |
| | | | | | | R-14, CORE<br>Run = 10.0 ft<br>REC=112", 93%<br>RQD=112", 93% | | |
| | | | | | 135 | | | |
| 136.0 | SANDSTONE, medium strong to strong, fresh, very slightly fractured, light gray, contains silty laminations | | 676.7 | | | | | |
| | | | | | 140 | | | |
| | | | | | | R-15, CORE<br>Run = 9.3 ft<br>REC=112", 100%<br>RQD=112", 100% | | |
| | | | | | 145 | | | |
| | | | | | 150 | | | |
| 152.2 | | | 660.5 | | | | | |

Bottom of Boring at 152.2 ft.
Boring terminated at selected depth.

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-6**<br>Contract Number: 16C15039.00<br>Sheet: 1 of 4 |
|---|---|---|---|

**Contractor:** Armstrong Drilling
Murraysville, Pennsylvania

**Contractor Foreman:** T. Armstrong

**Schnabel Representative:** Robin Reed

**Equipment:** HM D-50

**Method:** 3-1/4" ID Hollow Stem Auger,
HQ Double Barrel

**Hammer Type:** Auto Hammer (140 lb)

**Dates Started:** 11/8/16 **Finished:** 11/10/16

**X:** 2239343.727 ft **Y:** 704444.2066 ft

**Plunge:** -90 **Bearing:**

**Ground Surface Elevation:** 794± (ft) **Total Depth:** 133.0 ft

**Water Level Observations**

| Date | Time | Depth | Casing | Caved |
|---|---|---|---|---|
| | | | | |

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 0.1 | Rootmat and topsoil | | 793.8 | | | | | |
| | FILL, sampled as lean clay; moist, light brown with mottles of light gray, contains root fragments, soft to medium stiff | FILL | | | | S-1, SPT 4+2+2 REC=18", 100%<br>S-2, SPT 1+1+2 REC=3", 17%<br>S-3, SPT 2+3+4 REC=12", 67% | | |
| | Change: No roots | | | | | | | |
| | Change: light brown with mottles of pinkish gray | | | | 5 | S-4, SPT 2+3+4 REC=15", 83%<br>S-5, SPT 2+1+3 REC=5", 28%<br>S-6, SPT 3+3+5 | | |
| 7.0 | LEAN CLAY; moist, pinkish brown and pinkish gray, soft to medium stiff, probable ALLUVIAL material | | 786.9 | | | | | |
| | Change: pinkish brown and orangish brown | | | | 10 | S-7, SPT 3+3+4 REC=16", 89% | | |
| | | | | | | | | Moisture content increasing, auger cuttings gray at 13 ft. |
| | Change: gray | | | | 15 | S-8, SPT 2+3+3 REC=11", 61% | | |
| | Change: orangish brown | | | | | | | |
| | gray, loose | CL | | | 20 | S-9, SPT 1+1+3 REC=18", 100% | | |
| | | | | | | | | 11/18/16 End of drilling for the day. |
| | | | | | 25 | S-10, SPT 5+4+4 REC=6", 33% | PP = 0.50 tsf | Resume drilling, removed augers; hole advanced with washed casing |
| | | | | | 30 | S-11, SPT 4+4+6 REC=18", 100% | PP = 1.00 tsf | |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-6**<br>Contract Number: 16C15039.00<br>Sheet: 2 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 35.0 | LEAN CLAY; moist, gray, stiff, probable ALLUVIAL material, contains 0.25 inch thick layers of bluish green lean clay; possible varves (lacustrine deposit) | CL | 758.9 | | | S-12, SPT 4+5+5 | PP = 1.00 tsf | Bluish green layers possibly varves |
| | | | | | 40 | S-13, SPT 4+6+8 REC=18", 100% | PP = 2.25 tsf | |
| | Change: contains trace of mica and organics | | | | 45 | S-14, SPT 3+4+5 REC=15", 83% | | No pocket pen at 45 ft, sample suctioned out bottom of spoon |
| 50.5 | | CL | 743.4 | | 50 | S-15, SPT 6+8+7 REC=8", 44% | | No pocket pen at 50 ft, rock/gravel in bottom of shoe |
| 51.0 | SANDY LEAN CLAY; moist, gray and bluish green, contains fine sand, probable ALLUVIAL material | | 742.9 | | | | | |
| | POORLY GRADED SILTY SAND WITH GRAVEL, fine to medium; wet, gray and bluish green, medium dense, probable ALLUVIAL material | SM | | | | | | Firmed up at 53 ft.<br>Hard at 53 ft, softened at 54 ft. |
| 55.0 | | | 738.9 | | 55 | S-16, SPT REC=0", 0% | | |
| | NO RECOVERY, likely sand/gravel, installed sample retainer | | | | | | | |
| 58.0 | SANDY LEAN CLAY; moist, gray, contains fine sand, stiff, probable ALLUVIAL material | CL | 735.9 | | 60 | S-17, SPT 4+5+6 REC=18", 100% | | No pocket pen at 60 ft, sample suctioned out bottom of spoon |
| 63.0 | POORLY GRADED SILTY SAND, fine; moist, gray, contains layers of fine sandy silt, loose, probable ALLUVIAL material, moist to wet | SP-SM | 730.9 | | 65 | S-18, SPT 2+3+5 REC=18", 100% | | |
| 67.5 | DISINTEGRATED ROCK, sampled as; very dense, Hard from 67.5 to 68, broke thru at 68 to 70 ft. Likely zone of differentially weathered disintegrated rock | DR | 726.4 | | | | | |
| 70.0 | | DR | 723.9 | | 70 | S-19, SPT 50/1" REC=1", 100% R-1, CORE Run = 2.9 ft REC=30", 86% RQD=30", 86% R-2, CORE Run = 10.0 ft REC=92", 77% RQD=92", 77% | | Bedding dips generally shallow (0 - 5 degrees), some crossbedding in sandstone lithologies |
| 70.1 | DISINTEGRATED ROCK, sampled as; very dense, Light greenish gray sandstone | | 723.8 | | | | | |
| | SANDSTONE, weak to medium strong, slightly weathered to fresh, slightly fractured to very slightly fractured, light gray, very thin < 2.5 in at 0° to 20°, fine to medium grained, crossbedded, micaceous; core breakage from 70 - 74 ft is mechanical due to cavitation/wobble of rods in large diameter hole. Mechanical breakage occurs along (micaceous) bedding planes. | | | | 75<br>80 | | | |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-6**<br>Contract Number: 16C15039.00<br>Sheet: 3 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | SANDSTONE, weak to medium strong, slightly weathered to fresh, slightly fractured to very slightly fractured, light gray, very thin < 2.5 in at 0° to 20°, fine to medium grained, crossbedded, micaceous; core breakage from 70 - 74 ft is mechanical due to cavitation/wobble of rods in large diameter hole. Mechanical breakage occurs along (micaceous) bedding planes. *(continued)* | | | | 85<br>90<br>95<br>100<br>105<br>110<br>115<br>120<br>125 | R-3, CORE<br>Run = 10.0 ft<br>REC=118", 98%<br>RQD=118", 98%<br>R-4, CORE<br>Run = 10.0 ft<br>REC=120", 100%<br>RQD=120", 100%<br>R-5, CORE<br>Run = 6.2 ft<br>REC=50", 67%<br>RQD=50", 67%<br>R-6, CORE<br>Run = 13.2 ft<br>REC=48", 30%<br>RQD=0", 0%<br>R-7, CORE<br>Run = 0.6 ft<br>REC=5", 69%<br>RQD=0", 0%<br>R-8, CORE<br>Run = 10.0 ft<br>REC=110", 92%<br>RQD=88", 73% | | |
| 108.0 | SHALE, Rock type based on change in color of drill return (dark gray) and drill response (increased water pressure), no shale recovered in core run from 103 - 109.2 ft. | | 685.9 | | | | | |
| 109.2 | Imperial Mine, open from 109.2 - 114.5 ft. Pieces of dark gray shale recovered between 114.5 and 119.3 ft likely from roof cave in. If gob present beneath roof shale, likely washed out during coring. | | 684.7 | | | | | |
| 119.3<br>119.4 | Floor coal, black | | 674.6<br>674.5 | | | | | |
| | gray, Underclay, swells in barrel amd causes core blockages | | | | | | | Core barrel blocked off briefly at 120 ft |
| 122.6 | SHALE, gray with mottles of greenish gray, very thin < 2.5 in at 0° to 10°, Conglomeratic, contains clayey partings; core around 128 ft that appears ground up is attributable to running out of water at supply tank. | | 671.3 | | | | | Core barrel blocked off at 122.4, pulled inner barrel |

*(continued)*

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-6**<br>Contract Number: 16C15039.00<br>Sheet: 4 of 4 |
|---|---|---|---|

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | | | 130 | | | |
| 133.0 | | | 660.9 | | | | | |

Bottom of Boring at 133.0 ft.
Auger refusal at 70.1 ft.
Boring terminated at selected depth.

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| Schnabel ENGINEERING | TEST BORING LOG | Project: Guernsey Power Station<br>Byesville, Ohio | Boring Number: **B-6A**<br>Contract Number: 16C15039.00<br>Sheet: 1 of 1 |
|---|---|---|---|

**Contractor:** Armstrong Drilling
Murraysville, Pennsylvania

**Contractor Foreman:** T. Armstrong

**Schnabel Representative:** Robin Reed

**Equipment:** HM D-50

**Method:** 4-1/4" ID Hollow Stem Auger

**Hammer Type:** Auto Hammer (140 lb)

**Dates Started:** 11/11/16 **Finished:** 11/11/16

**Plunge:** **Bearing:**

**Ground Surface Elevation:** 794± (ft) **Total Depth:** 22.0 ft

**Water Level Observations**

| Date | Time | Depth | Casing | Caved |
|---|---|---|---|---|
| | | | | |

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | Bulk sample collected from 0 to 5.0 ft. | | | | | GRAB | | |
| 5.0 | Auger probe to 20.0 ft. No SPT sampling performed. See Boring B-6 for strata descriptions. | | 789.0 | | 5 | AUGER | | |
| | | | | | 10 | | | |
| | | | | | 15 | | | |
| 20.0 | Shelby Tube sample collected. | | 774.0 | | 20 | UNDIST REC=24", 100% | | |
| 22.0 | | | 772.0 | | | | | |

Bottom of Boring at 22.0 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.
Boring B-6A was offset 4.3 ft. north-northeast of Boring B-6 to collect Bulk and Shelby Tube samples.

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| Schnabel ENGINEERING | AUGER PROBE LOG | **Project:** Guernsey Power Station<br>Byesville, Ohio | **Auger Probe Number:** **CPT-02A**<br>**Contract Number:** 16C15039.00<br>**Sheet:** 1 of 1 |
|---|---|---|---|

**Contractor:** Armstrong Drilling
Murraysville, Pennsylvania

**Contractor Foreman:** T. Armstrong

**Schnabel Representative:** Robin Reed

**Equipment:** HM D-50

**Method:** 4-1/4" ID Hollow Stem Auger

**Hammer Type:** Auto Hammer (140 lb)

**Dates Started:** 11/28/16 **Finished:** 11/28/16

**Plunge:** -90 **Bearing:**

**Ground Surface Elevation:** 830± (ft) **Total Depth:** 10.0 ft

**Water Level Observations**

| Date | Time | Depth | Casing | Caved |
|---|---|---|---|---|
| | | | | |

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | Auger probe only to collect bulk samples. No SPT sampling performed.<br>Change: Bulk sample collected from 0 - 5 ft. | | | | | | | |
| | Change: Bulk sample collected from 5 - 10 ft. | | | | 5 | | | |
| 10.0 | | | 820.0 | | 10 | | | |

Bottom of Auger Probe at 10.0 ft.
Boring backfilled with cuttings upon completion.

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| Schnabel ENGINEERING | AUGER PROBE LOG | **Project:** Guernsey Power Station<br>Byesville, Ohio | **Auger Probe Number:** **CPT-04A**<br>**Contract Number:** 16C15039.00<br>**Sheet:** 1 of 1 |
|---|---|---|---|

**Contractor:** Armstrong Drilling
Murraysville, Pennsylvania

**Contractor Foreman:** T. Armstrong

**Schnabel Representative:** Robin Reed

**Equipment:** HM D-50

**Method:** 4-1/4" ID Hollow Stem Auger

**Hammer Type:** Auto Hammer (140 lb)

**Dates Started:** 11/15/16 **Finished:** 11/15/16

**Plunge:** -90 **Bearing:**

**Ground Surface Elevation:** 832± (ft) **Total Depth:** 5.0 ft

**Water Level Observations**

| Date | Time | Depth | Casing | Caved |
|---|---|---|---|---|
| | | | | |

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | Auger probe only to collect bulk sample . No SPT sampling performed. Change: Bulk sample collected from 0 - 5 ft. | | | | | | | |
| 5.0 | | | 827.0 | | 5 | | | |

Bottom of Auger Probe at 5.0 ft.
Boring backfilled with cuttings upon completion.

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| Schnabel ENGINEERING | AUGER PROBE LOG | **Project:** Guernsey Power Station<br>Byesville, Ohio | **Auger Probe Number:** **CPT-07A**<br>**Contract Number:** 16C15039.00<br>**Sheet:** 1 of 1 |
|---|---|---|---|

**Contractor:** Armstrong Drilling
Murraysville, Pennsylvania

**Contractor Foreman:** T. Armstrong

**Schnabel Representative:** Robin Reed

**Equipment:** HM D-50

**Method:** 4-1/4" ID Hollow Stem Auger

**Hammer Type:** Auto Hammer (140 lb)

**Dates Started:** 11/28/16 **Finished:** 11/28/16

**Plunge:** -90 **Bearing:**

**Ground Surface Elevation:** 830± (ft) **Total Depth:** 10.0 ft

**Water Level Observations**

| Date | Time | Depth | Casing | Caved |
|---|---|---|---|---|
| | | | | |

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | Auger probe only to collect bulk samples. No SPT sampling performed.<br>Change: Bulk sample collected from 0 - 5 ft. | | | | | | | |
| | Change: Bulk sample collected from 5 - 10 ft. | | | | 5 | | | |
| 10.0 | | | 820.0 | | 10 | | | |

Bottom of Auger Probe at 10.0 ft.
Boring backfilled with cuttings upon completion.

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| Schnabel ENGINEERING | AUGER PROBE LOG | **Project:** Guernsey Power Station<br>Byesville, Ohio | **Auger Probe Number:** **CPT-08A**<br>**Contract Number:** 16C15039.00<br>**Sheet:** 1 of 1 |
|---|---|---|---|

**Contractor:** Armstrong Drilling
Murraysville, Pennsylvania

**Contractor Foreman:** T. Armstrong

**Schnabel Representative:** Robin Reed

**Equipment:** HM D-50

**Method:** 4-1/4" ID Hollow Stem Auger

**Hammer Type:** Auto Hammer (140 lb)

**Dates Started:** 11/28/16 **Finished:** 11/28/16

**Plunge:** -90 **Bearing:**

**Ground Surface Elevation:** **Total Depth:** 5.0 ft

**Water Level Observations**

| Date | Time | Depth | Casing | Caved |
|---|---|---|---|---|
| | | | | |

| DEPTH (ft) | MATERIAL DESCRIPTION | SYMBOL | ELEV (ft) | STRATUM | SAMPLING DEPTH | SAMPLING DATA | TESTS | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | Auger probe only to collect bulk sample. No SPT sampling performed. Change: Bulk sample collected from 0 - 5 ft. | | | | | | | |
| 5.0 | | | | | 5 | | | |

Bottom of Auger Probe at 5.0 ft.
Boring backfilled with cuttings upon completion.

DRAFT

# APPENDIX B

# CONE PENETRATION TESTING (CPT) DATA REPORT PREPARED BY CONETEC, INC.



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# PRESENTATION OF SITE INVESTIGATION RESULTS

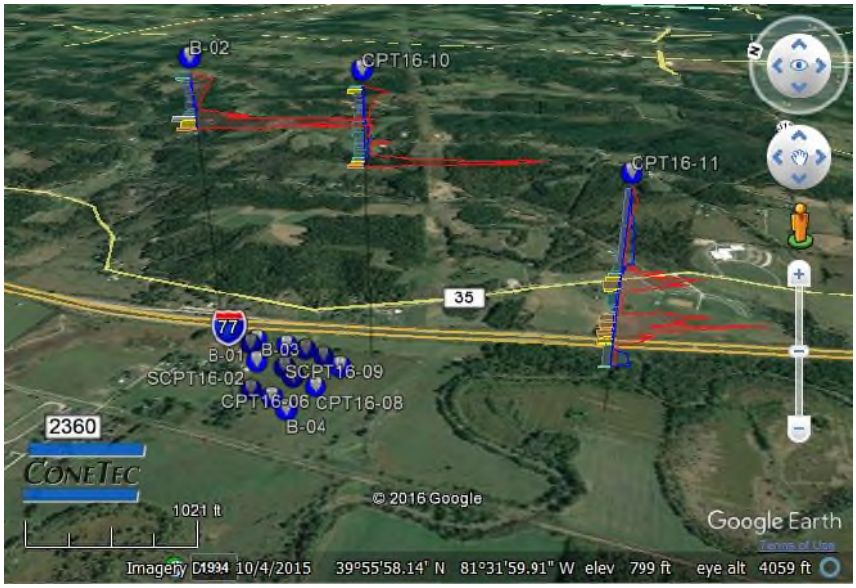
## Proposed Guernsey Power Station
## Byesville, Ohio

*Prepared for*:

Schnabel Engineering

ConeTec Job No: 16-53106

Project Start Date: 2-Nov-2016
Project End Date: 3-Nov-2016
Report Date: 11-Nov-2016




*Prepared by:*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Introduction

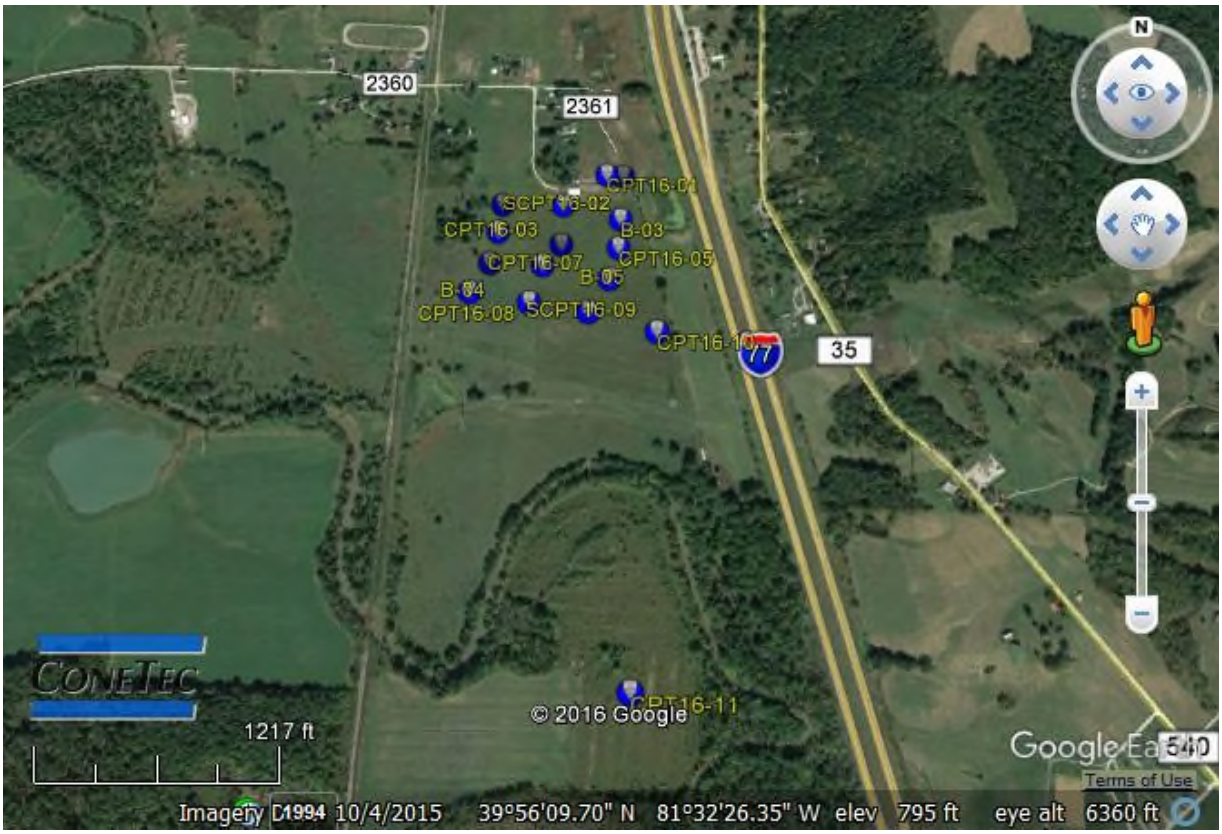
The enclosed report presents the results of a piezocone penetration testing (CPTu or CPT) and seismic piezocone penetration testing (SCPTu or SCPT) program carried out at the proposed Guernsey Power Station site located near Byesville, Ohio. The site investigation program was conducted by ConeTec Inc. (ConeTec), under contract to Schnabel Engineering of West Chester, Pennsylvania.

A total of 14 cone penetration tests and 2 seismic cone penetration tests were completed at 16 locations. The CPT and SCPT program was performed to evaluate the subsurface soil conditions. CPT and SCPT sounding locations were selected and numbered under supervision of Schnabel personnel (Ms. Robin Reed).

Project Information

| Project | |
|---|---|
| Client | Schnabel Engineering |
| Project | Guernsey Power Station |
| ConeTec project number | 16-53106 |

A map from Google earth including the CPT test locations is presented below.



| Rig Description | Deployment System | Test Type |
|---|---|---|
| CPT Track Rig | 20 ton track mounted (twin cylinders) | CPT and SCPT |

| Coordinates | | |
|---|---|---|
| Test Type | Collection Method | EPSG Number |
| CPT and SCPT | GPS (GlobalSat MR-350) | 32617 (WGS 84 / UTM North) |

| Cone Penetration Test (CPT) | |
|---|---|
| Depth reference | Ground surface at the time of the investigation. |
| Tip and sleeve data offset | 0.1 meter. This has been accounted for in the CPT data files. |
| Pore pressure dissipation (PPD) tests | Four pore pressure dissipation test was completed to determine the phreatic surface and consolidation characteristics. |
| Additional Comments | Shear wave velocity tests were conducted at various depth intervals at two locations. |

| Cone Description | Cone Number | Cross Sectional Area ($cm^2$) | Sleeve Area ($cm^2$) | Tip Capacity (bar) | Sleeve Capacity (bar) | Pore Pressure Capacity (psi) |
|---|---|---|---|---|---|---|
| 236:T1500F15U500 | 236 | 15 | 225 | 1500 | 15 | 500 |
| 467:T1500F15U500 | 467 | 15 | 225 | 1500 | 15 | 500 |

Limitations

This report has been prepared for the exclusive use of Schnabel Engineering (Client) for the project titled "Guernsey Power Station". The report's contents may not be relied upon by any other party without the express written permission of ConeTec. ConeTec has provided site investigation services, prepared the factual data reporting, and provided geotechnical parameter calculations consistent with current best practices. No other warranty, expressed or implied, is made.

The information presented in the report document and the accompanying data set pertain to the specific project, site conditions and objectives described to ConeTec by the Client. In order to properly understand the factual data, assumptions and calculations, reference must be made to the documents provided and their accompanying data sets, in their entirety.

The cone penetration tests (CPTu) are conducted using an integrated electronic piezocone penetrometer and data acquisition system manufactured by Adara Systems Ltd. of Richmond, British Columbia, Canada.

ConeTec's piezocone penetrometers are compression type designs in which the tip and friction sleeve load cells are independent and have separate load capacities. The piezocones use strain gauged load cells for tip and sleeve friction and a strain gauged diaphragm type transducer for recording pore pressure. The piezocones also have a platinum resistive temperature device (RTD) for monitoring the temperature of the sensors, an accelerometer type dual axis inclinometer and a geophone sensor for recording seismic signals. All signals are amplified down hole within the cone body and the analog signals are sent to the surface through a shielded cable.

ConeTec penetrometers are manufactured with various tip, friction and pore pressure capacities in both 10 $cm^2$ and 15 $cm^2$ tip base area configurations in order to maximize signal resolution for various soil conditions. The 15 $cm^2$ penetrometers do not require friction reducers as they have a diameter larger than the deployment rods. The 10 $cm^2$ piezocones use a friction reducer consisting of a rod adapter extension behind the main cone body with an enlarged cross sectional area (typically 44 mm diameter over a length of 32 mm with tapered leading and trailing edges) located at a distance of 585 mm above the cone tip.

The penetrometers are designed with equal end area friction sleeves, a net end area ratio of 0.8 and cone tips with a 60 degree apex angle.

All ConeTec piezocones can record pore pressure at various locations. Unless otherwise noted, the pore pressure filter is located directly behind the cone tip in the "$u_2$" position (ASTM Type 2). The filter is 6 mm thick, made of porous plastic (polyethylene) having an average pore size of 125 microns (90-160 microns). The function of the filter is to allow rapid movements of extremely small volumes of water needed to activate the pressure transducer while preventing soil ingress or blockage.

The piezocone penetrometers are manufactured with dimensions, tolerances and sensor characteristics that are in general accordance with the current ASTM D5778 standard. ConeTec's calibration criteria also meet or exceed those of the current ASTM D5778 standard. An illustration of the piezocone penetrometer is presented in Figure CPTu.

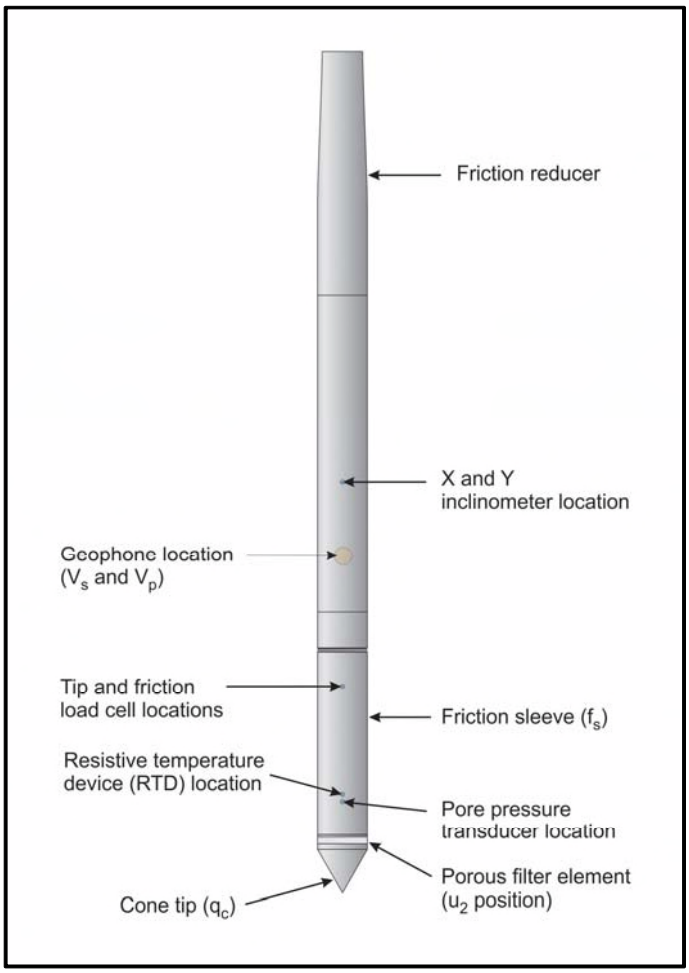



Figure CPTu. Piezocone Penetrometer (15 $cm^2$)

The ConeTec data acquisition systems consist of a Windows based computer and a signal conditioner and power supply interface box with a 16 bit (or greater) analog to digital (A/D) converter. The data is recorded at fixed depth increments using a depth wheel attached to the push cylinders or by using a spring loaded rubber depth wheel that is held against the cone rods. The typical recording intervals are either 2.5 cm or 5.0 cm depending on project requirements; custom recording intervals are possible. The system displays the CPTu data in real time and records the following parameters to a storage media during penetration:

- Depth
- Uncorrected tip resistance ($q_c$)
- Sleeve friction ($f_s$)
- Dynamic pore pressure (u)
- Additional sensors such as resistivity, passive gamma, ultra violet induced fluorescence, if applicable

All testing is performed in accordance to ConeTec's CPT operating procedures which are in general accordance with the current ASTM D5778 standard.

Prior to the start of a CPTu sounding a suitable cone is selected, the cone and data acquisition system are powered on, the pore pressure system is saturated with either glycerin or silicone oil and the baseline readings are recorded with the cone hanging freely in a vertical position.

The CPTu is conducted at a steady rate of 2 cm/s, within acceptable tolerances. Typically one meter length rods with an outer diameter of 1.5 inches are added to advance the cone to the sounding termination depth. After cone retraction final baselines are recorded.

Additional information pertaining to ConeTec's cone penetration testing procedures:

- Each filter is saturated in silicone oil or glycerin under vacuum pressure prior to use
- Recorded baselines are checked with an independent multi-meter
- Baseline readings are compared to previous readings
- Soundings are terminated at the client's target depth or at a depth where an obstruction is encountered, excessive rod flex occurs, excessive inclination occurs, equipment damage is likely to take place, or a dangerous working environment arises
- Differences between initial and final baselines are calculated to ensure zero load offsets have not occurred and to ensure compliance with ASTM standards

The interpretation of piezocone data for this report is based on the corrected tip resistance ($q_t$), sleeve friction ($f_s$) and pore water pressure (u). The interpretation of soil type is based on the correlations developed by Robertson (1990) and Robertson (2009). It should be noted that it is not always possible to accurately identify a soil type based on these parameters. In these situations, experience, judgment and an assessment of other parameters may be used to infer soil behavior type.

The recorded tip resistance ($q_c$) is the total force acting on the piezocone tip divided by its base area. The tip resistance is corrected for pore pressure effects and termed corrected tip resistance ($q_t$) according to the following expression presented in Robertson et al, 1986:

$$q_t = q_c + (1-a) \bullet u_2$$

where: $q_t$ is the corrected tip resistance
$q_c$ is the recorded tip resistance
$u_2$ is the recorded dynamic pore pressure behind the tip ($u_2$ position)
a is the Net Area Ratio for the piezocone (0.8 for ConeTec probes)

The sleeve friction ($f_s$) is the frictional force on the sleeve divided by its surface area. As all ConeTec piezocones have equal end area friction sleeves, pore pressure corrections to the sleeve data are not required.

The dynamic pore pressure (u) is a measure of the pore pressures generated during cone penetration. To record equilibrium pore pressure, the penetration must be stopped to allow the dynamic pore pressures to stabilize. The rate at which this occurs is predominantly a function of the permeability of the soil and the diameter of the cone.

The friction ratio (Rf) is a calculated parameter. It is defined as the ratio of sleeve friction to the tip resistance expressed as a percentage. Generally, saturated cohesive soils have low tip resistance, high

friction ratios and generate large excess pore water pressures. Cohesionless soils have higher tip resistances, lower friction ratios and do not generate significant excess pore water pressure.

A summary of the CPTu soundings along with test details and individual plots are provided in the appendices. A set of interpretation files were generated for each sounding based on published correlations and are provided in Excel format in the data release folder. Information regarding the interpretation methods used is included in an appendix.

For additional information on CPTu interpretations, refer to Robertson et al. (1986), Lunne et al. (1997), Robertson (2009), Mayne (2013, 2014) and Mayne and Peuchen (2012).

References

ASTM D5778-12, 2012, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils", ASTM, West Conshohocken, US.

Lunne, T., Robertson, P.K. and Powell, J. J. M., 1997, “Cone Penetration Testing in Geotechnical Practice”, Blackie Academic and Professional.

Mayne, P.W., 2013, “Evaluating yield stress of soils from laboratory consolidation and in-situ cone penetration tests”, Sound Geotechnical Research to Practice (Holtz Volume) GSP 230, ASCE, Reston/VA: 406-420.

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Shear wave velocity testing is performed in conjunction with the piezocone penetration test (SCPTu) in order to collect interval velocities. For some projects seismic compression wave (Vp) velocity is also determined.

ConeTec's piezocone penetrometers are manufactured with a horizontally active geophone (28 hertz) that is rigidly mounted in the body of the cone penetrometer, 0.2 meters behind the cone tip.

Shear waves are typically generated by using an impact hammer horizontally striking a beam that is held in place by a normal load. In some instances an auger source or an imbedded impulsive source maybe used for both shear waves and compression waves. The hammer and beam act as a contact trigger that triggers the recording of the seismic wave traces. For impulsive devices an accelerometer trigger may be used. The traces are recorded using an up-hole integrated digital oscilloscope which is part of the SCPTu data acquisition system. An illustration of the shear wave testing configuration is presented in Figure SCPTu-1.

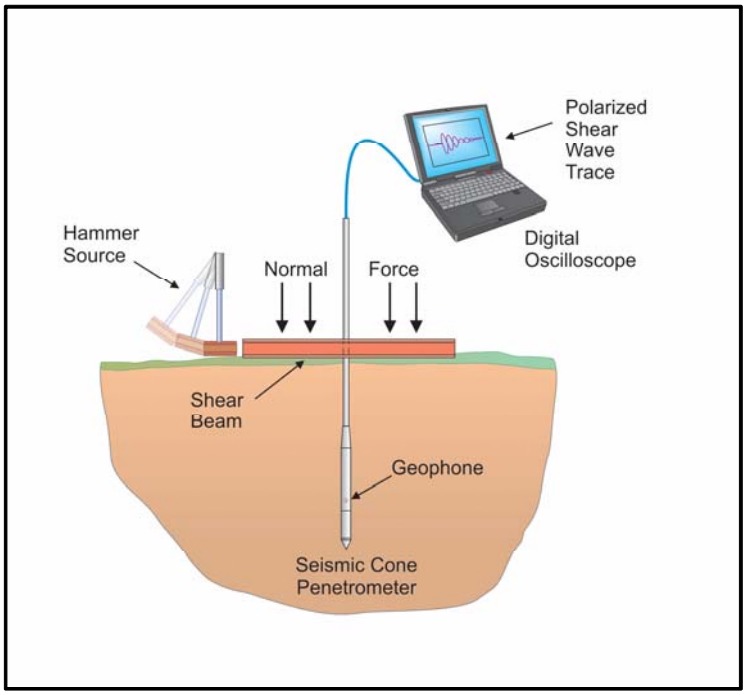


Figure SCPTu-1. Illustration of the SCPTu system

All testing is performed in accordance to ConeTec's SCPTu operating procedures.

Prior to the start of a SCPTu sounding, the procedures described in the Cone Penetration Test section are followed. In addition, the active axis of the geophone is aligned parallel to the beam (or source) and the horizontal offset between the cone and the source is measured and recorded.

Prior to recording seismic waves at each test depth, cone penetration is stopped and the rods are decoupled from the rig to avoid transmission of rig energy down the rods. Multiple wave traces are recorded for quality control purposes. After reviewing wave traces for consistency the cone is pushed to the next test depth (typically one meter intervals or as requested by the client). Figure SCPTu-2 presents an illustration of a SCPTu test.

For additional information on seismic cone penetration testing refer to Robertson et.al. (1986).

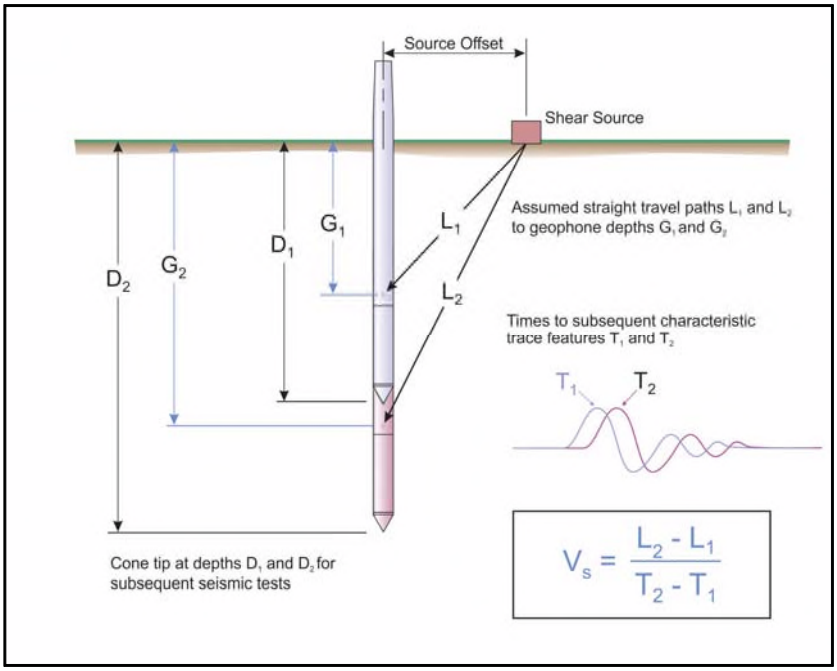


Figure SCPTu-2. Illustration of a seismic cone penetration test

Calculation of the interval velocities are performed by visually picking a common feature (e.g. the first characteristic peak, trough, or crossover) on all of the recorded wave sets and taking the difference in ray path divided by the time difference between subsequent features. Ray path is defined as the straight line distance from the seismic source to the geophone, accounting for beam offset, source depth and geophone offset from the cone tip.

The average shear wave velocity to a depth of 100 feet (30 meters) ($\bar{v}_s$) has been calculated and provided for all applicable soundings using the following equation presented in ASCE, 2010.

$$\bar{v}_s = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{v_{si}}}$$

where: $\bar{v}_s$ = average shear wave velocity ft/s (m/s)
$d_i$ = the thickness of any layer between 0 and 100 ft (30 m)
$v_{si}$ = the shear wave velocity in ft/s (m/s)
$\sum_{i=1}^{n} d_i$ = 100 ft (30 m)

Average shear wave velocity, $\bar{v}_s$ is also referenced to $V_{s100}$ or $V_{s30}$.

The layer travel times refers to the travel times propagating in the vertical direction, not the measured travel times from an offset source.

Tabular results and SCPTu plots are presented in the relevant appendix.

References

American Society of Civil Engineers (ASCE), 2010, “Minimum Design Loads for Buildings and Other Structures”, Standard ASCE/SEI 7-10, American Society of Civil Engineers, ISBN 978-0-7844-1085-1, Reston, Virginia.

Robertson, P.K., Campanella, R.G., Gillespie D and Rice, A., 1986, “Seismic CPT to Measure In-Situ Shear Wave Velocity”, Journal of Geotechnical Engineering ASCE, Vol. 112, No. 8: 791-803.

The cone penetration test is halted at specific depths to carry out pore pressure dissipation (PPD) tests, shown in Figure PPD-1. For each dissipation test the cone and rods are decoupled from the rig and the data acquisition system measures and records the variation of the pore pressure (u) with time (t).

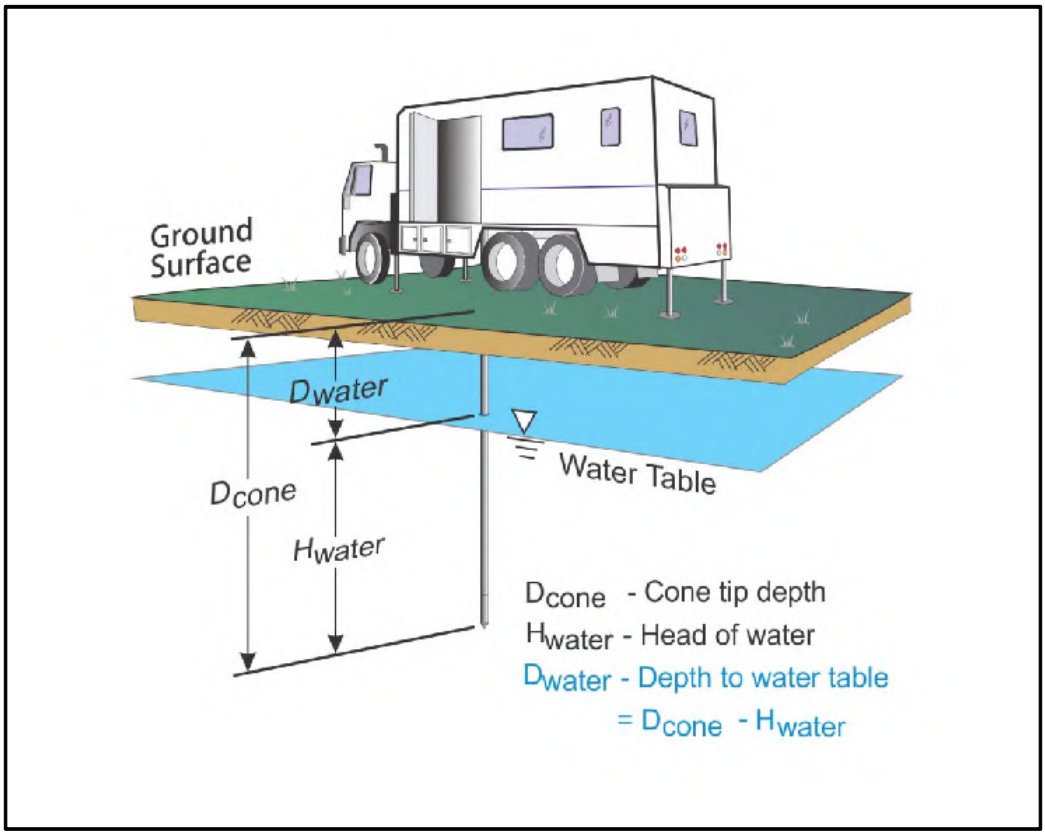


Figure PPD-1. Pore pressure dissipation test setup

Pore pressure dissipation data can be interpreted to provide estimates of ground water conditions, permeability, consolidation characteristics and soil behavior.

The typical shapes of dissipation curves shown in Figure PPD-2 are very useful in assessing soil type, drainage, in situ pore pressure and soil properties. A flat curve that stabilizes quickly is typical of a freely draining sand. Undrained soils such as clays will typically show positive excess pore pressure and have long dissipation times. Dilative soils will often exhibit dynamic pore pressures below equilibrium that then rise over time. Overconsolidated fine-grained soils will often exhibit an initial dilatory response where there is an initial rise in pore pressure before reaching a peak and dissipating.

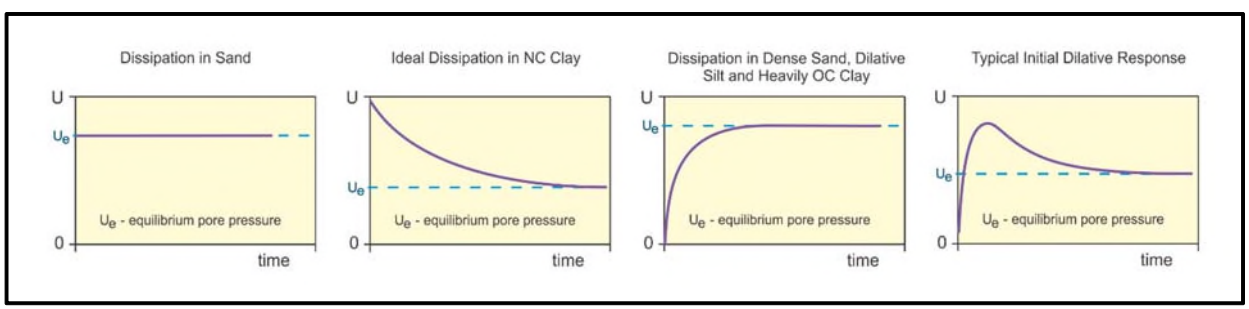


Figure PPD-2. Pore pressure dissipation curve examples

In order to interpret the equilibrium pore pressure ($u_{eq}$) and the apparent phreatic surface, the pore pressure should be monitored until such time as there is no variation in pore pressure with time as shown for each curve of Figure PPD-2.

In fine grained deposits the point at which 100% of the excess pore pressure has dissipated is known as $t_{100}$. In some cases this can take an excessive amount of time and it may be impractical to take the dissipation to $t_{100}$. A theoretical analysis of pore pressure dissipations by Teh and Houlsby (1991) showed that a single curve relating degree of dissipation versus theoretical time factor (T*) may be used to calculate the coefficient of consolidation ($c_h$) at various degrees of dissipation resulting in the expression for $c_h$ shown below.

$$c_h = \frac{T^* \cdot a^2 \cdot \sqrt{I_r}}{t}$$

Where:

T* is the dimensionless time factor (Table Time Factor)
a is the radius of the cone
$I_r$ is the rigidity index
t is the time at the degree of consolidation

Table Time Factor. T* versus degree of dissipation (Teh and Houlsby, 1991)

| Degree of Dissipation (%) | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
|---|---|---|---|---|---|---|---|
| T* ($u_2$) | 0.038 | 0.078 | 0.142 | 0.245 | 0.439 | 0.804 | 1.60 |

The coefficient of consolidation is typically analyzed using the time ($t_{50}$) corresponding to a degree of dissipation of 50% ($u_{50}$). In order to determine $t_{50}$, dissipation tests must be taken to a pressure less than $u_{50}$. The $u_{50}$ value is half way between the initial maximum pore pressure and the equilibrium pore pressure value, known as $u_{100}$. To estimate $u_{50}$, both the initial maximum pore pressure and $u_{100}$ must be known or estimated. Other degrees of dissipations may be considered, particularly for extremely long dissipations.

At any specific degree of dissipation the equilibrium pore pressure (u at $t_{100}$) must be estimated at the depth of interest. The equilibrium value may be determined from one or more sources such as measuring the value directly ($u_{100}$), estimating it from other dissipations in the same profile, estimating the phreatic surface and assuming hydrostatic conditions, from nearby soundings, from client provided information, from site observations and/or past experience, or from other site instrumentation.

For calculations of $c_h$ (Teh and Houlsby, 1991), $t_{50}$ values are estimated from the corresponding pore pressure dissipation curve and a rigidity index ($I_r$) is assumed. For curves having an initial dilatory response in which an initial rise in pore pressure occurs before reaching a peak, the relative time from the peak value is used in determining $t_{50}$. In cases where the time to peak is excessive, $t_{50}$ values are not calculated.

Due to possible inherent uncertainties in estimating $I_r$, the equilibrium pore pressure and the effect of an initial dilatory response on calculating $t_{50}$, other methods should be applied to confirm the results for $c_h$.

Additional published methods for estimating the coefficient of consolidation from a piezocone test are described in Burns and Mayne (1998, 2002), Jones and Van Zyl (1981), Robertson et al. (1992) and Sully et al. (1999).

A summary of the pore pressure dissipation tests and dissipation plots are presented in the relevant appendix.

References

Burns, S.E. and Mayne, P.W., 1998, "Monotonic and dilatory pore pressure decay during piezocone tests", Canadian Geotechnical Journal 26 (4): 1063-1073.

Burns, S.E. and Mayne, P.W., 2002, "Analytical cavity expansion-critical state model cone dissipation in fine-grained soils", Soils & Foundations, Vol. 42(2): 131-137.

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Sully, J.P., Robertson, P.K., Campanella, R.G. and Woeller, D.J., 1999, "An approach to evaluation of field CPTU dissipation data in overconsolidated fine-grained soils", Canadian Geotechnical Journal, 36(2): 369-381.

Teh, C.I., and Houlsby, G.T., 1991, "An analytical study of the cone penetration test in clay", Geotechnique, 41(1): 17-34.

The appendices listed below are included in the report:

- Cone Penetration Test Summary and Standard Cone Penetration Test Plots
- Normalized Cone Penetration Test Plots
- Seismic Cone Penetration Test Plots
- Seismic Cone Penetration Test Tabular Results
- Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots

Cone Penetration Test Summary and

Standard Cone Penetration Test Plots

CONETEC

| | |
|---|---|
| Job No: | 16-53106 |
| Client: | Schnabel Engineering |
| Project: | Guernsey Power Station |
| Start Date: | 02-Nov-2016 |
| End Date: | 03-Nov-2016 |

## *CONE PENETRATION TEST SUMMARY*

| Sounding ID | File Name | Date | Cone | Assumed Phreatic Surface[1] (ft) | Final Depth (ft) | Shear Wave Velocity Tests | Northing[2] (m) | Easting (m) | Refer to Notation Number |
|---|---|---|---|---|---|---|---|---|---|
| CPT16-01 | 16-53106_CP01 | 3-Nov-2016 | 467:T1500F15U500 | 9.5 | 8.53 | | 4421059 | 454330 | 3 |
| SCPT16-02 | 16-53106_SP02 | 3-Nov-2016 | 467:T1500F15U500 | 9.5 | 17.72 | 4 | 4420995 | 454250 | 3 |
| CPT16-03 | 16-53106_CP03 | 2-Nov-2016 | 236:T1500F15U500 | 9.5 | 14.76 | | 4420944 | 454133 | 3 |
| CPT16-04 | 16-53106_CP04 | 2-Nov-2016 | 236:T1500F15U500 | 9.5 | 18.87 | | 4420916 | 454247 | 3 |
| CPT16-05 | 16-53106_CP05 | 2-Nov-2016 | 236:T1500F15U500 | 9.5 | 21.98 | | 4420909 | 454349 | 3 |
| CPT16-06 | 16-53106_CP06 | 3-Nov-2016 | 467:T1500F15U500 | 9.5 | 8.37 | | 4420881 | 454120 | 3 |
| CPT16-07 | 16-53106_CP07 | 2-Nov-2016 | 236:T1500F15U500 | 9.5 | 15.91 | | 4420875 | 454214 | 3 |
| CPT16-08 | 16-53106_CP08 | 2-Nov-2016 | 236:T1500F15U500 | 9.5 | 11.48 | | 4420803 | 454191 | 3 |
| SCPT16-09 | 16-53106_SP09 | 3-Nov-2016 | 467:T1500F15U500 | 9.5 | 17.72 | 4 | 4420784 | 454295 | 3 |
| CPT16-10 | 16-53106_CP10 | 2-Nov-2016 | 236:T1500F15U500 | 9.5 | 26.74 | | 4420746 | 454414 | 3 |
| CPT16-11 | 16-53106_CP11 | 2-Nov-2016 | 236:T1500F15U500 | 9.5 | 60.04 | | 4420140 | 454356 | |
| B-01 | 16-53106_CPB01 | 3-Nov-2016 | 467:T1500F15U500 | 9.5 | 6.73 | | 4421057 | 454360 | 3 |
| B-02 | 16-53106_CPB02 | 3-Nov-2016 | 467:T1500F15U500 | 9.5 | 16.08 | | 4420999 | 454141 | 3 |
| B-03 | 16-53106_CPB03 | 3-Nov-2016 | 467:T1500F15U500 | 9.5 | 19.52 | | 4420967 | 454354 | 3 |
| B-04 | 16-53106_CPB04 | 3-Nov-2016 | 467:T1500F15U500 | 9.5 | 12.47 | | 4420826 | 454085 | 3 |
| B-05 | 16-53106_CPB05 | 3-Nov-2016 | 467:T1500F15U500 | 9.5 | 14.11 | | 4420848 | 454332 | 3 |
| Totals | 16 soundings | | | | 291.01 | 8 | | | |

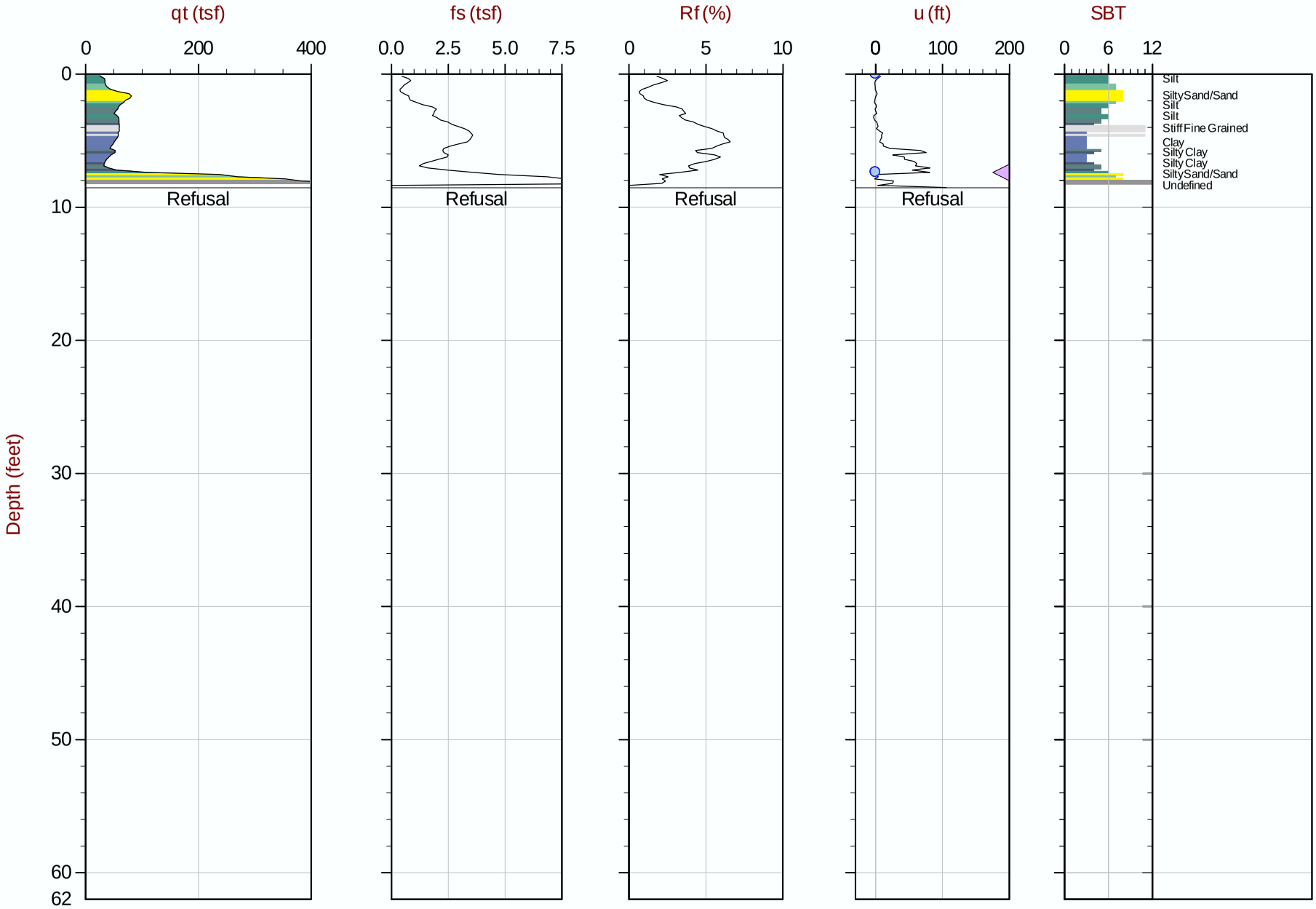
1. Assumed phreatic surface depths were determined from the pore pressure data unless otherwise noted. Hydrostatic data were used for calculated parameters.
2. Coordinates are WGS 84 / UTM Zone 17 and were collected using a MR-350 GlobalSat GPS Receiver.
3. Assumed phreatic surface estimated from adjacent CPT pore pressure dissipation test.
4. No phreatic surface detected

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-03 10:26
Site: Guernsey Power Station

Sounding: CPT16-01
Cone: 467:T1500F15U500

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Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CP01.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4421059m E: 454330m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

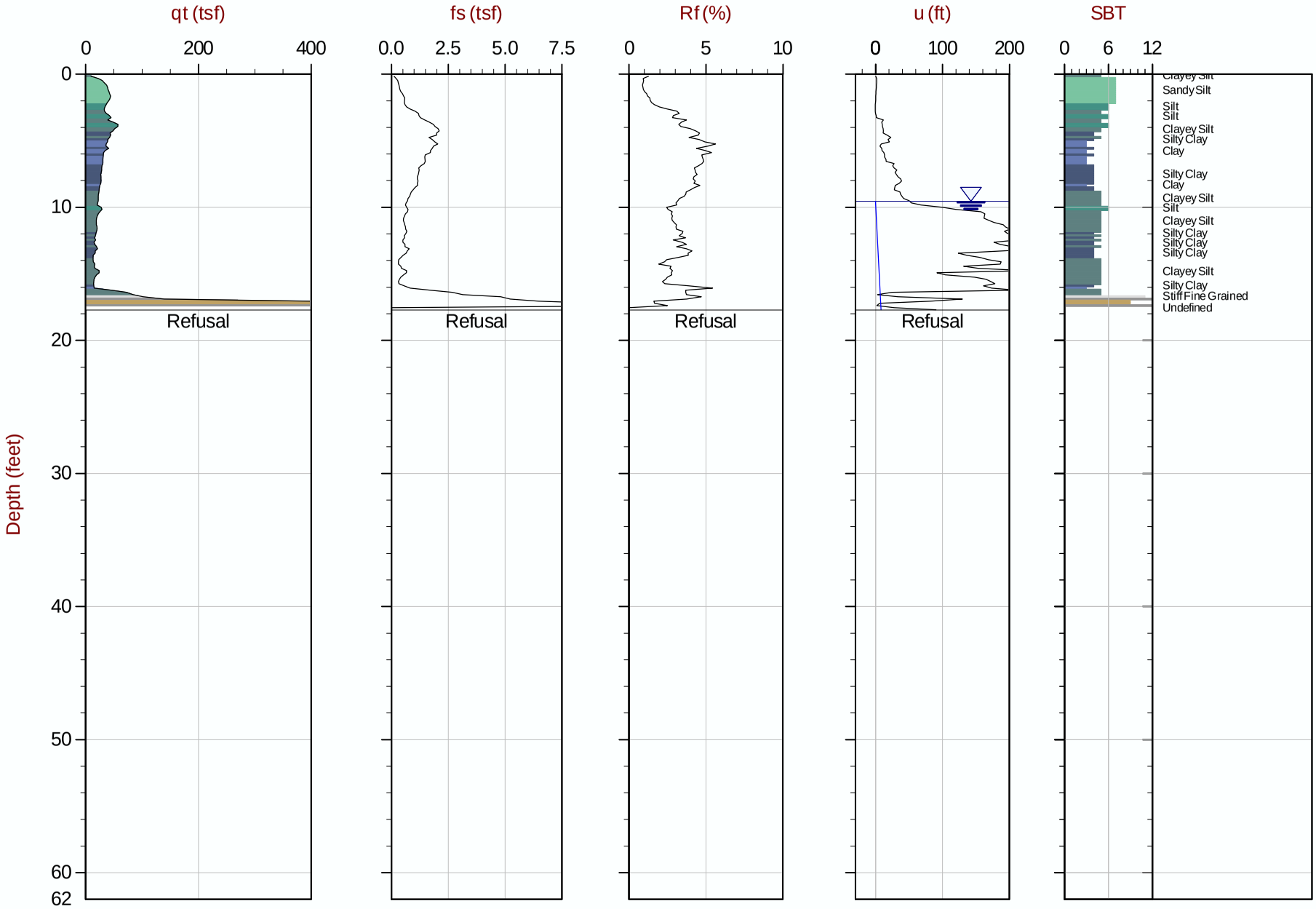
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-03 09:27
Site: Guernsey Power Station

Sounding: SCPT16-02
Cone: 467:T1500F15U500




Max Depth: 5.400 m / 17.72 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_SP02.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420995m E: 454250m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

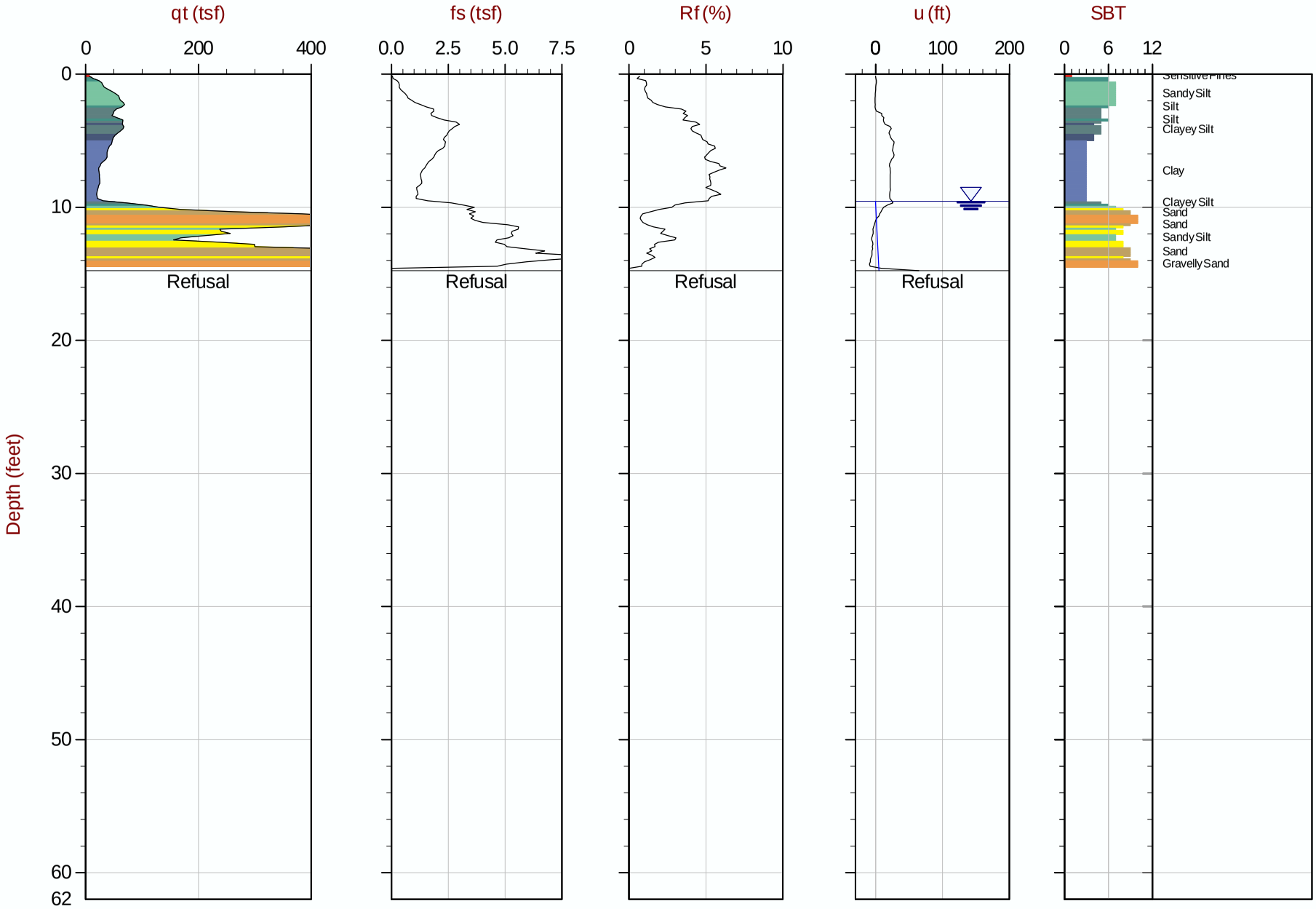
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-02 14:54
Site: Guernsey Power Station

Sounding: CPT16-03
Cone: 236:T1500F15U500




Max Depth: 4.500 m / 14.76 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CP03.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420944m E: 454133m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-02 15:20
Site: Guernsey Power Station

Sounding: CPT16-04
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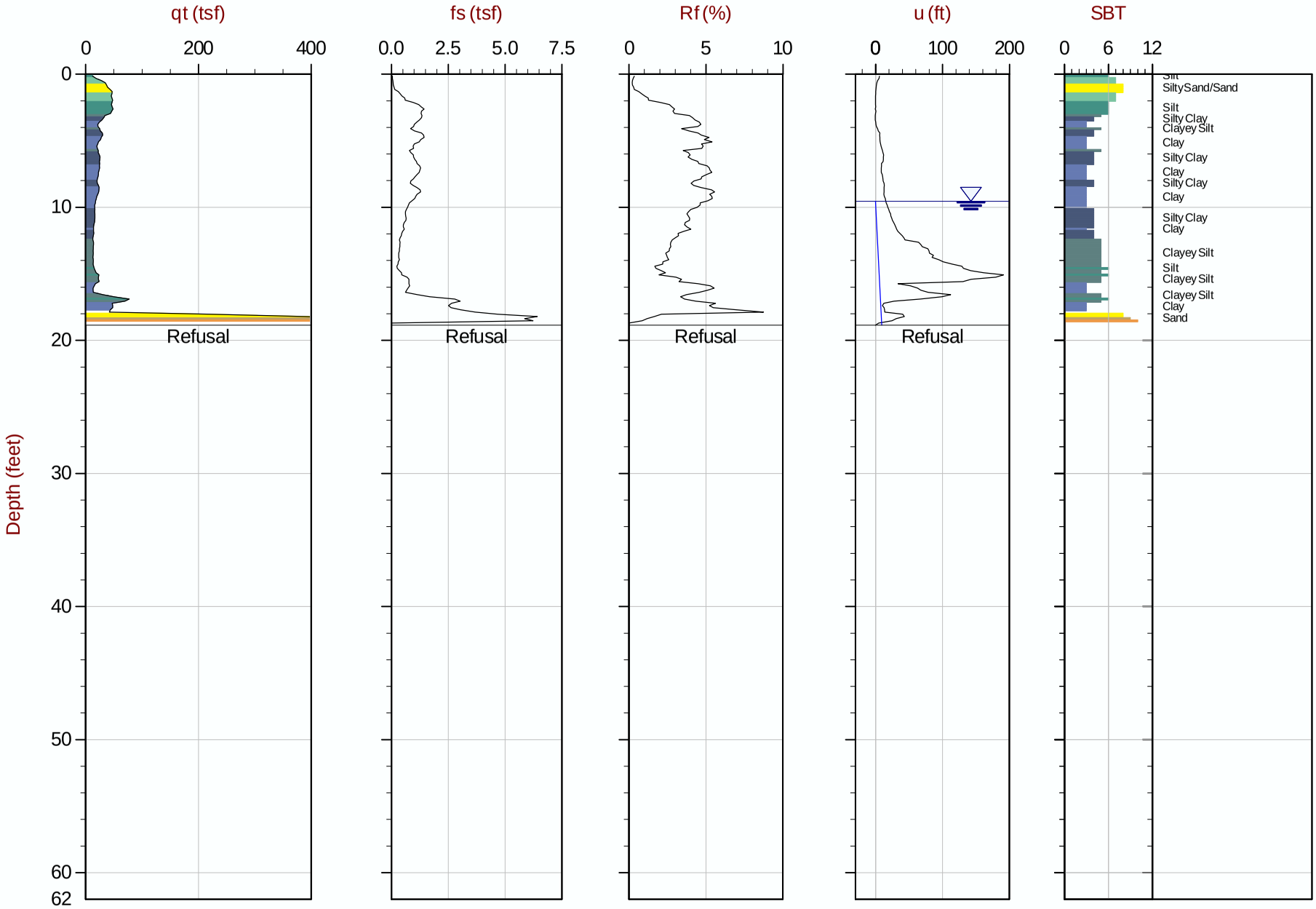



Max Depth: 5.750 m / 18.86 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CP04.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420916m E: 454247m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

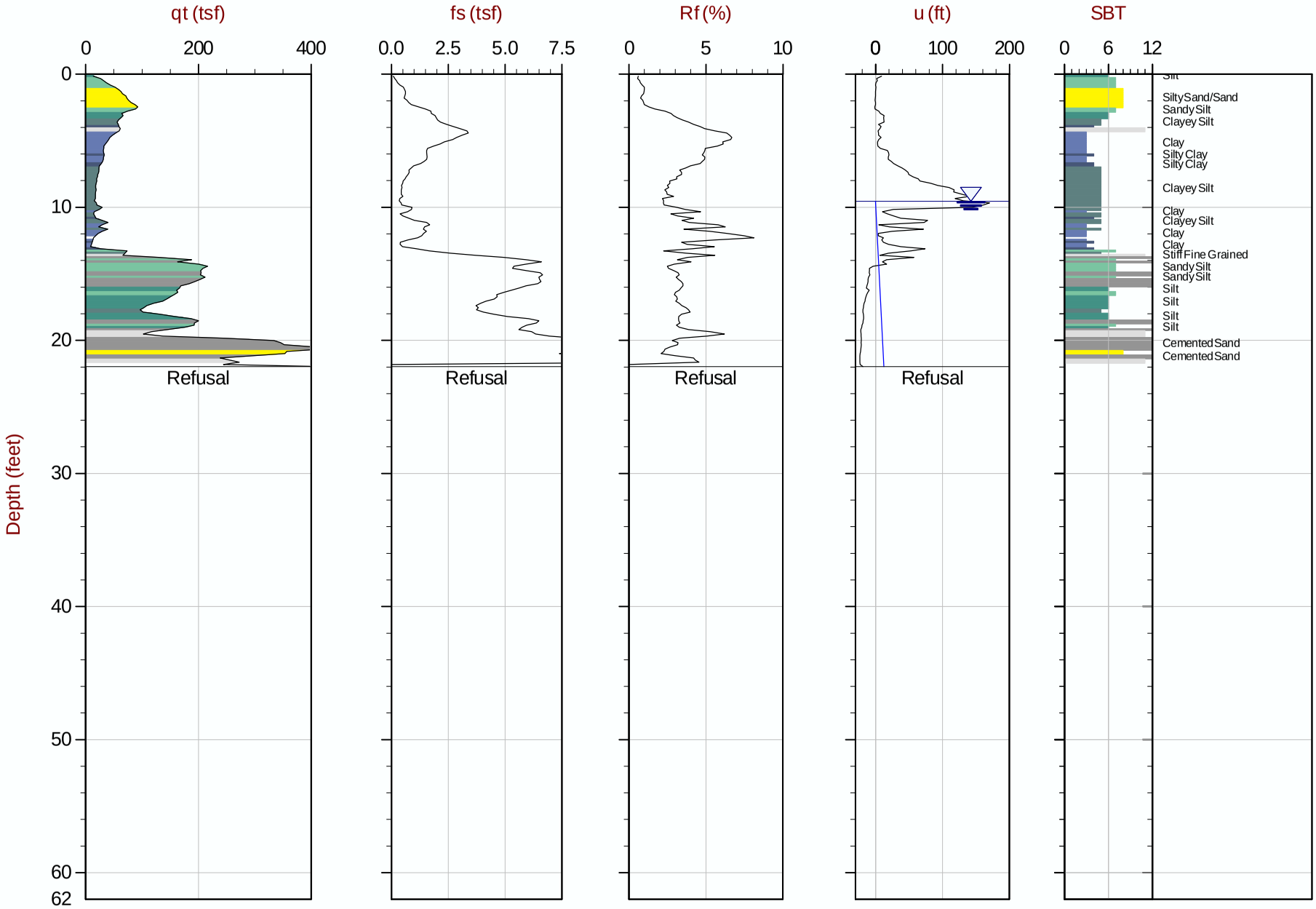
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-02 15:51
Site: Guernsey Power Station

Sounding: CPT16-05
Cone: 236:T1500F15U500




Max Depth: 6.700 m / 21.98 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CP05.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420909m E: 454349m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

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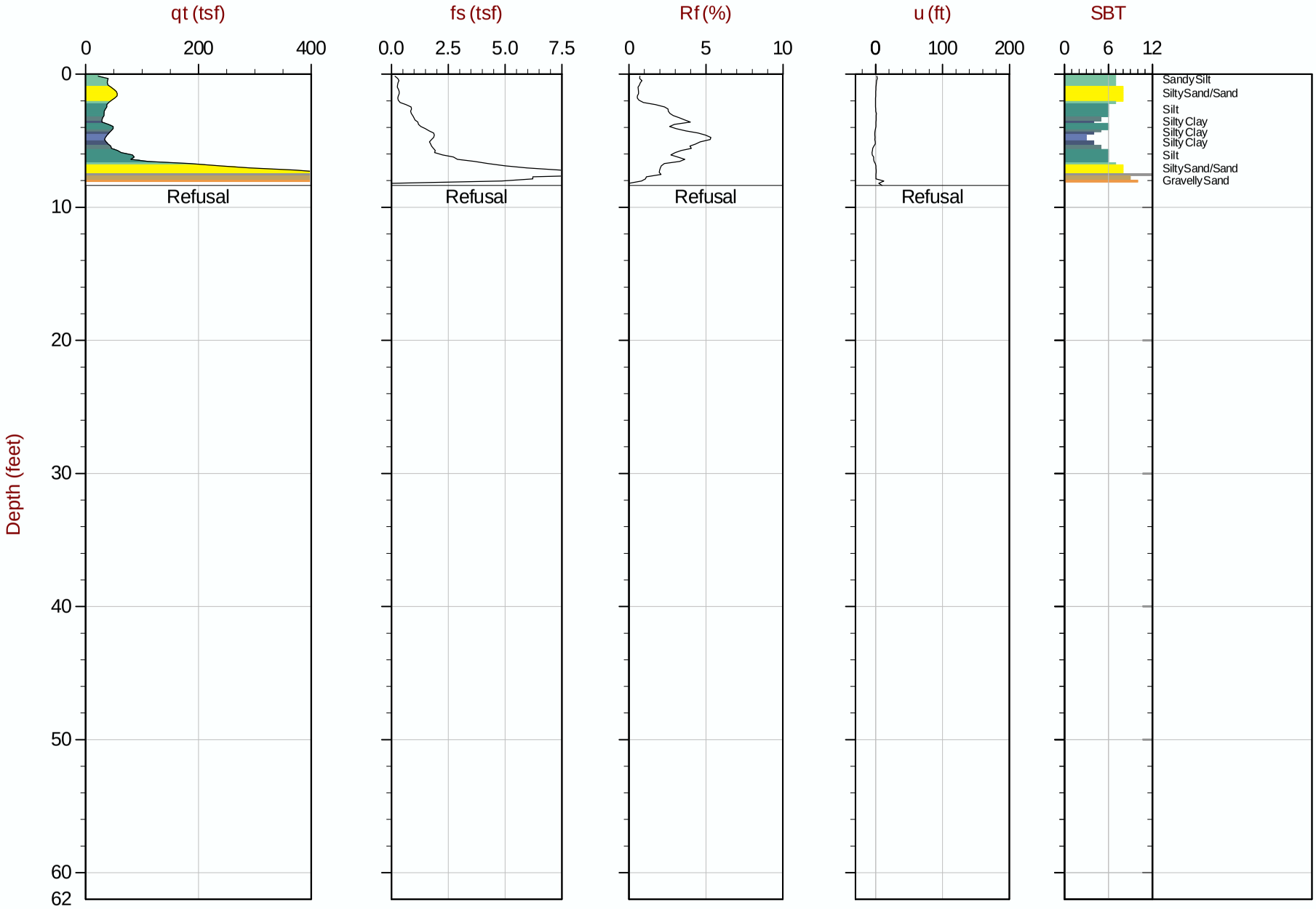
Date: 2016-11-03 12:02
Site: Guernsey Power Station

Sounding: CPT16-06
Cone: 467:T1500F15U500




Max Depth: 2.550 m / 8.37 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CP06.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420881m E: 454120m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

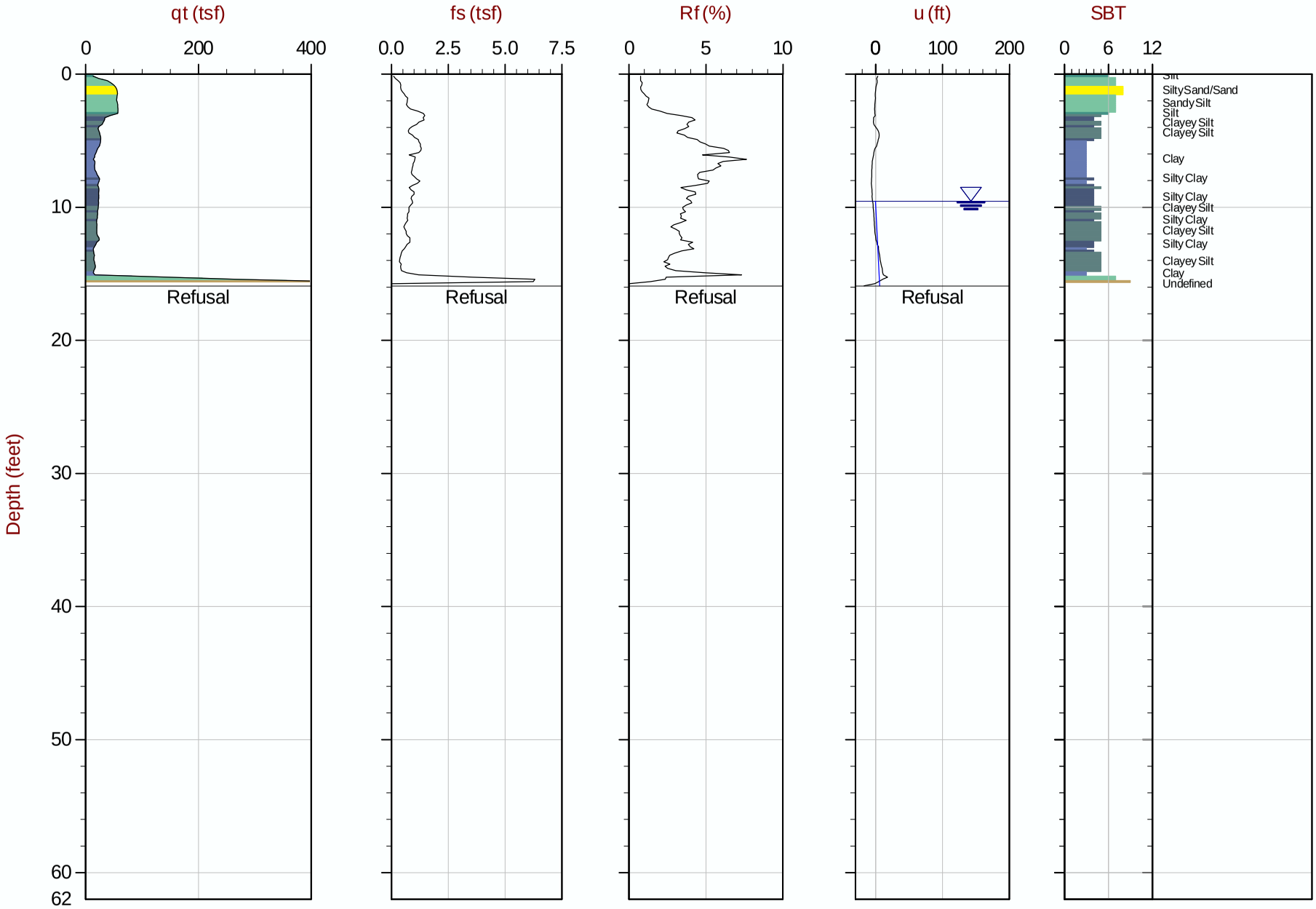
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-02 17:27
Site: Guernsey Power Station

Sounding: CPT16-07
Cone: 236:T1500F15U500




Max Depth: 4.850 m / 15.91 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CP07.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420875m E: 454214m

Hydrostatic Line  Ueq  Assumed Ueq  PPD, Ueq achieved  PPD, Ueq not achieved

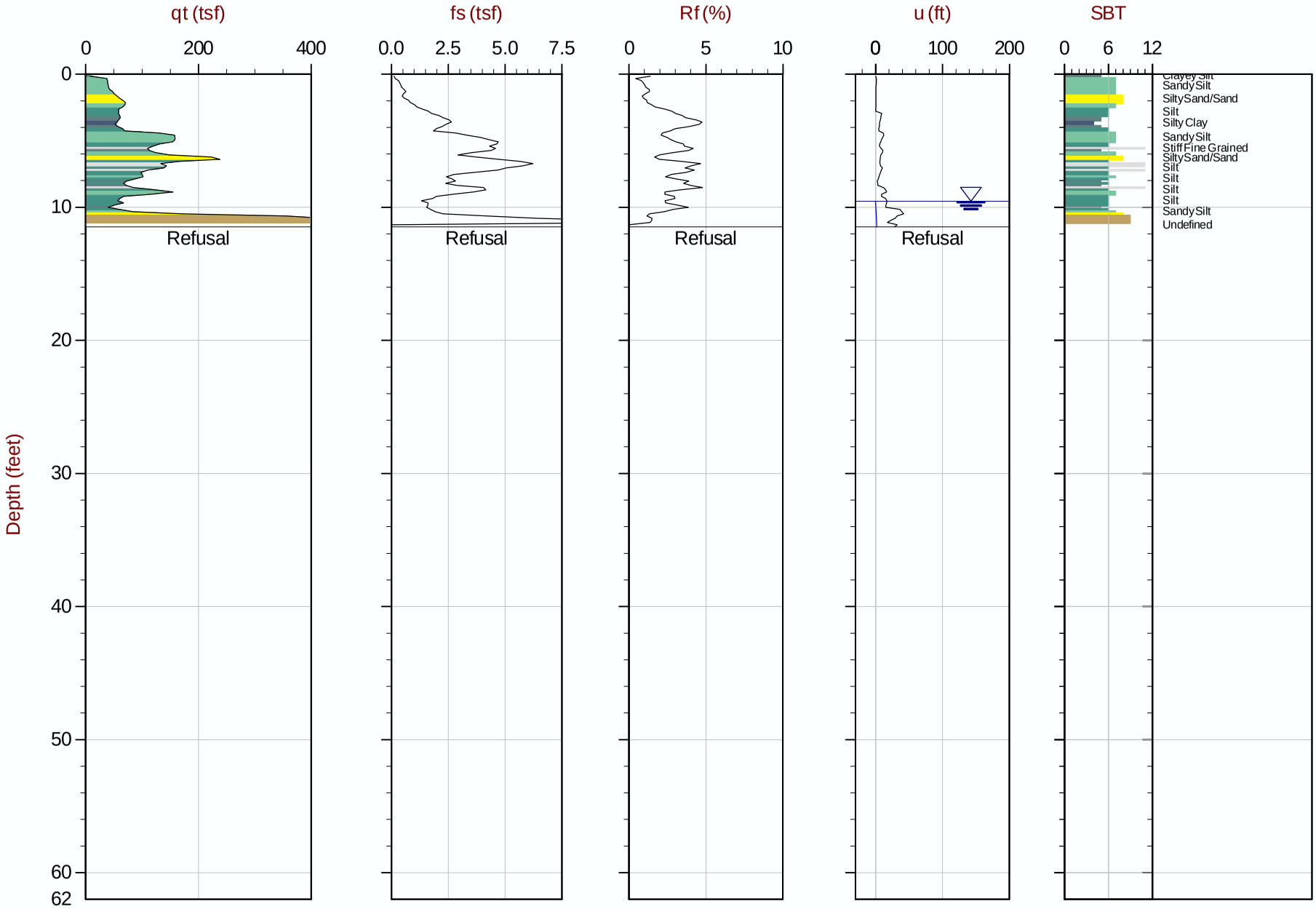
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-02 17:57
Site: Guernsey Power Station

Sounding: CPT16-08
Cone: 236:T1500F15U500




Max Depth: 3.500 m / 11.48 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CP08.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420803m E: 454191m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

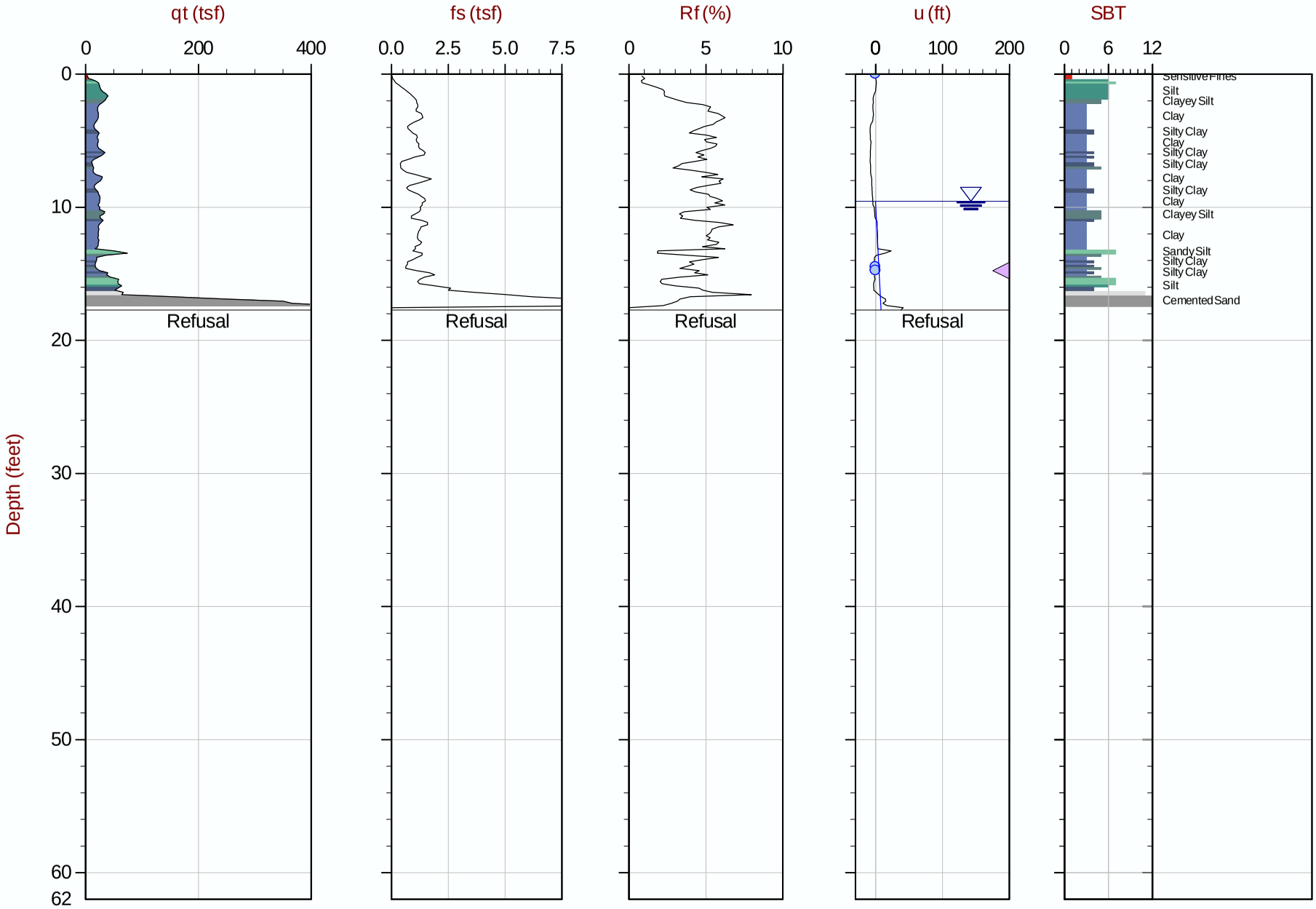
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-03 13:30
Site: Guernsey Power Station

Sounding: SCPT16-09
Cone: 467:T1500F15U500




Max Depth: 5.400 m / 17.72 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_SP09.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420784m E: 454295m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

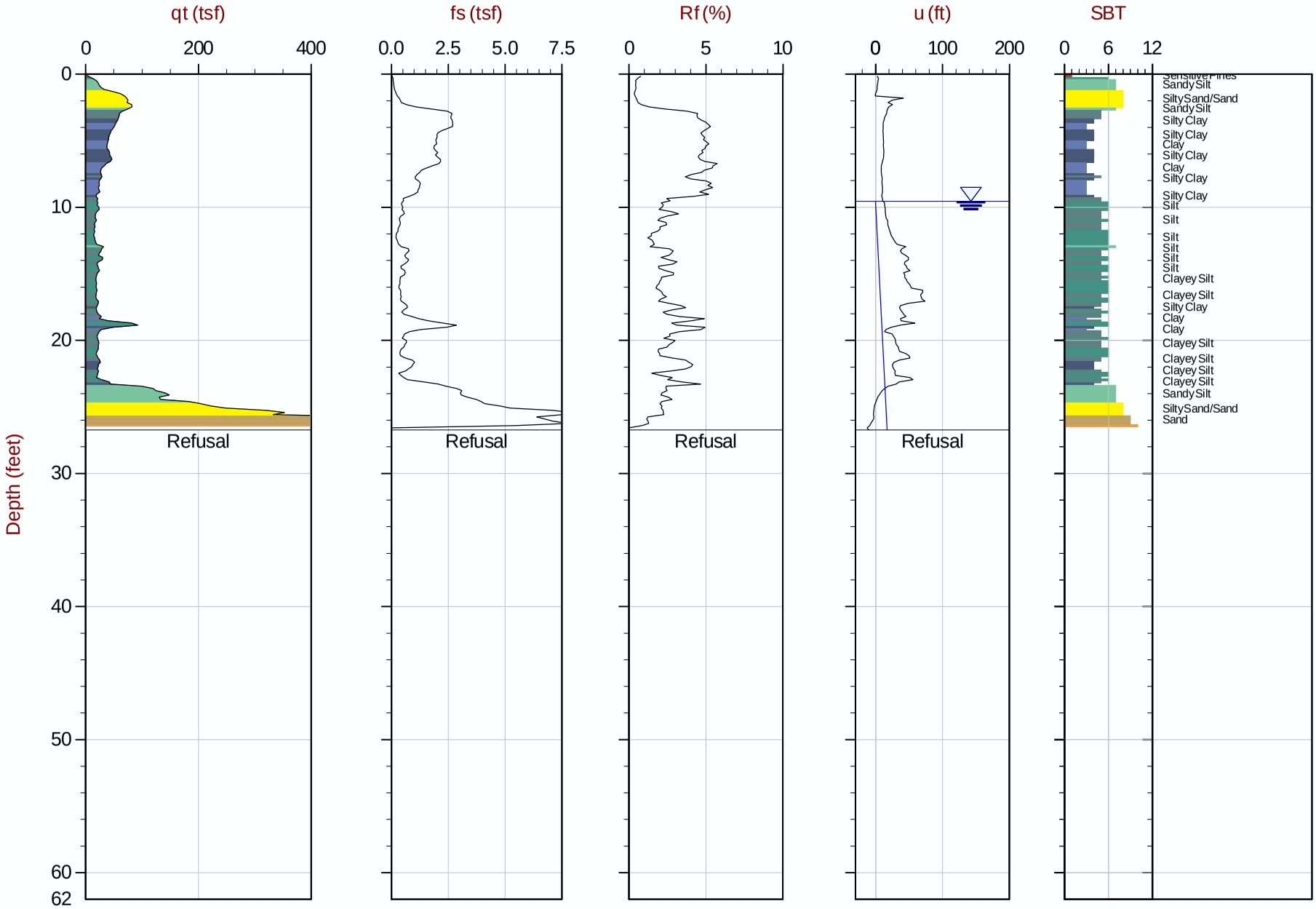
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-02 16:34
Site: Guernsey Power Station

Sounding: CPT16-10
Cone: 236:T1500F15U500




Max Depth: 8.150 m / 26.74 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CP10.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420746m E: 454414m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

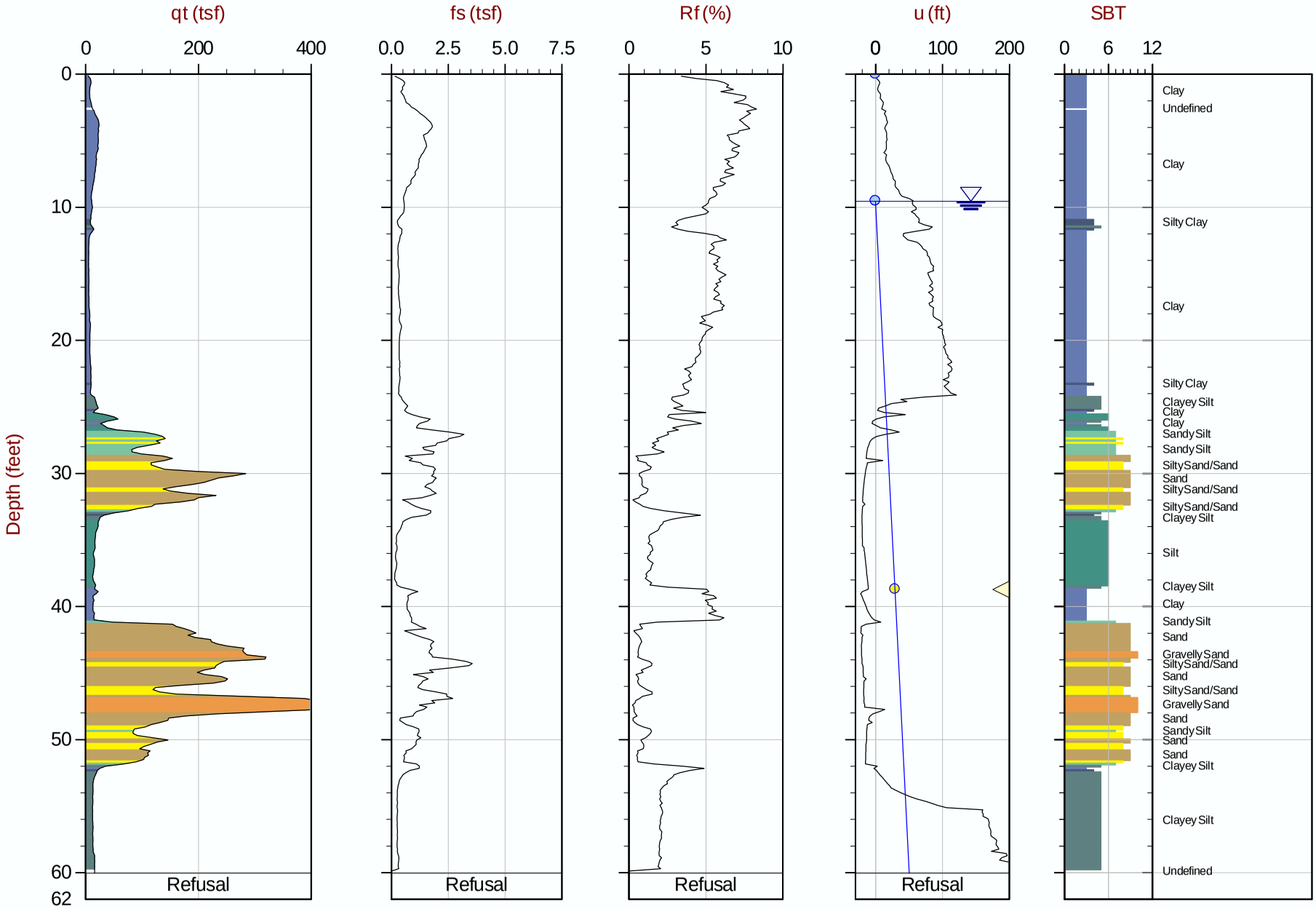
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-02 09:36
Site: Guernsey Power Station

Sounding: CPT16-11
Cone: 236:T1500F15U500




Max Depth: 18.300 m / 60.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CP11.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420140m E: 454356m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

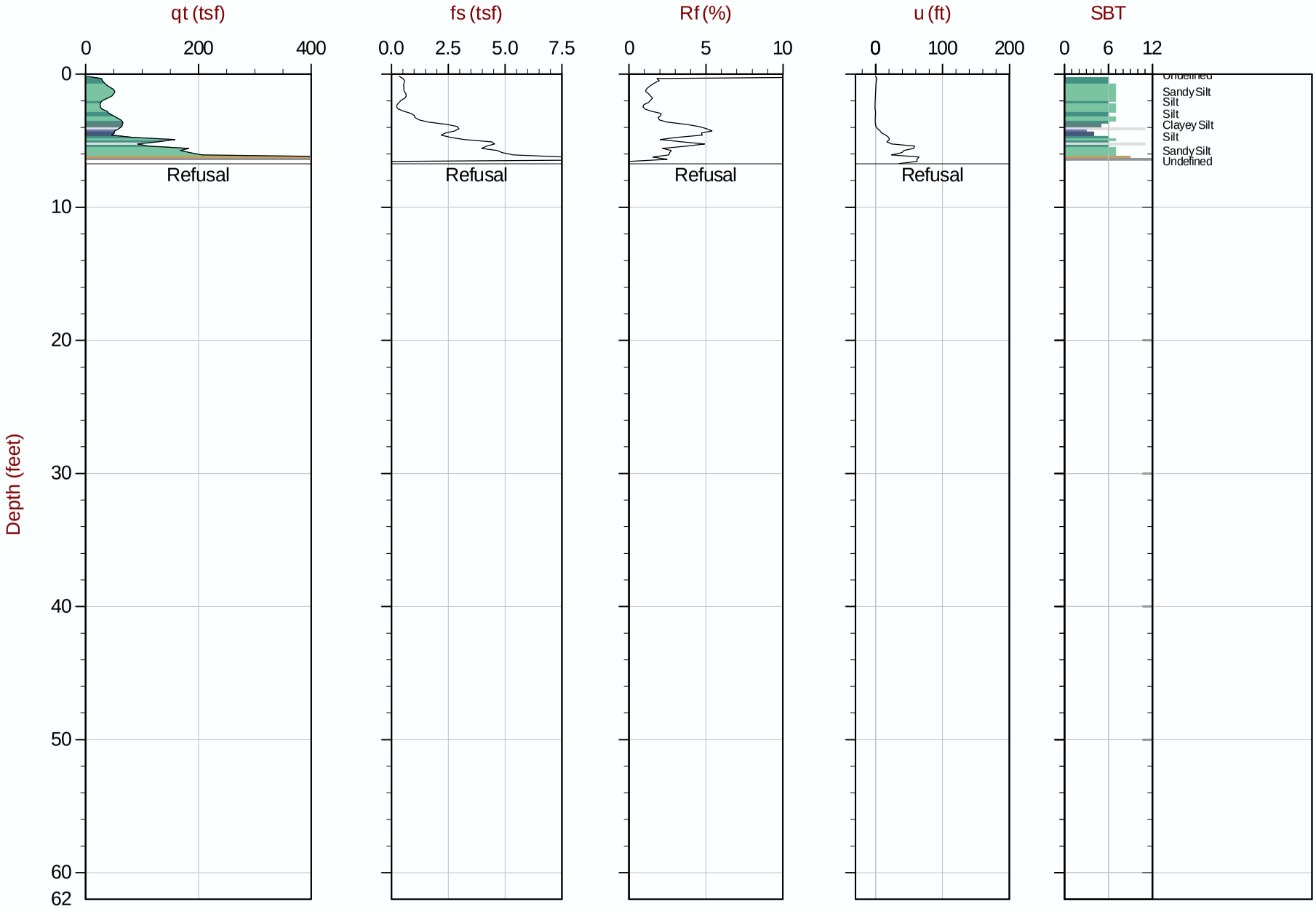
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-03 11:11
Site: Guernsey Power Station

Sounding: B-01
Cone: 467:T1500F15U500




Max Depth: 2.050 m / 6.73 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CPB01.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4421057m E: 454360m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

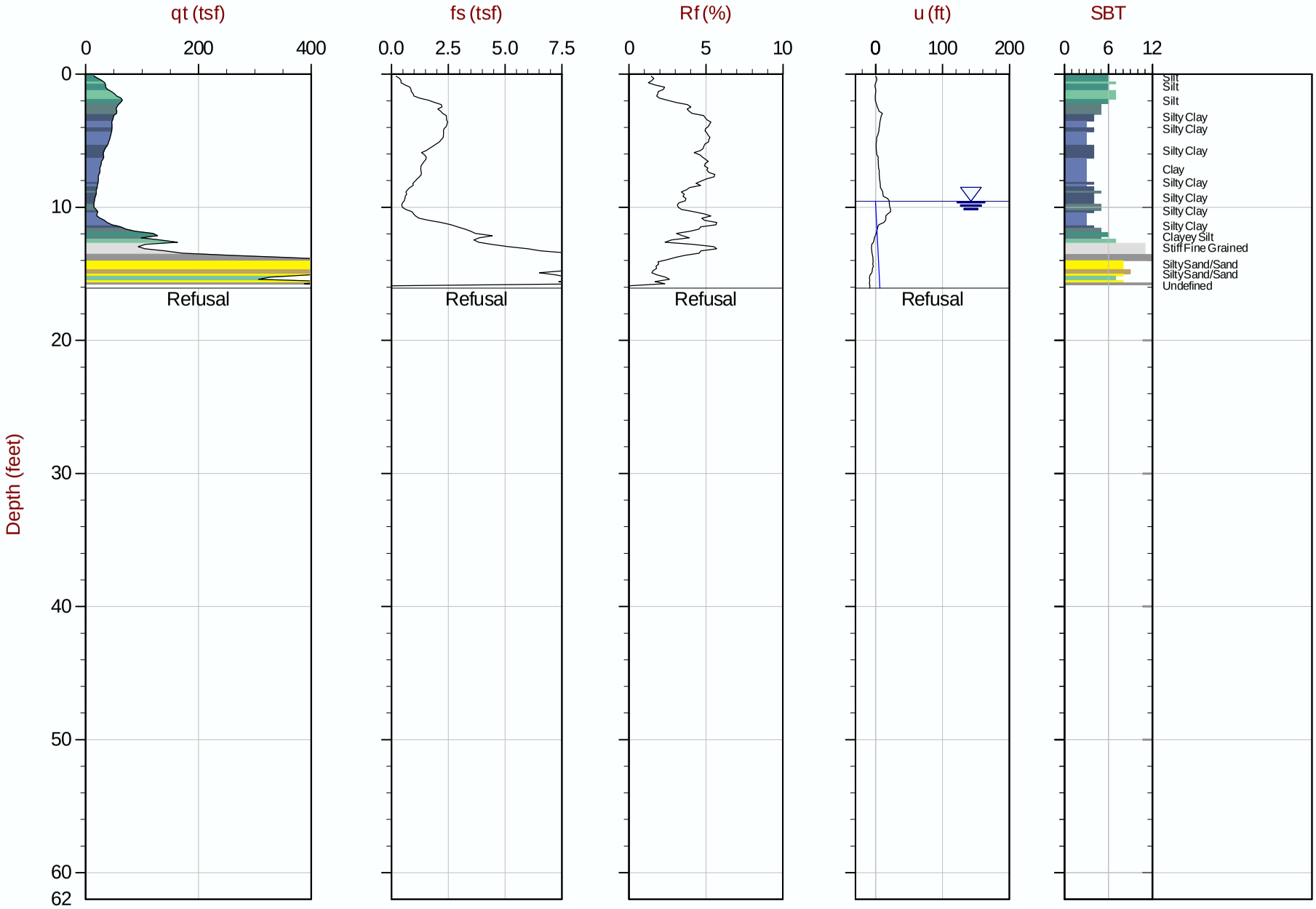
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-03 17:07
Site: Guernsey Power Station

Sounding: B-02
Cone: 467:T1500F15U500




Max Depth: 4.900 m / 16.08 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CPB02.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420999m E: 454141m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

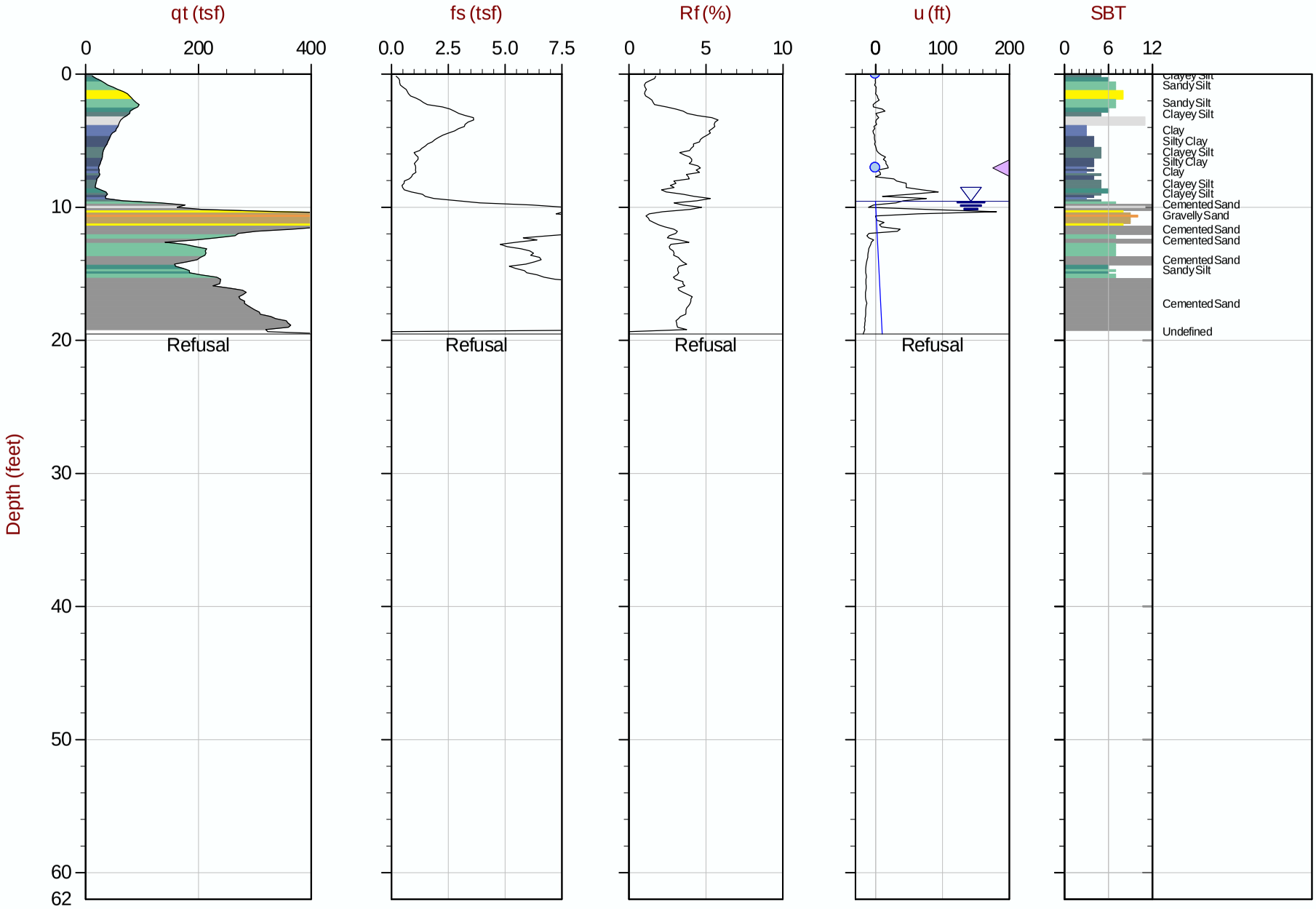
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-03 15:57
Site: Guernsey Power Station

Sounding: B-03
Cone: 467:T1500F15U500




Max Depth: 5.950 m / 19.52 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CPB03.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420967m E: 454354m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

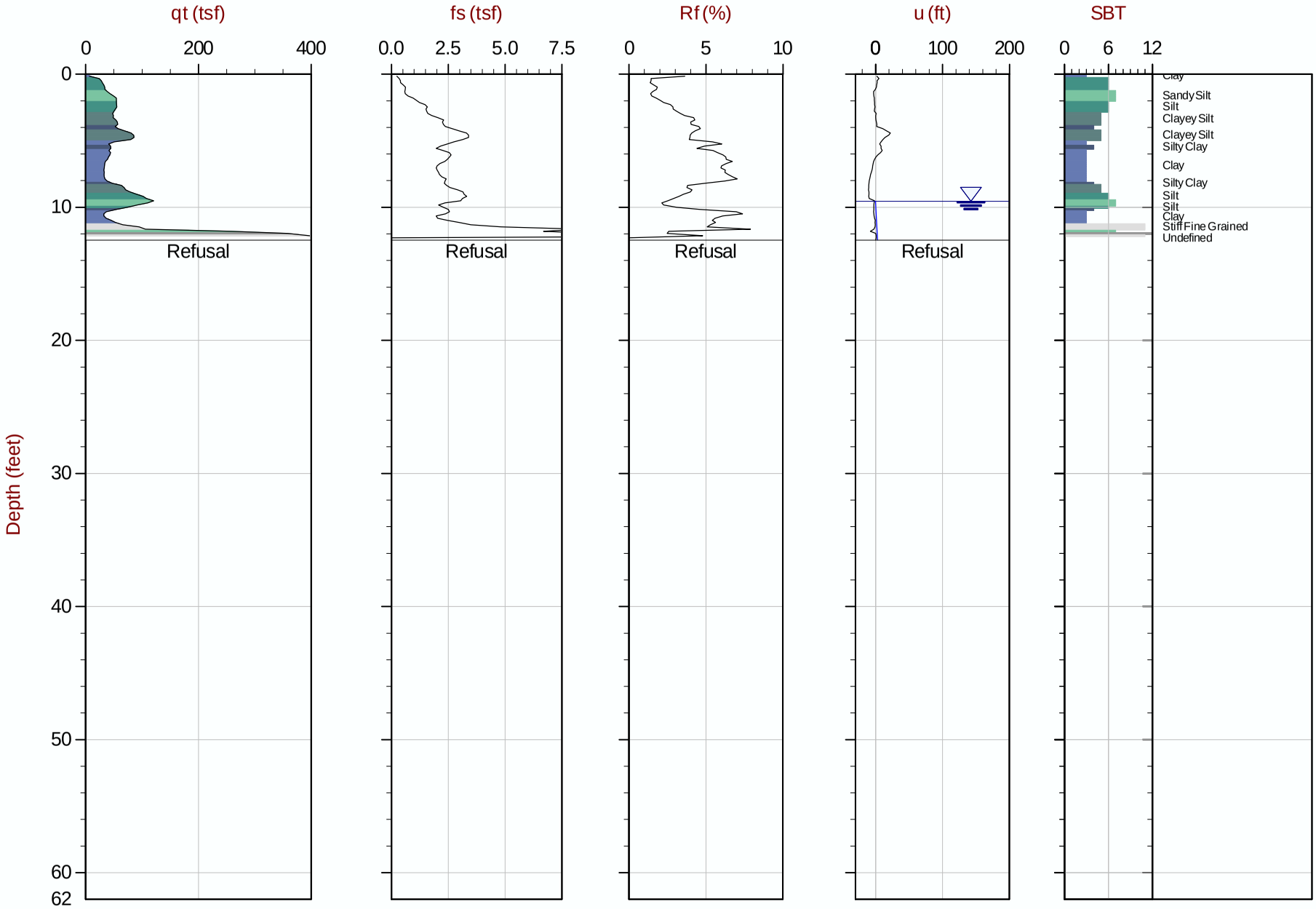
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-03 12:39
Site: Guernsey Power Station

Sounding: B-04
Cone: 467:T1500F15U500




Max Depth: 3.800 m / 12.47 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CPB04.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420826m E: 454085m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

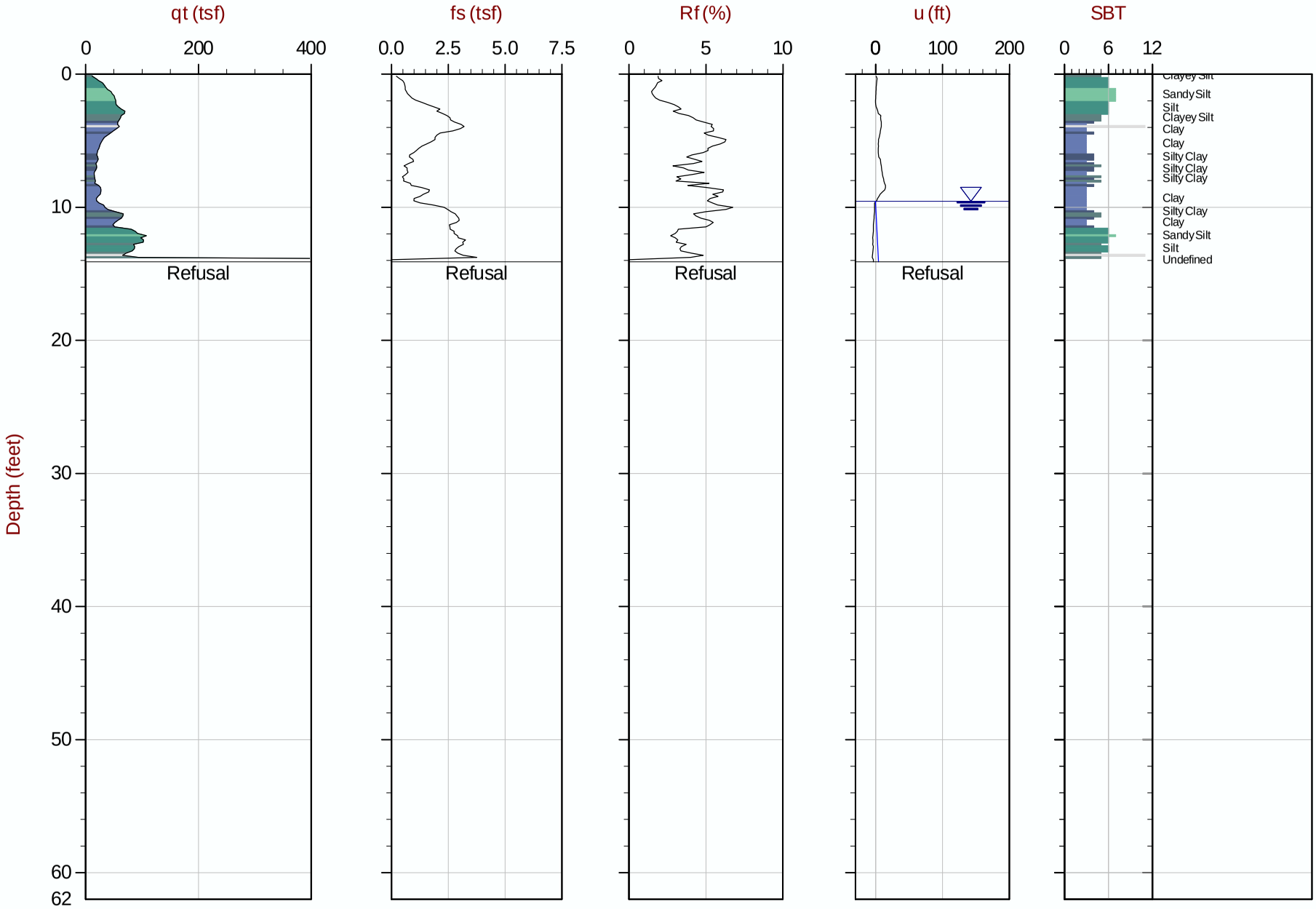
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-03 15:26
Site: Guernsey Power Station

Sounding: B-05
Cone: 467:T1500F15U500




Max Depth: 4.300 m / 14.11 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CPB05.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420848m E: 454332m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Normalized Cone Penetration Test Plots

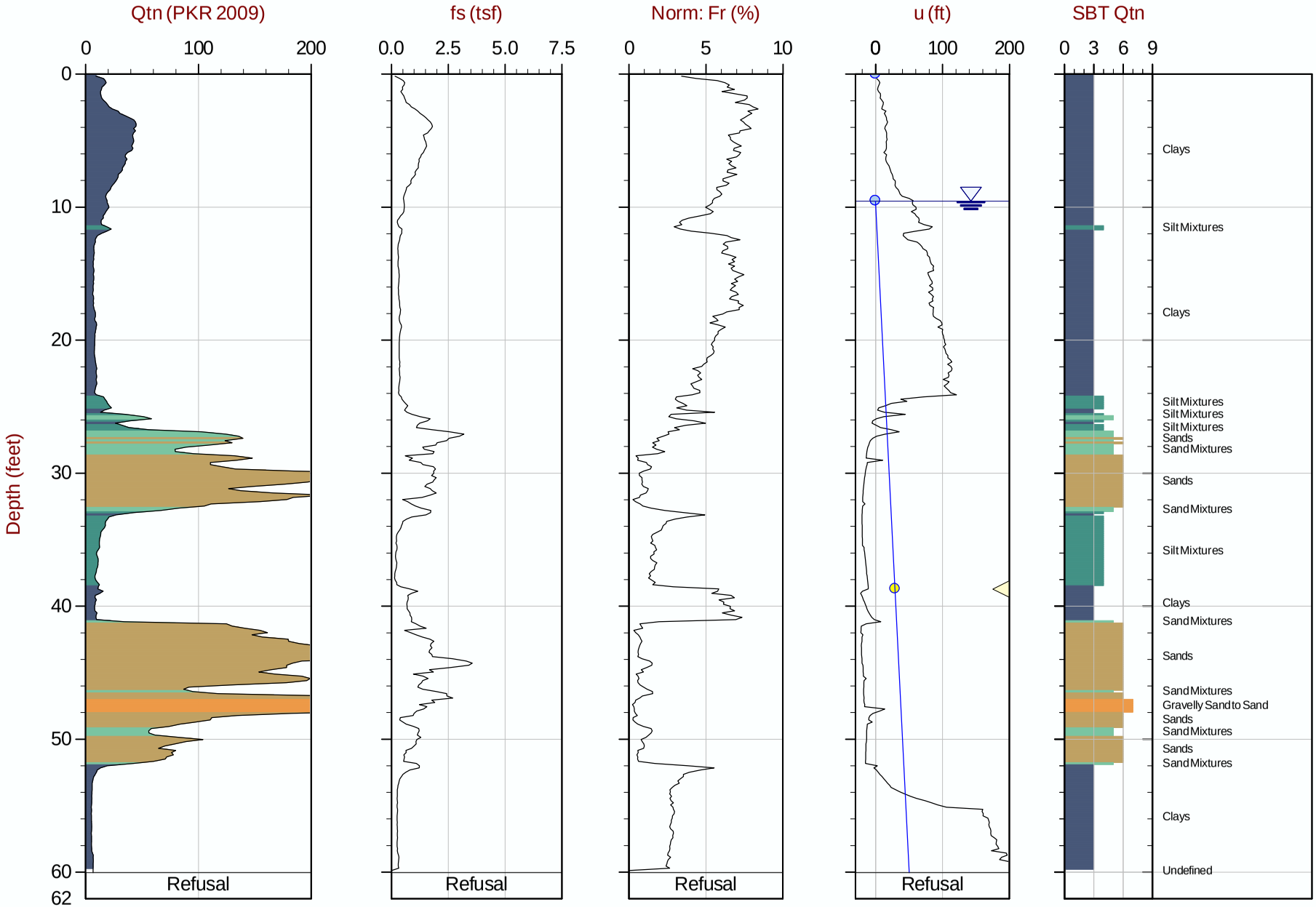
CONETEC

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-02 09:36
Site: Guernsey Power Station

Sounding: CPT16-11
Cone: 236:T1500F15U500




Max Depth: 18.300 m / 60.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_CP11.COR

SBT: Robertson, 2009 and 2010
Coords: UTM Zone 17 N: 4420140m E: 454356m

Hydrostatic Line  Ueq  Assumed Ueq  PPD, Ueq achieved  PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Seismic Cone Penetration Test Plots

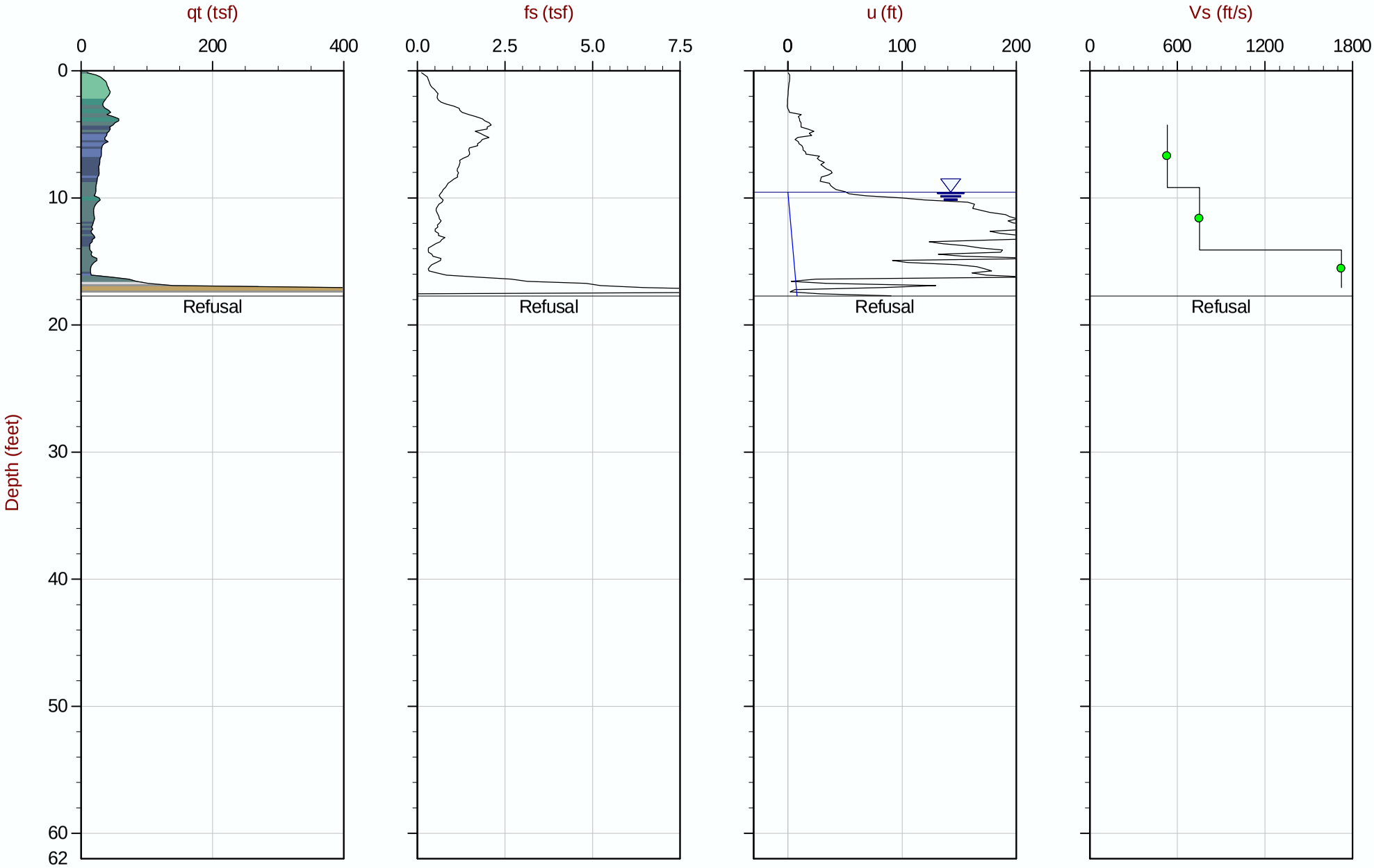
CONETEC

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-03 09:27
Site: Guernsey Power Station

Sounding: SCPT16-02
Cone: 467:T1500F15U500




Max Depth: 5.400 m / 17.72 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_SP02.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420995m E: 454250m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

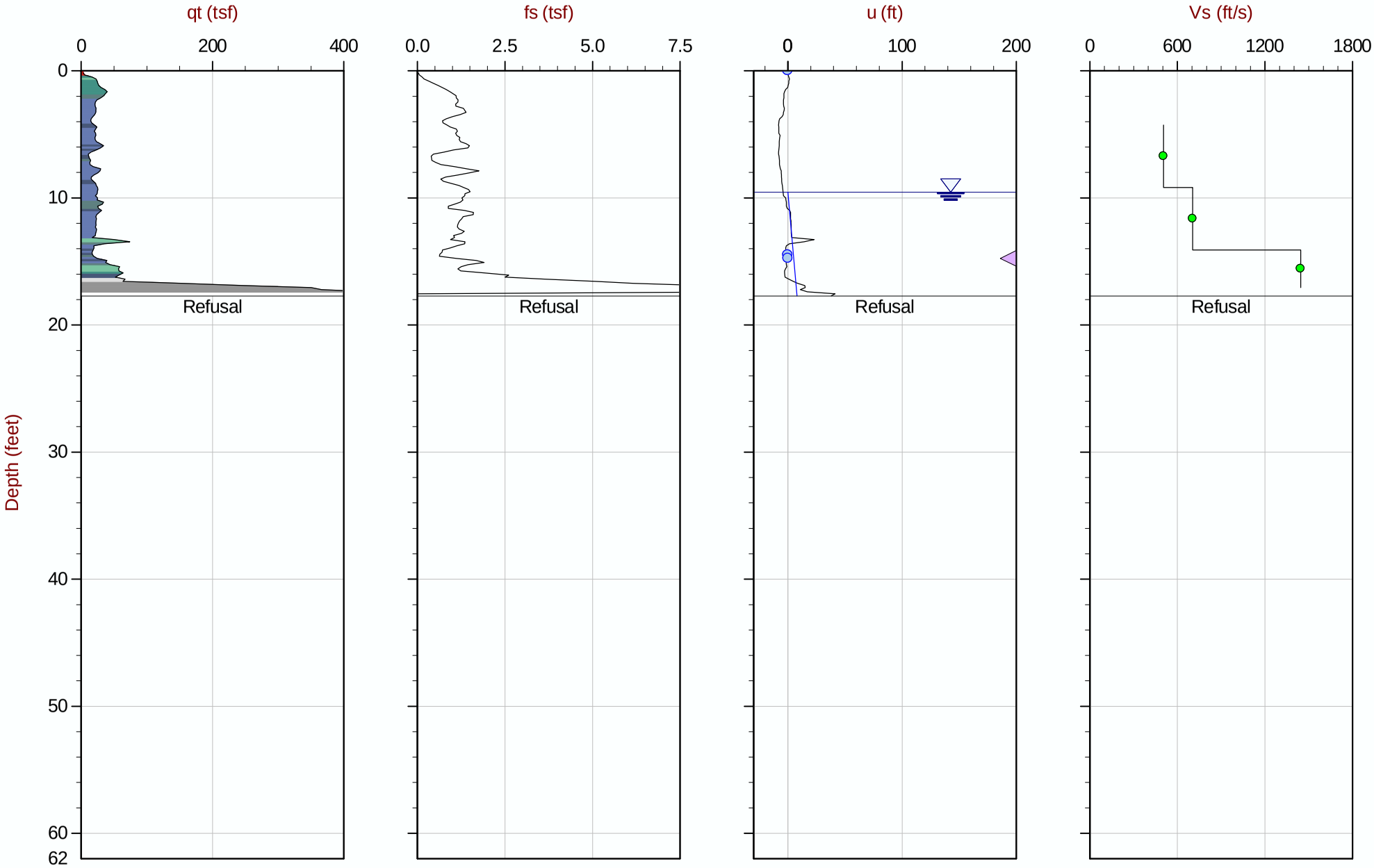
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 2016-11-03 13:30
Site: Guernsey Power Station

Sounding: SCPT16-09
Cone: 467:T1500F15U500




Max Depth: 5.400 m / 17.72 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 16-53106_SP09.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 17 N: 4420784m E: 454295m

Hydrostatic Line ○ Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Seismic Cone Penetration Test Tabular Results (Vs)

CONETEC

| | |
|---|---|
| Job No: | 16-53106 |
| Client: | Schnabel Engineering |
| Project: | Guernsey Power Station |
| Sounding ID: | SCPT16-02 |
| Date: | 03-Nov-2016 |

| | |
|---|---|
| Seismic Source: | Beam |
| Source Offset (ft): | 1.50 |
| Source Depth (ft): | 0.00 |
| Geophone Offset (ft): | 0.66 |

## *SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs*

| Tip Depth (ft) | Geophone Depth (ft) | Ray Path (ft) | Ray Path Difference (ft) | Travel Time Interval (ms) | Interval Velocity (ft/s) |
|---|---|---|---|---|---|
| 4.92 | 4.27 | 4.52 | | | |
| 9.84 | 9.19 | 9.31 | 4.79 | 9.01 | 531 |
| 14.76 | 14.11 | 14.19 | 4.88 | 6.48 | 752 |
| 17.72 | 17.06 | 17.13 | 2.94 | 1.70 | 1725 |

| | |
|---|---|
| Job No: | 16-53106 |
| Client: | Schnabel Engineering |
| Project: | Guernsey Power Station |
| Sounding ID: | SCPT16-09 |
| Date: | 03-Nov-2016 |

| | |
|---|---|
| Seismic Source: | Beam |
| Source Offset (ft): | 1.50 |
| Source Depth (ft): | 0.00 |
| Geophone Offset (ft): | 0.66 |

## *SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs*

| Tip Depth (ft) | Geophone Depth (ft) | Ray Path (ft) | Ray Path Difference (ft) | Travel Time Interval (ms) | Interval Velocity (ft/s) |
|---|---|---|---|---|---|
| 4.92 | 4.27 | 4.52 | | | |
| 9.84 | 9.19 | 9.31 | 4.79 | 9.45 | 506 |
| 14.76 | 14.11 | 14.19 | 4.88 | 6.92 | 705 |
| 17.72 | 17.06 | 17.13 | 2.94 | 2.03 | 1445 |

Pore Pressure Dissipation Summary and

Pore Pressure Dissipation Plots

CONETEC

| | |
|---|---|
| Job No: | 16-53106 |
| Client: | Schnabel Engineering |
| Project: | Guernsey Power Station |
| Start Date: | 02-Nov-2016 |
| End Date: | 03-Nov-2016 |

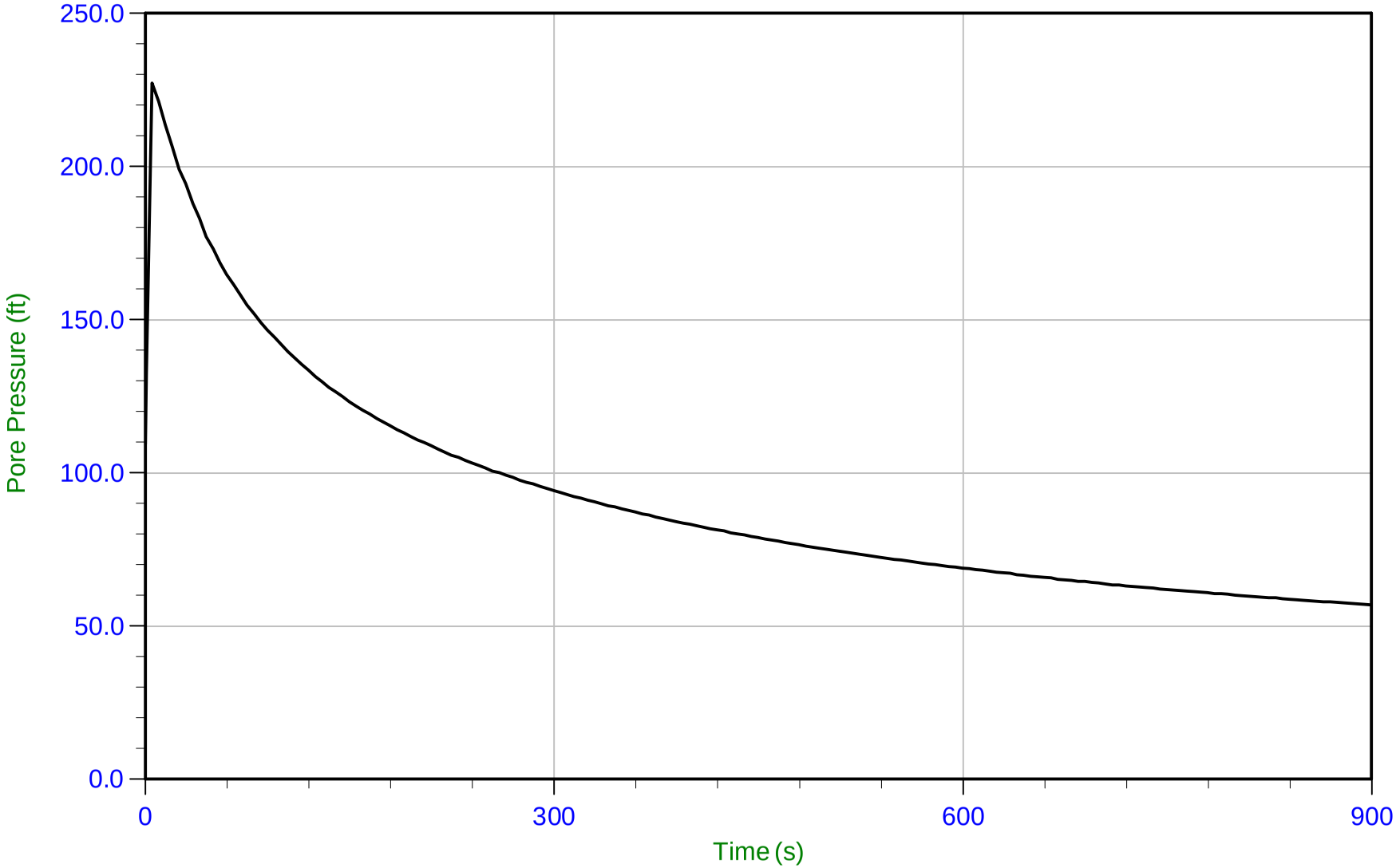
## *CPTu PORE PRESSURE DISSIPATION SUMMARY*

| Sounding ID | File Name | Cone Area ($cm^2$) | Duration (s) | Test Depth (ft) | Estimated Equilibrium Pore Pressure $U_{eq}$ (ft) | Calculated Phreatic Surface (ft) | Estimated Phreatic Surface (ft) | $t_{50}$ [a] (s) | Assumed Rigidity Index ($I_r$) | $c_h$ [b] ($cm^2$/min) |
|---|---|---|---|---|---|---|---|---|---|---|
| CPT16-01 | 16-53106_CP01.PPD | 15 | 900 | 7.38 | 0.00 | | 7.38 | 183 | 100 | 3.85 |
| SCPT16-09 | 16-53106_SP09.PPD | 15 | 3600 | 14.76 | 0.26 | | 14.50 | 1011 | 100 | 0.69 |
| CPT16-11 | 16-53106_CP11.PPD | 15 | 900 | 38.71 | 29.18 | 9.53 | | | | |
| B-03 | 16-53106_CPB03.PPD | 15 | 1800 | 7.05 | 0.00 | | 7.05 | 924 | 100 | 0.76 |
| Totals | 4 dissipations | | 120.0 min | | | | | | | |

a. Time is relative to where umax occurred

b. Houlsby and Teh, 1991

| | | |
|---|---|---|
| CONETEC | Schnabel Engineering | Job No: 16-53106<br>Date: 03-Nov-2016 10:26:46<br>Site: Guernsey Power Station |
| | | Sounding: CPT16-01<br>Cone: AD467 Area=15 cm² |



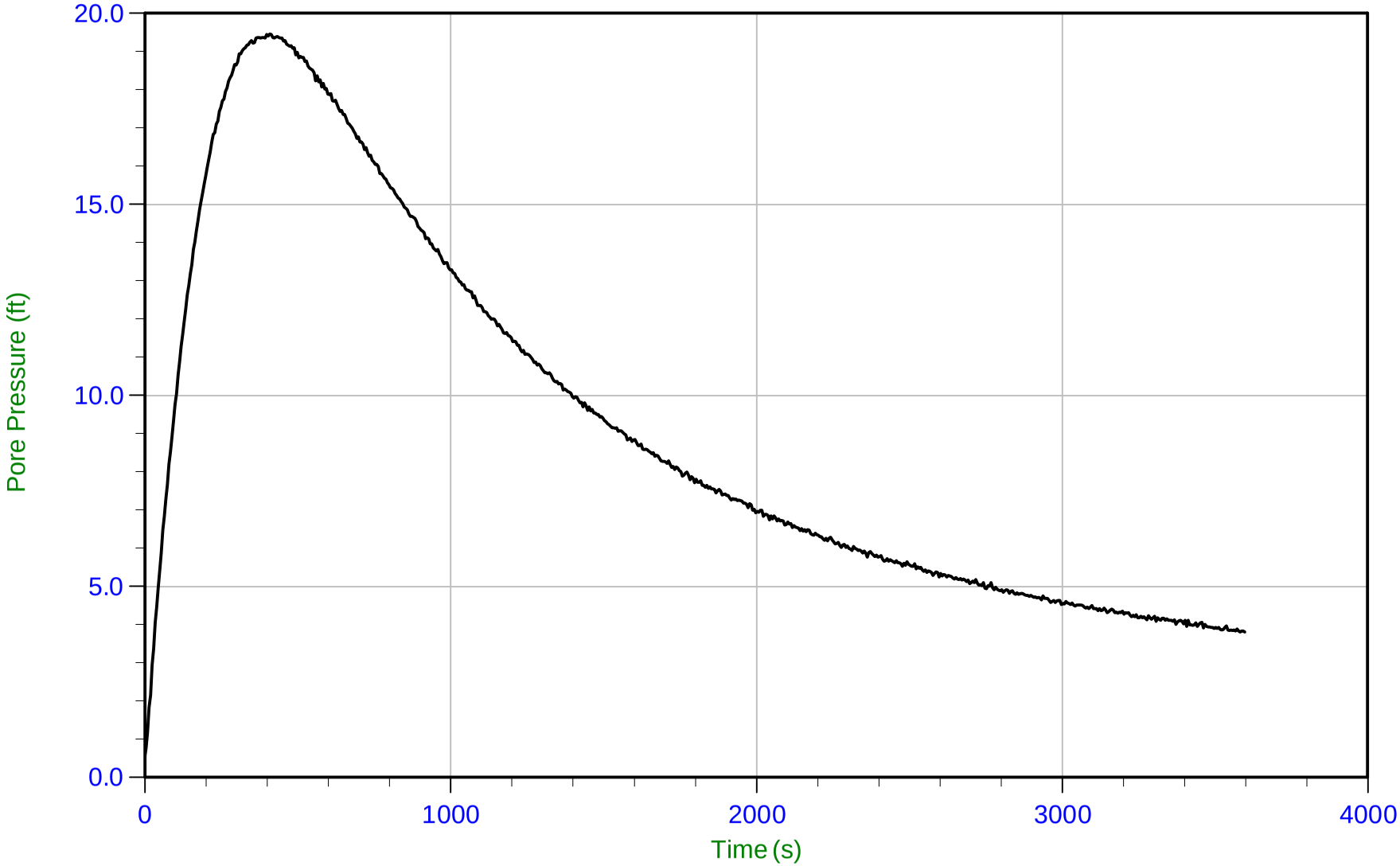

| Trace Summary: | | | | |
|---|---|---|---|---|
| | Filename: 16-53106_CP01.PPD | U Min: 56.9 ft | WT: 2.250 m / 7.382 ft | T(50): 182.5 s |
| | Depth: 2.250 m / 7.382 ft | U Max: 227.2 ft | Ueq: -0.0 ft | Ir: 100 |
| | Duration: 900.0 s | | U(50): 113.59 ft | Ch: 3.8 sq cm/min |

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 03-Nov-2016 13:30:13
Site: Guernsey Power Station

Sounding: SCPT16-09
Cone: AD467 Area=15 cm²




Trace Summary:

Filename: 16-53106_SP09.PPD
Depth: 4.500 m / 14.764 ft
Duration: 3600.0 s

U Min: 0.5 ft
U Max: 19.5 ft

WT: 4.420 m / 14.500 ft
Ueq: 0.3 ft
U(50): 9.86 ft

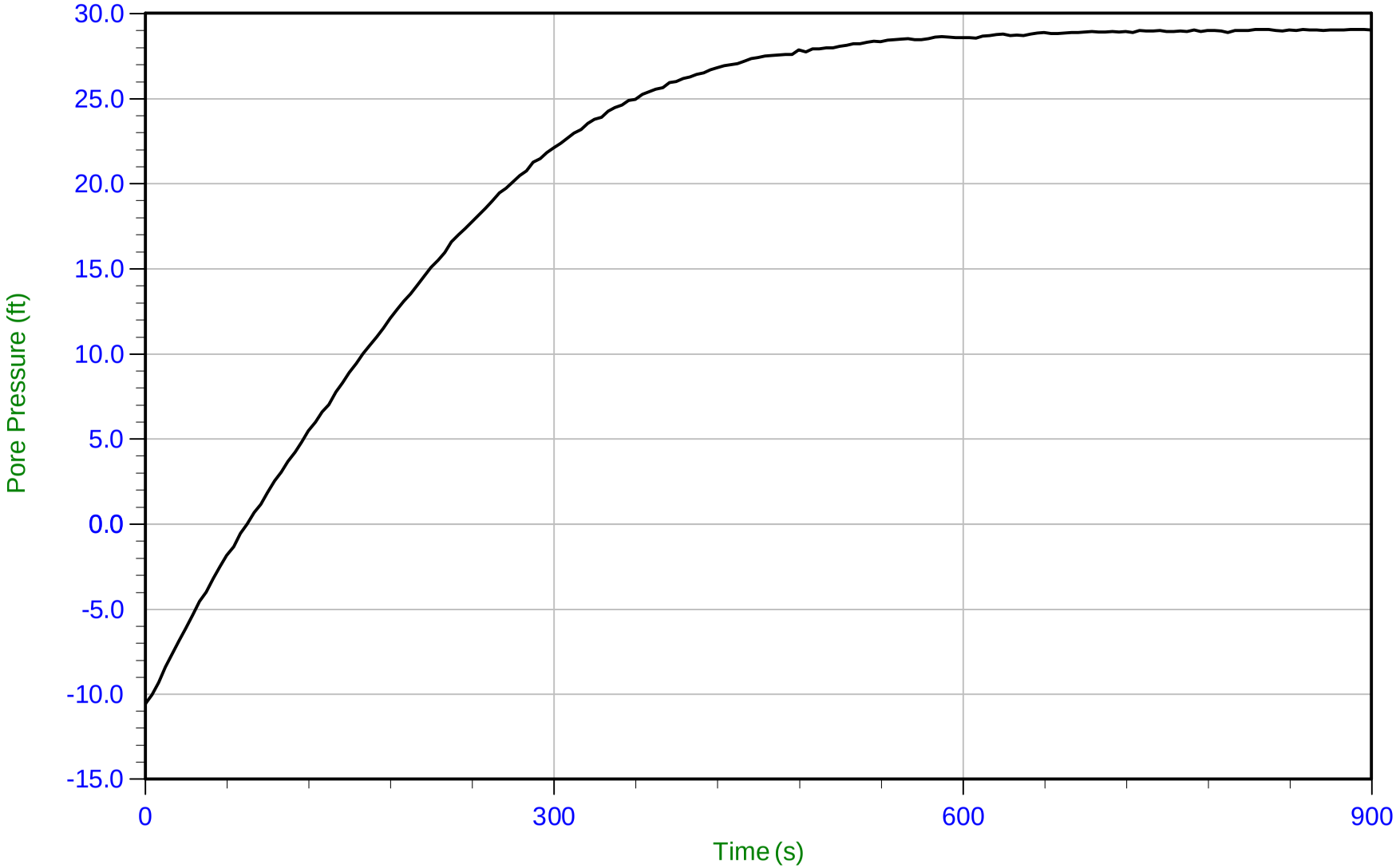
T(50): 1010.6 s
Ir: 100
Ch: 0.7 sq cm/min

CONETEC

# Schnabel Engineering

Job No: 16-53106
Date: 02-Nov-2016 09:36:06
Site: Guernsey Power Station

Sounding: CPT16-11
Cone: AD236 Area=15 cm²



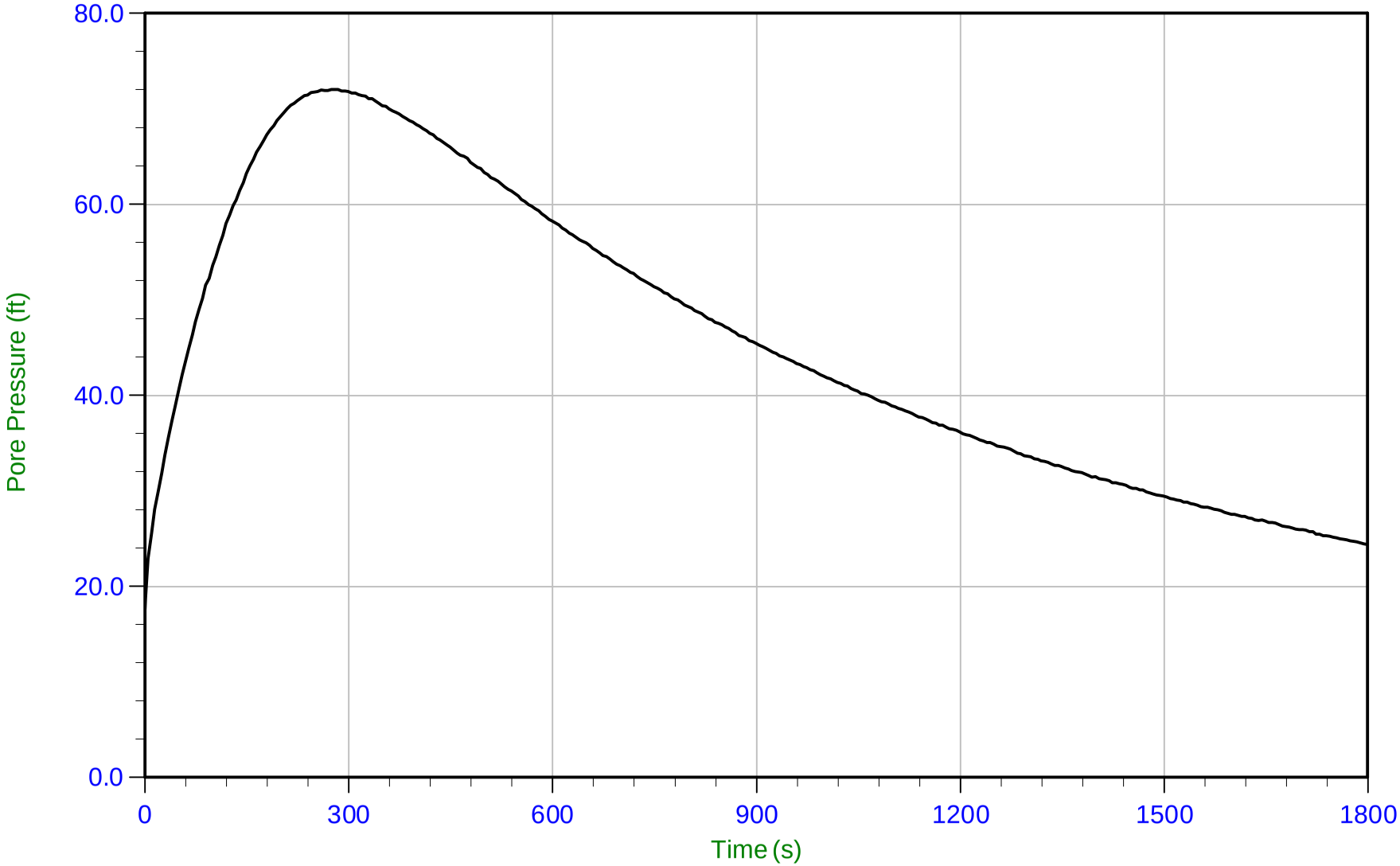

Trace Summary:

Filename: 16-53106_CP11.PPD
Depth: 11.800 m / 38.713 ft
Duration: 900.0 s

U Min: -10.6 ft
U Max: 29.1 ft

WT: 2.905 m / 9.531 ft
Ueq: 29.2 ft

| | | |
|---|---|---|
| CONETEC | Schnabel Engineering | Job No: 16-53106<br>Date: 03-Nov-2016 15:57:08<br>Site: Guernsey Power Station |
| | | Sounding: B-03<br>Cone: AD467 Area=15 cm² |




| Trace Summary: | | | | |
|---|---|---|---|---|
| | Filename: 16-53106_CPB03.PPD | U Min: 17.6 ft | WT: 2.150 m / 7.054 ft | T(50): 923.9 s |
| | Depth: 2.150 m / 7.054 ft | U Max: 72.0 ft | Ueq: -0.0 ft | Ir: 100 |
| | Duration: 1800.0 s | | U(50): 36.02 ft | Ch: 0.8 sq cm/min |

**This foregoing document was electronically filed with the Public Utilities**

**Commission of Ohio Docketing Information System on**

**3/16/2017 11:27:13 AM**

**in**

**Case No(s). 16-2443-EL-BGN**

Summary: Application of Guernsey Power Station, LLC Part 6 - Appendices D-I electronically filed by Teresa Orahood on behalf of Sally W. Bloomfield