FINAL REPORT
SUBSURFACE INVESTIGATION
PROPOSED WATER MAIN REPAIR AND REPLACEMENT
PROJECT ID NO.: 16785
GLENN RESEARCH CENTER
AT LEWIS FIELD

For:

NASA-Glenn Research Center at Lewis Field
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Submitted by:

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1. INTRODUCTION

This report presents the results of the subsurface investigation for repair and replacement of approximately 17,000 feet (ft) of water main at National Aeronautics and Space Administration (NASA) Glenn Research Center (GRC) at Lewis Field near Cleveland, Ohio. The investigation is part of a larger project at GRC to repair and/or replace more than 100,000 ft of deteriorating domestic water lines.

The investigation was conducted in general accordance with the Barr & Prevost proposal to NASA GRC dated September 14, 2011 and NASA's Statement of Work for Architect-Engineering Services for Final Design of FY13 Repair of City Water Main Piping, Phase 1, Project ID No. 16785, Revision 2.

The purpose of the investigation is to characterize the subsurface conditions along the proposed alignments, perform geotechnical analyses, and provide recommendations for the use of selected geotechnical parameters necessary for the installation of the rerouted water main.

2. LOCATION AND SITE CONDITIONS

Glenn Research Center is located in western Cuyahoga County, immediately northwest of the Cleveland-Hopkins International Airport (CHIA). This phase of the project is located in the central portion of the facility.

Specifically, it includes water mains along Walcott Road (Rd) (between Stratton Road intersection and K Rd intersection) the northern portion of Taylor Rd (between Stratton Rd intersection and K Rd intersection) and along Ames, Durand, and Moffett Roads. The project area is shown on Exhibit 1.

2.1. Geology

Physiographically, GRC is located on the Erie Lake Plain physiographic province (Brockman, 1998) and, specifically on the Upper Lake Plain (Ford, 1987), where from less than 10 ft to 20 ft of Kent Till 1 (glacial till) overlying bedrock. This is a sandy, stony till. Bedrock is mapped as Mississippian Bedford Shale overlying Devonian Ohio Shale at an approximate elevation of 700 ft, which at the site would be at a depth on the order of 50 ft.

No karst has been mapped in the immediate area (ODNR, 2006).

The Web Soil Survey (USDA, Natural Resources Conservation Service, 2013) maps the majority of the project site as Urban (not rated). However, the areas in proximity to northern end of Ames Rd and Taylor are mapped Mahoning-Urban land complex and are rated as very limited due to depth to saturated zone.

2.2. Hydrology/Hydrogeology

GRC's property is partly bounded by the Rocky River to the west, and crossed by Abram Creek, a tributary, in the western portion. Rocky River's elevation is about 640 ft and may indicate the elevation of the regional water table. The proposed water main alignment is located such that the pipe invert is significantly above 640 ft.

3. PROPOSED CONSTRUCTION

Twelve-inch main sizing has been selected for upgrades, to be installed using horizontal directional drilling at depths between 5 ft and 8 ft.

4. FIELD INVESTIGATION PROGRAM

Nine borings were drilled along the proposed water main alignments at approximate locations shown on Figure 1. They were drilled by Barr & Prevost, Inc. (BPI) between December 18 and 20, 2012.

Table 1: Boring Summary

Boring	Ground Elevation [1] (ft)	SPC (OH-N)[1] (ft)	Boring Depth (ft)
B-001-0-12	752.21	2143519, 638096	12.5
B-002-0-12	748.81	2142133, 637008	12.5
B-003-0-12	757.51	2144024, 637635	12.5
B-004-0-12	760.46	2142896, 636158	12.5
B-005-0-12	751.87	2143500, 637615	12.5
B-006-0-12	750.67	2143127, 637511	12.5
B-007-0-12	748.17	2142866, 637535	12.5
B-008-0-12	756.62	2143066, 636778	12.5
B-009-0-12	760.17	2142785, 635562	12.5

[1] Boring locations were estimated from facility mapping, elevations were derived from OGRIP Statewide elevation grids.

The borings were drilled using a mobile B-57 ORV mounted-rig with 3.25-inch diameter hollow stem augers. Soil samples were recovered at intervals of 2.5 ft using a split spoon sampler (ASTM method D

1586 – Test Method for Penetration Test and Split Barrel Sampling of Soils) and placed in sealed jars. The standard penetration test (SPT) was conducted using a CME auto hammer that has been calibrated as being 95.1% efficient and which results in N values that must be converted to N_{60} for use in analysis or for correlation purposes.

Field boring logs were prepared by Barr & Prevost's field personnel, including lithological description, and standard penetration test results recorded as blows per 6-inch increment of penetration. Groundwater related observations were included. Boring logs were prepared by Barr & Prevost based on the information obtained from the field logs and a review of the samples and cores in the laboratory by a geologist. Final classification of the soil strata took place once the laboratory test results became available. The logs of the borings are presented in Appendix A.

Each boring was sealed with non-shrink bentonite grout upon completion. Soil samples will be retained at the laboratory for 60 days following report submittal, after which time they will be discarded.

5. LABORATORY TESTING

Selected soil samples were subjected to a laboratory-testing program to develop information regarding the physical properties of the materials encountered. All split-spoon soil samples were tested for natural moisture content, and soil classification related testing (Atterberg limits, and particle size analysis), the results are shown on the boring logs (Appendix A).

Natural moisture content tests were performed in accordance with ASTM D 2216, Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock. The grain-size distributions were determined in accordance with ASTM D 422, Standard Test Method for Particle-Size Analysis of Soils. Index property (Atterberg Limits) testing was performed in accordance with the Multipoint Liquid Limit-Method A of ASTM D 4318, Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

6. SUBSURFACE CONDITIONS

Descriptions of the soils and rock encountered during the investigation are provided on the log of borings in Appendix A. To the depth explored, glacial till was the dominant material encountered and consisted of hard, damp, lean clay with varying amounts of sand and traces of gravel. Hand penetrometer readings indicate a compressive strength for this material of more than 4.5 tons per square foot (tsf).

In four of the borings the till was covered by up to 10 ft of fill, the composition of which varies from reworked glacial till (B-001-0-12 and B-007-0-12) to imported granular soil (B-005-0-12). Conditions at B-008 are unusual in that there is a stratum of very loose silty gravel extending from 8-12.5 ft. This is not characteristic of the natural soils in the area and should be assumed to be man-made fill.

The drill locations were all paved either with asphalt (consistent paving thickness of 11-13 inches) or compacted gravel (6-12 inches)

Ground water was observed during drilling only in B-008-0-12. This water may is likely to represent a perched zone in a former excavation that has subsequently been backfilled. The absence of a site-wide ground water table is consistent with the geological model for the site as discussed in Section 2.2.

7. DESIGN RECOMMENDATIONS

7.1. Vertical Earth Load

Nominal loads imposed on segments of a 12-inch diameter pipe installed by trenchless methods may be estimated as follows:

Soil load – glacial till (8' cover)	1,040 plf
Live load - (5 ft cover)	290 plf
(assumes H20 Highway loading only)	

7.2. Vertical Excavation Support

Excavations should be performed in compliance with local, state and federal regulations. The potential effect of ground movements on nearby structures, roadways and utilities should be considered when planning the construction program.

A temporary retaining system will be required to support the vertical walls of thrust and receiving pits required for trenchless water main installation. The design of such a system should consider a trapezoidal earth pressure distribution as shown in Exhibit 2. Allowance should be made for surcharge loads (such as traffic, excavated spoil, or construction equipment) that might be imposed near the retaining system. Surcharge loads should not impact stability if they are maintained a distance at least the supported depth away from its edge.

If sloped excavations are considered the walls should be sloped not steeper than 1 horizontal to 1 vertical (1:1).

7.3. Dewatering

Significant inflow of ground water into open excavations is not anticipated, although the possibility of perched ground water in zones of historic embankment or back-filled excavation cannot be ruled out. Surface water should be directed away from open excavations and the bottom of those excavations should

be sloped where possible to promote the drainage of unwanted water to points from which it can be pumped.

7.4. Backfill

All backfill material should be as specified, and pre-approved by the site engineer. It should be free of organic materials and debris. For backfill against structures such as valve chambers, porous granular material is recommended. Backfill under roads should also consist of granular material to facilitate compaction and minimize future settlement. The contractor should backfill all open excavations and trenches in accordance with the construction plan details and the specifications.

8. QUALIFICATIONS

This investigation was performed in accordance with accepted geotechnical engineering practice for the purpose of determining water line design related recommendations only. Verification of the subsurface conditions for purposes of determining contamination, the effect of excavation on slope stability or existing structures, is beyond the scope of this study. The analyses and recommendations submitted in this report are based upon the data obtained from the borings drilled at the locations shown on Exhibit 1, and presented on the Boring Logs (Appendix A). This report does not reflect any variations that may occur between the borings or elsewhere on the site, or variations whose nature and extent may not become evident until a later stage of construction. In the event that any changes in the nature, design or location of the proposed water lines are made, the conclusions and recommendations contained in this report should not be considered valid until the changes are reviewed, and the conclusions and recommendations in this report have been modified or verified in writing by a geotechnical engineer.

It has been a pleasure to be of service to NASA GRC on this project. Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

Barr & Prevost

STATE OF OHIO
STUART EDWARDS
E-47218
REGISTERED PROFESSIONAL ENGINEER
3/6/13

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REFERENCES

Bell Engineering and Barr & Prevost, Inc., 2012. *Distribution System Hydraulic Analysis-NASA GRC Lewis Field FY 13 Repair of City Water Main Piping Phase 1, Project ID No.: 16785.* July 2012, Revised October 2012.

Brockman S.C., 1998. *Physiographic Regions of Ohio*. Ohio Department of Natural Resources Division of Geological Survey

Brockman, C.S. and G. A. Schumacher, 2006. *Surficial Geology of the Cleveland North 30 X 60-minute quadrangles.* Ohio Division of Geological Survey Map SG-2 Cleveland North, scale 1:100,000.

National Clay Pipe Institute, 2006. *Clay Pipe Engineering Manual, 2006.*

Ohio Department of Natural Resources, 1996(1). *Preliminary Bedrock Geology of the Lakewood, Ohio Quadrangle.* Division of Geological Survey. G. Larsen. Open-File Map: BG-D2D7.

1996(2). *Bedrock Topography of the Lakewood, Ohio Quadrangle.* Division of Geological Survey, Vorbalu, K. (et. al.) Open-File Map: BT-D2D7.

2006. *Ohio Karst Areas.* Division of Geological Survey.

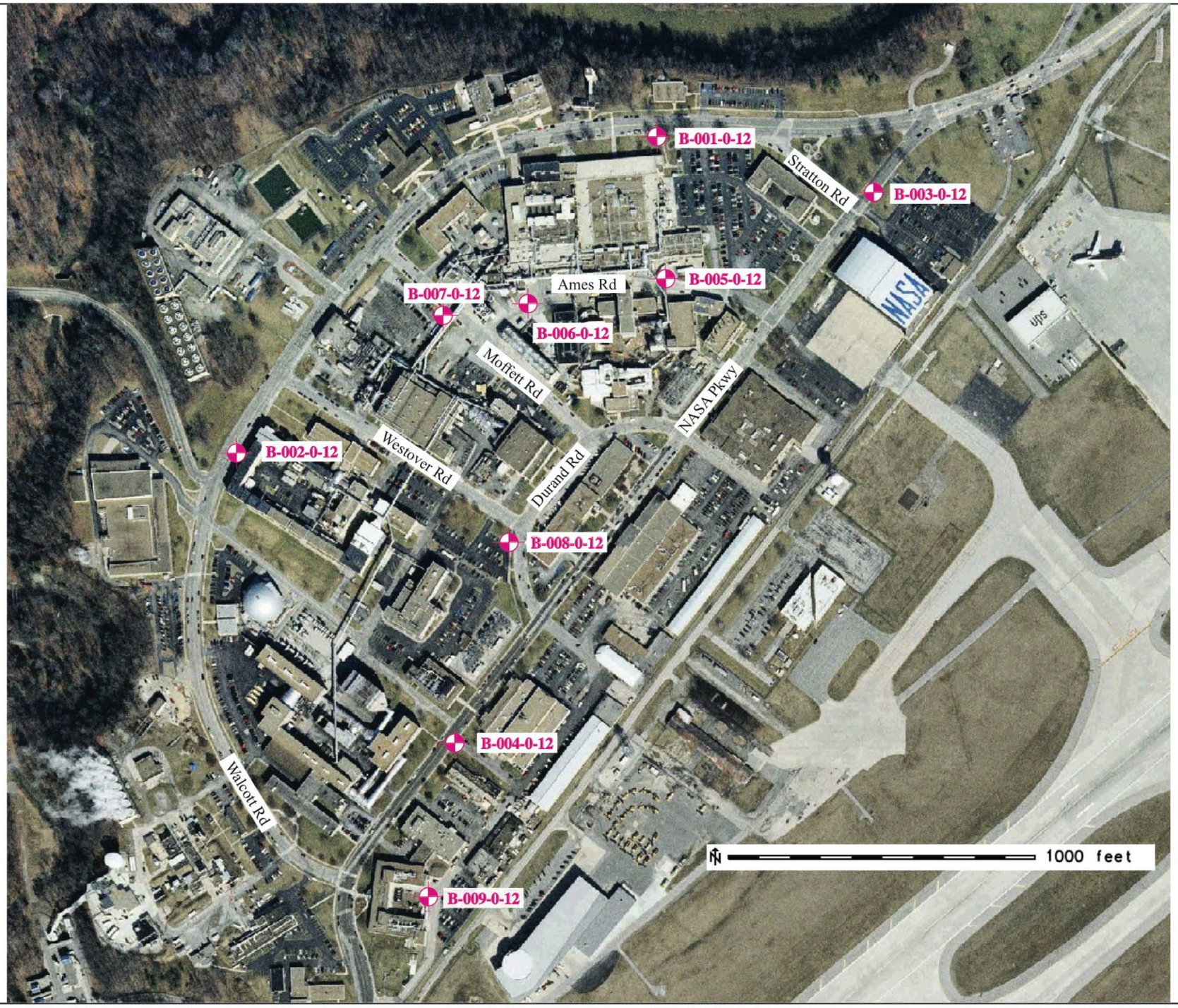
2012. *Earthquake Epicenters in Ohio and Adjacent Areas.* Division of Geological Survey.

U.S. Department of Agriculture, 2013. *Web Soil Survey, National Cooperative Soil Survey.* Natural Resource Conservation Service. January 21, 2012. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Terzaghi, K. and Peck, P.B., 1967. *Soil Mechanics In Engineering Practice.* 2nd Edition. John Wiley & Sons. New York.

U.S. Department of the Interior, 1994. *Lakewood Quadrangle, Ohio-Cuyahoga Co., 7.5 Minute Series (Topographic).* Geological Survey. NIMA 4666 IV NE-SERIES V852. Topography compiled 1953. Planimetry derived from imagery taken 1994. Public Land Survey System and survey control current as of 1963. Scale-1:24,000.

2010. *Lakewood Quadrangle, Ohio, 7.5-Minute Series.* U.S. Geological Survey. 2010. Imagery: NAIP, August 2004. Roads: 2006-2010 Tele Atlas. Hydrogeology: National Hydrography Dataset, 2004. Contours: National Elevation Dataset, 1998. Scale-1:24,000.



Legend:

B-005-0-12 Boring Location

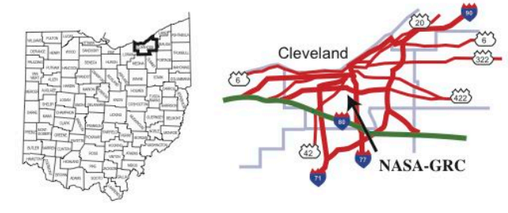


Exhibit 1

BARR & PREVOST
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Boring Locations
Proposed Water Main Repair and Replacement

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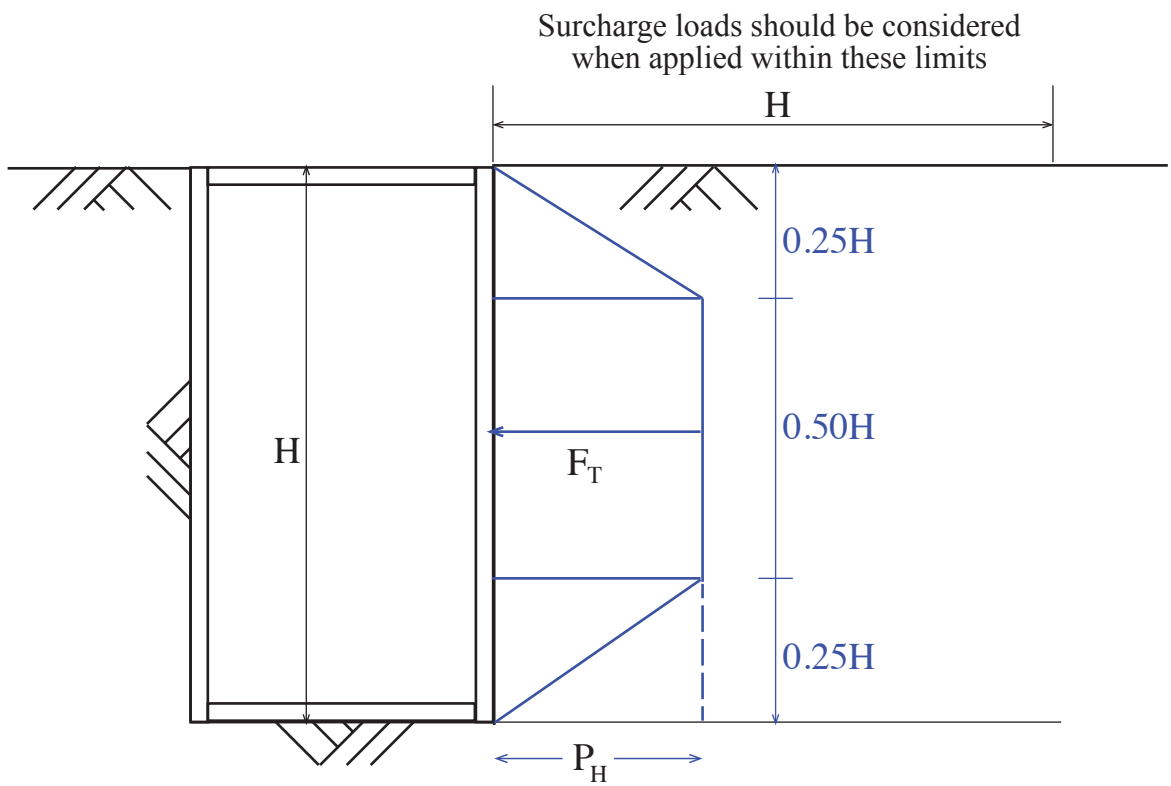
Project No.: 16785



$P_H = 0.4\ \gamma\ H$

e.g. $P_H = 0.4 \times 130 \times 10$

P_H = total pressure

P_T = total force/ft.

γ = soil density

H = retained height

Total Force Height

$F_T = P_H \times 0.75\ H$

$= 520 \times 0.75 \times 10 = 3{,}900$ plf

Exhibit 2

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Lateral Earth Pressure for Braced Excavation Design in Stiff Clay

NASA-Glenn Research Center
Project No.: 16785

APPENDIX A

LOG OF BORINGS AND LABORATORY TEST RESULTS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/29/13 16:45 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\NASA DOMESTIC WATERLINE\NASA DOMESTIC WATERLINE.GPJ

PROJECT: NASA DOMESTIC WATERLINE	DRILLING FIRM / OPERATOR: B & P / P. WEBB	DRILL RIG: MOBILE B57 ORV	STATION / OFFSET:
TYPE: WATERLINE	SAMPLING FIRM / LOGGER: B & P / R.WEBB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT:
PID: Client: NASA	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/30/11	ELEVATION: 752.2 (MSL) EOB: 12.5 ft.
START: 12/18/12 END: 12/18/12	SAMPLING METHOD: SPT	ENERGY RATIO (%): 95.1	COORD: 2143519.000 N, 638096.000 E

EXPLORATION ID B-1

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 752.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	MS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	USCS CLASS	HOLE SEALED
12.0", **GRANULAR BASE**, CONTAINS FEW ROOTS AND ORGANICS	751.2																		
SOFT TO STIFF, BROWN AND GRAY, **SANDY LEAN CLAY**, LITTLE GRAVEL, MOIST **(FILL)**		1 2	2 1 2	5	61	SS-1	0.4 - 0.9	-	-	-	-	-	-	-	-	-	23	CL (V)	
		3 4 5	2 2 4	10	61	SS-2	1.7 - 2.4	7	4	11	12	31	35	30	15	15	18	CL	
		6 7 8	2 3 2	8	39	SS-3	1.4 - 2.5	-	-	-	-	-	-	-	-	-	19	CL (V)	
@8.5'; SS-4 CONTAINS DECAYED ROOTS **(END FILL)**	741.7	9 10	2 2 4	10	56	SS-4	1.2 - 2.2	-	-	-	-	-	-	-	-	-	24	CL (V)	
HARD, BROWN MOTTLED WITH GRAY, **LEAN CLAY WITH SAND**, TRACE GRAVEL, MOIST	739.7	11 12 EOB	3 6 11	27	67	SS-5	4.5+	3	4	9	13	42	29	27	13	14	14	CL	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. CAVE DEPTH 6.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 20 GAL. BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/29/13 16:45 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\NASA DOMESTIC WATERLINE\NASA DOMESTIC WATERLINE.GPJ

PROJECT: NASA DOMESTIC WATERLINE	DRILLING FIRM / OPERATOR: B & P / P. WEBB	DRILL RIG: MOBILE B57 ORV	STATION / OFFSET:
TYPE: WATERLINE	SAMPLING FIRM / LOGGER: B & P / R.WEBB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT:
PID: Client: NASA	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/30/11	ELEVATION: 748.8 (MSL) EOB: 12.5 ft.
START: 12/18/12 END: 12/18/12	SAMPLING METHOD: SPT	ENERGY RATIO (%): 95.1	COORD: 2142133.000 N, 637008.000 E

EXPLORATION ID B-2

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 748.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	MS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	USCS CLASS	HOLE SEALED
6.0", **GRANULAR BASE**, CONTAINS ROOTS	748.3																		
HARD, BROWN MOTTLED WITH GRAY, **LEAN CLAY WITH SAND**, TRACE GRAVEL, DAMP		1 2	2 5 6	17	50	SS-1	3.7 - 4.5+	-	-	-	-	-	-	-	-	-	18	CL (V)	
		3 4 5	6 11 14	40	89	SS-2	4.5+	3	4	10	11	37	35	27	17	10	16	CL	
		6 7	13 13 18	49	100	SS-3	4.5+	-	-	-	-	-	-	-	-	-	12	CL (V)	
		8 9 10	5 13 17	48	78	SS-4	4.2 - 4.5+	-	-	-	-	-	-	-	-	-	13	CL (V)	
		11 12	4 11 25	57	56	SS-5	4.5+	2	3	10	12	42	31	25	12	13	9	CL	
	736.3	EOB																	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. CAVE DEPTH 8.5'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 20 GAL. BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/29/13 16:45 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\NASA DOMESTIC WATERLINE\NASA DOMESTIC WATERLINE.GPJ

PROJECT: NASA DOMESTIC WATERLINE	DRILLING FIRM / OPERATOR: B & P / P. WEBB	DRILL RIG: MOBILE B57 ORV	STATION / OFFSET:
TYPE: WATERLINE	SAMPLING FIRM / LOGGER: B & P / R.WEBB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT:
PID: Client: NASA	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/30/11	ELEVATION: 757.5 (MSL) EOB: 12.5 ft.
START: 12/19/12 END: 12/19/12	SAMPLING METHOD: SPT	ENERGY RATIO (%): 95.1	COORD: 2144024.000 N, 637635.000 E

EXPLORATION ID B-3

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 757.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	MS	FS	SI	CL	LL	PL	PI	WC	USCS CLASS	HOLE SEALED
13.0", **ASPHALT**	756.4																		
VERY STIFF TO HARD, GRAY-BROWN, **CLAYEY SAND WITH GRAVEL**, DAMP **(FILL)**	754.5	1 2	8 5 5	16	67	SS-1	2.6 - 4.5+	30	9	13	9	21	18	24	15	9	10	SC	
VERY STIFF TO HARD, BROWN TO BROWN MOTTLED WITH GRAY, **LEAN CLAY WITH SAND**, TRACE GRAVEL, DAMP		3 4 5	6 6 8	22	44	SS-2	4.5+	-	-	-	-	-	-	-	-	-	16	CL (V)	
		6 7	4 8 12	32	100	SS-3	4.5+	3	5	7	11	31	43	32	17	15	15	CL	
		8 9	3 6 8	22	72	SS-4	3.4 - 4.5+	-	-	-	-	-	-	-	-	-	13	CL (V)	
	747.0	10																	
HARD, GRAY AND RED-BROWN, **SANDY SILTY CLAY**, TRACE GRAVEL, DAMP	745.0	11 12 EOB	8 19 24	68	89	SS-5	4.5+	2	3	6	21	42	26	19	12	7	9	CL-ML	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. CAVE DEPTH 10.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 20 GAL. NON-SHRINK GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/29/13 16:46 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\NASA DOMESTIC WATERLINE\NASA DOMESTIC WATERLINE.GPJ

PROJECT: NASA DOMESTIC WATERLINE	DRILLING FIRM / OPERATOR: B & P / P. WEBB	DRILL RIG: MOBILE B57 ORV	STATION / OFFSET:
TYPE: WATERLINE	SAMPLING FIRM / LOGGER: B & P / R.WEBB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT:
PID: Client: NASA	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/30/11	ELEVATION: 760.5 (MSL) EOB: 12.5 ft.
START: 12/20/12 END: 12/20/12	SAMPLING METHOD: SPT	ENERGY RATIO (%): 95.1	COORD: 214896.000 N, 636158.000 E

EXPLORATION ID B-4

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 760.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	MS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	USCS CLASS	HOLE SEALED
11.0", **ASPHALT**	759.5																		
VERY STIFF TO HARD, BROWN MOTTLED WITH GRAY AND DARK GRAY, **LEAN CLAY**, TRACE SAND, DAMP		1, 2	2 3 6	14	67	SS-1	3.8 - 4.5+	0	0	1	2	35	63	40	20	20	20	CL	
SS-2 NO RECOVERY		3, 4, 5	5 5 4	14	0	SS-2	-	-	-	-	-	-	-	-	-	-	-		
@6.0'; VERY STIFF TO HARD, BROWN MOTTLED WITH GRAY, **SANDY LEAN CLAY**, LITTLE TO TRACE GRAVEL, MOIST TO DAMP		6, 7, 8	6 8 14	35	89	SS-3	3.8 - 4.5+	3	8	10	13	31	35	29	13	16	21	CL	
@8.0'; CHANGES TO GRAY MOTTLED WITH BROWN TO GRAY		9, 10	2 6 9	24	72	SS-4	4.5+	-	-	-	-	-	-	-	-	-	13	CL (V)	
	748.0	11, 12 EOB	6 9 12	33	61	SS-5	4.5+	-	-	-	-	-	-	-	-	-	8	CL (V)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. CAVE DEPTH 8.6'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 20 GAL. NON-SHRINK GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/29/13 16:46 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\NASA DOMESTIC WATERLINE\NASA DOMESTIC WATERLINE.GPJ

PROJECT: NASA DOMESTIC WATERLINE	DRILLING FIRM / OPERATOR: B & P / P. WEBB	DRILL RIG: MOBILE B57 ORV	STATION / OFFSET:	EXPLORATION ID B-5
TYPE: WATERLINE	SAMPLING FIRM / LOGGER: B & P / R.WEBB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT:	
PID: Client: NASA	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/30/11	ELEVATION: 751.9 (MSL) EOB: 12.5 ft.	PAGE 1 OF 1
START: 12/19/12 END: 12/19/12	SAMPLING METHOD: SPT	ENERGY RATIO (%): 95.1	COORD: 2143500.000 N, 637615.000 E	

MATERIAL DESCRIPTION AND NOTES	ELEV. 751.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	MS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	USCS CLASS	HOLE SEALED
11.0", **ASPHALT**	751.0																		
1.0", **GRANULAR BASE**	750.9																		
MEDIUM DENSE TO DENSE, BROWN, **POORLY GRADED SAND WITH SILT AND GRAVEL**, TRACE CLAY, WET **(FILL)**		1 2 3 4 5	8 8 8	25	72	SS-1	-	-	-	-	-	-	-	-	-	-	14	SP-SM (V)	
			6 9 15	38	83	SS-2	-	2	13	32	44	5	4	NP	NP	NP	16	SP-SM	
	746.4																		
HARD, GRAY MOTTLED WITH BROWN TO GRAY, **SANDY LEAN CLAY**, TRACE GRAVEL, MOIST TO DAMP		6 7	4 7 18	40	72	SS-3	4.5+	-	-	-	-	-	-	-	-	-	12	CL (V)	
		8 9 10	7 14 23	59	72	SS-4	4.5+	2	5	14	15	43	21	20	11	9	9	CL	
		11 12	10 21 23	70	72	SS-5	4.5+	-	-	-	-	-	-	-	-	-	9	CL (V)	
	739.4	EOB																	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. CAVE DEPTH 9.6'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 20 GAL. NON-SHRINK GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/29/13 16:46 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\NASA DOMESTIC WATERLINE\NASA DOMESTIC WATERLINE.GPJ

PROJECT: NASA DOMESTIC WATERLINE	DRILLING FIRM / OPERATOR: B & P / P. WEBB	DRILL RIG: MOBILE B57 ORV	STATION / OFFSET:
TYPE: WATERLINE	SAMPLING FIRM / LOGGER: B & P / R.WEBB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT:
PID: Client: NASA	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/30/11	ELEVATION: 750.7 (MSL) EOB: 12.5 ft.
START: 12/20/12 END: 12/20/12	SAMPLING METHOD: SPT	ENERGY RATIO (%): 95.1	COORD: 2143127.000 N, 637511.000 E

EXPLORATION ID B-6

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 750.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	MS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	USCS CLASS	HOLE SEALED
12.0", **ASPHALT**	749.7																		
HARD, BROWN MOTTLED WITH GRAY TO BROWN, **LEAN CLAY WITH SAND**, TRACE GRAVEL, MOIST TO DAMP		1 2	2 4 6	16	72	SS-1	4.5+	3	4	8	12	33	40	30	14	16	16	CL	
		3 4 5	4 8 10	29	72	SS-2	4.5+	-	-	-	-	-	-	-	-	-	16	CL (V)	
		6 7	1 12 19	49	56	SS-3	4.5+	-	-	-	-	-	-	-	-	-	11	CL (V)	
	742.7	8																	
HARD, GRAY, **SANDY SILTY CLAY**, SOME CLAY, TRACE GRAVEL, DAMP		9 10	18 24 27	81	89	SS-4	4.5+	2	4	12	14	42	26	23	16	7	9	CL-ML	
		11 12	14 27 37	101	61	SS-5	4.5+	-	-	-	-	-	-	-	-	-	9	CL-ML (V)	
	738.2	EOB																	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. CAVE DEPTH 8.6'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 20 GAL. NON-SHRINK GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/29/13 16:46 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\NASA DOMESTIC WATERLINE\NASA DOMESTIC WATERLINE.GPJ

PROJECT: NASA DOMESTIC WATERLINE	DRILLING FIRM / OPERATOR: B & P / P. WEBB	DRILL RIG: MOBILE B57 ORV	STATION / OFFSET:
TYPE: WATERLINE	SAMPLING FIRM / LOGGER: B & P / R.WEBB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT:
PID: Client: NASA	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/30/11	ELEVATION: 748.2 (MSL) EOB: 12.5 ft.
START: 12/19/12 END: 12/19/12	SAMPLING METHOD: SPT	ENERGY RATIO (%): 95.1	COORD: 2142866.000 N, 637535.000 E

EXPLORATION ID B-7

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 748.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	MS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	USCS CLASS	HOLE SEALED
13.0", **ASPHALT**	747.1																		
MEDIUM STIFF TO VERY STIFF, BROWN, GRAY-BROWN AND GRAY, **LEAN CLAY WITH SAND**, TRACE GRAVEL, DAMP TO MOIST **(FILL)**		1 2	3 3 4	11	17	SS-1	2.9 - 3.2	-	-	-	-	-	-	-	-	-	13	CL (V)	
		3 4	2 2 3	8	72	SS-2	0.8 - 2.2	1	2	5	12	43	37	40	24	16	31	CL	
(END FILL)	742.7	5																	
HARD, BROWN MOTTLED WITH GRAY, **SANDY LEAN CLAY**, LITTLE GRAVEL, DAMP		6 7	4 5 7	19	78	SS-3	3.0 - 4.5	-	-	-	-	-	-	-	-	-	18	CL (V)	
		8 9	5 9 15	38	78	SS-4	4.5+	-	-	-	-	-	-	-	-	-	14	CL (V)	
		10 11 12	8 16 24	63	83	SS-5	4.5+	7	6	4	12	40	31	29	17	12	12	CL	
	735.7	EOB																	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. CAVE DEPTH 9.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 20 GAL. NON-SHRINK GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/29/13 16:46 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\NASA DOMESTIC WATERLINE\NASA DOMESTIC WATERLINE.GPJ

PROJECT: NASA DOMESTIC WATERLINE	DRILLING FIRM / OPERATOR: B & P / P. WEBB	DRILL RIG: MOBILE B57 ORV	STATION / OFFSET:
TYPE: WATERLINE	SAMPLING FIRM / LOGGER: B & P / R.WEBB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT:
PID: Client: NASA	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/30/11	ELEVATION: 756.6 (MSL) EOB: 12.5 ft.
START: 12/19/12 END: 12/19/12	SAMPLING METHOD: SPT	ENERGY RATIO (%): 95.1	COORD: 2143066.000 N, 636778.000 E

EXPLORATION ID B-8

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 756.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	MS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	USCS CLASS	HOLE SEALED
12.0", **ASPHALT**	755.6																		
4.0", **GRANULAR BASE**	755.3																		
STIFF TO VERY STIFF, GRAY MOTTLED WITH BROWN AND DARK GRAY, **LEAN CLAY WITH SAND**, TRACE GRAVEL, SLIGHTLY ORGANIC, MOIST	753.6	1 2	2 5 6	17	67	SS-1	1.6 - 2.6	0	2	3	10	40	45	38	20	18	24	CL	
STIFF TO VERY STIFF, BROWN, **CLAYEY SAND**, LITTLE GRAVEL, DAMP		3 4 5	2 1 4	8	28	SS-2	1.7 - 3.5	-	-	-	-	-	-	-	-	-	14	SC (V)	
	748.6	6 7 8	1 4 7	17	61	SS-3	1.0 - 2.5	4	10	31	18	19	18	29	17	12	16	SC	
LOOSE TO VERY LOOSE, BROWN AND GRAY, **SILTY GRAVEL WITH SAND**, TRACE CLAY, DAMP		9 10	3 3 3	10	61	SS-4	-	-	-	-	-	-	-	-	-	-	14	GM (V)	
	744.1	W 11 12 EOB	1 WOH 1	2	61	SS-5	-	-	-	-	-	-	-	-	-	-	21	GM (V)	

NOTES: GROUNDWATER ENCOUNTERED AT 11.0' DURING DRILLING. CAVE DEPTH 9.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: POURED 20 GAL. BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/29/13 16:46 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\NASA DOMESTIC WATERLINE\NASA DOMESTIC WATERLINE.GPJ

PROJECT: NASA DOMESTIC WATERLINE	DRILLING FIRM / OPERATOR: B & P / P. WEBB	DRILL RIG: MOBILE B57 ORV	STATION / OFFSET:
TYPE: WATERLINE	SAMPLING FIRM / LOGGER: B & P / R.WEBB	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT:
PID: Client: NASA	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/30/11	ELEVATION: 760.2 (MSL) EOB: 12.5 ft.
START: 12/19/12 END: 12/19/12	SAMPLING METHOD: SPT	ENERGY RATIO (%): 95.1	COORD: 2142785.000 N, 635562.000 E

EXPLORATION ID B-9

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 760.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	MS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	USCS CLASS	HOLE SEALED
12.0", **ASPHALT**	759.2																		
4.0", **GRANULAR BASE**	758.9																		
VERY STIFF TO HARD, BROWN CHANGING TO GRAY MOTTLED WITH BROWN, **SANDY LEAN CLAY**, LITTLE GRAVEL, DAMP		1, 2	5 / 5 / 8	21	67	SS-1	3.0 - 4.5+	13	6	9	12	28	32	31	18	13	15	CL	
		3, 4, 5	3 / 9 / 13	35	78	SS-2	4.5+	-	-	-	-	-	-	-	-	-	16	CL (V)	
@5.5'; HARD, GRAY MOTTLED WITH BROWN, **LEAN CLAY WITH SAND**, TRACE GRAVEL, DAMP		6, 7	4 / 9 / 12	33	78	SS-3	4.5+	4	3	9	12	31	41	30	17	13	14	CL	
		8, 9	5 / 8 / 11	30	67	SS-4	4.5+	-	-	-	-	-	-	-	-	-	14	CL (V)	
	749.7																		
HARD, GRAY, **SANDY SILTY CLAY**, TRACE GRAVEL, DAMP	747.7	11, 12 EOB	5 / 21 / 38	94	78	SS-5	4.5+	3	6	16	15	39	21	21	15	6	10	CL-ML	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. CAVE DEPTH 10.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 20 GAL. NON-SHRINK GROUT