Geotechnical Investigations – Water Main Construction

GHD Water

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Water Main Construction
Why Consider Geotechnical Evaluations?

- Not a typically a part of routine watermain construction
  - Open cut in previously excavated areas, known conditions
  - Minimum depth installation (4’ to 5’) cover
  - Leave any needed subsurface explorations up to contractor

Water Main Construction
Why Consider Geotechnical Evaluations?

- Special Watermain Construction Conditions
  - Trenchless Construction
  - “Cross Country” projects
  - Information for Bidders
  - Other

Water Main Construction
Why Consider Geotechnical Evaluations?

- Other subsurface concerns – not included
  - Existing utilities
  - Soil contamination
  - Seismic concerns
  - Foundation designs – above ground piping

Water Main Construction
Why Consider Geotechnical Evaluations?

- Trenchless
  - Auger Bores/Jacking/Ramming
  - Horizontal directional drill
- “Cross Country” projects
  - Use of native material for backfill/bedding
- Information for bidders
  - Rock & groundwater
- Other
  - Corrosive soils
  - Undermined areas
  - Sinkholes/caves

Water Main Construction
Why Consider Geotechnical Evaluations?

- Review geotechnical information for these special conditions
  - Benefits & Risks
  - Application on Projects
  - Discussion

Geotechnical Evaluations – Goals*

- Determination of soil & stratification
- Soil samples for testing
- Depth and nature of bedrock
- *In situ* tests
- Special construction conditions
- Water table

- *Das, Braja M., “Principals of Geotechnical Engineering Fifth Edition”. 2002

Geotechnical Evaluations – Preliminary Design Information

- Site survey
- Preliminary layout
- Depth to trench bottom/Planned subgrade
- Scope of Work
- Review existing geologic and soil surveys, previous geotechnical evaluations

Geotechnical Evaluations – Field Investigations

- Borings
  - Varied drilling rigs, sizes, and capabilities
  - Small footprint/limit of disturbance
  - Greater depths
  - Sampling – split spoon samples
  - Penetration testing
  - Rock corings & characterization

- Test Pits
  - Open cut excavation
  - Larger footprint and disturbance
  - Limited depth
  - Safety for open cut
  - Less expensive, faster

On-Site Soils Evaluation – 24 inch Pipe Line

Site 151+50- Moved to 153+50
Latitude / Longitude – 40o 49.148 N - 76o 30.704 W
Soils Mapping – ShA
Soil Sampling – Yes (Composite Sample – 15 inches to 6 feet)

-2 to 0 inches	Decomposing organic (hemic)material with leaf litter
0 to 6 inches A1	7.5YR3/2, channery silt loam, mod m granular, sl. sticky, near saturated redoximorphic (c1f)
6 to 15 inches Bg	7.5YR4/1, channery silt loam, sl. sticky, redoximorphic (c2p), saturated
15 to 32 inches Bdg	7.5YR5/2, channery heavy loam, wk v. coarse platy, sticky, sl. plastic when wet redoximorphic (c3p), seepages at 15 inches, horizon near saturated
32 to 55 inches Bx1	5YR4/3, channery loam, wk v. coarse prismatic, firm, brittle, many Mn staining redoximorphic features (m3p), sl sticky and sl. plastic when wet, seepages at 32 inches
50 to 80 inches BC	2.5YR4/4, channery sandy loam, wk v. coarse platy, tight in place, redoximorphic features (c2p)

Material from 15 to 72 composite sample collected and tested- Midlantic Engineering Inc. (USCS Classification ASTM D-2487- (CL))

Upward vertical seepage started at 80 inches and rose to 74 inches within 20 minutes. Upward vertical seepage appeared to stop. Therefore, it appears likely that there may be a saturated soil horizon below 80 inches that is partially confined

Note: Hydric Soil Indicators are present.

Geotechnical Evaluations – Lab Tests

- Gradations
- Moisture-density relationship
- Acidic soils and chemical content
- Expansive soils
- Other

Enclosure (11)
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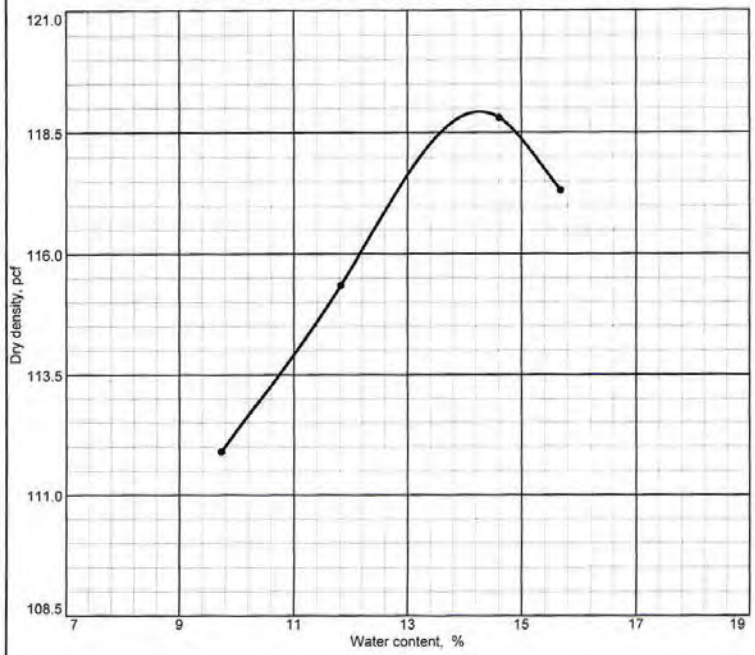
MOISTURE-DENSITY RELATIONSHIP



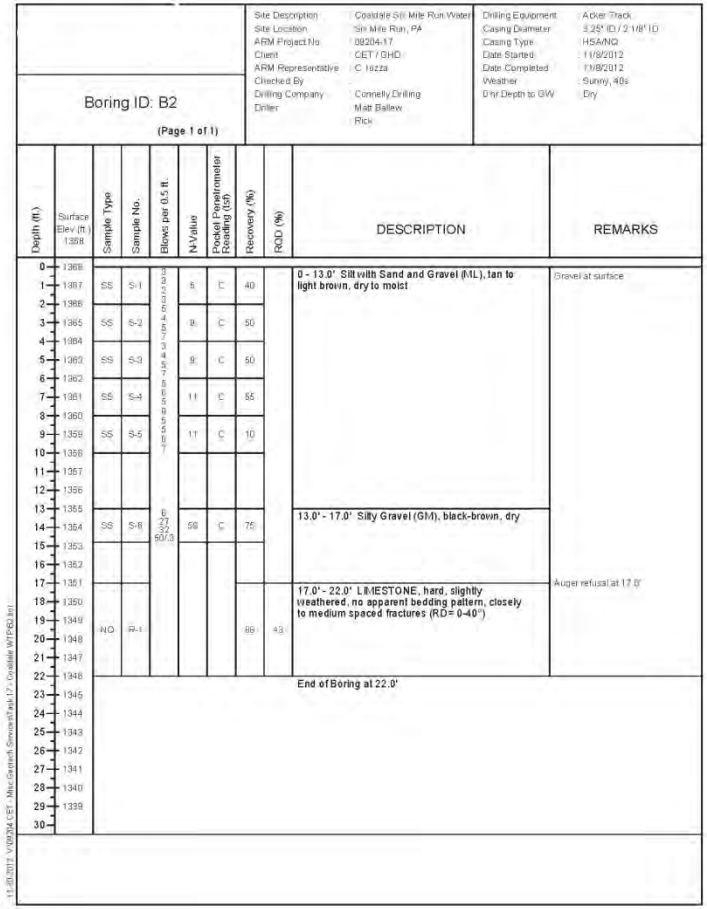
Test specification: ASTM D 698-00a Method C Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
15"-72"	CL	A-4(3)			30	10	0.0	53.3

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 118.9 pcf Optimum moisture = 14.3 %	brown sandy LEAN CLAY

Geotechnical Evaluations – Report*

- Report
  - Scope and general description
  - Geologic conditions
  - Details of boring/test pits
  - Description of subsoil conditions
  - Recommendations/limitations
- Figures
  - Location of bores/test pits
  - Boring logs
  - Lab test results



Boring ID: B2

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Site Description	Coaldale Sill Mile Run Water
Site Location	Sill Mile Run, PA
ARM Project No	00204-17
Client	CET / GHD
ARM Representative	C. Iozza
Checked By	
Drilling Company	Connelly Drilling
Driller	Matt Ballew Rick
Drilling Equipment	Acker Track
Casing Diameter	3.25" ID / 2 1/8" ID
Casing Type	HSA/NQ
Date Started	11/9/2012
Date Completed	11/9/2012
Weather	Sunny, 40s
0 hr Depth to GW	Dry

Depth (ft.)	Surface Elev (ft.) 1368	Sample Type	Sample No.	Blows per 0.5 ft.	N-Value	Pocket Penetrometer Reading (tsf)	Recovery (%)	RQD (%)	DESCRIPTION	REMARKS
0	1368									
1	1367	SS	S-1	3 3 2	5	C	40		0 - 13.0' Silt with Sand and Gravel (ML), tan to light brown, dry to moist	Gravel at surface
2	1366									
3	1365	SS	S-2	3 4 4	8	C	50			
4	1364									
5	1363	SS	S-3	3 4 5	9	C	50			
6	1362									
7	1361	SS	S-4	3 5 6	11	C	55			
8	1360									
9	1359	SS	S-5	3 5 7	11	C	10			
10	1358									
11	1357									
12	1356									
13	1355								13.0' - 17.0' Silty Gravel (GM), black-brown, dry	
14	1354	SS	S-6	6 27 32 50/3	59	C	75			
15	1353									
16	1352									
17	1351									Auger refusal at 17.0'
18	1350								17.0' - 22.0' LIMESTONE, hard, slightly weathered, no apparent bedding pattern, closely to medium spaced fractures (RD= 0-40")	
19	1349	NQ	R-1				89	43		
20	1348									
21	1347									
22	1346								End of Boring at 22.0'	
23	1345									
24	1344									
25	1343									
26	1342									
27	1341									
28	1340									
29	1339									
30										

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Geotechnical Evaluations
Trenchless Construction

- Types of Trenchless Construction
  - Auger Bores
  - Pipe Ramming/Jacking
  - Horizontal Directional Drills (HDD)
  - Tunnelling/ Microtunnelling

Geotechnical Evaluations
Trenchless Construction - HDD

- Materials
  - HDPE, PVC, & DIP
  - Casings less common
- Classifications
  - Micro HDD – Services
  - Mini HDD – 12” dia. & less, couple hundred foot length, <15’ depths
  - Midi HDD – Between Mini & Maxi
  - Maxi HDD – Up to 48” dia., several thousand foot length, >25’ depths

Geotechnical Evaluations
Trenchless Construction - HDD

- Maxi HDD Standard
  - ASTM F1962 Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings
- Mini HDD Standard
  - Plastic Pipe Institute (PPI) TR-46 Guidelines for the Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe

Geotechnical Evaluations
Trenchless Construction - HDD

- Maxi HDD
  - Significant design and construction undertaking
  - Extensive geotechnical and related information recommended
- Mini HDD
  - More routine design and construction
  - Geotechnical determination dependent on project scope

Geotechnical Evaluations
Trenchless Construction - HDD

- Mini HDD
  - Soil conditions impacts
    - Suitability for HDD
    - Cost per LF
    - Rock vs. cobbles
    - Worst case pricing

Geotechnical Evaluations
Trenchless Construction – Auger/Ramming/Jacking

- Materials
  - HDPE, PVC, & DIP
  - Casings more common - steel
- Common Applications
  - PennDOT highway
  - Railroads

Geotechnical Evaluations
Trenchless Construction – Auger/Ramming/Jacking

- Many of the same concerns with HDD
  - Cost per linear foot impacts
  - Cobbles
  - Casing design

Geotechnical Evaluations
Trenchless Construction – Cost

Job Number	Diameter	Average HDD Length (ft)	Pipe Material	Number of Drills	Cost per foot	Bid Date	Details
1699.1602	12"	133	HDPE	3	$85	2012	PennDOT Highway and stream crossing
1699.2207	8"	60	HDPE	2	$102	2012	PennDOT Highway crossing
1699.2401	8"	200	HDPE	1	$84	2011	Stream crossing
1699.4001	12"	250	HDPE	1	$60	2011	PennDOT bridge and stream crossing
1699.4701	12"	100	HDPE	1	$148	2009	PennDOT Highway crossing
1699.4701	12"	360	HDPE	1	$147	2010	Railroad & Stream crossing
1699.4702	8"	75	HDPE	4	$170	2010	PennDOT Highway crossings, tight conditions
1699.4703	8"	400	HDPE	1	$75	2010	PennDOT bridge and stream crossing
1699.4704	8"	160	HDPE	2	$64	2011	PennDOT highway
1699.4705	8"	160	HDPE	1	$127	2013	PennDOT culvert and stream crossing
1699.8901	8" & 6"	90	HDPE	4	$72	2011	Stream crossings (Twp bridges)
1699.6701	12"	140	HDPE	1	$130	2008	PennDOT highway
1699.9601	8"	80	HDPE	1	$125	2009	PennDOT highway
1699.9601	12"	250	HDPE	1	$180	2009	Stream crossings - open cut was $275 per foot
1699.9601	12"	150	HDPE	1	$190	2009	Stream crossings - open cut was $350 per foot
			Average cost per foot		$117		
202.2002	8"	110	Steel with DIP	1	$530	2008	PennDOT highway crossing
1699.97	12"	45	Steel with DIP	1	$980	2009	Railroad crossing
1699.97	12"	90	Steel with DIP	1	$344	2009	PennDOT highway crossing
1699.6701	12"	70	Steel with DIP	1	$435	2008	Railroad crossing
1999.35	12"	250	Steel with DIP	1	$420	2009	Railroad crossing
			Average cost per foot		$436		

Geotechnical Evaluations
"Cross Country" Projects

- Raw Water Mains
- Transmission Mains
- Pipe selection and design
- Bedding and backfill design, reuse of existing material
  - Minimize imported material

Geotechnical Evaluations
Cross Country Projects - Experience

- 24” Transmission Main project – 17,000 feet
  - Goals for Geotechnical Evaluation
    - Trench detail to minimize impact to the site
    - Minimize use of stone
    - Characterize if feasible to crush onsite rock for bedding

Geotechnical Evaluations
Cross Country Projects – Scope of Evaluation

- 24” Transmission Main project – 17,000 feet
  - Scope of Geotechnical Evaluation
    - Test pits planned about every 1,000 ft
    - Lab testing of soil
    - Report on findings

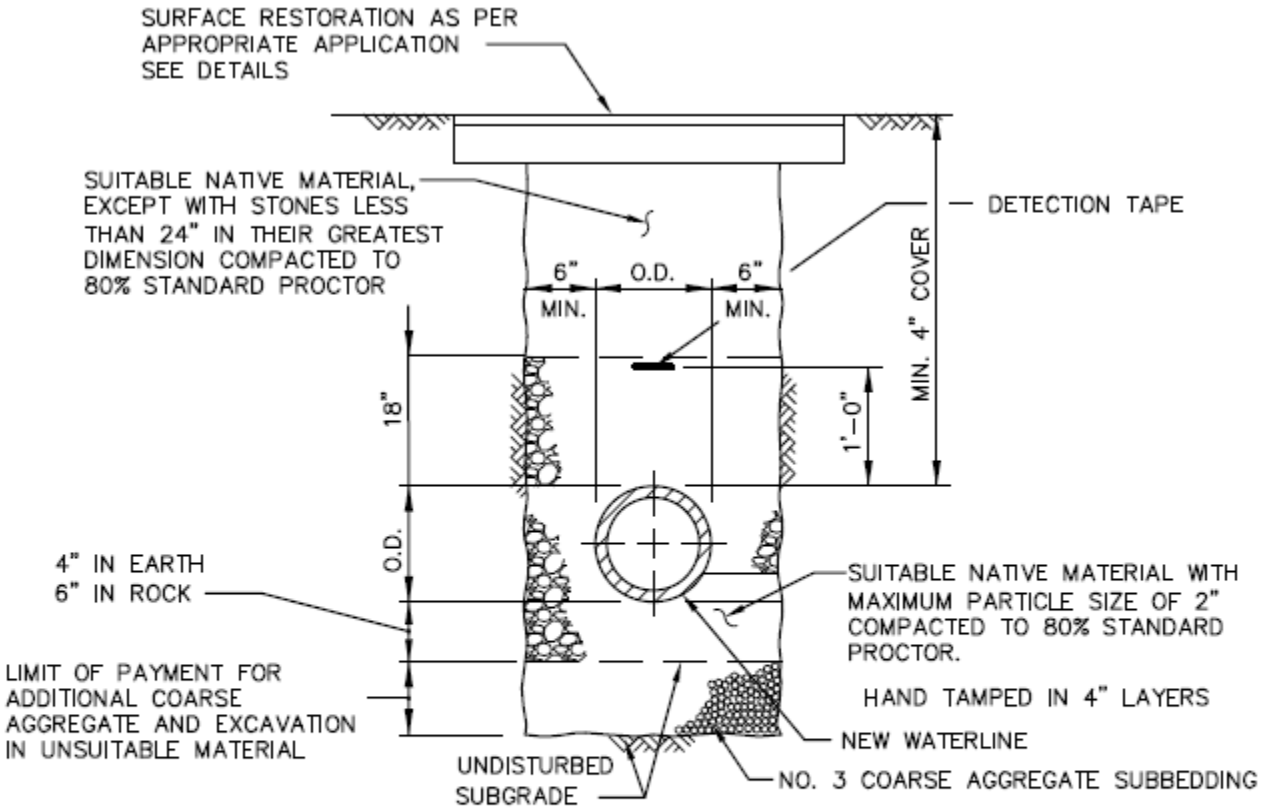
Geotechnical Evaluations
Cross Country Projects – Findings

- 24” Transmission Main project – 17,000 feet
  - Test pit locations were adjusted based on soil types and geotech engineer’s judgement
  - More emphasis put on field work vs. lab work
  - Test pits excavated to about 7’ below grade
  - Bedrock not encountered
  - More groundwater than expected

Geotechnical Evaluations
Cross Country Projects – Project Bidding

- 24” Transmission Main project – 17,000 feet
  - Two bid alternates in bid form
    - Use of all native bedding and backfill (stone bedding as directed in wet areas
    - Stone bedding and initial backfill, remaining native backfill
    - 11,000 lf in alternate (remainder within gravel road)

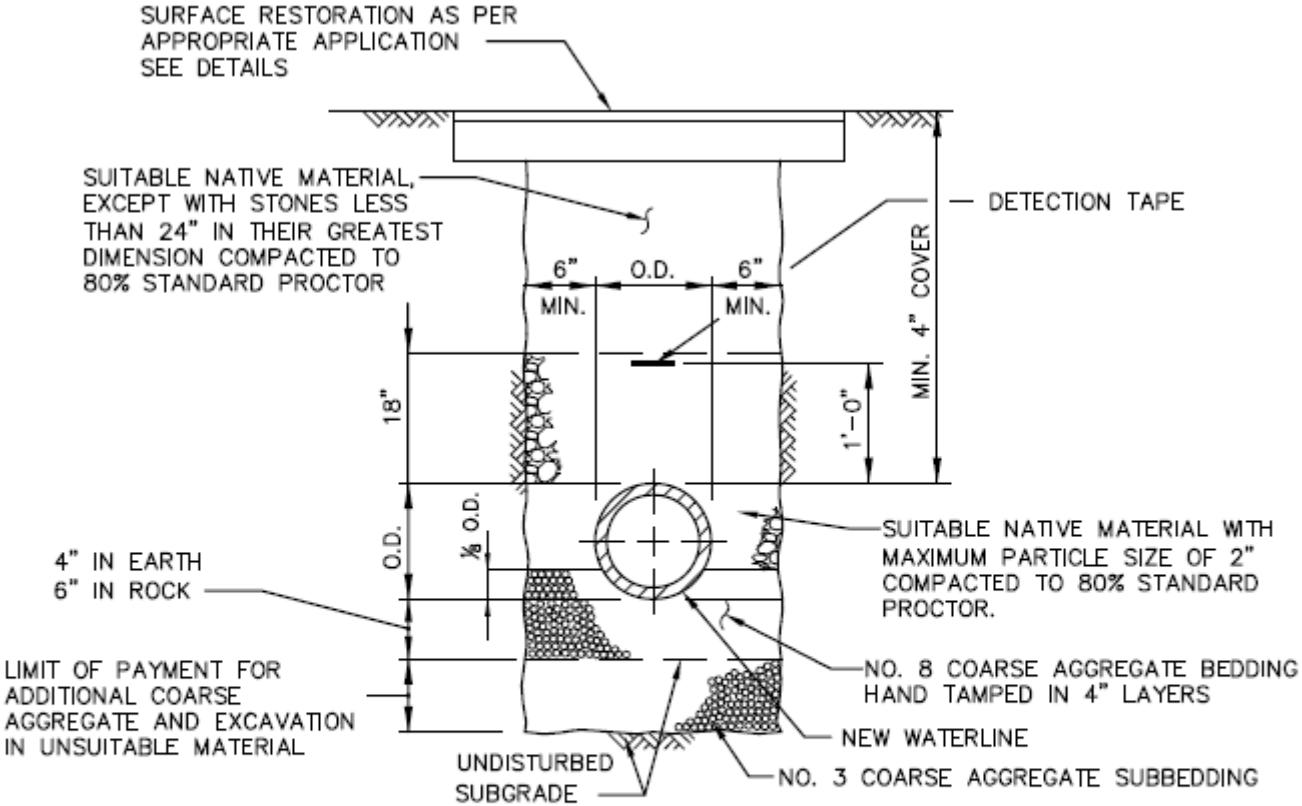
Geotechnical Evaluations
Cross Country Projects – Project Bidding



NOTES:

1. ALL STONE GRADATIONS ARE AASHTO CLASSIFICATION, UNLESS OTHERWISE NOTED.
2. SPREAD ROCKS OVER 24" IN SIZE ON SURFACE WITHIN LIMITS OF DISTURBANCE.
3. SUITABLE NATIVE MATERIAL SHALL BE LOAM, CLAY, SAND, OR GRAVEL AND SHALL BE FREE OF CINDERS, ASHES, REFUSE, VEGETABLE OR ORGANIC MATERIAL, BOULDERS, ROCKS OR STONES OVER 2" PARTICLE SIZE, FROZEN SOIL OR OTHER UNSUITABLE MATERIAL.

Geotechnical Evaluations
Cross Country Projects – Project Bidding



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Geotechnical Evaluations
Cross Country Projects – Bid Results

- 24” Transmission Main project – 17,000 feet
  - Average two low bidders (Installation only)
    - All native bedding/backfill - $24/ft
    - 6” of stone bedding/native backfill - $27/ft
    - Stone bedding & initial backfill - $31/ft
    - Stone bedding & stone backfill - $41/ft
- Alternate cost savings - $64,000 on $1.34 million
- Geotechnical Cost - $8,000 to $10,000

Geotechnical Evaluations
Cross Country Projects – Bid Feedback

- 24” Transmission Main project – 17,000 feet
  - Talked to Bidders on project on use of geotechnical report
    - Wide range of feedback
    - All indicated report was helpful
    - One bidder noted it allowed them to reduce bid by around $50,000

Geotechnical Evaluations
Information for Bidders – Contract Documents

- EJCDC Documents – C-700, 2007
  - “Technical Information”
  - Contractor may rely on accuracy of “technical data” contained in subsurface reports and drawings, but documents are not contract documents
    - May not rely on technical data for completeness, application to contractors means, methods, techniques, contractor interpretation
    - Possible claims due to differing subsurface conditions if technical data is inaccurate, materially different
    - Must be something not known to contractor and could not be reasonably discovered as required by bidding documents

Geotechnical Evaluations
Information for Bidders – Benefits

- More accurate bid prices
- More equitable information to bidders, less bid variation
- Assist in estimating quantities

Geotechnical Evaluations
Information for Bidders – Scope & Risks

- How much to be representative
  - Cost
- Differing conditions & characterizations
- Why should Owner pay for geotechnical
- Part of Bidding Document requirements
- Claims
- Rock clause
- Blasting

Geotechnical Evaluations
Information for Bidders – Rock Clause

- Rock Clause language
  - Measurements, equipment, attempts
  - Estimation of quantity
- Re-bid one projects with rock clause added
  - 3,000 feet of 20”, 2,000 feet of 8”
    - Increased project cost by $50,000
    - Used about half of estimated quantity

Water Main Construction
Geotechnical Evaluations - Conclusions

- Project by Project determination based on size and scope of project, materials and techniques to be utilized
  - Trenchless applications
  - Cross Country projects

Water Main Construction
Why Consider Geotechnical Evaluations?

- Questions & Discussion

At a glance

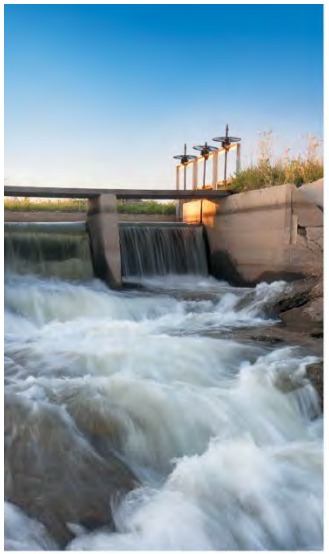

GHD
leading engineering, architecture and environmental consulting company
operating in 5 continents
100+ offices worldwide
80+ years in operation
6500+ people
2012 revenue: AUD 1118 million
serving 5 global markets
70+ service lines

Where are we?

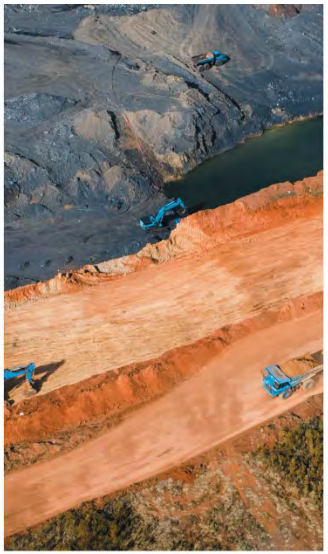

UK
Asia
Canada
Middle East
USA
Australia & New Zealand
South America

Strategy

Our goal is to be a leader in our five global markets

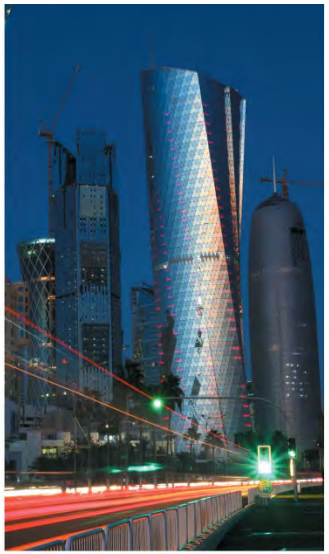


Water



Energy & Resources

Environment



Property & Buildings

Transportation

We seek to achieve this through a client-centered culture and a One GHD collaborative network

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