GEOTECHNICAL EVALUATION
LEVEE EVALUATION AND CERTIFICATION
4403 SOUTH DISHMAN-MICA ROAD
SPOKANE COUNTY, WASHINGTON

Inland Pacific Engineering Company Project No. 14-037

February 12, 2015
Revised August 29, 2016

IPEC

Inland Pacific Engineering Company
Geotechnical Engineering and Consulting

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Geotechnical Engineering and Consulting

February 12, 2015
Project No. 14-037

NAI Black
c/o Mr. Bryan Walker
107 South Howard
Suite 500
Spokane, WA 99201

Re: **Geotechnical Evaluation**
Chester Creek Levee Certification
4403 South Dishman-Mica Road
Spokane County, WA

Dear Mr. Walker:

We have completed the geotechnical evaluation for the Chester Creek levee Certification at the above-referenced site in Spokane, Washington. The purpose of evaluation was to evaluate the existing levee for conformance to 44 CFR 65.10 of the Code of Federal Regulations for certification by the Federal Emergency Management Agency (FEMA).

We appreciate the opportunity to provide our services to you on this project. If you have any questions or need additional information, please do not hesitate to call me at (509) 209-6262 at your convenience.

Sincerely,
Inland Pacific Engineering Company

Paul T. Nelson, P.E.
Principal Engineer

Attachment: Geotechnical Evaluation Report

GEOTECHNICAL EVALUATION
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4403 SOUTH DISHMAN-MICA ROAD
SPOKANE COUNTY, WASHINGTON

Inland Pacific Engineering Company Project No. 14-037

February 12, 2015
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Prepared for:

NAI Black
Spokane, Washington

IPEC

Inland Pacific Engineering Company
Geotechnical Engineering and Consulting

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1.0 INTRODUCTION

1.1 Project Description

We understand that the proposed project may consist of a residential development. The site consists of 91 acres currently developed as a golf course. Stormwater runoff will be treated using drywells and/or gravel galleries for subsurface infiltration. These type of facilities will also be used to manage potential floodwaters, if needed.

1.2 Purpose

The purpose of our services is to evaluate the existing levee for conformance to 44 CFR 65.10 of the Code of Federal Regulations for certification by the Federal Emergency Management Agency (FEMA).

1.3 Scope

Our services were requested by Mr. Bryan Walker of NAI Black. Mr. Walker authorized us to proceed on February 24, 2014. The scope of work agreed upon consisted of the following:

- review of existing geotechnical data and reports for the development, if available
- drill 6 penetration test borings at the site to a depth of 25 feet,
- performing laboratory tests on samples obtained from the test pits,
- classifying the soils and preparing boring logs, and
- submitting a geotechnical report containing logs of the borings, results of our field investigation and laboratory testing, and our analyses, opinions, and recommendations relative to the conformance of the existing levee to FEMA standards.

1.4 Available Information

We were provided a topographic survey for the project site by WCE. This topographic survey showed the existing roadways, existing structures, property lines, and existing ground surface elevation contours. This plan was prepared by WCE and was dated November 7, 2013.

We also performed a preliminary geotechnical evaluation for the property in December 2013. The results of that evaluation, along with our opinions and recommendations, are summarized in our Preliminary Geotechnical Evaluation dated December 31, 2013.

In conjunction with this evaluation, West Consultants, Inc. (WEST) has been contracted by NAI Black to provide a FEMA Conditional Letter of Map Revision submittal (CLOMR). They have provided Inland Pacific Engineering Company (IPEC) water surface elevations and velocity output from their revised RAS model to assist us in our evaluation.

1.5 Locations and Elevations

The borings were drilled at or near locations selected by us. The boring locations are shown on the Boring Location Map in Appendix A. The borings were staked by Whipple Consulting Engineers, Inc. (WCE). Ground surface elevations at the borings were provided by WCE.

2.0 RESULTS

2.1 Logs

Log of Boring sheets indicating the vertical sequence of soils and materials encountered and groundwater observations are included in Appendix B. The strata changes were inferred from the changes in the penetration test samples and auger cuttings brought to the surface. Please note that the depths shown as changes between the strata are only approximate. The changes are likely transitions and the depths of changes vary between the borings. Geologic origins for each stratum are based on the soil type, available geologic maps, previous geotechnical reports for this and adjacent sites, and available common knowledge of the depositional history of the site.

2.2 Site Conditions

The site was used as a golf course prior to our evaluation. The site is relatively level with some elevated golf greens and excavated areas for water hazards. The site is primarily grass-covered with scattered trees along the fairways and pine trees in the undeveloped area to the northwest. The clubhouse building is present at the southwest corner. The existing levee is on the east side of Chester Creek between Thorpe Road and Dishman-Mica Road. The creek side of the levee is typically at a 2.3:1 to 3:1 (H:V) slope. The land side of the levee is also at a 3:1 slope from the Dishman-Mica Road bridge to approximately 300 feet southeast. Between this point and Thorpe Road, the land side slope is much less and, in some areas, relatively level with the crest.

2.3 Soils

Geologic maps indicate the soils in this area consist primarily of alluvial and/or glacially deposited silts, clays, sands, and gravels. According to the Soil Survey of Spokane County, the site soils are classified by the Natural Resource Conservation Service (NRCS) as Narcisse silt loam and Endoaquolls and Fluvaquents. The native soils encountered in the borings were consistent with the NRCS data.

The borings typically encountered existing fill or "possible fill" in the upper 9 to 12 feet (it was considered "possible fill" because it did not appear to be native soil, but no indicator, such as debris, etc., was found to confirm our opinion). Below the fill or "possible fill", the borings encountered water-deposited silty to clayey sands and/or poorly graded sands to their termination depths. Boring B-1 encountered alluvial lean clay below the 18-foot depth. Borings B-2, B-3, and B-5 encountered layers of lean to silty clay embedded in the sands at various depths.

2.4 Penetration Resistances

Penetration resistances (N-values) in the fill or "possible fill" ranged from 2 to 23 blows per foot (BPF) and averaged 11 BPF. Penetration resistances in the sands ranged from 3 to 19 BPF and averaged 10 BPF, indicating that these soils were very loose to medium dense, but were typically loose. Penetration resistances in the clays ranged from 2 to 6 BPF indicating that these soils were soft to medium in consistency.

2.5 Groundwater

Groundwater was not encountered in Borings B-1 and B-2 during or immediately after drilling. Boring B-1 was left open for 2 days and groundwater was not observed at that time. Groundwater was encountered in the remaining borings at depths ranging from 7.5 to 18 feet after drilling and/or up to 1 day later. These depths correspond to elevations ranging from 1996.9 to 2007.2. These observed levels are generally below the level of Chester Creek.

Based on our experience in the vicinity of the site, along with numerous test pits excavated on the site previously, it is our opinion that this portion of the creek is the beginning of the recharge section as evidenced by the typical lack of water in the creek further downstream. Also, the test pits previously excavated at the site east of the levee did not encounter groundwater. Well log data in the vicinity of the site indicate that groundwater is typically 50 to 80 feet below the surface.

2.6 Laboratory Testing

We obtained soil samples from the borings during our site investigation. The tests performed included the following:

1. ASTM D 6913, Sieve Analysis
2. ASTM D 4318, Atterberg Limits'
3. ASTM D 5084, Permeability
4. ASTM D 3080, Direct Shear
5. ASTM D 4767, Consolidated-Undrained Triaxial Compression

These tests were used to aid in classifying the soils and in the engineering analyses and formulation of engineering opinions and recommendations. The tests were performed by outside laboratories subcontracted to Inland Pacific Engineering Company (IPEC). The tests were performed by Budinger & Associates, Inc. and GN Northern, Inc. Attached are data sheets summarizing the tests performed.

3.0 ANALYSIS AND RECOMMENDATIONS

3.1 History

The levee was constructed in the early 1990's by the golf course property owner. As such, design plans or as-built drawings are not available. However, an as-built survey was completed by WCE in 2014.

3.2 Freeboard

We were provided 100-year flood elevations by WEST. They provided us a plan view of the levee with flood elevations at 5 locations starting at the bridge on Thorpe Road and ending at the bridge on Dishman-Mica Road. The elevations ranged from 2012.1 at Thorpe Road to 2010.4 at Dishman-Mica Road. Please refer to the WEST report for a complete summary of the floodplain analysis.

According to 44 CFR Section 65.10(b)(1), an additional 1 foot of freeboard is required within 100 feet of bridge structures. This will require the top of the levee to be at elevation 2016.1 at the Thorpe Road bridge and extending 100 feet north. Since the existing levee is at elevation 2015 in this area, it will be necessary to raise this portion of the levee to meet the minimum freeboard requirements. This will also be necessary at and between the pedestrian bridges near the middle of the levee alignment. At these bridges, the top of the levee will need to be raised to elevation 2015.1 south of the southern pedestrian bridge to elevation 2014.8 north of the northern pedestrian bridge. The freeboard requirement for the Dishman-Mica Road bridge is adequate.

3.3 Closures

There are no penetrations of the levee so closure devices are not required.

3.4 Embankment Protection

The levee is currently grass-covered for erosion protection. We evaluated the erosion protection for the creek side of the levee using the results of the HEC-RAS analysis by WEST. They provided flow velocities for the 100 and 500-year flood events. The flow velocities are shown in the following table.

River Station	100-year Channel Velocity (ft/sec)	500-year Channel Velocity (ft/sec)
21500	Thorpe Road	
21482.42	6.9	7.1
21456.36	2.4	2.5
21231.71	2.5	2.6
21013.79	3.4	3.5
20975.95	2.9	3.0
20970	Pedestrian Bridge	
20967.18	2.8	2.9
20928.94	2.0	2.0
20895.90	1.9	1.9
20868.07	1.9	2.0
20838.54	2.2	2.3
20830	Pedestrian Bridge	
20828.27	2.0	2.1
20779.14	2.4	2.4
20554.71	3.2	3.3
20492.77	1.4	1.5
20450	Dishman-Mica Road	

As shown in the table, the average flow velocity is typically less than 3 feet per second. At these velocities, it is our opinion that the vegetative erosion protection is adequate given the age of the levee and that no significant erosion is visible. We did note, however, that vegetation is not present below and adjacent to the pedestrian bridge abutments. We recommend that the levee slopes at these locations be protected with erosion matting or rip rap. We also recommend erosion matting or rip rap from the Thorpe Road bridge to River Station 21600 due to higher flow velocity. Also, all trees on or adjacent to the levee on the levee side of the creek will need to be removed.

3.5 Embankment and Foundation Stability

We evaluated the embankment and foundation stability for conditions described in EM 1110-2-1913, "Design and Construction of Levees, by the US Corps of Engineers dated April 30, 2000, Chapter 6. We analyzed the levee embankment for the following cases:

1. CASE I, End of construction.
2. CASE II: Sudden drawdown.
3. CASE III: Steady state seepage from full flood stage.

We performed slope stability analyses for each case. We analyzed the levee embankment with 2.3:1 slopes. This configuration is considered to have the lowest factor of safety. For our analyses, we used XSTABL software which is based on a software program developed at Purdue University.

For these cases, we calculated the minimum factors of safety as shown in the following table.

CASE	Minimum Factor of Safety
I	1.58
II	1.50
III	1.55

For stability, a minimum factor of safety of 1.5 is generally considered acceptable. Based on this analysis, it is our opinion that the levee will be stable with respect to global slope stability provided the recommendations of this report are followed.

3.6 Settlement

The average depth of fill is approximately 10 feet. This would result in a loading increase of approximately 1,250 pounds per square foot (psf) on the bearing soils. Based on the data obtained from the borings, the levee was constructed above loose to medium dense sands. Settlement in these soils would have occurred shortly after construction. Also, given the age of the levee, it is our opinion that significant additional long term settlement will not occur.

We did analyze the silty clay layer encountered in Boring B-5 with a 1-foot raise in grade should it be necessary to maintain minimum freeboard. For our analysis, we used a unit weight of 125 pounds per cubic foot (pcf) for the embankment fill soils and a compression index of 0.15 for the silty clay and assumed total saturation of the clay layer. Based on these parameters, we estimated the additional settlement to be less than 0.35 inches or 0.03 feet.

3.7 Interior Drainage
Interior drainage systems have been designed by WCE. We understand that these systems will include detention ponds with multiple drywells to control flood waters and infiltrate them into the ground. Please refer to the WCE report for a comprehensive description of the interior drainage system.

3.8 Operation Plans
The Operation Plan is provided in Appendix D.

3.9 Maintenance Plan
The Maintenance Plan is provided in Appendix D.

3.10 Certification
Based on the historical data obtained, the results of the borings and laboratory tests performed, and the available geologic data, we certify that, to the best of our knowledge, that the Chester Creek levee has been constructed in accordance with sound engineering principles and will provide reasonable protection from the 100-year and 500-year floods and meets the requirements of 44 CFR 65.10 provided the recommendations of this report are followed.

4.0 PROCEDURES

4.1 Excavation and Sampling
The borings were completed between April 7 and 10, 2014 using a tracked drill rig operated by an independent firm working under subcontract to IPEC. A geotechnical engineer from our firm continuously observed the borings and logged the surface and subsurface conditions. After we logged the borings, they were abandoned in accordance with state requirements.

4.2 Soil Classification
The soils encountered in the borings were visually and manually classified in the field by our field personnel in accordance with ASTM D 2488, "Description and Identification of Soils (Visual-Manual Procedures)".

5.0 GENERAL RECOMMENDATIONS

5.1 Basis of Recommendations
The analyses and recommendations submitted in this report are based on the data obtained from the borings performed at the locations indicated on the Boring Location Map in Appendix A. It should be recognized that the explorations performed for this evaluation reveal subsurface conditions only at discreet locations across the project site and that actual conditions in other areas could vary. Furthermore, the nature and extent of any such variations would not become evident until additional explorations are performed or until construction activities have begun. If significant

variations are observed at that time, we may need to modify our conclusions and recommendations contained in this report to reflect the actual site conditions.

5.2 Groundwater Fluctuations

We made water level observations in the borings at the times and conditions stated on the boring logs. These data were interpreted in the text of this report. The period of observation was relatively short and fluctuation in the groundwater level may occur due to rainfall, flooding, irrigation, spring thaw and other seasonal and annual factors not evident at the time the observations were made. Design drawings and specifications and construction planning should recognize the possibility of fluctuations.

5.3 Use of Report

This report is for the exclusive use of the addressee and the copied parties to use in design of the proposed project and to prepare construction documents. In the absence of our written approval, we make no representations and assume no responsibility to other parties regarding this report. The data, analyses, and recommendations may not be appropriate for other structures or purposes. We recommend that parties contemplating other structures or purposes contact us.

5.4 Level of Care

Services performed by the geotechnical engineers for this project have been conducted in a manner consistent with that level of care ordinarily exercised by members of the profession currently practicing in this area under similar budget and time restraints. No warranty, expressed or implied, is intended or made.

5.5 Professional Certification

This report was prepared by me or under my direct supervision and I am a duly registered engineer under the laws of the State of Washington.

Paul T. Nelson, P.E.
Principal Engineer

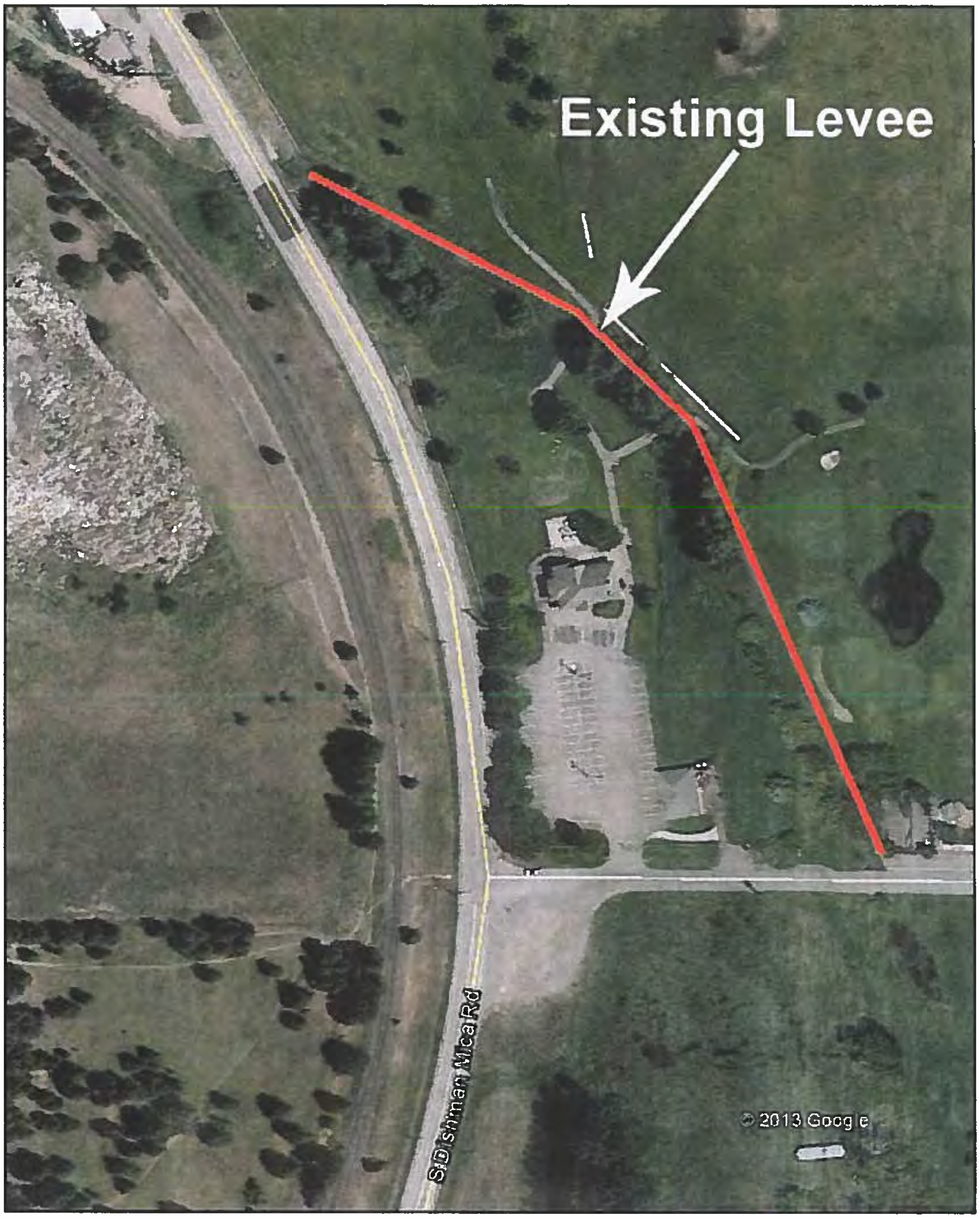
PAUL T NELSON
STATE OF WASHINGTON
37228
REGISTERED
PROFESSIONAL ENGINEER

2-12-15

APPENDIX A

SITE LOCATION MAP, NRCS MAP, TEST PIT LOCATION MAP

FIGURE 1

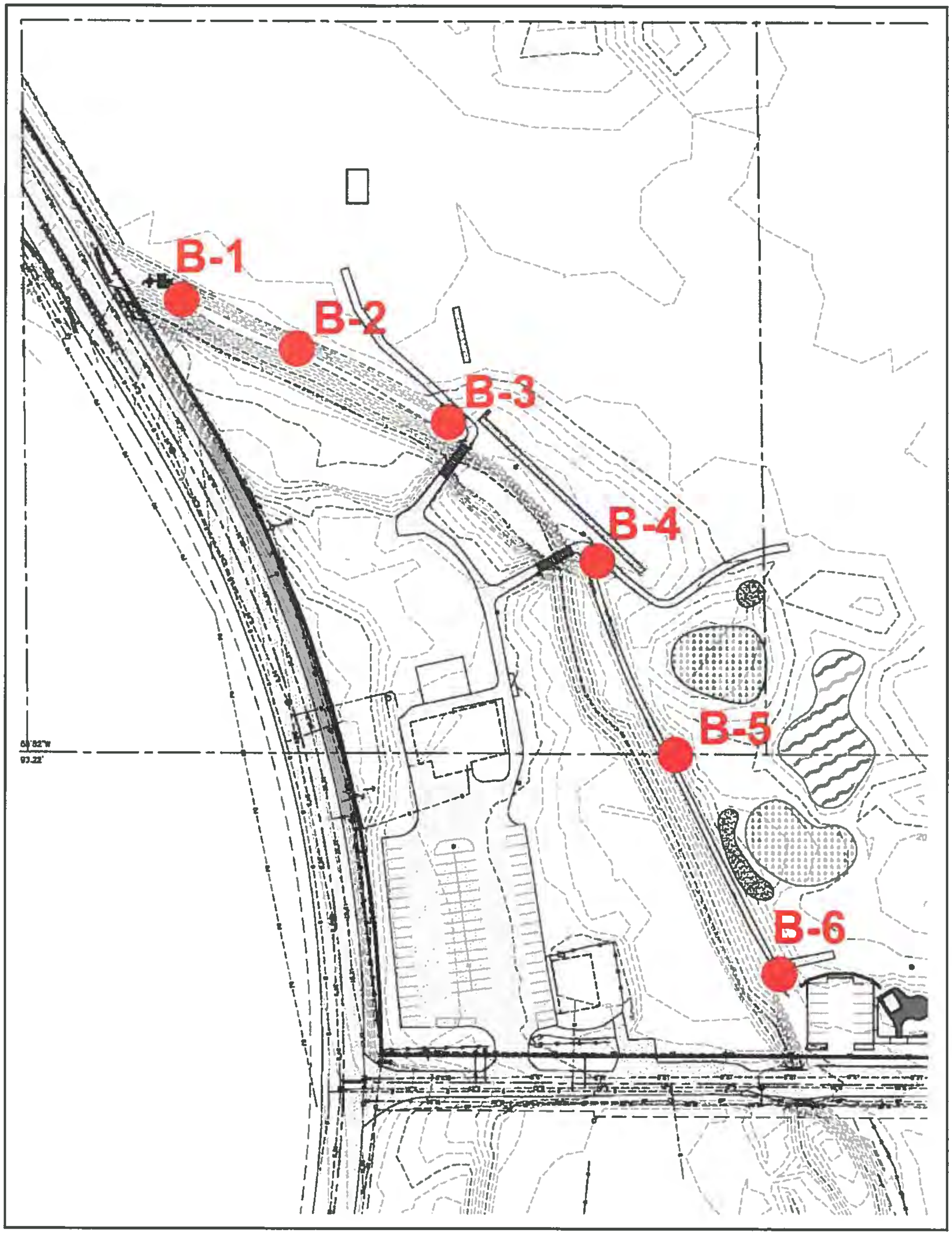


Site Location Map		
IPEC Inland Pacific Engineering Company Geotechnical Engineering and Consulting	Project No. 14-037 Painted Hills Golf Course Levee 4403 South Dishman-Mica Road Spokane Valley, WA	March 10, 2014

FIGURE 2

NRCS Map		
IPEC Inland Pacific Engineering Company Geotechnical Engineering and Consulting	Project No. 14-037 Painted Hills Golf Course Levee 4403 South Dishman-Mica Road Spokane Valley, WA	March 10, 2014

FIGURE 3



Boring Location Map		
IPEC Inland Pacific Engineering Company Geotechnical Engineering and Consulting	Project No. 14-037	March 10, 2014
	Painted Hills Golf Course Levee 4403 South Dishman-Mica Road Spokane Valley, WA	

APPENDIX B

LOGS OF TEST PITS, DECRIPTIVE TERMINOLOGY

LOG OF BORING

IPEC
Inland Pacific Engineering Company
Geotechnical Engineering and Consulting

PROJECT: 14-037
Levee Evaluation and Certification
Painted Hills Golf Course Property
4403 South Dishman-Mica Road
Spokane County, WA

BORING: **B-1**
LOCATION: See Boring Location Map
DATE: 4/7/14
SCALE: 1"=4'

ELEV. 2015.5	DEPTH 0.0	ASTM D2487 SYMBOL	DESCRIPTION OF MATERIALS	N	WL	TESTS OR NOTES
2014.0	1.5	FILL	Silty Sand, fine to medium grained, with roots, dark brown, moist.			
2007.5	18.0	FILL	Sandy Silt, gray-brown to brown, moist.	14 12 7		
2004.5	11.0	FILL	Poorly Graded Sand, fine to medium grained, gray-brown to brown, moist.	10		
1997.5	18.0	SC-SM	SILTY CLAYEY SAND, fine to medium grained, brown, moist to wet, medium dense. (Alluvium)	14		
1990.5	25.0	CL	LEAN CLAY, brown, wet, medium. (Alluvium)	6		Thinwall sample from 21'-23' Thinwall sample from 23'-25'
			End of Boring. Groundwater not encountered with 24' of hollow-stem auger in the ground. Groundwater not encountered immediately after withdrawal. Groundwater not encountered 2 days after withdrawal. Boring then grouted to surface.			

LOG OF BORING

IPEC
Inland Pacific Engineering Company
Geotechnical Engineering and Consulting

PROJECT:	14-037 Levee Evaluation and Certification Painted Hills Golf Course Property 4403 South Dishman-Mica Road Spokane County, WA	BORING:	**B-2**
		LOCATION:	See Boring Location Map
		DATE: 4/7/14	SCALE: 1"=4'

ELEV. 2015.2	DEPTH 0.0	ASTM D2487 SYMBOL	DESCRIPTION OF MATERIALS	N	WL	TESTS OR NOTES
2013.7	1.5	FILL	Clayey Sand, fine to medium grained, with roots, dark brown, wet.			
2005.2	10.0	FILL	Silty Sand, fine to medium grained, dark brown, moist to wet.	3 4 4 3		
2003.2	12.0	SC-SM	SILTY CLAYEY SAND, fine grained, brown, wet, very loose. (Alluvium)			
1994.7	20.5	SP	POORLY GRADED SAND, fine to medium grained, brown, water-bearing, loose. (Alluvium)	8 7		
1992.2	23.0	CL	LEAN CLAY, brown, wet. (Alluvium)			Thinwall sample from 21'-23'
1991.2	24.0	SM	SILTY SAND, fine grained, brown, water-bearing. (Alluvium)			
1989.7	25.5	SP	POORLY GRADED SAND, fine to medium grained, brown, water-bearing, medium dense. (Alluvium)	13		
			End of Boring. Groundwater not encountered with 24' of hollow-stem auger in the ground. Groundwater not encountered immediately after withdrawal. Boring then grouted to surface.			

LOG OF BORING

IPEC
Inland Pacific Engineering Company
Geotechnical Engineering and Consulting

PROJECT:	14-037 Levee Evaluation and Certification Painted Hills Golf Course Property 4403 South Dishman-Mica Road Spokane County, WA
BORING:	B-3
LOCATION:	See Boring Location Map
DATE:	4/7/14
SCALE:	1"=4'

ELEV. 2014.6	DEPTH 0.0	ASTM D2487 SYMBOL	DESCRIPTION OF MATERIALS	N	WL	TESTS OR NOTES
2013.1	1.5	FILL	Clayey Sand, fine to medium grained, with roots, black, wet.			
2009.6	5.0	FILL	Silty Sand, fine to medium grained, dark brown, moist.	8 5		
2004.6	10.0	FILL	Poorly Graded Sand, fine to medium grained, brown, moist.	23 6		
2002.6	12.0	CL	SANDY LEAN CLAY, brown, wet, medium. (Alluvium)			
1989.1	25.5	SC	CLAYEY SAND, fine to medium grained, with seams of Poorly Graded Sand, brown, wet to water-bearing, loose to medium dense. (Alluvium)	7 13 14		
			End of Boring. Groundwater down 10.5' with 24' of hollow-stem auger in the ground. Groundwater down 10.5' immediately after withdrawal. Boring then grouted to surface.			

LOG OF BORING

IPEC
Inland Pacific Engineering Company
Geotechnical Engineering and Consulting

PROJECT:	14-037 Levee Evaluation and Certification Painted Hills Golf Course Property 4403 South Dishman-Mica Road Spokane County, WA	BORING:	B-4
		LOCATION:	See Boring Location Map
		DATE: 4/8/14	SCALE: 1"=4'

ELEV. 2014.9	DEPTH 0.0	ASTM D2487 SYMBOL	DESCRIPTION OF MATERIALS	N	WL	TESTS OR NOTES
2010.9	4.0	FILL	Silty to Silty Clayey Sand, fine to medium grained, with roots, dark gray, moist.	18		
2005.9	9.0	FILL	Silty Sand, fine grained, brown to gray, moist.	14 15		
2000.9	14.0	SP-SM	POORLY GRADED SAND WITH SILT, fine to medium grained, moist, medium dense. (Alluvium)	13		
1996.9	18.0	SC	CLAYEY SAND, fine to medium grained, brown, wet, loose. (Alluvium)	7		Thinwall sample from 16'-18'
1989.4	25.5	SP-SM	POORLY GRADED SAND WITH SILT, fine to medium grained, brown, water-bearing, medium dense. (Alluvium)	19 17		
			End of Boring. Groundwater down 19' with 24' of hollow-stem auger in the ground. Groundwater down 19' immediately after withdrawal. Groundwater down 18' 1 day after withdrawal. Boring then grouted to surface.			

LOG OF BORING

IPEC
Inland Pacific Engineering Company
Geotechnical Engineering and Consulting

PROJECT:	14-037 Levee Evaluation and Certification Painted Hills Golf Course Property 4403 South Dishman-Mica Road Spokane County, WA
BORING:	B-5
LOCATION:	See Boring Location Map
DATE:	4/10/14
SCALE:	1"=4'

ELEV.	DEPTH	ASTM D2487 SYMBOL	DESCRIPTION OF MATERIALS	N	WL	TESTS OR NOTES
2014.6	0.0					
2014.1	0.5	FILL	Silty Sand, fine to medium grained, with roots, dark brown, moist.			
2010.6	4.0	FILL	Clayey Sand, fine grained, dark-gray to gray brown, moist to wet.	3		
2007.6	7.0	FILL	Silty Sand, fine to mediun grained, dark brown, moist to wet.	6		
2005.6	9.0	CL-ML	SANDY SILTY CLAY, brown, wet, soft. (Alluvium)	2		
1997.6	17.0	SC-SM	SILTY CLAYEY SAND, fine grained, with/seams of Poorly Graded Sand, brown, wet to water bearing, loose to very loose. (Alluvium)	5 Thinwall sample from 11'-13' 3		
1989.1	25.5	SP	POORLY GRADED SAND, fine to medium grained, brown, water-bearing, loose to medium dense. (Alluvium)	8 16		
			End of Boring. Groundwater down 17.5' with 24' of hollow-stem auger in the ground. Groundwater down 8.5' immediately after withdrawal. Groundwater down 8.5' 3 hours after withdrawal. Boring then grouted to surface.			

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LOG OF BORING

IPEC
Inland Pacific Engineering Company
Geotechnical Engineering and Consulting

PROJECT: 14-037 Levee Evaluation and Certification Painted Hills Golf Course Property 4403 South Dishman-Mica Road Spokane County, WA	BORING: **B-6** LOCATION: See Boring Location Map DATE: 4/10/14 SCALE: 1"=4'

ELEV. 2014.7	DEPTH 0.0	ASTM D2487 SYMBOL	DESCRIPTION OF MATERIALS	N	WL	TESTS OR NOTES
2013.7	1.0	FILL	Silty Sand, very fine to medium grained, with roots, dark brown, moist.			
2010.7	4.0	FILL	Silty Sand, fine to medium grained, gray-brown, moist.	4		
2007.7	7.0	SC	Clayey Sand, very fine to fine grained, dark gray, wet. (Possible Fill)	4		
2002.7	12.0	SM	SILTY SAND, fine to medium grained, brown-gray, wet to water-bearing, very loose. (Possible Fill)	2 3		Thinwall sample from 11'-12'
1996.7	18.0	SM	SILTY SAND, fine to medium grained, brown, water-bearing, medium dense. (Alluvium)	8		
1989.2	25.5	SP	POORLY GRADED SAND, fine to medium grained, with seams of Clayey Sand, brown, water-bearing, loose. (Alluvium)	8 8		
			End of Boring. Groundwater down 22.5' with 24' of hollow-stem auger in the ground. Groundwater down 7.5' immediately after withdrawal. Boring then grouted to surface.			

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Inland Pacific Engineering Company
Geotechnical Engineering and Consulting

RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N-VALVE			
COARSE-GRAINED SOILS		FINE-GRAINED SOILS	
DENSITY	N(BLOWS/FT)	CONSISTENCY	N(BLOWS/FT)
Very Loose	0 - 4	Very Soft	0 - 1
Loose	4 - 10	Soft	2 - 3
Medium-Dense	11 - 30	Rather Soft	4 - 5
		Medium	6 - 8
Dense	31 - 50	Rather Stiff	9 - 12
		Stiff	13 - 16
Very Dense	> 50	Very Stiff	17 - 30
		Hard	> 30

USCS SOIL CLASSIFICATION					
MAJOR DIVISIONS			GROUP DESCRIPTIONS		
Coarse-Grained Soils <50% passes #200 sieve	Gravel and Gravelly Soils <50% coarse fraction passes #4 sieve	Gravel (with little or no fines)	GW	Well Graded Gravel	
			GP	Poorly Graded Gravel	
		Gravel (with >12% fines)	GM	Silty Gravel	
			GC	Clayey Gravel	
	Sandy and Sandy Soils >50% coarse fraction passes #4 sieve	Sand (with little or no fines)	SW	Well Graded Sand	
			SP	Poorly Graded Sand	
		Sand (with >12% fines)	SM	Silty Sand	
			SC	Clayey Sand	
Fine-Grained Soils >50% passes #200 sieve	Silt and Clay Liquid Limit < 50		ML	Silt	
			CL	Lean Clay	
			OL	Organic Silt and Clay (low plasticity)	
	Salt and Clay Liquid Limit > 50		MH	Inorganic Silt	
			CH	Fat Clay	
			OH	Organic Clay and Silt (med to high plasticity)	
Highly Organic Soils			PT	Peat	Muck

MODIFIERS	
DESCRIPTION	RANGE
Occasional	<5%
Trace	5% - 12%
With	>12%

MOISTURE CONTENT	
DESCRIPTION	FIELD OBSERVATION
Dry	Absence of moisture, dusty, dry to the touch
Moist	Dry of optimum moisture content
Wet	Wet of optimum moisture content

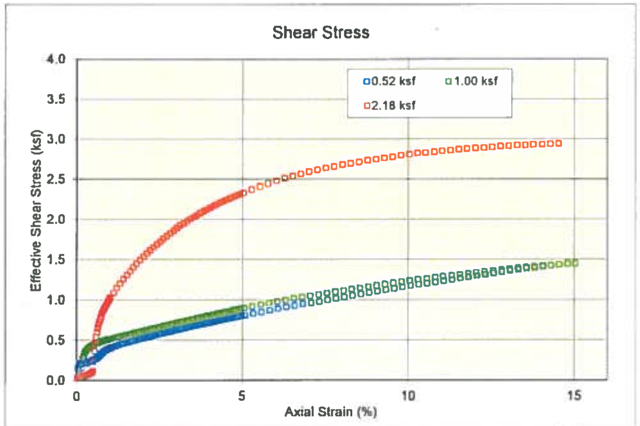
MAJOR DIVISIONS WITH GRAIN SIZE								
SIEVE SIZE								
12"	3"	3/4"	4	10	40	200		
GRAIN SIZE (INCHES)								
12	3	0.75	0.19	0.079	0.0171	0.0029		
Boulders	Cobbles	Gravel		Sand			Silt and Clay	
		Coarse	Fine	Coarse	Medium	Fine		

APPENDIX C

LABORATORY TEST RESULTS

Report of CU Triaxial Shear Test

ASTM D4767-11



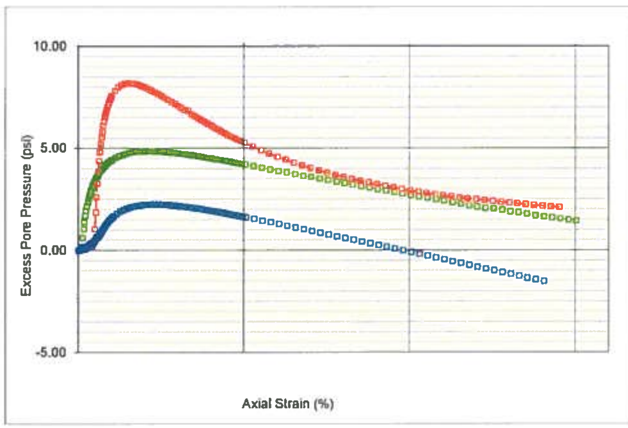
Laboratory Number: 14-0268
Sample Number: B1 21'-23'
Sample Description: Brown Clay
Sample Source: Shelby 2.8" Tube

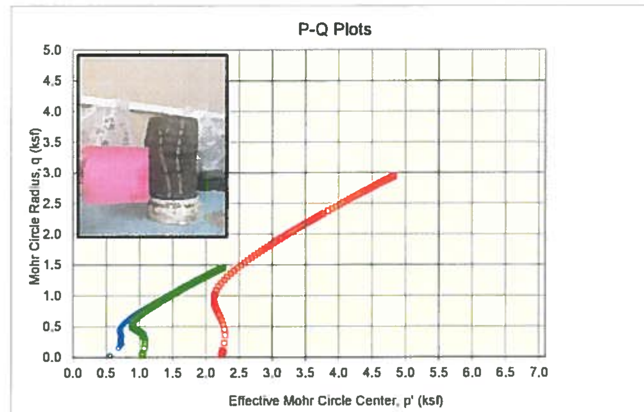
Shear rate 2.67%/hour

	0.52 ksf	1.00 ksf	2.18 ksf
Initial dry unit weight (pcf)	109.0	111.9	124.4
Initial Wc (%)	25.5%	23.2%	12.9%
Final dry unit weight (pcf)	110.1	114.8	127.5
Final Wc (%)	19.6%	17.6%	16.3%

Consolidation Stress (ksf)	Peak Failure Stress p (ksf)	q (ksf)
0.52	2.25	1.47
1.00	2.25	1.46
2.18	4.82	2.95

Above values are effective stresses



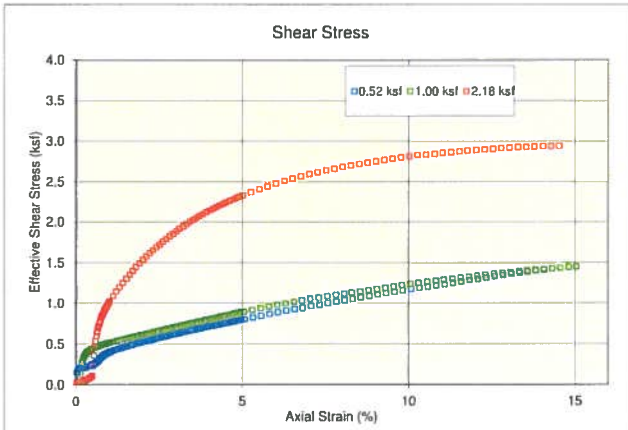


Budinger & Associates
1101 North Fancher Road
Spokane Valley WA 99212

TRIAXIAL SHEAR TEST RESULTS
Project: Painted Hills Levee
Location: 4403 S Dishman-Mica Rd, Spokane Valley, WA
Project Number: L14183

Report of CU Triaxial Shear Test

ASTM D4767-11

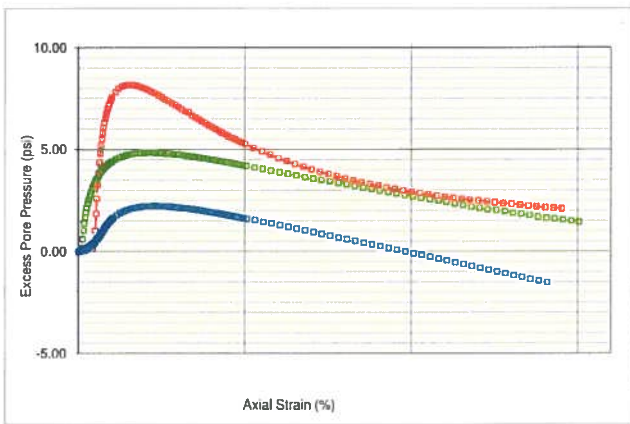


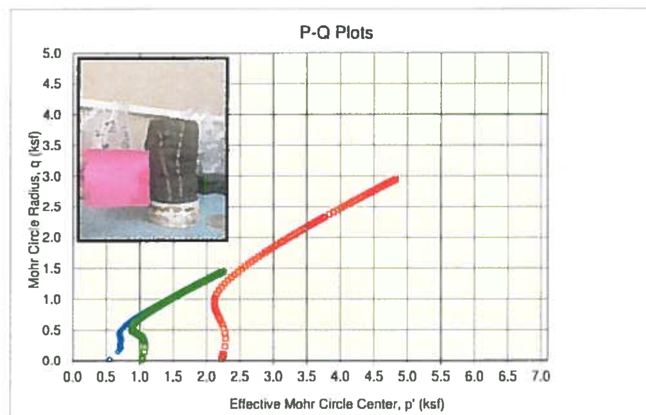
Laboratory Number: 14-0271
Sample Number: B4 @ 16'-18'
Sample Description: Brown Clay
Sample Source: Shelby 2.8" Tube

Shear rate 2.67%/hour	0.52 ksf	1.00 ksf	2.18 ksf
Initial dry unit weight (pcf)	109.0	111.9	124.4
Initial Wc (%)	25.5%	23.2%	12.9%
Final dry unit weight (pcf)	110.1	114.8	127.5
Final Wc (%)	19.6%	17.6%	16.3%

Consolidation Stress (ksf)	Peak Failure Stress p (ksf)	q (ksf)
0.52	2.25	1.47
1.00	2.25	1.46
2.18	4.82	2.95

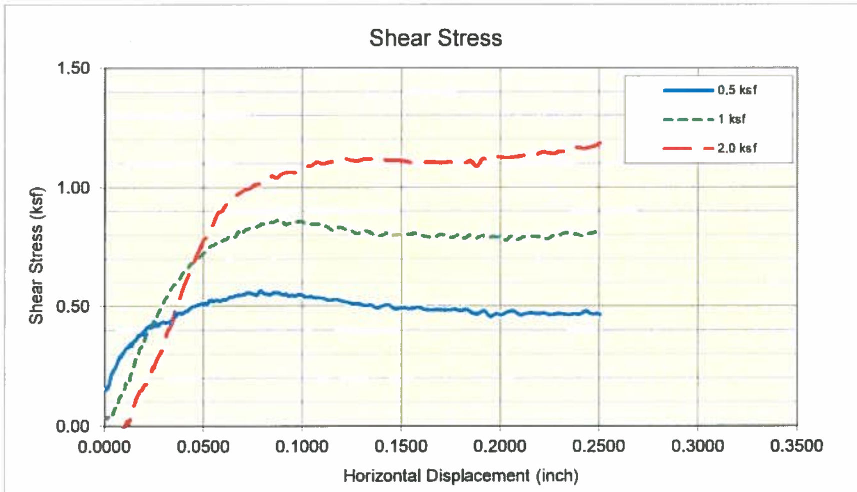
Above values are effective stresses





Report of Direct Shear Test

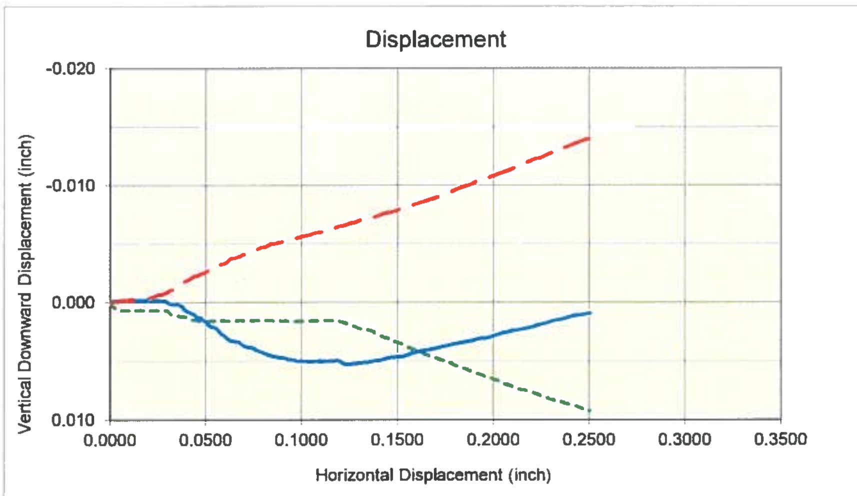
ASTM D3080

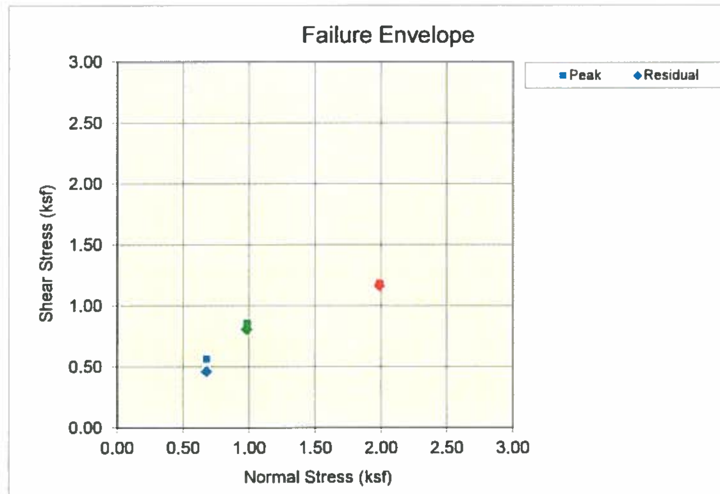


Laboratory Number:	14-0268
Sample Number:	B1 21-23 feet
Sample Description:	Brown Clay
Sample Source:	Shelby 2.8 inch tube

Shear rate .015 in./min.

	0.5 ksf	1 ksf	2.0 ksf
Initial dry unit weight (pcf)	97.5	80.0	92.0
Initial Wc (%)	22.6%	35.2%	30.0%
Final Wc (%)	27.0%	32.7%	36.2%
Normal Stress (ksf)	0.68	0.98	1.98
Peak Shear Stress (ksf)	0.57	0.86	1.19
Residual Failure Stress (ksf)	0.47	0.81	1.17





Budinger & Associates

DIRECT SHEAR TEST RESULTS
Project: Painted Hills Levee
Location: 4403 S Dishman-Mica Rd, Spokane Valley, WA
Project Number: L14183

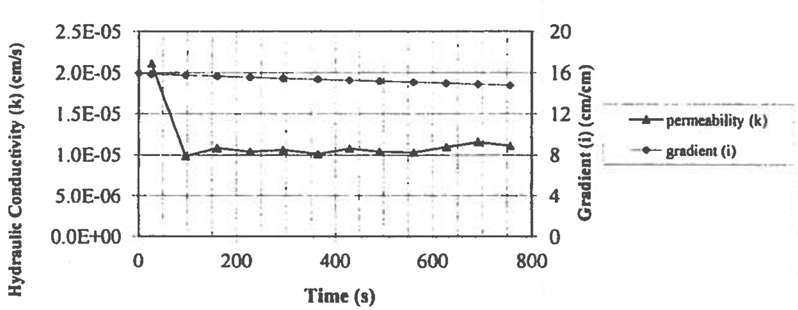
ASTM D 5084
Permeability (Flexible Wall) Test Data Results

Project No.:	L14183	Project Location:	Painted Hills Levee		Remolded
Sample ID:	B6 @ 11'-12'	Sample Description:	silt with some sand		X Undisturbed
Tested By:	TB	Initial Dry Density:	112.7 pcf		
Sampled By:	B&A	Final Moisture Content:	19.7%		
Laboratory No:	14-0273	Date Tested:	5/8/14		
			Chamber	42.0	$a_{\text{influent burett}}$ 0.906 cm^2
System Constant, C	0.906 (cm^2)		Upper	39.0	Final Length, L_f 9.860 cm
			Lower	41.0	Final Area, A_f 40.496 cm^2
			Test gradient	14.3	

Date	Time (s)	Temp		Burette Readings		Incremental Flow			Head Difference[1]	Gradient	Prelimnary[2]	ASTM Falling Head Final[3]	ASTM Constant Head
		°C	R_T	Upper V_U(t) (cc)	Lower V_L(t) (cc)	Inflow (lower) (cc)	Outflow (upper) (cc)	Ratio In/Out	h (t) (cm)		kA/L (cm^2/sec)	k_{20} (x10) (cm/sec)	k (cm/sec)
5/8/14	0	21	0.980	19.5	2.7				157.5	15.98			
	26	21	0.980	19.0	3.0	0.3	0.5	0.6	156.7	15.90	8.9E-05	2.1E-05	2.4E-05
	96	21	0.980	18.5	3.5	0.5	0.5	1.0	155.7	15.79	4.1E-05	9.9E-06	1.1E-05
	160	21	0.980	18.0	4.0	0.5	0.5	1.0	154.7	15.69	4.6E-05	1.1E-05	1.2E-05
	227	21	0.980	17.5	4.5	0.5	0.5	1.0	153.7	15.59	4.4E-05	1.0E-05	1.2E-05
	293	21	0.980	17.0	5.0	0.5	0.5	1.0	152.7	15.49	4.5E-05	1.1E-05	1.2E-05
	363	21	0.980	16.5	5.5	0.5	0.5	1.0	151.7	15.39	4.2E-05	1.0E-05	1.1E-05
	429	21	0.980	16.0	6.0	0.5	0.5	1.0	150.7	15.29	4.5E-05	1.1E-05	1.2E-05
	491	21	0.980	15.5	6.4	0.4	0.5	0.8	149.8	15.20	4.4E-05	1.0E-05	1.2E-05
	561	21	0.980	15.0	6.9	0.5	0.5	1.0	148.8	15.09	4.3E-05	1.0E-05	1.2E-05
	627	21	0.980	14.5	7.4	0.5	0.5	1.0	147.8	14.99	4.6E-05	1.1E-05	1.2E-05
	690	21	0.980	14.0	7.9	0.5	0.5	1.0	146.8	14.89	4.9E-05	1.2E-05	1.3E-05
	756	21	0.980	13.5	8.4	0.5	0.5	1.0	145.8	14.79	4.7E-05	1.1E-05	1.3E-05
											k_{avg}= last 4	1.1E-05 cm/s	cm/s

Permeant liquid: standard water

Run 1 Permeability & Gradient vs Time



Budinger & Associates, Inc.
Geotechnical & Environmental Engineers
Construction Materials Testing & Special Inspection

GN Northern, Inc.
11115 E. Montgomery Ave., Suite C
Spokane Valley, WA 99206

LABORATORY SIEVE ANALYSIS

Northern, Inc.

Project:	Painted Hills	**Date Received:**	5/15/2014
Client:	IPEC	**Job #:**	S14-033
Material:		**W.O. #:**	
Source:	B1 @ 5' & 7.5' (combined)	**Lab #:**	335

Sieve Size	Percent Passing	Specifications Minimum	Specifications Maximum
4"			
3"			
2 1/2"			
2"			
1 1/2"			
1 1/4"			
1"			
3/4"			
5/8"			
1/2"			
3/8"			
1/4"	100.0%		
#4	99.9%		
#8	98.5%		
#10	97.8%		
#16	94.0%		
#20			
#30	85.2%		
#40	80.2%		
#50	75.9%		
#60			
#80			
#100	68.2%		
#200	61.3%		

Sieve Analysis Data: ASTM D422, D1140

Fineness Modulus:	
% Gravel:	0.09
% Sand:	38.60
% Silt & Clay:	61.31
Moisture Content:	8.8%

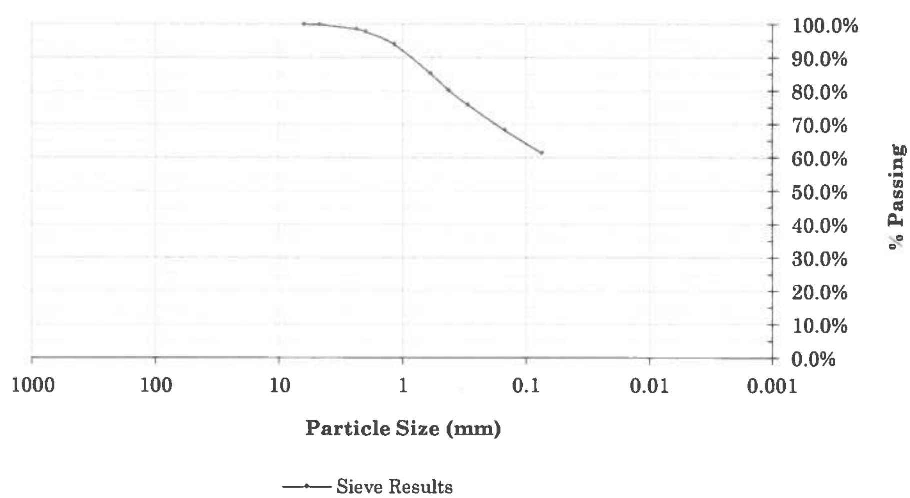
Coefficient of Uniformity Cu, and Curvature Cc

$D_{60\ (mm)} =$ $C_u =$

$D_{30\ (mm)} =$ $C_c =$

$D_{10\ (mm)} =$

Grain Size Distribution



Reviewed by: ____________________ **Date:** 6/30/2014

GN Northern, Inc.
11115 E. Montgomery Ave., Suite C
Spokane Valley, WA 99206

LABORATORY SIEVE ANALYSIS

GN Northern, Inc.

Project:	Painted Hills	**Date Received:**	5/15/2014
Client:	IPEC	**Job #:**	S14-033
Material:		**W.O. #:**	
Source:	B2 @ 5'	**Lab #:**	336

Sieve Size	Percent Passing	Specifications Minimum	Specifications Maximum
4"			
3"			
2 1/2"			
2"			
1 1/2"			
1 1/4"			
1"			
3/4"			
5/8"			
1/2"			
3/8"			
1/4"	100.0%		
#4	99.4%		
#8	95.3%		
#10	93.7%		
#16	87.6%		
#20			
#30	77.8%		
#40	73.1%		
#50	69.3%		
#60			
#80			
#100	64.7%		
#200	61.3%		

Sieve Analysis Data: ASTM D422, D1140

Fineness Modulus:	
% Gravel:	0.58
% Sand:	38.13
% Silt & Clay:	61.29
Moisture Content:	11.4%

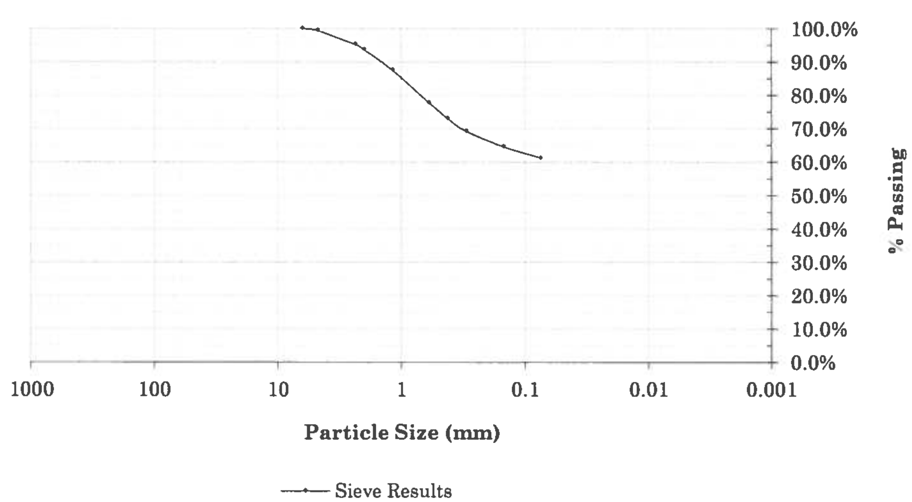
Coefficient of Uniformity Cu, and Curvature Cc

$D_{60\ (mm)} =$ $C_u =$

$D_{30\ (mm)} =$ $C_c =$

$D_{10\ (mm)} =$

Grain Size Distribution



Reviewed by: ____________________ **Date:** 6/30/2014

GN Northern, Inc.
11115 E. Montgomery Ave., Suite C
Spokane Valley, WA 99206

LABORATORY SIEVE ANALYSIS

Northern, Inc.

Project: Painted Hills		**Date Received:** 5/15/2014	
Client: IPEC		**Job #:** S14-033	
Material:		**W.O. #:**	
Source: B2 @ 15'		**Lab #:** 337	

Sieve Size	Percent Passing	Specifications Minimum	Specifications Maximum
4"			
3"			
2 1/2"			
2"			
1 1/2"			
1 1/4"			
1"			
3/4"			
5/8"			
1/2"			
3/8"			
1/4"	100.0%		
#4	99.1%		
#8	94.3%		
#10	92.1%		
#16	80.6%		
#20			
#30	54.2%		
#40	42.5%		
#50	33.0%		
#60			
#80			
#100	21.7%		
#200	18.2%		

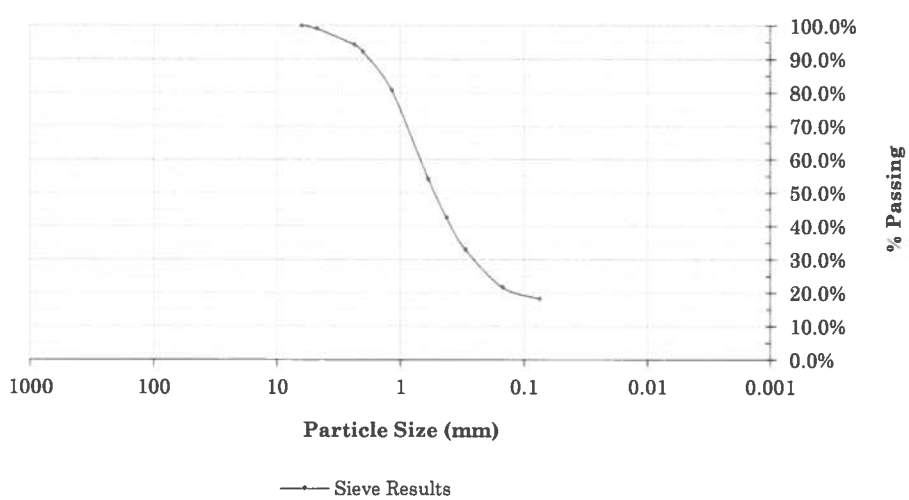
Sieve Analysis Data: ASTM D422, D1140

Fineness Modulus:	
% Gravel:	0.89
% Sand:	80.93
% Silt & Clay:	18.18
Moisture Content:	

Coefficient of Uniformity Cu, and Curvature Cc

$D_{60\,(mm)}$ = C_u=
$D_{30\,(mm)}$= C_c=
$D_{10\,(mm)}$=

Grain Size Distribution



Reviewed by: ____________________ **Date:** 6/30/2014

GN Northern, Inc.
11115 E. Montgomery Ave., Suite C
Spokane Valley, WA 99206

LABORATORY SIEVE ANALYSIS

Northern, Inc.

Project:	Painted Hills	**Date Received:**	5/15/2014
Client:	IPEC	**Job #:**	S14-033
Material:		**W.O. #:**	
Source:	B3 @ 15'	**Lab #:**	338

Sieve Size	Percent Passing	Specifications Minimum	Specifications Maximum
4"			
3"			
2 1/2"			
2"			
1 1/2"			
1 1/4"			
1"			
3/4"			
5/8"			
1/2"			
3/8"			
1/4"	100.0%		
#4	99.2%		
#8	95.0%		
#10	93.3%		
#16	86.4%		
#20			
#30	73.5%		
#40	66.3%		
#50	59.4%		
#60			
#80			
#100	46.4%		
#200	40.4%		

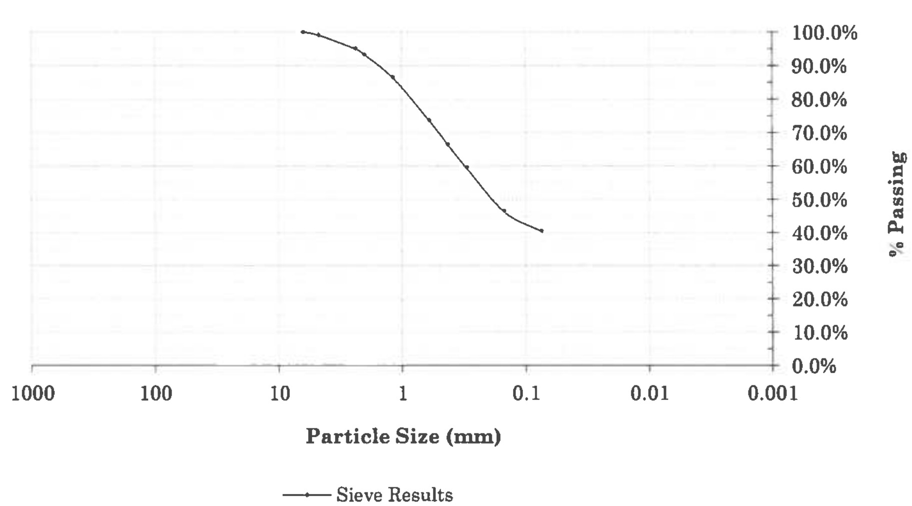
Sieve Analysis Data: ASTM D422, D1140

Fineness Modulus:	
% Gravel:	0.84
% Sand:	58.80
% Silt & Clay:	40.36
Moisture Content:	14.2%

Coefficient of Uniformity Cu, and Curvature Cc

$D_{60\ (mm)}$ = C_u=
$D_{30\ (mm)}$= C_c=
$D_{10\ (mm)}$=

Grain Size Distribution



Reviewed by: ____________________ **Date:** 6/30/2014

GN Northern, Inc.
11115 E. Montgomery Ave., Suite C
Spokane Valley, WA 99206

LABORATORY SIEVE ANALYSIS

Northern, Inc.

Project:	Painted Hills	**Date Received:**	5/15/2014
Client:	IPEC	**Job #:**	S14-033
Material:		**W.O. #:**	
Source:	B4 @ 5'	**Lab #:**	339

Sieve Size	Percent Passing	Specifications Minimum	Specifications Maximum
4"			
3"			
2 1/2"			
2"			
1 1/2"			
1 1/4"			
1"			
3/4"			
5/8"			
1/2"			
3/8"			
1/4"	100.0%		
#4	89.5%		
#8	86.1%		
#10	84.9%		
#16	80.8%		
#20			
#30	73.3%		
#40	69.3%		
#50	65.3%		
#60			
#80			
#100	57.8%		
#200	51.0%		

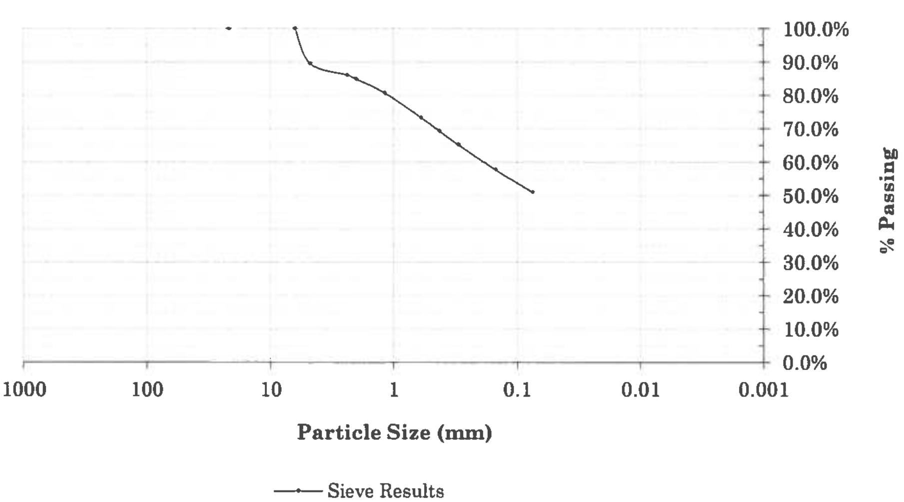
Sieve Analysis Data: ASTM D422, D1140

Fineness Modulus:
% Gravel: 10.52
% Sand: 38.47
% Silt & Clay: 51.01
Moisture Content: 12.5%

Coefficient of Uniformity Cu, and Curvature Cc

$D_{60\,(mm)}$ =
$D_{30\,(mm)}$ =
$D_{10\,(mm)}$ =
C_u =
C_c =

Grain Size Distribution



Reviewed by: ____________________ **Date:** 6/30/2014

GN Northern, Inc.
11115 E. Montgomery Ave., Suite C
Spokane Valley, WA 99206

LABORATORY SIEVE ANALYSIS

Project:	Painted Hills	**Date Received:**	5/15/2014
Client:	IPEC	**Job #:**	S14-033
Material:		**W.O. #:**	
Source:	B4 @ 10'	**Lab #:**	340

Sieve Size	Percent Passing	Specifications Minimum	Specifications Maximum
4"			
3"			
2 1/2"			
2"			
1 1/2"			
1 1/4"			
1"			
3/4"			
5/8"			
1/2"			
3/8"			
1/4"	100.0%		
#4	98.2%		
#8	89.4%		
#10	86.7%		
#16	74.3%		
#20			
#30	47.6%		
#40	36.6%		
#50	28.8%		
#60			
#80			
#100	21.1%		
#200	18.1%		

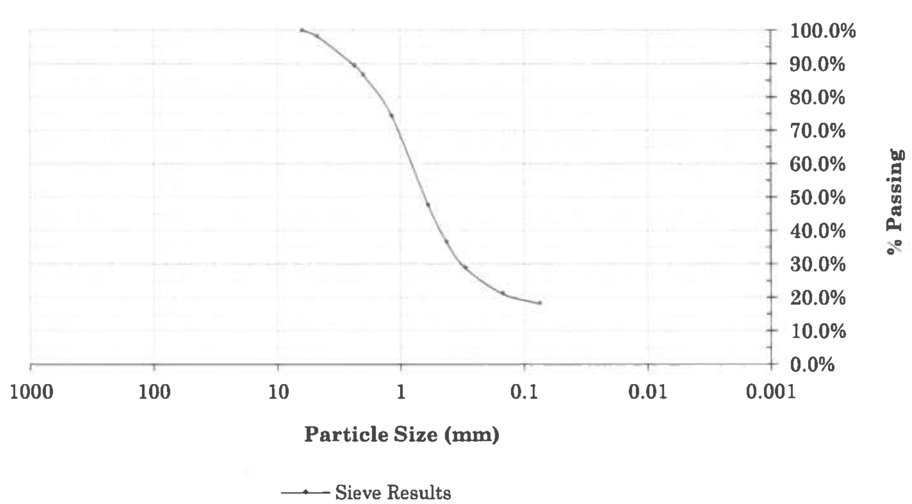
Sieve Analysis Data: ASTM D422, D1140

Fineness Modulus:	
% Gravel:	1.76
% Sand:	80.15
% Silt & Clay:	18.09
Moisture Content:	

Coefficient of Uniformity Cu, and Curvature Cc

$D_{60\,(mm)}$ = C_u=
$D_{30\,(mm)}$= C_c=
$D_{10\,(mm)}$=

Grain Size Distribution



Reviewed by: ____________________ **Date:** 6/30/2014

GN Northern, Inc.
11115 E. Montgomery Ave., Suite C
Spokane Valley, WA 99206

LABORATORY SIEVE ANALYSIS

GN Northern, Inc.

Project:	Painted Hills	**Date Received:**	5/15/2014
Client:	IPEC	**Job #:**	S14-033
Material:		**W.O. #:**	
Source:	B4 @ 15'	**Lab #:**	337

Sieve Size	Percent Passing	Specifications Minimum	Specifications Maximum
4"			
3"			
2 1/2"			
2"			
1 1/2"			
1 1/4"			
1"			
3/4"			
5/8"			
1/2"			
3/8"			
1/4"	100.0%		
#4	98.9%		
#8	93.0%		
#10	90.4%		
#16	76.5%		
#20			
#30	44.3%		
#40	30.1%		
#50	18.7%		
#60			
#80			
#100	4.9%		
#200	0.6%		

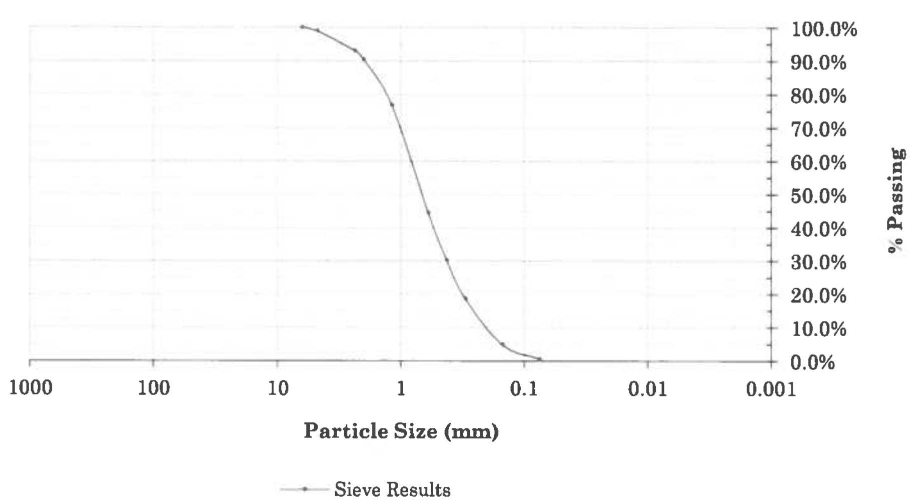
Sieve Analysis Data: ASTM D422, D1140

Fineness Modulus:	
% Gravel:	1.10
% Sand:	98.30
% Silt & Clay:	0.60
Moisture Content:	

Coefficient of Uniformity Cu, and Curvature Cc

$D_{60\,(mm)}$ = C_u=
$D_{30\,(mm)}$= C_c=
$D_{10\,(mm)}$=

Grain Size Distribution



Reviewed by: ____________________ **Date:** 6/30/2014

GN Northern, Inc.
11115 E. Montgomery Ave., Suite C
Spokane Valley, WA 99206

LABORATORY SIEVE ANALYSIS

GN Northern, Inc.

Project:	Painted Hills	**Date Received:**	5/15/2014
Client:	IPEC	**Job #:**	S14-033
Material:		**W.O. #:**	
Source:	B4 @ 20'	**Lab #:**	341

Sieve Size	Percent Passing	Specifications Minimum	Specifications Maximum
4"			
3"			
2 1/2"			
2"			
1 1/2"			
1 1/4"			
1"			
3/4"			
5/8"			
1/2"			
3/8"			
1/4"			
#4	70.1%		
#8	68.7%		
#10	67.8%		
#16	60.6%		
#20			
#30	37.1%		
#40	29.3%		
#50	25.0%		
#60			
#80			
#100	20.6%		
#200	18.6%		

Sieve Analysis Data: ASTM D422, D1140

Fineness Modulus:	
% Gravel:	
% Sand:	51.56
% Silt & Clay:	18.57
Moisture Content:	12.1%

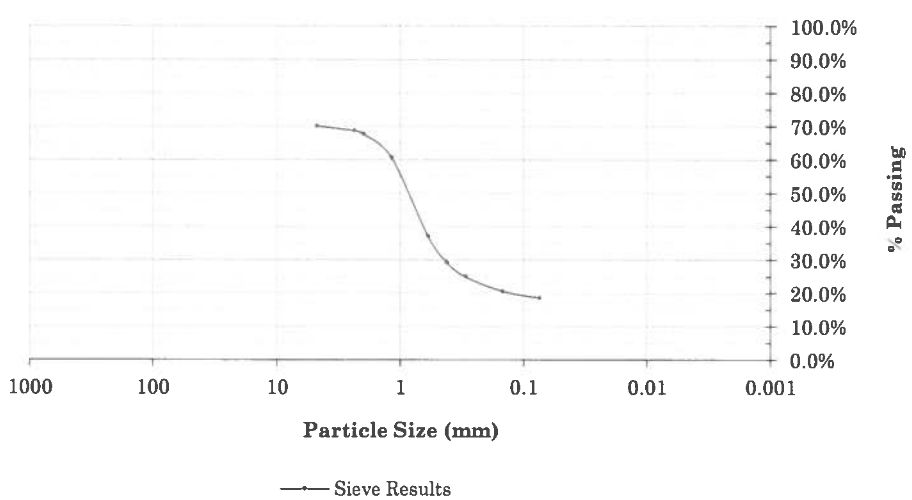
Coefficient of Uniformity Cu, and Curvature Cc

$D_{60\,(mm)} =$ $C_u =$

$D_{30\,(mm)} =$ $C_c =$

$D_{10\,(mm)} =$

Grain Size Distribution



Reviewed by: ____________________ **Date:** 6/30/2014

Project: Painted Hills
Client: IPEC
GN Job #: S14-033
IPEC Job #: 14-037

200 Wash / ASTM D1140

Sample Location / ID	% Retained	% Passing
B6@ 15'	56.7%	43.3%
B4@5'	50.7%	49.3%
B2@5'	48.4%	61.6%
B4@10'	85%	14.8%
B3@15'	70.6%	29.4%
B6@5'	42.7%	57.3%

REMARKS:

REVIEWED BY: Karl A. Harmon

Karl A. Harmon, LEG, PE

APPENDIX D

OPERATION AND MAINTENANCE MANUAL

CHESTER CREEK LEVEE

OPERATION & MAINTENANCE MANUAL

FOR

LEVEE OPERATION AND MAINTENANCE

Chester Creek Homeowners Association

IPEC Project No. 14-037

FEBRUARY 2015

By

Inland Pacific Engineering Company
3012 North Sullivan Road
Building S-5, Suite C
Spokane Valley, WA 99216

1.00 PURPOSE

This Operations and Maintenance manual is intended to provide general operations and maintenance guidelines for the Chester Creek levee located at 4403 South Dishman-Mica Road in Spokane County, Washington. The Homeowners Association will maintain the drainage facilities. This includes general maintenance for the levee whether in or out of Spokane County public road rights-of-ways. Implementation of these guidelines will ensure that the levee will function as required by 44 CFR 65.10 of the Code of Federal Regulations for certification by the Federal Emergency Management Agency (FEMA).

2.00 INTRODUCTION

The Chester Creek levee is on the east side of Chester Creek between Thorpe Road and Dishman-Mica Road. The creek side of the levee is typically at a 2.3:1 to 3:1 (H:V) slope. The land side of the levee is also at a 3:1 slope from the Dishman-Mica Road bridge to approximately 300 feet southeast. Between this point and Thorpe Road, the land side slope is much less and, in some areas, relatively level with the crest. The levee was constructed by the previous landowner for the development of the golf course on the property. We believe the levee was constructed in the early 1990's by the property owner.

The operation and maintenance of the levee is required to ensure that the levee certification obtained and future or on-going FEMA requirements are met.

3.00 GENERAL OPERATION AND MAINTENANCE

3.10 Operation – During flood periods, the levee should be patrolled to locate possible sand boils, unusual wetness of the landward slope, or levee breaches. The inspector may look for indications of sliding or sloughing, that scouring action is not occurring, that no reaches might be overtopped, and that no other conditions exist that might adversely affect the integrity of the levee.

- Boils – A boil is a condition where enough pressure is produced by high water levels so that water is piped through or under the levee with sufficient velocity to carry earthen materials to the landward side of the levee. If not controlled, these particles of earthen materials will be eroded from within the levee, causing subsidence to the levee section. The continuation of this process may result in a break in the levee, allowing flood waters to flow over the crest or through the levee.
- Scour – Careful observation should be made of the creek-side slope of the levee to detect potential erosion due to current action. Careful observation at the locations of bridge structures should be made. In general, current velocities in Chester Creek are not expected to cause significant scouring.
- Levee Topping – If the anticipated high water level will exceeds the top elevation of

the levee, steps should be taken to provide emergency topping to raise the levee grade above forecasted water levels. These steps could include sandbagging or hauling additional fill to raise the levee height.

A post-flood assessment of the levee should be completed within 24 hours of the event. The assessment should document any damage to the levee caused by flood waters. Any repairs necessary should then be completed after review and evaluation of options.

3.20 Maintenance – Maintenance activities for the levee are described in this section. Below is a maintenance description for each of the elements affecting levee performance.

- Inspections – Levee inspection should include a visual inspection of the levee at a minimum of every 12 months for signs of erosion or settlement. Preferably, the inspection should be completed in the fall prior to the rainy season. The inspections should include the following:
    - Unusual settlement, sloughing, or material loss of grade.
    - Caving on both the creekside and landside of the levee which might affect stability of the levee section.
    - Seepage or saturated areas that may be occurring.
    - Drainage in the creek is in good working condition, facilities are not being clogged.
    - Crown of levee is shaped to drain properly.
    - Unauthorized vehicles on the levee.
    - Rodent damage along the levee.
- Erosion Protection – The levee vegetation is a grass cover. The grass should be mowed to a minimum height no shorter than 3 inches. The last mowing should occur to allow for the grass to grow to 8-10 inches for winter protection and extend out 15 feet from the toe of the levee.

  No trees should be growing on the levee or in the creek channel. No excavations, structures, or other obstructions should be on the levee or levee easement.

  Remove accumulation of drift, grass clippings, or other objectionable materials from the levee side slopes and/or crest.

Attached is a checklist for the annual or post-flood inspection.

CHESTER CREEK LEVEE
4403 SOUTH DISHMAN-MICA ROAD
SPOKANE COUNTY, WA

LEVEE CHECKLIST

Date: ____

Item	Location and Description	Action
Has levee settled or lost cross section?		
Has stream action caused any levee slope washing or scouring?		
Has there been any seepage or saturated areas?		
Has vegetation been maintained?		
Have weeds been removed? Dates?		
Condition of any riprap?		
Have there been any authorized or unauthorized encroachments?		
Have burrowing animals been exterminated/removed and the levee repaired?		
Is the creek channel free of obstructions and/or debris?		
Are there any areas where the creek is affecting the levee slopes?		
Has there been any recent high water events?		
Miscellaneous conditions: ____________________ ____________________		

Note: Use additional sheets as necessary.

Signed:______________________________

Title:_______________________________