THURBER ENGINEERING LTD.

MEMORANDUM

To:	HDR Inc.	Date:	June 8, 2023
Attn:	Walt Bayless, P.Eng.	File:	31226
From	McKenzie Douglas, EIT Steven Coulter, P.Eng.		
Reviewer:	Stephen Bean, P.Eng.		

CVRD SEWER CONVEYANCE SYSTEM PROJECT
GEOTECHNICAL CONSIDERATIONS FOR SEWER ALGINMENT OPTIONS

Dear Walt,

At the request of HDR, Thurber Engineering Ltd. (Thurber) has completed a constructability and design assessment of two proposed alignments (Curtis Road and Brent Road) for the proposed Comox Valley Regional District (CVRD) Sewer Conveyance System Project.

It is a condition of this memorandum that the performance of Thurber's professional services is subject to the attached Statement of Limitations and Conditions.

1. BACKGROUND

The Comox Valley Sewerage Service (CVSS) provides transmission and treatment of wastewater for approximately 45,000 people within the Town of Comox, City of Courtenay, Department of National Defense and K'ómoks First Nation (KFN). Wastewater from the majority of the City of Courtenay, The Town of Comox and the KFN is transmitted to the Comox Valley Water Pollution Control Center (CVWPCC) through a large diameter forcemain that follows the shoreline from the Courtenay River estuary to Goose Spit, along Willemar Bluff and then on to the CVWPCC.

The section of forcemain along Willemar Bluffs is exposed to coastal wave action and the depth of cover has deteriorated, resulting in the forcemain posing significant environmental and operational hazards. To address these hazards, the forcemain will be replaced with a new one on an inland alignment. Two revised alignment options for the eastern section of the alignment are currently being considered:

- Curtis Road Alignment – about 1.4 km long (Approx. Sta. 17+500 to 18+900)
- Brent Road Alignment – about 2.3 km long (Approx. Sta. 0+950 to 3+250)

The Curtis Road alignment is about 1.4 km long and extends east along Balmoral Road from the intersection of Lazo Road and Balmoral Road, north along Morland Road, then west along Curtis Road to the Treatment Plant. The Brent Road option is about 2.3 km long and extends north along Lazo Road from the intersection of Lazo Road and Balmoral Road and then south along Brent Road to the Treatment plant. The two proposed alignments are shown on the attached Figure 301.

Although the Curtis Road alignment is shorter than the Brent Road alignment, there is a nominally 400 m long section extending from about Sta. 18+200 to 18+600, where the road runs across a relatively steep slope. Design and construction of the forcemain along this section could be particularly challenging as the slope and road embankment is steep and marginally stable and the road is narrow and there would be a restricted working area during construction.

Stephen Bean, P.Eng, Steven Coulter, P.Eng., and McKenzie Douglas, EIT, from Thurber attended a site visit on May 23, 2023 to observe the site conditions along both alignment options. During this visit it was identified that the design and construction of the Curtis Road alignment would be more difficult than along the Brent Road alignment due to the steep slopes and narrow, curved alignment. Field observations along the steep slope part of the Curtis Road alignment included exposed sand slopes, as steep as about 1H:1V, and “pistol butted” trees and longitudinal asphalt cracking, indicating on-going slope movement.

This memo compares geotechnical design and construction issues along both alignments.

2. DESIGN CONSIDERATIONS

2.1 Curtis Road Option

Design of the Curtis Road alignment from about Sta. 18+200 to 18+600 would have to address static and seismic stability of the slope supporting the forcemain. The slope in this section is expected to have an existing factor of safety against static instability of close to 1.0. The slope should be designed for static factor of safety of 1.5. Under seismic loading, a factor of safety of 1.0 to 1.1 is typically considered acceptable in a pseudo-static analysis using a horizontal acceleration equal to one-half of the peak ground acceleration (PGA). This seismic stability analysis assumes that some movement (e.g. 50 mm to 100 mm) is acceptable.

Stability of the slope could be increased either by reinforcing it or flattening it. Conceptually, slope reinforcement could include an anchored secant pile wall. Design and construction of such walls

is difficult and is expected to cost more than land acquisition required for slope flattening. Accordingly, our assessment of slope stability examined flattening slopes for increasing slope stability.

We used the software program Slide2 published by Rocscience to assess the stability of the slope and measures needed to increase its stability to acceptable levels. Previous Test Hole AH17-02 was used for geological parameters. The seismic analysis used a PGA of 0.418 g, which was obtained from the 2020 NBCC seismic hazard calculator. As shown in Figure 1 and Figure 2, the static and seismic analysis of the slope below the existing road configuration (i.e. supporting the future forcemain) show that the existing factors of safety are less than 1.5 and 1.1, respectively. As shown in Figures 3 and 4, the slope below the forcemain would have to be flattened and widened to a slope angle of 2H:1V to provide adequate static and seismic factors of safety of about 1.72 and 1.08, respectively. This analysis assumed that the flattening and widening would be carried out using well-graded crushed granular fill.

2.2 Brent Road Option

There appears to be no significant geotechnical design issues along this alignment. Design of the forcemain is expected to comprise a typical utility trench. Some minor slope trimming may be required along Brent Road and some stability assessment may be required through the Lazo Marsh section. We anticipate that relatively minor geotechnical design input would be required for this alignment.

3. CONSTRUCTION CONSIDERATIONS

3.1 Curtis Road Option

The two main concerns about constructability of the Curtis Road alignment are that the space for excavation and construction is restricted and that the steep slope above the road requires stabilization for temporary stability and worker safety.

Considering the limited space and the slope above the road, we foresee that excavation support would possibly comprise a sheet pile-supported excavation including additional internal structural bracing with struts and walers. Conceptually, the sheet pile toe might be installed to 2 times the excavation depth and a single row of bracing and walers would be installed at about a depth of 1 m below ground surface. The structural requirements for the bracing could be demanding as it would have to support the slope above the road.

Pile driving close to the loose soils in the slope is also a concern due to the vibrations associated with construction. Excavation of a braced trench is more difficult than an unsupported trench as

the struts restrict excavation. Further, the working room remaining on the road beside the sheet pile-supported excavation will be very narrow, restricting excavation access and access for other construction activities.

Slope stability analyses indicated that to achieve a factor of safety of 1.3 under temporary static conditions, the sand slope above the road would need to be flattened to 2.3H:1V. The output from Slide2 is shown on Figure 5.

3.2 Brent Road Option

Construction along the Brent Road alignment is generally expected to use conventional utility construction methods, possibly with an open cut and a trench box. Probably the most significant concern is at the north end of the alignment where the alignment crosses the wetlands of Lazo Marsh (Approx. Sta. 2+200 to 2+350).

The groundwater conditions are unknown at the wetland crossing; however, the presence of surface water in the wetlands indicates that there is groundwater in the road embankment fill and likely within the depth of the trench excavation. If the road embankment subgrade is relatively impermeable soil (such as dense glacial till), coffer dams and sump and pumps can likely be used to control the water in the excavation during construction. If the subgrade soils are permeable (such as sand), the excavation could possibly be carried out using a sheet pile supported excavation with internal sumps, well points with an unsupported excavation, or a combination of a supported excavation and well points.

Although groundwater control is expected to be required at the wetland crossing, it is not expected to be particularly challenging from both engineering and construction perspectives. We strongly recommend that further investigation be carried out in this area. The investigation could include two test holes through the road embankment into the subgrade soils with the installation of piezometers to measure water levels and estimate permeability. Depending on the conditions encountered during test hole drilling, well testing might be completed to further evaluate groundwater conditions. Further input for this investigation can be provided if the CVRD wants to explore this option further.

4. CONCLUSION

Based on geotechnical considerations, the Curtis Road alignment would be far more difficult and expensive and have much higher risks (both during construction and after construction) than the Brent Road alignment.

We trust this memo provides sufficient information for your purposes at this time. Should you require clarification of any item or need additional information, please contact us at your convenience.

Signed by,

McKenzie Douglas, EIT
Junior Geotechnical Engineer

Steven Coulter, M.Sc., P.Eng.
Principal Engineer

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
S. M. BEAN
June 9/23

Reviewed by,

Stephen Bean, M.Eng., P.Eng.
Review Principal

Attachments

- Statement of Limitations and Conditions
- Figure 301 – Curtis Road Option and Brent Road Option
- WSP test hole log
- HDR Cross Section Figure 2-17b
- Slide2 output. Figures 1 to 5.

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

NORTH

BRENT ROAD OPTION

CURTIS ROAD OPTION

LAZO RD

BRENT RD

CURTIS RD

MORLAND RD

BALMORAL RD

0+000

1+500

2+000

2+500

3+000

3+243.94

17+000

17+500

18+000

18+400

18+500

TH22-04

TH22-09

TH22-07

TH22-02

TH22-10

MR20-01

MR20-02

MR20-03

MR20-04

MR20-05

SH20-01

SH20-02

SH20-03

SH20-04

SH20-05

SH20-06

SH20-07

SH20-08

SH20-09

AH17-01

AH17-02

AH17-03

AH17-04

AH17-05

AH17-06

DRAFT FOR DISCUSSION PURPOSES ONLY
MAY 29, 2023

0 100 200 300m

LEGEND:

- TH22-02 — 2022 THURBER TEST HOLE
- TH22-09 — 2022 THURBER TEST HOLE WITH PIEZOMETER INSTALLED
- PROPOSED ALIGNMENTS (May 24, 2023)
- SH20-07 — WSP SONIC DRILL HOLE
- MR20-04 — WSP MUD ROTARY DRILL HOLE
- AH17-04 — EXP AUGER DRILL HOLE

NOTES:

1. TEST HOLE LOCATIONS TAKEN FROM WSP AND THURBER REPORTS.
2. AERIAL IMAGERY FROM GOOGLE EARTH.
3. PROPOSED ALIGNMENTS PROVIDED BY HDR ON MAY 24, 2023.

THURBER ENGINEERING LTD.

HDR INC.

PLAN
CURTIS ROAD OPTION vs BRENT ROAD OPTION

CVRD SEWER SYSTEM CONVEYANCE PROJECT — COMOX VALLEY REGIONAL DISTRICT, B.C.

DESIGNED	DRAWN	APPROVED	DATE	SCALE	PROJECT No.	FIGURE. NO.	REV.
MPD	DRB	SMB	MAY 29, 2023	1:6,000	31226	FIGURE 301	-

Services Inc.
275-3001 Wayburne Drive
Burnaby, BC V5G 4W3
Telephone: 604-709-4645

RECORD OF AUGERHOLE : AH17-01

PROJECT NUMBER VAN-00238945-A0
PROJECT NAME CVRD PS# 2
DRILLING DATE 2017-05-26
DRILLING CONTRACTOR Drillwell Enterprises Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Gus Pech GP1300 Truck Mounted Drill
LOGGED BY DGS **CHECKED BY** BW

CLIENT OPUS
PROJECT LOCATION
AUGERHOLE LOCATION N: 5504581 E: 363981
ELEVATION
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** —
▼ **AT END OF DRILLING** —
▼ **AFTER DRILLING** —

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m ▲ 20 40 60 80 / DYNAMIC CONE BLOWS/0.3m 20 40 60 80	POCKET PEN. (kPa) ⊙ 100 200 300 400 / FIELD VANE SHEAR (kPa) Peak ● Remold ○ 40 80 120 160	FINES CONTENT (%) □ 20 40 60 80 / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL 20 40 60 80
		ASPHALT, 50mm	0.0	S1	AU				
		GRAVELLY SAND, some silt, brown, damp, (compact) sand was well-graded (FILL)	0.1	S2	AU				
		GRAVELLY SAND, some silt, frequent cobbles, reddish brown, moist, (compact) (FILL)	0.5						
1		SAND, trace silt, brown with black and orange pockets, damp, (compact) medium grained		S3	AU				
2									
3		-rounded gravel pockets become frequent		S4	AU				
4		-becomes moist		S5	AU				

Bottom of hole at 4.6m.

Services Inc.
275-3001 Wayburne Drive
Burnaby, BC V5G 4W3
Telephone: 604-709-4645

RECORD OF AUGERHOLE : AH17-02

PROJECT NUMBER VAN-00238945-A0
CLIENT OPUS
PROJECT NAME CVRD PS# 2
PROJECT LOCATION
DRILLING DATE 2017-05-26
AUGERHOLE LOCATION N: 5504360 E: 363772
DRILLING CONTRACTOR Drillwell Enterprises Ltd.
ELEVATION
DRILLING METHOD Solid Stem Auger
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** —
▼ **AT END OF DRILLING** —
▼ **AFTER DRILLING** —
EQUIPMENT TYPE Gus Pech GP1300 Truck Mounted Drill
LOGGED BY DGS **CHECKED BY** BW

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m ▲ 20 40 60 80 / DYNAMIC CONE BLOWS/0.3m	POCKET PEN. (kPa) ⊙ 100 200 300 400 / FIELD VANE SHEAR (kPa) Peak ● Remold ○ 40 80 120 160	FINES CONTENT (%) □ 20 40 60 80 / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL 20 40 60 80
		SOD/TOPSOIL	0.0	S1	AU		33		
		SAND & GRAVEL, some silt, some cobbles, greyish brown, damp, (compact) (FILL)	0.3						
		SAND, trace silt, yellowish brown, damp, (compact) medium grained, (FILL)	0.5	S2	AU		17		
1		SILTY SAND to SAND, some silt, frequent rootlets and organic remnants, dark brownish black, damp, (firm to soft) (FILL)					8		
				S3	AU		2		
							4		
2		SAND, trace silt, occasional rootlets and pockets of organics, mottled reddish brown with grey and black pockets, damp, (loose) (FILL)	1.8				5		
							4		
							4		
				S4	AU		5		
3							4		
							6		
		SAND, trace silt, reddish brown, damp, (loose to compact) fine to medium grained	3.7				8		
4							8		
				S5	AU		10		
							12		
5							14		
							16		
							20		
				S6	AU		22		
6							27		

Bottom of hole at 6.1m.

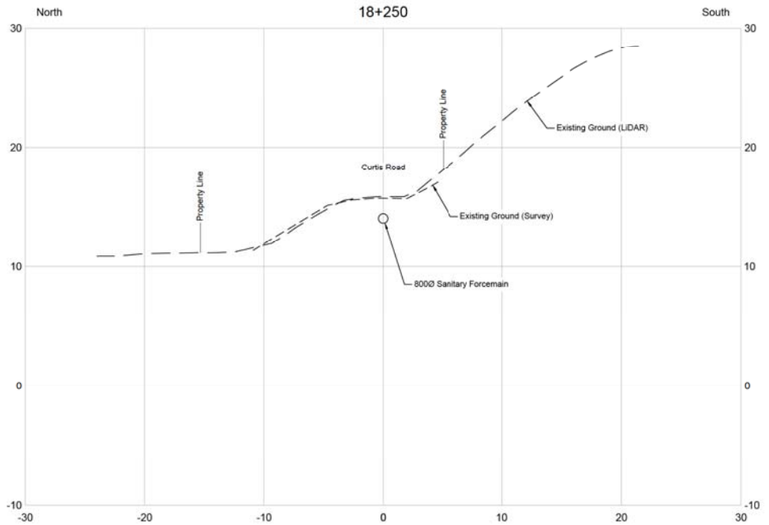
Services Inc.
275-3001 Wayburne Drive
Burnaby, BC V5G 4W3
Telephone: 604-709-4645

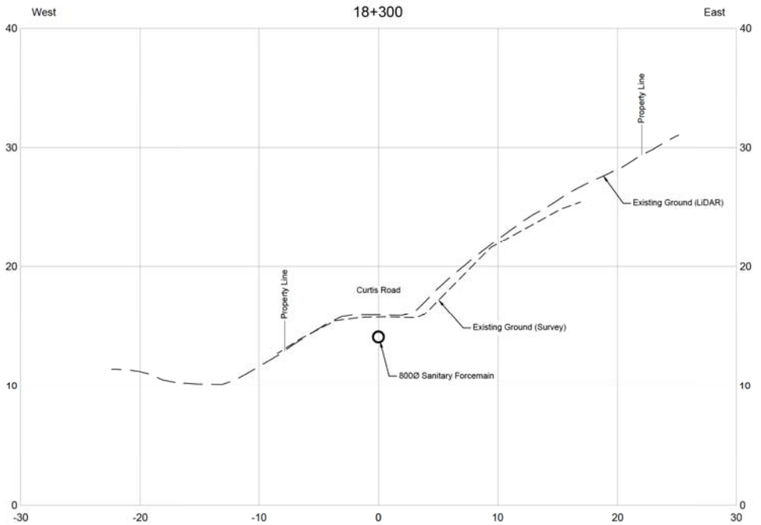
RECORD OF AUGERHOLE : AH17-03

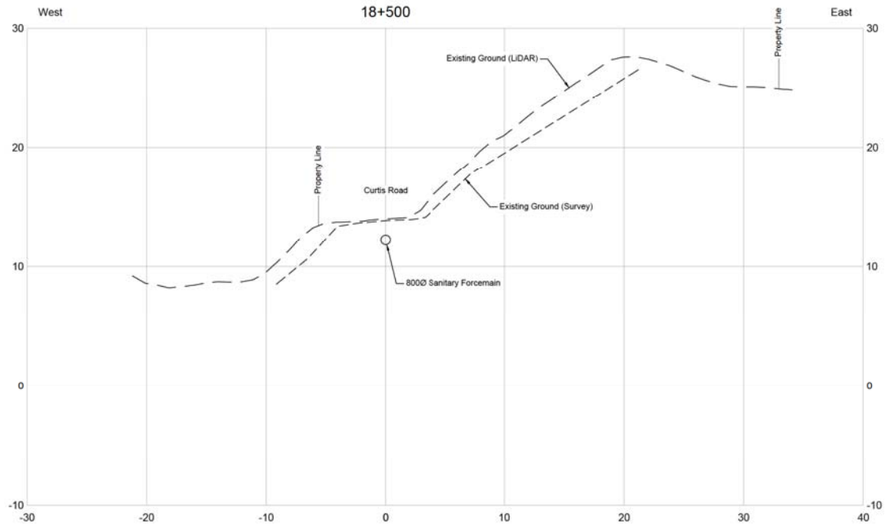
PROJECT NUMBER VAN-00238945-A0
CLIENT OPUS
PROJECT NAME CVRD PS# 2
PROJECT LOCATION
DRILLING DATE 2017-05-26
AUGERHOLE LOCATION N: 5504281 E: 363508
DRILLING CONTRACTOR Drillwell Enterprises Ltd.
ELEVATION
DRILLING METHOD Solid Stem Auger
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** —
▼ **AT END OF DRILLING** —
▼ **AFTER DRILLING** —
EQUIPMENT TYPE Gus Pech GP1300 Truck Mounted Drill
LOGGED BY DGS **CHECKED BY** BW

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m ▲ 20 40 60 80 / DYNAMIC CONE BLOWS/0.3m 20 40 60 80	POCKET PEN. (kPa) ⊙ 100 200 300 400 / FIELD VANE SHEAR (kPa) Peak ● Remold ○ 40 80 120 160	FINES CONTENT (%) □ 20 40 60 80 / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL 20 40 60 80
0		SOD/TOPSOIL	0.0						
		SILTY SAND, some gravel, frequent rootlets, dark brown, damp, (compact) (FILL)		S1	AU				
		SAND, some gravel, trace silt, reddish brown, damp, (loose to compact) coarse grained	0.5						
1				S2	AU				
2		SILTY SAND, some gravel, grey, damp, (compact to dense) sand was fine grained, gravel was angular to sub-rounded (TILL-LIKE) -very hard drilling	1.8						
3				S3	AU				
4				S4	AU				

Bottom of hole at 4.6m.







HDR

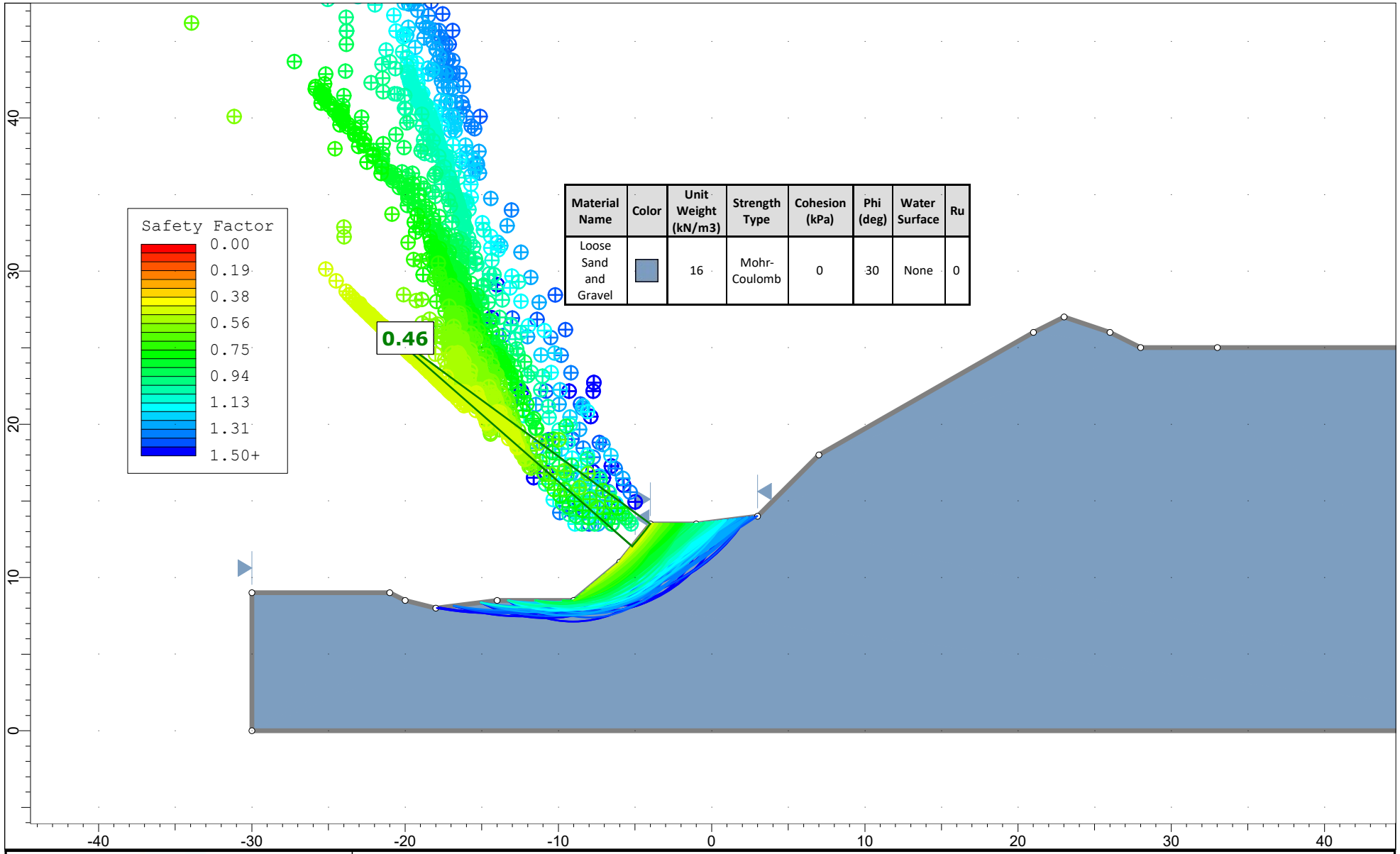
Comox Valley Regional District

Comox Valley Regional District
Hydraulic Profile Under PWWF and ADWF

Curtis Road Critical Sections

JOB NUMBER	10308968
DATE	Apr 26 2023
SCALE	1: 250

Figure 2-17b



THURBER

SLIDEINTERPRET 9.024

Project **CVRD SEWER CONVEYANCE SYSTEM PROJECT**

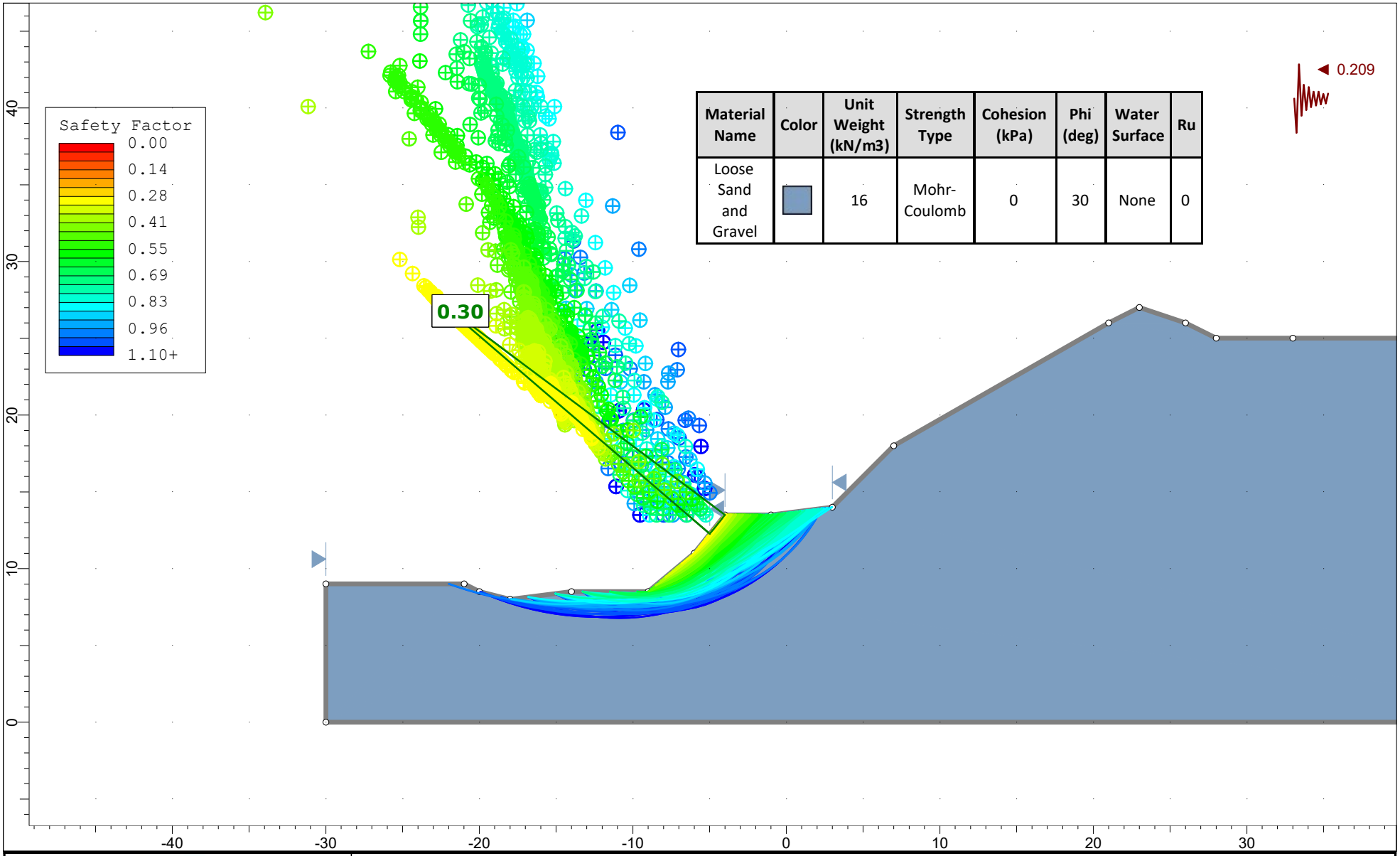
Client HDR Inc.

Project Number 31226

Date 2023-06-07

Title Figure 1

File Name mpd_curtis road slope stability_31226_r1.slmd



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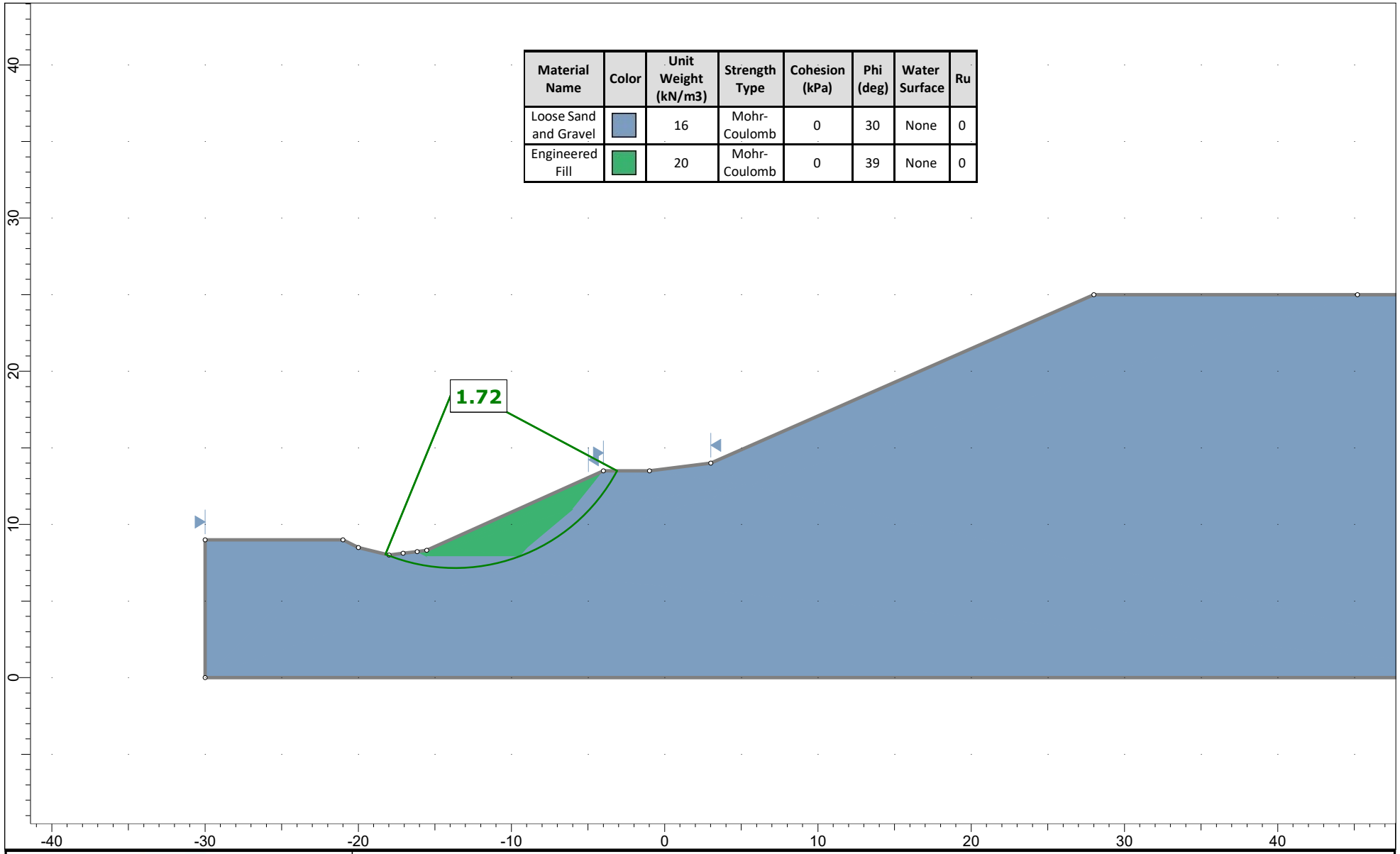
SLIDEINTERPRET 9.024

Project	**CVRD SEWER CONVEYANCE SYSTEM PROJECT**
Client	HDR Inc.
Project Number	31226
Date	2023-06-07
Title	Figure 2
File Name	mpd_curtis road slope stability_31226_r1.slmd

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru
Loose Sand and Gravel		16	Mohr-Coulomb	0	30	None	0
Engineered Fill		20	Mohr-Coulomb	0	39	None	0



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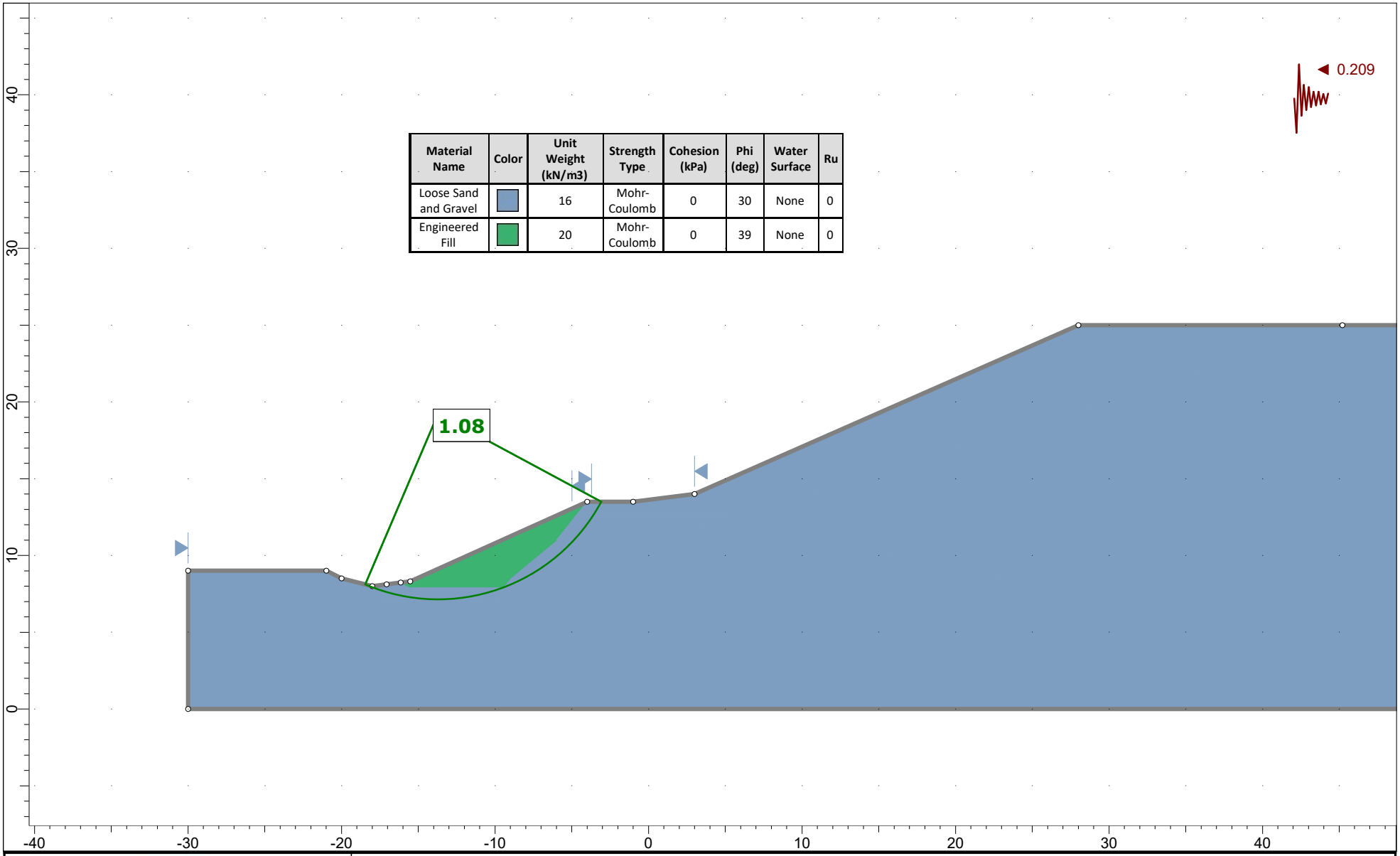
SLIDEINTERPRET 9.024

Project	**CVRD SEWER CONVEYANCE SYSTEM PROJECT**
Client	HDR Inc.
Project Number	31226
Date	2023-06-07
Title	Figure 3
File Name	mpd_curtis road slope stability_31226_r1.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru
Loose Sand and Gravel		16	Mohr-Coulomb	0	30	None	0
Engineered Fill		20	Mohr-Coulomb	0	39	None	0

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SLIDEINTERPRET 9.024

Project **CVRD SEWER CONVEYANCE SYSTEM PROJECT**

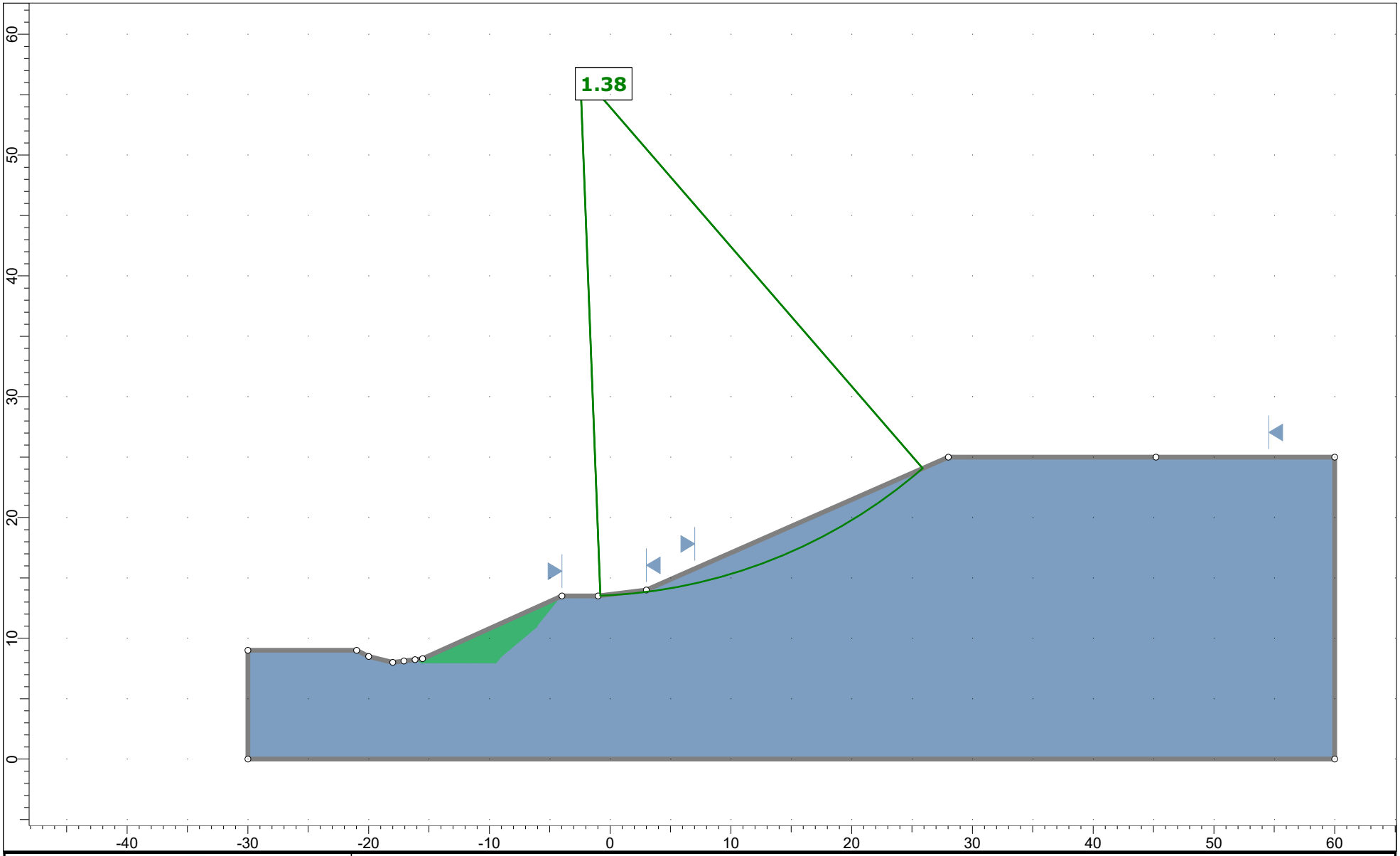
Client HDR Inc.

Project Number 31226

Date 2023-06-07

Title Figure 4

File Name mpd_curtis road slope stability_31226_r1.slmd



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SLIDEINTERPRET 9.024

Project	**CVRD SEWER CONVEYANCE SYSTEM PROJECT**
Client	HDR Inc.
Project Number	31226
Date	2023-06-07
Title	Figure 5
File Name	mpd_curtis road slope stability_31226_r1.slmd