



May 30, 2017

WSP Reference No: 171-05352-00

City of Surrey
Engineering Department / Operations Division
6651 148 Street
Surrey, BC V3S 3C7

Attention: Mr. Matthew Brown

Subject: Geotechnical Review of Large Stockpile
Stokes Pit – 19525 20th Ave., 19648 24th Ave., 19500 26th Ave., 2990 194th St.,
Surrey, BC

1. INTRODUCTION

This letter summarizes our geotechnical desktop study of the following geotechnical reports:

- Trow Associated Inc. (Trow) report of November 30, 2007 (Trow File 071-03420).
- GeoPacific Consultants Ltd. (GeoPacific) report of August 17, 2016 (GeoPacific File 14147).
- Active Earth Engineering Ltd. (AEE) report of January 12, 2017 (AEE Project 1286).

Our desktop study of the above reports focuses on a review of the geotechnical suitability of fill in the large stockpile at Stokes Pit. Our scope of work is intended to answer the following two questions:

- Can the fill material be used as structural fill.
- Can the fill material below the design grades for the proposed light industrial development remain in place.

2. BACKGROUND INFORMATION

2.1 SITE DESCRIPTION

The large stockpile of fill is located between 196th Street to the east, the road right-of-ways for 20th Avenue to the south and 24th Avenue to the north and the existing light industrial buildings and 194th Street to the west.

We understand from the AEE report that the total volume of the stockpile is in the order of 1 million cubic meters. Based on the contour lines shown on the AEE Figure A, the surface of the stockpile generally varies from approximately Elev. 45 to 53 m. We expect that the design grades for the proposed light industrial development will be in the range of Elev. 43 m for the building floors and Elev. 42 m for the roads and parking areas.

2.2 FINDINGS OF PREVIOUS REPORTS

2.2.1 SOIL CONDITIONS

The following test hole logs that pertain to the large stockpile of fill were included in the reports which were reviewed:

Trow Report

- Sixteen augered holes (AH-9 to AH-15 and AH-17 to AH-25) completed to depths ranging from 3.0 to 13.7 m.
- Nine test pits (TP-7 to TP-15) completed to depths ranging from 0.9 to 3.4 m.

GeoPacific Report

- Nine excavated test pits (TP16-08 to TP16-16) completed to depths ranging from 2.7 to 3.7 m.

AEE Report

- Four augered holes (AE16-BH1 to AE16-BH3 and AE16-MW2) completed to depths ranging from 9.2 to 12.2 m.
- Three electric cone penetration tests (AE16-CPT1 to AE16-CPT3) completed to depths ranging from 7.65 to 9.55 m.

**The AEE Report references a Thurber Engineering Ltd. Memorandum titled Review of Dyke Fill Material at Stokes Pit dated January 29, 2014. The Thurber report was not provided for review under the current scope of work.*

Four cross-sections showing site topography and interpreted soil conditions were prepared by AEE as part of their above-referenced report (AEE Figures 2 through 5). Based on these cross sections, the upper and lower horizons of the fill were inferred by AEE to vary across the site between approximately Elev. 53 m and Elev. 39 m, respectively. The total inferred thickness of the fill varies between approximately less than 1 m thick and up to approximately 12.5 m thick.

2.2.2 RE-USE OF FILL

Discussion on re-use of the fill material provided in the Trow, GeoPacific and AEE reports is summarized below. The Trow report has the following comments regarding the fill in the stockpile:

- Variable fills from sand and silt, organic silt to silt with some sand and gravel, as well as some organics, wood and construction debris.
- Variable fill consistency or compactness from soft to stiff or loose to compact.
- Most of the granular site soils are suitable to be used as structural fill.
- Care should however be taken during bulk excavation to separate the existing clean granular soils from intermittent silt layers.

The GeoPacific report has the following comments:

- The majority of existing fills in the stockpile are at an elevated moisture content and/or contain organics or debris, which are unsuitable for structural fill.
- To permit reuse of the stockpile fills as bulk grading fills, drying is anticipated to be required for a greater portion of the stockpile fills, especially the till-like fills.
- In addition, selective excavation will be required in order to remove debris and organic fills present within the stockpile.
- The stockpile fills may be used as bulk grading fills conditional to reaching suitable moisture content for compaction and the removal of organics and debris.

The AEE report has the following comments:

- The soil stockpile includes a range of soil types, but the largest portion of soil is classified as well-graded silty sand.
- Small layers of sand with gravel and lower silt content were encountered at a few discrete locations; however, significant volumes of this type of material was not observed in this investigation, nor in previous investigations by others.
- For suitable placement of structural fill, the soil should be within 2% of the estimated optimum moisture content. Of the 20 moisture content samples only 5 were within 2% of the estimated optimum moisture content for compaction.
- The silty sand and gravel, and till-like fill with suitable moisture content of less than 16% may be used under access roads, parking areas and possibly under slabs. It is cautioned that any use of this fill must meet the structural requirements of each development and must be placed under strict moisture and compaction control supervision by the geotechnical engineer. Soil logs contain descriptions of organics, refuse and demolition debris which, along with high moisture contents, will make some of this material unsuitable as structural fill, requiring segregation during placement. Separation of the suitable material for re-use will be labour intensive.
- There is a large volume of fill that is not suitable for structural purposes, including beneath roadways, slabs, etc.

3. DISCUSSION

Based on our review of the three reports discussed above, we consider that in general these reports present similar findings and recommendations. We point out that we have not inspected or tested any of the site soils; since our terms of reference at this time is to undertake a desktop study.

For this study, we have reviewed the test hole logs included in the three above-referenced geotechnical reports in order to address the two questions outlined in Section 1.0 regarding the stockpile of fill. Discussion addressing these questions is provided in the following sections.

3.2 CAN THE FILL IN THE STOCKPILE BE USED AS STRUCTURAL FILL

Based on our review, the following fill materials present at the site can potentially be used as structural fill:

- Sand & Gravel
- Sand
- Silty Sand
- Sand & Silt

The use of these soils as structural fill will be contingent on these soils being separated from the silt, organics and debris. Where the in situ moisture content of these soils are above optimum moisture content for compaction, it will also be necessary to dry these soils out such that they are within approximately 2% of the optimum moisture for compaction.

The following fill materials present at the site are considered to not be acceptable as structural fill:

- Silt
- Organic Silt
- Peat
- Topsoil
- Debris

We have reviewed each layer of fill described in the test holes with respect to whether it can be used as structural fill. For our review we have assumed that 90% of the Sand & Gravel, Sand, Silty Sand, and Sand & Silt layers can be used as structural fill, provided that appropriate moisture content conditioning is undertaken. Also, where these soils contain debris, we have assumed that only 50% can be used.

The remaining silt, organic silt, peat, topsoil and debris which is unsuitable for use as structural fill will need to be removed from the site, or used in areas that are not sensitive to settlement.

The attached table presents our assessment of the fill based on the test hole information provided to us and, assuming that these test holes provide an accurate description of the fill in the stockpile, we consider that approximately 40% of the fill can be used as structural fill. However, we consider that to use even 40% of the fill, the earthwork operation will be very intensive. We expect that the earthworks operation will include the following:

- The potentially usable soils will need to be separated from the unacceptable soils and materials.
- The potentially useable materials that are above the optimum moisture content for compaction will need to be spread out in thin lifts (approximately 300 mm thick) in the dry

summer months in order to dry out. The Contractor will likely need to blade the material to ensure that the entire lift is exposed to dry weather and able to dry. Sufficient space will be required to spread the material out.

- Once these materials are dried out to near optimum moisture content, they can be compacted.
- Following compaction and approval by the Geotechnical Engineer, the next 300 mm thick lift of fill can be placed, allowed to dry out and then compacted.

3.2 CAN THE FILL MATERIAL BELOW THE DESIGN GRADES FOR THE PROPOSED LIGHT INDUSTRIAL DEVELOPMENT REMAIN IN PLACE

We have reviewed the geotechnical suitability of the fill material remaining in place below the proposed buildings, roads and parking areas and have the following comments:

- **For buildings**, the fill should be removed and replaced with structural fill where conventional footings and slab-on-grade floors are used. If pile foundations are used to support buildings, including the ground floor slab, the fill could remain in place provided that a free-draining granular layer is in place below the floor and the lateral seismic loads can be resisted by the piles.
- **For roads and parking areas**, the fill could potentially remain in place below the pavement section. However, the structural pavement design will depend on the road classification and traffic volume projections. Given that the existing fill would be a relatively poor subgrade for pavement support, the pavement section would need to be exceed the minimum thicknesses for standard pavement sections in the City of Surrey Supplementary Standard Drawings and may need to be 0.9 to 1.0 m thick.

Based on the finished asphalt being at approximately Elev. 42 m and the underside of the pavement section at approximately Elev. 41 m, only about 1 to 2 m of fill would remain in place. Refer to the attached "marked-up" AEE Figures 2 to 5. Based on our review of the test hole logs, this 1 to 2 m of fill generally consists of silt and sand with occasional debris and organics, which would be a relatively weak subgrade, but settlement should not be much more than what would normally be expected for roads and pavement areas since these soils have been preloaded with the stockpile of fill. There will be some areas, such as at test hole AH-18, where organic silt and peat fill will need to be subexcavated below the pavement section.

- There may be a scenario where the City of Surrey removes the fill down to the design grades in the lots for the proposed light industrial development and then only prepares and builds the roads and site servicing for the development. The lots could then be sold with full disclosure that some fill remains in place and it will be the responsibility of each lot owner along with their design team, including the Geotechnical Consultant, to adequately design the building foundations, servicing and parking areas for the site-specific soil conditions for each lot.

4. CLOSURE

The geotechnical desktop study and comments presented in this letter are strictly for the benefit of the City of Surrey and their appointed agents and are not to be considered as a substitute for analyses, review and inspections required by the Geotechnical Engineers of Record for the buildings and roads for this project.

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Contractors should make their own interpretation of the soil logs and the site conditions for the purposes of bidding and performing work on the site.

Yours truly,

[Original signed by: Randy R. Hillaby, P.Eng. / Graeme McAllister, P.Eng.]

Randy R. Hillaby, P.Eng.
Senior Engineer, Geotechnical

Reviewed by: Graeme McAllister, P.Eng.

RRH/mg

Encl. Terms of Reference
 Table – Stokes Pit Review
 "Marked up" AEE Figures 2 to 5



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STOKES PIT REVIEW

20th to 24th Avenue, 194th Street
Surrey, BC

May 16, 2017
171-05352-00

Location	Potential Structural Fill Depth Interval (m)			Potential Reuse %	Reuseable Thickness (m)	Thickness of Fill @ Test Location (m)	Potential Reuse of Fill Encountered %	Comment
	Top	Bottom	Thickness					
AH9	0	1.9	1.9	90.0%	1.7			OK
	1.9	2.4	0.5	0.0%	0			Silt
	2.4	6.1	3.7	90.0%	3.3			OK
					5	6.1	82%	
AH10	0	5.6	5.6	0.0%	0			Silt/Debris
	5.6	8.2	2.6	50.0%	1.3			Debris
					1.3	8.2	16%	
AH11	0	0.6	0.6	0.0%	0			Organic
	0.6	1.4	0.8	0.0%	0			Silt
					0	1.4	0%	
AH12	0	1.3	1.3	0.0%	0			Organic
	1.3	2	0.7	90.0%	0.6			OK
					0.6	2	31%	
AH13	0	0.2	0.2	0.0%	0			Organic
	0.2	3.5	3.3	50.0%	1.65			Debris
					1.65	3.5	47%	
AH14	0	3.2	3.2	50.0%	1.6			Debris
	3.2	3.8	0.6	0.0%	0			Silt
	3.8	7.6	3.8	0.0%	0			Silt/Organic
					1.6	7.6	21%	
AH15	0	0.4	0.4	90.0%	0.4			OK
	0.4	0.8	0.4	0.0%	0			Debris
	0.8	1.5	0.7	90.0%	0.6			OK
	1.5	3.7	2.2	50.0%	1.1			Debris
	3.7	6.1	2.4	0.0%	0			Organic
	6.1	8.5	2.4	90.0%	7.2			OK
					4.3	8.5	51%	
AH17	0	0.4	0.4	90.0%	0.4			OK
	0.4	1.8	1.4	50.0%	0.7			Debris
	1.8	5.8	4	0.0%	0			Silt
					1.1	5.8	19%	
AH18	0	4.6	4.6	50.0%	2.3			Debris
	4.6	6.1	1.5	0.0%	0			Organic
					2.3	6.1	38%	
AH19	0	0.05	0.05	0.0%	0			Organic
	0.05	4.7	4.65	50.0%	2.3			Debris
					2.3	4.65	49%	
AH20	0	3.1	3.1	50.0%	1.5			Debris
	3.1	5.3	1.8	0.0%	0			Organic
	5.3	12.5	7.2	50.0%	3.6			Debris
					5.1	12.5	41%	
AH21	0	0.6	0.6	90.0%	0.5			OK
	0.6	3.4	2.8	0.0%	0			Organic
	3.4	9.3	5.9	50.0%	3			Debris
					3	9.3	32%	



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	Top	Bottom	Thickness					
AH22	0	11	11	0.0%	0	11	0%	Silt
AH23	0	0.5	0.5	90.0%	0.5			OK
	0.5	2.9	2.4	50.0%	1.2			Debris
	2.9	6.1	3.2	0.0%	0			Organic
	6.1	9.8	3.7	50.0%	1.85			Debris
					3.5	9.8	36%	
AH24	0	5.2	5.2	0.0%	0	5.2	0%	Silt/Organic
AH25	0	1.2	1.2	90.0%	1.1			OK
	1.2	8.2	7	0.0%	0			Organic
					1.1	8.2	13%	
TP7	0	0.8	0.8	50.0%	0.4			Debris
	0.8	1.2	0.4	0.0%	0			Organic
					0.4	1.2	33%	
TP8	0	0.3	0.3	50.0%	0.15			
	0.3	0.9	0.6	0.0%	0			
					0.15	0.9		
TP9	0	1.2	1.2	50.0%	0.6	1.2	50%	Debris
TP10	0	0.3	0.3	90.0%	0.3			OK
	0.3	0.4	0.1	0.0%	0			Organic
	0.4	1.5	1.1	50.0%	0.55			Debris
					0.85	1.5	57%	
TP11	0	1.7	1.7	0.5%	0.85	1.7	50%	Debris
TP12	0	1.8	1.8	0.5%	0.9			Debris
	1.8	2.4	0.6	0.0%	0			Organic
					0.9	2.4	38%	
TP13	0	0.4	0.4	0.9%	0.35			OK
	0.4	0.9	0.5	0.0%	0			Silt
					0.35	0.9	39%	
TP14	0	0.25	0.25	0.9%	0.25			OK
	0.925	1.2	0.95	0.0%	0			Silt
					0.25	1.2	21%	
TP15	0	0.25	0.25	0.9%	0.25			OK
	0.25	1.2	0.95	0.0%	0			Silt
					0.25	1.2	21%	
BH1	0	2.7	2.7	0.9%	2.4			OK
	2.7	3.7	1	0.0%	0			Organic
	3.7	6.1	2.4	0.5%	1.2			
	6.1	8.2	2.1	0.0%	0			
	8.2	9.2	1	0.9%	0.9			
	9.2	11.9	2.7	0.0%	0			
					4.5	11.9	38%	
BH2	0	3.7	3.7	0.9%	3.3			OK
	3.7	7	3.3	0.0%	0			Clay/Organic
	7	8.2	1.2	0.9%	1.1			
					4.4	9.2	54%	



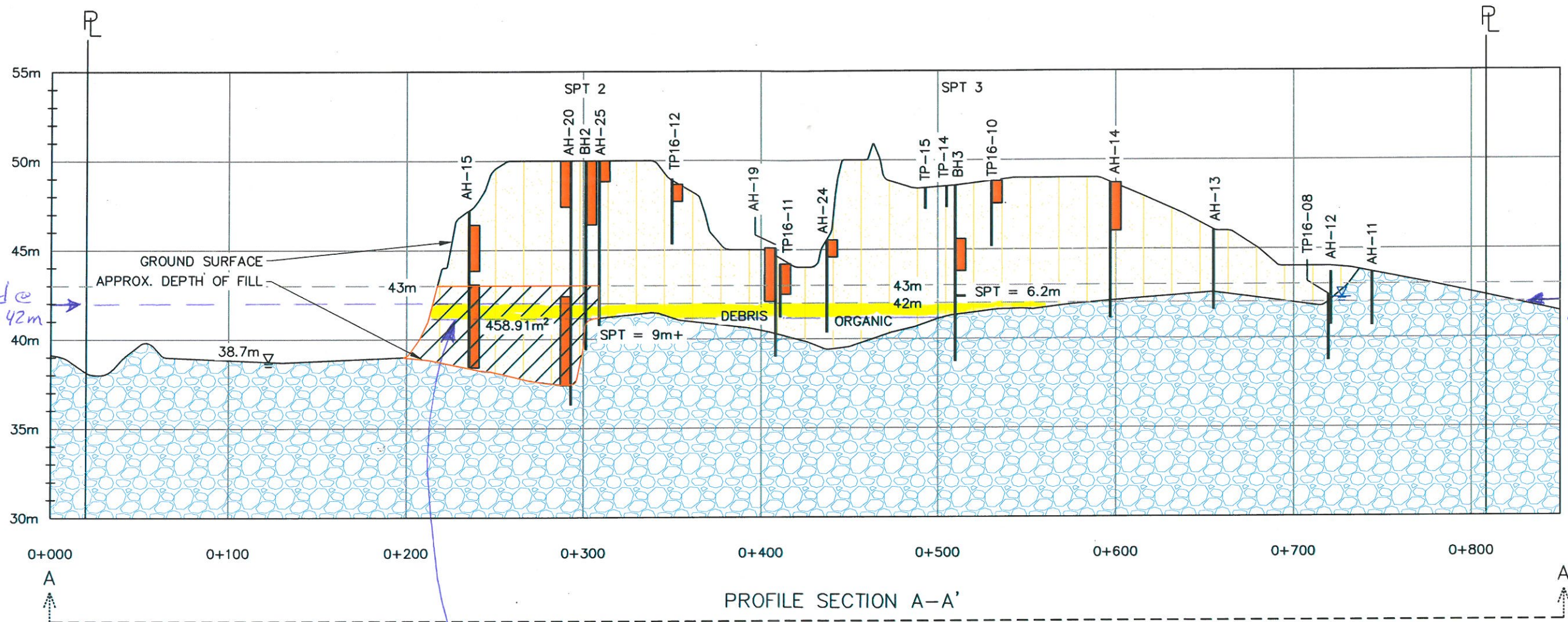
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	Top	Bottom	Thickness					
BH3	0	4.9	4.9	0.9%	4.4			OK
	4.9	6.7	1.8	0.0%	0			Silt/Organic
					4.4	6.7	65%	
MW2	0	1.8	1.8	0.9%	1.6			OK
	1.8	2.5	0.7	0.0%	0			Silt/Organic
	2.5	9.1	6.6	0.9%	5.9			
					7.5	9.1	83%	
TP16-08	0	0.6	0.6	0.9%	0.55			OK
	0.6	3.2	2.6	0.5%	1.3			Debris
					1.85	3.2	58%	
TP16-09	0	0.5	0.5	0.9%	0.45			OK
	0.5	2.2	1.7	0.5%	0.85			Some Organic
	2.2	3.8	1.6	0.0%	0			
					1.3	3.8	34%	
TP16-10	0	1	1	0.9%	0.9			OK
	1	2.4	1.4	0.5%	0.7			Debris
	2.4	3.7	1.3	0.9%	1.2			OK
					2.8	3.7	76%	
TP16-11	0	1.2	1.2	0.9%	1.1			OK
	1.2	3	1.8	0.5%	0.9			Debris
					2	3	66%	
TP16-12	0	1	1	0.0%	0			Organic
	1	2	1	0.5%	0.5			Some Organic
					2	3.7	54%	
TP16-13	0	1.2	1.2	0.9%	1.1			OK
	1.2	3.2	2	0.0%	0			Organic
					1.1	3.2	34%	
TP16-14	0	0.3	0.3	0.9%	0.3			OK
	0.3	3.4	3.1	0.5%	1.55			Debris
					1.85	3.4	54%	
TP16-15	0	2.7	2.7	0.9%	2.4	2.7	90%	OK
TP16-16	0	0.3	0.3	0.9%	0.3			OK
	0.3	2.7	2.4	0.5%	1.2			Debris
					1.5	2.7	55%	
TOTAL					74.95	187.35	40%	

VERTICAL SCALE 1:250
(EXAGGERATION 10x)
ELEVATION (GEODETIC) (m)

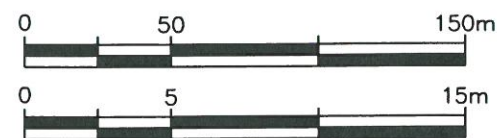


LEGEND

-  POSSIBLE FILL TO REMAIN IN PLACE WITH FURTHER INVESTIGATION
-  NATIVE SOIL
-  INFERRED POOR QUALITY FILL
-  POTENTIAL REUSABLE FILL

HOR SCALE 1:2500

VERT SCALE 1:250



1m thick
pavement section.



CLIENT NAME:
SURREY CITY DEVELOPMENT
CORPORATION

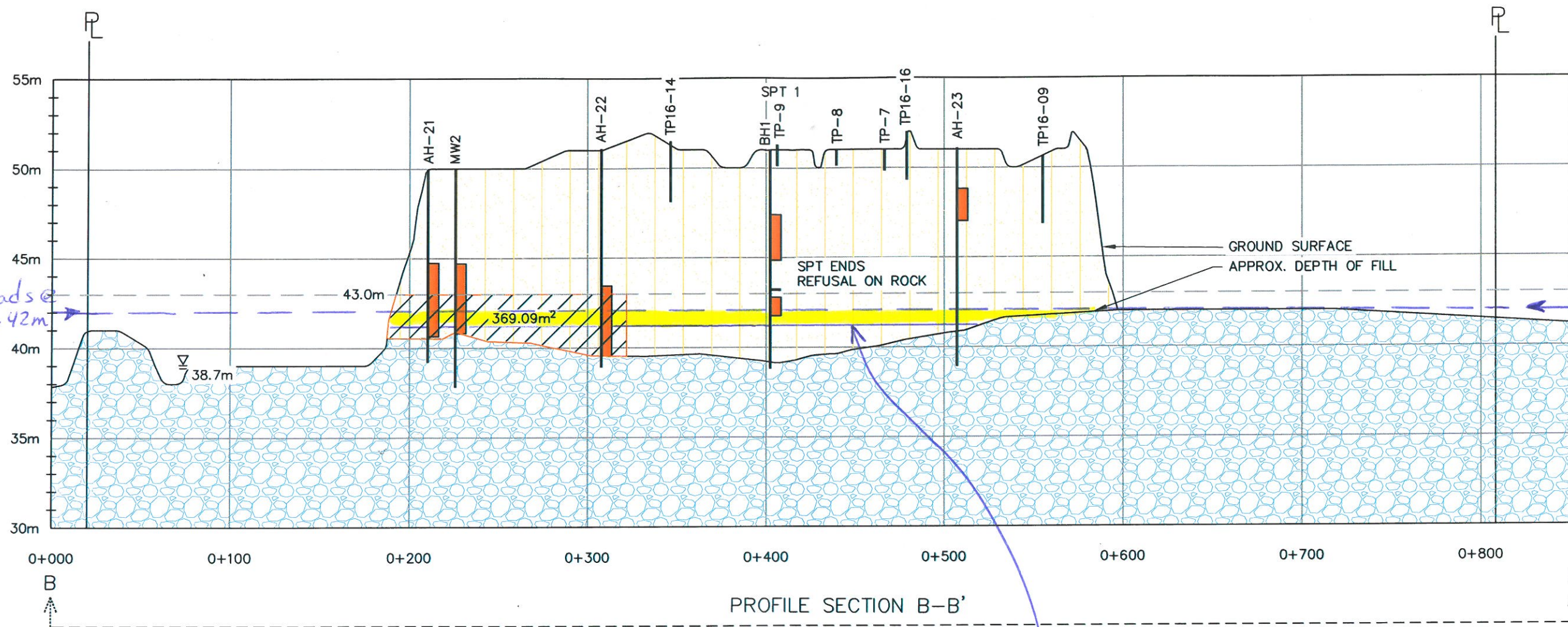
PROJECT LOCATION:
SURREY, BC

CROSS SECTION A-A
19525 20th AVE / 19468 24th AVE / 19500 26th AVE & 2990 194th ST

DWN BY: EB DWG NAME: 1286-2 DATE: 2016-12-21
CHK'D: MP PLOT: CADFILE: 1286

FIGURE 2

VERTICAL SCALE 1:250
(EXAGGERATION 10x)
ELEVATION (GEODETIC) (m)

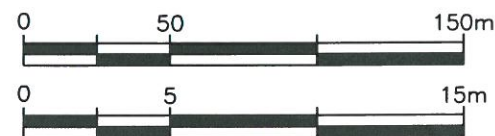


LEGEND

- POSSIBLE FILL TO REMAIN IN PLACE WITH FURTHER INVESTIGATION
- NATIVE SOIL
- INFERRED POOR QUALITY FILL
- POTENTIAL REUSABLE FILL

HOR SCALE 1:2500

VERT SCALE 1:250



REFERENCE: CITY OF SURREY - COSMOS MAPPING SYSTEM



CLIENT NAME:
SURREY CITY DEVELOPMENT
CORPORATION

PROJECT LOCATION:
SURREY, BC

CROSS SECTION B-B
19525 20th AVE / 19468 24th AVE / 19500 26th AVE & 2990 194th ST

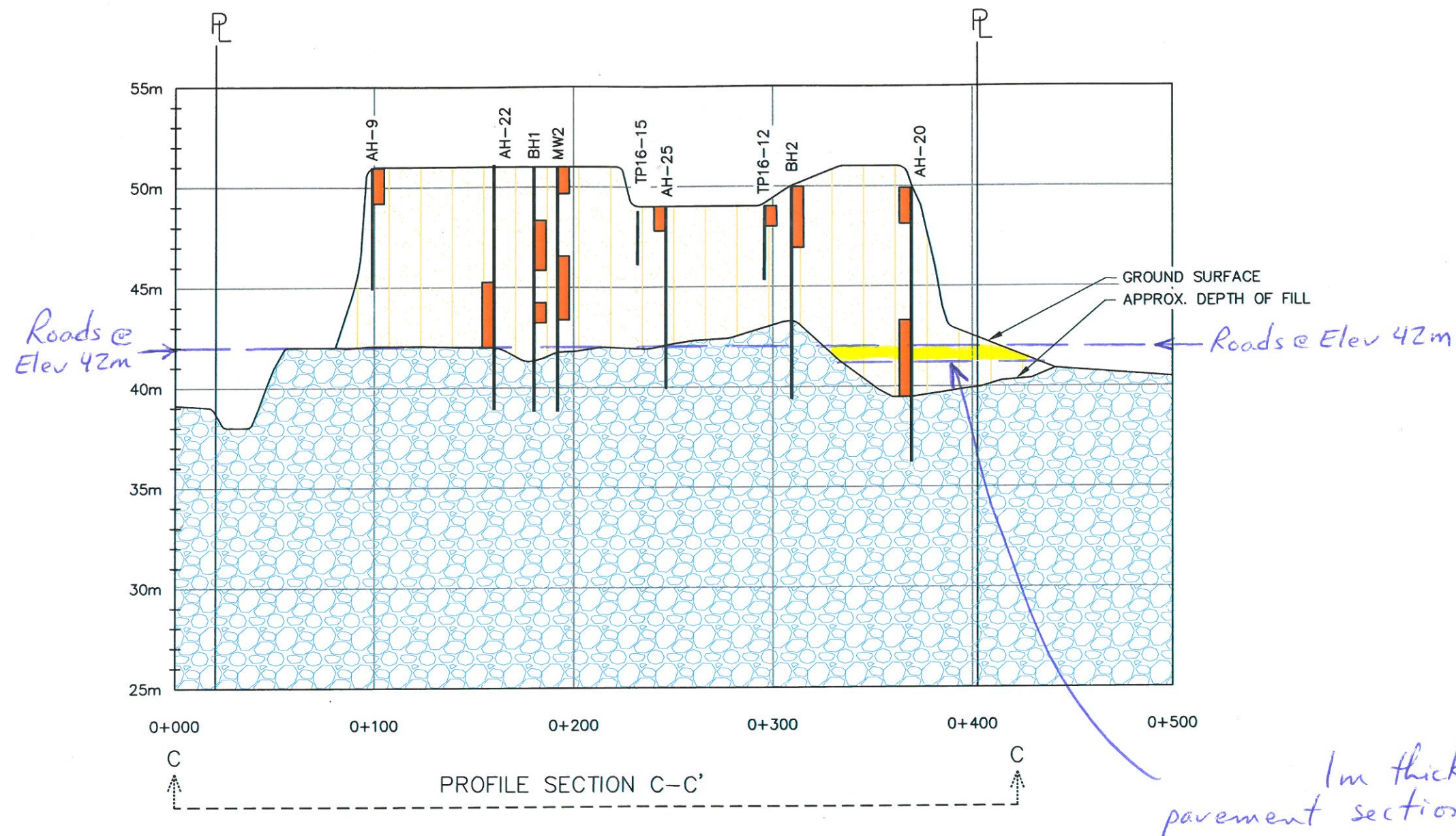
OWN BY: EB
CHK'D: MP

DWG NAME: 1286-3
PLOT:

DATE: 2016-12-21
CADFILE: 1286

FIGURE 3

VERTICAL SCALE 1:200
(EXAGGERATION 10x)
ELEVATION (GEODETIC) (m)

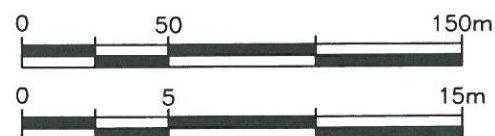


LEGEND

- NATIVE SOIL
- INFERRED POOR QUALITY FILL
- POTENTIAL REUSABLE FILL

HOR SCALE 1:2500

VERT SCALE 1:250



CLIENT NAME:
SURREY CITY DEVELOPMENT
CORPORATION

PROJECT LOCATION:
SURREY, BC

CROSS SECTION C-C
19525 20th AVE / 19468 24th AVE / 19500 26th AVE & 2990 194th ST

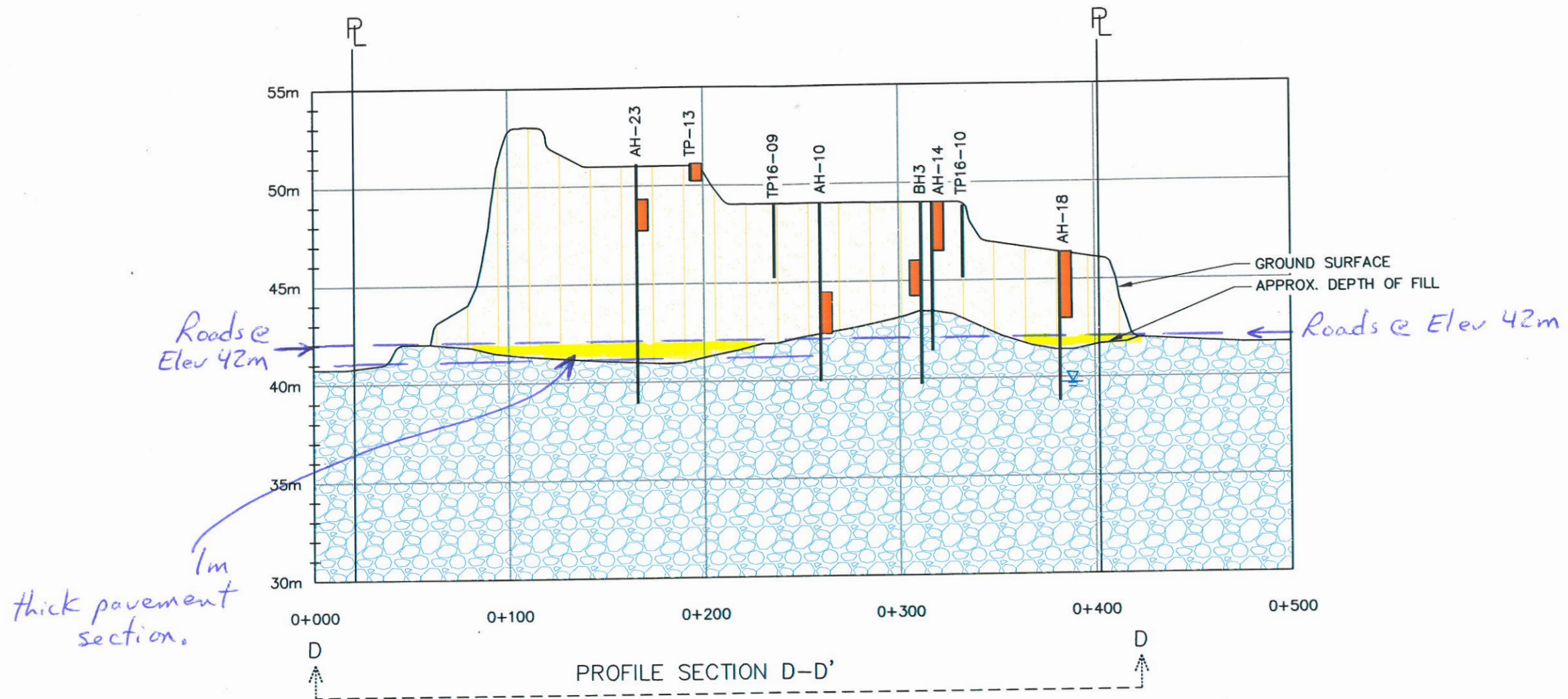
DWN BY: EB
CHK'D: MP

DWG NAME: 1286-4
PLOT:

DATE: 2016-12-21
CADFILE: 1286

FIGURE 4

VERTICAL SCALE 1:200
(EXAGGERATION 10x)
ELEVATION (GEODETIC) (m)



LEGEND

- NATIVE SOIL
- INFERRED POOR QUALITY FILL
- POTENTIAL REUSABLE FILL

HOR SCALE 1:2500

VERT SCALE 1:250



CLIENT NAME:
SURREY CITY DEVELOPMENT
CORPORATION

PROJECT LOCATION:
SURREY, BC

CROSS SECTION D-D
19525 20th AVE / 19468 24th AVE / 19500 26th AVE & 2990 194th ST

DWN BY: EB
CHK'D: MP

DWG NAME: 1286-5
PLOT:

DATE: 2016-12-21
CADFILE: 1286

FIGURE 5