REPORT N^{O} 161-08447-00

UPLANDS COMBINED SEWER SEPARATION PROJECT, OAK BAY, BC

GEOTECHNICAL INVESTIGATION REPORT

AUGUST 2016

WSP

UPLANDS COMBINED SEWER SEPARATION ROJECT, OAK BAY, BC

GEOTECHNICAL INVESTIGATION REPORT

District of Oak Bay

Version 02 – Final

Project no: 161-08447-00
Date: August 15, 2016

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APPENDICES

1 INTRODUCTION

WSP Canada Inc. (WSP) was retained by the District of Oak Bay (District) to carry out a geotechnical investigation and provide an assessment and recommendations to aid in the design and construction of a separated sewer system in the Uplands neighbourhood of Oak Bay, BC. The primary objectives of our subsurface investigation included detecting shallow bedrock within the depth of the proposed sewer alignment (typically < 5 m depth), assessing existing soil deposits for reuse as trench backfill, and measuring groundwater levels. Accordingly, we have completed our geotechnical investigation and the information gathered has aided in the development of our comments and recommendations included in this report. Our work was carried out in accordance with the scope of work in our accepted proposal dated April 22, 2016 as well as the signed contract dated June 28, 2016.

2 PROJECT DESCRIPTION

We understand that the District intends to separate the existing combined sewer system into separate storm and sanitary sewers along the alignments shown in the Humber and Rutland Catchment design drawings, Figures 2A and 2B, prepared by McElhanney Consulting Services Ltd. and included in the RFP documents. In order to optimize the system configuration and design, the District requires subsurface information regarding the bedrock profile, suitability of existing soils for reuse as trench backfill, groundwater conditions as well as excavation and backfill recommendations and other relevant geotechnical conditions and comments which may impact the design and construction of the proposed sewer system. The subsurface information and recommendations contained herein will also aid bidding contractors in providing accurate prices to the District.

The reader should understand that in preparing this report, we have assumed the proposed sewer depths shown on McElhanney Consulting Services Ltd.'s Plan & Profile drawings for Option 1.

3 SCOPE OF WORK

The agreed scope of work comprised of:

- Desktop review of existing subsurface soil and utility information;
- Field Reconnaissance of proposed sewer alignment;
- 2 day geophysical survey of entire proposed sewer alignments with the aim of profiling shallow bedrock;

- 1 day of truck mounted augering to characterize and sample the soil as well as assess the groundwater conditions;
- 1 day of rock probing to profile the bedrock;
- Laboratory soil testing;
- Attend site to measure groundwater levels within standpipes;
- Delivery of geotechnical report for client review.

As a result of encountering some unforeseen impediments during our drilling investigation, a request to complete an additional half day of drilling was approved by the District on June 27, 2016.

The attached Terms of Reference for Geotechnical Reports (Appendix G) forms a part of and should be read in conjunction with this report.

4 GEOTECHNICAL INVESTIGATION

4.1 DESKTOP STUDY

4.1.1 PUBLISHED GEOLOGY MAPPING

Our experience in this particular region of Oak Bay as well as a review of published surficial geology mapping[1] indicates the site to be underlain by a mix of various soil deposits with shallow bedrock in some areas, particularly in the vicinity of Norfolk and Exeter Roads. The western portion of the proposed Rutland Catchment is shown to be generally underlain by either the Victoria Clay sequence or older Pleistocene soil deposits (Vashon glacial till/Quadra sands) with deep bedrock, typically not within 5 m of the surface. Within the eastern half the Victoria Clay deposits are shown with near surface (<5 m) and surficial bedrock in some areas. As for the proposed Humber catchment, either the Victoria Clay sequence or older Pleistocene soil deposits with bedrock typically not within 5 m of the surface are indicated in the northern and western portions. Victoria Clay deposits with near surface (<5 m) and surficial bedrock is displayed within the eastern and southern portions of the catchment.

4.1.2 HISTORICAL DATA

We also completed a review of existing water well logs within the study area, accessed through the Ministry of Environment.

WSP (operating as B.H. Levelton) completed a drilling investigation for the CRD along Beach Drive in 1989 to aid the design and construction of the CRD’s East Coast Interceptor pressurized sewer main. The investigation included thirty two auger holes along Beach Drive from Cattle Point to Ripon Road to

[1] BC Ministry of Energy and Mines (2000) Quaternary Geology of Map of Greater Victoria

determine the soil, groundwater and bedrock conditions; the results of which have been incorporated into our current spatial soil descriptions, groundwater assessment and bedrock profiling.

4.2 FIELD RECONNAISSANCE OBSERVATION

Prior to undertaking our subsurface investigation, we completed a visual survey of the surface conditions along the alignment in order to better plan our drilling locations. Surficial bedrock outcrops, topographical anomalies and adverse drilling conditions such as low tree cover and parking/traffic hotspots were recorded.

4.3 GROUND PENETRATING RADAR SURVEY

The first stage of our subsurface geotechnical investigation, the ground penetrating radar (GPR) survey, was completed on June 7 and 10, 2016 using UtilityScan 270 equipment supplied and operated by Western Utilities of Victoria BC. Approximately 9 km of paved road was surveyed over two days in order to gather preliminary information on potential bedrock locations and depth. The goal of the ground penetrating radar (GPR) survey was to detect areas of suspected shallow bedrock within the proposed sewer alignment thus allowing for focused and targeted rock probing to confirm the survey results. Selected screenshots from the GPR equipment and plan drawings showing the results of the GPR survey are provided in Appendix E and Figures 2A/B.

During the GPR survey, WSP engineering staff observed and recorded regions displaying potential shallow bedrock in order to effectively plan and layout the drilling investigation.

The GPR equipment was then used on June 15, 17 and 21, 2016 to aid the utility locating and drill hole layout.

4.4 SUBSURFACE INVESTIGATION

On June 20, 2016 a total of eleven boreholes were advanced to depths up to 6.7 m below the ground surface to permit visual characterization of the subsurface soil and groundwater conditions while also allowing sample collection for laboratory testing. The boreholes were completed with a truck mounted power auger supplied and operated by Drillwell Enterprises of Duncan BC. While drilling BH16-03 and -08 we encountered concrete immediately below the asphalt road surface which forced us to abandon the boreholes. Subsequent discussions with District staff informed us that the concrete was the old road surface. The District approved an additional 1/2 day of drilling in order to revisit these locations with the rock probe which can penetrate concrete.

On June 22 and 30, 2016 a total of forty one rock probe holes were completed using a Flexiroc top-drive hydraulic drill mounted on a flatbed truck supplied and operated by Western Grater Contracting of Victoria BC. The boreholes and rock probe holes were located relative to site features and are estimated to have a plan accuracy of +/- 3 m; their locations are shown on the attached Rock Probe & Borehole Location Plans Humber and Rutland, Figures 1A/B. The subsurface investigation was supervised full time by WSP engineering staff in order to log the conditions encountered and retrieve soil samples. Photographs of the drilling investigation are provided within Appendix B. A selection of disturbed samples were retrieved during our investigation, with 11 tested for moisture content and gradation analysis and a clay sample tested for Atterberg Limits and moisture content. Details of the soil and groundwater conditions encountered in each auger hole can be found on the attached Borehole Logs within Appendix C. The bedrock depth encountered in the rock probe holes is listed immediately below the rock probe hole label on the Rock Probe & Borehole Location Plans, Figures 1A/B, as well as on the Rock Probe Results Table in Appendix D.

4.5 GROUNDWATER

Soil samples collected by WSP during the augering were tested for water content and three standpipes were installed within BH16-1, -4 and -10 in order to measure the groundwater levels; these are comprised of a PVC pipe with slots to allow groundwater entry, surrounded by filter sand and capped with bentonite. We returned to site to measure groundwater levels within the standpipes on July 8, 2016.

Several rock probe holes displayed wet soil conditions, particularly in the fine grained silt/clay soils; these locations are discussed within Section 5.3.

4.6 LAB TESTING

The following laboratory tests were carried out on select samples at WSP's geotechnical testing lab in Victoria BC.

Gradation Analysis (ASTM C-136 & C-117) – 11 samples

Natural Water Content (ASTM D 4959) – 12 samples

Atterberg Limit Determination (ASTM D 4318) – 1 sample

Results of the water content and Atterberg limit testing are provided on individual borehole logs within Appendix C. Detailed soil lab testing results are provided within Appendix F.

5 SUBSURFACE CONDITIONS

5.1 SOIL TYPES

5.1.1 FILL

Minor thicknesses of granular pavement support (fill) were encountered in most holes advanced through the asphalt. Such was typically comprised of brown pit run sand and gravel with interspersed topsoil in some locations and was generally 100 to 150 mm thick except within TH16-7 where almost 600 mm of sand and gravel fill was observed below the asphalt. It should be recognized that distinguishing the interface between the existing pit run fill and the native sands was difficult due to the disturbance caused by the auger head as it enters the soils and the similar material color and gradations.

5.1.2 SAND

Various gradations of sand were encountered within boreholes BH16-1,-2,-4,-7,-9,-10 and -11, all of which are generally west of Ripon Road. Cuttings observed during the rock probe holes in this region also consisted of sand. Some variation in the gradation and fines content was observed, however, the vast majority of sand we encountered consisted of fine to medium grained grey/brown sand with very little fines content (1% to 7% by mass). Based on drilling observations, we estimate the sands are in a compact to dense state. Observed moisture contents above the water table were between 4 and 8%; the sample taken from below the water table had a moisture content of approximately 13%. Gradation charts for the various grades of sand are included within Appendix F. Some of the sand encountered near the ground surface displays higher fines content, 31% and 25% by mass, visible in Aggregate Gradation Report No's 1 and 3 respectively.

5.1.3 GLACIAL TILL

A layer of hard brown sandy clay/silt with trace gravel was encountered at a depth of 1.5 and 2 m below the ground surface within BH16-1 and -10 respectively. The soil layer was 1.5 and 1.2 m thick within BH16-1 and-10 respectively. We interpret this soil type to be part of the Vashon glacial till formation, a glacially overridden, overconsolidated, basal till deposited during the last glaciation of the region. We expect a relatively thin layer of the Vashon till could be encountered within the sand deposits along segments of the proposed alignment west of Ripon Road. Variable thicknesses of this soil type should also be anticipated below the Victoria Clay Sequence.

5.1.4 CLAY AND SILT

Stiff to hard brown clay and silt was encountered within BH16-5 and -6 and is interpreted to be part of the Victoria Clay Sequence, a fine grained glaciomarine soil deposit originating from the end of the last glaciation of the region, when sea levels were higher than today.

While we did not encounter such during our borehole investigation, in deeper deposits, the brown, drier, harder upper layers of the clay sequence are typically underlain by grey, wetter, soft to firm clays. While the transition depth varies, the clays and silts typically begin to get significantly wetter and softer below 3 to 5 m depth. In areas very near to the ocean or historically overlain by wetlands, this transition can be much less or nonexistent as the upper brown clay and silt has not had the right environmental conditions or sufficient time to desiccate and consolidate (dry out, densify and harden) since deposition. The harder brown clay near the surface is a desiccated and consolidated (dried out, denser and harder) version of the grey clay at depth. We anticipate this soil type will be encountered along the southern length of Ripon Road and much of the proposed alignment east of Ripon Road. Due to much of the proposed sewer being relatively shallow in this area, approximately 2 to 3 m below surface grade, we anticipate a very minor amount of soft to firm grey clay would be encountered in the associated excavations.

5.2 BEDROCK

Surficial bedrock outcrops were observed within the study area, located entirely along or east of Ripon Road, as shown on Figures 1A/B. Such were generally found to be consistent with the general soil and bedrock locations shown within published surficial geology mapping. Boreholes BH16-5 and -6 both were terminated on inferred bedrock and 27 of 41 (66%) of the rock probes terminated within bedrock. Of the 27 probe holes which terminated within bedrock, we expected 23 (85%) of those to encounter bedrock based on the GPR survey results, while 4 (15%) probe holes encountered bedrock where the GPR survey did not indicate any bedrock within 5 m of the ground surface. Observed/encountered bedrock locations and depths are displayed on Figures 1A/B.

Results of the GPR bedrock survey and the rock probing data have been combined to produce Figures 2A/B which provide a probabilistic estimation of the bedrock profile along the proposed sewer alignment. Figures 2A/B display the relative probabilities of encountering bedrock within 5 m of the ground surface. Below is a further explanation of the color system used in the drawings to describe the probabilities of bedrock.

5.2.1 GREEN

No bedrock was detected by GPR, rock probe, or surficial inspection within the green segments on Figures 2A/B, accordingly, we anticipate a low probability of bedrock being encountered within 5 m of the ground surface along these segments.

5.2.2 ORANGE

Within the orange segments on Figures 2A/B the GPR and rock probe results suggest intermittent but erratically spaced bedrock knolls rising up to just below the road surface in some areas. Based on the GPR and rock probe results, we estimate that shallow (within 5 m of ground surface) bedrock knolls exist across 30 to 60% of the orange segments, reaching depths typically between 1 and 4 m below the road surface.

5.2.3 RED

The GPR survey and rock probing within the red segments shown in Figures 2A/B frequently detected bedrock knolls within 5 m of the ground surface. We anticipate the bedrock profile in these areas is globally much closer to the ground surface than within the orange segments and that bedrock will be encountered along much of the proposed trench excavations down to 5 m depth. Based on the GPR and rock probe results, we estimate that bedrock knolls exist across 50 to 80% of the red segments, at depths typically between 1 and 3.5 m below the road surface.

Based on our experience, the subsurface bedrock profile across much of Victoria is typically very erratic and difficult to accurately map, accordingly, caution should be applied when extrapolating between points of known bedrock and assuming depths along alignment segments. As can be seen with surficial bedrock outcrops near the study area such as along the shoreline below Beach Drive or near Uplands/Cattle Point Parks, the bedrock is typically shaped as rounded knolls protruding from the ground surface, from several centimeters wide and high to tens of meters wide and high. Between these rounded protrusions of bedrock often exist bowls and valleys both shallow and deep, which have been filled up with the glacial till, sand and clay during glaciation events.

Based on observations of nearby surficial bedrock outcrops, as well as rock probe cuttings, the bedrock appears to be mostly comprised of volcanic granodiorite with some metamorphic gneiss as well. Both types of bedrock are known locally to be typically hard and sound in composition.

5.3 GROUNDWATER

Our review of existing water well drilling logs within the study area, accessed through the Ministry of Environment, showed relative consistency with the above geologic generalizations and also indicated the static groundwater table is typically quite far below the ground surface (>30 m) in areas west of Ripon Road where deeper sandy soil deposits exist. We understand anecdotally that during the wet months, the groundwater table is elevated to at or near the ground surface in the vicinity of the intersection of Ripon and Norfolk Roads and along Beach Drive between Ripon and Exeter Roads where groundwater seepage has been reported in the past. This may be in part due to the topography and subsurface stratigraphy sloping down towards the ocean thus allowing groundwater to seep out of the sand layers exposed on slopes which may be confined by glacial till and bedrock or at a considerable depth elsewhere.

During our borehole investigation we encountered groundwater within BH16-7 and -11 at a depth of 2.1 and 3 m respectively; this was observed as an abrupt transition from dry/moist sand to wet sand. As shown within the borehole logs in Appendix C, water contents spiked from a baseline of 3 to 8% by mass above the water table up to approximately 13% below the water table.

Wet soil conditions were observed at 3, 1.8 and 3.6 m depth during rock probing at RP16-16, -21, and -26 respectively, as indicated on the Rock Probe Results Table in Appendix D. This was inferred by wet probe steel during retrieval. Rock probing elsewhere revealed dry to moist cuttings and/or no water marks on drill steel. We expect these results indicate localized areas where the groundwater is elevated or perched, possibly due to subsurface variations in the bedrock and/or glacial till topography which are collecting and possibly channeling groundwater below the surface.

Of the three standpipes installed as part of our investigation, only one recorded standing water as of July 8, 2016. The stand pipe located within BH16-10 was recorded to have a water level at a depth of 5.95 m below surface level.

6 DISCUSSION & RECOMMENDATIONS

6.1 TEMPORARY EXCAVATIONS

All temporary unsupported excavations should be conducted in accordance with the Workers Compensation Board WorkSafe BC regulations.

We recommend that the proposed sewer replacement work be carried out during the drier summer months in order to minimize negative impacts of rainwater/groundwater on the excavation stability, subgrade disturbance, finer grained material compaction efforts and sediment control etc.

Below is presented preliminary guidance for temporary excavations derived from our local experience and observations during our subsurface investigation. We expect excavations within the undisturbed native soils will remain safe and stable for worker entry if sloped in accordance with the below guidelines, however, under WorkSafe BC guidelines, a site specific excavation assessment by a qualified Geotechnical Engineer is required.

Soil Type	Sidewall Slopes	Comments
Compact to Dense brown/grey sand	1 Horizontal: 2 Vertical	[1]
Stiff to Hard clay/silt/silty glacial till	1 Horizontal: 4 Vertical	[2]Can slope vertical down to 2.5 m
Soft to Firm clay/silt	1 Horizontal: 2 Vertical	[1]
Sound bedrock	Vertical	Depending on post blast fracturing, shoring cage may be required

Notes:

[1] Subject to change if groundwater encountered.

[2] If excavating deeper than 2.5 m unsupported, full depth must be sloped at minimum 1 Horizontal: 4 Vertical.

In areas where there is adequate space to permit safe unsupported soil slopes, a combination of benching, sloping and shoring **may** be utilized to reach design depths.

A shoring cage will be required for excavations sloped steeper than the above unless directed otherwise by a qualified Geotechnical Engineer.

Given the sewer replacement will primarily take place below paved roads, we anticipate a requirement to maintain a minimal excavation footprint. For vertical excavations extending deeper than a single shoring cage, we have worked with local contractors who stacked two cages on top of each other with a stabilizing flange installed to prevent the cages from shifting out of place. We expect this method of excavation could be effective given the observed soil conditions and proposed depths of excavation.

We believe there is a high probability of encountering the groundwater table within excavations in sand in several locations discussed within Section 5.3 above, which could produce a condition known as running sands. In the case running sands are encountered, we recommend that a localized dewatering program be completed prior to excavation. Excavating to the design depths within a running sands condition would likely be challenging. Closely installed steel sheet piling can often be used to excavate vertically within these conditions but is very costly and may be impractical given the running sand condition would also be occurring within the base of the trench. In our experience, a well point dewatering program is typically the most practical and economical way to excavate below the water table in sand. Once completed, standard excavation and shoring techniques used above the water table may be used such as sloping, benching and shoring cages or combinations of such.

We recommend that the contractors submit their proposed excavation and shoring methodologies for the various soil and groundwater conditions to the District for review and acceptance.

Based on our site observations and experience, we anticipate that bedrock removal during trench excavations will likely require drilling and blasting.

For all excavations, we recommend scaling rock faces, coarser materials and fragments of detached asphalt from the excavation faces prior to worker entry.

Soil stockpiles, construction vehicles and construction material stockpiles should be set back from the crest of trench excavations a minimum horizontal distance equal to the depth to the base of the excavation. This should be reviewed and verified by a qualified Geotechnical Engineer at the time of excavation.

Surface water should be directed away from excavations.

We recommend that the contractor submit an erosion and sediment control plan for review by the District.

The above comments and recommendations pertaining to temporary excavations must be confirmed on site at the time of excavation by a qualified Geotechnical Engineer.

6.2 TRENCH SUBGRADE

Given the native soil types encountered during our borehole investigation, we expect suitable trench subgrade soils will be encountered throughout the vast majority of the proposed sewer alignments, however, there exists a moderate probability of encountering soft clay and saturated (running) sands in several short alignment segments as discussed in Section 5.1 above. It may not be possible to adequately compact conventional sand bedding material overtop of saturated sands and soft clays. In these areas we recommend the use of a heavy weight non-woven geotextile and 10 mm rounded pea gravel rather than typical bedding sand. The geotextile would be placed along the subgrade to provide separation and reinforcement and would extend up the trench walls to be folded overtop of the pea gravel cover material to then provide separation between the pea gravel and trench backfill. The 10 mm rounded pea gravel does not require compaction which makes it effective for applications in low strength/high sensitivity subgrade situations. As always, care will be required by the contractor in order to minimize disturbance to the subgrade soils such as avoiding the use of a toothed bucket when excavating at subgrade elevation and avoiding the combination of standing water and workers on the subgrade.

6.3 REUSE OF EXISTING SOILS AS TRENCH BACKFILL

Much of the soils encountered during our borehole investigation along the northern half of Ripon Road as well as west of Ripon Road consisted of various grades of sand with very little fines content (particles passing the 0.075 mm sieve). This is confirmed in the borehole logs and soil gradation testing on samples retrieved during the drilling. We consider the native sands with very little fines content suitable for reuse as trench backfill above the pipe bedding and cover zone, and below the asphalt support structure, however, compliance with the Districts requirements should be confirmed. In our experience, coarse material with less than 15% fines content by mass (material passing the 0.075 mm sieve) and no particles greater than 100 mm in size are acceptable for trench backfill. While much of the sand encountered had a small amount of inherent moisture content, sand can dry out relatively quickly once removed from the ground and exposed to open air, therefore, moisture conditioning may be required prior to compaction of the sand backfill in order to enhance compaction efforts. It should also be recognized that silty backfill soils can be very sensitive to moisture and their use can be challenging during the wet months.

Existing granular fills below the roads were mainly comprised of brown pit run sand and gravel, however, we observed intermixed organic soils within the sand and gravel in some areas. Accordingly, we expect some of the granular fill will be suitable for reuse as general trench backfill as long as it's free of organic soils.

The silt, clay and fine grained glacial till soils encountered are not considered suitable for reuse as trench backfill material below roads due to the effort and cost associated with properly moisture conditioning and compacting the fine grained soils, however, it may be practical to use within boulevard and park areas where surficial foundation support and long term soil settlement are of low importance.

Shotrock from blasted bedrock areas within trenches is typically considered unsuitable for reuse as trench backfill as it is usually broken into large blocks/fragments with relatively low energy blasts, as opposed to high energy blasts in land development which pulverize the bedrock into a well graded shotrock.

All trench backfill materials should be clean of organics and placed in suitably thin lifts for the compaction equipment used and compacted to at least 95% of their Modified Proctor Dry Density (MPMDD), as confirmed by field density testing.

6.4 PIPE BEDDING

Pipe bedding and cover material placed up to an elevation of 0.2 m above the pipe crown should conform to municipal specifications unless directed otherwise by a qualified professional engineer. It may be possible to reuse some of the native sands encountered during our borehole investigation for pipe bedding and cover. Typically, bedding sand must all pass the 9.5 mm sieve and have less than 8% fines content (material passing the 0.075 mm sieve). After review of our gradation testing results, it is clear that much of the native sand we encountered would meet this specification. While it is our opinion that native sand meeting this criteria is suitable for reuse as bedding sand, the specifications for bedding sand should be confirmed by the civil engineer. It will also be important to properly match the gradations of the pipe bedding and cover materials with the trench subgrade and backfill to prevent fines migration and piping within the trench.

All pipe bedding and cover materials should be placed in suitably thin lifts for the compaction equipment used and compacted to at least 95% of their MPMDD, as confirmed by field density testing.

6.5 PAVEMENT REINSTATEMENT

During sewer installation and trench backfill, where subgrade fill is required to reinstate the desired road subgrade elevation, the native sand would likely be suitable for use as road subgrade fill. The material should be placed in suitably thin lifts for the compaction equipment used and compacted to at least 95% of the material's MPMDD, as confirmed by field density testing.

We recommend that the asphalt base and subbase materials conform to the Districts specifications or, if the District does not have their own specifications, those contained in the Master Municipal Construction Documents (MMCD) Volume II. The subbase and base materials should be compacted to at least 95% of their MPMDD, as confirmed by field density testing. Prior to paving, we recommend that the prepared base surface be proof-rolled with a fully loaded dump truck. Areas that exhibit excessive deflection or rutting should be sub-excavated to remove suspect material and reinstated accordingly.

7 FUTURE GEOTECHNICAL INPUT

We recommend provisions for the following geotechnical services be included in detailed design, tender and construction phases:

- Geotechnical consultation with the District and civil team throughout detailed design, tender and construction;
- Trench subgrade review;
- Review of unsupported temporary excavations and/or trenchless designs (ie. pipe bursting);
- Bedrock blast monitoring/specification development;
- Review and testing of fill material gradation, placement and compaction;
- Proof roll observation;
- Asphalt testing.

We would be pleased to provide additional input and cost estimates for any of the above or below services upon request.

We also offer the following services which are often required for projects such as this:

- Environmental Services if contaminated soil or groundwater are uncovered during construction excavations;
- We are currently working with several local municipalities to provide a broad, high level assessment of seismic resilience of municipal infrastructure and we would be happy to provide further details on such if the District is interested.

8 CLOSURE

This geotechnical report has been prepared by WSP Canada Inc. exclusively for the District of Oak Bay and their appointed agents.

Any use of this report by third parties, or any reliance on or decisions made based on it, are the responsibility of such third parties. WSP does not accept responsibility for damages suffered, if any, by a third party as a result of their use of this report.

The borehole and rock probe logs attached to this report provide description of the soil and groundwater conditions encountered at discrete locations. In addition, the GPR survey data we have incorporated into our assessment is subject to operator interpretation. While we have used our professional experience to conservatively extrapolate the results of our subsurface investigation, some level of error or inaccuracy will always inherently exist due to the horizontal and vertical variability of the soil and bedrock profiles. The GPR survey results were used to enhance the linear interpolation of subsurface bedrock conditions confirmed by rock probe; however, the GPR equipment has its own inherent uncertainty.

Contractors should make their own interpretation of the borehole and rock probe logs as well as the bedrock probability maps for the purposes of bidding and performing work at the site.

We trust the information enclosed within this report and appendices meets your requirements, if you have any questions or require further information, please don't hesitate to contact the undersigned.

Yours truly,
WSP Canada Inc.

R. D. SCOTT
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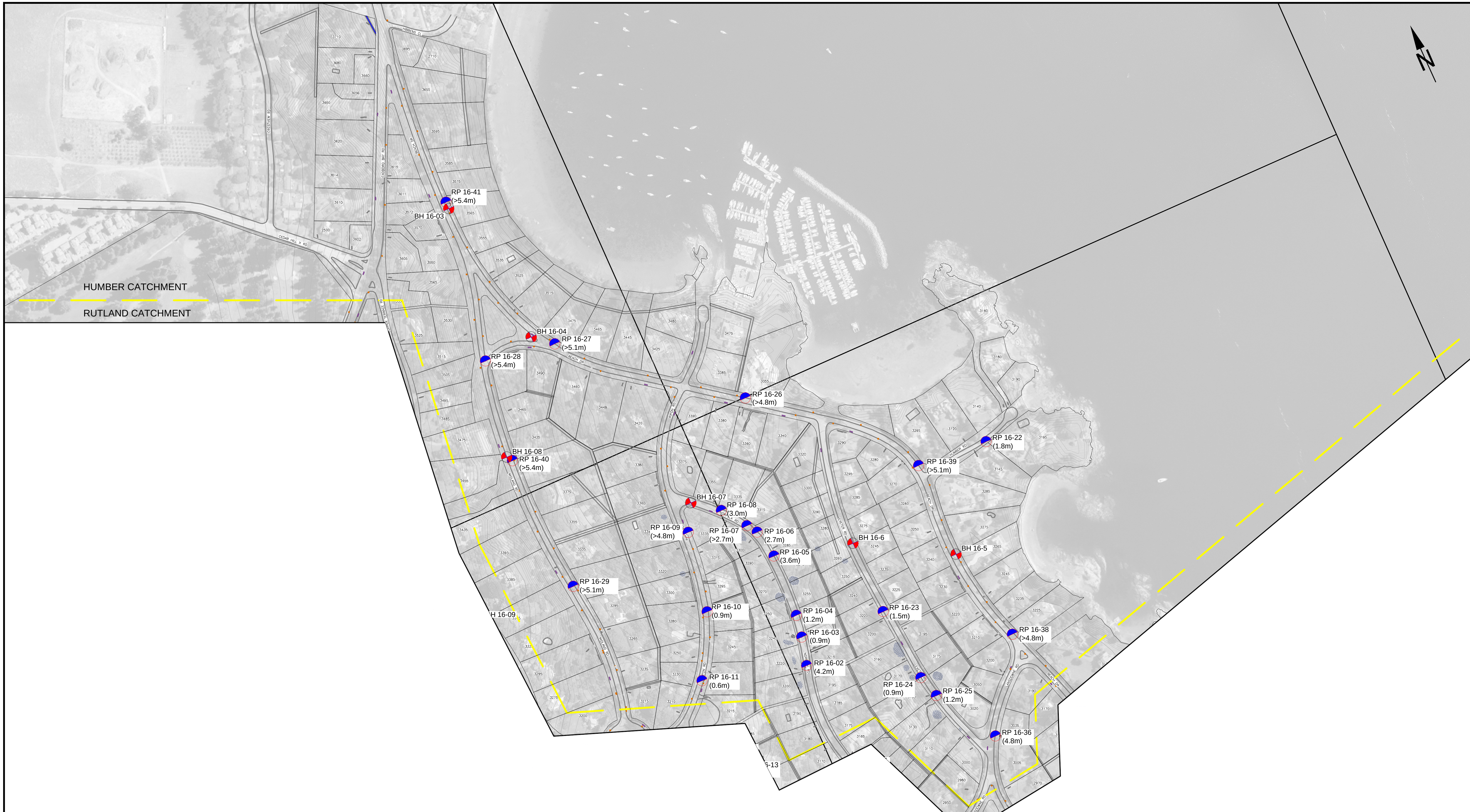
BRITISH COLUMBIA
ENGINEER
15 Aug 2016.

Per: Patrick Sails, P.Eng.
Geotechnical Project Engineer

Russell Scott, M.Sc., P.Eng.
Senior Geotechnical Project Manager

Appendix A

FIGURES



LEGEND:

WSP BOREHOLE LOCATION (JUNE 2016)

WSP ROCKPROBE LOCATION
(METERS TO BEDROCK)

BEDROCK OBSERVED AT SURFACE

Base Plan: McElhanney Consulting Services Ltd. - Uplands Combined Sewer Separation Option 2, Project Number 15-326, Dated: October 2015

REV.:	DESCRIPTION:	DATE : (M/D/YR)
1	FINAL	AUG/15/2016
0	ISSUED FOR CLIENT REVIEW	JUL/22/2016

PROJECT: Uplands Combined Sewer Separation Project

CLIENT: The District of Oak Bay

TITLE: Rockprobe and Borehole Location Plan - Humber Catchment

DATE: AUG 2016
DESIGN BY: PS
DRAWN BY: DP
CHECKED BY: CM
SCALE: 1:5000
PROJECT No.: 161-08447-00
FIGURE No.: 1A

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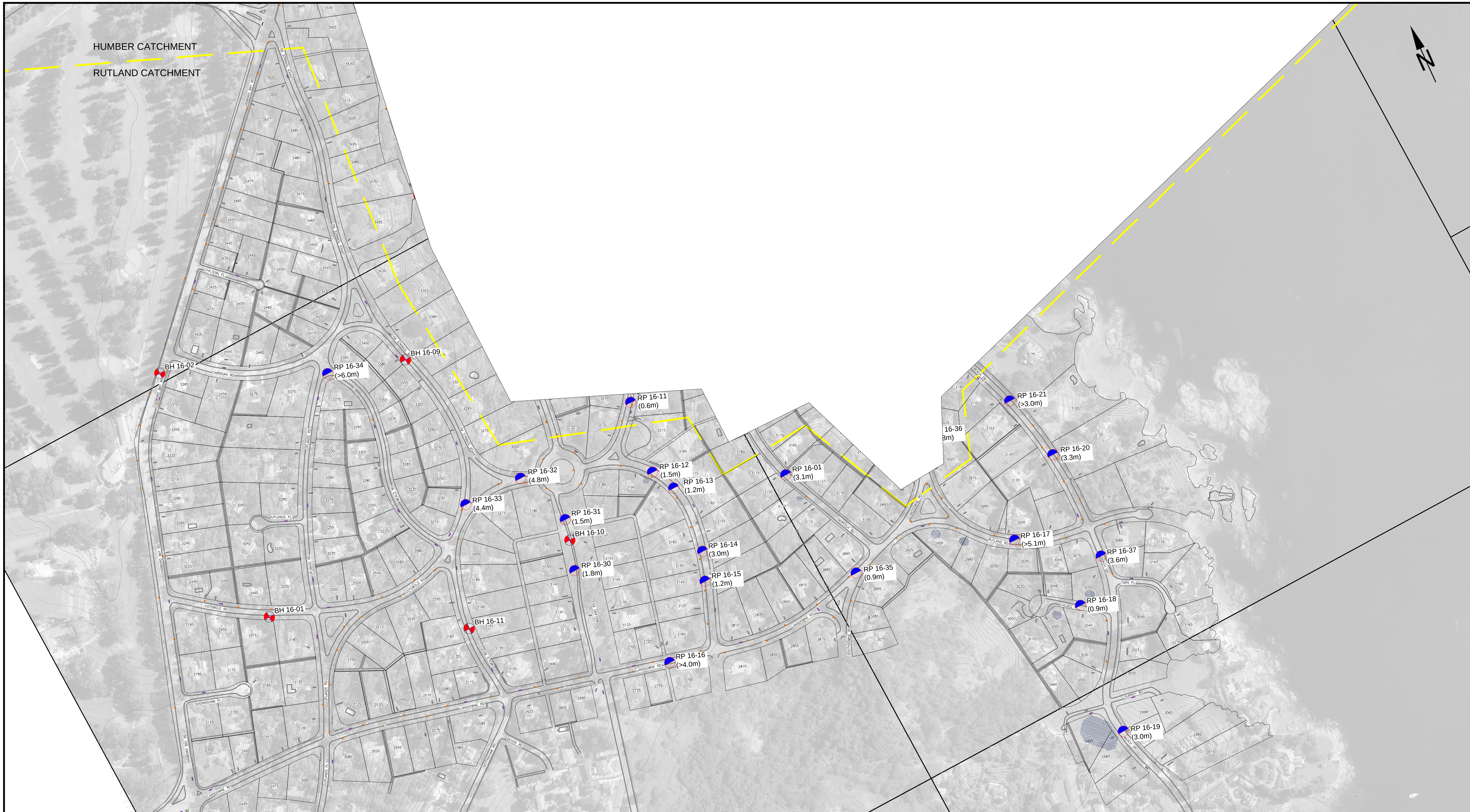

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(METERS TO BEDROCK)

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REV.:	DESCRIPTION:	DATE: (M/D/YR)
1	FINAL	AUG/15/2016
0	ISSUED FOR CLIENT REVIEW	JUL/22/2016

PROJECT: Uplands Combined Sewer Separation Project

CLIENT: The District of Oak Bay

TITLE: Rockprobe and Borehole Location Plan - Rutland Catchment

DATE:	AUG 2016
DESIGN BY:	PS
DRAWN BY:	DP
CHECKED BY:	CM
SCALE:	1:5000
PROJECT No.:	161-08447-00
FIGURE NO.:	1B

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