



THURBER ENGINEERING LTD.

**FOUNDATION DESKTOP STUDY REPORT
PRELIMINARY DESIGN AND ENVIRONMENTAL ASSESSMENT
HIDDEN VALLEY CULVERT REHABILITATION
HIGHWAY 403 AND HIGHWAY 6 INTERCHANGE
HAMILTON, ONTARIO
SITE 10-192/C
WO#16-20004**

GEOCRES NO. 30M5-340

**Latitude: 43.306616°
Longitude: -79.867051°**

Report

to

AECOM

Date: November 9, 2022
File: 25963



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PART 1: FACTUAL INFORMATION

1.0 INTRODUCTION

This report presents the results of a foundation desktop study carried out by Thurber Engineering Ltd. (Thurber) for the preliminary design and environmental assessment of the culvert rehabilitation at Hidden Valley Road and Highway 403 located in Hamilton, Ontario. Although named a culvert, this is in fact a vehicular tunnel carrying Hidden Valley Road under Highway 403.

This Phase 1 study is carried out for planning, structure evaluation and preliminary design purposes only. As part of the Phase 1 scope, a desktop study is to be carried out based on currently available subsurface and foundation information. Where this study determines that the existing foundation information is insufficient to complete the preliminary design, additional foundation investigation and assessment will be recommended for completing Phase 1. It is understood that the budget for this additional investigation is to be drawn from the Phase 2 contingency upon approval by MTO.

Thurber was retained by AECOM to carry out this Phase 1 study under the Ministry of Transportation Ontario (MTO) Assignment Number 2016-E-0027.

This site is a part of the overall Highway 403 and Highway 6 Interchange Improvements project where up to 12 bridges and 2 culverts are planned to be replaced, reconstructed or rehabilitated.

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



The following references and drawings are available for the general vicinity of this site.

- Foundation Investigation Report, Highway Bridge West of Aldershot crossing at Hidden Valley, Report No. S-500-505/55/T-93-1, Geocres No. 30M05-064 prepared by Racey, MacCallum and Associates Limited, dated July 19, 1955. (Reference 1).
- Fill Failure Memorandum, Highway 403 and Hidden Valley Road, Station 231+50 to Station 232+00, District No. 4 (Hamilton), W.J. 68-F-51, W.P. 16-56-1, Geocres No. 30M05-067, dated July 8, 1968. (Reference 2).
- Archive drawings (Hidden Valley Road Bridge FW-14, Roadway Arch - Foundation Plan, Roadway Arch - Cross Section, and Grindstone Creek Bridge FW-13 – Site Plan, Department of Highways Ontario, Bridge Office, Toronto – East of Flamborough Township at Aldershot, TWP# 1337-192-1-A, 2-A & 3-A, dated April and June 1956 (Reference 3).

2.0 SITE AND PROJECT DESCRIPTION

The existing culvert is located at the crossing of Hidden Valley Road and Highway 403, approximately 2.5 km east of the Highway 6 and Highway 403 interchange, in the City of Hamilton, Ontario. This arch structure allows vehicular traffic to cross under the highway.

Highway 403 in the vicinity of the site generally runs in an east to west orientation along relatively flat terrain. Hidden Valley Road runs in a north to south direction and passes through the Highway 403 embankment. CN rail tracks run parallel to Highway 403 at approximately 75 m to the south. Grindstone Creek is located about 50 m east of the Hidden Valley culvert centreline. An arch culvert carries the creek under the highway. The lands surrounding the site are generally residential and commercial.

According to the archive drawings, the existing structure is a one-span concrete arch culvert of approximately 96.8 m in length and 16.3 m in width. The culvert is orientated at an approximate 33° skew to the centreline of Highway 403. The maximum height of the opening inside the arch is approximately 6.9 m. Wingwalls are located at each of the four corners of the structure. The lengths of the wingwalls range between 8.7 m and 9.3 m. The heights of the wingwalls are in the order of 3 m above ground surface. The existing culvert footings were designed to have a width of approximately 2.3 m, and minimum embedment depths into “solid” rock in the order 0.9 m to 1.4 m. Based on a preliminary general arrangement (GA) drawing dated May 2021 and provided by AECOM to Thurber in October 2021, the Hidden Valley Road grade varies from north to south



from approximate Elevations 98.2 to 97.0. The highway embankment is up to the order of 12 m to 13 m in height. The existing arch structure and wingwalls have been designed to be supported on spread footings founded on bedrock.

A previous investigation was conducted in 1968 (Reference 2) to assess a “fill failure” occurring at an embankment location just below highway grade on the north side of the westbound lanes of Highway 403, approximately 35 m to 40 m west of Hidden Valley Road. A V-shaped gully was reportedly formed, and was approximately 1.5 m to 2.1 m in width and 1.5 m to 2.1 m in depth. Photos included in the report are barely legible, but they appear to show that it was surficial slope movement. The report states that the main cause of the failure was lack of effective drainage resulting in surficial erosion. No record is available to confirm subsequent repairs to the fill failure.

No record is available on the year of construction of the arch structure with wingwalls, or if there was any previous rehabilitation completed at this site.

Selected photographs of the site are included in Appendix C.

Preliminary General Arrangement (GA) drawings provided by AECOM indicate that two culvert configuration alternatives are currently being considered as part of the preliminary design for the culvert rehabilitation. One additional travel lane is proposed for each of the Highway 403 EBL and WBL directions. The two rehabilitation alternatives are as follows:

- Alternative 1 – The proposed rehabilitation program shown in GA drawing dated May 2021 provided by AECOM to Thurber in October 2021, shows the following:
 - Construction of four new retaining walls, one at each corner of the existing arch structure. Each of the new retaining walls will be up to about 3 m higher than the existing retaining walls, with the top of wall sloping down and away from the arch. The new walls appear to be in the order of 10 m long. The alignment of the new walls will be closer to the road than the existing ones.
- Alternative 2 – The proposed rehabilitation program indicated in GA drawing dated April 2022 provided by AECOM to Thurber shows the following:
 - Combine the rehabilitation programs for both existing adjacent culverts (Hidden Valley Culvert and Grindstone Creek Culvert) at this location, by installing Retained Soil



Systems (RSS) above both culverts. The retaining walls will be installed at the crest of the slope of the Highway 403 embankment, one near each end (north and south) of the culverts. Both RSS walls will be 36 m in length and about 2 m in retained height. The RSS walls will eliminate the need for retaining walls proposed at the corners of the culvert considered in Alternative 1.

The main purpose of using RSS in Alternative 2 is to reduce environmental impacts and eliminate in-water operation at the nearby Grindstone Creek Culvert.

The project area is situated within the physiographic region known as the Niagara Escarpment, which forms a north-south trending strip, and is a major topographic break in the bedrock between the carbonate Amabel Formation to the west and the soft sediments of the Queenston Formation to the northeast. At many locations, the Queenston Formation consists of up to 1.2 m of very weathered bedrock (red clay) which grades downward into typical brick-red shale and often with green mottling. Thin to medium hard/strong beds of grey-green and reddish argillaceous limestone are present at most locations. The Queenston shale is overlain by Halton Till in the area of the site. The Halton Till is a red clay to clayey silt till and is exposed in the form of a till plain extending from Lake Ontario southward to the Niagara escarpment.

3.0 SITE OBSERVATIONS

A site reconnaissance visit was conducted by a Thurber Senior Geotechnical Engineer on July 14, 2021 to observe conditions related to the foundation performance of the existing arch structure and approaches. The following observations for the Hidden Valley Road culvert have been noted during our site visit.

- There was no visible sign of settlement or distress along the culvert alignment or at the wingwalls.
- The existing approach embankments are fully covered with heavy vegetation including bushes and trees, and appeared to be in good condition. The embankment slopes adjacent to the culvert did not exhibit obvious signs of instability or bulging.
- The exterior surfaces of the wingwalls were typically in fair to good condition, despite the presence of a few minor vertical and horizontal cracks.
- Multiple spots of water seepage were noted on the interior face of the arch.



- There were intermittent transverse and longitudinal cracks on the pavement of Hidden Valley Road along the culvert. The severity of the cracks may be described as slight to moderate.

Selected photographs of the site taken during the site visit are presented in Appendix C.

4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

A foundation investigation was conducted and reported in 1955 (Reference 1) for Hidden Valley Road Culvert and Grindstone Creek Culvert. These sites are located approximately 45 m to 50 m apart. Six boreholes (numbered 1 to 6) were drilled in proximity to the original culvert alignments. The actual locations of these boreholes in relation to the existing culvert cannot be confirmed since a co-ordinate system was not used at the time and there was no available record of the as-built locations of the culvert. It is noted that the proposed works for the Grindstone Creek Culvert are addressed under separate cover.

In general, Boreholes 1 to 6 of the 1955 investigation (Reference 1) were advanced through soils using a 75 mm (3 in.) diameter “extra-heavy duty” pipe driven by a 300 lb. drop hammer to refusal on shale bedrock, and further advanced by rock coring using an AXT diamond bit. Record of Borehole Sheets from the previous investigation are presented in Appendix A.

In general, the subsurface stratigraphy encountered in the boreholes, prior to culvert and Highway 403 embankment construction, consists of typically stiff to very stiff, red to occasionally grey-green silty clay. The thickness of the silty clay varied from 0.76 m to 1.3 m. An N-value of 75 blows was recorded in Borehole 1 using a “standard” 50 mm (2 in.) split spoon sampler. The silty clay is underlain by shale bedrock of the Queenston Formation.

Results of the 1968 investigation for the fill failure (Reference 2), after the culvert construction, indicated that the embankment material consisted of compact to very dense silty sand to sandy silt overlying weathered to sound red shale. Occasional seams of shale or silty clay, up to 300mm in thickness, were encountered within the fill material.

The bedrock encountered below the native silty clay and/or embankment fill, was described as red, slightly calcareous clay shale with green interbeds and horizontal beddings. The rock was also described as soft with fissility along the bedding planes. Typically, the upper 1 m to 2 m of the Queenston shale is completely to highly weathered. Below that depth, the degree of weathering of the shale varies from moderate to fresh. For the purpose of reporting herein, this



upper zone will be referred to as weathered shale and the underlying sound portion will be considered as shale bedrock.

The depths and elevations where shale bedrock was proven are presented in Table 4.1.

Table 4.1 – Depth and Elevation of Top of Bedrock

Approximate location relative to existing culvert ⁽¹⁾	Borehole	Bedrock Depth ⁽²⁾ (m)	Bedrock Elevation ⁽³⁾ (m)	Comments
North side	2 ⁽⁴⁾	0.8	94.7	Shale bedrock proven by coring
	6 ⁽⁵⁾	0.8	93.6	Shale bedrock proven by coring
Middle	1 ⁽⁴⁾	1.3	93.8	Shale bedrock proven by coring
	5 ⁽⁵⁾	0.8	93.4	Shale bedrock proven by coring
South side	3 ⁽⁴⁾	0.8	93.4	Shale bedrock proven by coring
	4 ⁽⁵⁾	0.8	92.9	Shale bedrock proven by coring

⁽¹⁾ The actual locations of these boreholes cannot be confirmed due to incomplete information.

⁽²⁾ All depths were converted from Imperial Units and relative to the ground surface prior to construction of the existing culvert.

⁽³⁾ It is unknown how the elevations are related to the Canadian Geodetic Datum currently in use.

⁽⁴⁾ Boreholes 1, 2 and 3 were drilled along Hidden Valley Road culvert alignment

⁽⁵⁾ Boreholes 4, 5 and 6 were drilled along Grindstone Creek culvert alignment

Rock core recovery values ranged from 42 percent to 100 percent, except for Run 2 in Borehole 1 where the recovery was considered poor at 20 percent.

Groundwater levels measured in the boreholes in Reference 1 are presented in Table 4.2.

Table 4.2 – Groundwater Level Measurements

Approximate location relative to existing culvert ⁽¹⁾	Borehole	Water Level Depth ⁽²⁾ (m)	Water level Elevation ⁽³⁾ (m)
North side	2 ⁽⁴⁾	1.3	94.2
Middle section	1 ⁽⁴⁾	1.1	94.0
South side	3 ⁽⁴⁾	0.9	93.3
	4 ⁽⁵⁾	1.0	92.7

Note: Refer to the notes under Table 4.1 above.



5.0 EXISTING FOUNDATION AND EMBANKMENT

Based on archive design drawings (Reference 3) and foundation recommendations (Reference 1), the existing Hidden Valley Road structure consists of a concrete arch culvert supported on spread footings. Wingwalls are located at each corner of the culvert. The spread (strip) footings of the culvert and wingwalls are founded on shale bedrock. Based on previous Boreholes 1 to 4 drilled in close proximity to the culvert footprint, the bedrock was present at 0.8 m to 1.3 m depths below original ground surface.

GEOCRETS information (Reference 1) indicates that the design of the spread footings was carried out in accordance with the 1953 Edition of the National Building Code of Canada, which at the time, showed an allowable bearing value of 950 KPa (10 tsf) for hard shale and a bearing value of 480 KPa (5 tsf) for soft shale or hard glacial till. The rock properties were considered to lie between hard and soft shale, and a permissible bearing value of 715 KPa (7.5 tsf) was recommended for the spread footings at this site. This value is also presented in Archive Drawings dated 1956 (Reference 3).

The archive drawings indicate that the culvert footings were designed to be placed 0.9 m to 1.4 m into the bedrock, in order to reach “solid” bedrock. The archive drawings show that the top of the culvert footings decreases gradually from the north side of the culvert to the south side from Elevations 94.5 to 93.2. The design width of the culvert footings is approximately 2.7 m.

The culvert footings were designed to be founded on bedrock at founding levels varying from estimated elevations 93.6 to 92.0 from the north end of the culvert to the south end of the culvert.

The wingwall footings were also founded on bedrock with a width of 3.5 m. The founding levels of the wingwall footings were as follows:

<u>Retaining wall location relative to the culvert</u>	<u>Founding level</u>
SE and SW	92.6
NW and NE	93.9

The previous foundation report recommended that in order to increase the resistance against lateral thrust, the base of the footings be excavated 0.6 m to 0.9 m into rock. According to archive drawings, the retaining wall footings were designed to be founded approximately 0.3 m to 0.4 m above the founding level of the culvert footings.



The archive drawings show that the embankment slopes were designed to have an inclination of 2H : 1V.

6.0 ASSESSMENT OF EXISTING FOUNDATIONS

The archive boreholes from Reference 1 were advanced at locations and elevations that cannot be confirmed. Given the uncertainties regarding the archive boreholes and lack of information on the shale and the embankment fill, it is recommended that new boreholes be advanced for each alternative at selected locations presented in Section 12, in order to obtain adequate information for preliminary design of the proposed retaining walls.

A foundation assessment of the existing culvert, based on current information, has been carried out to provide preliminary information to the designers regarding the feasibility of the proposed foundations.

For both rehabilitation alternatives, the designer should establish the additional loading, if any, on the culvert footings. Should the additional foundation loading be less than 10 percent of the existing loading and in accordance with current MTO practice, it is not anticipated that the proposed rehabilitation works for the culvert would have an impact on the existing culvert foundations, provided that the footings are structurally sound.

6.1 Alternative 1 - Retaining Walls at Corners of Existing Culvert

There is insufficient subsurface information for assessing the strength and deformation characteristics of the shale bedrock. There is very limited to no data on unconfined compressive strength, rock quality and fracture index on which the geotechnical resistance may be based. For the purpose of this assessment, the Hoek and Brown rock characterization criteria and typical range of unconfined compressive strengths for Queenston shale have been used. Reference has also been made to geotechnical resistances found in published information and past projects in the general area of the site.

For spread footings founded on undisturbed, weathered, fair quality Queenston shale bedrock, it is assessed that the factored geotechnical resistance would be in the order of 1,000 kPa at Ultimate Limit States (ULS). For sound, slightly weathered to fresh intact shale, it is assessed that the factored geotechnical resistance at ULS could be up to the order of 1,500 kPa or higher depending on fracture patterns and rock strength etc. These values apply to vertical and concentric loads. The SLS condition does not apply to footings founded on unyielding bedrock.



According to the archive drawings, the existing culvert and retaining wall footings were founded on undisturbed solid Queenston shale (below the weathered zone) and designed as per the recommendations in Reference 1 outlined above. The recommended design bearing capacity of 715 kPa from Reference 1 is lower than the assessed values above.

At the time of preparation of this desktop study, the type of retaining walls proposed at each corner is unknown. However, it is anticipated that for any selected option (concrete cantilever, etc.), the new walls will be founded on shale bedrock.

Given that there is no borehole information close to the new wingwall alignments, new boreholes are proposed in Section 12 for preliminary foundation design. It is anticipated that the factored geotechnical resistance at Ultimate Limit States (ULS) available for design would not be less than the 715 kPa reported to have been used in the design of the existing walls.

6.2 Alternative 2 - Retained Soil Systems (RSS) Walls

RSS walls are proposed above the culvert and to be founded on the existing embankment fill, near Elevations 104.5 and 130.8 at the north and south sides of the embankment, respectively. Reference 2 (1968) indicates that the embankment fill on the north embankment consists of compact to very dense silty sand to sandy silt overlying weathered to sound shale. There is no available information on the south embankment.

There is insufficient information of the existing embankment fill and the underlying soil/shale to provide foundation recommendations and geotechnical resistances for RSS walls founded on the existing fill. A borehole program is presented in Section 12 to obtain information for preliminary design of the proposed RSS walls.

RSS walls will require excavations upslope for reinforcing strip installation (up to the order of 0.7 to 1.0 times the wall height) and backfill placement. Temporary protection (shoring) will be required to facilitate construction of this type of wall.

During Phase 2, global stability of the overall embankment slope with an RSS wall and settlement analysis due to additional fill loading should be carried out. The designers should assess the implication and effect of additional loading on the existing culvert.

7.0 EMBANKMENT DESIGN AND CONSTRUCTION

Reference 1 recommended that the design of the approach and side slopes be at an inclination of 2H : 1V. The existing Highway 403 embankment fills are up to about 13 m in height in the



vicinities of the culvert inlet and outlet. According to the available preliminary GA drawing, these embankment slopes are at an inclination 2H : 1V. Our site observations also indicate that the existing approach fills are in stable condition.

Preliminary GA drawings for both alternatives indicate the proposed addition of one travel lane on each of the EBL and WBL. The preliminary GA drawing for Alternative 1 does not appear to illustrate any change to the embankment configuration. Alternative 2 will require embankment widening and grade raise in the order of 0.5 m at the EBL. It is anticipated that some regrading within the lower portion of the highway embankment slopes will be required to accommodate the new wingwalls and probable decommissioning of the existing walls.

The new slopes should be designed to match the existing slope configuration with an inclination of 2H : 1V or flatter. Where applicable, benching of the existing earth slope surface should be carried out as per OPSD 208.010 in order to enhance the keying in of the new fill.

Should more extensive slope reconstruction be required, earth fill embankments higher than 8 m should be incorporated with mid-height berms at each 8 m vertical interval. The berms should:

- extend for the length over which the embankment height exceeds 8 m
- be at least 2 m wide
- have 2 percent positive grade to shed run-off water

The subgrade for new fill (if required) is expected to be existing fill, native silty clay or weathered shale. No global stability issues are anticipated for the slopes at this site provided the approved new fill is placed and compacted in accordance with OPSS.PROV 206 and OPSS.PROV 501, and provided that all surficial vegetation, organics and topsoil, soft/loosened or wet soils and debris are removed from the proposed embankment footprints prior to fill placement.

It is recommended that all exposed slope surfaces be vegetated and seeded in accordance with current MTO practice with reference to OPSS.PROV 804.

Drainage measures at the top of the embankment should be designed to minimize surface runoff and precipitation from flowing perpendicularly down the slope. This occurrence could enhance surficial erosion on the embankment face.

For Alternative 1, foundation settlement of the soil subgrade due to the new fill (if required), is expected to take place as the fill is placed and be completed by the end of construction. The magnitude of post construction settlement due to compression of the embankment fill itself



depends on the type of materials to be used, but is not anticipated to exceed 25 mm if the new fill is placed and compacted as outlined above.

For Alternative 2, foundation settlement of the soil subgrade due to the new fill and construction of RSS wall will be analyzed and preliminary estimates provided in Phase 2.

8.0 LATERAL EARTH PRESSURES

Backfill to the culvert wing walls should consist of free-draining granular material conforming to OPSS.PROV 1010 Granular A or B Type II specifications. Compaction should be carried out in accordance with OPSS.PROV 206 and OPSS.PROV 501.

Earth pressures acting on the culvert wingwalls may be assumed to impose a triangular distribution. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC 2019 but are generally given by the expression:

$$p_h = K (\gamma h + q)$$

where

p_h	=	horizontal pressure on the wall at depth h (kPa)
K	=	earth pressure coefficient (see table below)
γ	=	bulk unit weight of retained soil (see table below)
h	=	depth below top of fill where pressure is computed (m)
q	=	value of any surcharge (kPa)

Earth pressure coefficients for backfill are dependent on the material used as backfill. Recommended unfactored values are shown in the following Table 8.1. The at-rest coefficients should be employed for restrained walls. Active pressures should be used for unrestrained walls.

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is generally preferred as it results in lower earth pressures acting on the wall.



Table 8.1 - Earth Pressure Coefficients (K)

Loading Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		Embankment Fill $\phi = 30^\circ, \gamma = 20.0 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H : 1V)	Horizontal Backfill	Sloping Backfill (2H : 1V)
Active (Unrestrained Wall)	0.27	0.40	0.33	0.48
At-rest (Restrained Wall)	0.43	0.62	0.50	0.72
Passive	3.7	-	3.0	-

9.0 EXCAVATION AND GROUNDWATER CONTROL

All excavations must be carried out in accordance with OPSS.PROV 902 and the Occupational Health and Safety Act (OHSA). For the purposes of assessing excavation slope and temporary support requirements in compliance with the OHSA, the embankment fill, native silty clay and weathered shale are classified as Type 3 soils.

For Alternative 1, shale excavation will likely be required at the foundation locations to prepare the founding surface of the retaining walls. Shale excavation should be carried out using methods that will avoid disturbing the bedrock below the founding elevation. It is possible that excavation of the bedrock will become more arduous should the stronger limestone and siltstone layers be encountered. The contractor may have to employ specialized methods such as ripping, and pneumatic breaking to dislodge the stronger layers.

For Alternative 2, the anticipated excavations for construction of the new RSS walls will be carried out within the existing embankment fill and will not extend below the groundwater level.

Given the anticipated shallow excavations and the general layout of the site, it is anticipated that any excavation required to be carried out for construction of the new retaining walls will not extend below the groundwater level. Seepage or perched water from the approach fills as well as surface runoff and precipitation are to be expected. In addition, concentrated seepage may be experienced from seams or fractures in the shale bedrock. All surface runoff should be



diverted away from excavations. This is critical for footings founded on shale, since shale will soften and deteriorate if water is allowed to accumulate on the proposed footing base.

The Contractor should be prepared to pump from properly filtered sumps to remove any seepage water or surface water collecting in an excavation. Unwatering must remain operational and effective until the excavation is backfilled.

The design of any dewatering system that may be required is the responsibility of the Contractor.

Where required, construction will need to be carried out in conjunction with temporary protection.

Dewatering of all excavations should be carried out in accordance with OPSS.PROV 517, SP 517F01 Amendment to OPSS 517, November 2016 (issued July 2017).

10.0 TEMPORARY PROTECTION SYSTEMS

Temporary protection (shoring) systems will likely be required for construction of the new retaining walls in general accordance with OPSS.PROV 539. It is recommended that Performance Level 2 be specified. The use of temporary protection to retain the embankment slope will be required should any excavation cut into the existing embankment fill.

For Alternative 1, due to shallow bedrock, sheetpiles and driven H-piles may not be suitable for use as temporary protection. A soldier pile and lagging wall socketted within bedrock (using pre-drilled holes) should be feasible.

The selection and design of suitable temporary protection systems are the responsibilities of the Contractor. All shoring systems must be designed by a Professional Engineer experienced in such designs.

11.0 ADJACENT STRUCTURES AND BURIED UTILITIES

It is recommended that the exact locations of any existing utilities and drainage pipes that are present in the vicinity of the work areas be established by the designer and compared with the extent of the potential work zones related to the proposed construction.

The utilities and drainage pipes should not be undermined or damaged during construction of the new retaining walls, and probable demolition of the existing walls. Relocation of, and/or special protective measures for, some or all of these affected utilities may be required.



12.0 INVESTIGATION FOR PRELIMINARY DESIGN

References 1 to 3 are available from the GEOCREST library for this site. As discussed previously, the foundation investigation and reporting were carried out in the late 1950's prior to construction of the existing culvert. The locations and elevations of the boreholes cannot be confirmed. It is also known that the site topography had been altered as part of the original construction. Moreover, the archive boreholes do not provide much information on the shale including unconfined compressive strength, rock quality and fracture pattern to facilitate a more detailed assessment of rock geotechnical resistance that is critical for the retaining wall foundation design for Alternative 1. There is also no information on the embankment fill for Alternative 2. Accordingly, it will be necessary to carry out additional site investigation and field testing to support the preparation of foundation design recommendations for preliminary design of the new retaining walls.

In consideration of the currently available design information, a preliminary investigation for preliminary design is proposed as follows:

- One (1) borehole near the proposed south RSS wall.

The borehole will be drilled from Highway 403 EBL grade and will be advanced to practical refusal on shale bedrock, after which the rock will be cored for about 3 m.

Based on the archive information, the existing embankment heights are in the order of 13m to 14 m and the bedrock is approximately 2 m to 3 m below the Hidden Valley Road grade. Therefore, it is anticipated that the borehole drilled from Highway 403 grade will be up to about 18 m deep.

- A similar borehole will be advanced for the Grindstone Creek Culvert. The results of that borehole will also be used for preliminary design assessment.

The locations of the proposed boreholes are schematically shown on plan in Appendix D for illustrative purposes.

13.0 CLOSURE

Engineering analysis and preparation of the preliminary foundation design report were carried out by Ms. R. Palomeque Reyna, P.Eng. The report was reviewed by Dr. Sydney Pang, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



THURBER ENGINEERING LTD.



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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.



Appendix A

Record of Borehole Sheets and Borehole Plan (GEOCRES Previous investigation)

Order No.: 5-500-505/55/T-93 RACEY, MACCALLUM AND ASSOCIATES
LIMITED

M. CHEVRIER
Driller

Hole Begun 10/6/55

Foundation Engineering Division

Hole Ended 10/6/55

Engineering Data Sheet for Borehole: Nº 1

Helper

Job Name: HIDDEN VALLEY BRIDGE

P.E.M.M.

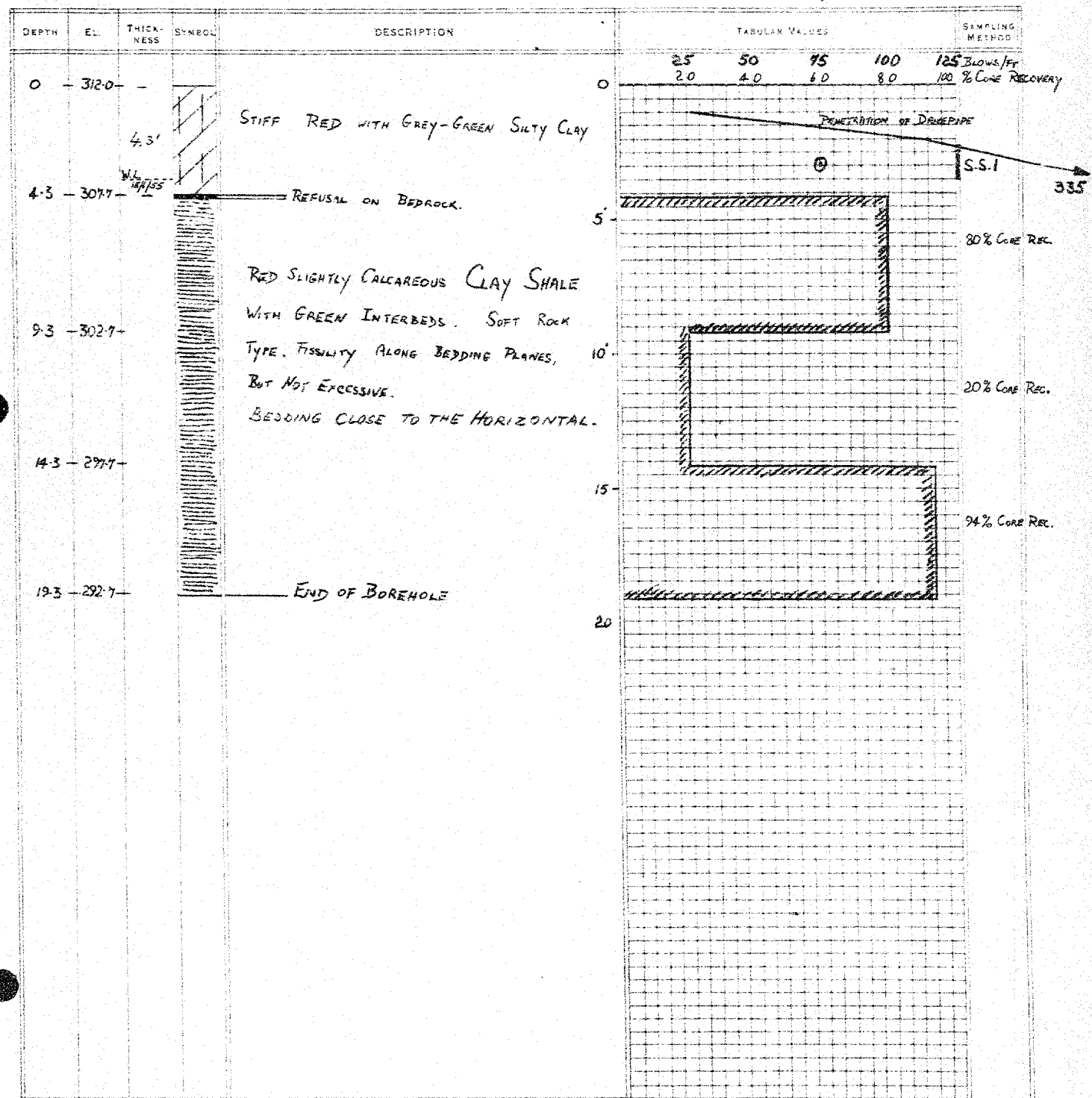
Job Located: _____

Checked by

Hole Located: AS SHOWN ON ATTACHED SKETCH PLAN.

Hole Elevation: 312.0 Datum: _____

11 Day 7 Month 55 Year



Order No.: 5502-505/55/T-93 RACEY, MacCALLUM AND ASSOCIATES
LIMITEDM. CHEVRIER
DrillerHole Begun 11/6/55

Foundation Engineering Division

Hole Ended 11/6/55Engineering Data Sheet for Borehole: N° 2

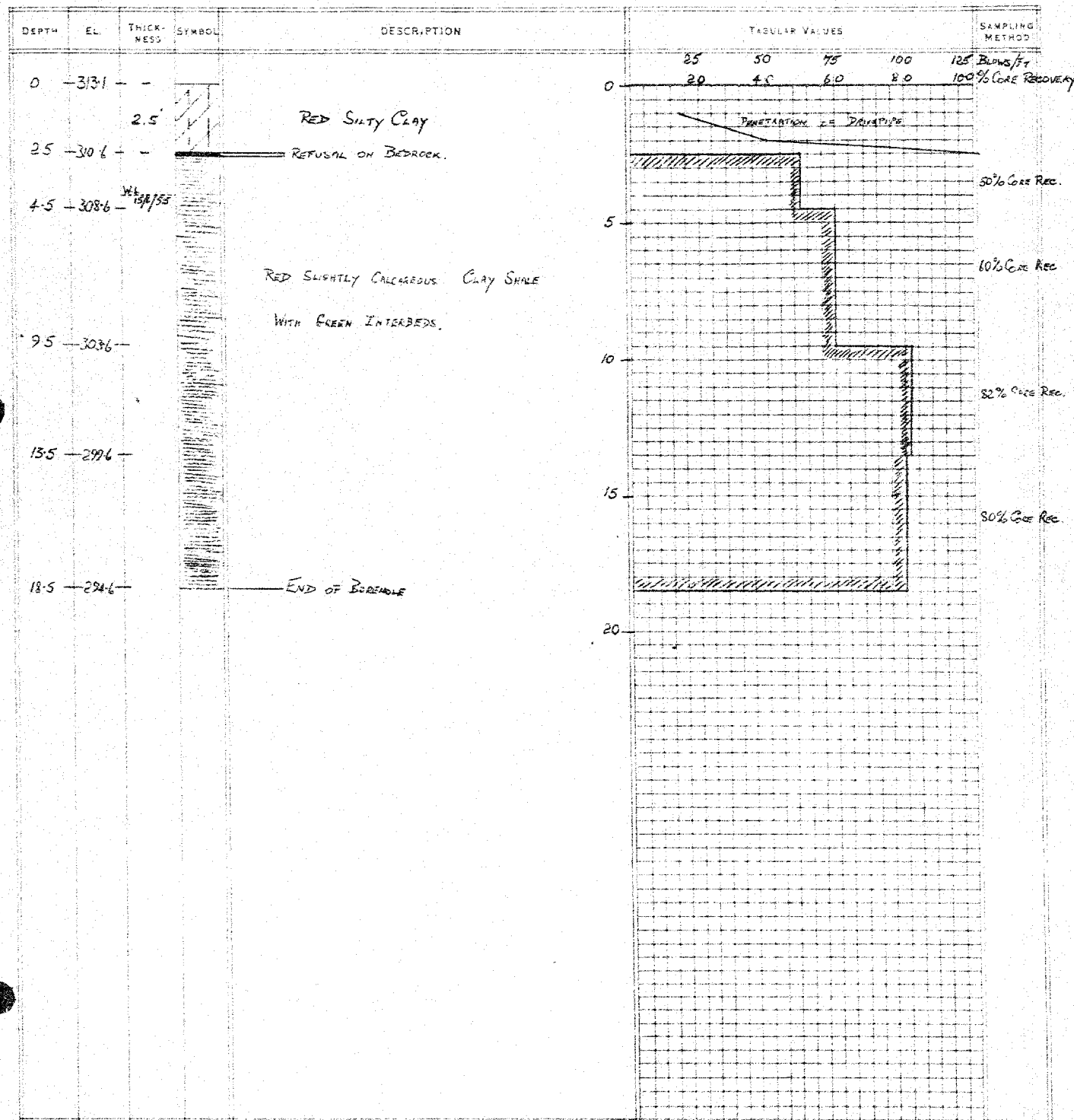
Helper

Job Name:

P.E.M.M.

Job Located:

Checked by

Hole Located: AS SHOWN ON ATTACHED SKETCH PLANHole Elevation: 313.1 Datum:11 7 55
Day Month Year

Order No. 5-500-503/55/T-93 RACEY, MACCALLUM AND ASSOCIATES
LIMITEDM. CHEVRIER
DrillerHole Begun 13/6/55

Foundation Engineering Division

Hole Ended 13/6/55Engineering Data Sheet for Borehole: 1123

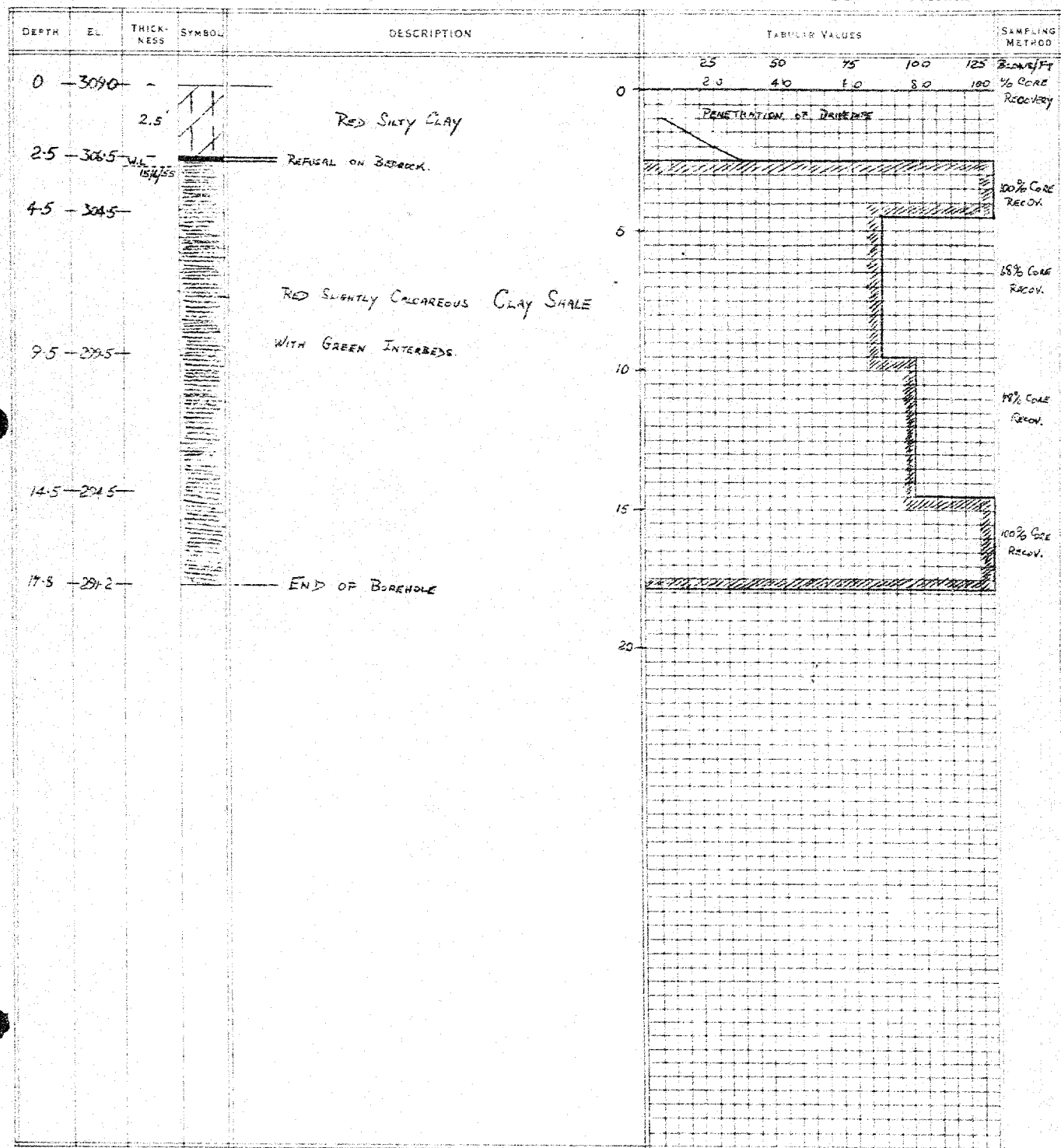
Helper

Job Name:

P.E.M.M.

Job Located:

Checked by

Hole Located: As shown on attached sketch plan.Hole Elevation: 302.0 Datum:11 7 55
Day Month Year

Order No. S-500-505/5/T-93 RACEY, MacCALLUM AND ASSOCIATES
LIMITEDM. CHEVRIER
DrillerHole Begun 13/4/55

Foundation Engineering Division

Hole Ended 14/4/55Engineering Data Sheet for Borehole: N^o 4

Helper

Job Name:

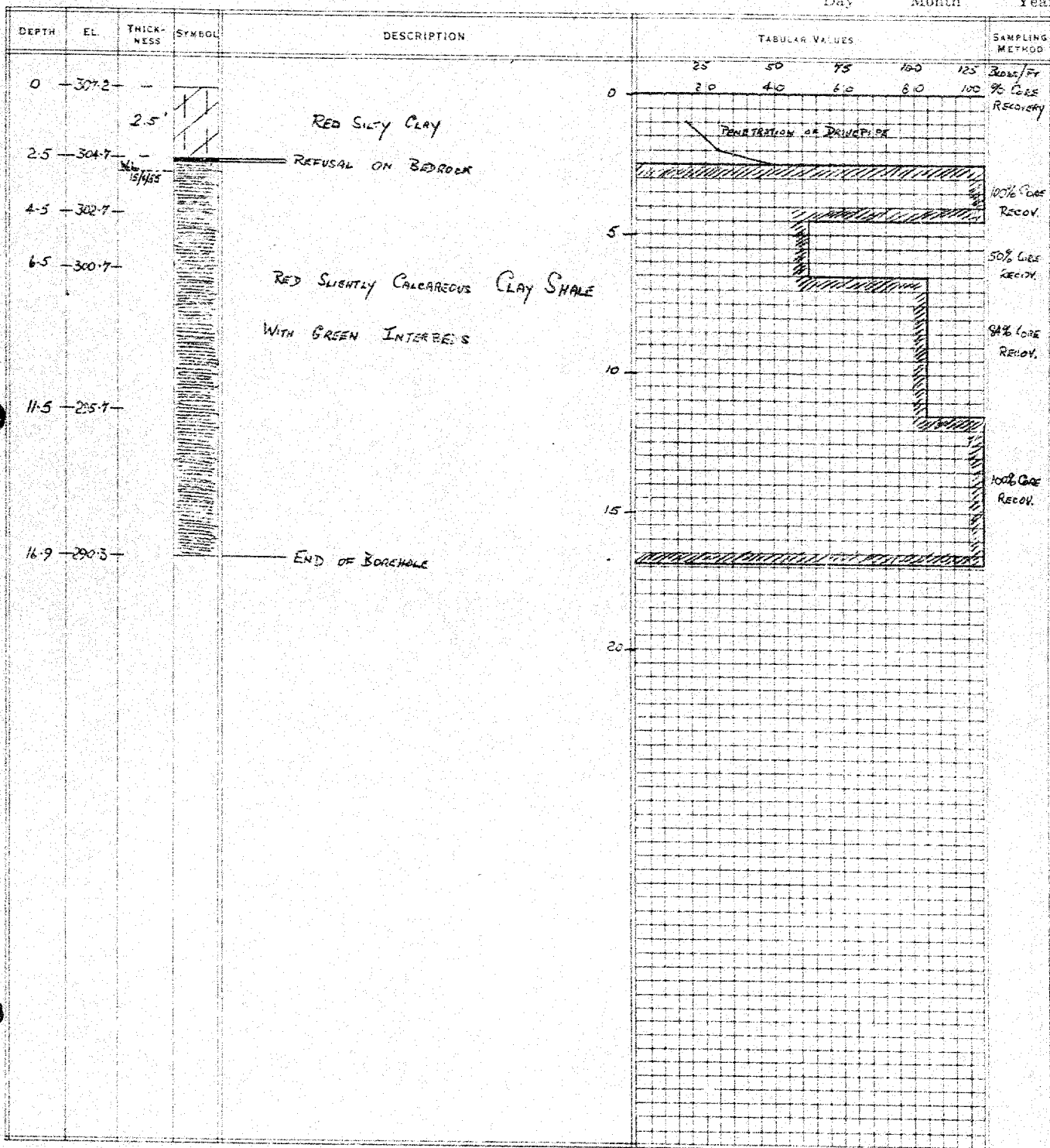
P.E.M.M.

Job Located:

Checked by

Hole Located: As shown on attached sketch planHole Elevation: 307.2 Datum:

11 Day 7 Month 55 Year



Order No. 5-506-SU/55/T-93 RACEY, MACCALLUM AND ASSOCIATES

LIMITED

M. CHEVRIER
DrillerHole Begun 14/1/55

Foundation Engineering Division

Hole Ended 14/1/55Engineering Data Sheet for Borehole: N° 5

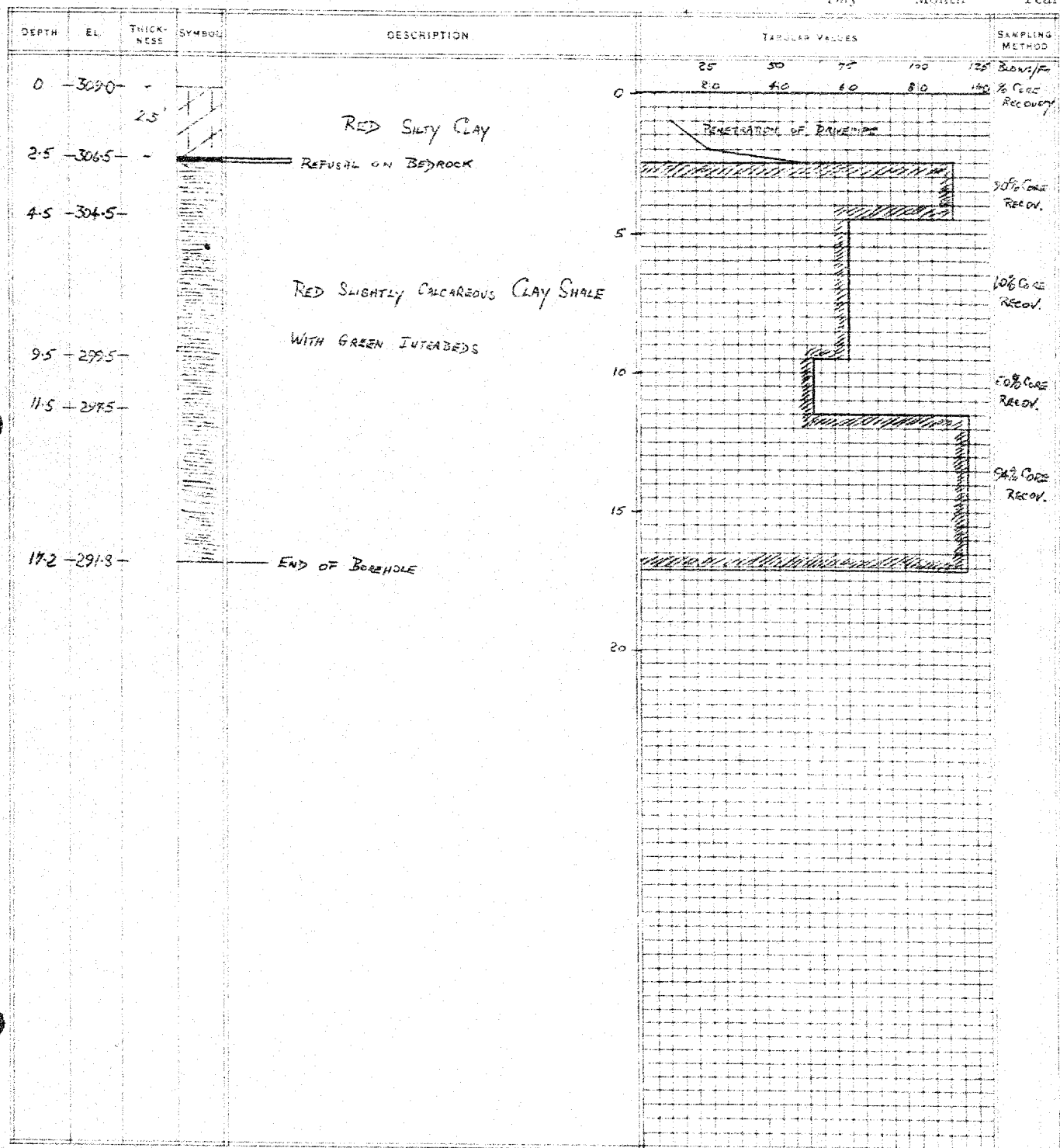
Helper

Job Name:

P.E.M.M.

Job Located:

Checked by

Hole Located: As shown on attached sketch planHole Elevation: 302.0 Datum:12
Day7
Month55
Year

Order No.: S-500-505/55/T-93 RACEY, MACCALLUM AND ASSOCIATES
LIMITEDM. C. NEYRER
DrillerHole Begun 12/4/55

Foundation Engineering Division

Hole Ended 15/4/55Engineering Data Sheet for Borehole: NB 6

Helper

Job Name:

Job Located:

Hole Located: As shown on attached sketch planHole Elevation: 309.5 Datum:

P.E.M.M.

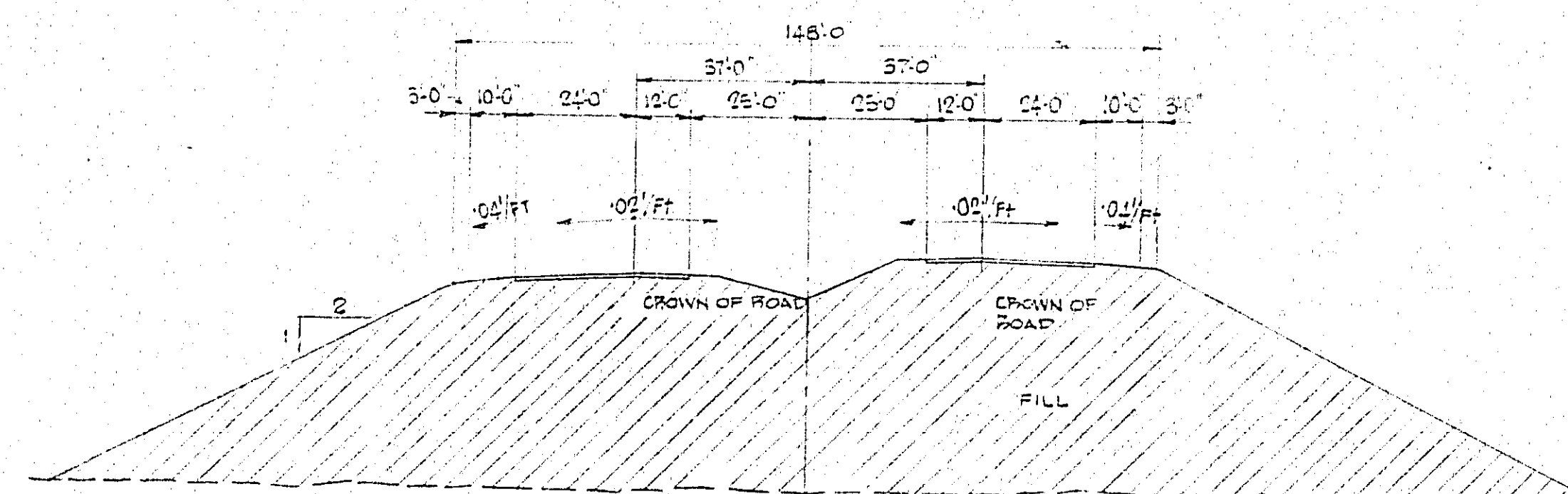
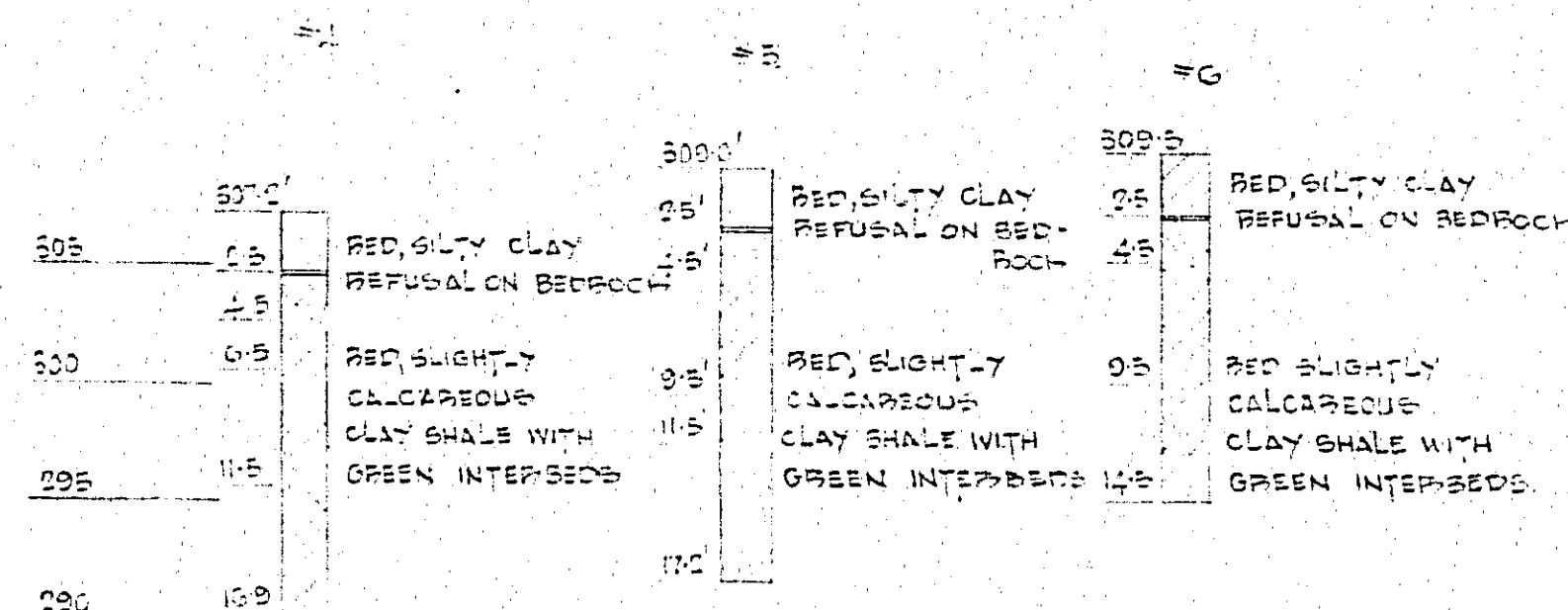
Checked by

12 Day 7 Month 55 Year

DEPTH	EL.	THICK- NESS	SYMBOL	DESCRIPTION	TABULAR VALUES	SAMPLING METHOD
0	309.5	-			25 50 75 100 125 150 175 200	17.5' BRAND/FI 100% CORE RECOVERED
2.5	307.0	2.5		RED Silty Clay	20 40 60 80 100 120 140 160 180 200	
4.5	305.0	-		REFUSAL OF BED ROCK		42% CORE RECOV.
9.5	300.0	-		RED SLIGHTLY CALCAREOUS CLAY SHALE WITH GREEN INTERBEDS		16% CORE RECOV.
14.5	295.0	-		END OF BOREHOLE		40% CORE RECOV.

ENGINEERS ARE: EAGER, MACGILLIVRAY & ASSOCIATES LTD - JUNE 1986
ENGINEERS ARE FOR GENERAL INFORMATION ONLY, AND ARE NOT
GUARANTEED BY THE DEPARTMENT. THE COMPLETE SOIL INVESTIGATION
REPORT NR BA-42 MAY BE SEEN AT THE BRIDGE OFFICE DOWNSVIEW.
THE DEPARTMENT DOES NOT GUARANTEE THE ACCURACY OF THIS
REPORT NOR THE ABRIDGED VERSION SHOWN HERE.
LEVEL OF EXISTING GROUND & PROFILE OF CONTROLLED ACCESS.
HIGHWAY TAKEN FROM D.H.O. PLAN E-2395-1, DATED AUGUST 5, 1980.
MAXIMUM ALLOWABLE SOIL PRESSURE FOR FOOTINGS = 7 1/2 TONS/50 sq. ft.

#1	#2	#3
310	315	3000
305	310	2950
300	305	2900
295	300	2850
290	295	2800
285	290	2750
280	285	2700
275	280	2650
270	275	2600
265	270	2550
260	265	2500
255	260	2450
250	255	2400
245	250	2350
240	245	2300
235	240	2250
230	235	2200
225	230	2150
220	225	2100
215	220	2050
210	215	2000
205	210	1950
200	205	1900
195	200	1850
190	195	1800
185	190	1750
180	185	1700
175	180	1650
170	175	1600
165	170	1550
160	165	1500
155	160	1450
150	155	1400
145	150	1350
140	145	1300
135	140	1250
130	135	1200
125	130	1150
120	125	1100
115	120	1050
110	115	1000
105	110	950
100	105	900
95	100	850
90	95	800
85	90	750
80	85	700
75	80	650
70	75	600
65	70	550
60	65	500
55	60	450
50	55	400
45	50	350
40	45	300
35	40	250
30	35	200
25	30	150
20	25	100
15	20	50
10	15	0
5	10	-50
0	5	-100
-5	0	-150
-10	-5	-200
-15	-10	-250
-20	-15	-300
-25	-20	-350
-30	-25	-400
-35	-30	-450
-40	-35	-500
-45	-40	-550
-50	-45	-600
-55	-50	-650
-60	-55	-700
-65	-60	-750
-70	-65	-800
-75	-70	-850
-80	-75	-900
-85	-80	-950
-90	-85	-1000
-95	-90	-1050
-100	-95	-1100
-105	-100	-1150
-110	-105	-1200
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-220	-215	-2300
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-240	-235	-2500
-245	-240	-2550
-250	-245	-2600
-255	-250	-2650
-260	-255	-2700
-265	-260	-2750
-270	-265	-2800
-275	-270	-2850
-280	-275	-2900
-285	-	



TYPICAL CROSS-SECTION
THROUGH FILL NEAR STRUCTURE
SCALE 30' TO 1"

REINFORCING

D-3636-1 SITE PLAN

D-3636-2 PLAN, SECTION & MISC. DETAILS

D-3636-3 FTG. PLAN, REINFR. & MISC. DETAILS

D-3636-4 PANEL 'A' INTRADOS REINF.

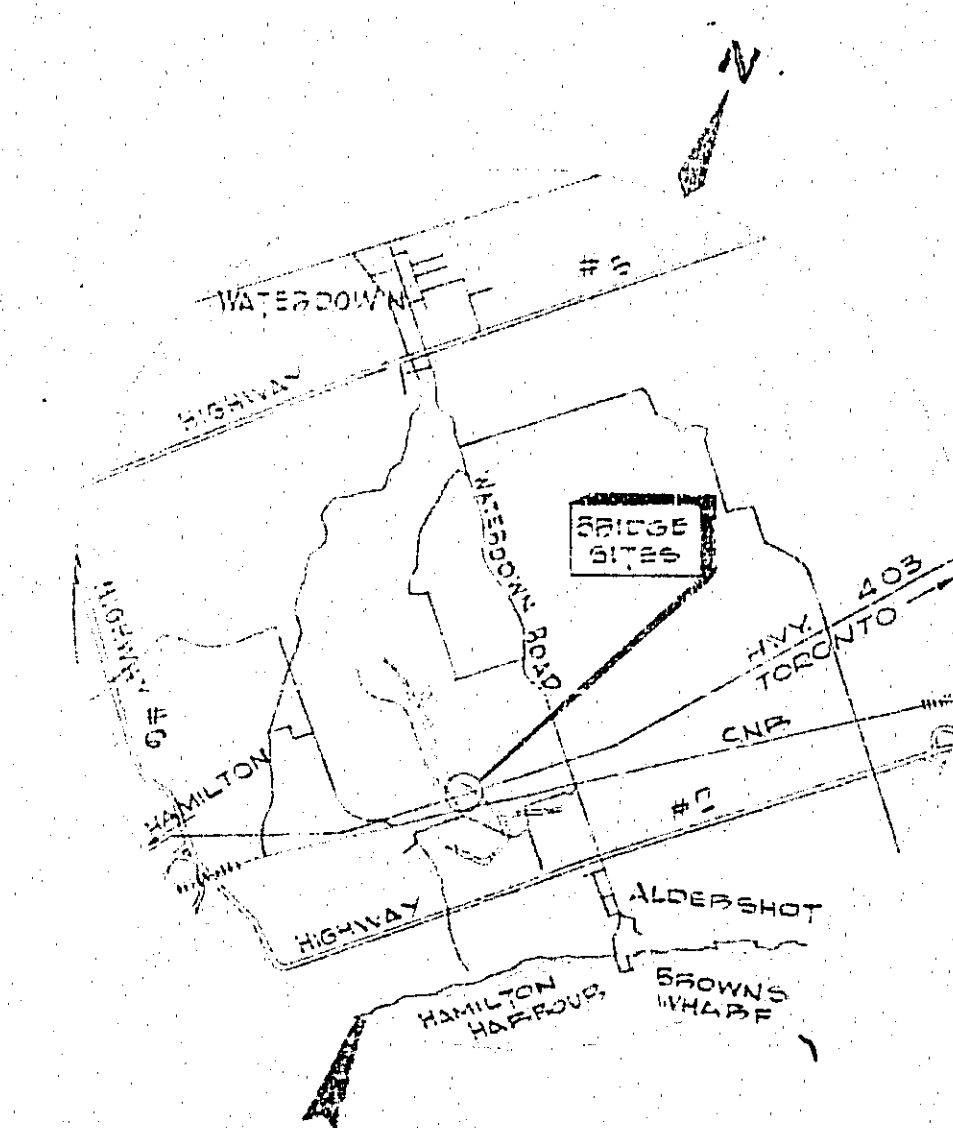
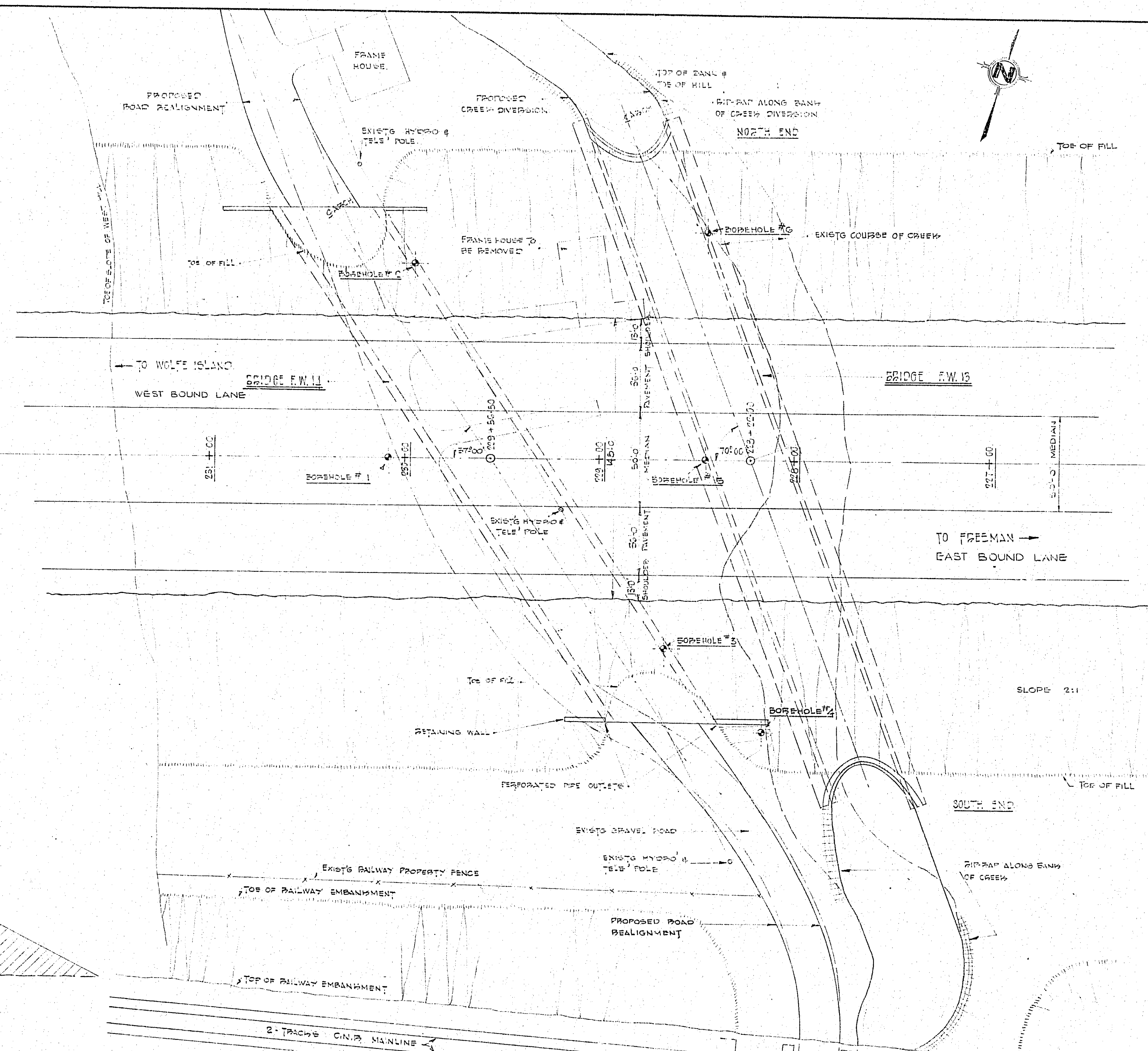
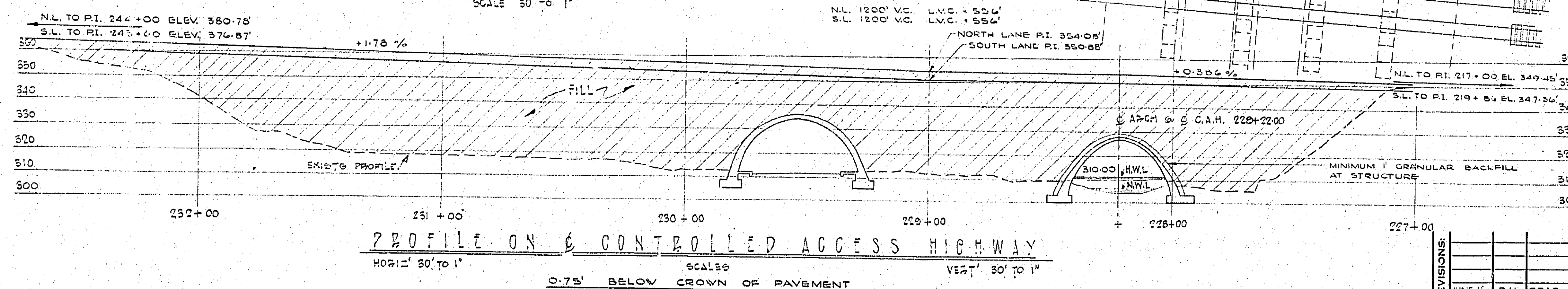
D-3636-5 PANEL 'A' EXTRADOS REINF.-PANEL 'C' EXTRADOS & INTRADOS, REINF.

D-3636-6 REINFORCING STEEL SCHEDULE

D-3636-7 REINFORCING STEEL SCHEDULE.

D-3636-8 REINFORCING STEEL SCHEDULE.

D-3636-9 REINFORCING STEEL SCHEDULE.



KEY PLAN
SCALE: 1 IN. = 1 MI.

NOTE TO DISTRICT ENGINEER - CONCRETE WORK ON THIS STRUCTURE MUST NOT BE COMMENCED UNTIL MONUMENTS TO FIX CONTROL POINTS HAVE BEEN ERECTED & CHECKED BY THE DISTRICT ENGINEER.

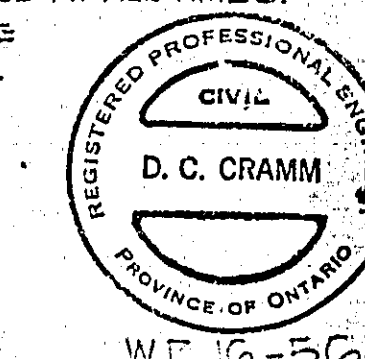
NOTE TO CONTRACTOR - STRUCTURE TO BE BUILT IN ACCORDANCE WITH SPECIFICATIONS FOR STRUCTURES, D.H.O. FORM NO 9, AND THE SPECIAL PROVISIONS, EXTRA COPIES OF WHICH MAY BE OBTAINED FROM THE DISTRICT ENGINEER.

CONCRETE MIX - ALL CONCRETE IN STRUCTURE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF 3000 P.S.I. AT 28 DAYS. APPROVED ADMIXTURE SUPPLIED BY CONTRACTOR AND ADDED TO CONCRETE AS DIRECTED BY ENGINEER.

REINFORCING STEEL - CLEAR COVER IN FOOTINGS - 3" CLEAR COVER IN ALL CONCRETE IN CONTACT WITH EARTH OR ROCK - 3" CLEAR COVER IN ALL REMAINING CONC' IN STRUCTURE - 2" EXCEPT WHERE OTHERWISE NOTED. ALL BAR SPLICES TO BE LAPPED 35 DIAMETERS EXCEPT WHERE OTHERWISE NOTED.

CONSTRUCTION NOTES

1. FOUNDATIONS: FOOTINGS DESIGNED FOR A MAXIMUM ALLOWABLE SOIL PRESSURE OF TONS PER SQ. FT. EXCAVATIONS FOR FOOTINGS TO BE CUT AS NEARLY AS POSSIBLE AND COMPLETELY FILLED WITH CONCRETE.
2. CONSTRUCTION JOINTS SHALL BE MADE ONLY WHERE LOCATED ON THE DRAWINGS UNLESS OTHERWISE APPROVED BY THE ENGINEER. EACH ARCH SECTION MUST BE PLACED CONTINUOUSLY IN ONE POUR.
3. ARCH CHOKING MUST NOT BE STRUCK UNTIL CONCRETE HAS REACHED ITS DESIGN STRENGTH, AND IN ANY CASE NOT LESS THAN 14 DAYS AFTER CONCRETE HAS BEEN PLACED. THE ENGINEER MUST GIVE WRITTEN PERMISSION BEFORE REMOVAL IS BEGUN.
4. FILL OVER ARCH TO BE PLACED EVENLY & SIMULTANEOUSLY ON BOTH SIDES AND FOR THE FULL LENGTH.
5. FILL AGAINST ARCH SHALL BE COMPACTED IN 6" LAYERS.
6. FALSEWORK AT CENTRE OF ARCH TO BE REMOVED FIRST THEN WORKING EACH WAY FROM THE SIDES. THE REMAINING FALSEWORK SHALL BE REMOVED SO THAT THE ARCH SUPPORT IS EQUALLY BALANCED AT ALL TIMES.
7. PROVISION FOR THE DEFLECTION OF FALSEWORK WILL BE MADE BY THE CONTRACTOR IN ADDITION TO THE D.L. DEFLECTION.



SIN	0.939693
COS	0.342020
TAN	2.747477

SIN	0.838071
COS	0.544639
TAN	1.539805

G.C. PARKER AND ASSOCIATES LIMITED
HAMILTON CONSULTING ENGINEERS ONTARIO

DEPARTMENT OF HIGHWAYS:-ONTARIO-
BRIDGE OFFICE:-TORONTO


GRINDSTONE CREEK
EAST FLAMBOROUGH TOWNSHIP.


AT ALDERSHOT
BRIDGE FW-13

BRIDOL FW-13
THE KING'S HIGHWAY No. 403
CO. HALTON
DIST. N

SITE PLAN

APPROVED


 BRIDGE ENGINEER


 DESIGN ENGINEER

DESIGN	V. B. A	CHECK	J. A. B	CONTRACT NUMBERS			41
DRAWING	G. S. N	CHECK	J. A. B				61

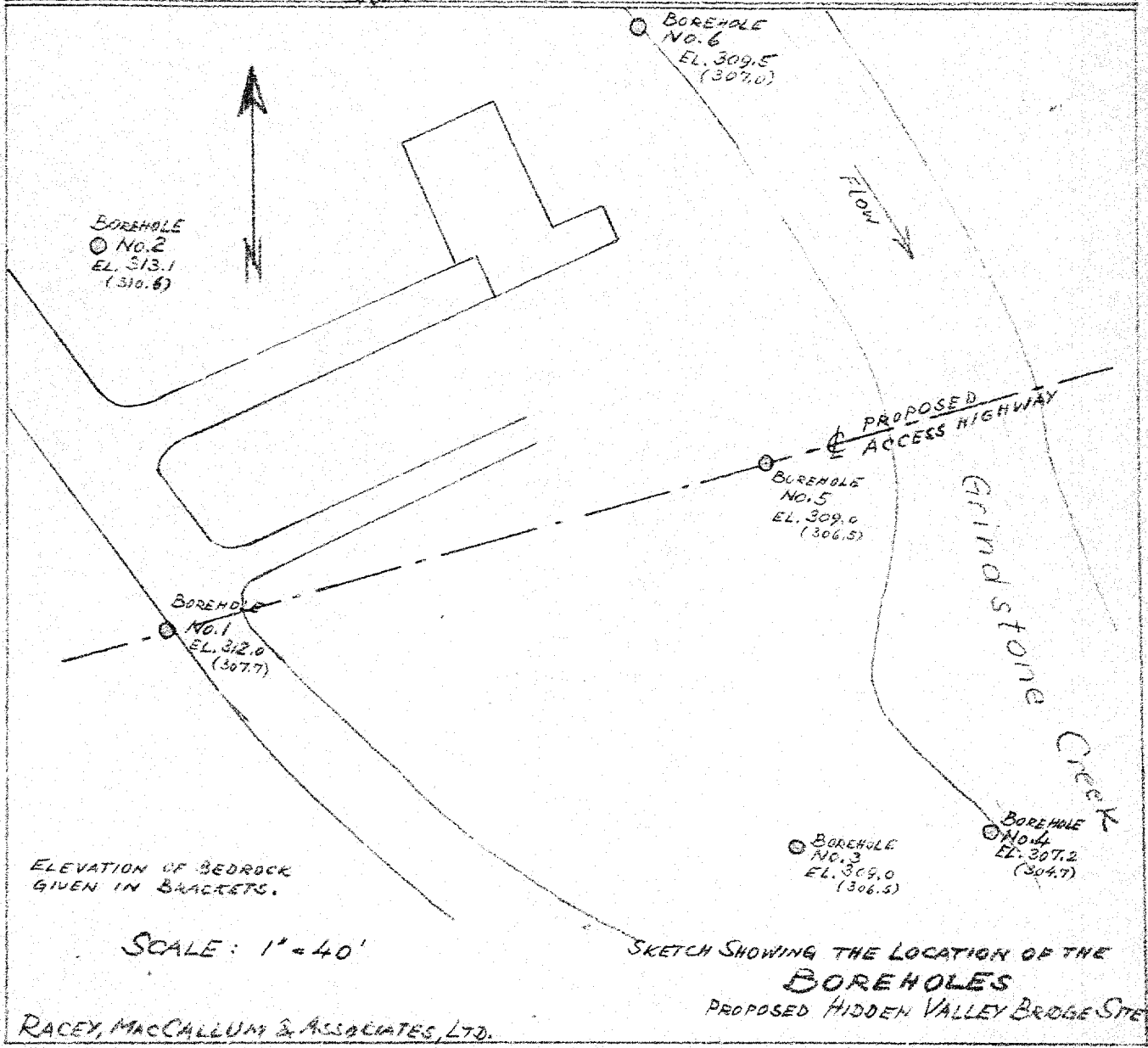
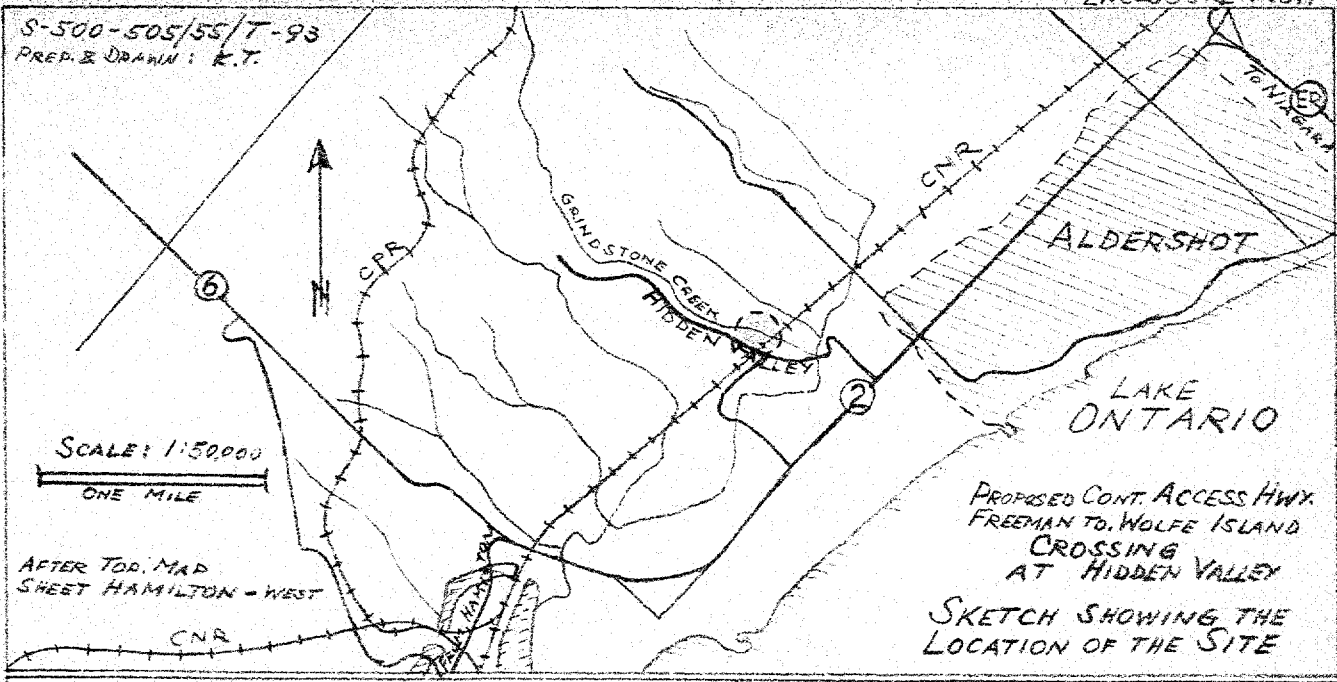
TRACING	F. H. Y	CHECK	D. C. C	LOADING	
DATE	JUNE 29, 1956			H20-516	DRAWING NUMBER D-5553 +

Twp #1337-193-1-A 337-50

~~10-193~~

~~D36,6~~
~~1 to 9~~

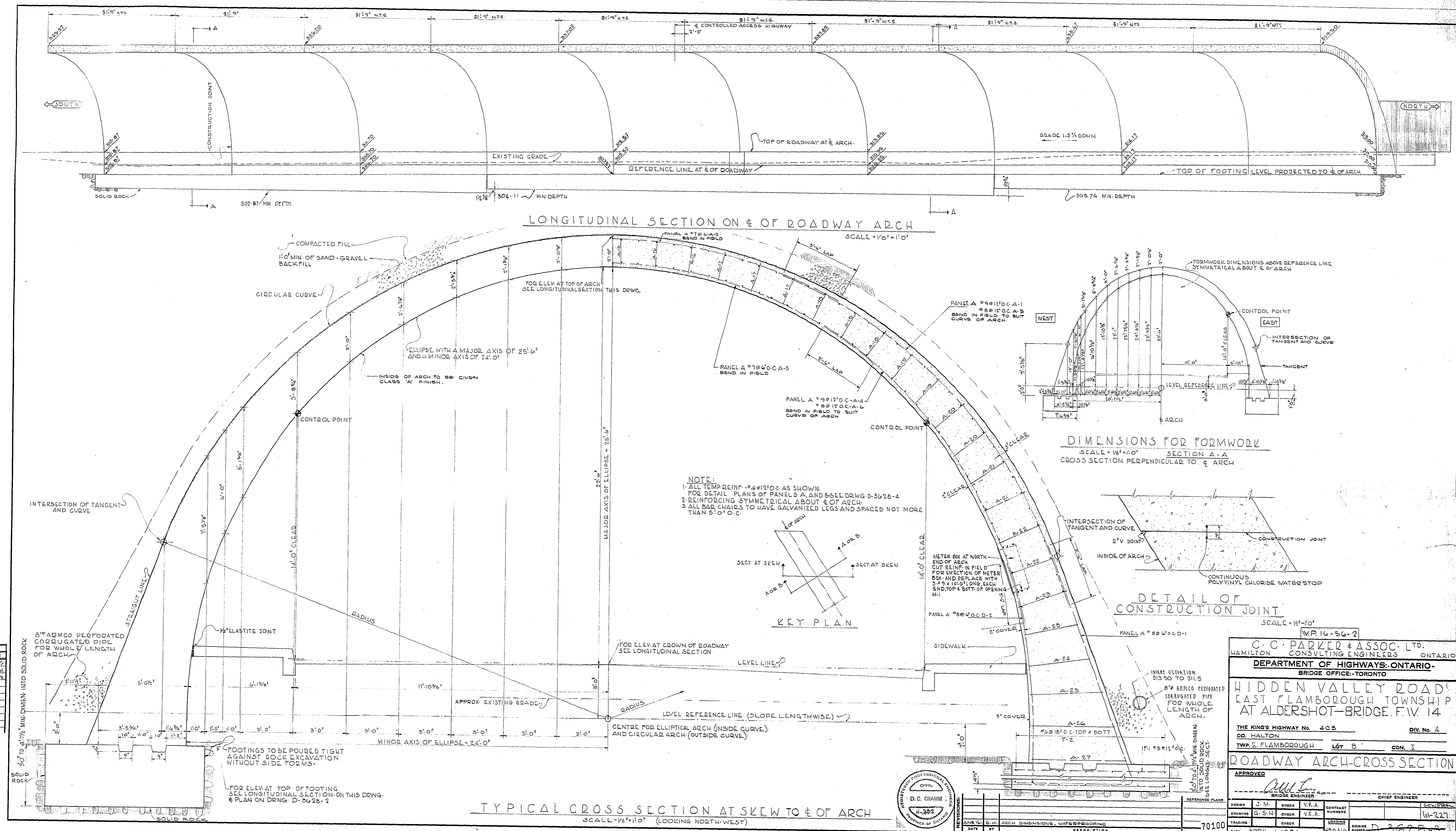
S-500-505/55/T-93
PREP. & DRAWN: K.T.





Appendix B

Archive Drawings of Existing Culvert

[illegible]

C. C. PARKER & ASSOC. LTD.
 HAMILTON CONSULTING ENGINEERS ONTARIO
 DEPARTMENT OF HIGHWAYS: ONTARIO-
 BRIDGE OFFICE: TORONTO
 HIDDEN VALLEY ROAD
 EAST FLAMBOROUGH TOWNSHIP
 AT ALDERSHOT-BRIDGE, F.V. 14
 THE KING'S HIGHWAY No. 403 DIV. No. 4
 CO. HALTON
 TWP. 5 FLAMBOROUGH LOT 8 CON. I
 ROADWAY ARCH-CROSS SECTION
 APPROVED
 BRIDGE ENGINEER
 CHIEF ENGINEER
 DESIGN J. M. CHECK V.R.A. CONTRACT NUMBER
 DRAWING G. S. N. CHECK V.R.A. H20-SIG 6-227
 TRACING
 DATE APRIL 1, 1956
 LOADING BRIDGE NUMBER D 3628-3



Appendix C
Selected Site Photographs



Photo 1- Hidden Valley Road culvert, north side
Photo taken on July 14, 2021



Photo 2- Hidden Valley Road culvert, northwest side
Photo taken on July 14, 2021



Photo 3- Hidden Valley Road culvert, northwest side
Photo taken on July 14, 2021



Photo 4- Hidden Valley Road culvert , northeast side
Photo taken on July 14, 2021



Hidden Valley
Road Culvert

Grindstone
Creek Culvert



Photo 5- Hidden Valley Road culvert and Grindstone Creek Culvert, south side
Photo taken on July 14, 2021



Photo 6- Hidden Valley Road culvert, south side
Photo taken on July 14, 2021



Photo 7- Hidden Valley Road culvert, south side
Photo taken on July 14, 2021



Photo 8- Hidden Valley Road culvert, southeast side
Photo taken on July 14, 2021



Appendix D

Plan of Proposed Boreholes



PLAN

- PROPOSED BOREHOLES
- PREVIOUS BOREHOLES (PREVIOUS INVESTIGATION 1960)

HIGHWAY 403 & HIGHWAY 6 INTERCHANGE
 GRINDSTONE CREEK CULVERT / HIDDEN VALLEY ROAD CULVERT
 REHABILITATION ALTERNATIVE 2
 PRELIMINARY DESIGN & ENVIRONMENTAL ASSESSMENT
 PROPOSED BOREHOLE LOCATIONS

(N.T.S. SCHEMATIC ONLY)

