

## **MEMORANDUM**

To: Howard Black, P.Eng.  
cc. Larry Ng, P.Eng.  
SNC Lavalin Inc.

Date: July 3, 2015

From: Rocio Palomeque Reyna, P.Eng.  
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(Reviewed by P.K. Chatterji, P.Eng.)

File: 19-92-118

**PHASE 1 DESKTOP EVALUATION  
EXISTING FOUNDATIONS OF  
W- N/S WESTON ROAD RAMP OVER THE HUMBER RIVER  
HIGHWAY 401, SITE # 37-188  
TORONTO, ONTARIO  
WP 2037-13-00, ASSIGNMENT 2013-E-0044  
GEOCRES NO. 30M11-255**

## **PART 1 – FACTUAL INFORMATION**

### **1 Introduction**

This memorandum presents the factual findings from a foundation review carried out for the existing Highway 401 W–N/S Weston Road Ramp structure over the Humber River located in Toronto, Ontario. The purpose of this desktop evaluation is to summarize currently available subsurface information pertinent to the foundation aspects of the proposed structural rehabilitation works. This information is available from the MTO Geocres system, geological records and observations from a site reconnaissance visit.

Thurber carried out this desktop evaluation as a sub-consultant to SNC-Lavalin Inc. (SLI) under the MTO Consultant Assignment No. 2013-E-0044.

Reference is made to a foundation investigation report and relevant correspondence filed in GEOCRES and historical design drawings provided by SLI as follows:

- Foundation Investigation Report for Proposed Widening and Erection of New Structures at Hwy. 401 over the Humber River, Toronto By-Pass, District 6, W.J. 63-F-96, W.P. 237-60, Geocres 3011M-122 prepared by the Department of Highways Ontario (DHO), dated October 18, 1963 (Reference 1).



- Department of Highways Ontario (DHO) drawings titled “Humber River Bridge No.4, E. to N. & South Bound-Ramp ‘A’, King’s Highway No. 401, Twp. North York/Etobicoke, Site 37-188”, W.P. No. 237-60-4, (i) General Arrangement Drawing No. D-5384-1, (ii) Bore Hole Locations & Soil Strata Drawing No. D-5384-2, (iii) Footing Layout & Details Drawing No. D-5384-6, (iv) East Abutment, Wingwalls & Approach Slab Drawing No. D-5384-7, dated 1963 to 1964 (Reference 2).
- Foundation engineering related letters and memoranda dated 1963 to 1964 (Reference 3).

## **2 Site Description**

The existing Highway 401 W–N/S Weston Road Ramp structure is located at the southwest quadrant of the Highway 401 and Weston Road interchange in Toronto. The structure is a three-span concrete bridge supported on two piers and two abutments. The west abutment and both piers are supported by driven steel H-piles. The east abutment is supported on spread footings. The upper slope of the west and east approach fills are at an approximate 2H : 1V inclination, whereas the lower slope (near water) with rock protection (rip-rap) are up to 1.5H : 1V.

The natural terrain along the river banks is generally sloping towards the river channel. The immediate vicinity of the bridge is moderately vegetated by grass with some trees and shrubs.

At the location of this bridge, the Humber River flows in a southwesterly direction towards Lake Ontario. The 1964 GA drawing indicated that the river level was at Elevation 119.85 m (393.19ft.). High water level and expected high water level are shown to be at Elevations 122.65 m (402.40ft.) and 124.97 m (410.00 ft.), respectively. An existing sanitary trunk sewer is shown to run in close proximity to the west abutment piles.

Based on existing geological records, the site is located within the portion of the Humber River valley which lies within a physiographic region known as the Peel Plain. At shallow depths, more recent alluvial sand and silt deposits overlie clayey silt till grading into sandy silt till with depth. The site is underlain by grey shale to dolomitic shale of the Georgian Bay formation.

## **3 Subsurface Conditions**

A site investigation was completed by the DHO in 1963 for several bridges for the interchange and documented in Reference 1. Four boreholes relevant to this ramp, numbered 12 to 15 (attached) were drilled along the W–N/S Weston Road Ramp alignment. Boreholes 12, 13, 14 and 15 were located close to the east pier, west pier, west abutment and east abutment, respectively. These four boreholes were advanced to depths ranging between 9.9 and 15.4 m (32.6 to 50.6 ft.).

In general, the subsurface conditions at this site consist of surficial, typically loose to compact silty sand overlying dense to very dense silt till with occasional boulders. The till was described as slightly cohesive grading to non-cohesive with depth. Weathered shale was found to be present within the lower portion of the glacial till deposit at some locations. Bedrock was contacted below the till at three borehole locations. Further details of the subsurface conditions are outlined as follows:

- A 300-mm thick layer of topsoil was identified surficially in Borehole 12.
- Native brown silty sand containing trace of gravel and some organics was contacted below the topsoil in Borehole 12 and surficially in Boreholes 13, 14 and 15. The thickness of the silty sand ranged from 1.2 to 1.5 m in Boreholes 12, 13 and 15, and was up to 5.5 m in Borehole 14. The base of this sand layer varied between Elevations 117.3 to 118.9 m in Boreholes 12, 13 and 14, and at Elevation 130.1 m in Borehole 15. The silty sand was in a typically loose to compact state as indicated by SPT 'N' values ranging from 6 to 23 blows per 0.3 m penetration, except for a dense ('N' = 39) zone near the base of the deposit in Borehole 14.
- Brown to grey clayey silt till containing sand and gravel grading to sandy silt till, with occasional boulders and layers of silt and sand, was contacted below the silty sand in all four boreholes. The till was in a compact to very dense state as indicated by SPT 'N' values varying from 12 blows per 0.3 m penetration to greater than 100 blows for less than 0.3 m of penetration.
- Weathered shale was identified within the lower portion of the till deposit in Boreholes 13 and 14 below Elevations 113.9 and 112.0 m, respectively.
- Grey shale and dolomitic shale bedrock was contacted at depths and elevations shown below:

Foundation Unit	Borehole	Bedrock Depth (m)	Bedrock Elevation (m)
West Abutment	14	12.8	110.0
West Pier	13	7.9	112.2
East Pier	12	6.3	114.3
East Abutment	15	Terminated in till at Elevation 116.3 m	

- A water level was measured at Elevation 119.6 m in Borehole 13. The water level in the Humber River was at Elevation 119.8 m during the investigation. Elevations of high water level and expected high water level in the Humber River are reportedly at Elevations 122.7 and 124.9 m, respectively. It is anticipated that groundwater levels adjacent to the river will depend on fluctuations of the river water level.

## **PART 2 – FOUNDATION DISCUSSION AND RECOMMENDATIONS**

This part of the desktop evaluation provides an interpretation of the geotechnical data presented in the first part and presents a foundation design assessment to assist the design team in assessing whether the existing foundations will safely support the new loads imposed by the proposed rehabilitation works, or if augmentation of the existing foundations, new and/or detour foundations are required. Given that this is an early stage and that much of the design concepts are still under development, this part of the report is considered preliminary and is subject to revision and amendments as the design progresses.

### **4 Project Information**

Based on design information provided by SLI to date, the proposed works is to replace the superstructure with a widened bridge deck. It is understood that several options are currently being considered as follows:

- Option 1 – Superstructure replacement while allowing traffic flow on a temporary steel bridge to be located just south of the existing bridge.
- Option 2A & 2B – Superstructure replacement with full traffic closure during construction, where Option 2A is conventional replacement and Option 2B is Accelerated Bridge Construction (ABC) replacement.
- Option 3 – Superstructure replacement using RBR Lateral Sliding technique.
- Option 4 – New structure to be constructed on a separate alignment to the south of existing bridge.
- Option 5 – Superstructure replacement using prefabricated orthotropic steel with steel girders, RBR lateral sliding technique.
- Option 6 – Superstructure replacement supported by existing piers and abutments with extensions to the north side.

Based on the latest preliminary design information provided by SLI, only Option 2, Option 4 and Option 6 are likely to be further considered.

## 5 Existing Bridge Foundation

Based on the 1964 GA and foundation drawings, the west abutment, west and east piers are supported on driven H-piles, and the east abutment is supported on spread footings. The bridge has a curved alignment with an overall length of 102.6 m on the south face and 106.8 m on the north face. The bridge deck is 9.6 m wide throughout. The west and east approach embankments are approximately 5.8 m and 3.3 m in height, respectively.

The DHO foundation investigation report (Reference 1) recommended that the bridge be supported on spread footings founded on the dense glacial till with a safe bearing capacity of 4 t.s.f. The recommended founding elevations vary between 388.0 and 408.0 ft. (west to east). As an alternative, the report also recommended using end-bearing 12 BP 74 steel H-piles driven to practical refusal into the till or bedrock contact at around Elevation 375.0 ft. or below, with pile design loads being the maximum allowable for the pile section.

Based on the original design drawings and the previous foundation investigation report (References 1 and 2), the design founding conditions and locations have been converted to S.I. units and are summarized in the table below:

Foundation Unit	Foundation System	Axial pile load or safe footing bearing capacity (working stress design)	Design pile length	Design pile tip / Footing elevation	Recommend-ed founding stratum (Ref. 1)	Likely founding stratum (BH #)
West Abutment	Driven H-Piles HP 310x110	560 kN per pile (63 tons*)	7.9 m (26.0 ft.)	114.1 m (374.3 ft.)	Dense till or bedrock	Very dense silt till (BH 14)

West Pier	(12 BP 74 equivalent)	640 kN per pile (72 tons*)	5.3 m (17.5 ft.)	≈112.2 m (≈368.1 ft.)		Weathered shale / top of shale bedrock (BH 13)
East Pier		640 kN per pile (72 tons*)	4.6 (15.0 ft.)	113.4 (372.2 ft.)		Shale bedrock (BH 12)
East Abutment	Spread footings	383 kPa (4 t.s.f. *)	-	124.0 m (406.7 ft.)	Dense till	Dense to very dense silt till (BH 15)

\* short ton (although not specifically defined, it is customary to assume that the short ton has been used in Canada at that time).

## 6 Foundation Assessment

A foundation design assessment was carried out for the piers and abutments in accordance with the Canadian Highway Bridge Design Code (2010) and Canadian Foundation Engineering Manual (4th Edition). The assessment was based on available subsurface data presented in Part 1 of this memo and interpreted foundation design data summarized in the table above. Since there is no available pile driving records or as-built drawings, the actual pile tip and footing base elevations, and founding strata, cannot be confirmed.

In order to fully mobilize the structural resistance of a pile section, the piles would have to be adequately seated within the sound shale bedrock. At this site, it is reasonable to assume that many piles driven to practical refusal might not have reached bedrock, but rather seated within the very dense glacial till, the weathered shale or boulders overlying bedrock. Since there is no available information to confirm the pile driving and seating conditions, there is no basis to assume that full pile structural resistance has been mobilized.

Results of this foundation assessment are summarized in the following:

West Abutment - In recognition of the fact that the west abutment piles did not reach bedrock and were likely terminated in the overlying very dense silt till, and also considering a pile length of approximately 8 m, each 12 BP 74 (HP 310 x 110) pile is assessed to have an axial factored geotechnical resistance of 1,000 kN at Ultimate Limit States (ULS<sub>f</sub>) and a geotechnical resistance of 800 kN at Serviceability Limit States (SLS up to 25 mm settlement).

West Pier – It appears that the pile tips are located within the weathered shale and just above the shale bedrock. In view of the relatively short pile length of about 5 m (low confining stress), the assessed axial factored geotechnical resistance at ULS<sub>f</sub> for a 12 BP 74 pile (HP 310x110) is 1,000kN per pile and a geotechnical resistance at SLS (up to 25 mm settlement) is 800 kN per pile.

East Pier – It is noted that boulders were identified above bedrock in Borehole 12 located close to the east pier. Although the design pile tip elevation was below the top of bedrock elevation,







The loading assessment at each foundation element is as follows:

#### **Proposed 11.0 m Roadway Width**

- The above maximum proposed loading values at the west abutment are less than the assessed ULS and SLS pile resistances. The small increase in loading due to the proposed rehabilitation works is not expected to impact the performance of the existing foundations provided that the foundation elements are structurally adequate.
- The above maximum proposed loading values at the west and east piers are up to 20% above the assessed SLS pile resistance and more than 55% above the assessed ULS pile resistance.
- The above proposed bearing pressures at the east abutment are less than the assessed ULS geotechnical resistance, and about 3% higher than the assessed SLS resistance. Such modest loading increase due to the proposed rehabilitation works is not expected to impact the performance of the existing foundations with extensions provided that the foundation elements are structurally adequate.

#### **Proposed 9.5 m Roadway Width**

- The above maximum proposed loading values at the west abutment are less than both the existing loadings and the assessed ULS and SLS pile resistances. The existing foundations may remain in use provided that the foundation elements are structurally adequate.
- The above maximum proposed loading values at the west and east piers are about 2% above the assessed SLS pile resistance and 31% above the assessed ULS pile resistance.
- The above proposed bearing pressures at the east abutment are less than both the existing loadings and the assessed ULS and SLS geotechnical resistances. The existing foundations may remain in use provided that the foundation elements are structurally adequate.

As a general guideline, if the rehabilitation strategy does not result in an increase of the loading on a foundation element by more than 10%, the foundation may remain in service subject to structural evaluation of the foundations. The proposed loadings on the piles of both piers are significantly more than 10% above the assessed geotechnical resistances under most loading conditions as indicated above. The proposed loadings on both abutments appear to be significantly less than a 10% increase. It is noted that any major alteration to the existing foundation elements including widenings and new foundations will require additional boreholes and geotechnical analysis as part of the detailed foundation investigation and design (Phase 2).

Based on the above assessment, we recommend that all existing foundation elements be augmented if Option 6 (bridge widening to the north) is selected. Such augmentation will involve extension of the existing pile caps supported by additional piles at the west abutment and both piers, as well as extension of the footing at the east abutment. The addition of 4 piles would bring the total number of piles at the west abutment to 15.



## **7 Existing Utilities**

A 72 in. diameter Weston sanitary trunk sewer is shown on the GA drawing (Reference 2) located in close proximity to the west abutment piles. No other information on this utility can be found in References 1 to 3. It is important to confirm the existence, exact location, existing conditions and operational status (active, inactive, abandoned, decommissioned) of this sewer. Should an extended west abutment, or a new west abutment and a new pier be required as part of this bridge rehabilitation project, it is important to confirm that this sewer will not interfere with the new foundations, or will not be adversely affected by construction of the new foundations. It should also be prudent to confirm that there is no other buried utilities in the general vicinity of this site.

## **8 Foundation Options**

In order to provide recommendations for detail foundation design, a Phase 2 investigation program is required as outlined below. For Option 6 involving augmentation of existing foundations, preliminary consideration may be given to using micropiles socketted in shale bedrock for foundation support to the extensions at the west abutment, west and east piers in order to minimize potential adverse impacts on the existing adjacent foundations due to vibration should pile driving be required for the extensions.

Information provided by SLI indicated that the MTO has endorsed Option 4 – New bridge on new alignment and that Thurber should proceed to detail investigation for this option.

## **9 Detail Foundation Investigation and Design (Phase 2)**

A site investigation and field testing program consisting of 10 boreholes to be drilled to the order of 10 to 20 m depths is proposed. The attached Figure C1 shows the tentative layout of boreholes for this option relative to the proposed preliminary bridge outline provided by SLI. It is noted that the two boreholes for the proposed east pier will have to be drilled at the crest of the east river bank slopes instead of at the edge of the river flow channel due to access and setup difficulties. The implication of this borehole relocation to depths of new piles is anticipated to be minor as the top of bedrock at the proposed east pier location can be readily interpolated between newly advanced boreholes and the archived records of boreholes drilled for the existing bridge. Minor repositioning of some or all of the other boreholes may also be required due to factors such as site topography, surface features and buried utilities.

## **10 Closure**

The above desktop foundation evaluation has been based on preliminary design information provided by SLI to date. Should there be changes to the design requirements, these recommendations will be subject to revision and amendments as required.





THURBER ENGINEERING LTD.



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Appendices



## Appendix A

### GEOCRES Information

FOUNDATION SECTION

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE			LIQUID LIMIT — WL			BULK DENSITY P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BLOWS / FOOT —			PLASTIC LIMIT — WP				
							20 40 60 80 100			WATER CONTENT — W				
							SHEAR STRENGTH P.S.F.			WP — W — WL				
									WATER CONTENT % 15 30 45					
395.5	Groundlevel													
1.0	Topsoil													
5.3	Silty fine sand and traces of organics. Compact. Brown.		1	SS	40	390								
	Clayey silt, sand and gravel. (Glacial till). Occasional boulder below elev. 380.3		2	SS	78									
			3	SS	>100									
			4	SS	>100	380								
375.0	V. dense. Grey.		5	SS	>100									
20.6	Bedrock. (Shale and dolomitic shale).		6	RC	-									
			7	RC	-									
			8	RC	-	370								
			9	RC	-									
			10	RC	-									
363.0	Grey.		11	RC	-									
32.6	End of borehole.					360								

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH DIVISION

## RECORD OF BOREHOLE NO. 13

FOUNDATION SECTION

JOB 63-F-96 LOCATION Stn. 385+64 & 222' to left of E, Hwy. 401 ORIGINATED BY B.M.G.  
W.P. 237-60 BORING DATE Sept. 16, 1963. COMPILED BY B.M.G.  
DATUM G.S.C. BOREHOLE TYPE Washboring using BX Casing. CHECKED BY H.S.

[illegible]

FOUNDATION SECTION

SOIL PROFILE		STRAT. PLOT	SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— WL		BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	PLASTIC LIMIT ——— WP	WATER CONTENT ——— W		
403.0	Groundlevel											
385.0	Silty fine sand and trace of gravel with silt. Organics to elev. 390.0. Loose to dense.		1	SS	12	400						
			2	SS	9							
	Brown changing to grey at elev. 394.7.		3	SS	6	390						
			4	SS	39							
385.0			5	SS	>100	380						
18.0	Sand, gravel and clayey silt with occasional boulder. (Glacial till) Occasional layers of silt and sand. Weathered shale below elev. 367.3		6	SS	>100							
			7	SS	>100							
			8	SS	>100							
			9	SS	>100	370						
	V. dense.		10	SS	>100							
361.0	Grey.					360						
42.0	Bedrock.		11	RC	-							
355.0	(Shale and dolomitic shale). Grey		12	RC	-							
48.0	End of borehole.					350						

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH DIVISION

## RECORD OF BOREHOLE NO. 15

FOUNDATION SECTION

JOB 63-F-96

LOCATION Stn. 383/88 & 344<sup>1</sup> to left of C, Hwy. 401

ORIGINATED BY B.M.G.

W. P. 237-60

BORING DATE Sept. 20, 1963.

COMPILED BY B.M.G.

DATUM G.S.C.

BOREHOLE TYPE Pennsylvania Auger - 4 1/2" Ø

CHECKED BY                      H.S.

SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	LQUID LIMIT ——— WL PLASTIC LIMIT ——— WP WATER CONTENT ——— W <div style="text-align: center;">WP      W      WL</div>	BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT	SHEAR STRENGTH P.S.F.	WATER CONTENT % <div style="text-align: center;">— o —</div>	P.C.F.
432.0	Groundlevel							
0.0	Silty fine sand. Brown	<div style="background-color: #cccccc; width: 10px; height: 10px;"></div>			430			
5.0	Clayey silt, silt, sand and gravel. (Glacial till) Organics around elev. 410.0  Compact to v. dense.  Br. grey changing to grey at elev. 396.0	<div style="width: 10px; height: 10px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px);"></div>	1	SS	23			
			2	SS	20			
			3	SS	30			
			4	SS	12			
			5	SS	14			
			6	SS	23			
			7	SS	59			
			8	SS	85			
			9	SS	46			
			10	SS	37			
			11	SS	>100			
			12	SS	>100			
381.5			13	SS	>100			
50.6	End of borehole.				380			

## ABBREVIATIONS USED IN THIS REPORT

### PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

### DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

### TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

### SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	UNCONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY



# ABBREVIATIONS USED IN THIS REPORT

## SOIL PROPERTIES

$\gamma$	UNIT WEIGHT OF SOIL (BULK DENSITY)
$\gamma_s$	UNIT WEIGHT OF SOLID PARTICLES
$\gamma_w$	UNIT WEIGHT OF WATER
$\gamma_d$	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
$\gamma'$	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
$S_r$	DEGREE OF SATURATION
$w_L$	LIQUID LIMIT
$w_p$	PLASTIC LIMIT
$I_p$	PLASTICITY INDEX
s	SHRINKAGE LIMIT
$I_L$	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
$I_C$	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
$e_{max}$	VOID RATIO IN LOOSEST STATE
$e_{min}$	VOID RATIO IN DENSEST STATE
$I_D$	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY $D_r$ IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
$m_v$	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
$C_v$	COEFFICIENT OF CONSOLIDATION
$C_c$	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
$T_v$	TIME FACTOR = $\frac{C_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
$\tau_f$	SHEAR STRENGTH
$c'$	EFFECTIVE COHESION
$\phi'$	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
$c_u$	APPARENT COHESION
$\phi_u$	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
$\mu$	COEFFICIENT OF FRICTION
$S_i$	SENSITIVITY

## GENERAL

$\pi$	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

## STRESS AND STRAIN

u	PORE PRESSURE
$\sigma$	NORMAL STRESS
$\sigma'$	NORMAL EFFECTIVE STRESS ( $\bar{\sigma}$ IS ALSO USED)
$\tau$	SHEAR STRESS
$\epsilon$	LINEAR STRAIN
$\gamma$	SHEAR STRAIN
$\nu$	POISSON'S RATIO ( $\mu$ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
$\eta$	COEFFICIENT OF VISCOSITY

## EARTH PRESSURE

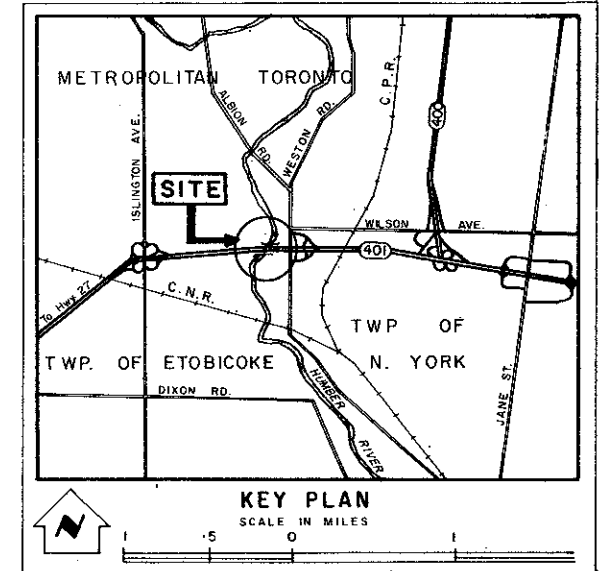
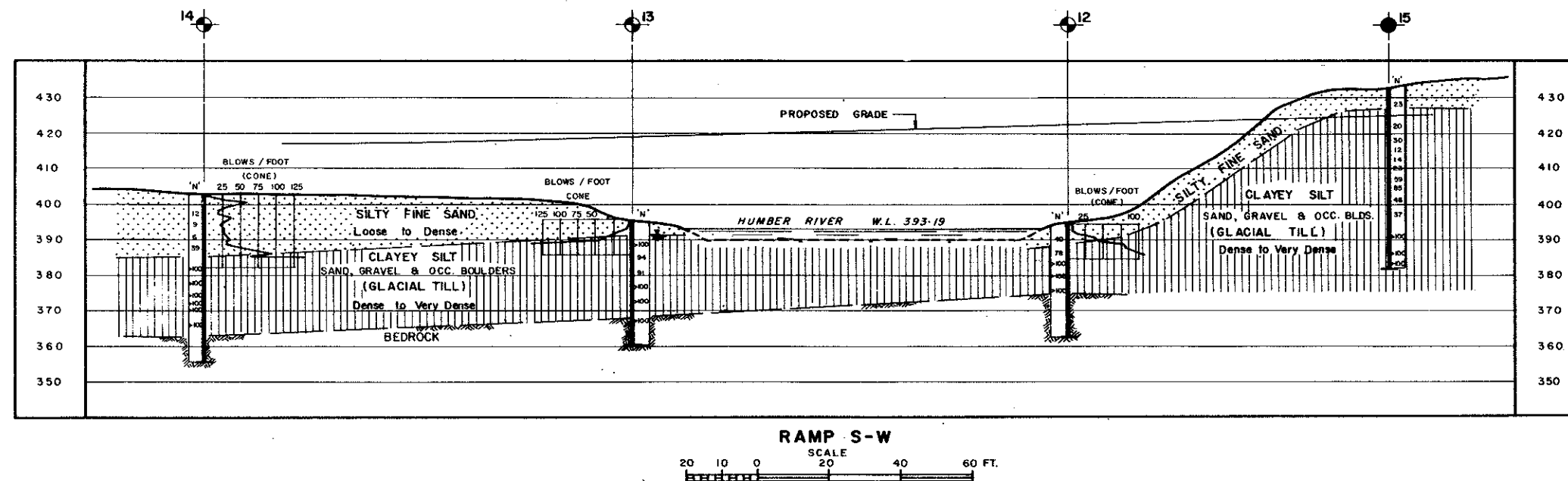
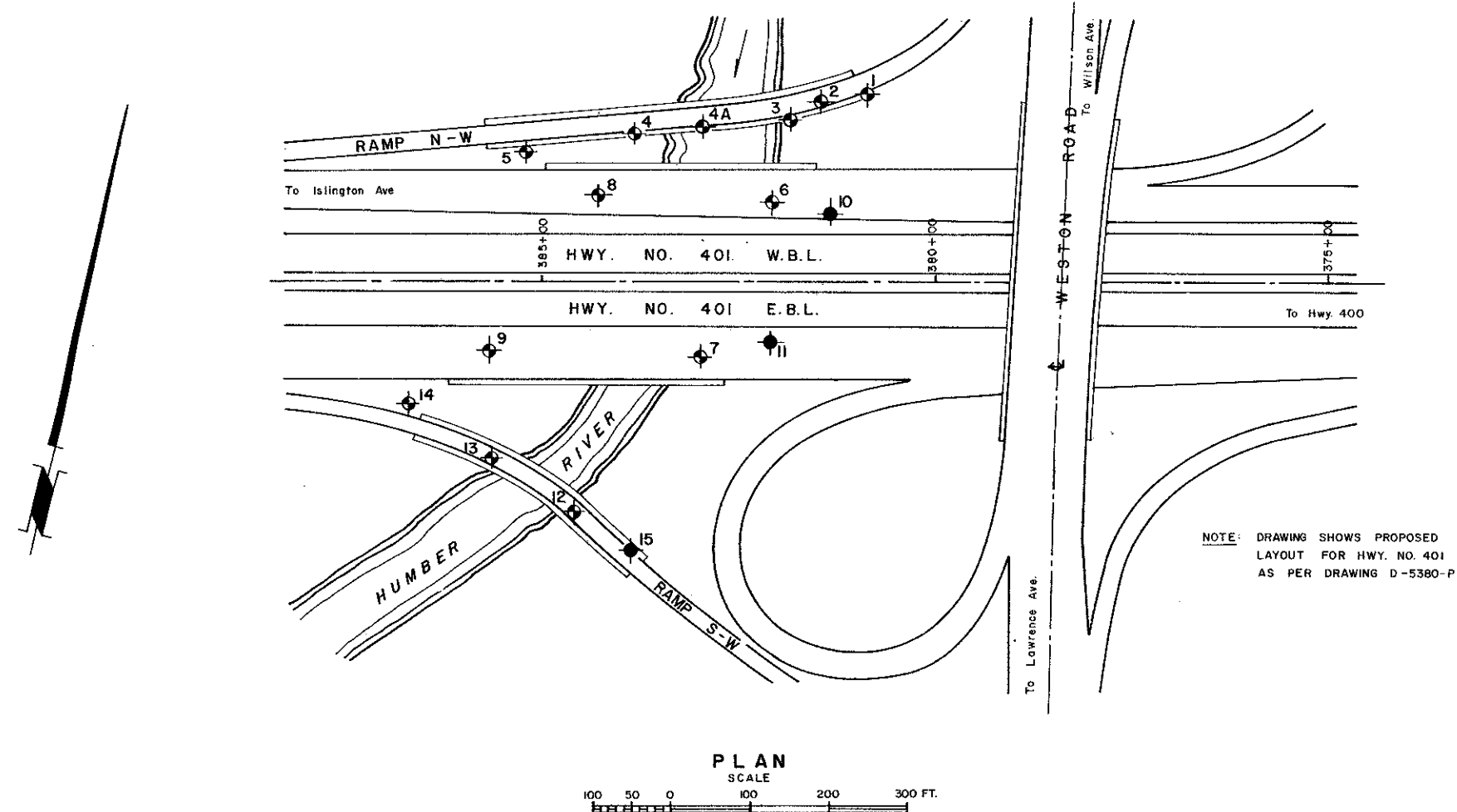
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
$K_0$	COEFFICIENT OF EARTH PRESSURE AT REST

## FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
$k_s$	MODULUS OF SUBGRADE REACTION

## SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
$\beta$	ANGLE OF SLOPE TO HORIZONTAL



#### LEGEND

- Bore Hole
- ⊕ Cone Penetration Hole
- ⊕ Bore & Cone Penetration Hole
- Water Levels established at time of field investigation, Sept. 1963
- Stations on Hwy. 401 Taken off Consultant's Plan.
- (DE LEUW CATHER AND CO. LTD.)

NO.	ELEVATION	STATION	OFFSET
1	445.7	380+91	236' RT.
2	418.7	381+43	223' RT.
3	396.7	381+88	201' RT.
4	399.6	383+83	185' RT.
4A	393.9	382+98	192' RT.
5	402.0	385+20	160' RT.
6	398.3	382+03	95' RT.
7	395.6	382+98	100' LT.
8	400.3	384+28	103' RT.
9	401.0	385+73	90' LT.
10	420.8	381+35	85' RT.
11	421.3	382+11	79' LT.
12	395.5	384+65	294' LT.
13	394.0	385+64	222' LT.
14	403.0	386+71	159' LT.
15	432.0	383+88	344' LT.

#### NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISIONS	DATE	BY	DESCRIPTION
JUNE/64	F.C.	PROPOSED LAYOUT ON PLAN OF HWY. 401	

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH DIVISION - FOUNDATION SECTION

HUMBER RIVER BRIDGE N° 4  
E. TO N. & SOUTH BOUND - RAMP 'A'  
KING'S HIGHWAY NO. 401 DIST. NO. 6  
CO. YORK  
TWP. N. YORK/ETOBICOKE LOT 10 & 25 CON. V & B

#### BORE HOLE LOCATIONS & SOIL STRATA

SUBM'D. B.G.	CHECKED	W.P. NO. 237-60-4	M.S.R. DRAWING NO.
DRAWN F.C.	CHECKED	JOB NO. 63-F-96	63-F-96A
DATE OCT. 23, 1963	SITE NO. 37-158	BRIDGE DRAWING NO.	
APPROVED	CONT. NO. 65-35	D-5384-2	



## Appendix B

### Archived Drawings

## GENERAL NOTES

## TO ENGINEER

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

## TO CONTRACTOR

STRUCTURE TO BE BUILT IN ACCORDANCE WITH FORM NO. 9 AND THE SPECIAL PROVISIONS, EXTRA COPIES OF WHICH MAY BE OBTAINED FROM THE ENGINEER.

1. CONCRETE MIX — (MINIMUM CONCRETE STRENGTH @ 28 DAYS)
- FOUNDATIONS & SUBSTRUCTURE 3,000 p.s.i.
  - DECK, CURBS, & PARAPET WALLS 4,000 p.s.i.
  - PIER COLUMNS & CAPS 5,000 p.s.i.

APPROVED ADJUSTURES SUPPLIED BY THE CONTRACTOR WILL BE ADDED TO ALL CONCRETE AS SPECIFIED BY THE ENGINEER.

2. CLEAR COVER ON REINFORCING STEEL
- |                   |                   |                     |
|-------------------|-------------------|---------------------|
| TOOTINGS          | PIER CAPS         | DICK - 1 INCH @ TOP |
| ABUTMENTS         | BALLAST WALL (RT) | @ BOTTOM            |
| PIER COLUMNS      | CURBS             |                     |
| VINOWALLS         | PARAPET WALLS     | 2 INCHES            |
| BALLAST WALL (LT) | END POSTS         |                     |
|                   | APPROACH SLABS    |                     |

## 3. BORING DATA

THE COMPLETE SOIL INVESTIGATION REPORT FOR THIS STRUCTURE MAY BE EXAMINED AT THE BRIDGE OFFICE AND FOUNDATION OFFICE, DOWNSVIEW, AND AT THE TORONTO DISTRICT OFFICE. THE DEPARTMENT DOES NOT GUARANTEE THE ACCURACY OF THIS REPORT OR THE ABRIDGED VERSION SHOWN ON THESE PLANS.

## 4. CONSTRUCTION NOTES

- ALL EXPOSED EDGES TO BE CHAMFERED 1" x 1" EXCEPT AS NOTED.
- ALL CONSTRUCTION JOINTS MUST BE APPROVED BY THE ENGINEER.
- THE GENERAL CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BRIDGE SLABS DEAD LEVEL TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF PLUS OR MINUS 1/8 INCH. IF THEY ARE CAST TOO HIGH THEY SHALL BE GROUND DOWN BY THE GENERAL CONTRACTOR. IF THEY ARE CAST TOO LOW THE GENERAL CONTRACTOR SHALL PROVIDE FULL BEARING SURFACES TO BRING THEM UP TO THE CORRECT ELEVATIONS. THE USE OF GROUT IS PROHIBITED.
- THE GENERAL CONTRACTOR SHALL BE RESPONSIBLE FOR INSURING THAT THE FINAL DECK ELEVATIONS CONFORM WITH ELEVATIONS SHOWN.

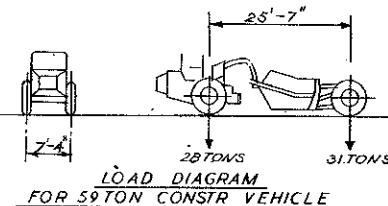
NO CONCRETE SHALL BE PLACED ABOVE THE BRIDGE SEAT UNTIL CONCRETE IN THE DECK HAS BEEN PLACED.

THE BRIDGE IS DESIGNED FOR H20-S16 AASHTO LOADING, OR FOR ONE LOADED 59 TON CONSTRUCTION VEHICLE ON THE BRIDGE AT ONE TIME. CONDITIONS OF LOADING FOR THE 59 TON VEHICLE ARE: THE 3" ASPHALT FILL IS NOT ALLOWED ON DECK AND THE VEHICLE MUST TRAVEL ON SPECIALLY PREPARED WOODEN MATS AS DECK CONCRETE MUST NOT BE LOADED DIRECTLY. SPEED OF LOADED VEHICLE MUST NOT EXCEED 10 M.P.H.

YORK MILLS G.B.M. ELEV. 561.81. HOGGS HOLLOW VIADUCT OVER DON RIVER, WEST OF YONGE ST. AND IMMEDIATELY NORTH OF NORTHERLY CITY LIMITS OF TORONTO. TABLET IN CONCRETE SIDEWALK ALONG SOUTH SIDE OF VIADUCT, 16 INCHES EAST OF WEST FACE OF EAST ABUTMENT AND 6 INCHES NORTH OF BALUSTRADE N#487-S.

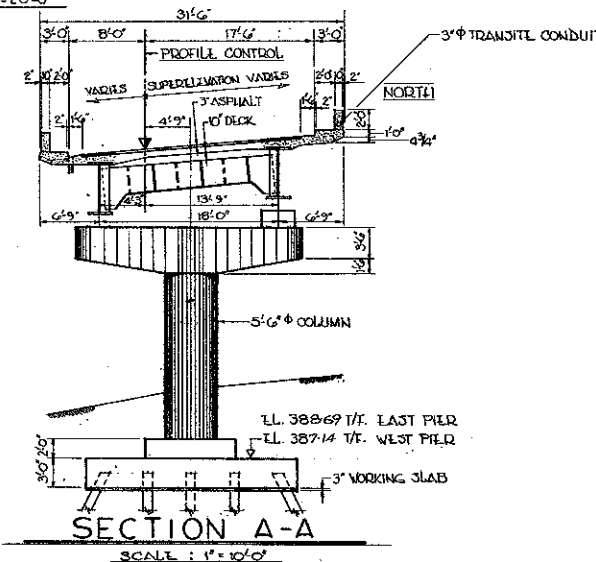
## REF. DRWS

2065 BY DELLUM & CATHY  
C-163-2H STATIONS & PAVT DIMENSIONS  
872 - FOR BRIDGE #4 GRAPHIC PROFILE  
1246-R-6A WESTON SANITARY  
1246-R-6 TRUNK SEWER

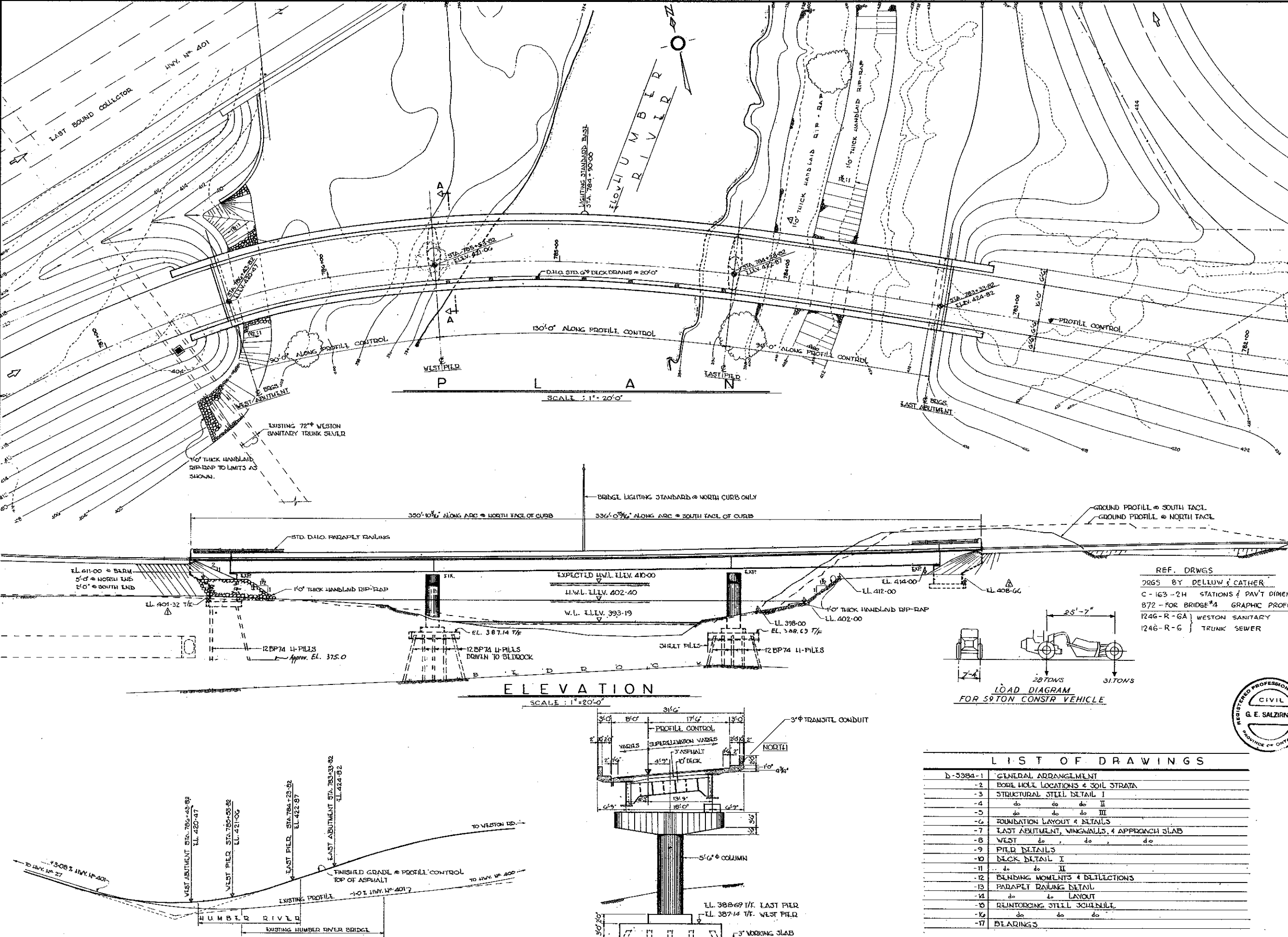


## LIST OF DRAWINGS

D-5384-1	GENERAL ARRANGEMENT
-2	BORE HOLE LOCATIONS & SOIL STRATA
-3	STRUCTURAL STEEL DETAIL I
-4	do do do II
-5	do do do III
-6	FOUNDATION LAYOUT & DETAILS
-7	EAST ABUTMENT, VINOWALLS, & APPROACH SLAB
-8	WEST do do do do
-9	PIER DETAILS
-10	DECK DETAIL I
-11	do do do II
-12	BENDING MOMENTS & DEFLECTIONS
-13	PARAPET RAILING DETAIL
-14	do do LAYOUT
-15	REINFORCING STEEL SCHEDULE
-16	do do do
-17	BEARINGS



## PROFILE OF RAMP

DEPARTMENT OF HIGHWAYS ONTARIO  
BRIDGE DIVISIONHUMBER RIVER BRIDGE NO. 4  
E. TO N. & SOUTH BOUND-RAMP A

KING'S HIGHWAY No. 401 DIST. No. 6

CO. YORK

TWP. NORTH YORK/ETOBICOKE Lot 10 &amp; 25 CON. V &amp; B

## GENERAL ARRANGEMENT

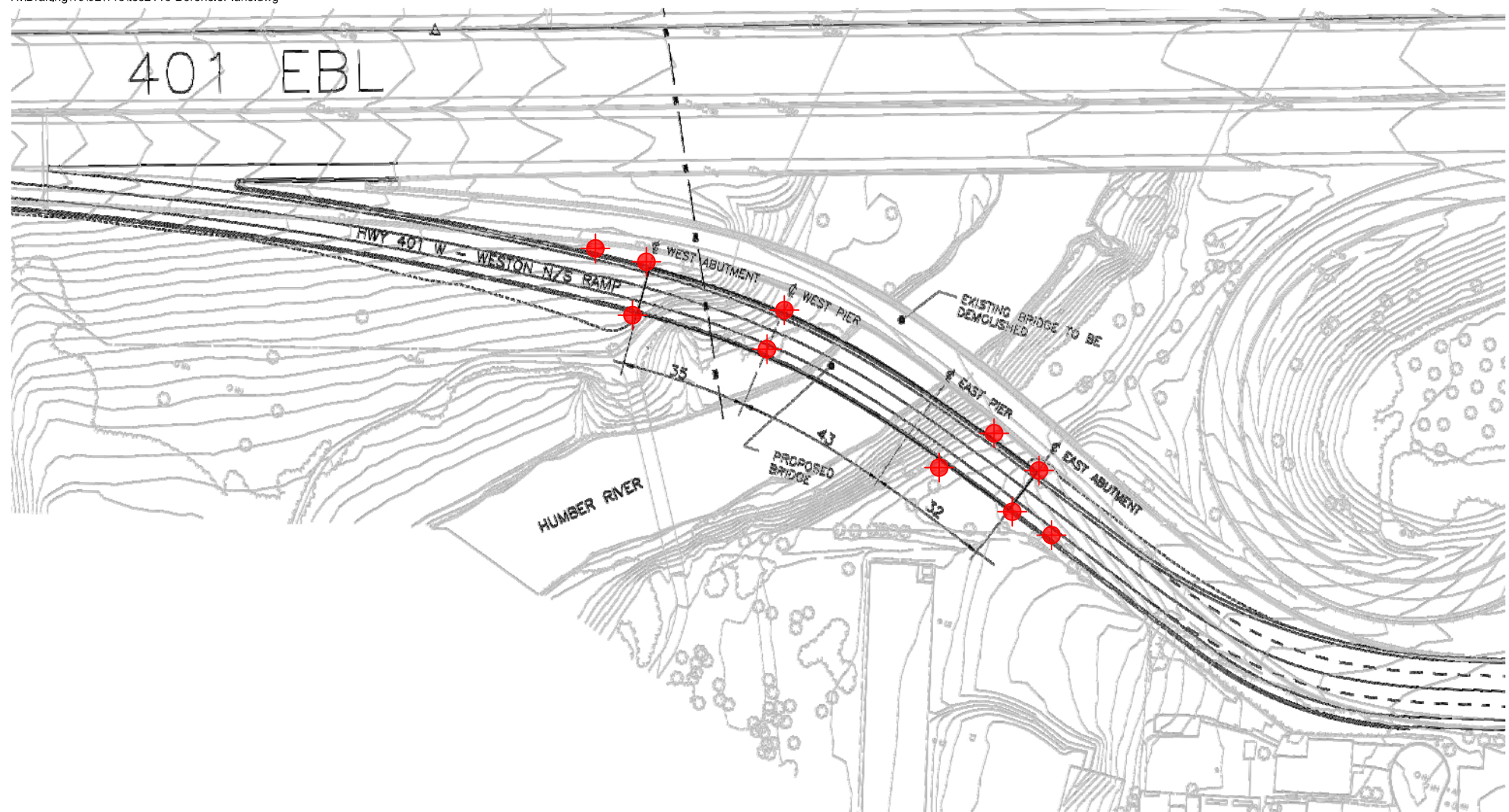
APPROVED	<i>John Long</i>	BRIDGE ENGINEER	SITE No. 37-188	W.P. No. 237-60-4
DESIGN	G.S.	CHECK	P.O.L.	CONTRACT No. 65-55
DRAWING	11.1.	CHECK	P.S.	DRAWING No. D-5384-1
DATE	SEPT 1964	LOADING	H20 S16	





## Appendix C

### Proposed Phase 2 Boreholes



PROPOSED BOREHOLES (10)

WESTON N/S RAMP  
PROPOSED BOREHOLE LOCATIONS  
OPTION 4 - REPLACEMENT ON NEW ALIGNMENT  
(N.T.S. SCHEMATIC ONLY)

FIGURE C1