

Final

249 Sunview Street, City of Waterloo Stormwater Management Report



Prepared for Lester Sunview Development Inc.
by Arcadis IBI Group

IBI GROUP

October 23, 2023

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1 INTRODUCTION

IBI Group was retained to prepare a Stormwater Management Report in support of an application for a proposed apartment building development located at 249 Sunview Street in the City of Waterloo. The 0.219 ha property is bounded by residential development to the north, south, and west (refer to Figure 1).

This Report addresses the stormwater management quantity and quality control requirements to accommodate construction of a new building development on the site.

2 EXISTING CONDITIONS

The developing property consists of three single lots (249, 251, and 253 Sunview Street) containing residential houses, concrete walkways, asphalt driveways, various sheds, pads and decks, and grass yards.

Referring to Figure 2, runoff from the existing lots within Area 100 and Area 101 drains overland toward the south. Flows then enter an existing 250mm diameter storm sewer on Sunview Street via road catch basins. No external areas drain onto the property.

Based on the Geotechnical Investigation completed by Chung & Vander Doelen Engineering Ltd. (November 27, 2015, included Appendix C), site soils include sandy silt to sand and silt, with groundwater levels 6.0m below existing grade. Based on the soils on site, a CN value of 66 was used for the modelling of pervious areas.

3 PROPOSED CONDITIONS

The existing houses will be demolished and replaced with a new residential apartment building, grass and landscaped areas, and parking areas, as shown on Figure 3. Based on the proposed stormwater management design outlined below, minor runoff from the development will be collected in a site storm sewer and routed to the existing 250mm diameter storm sewer on Sunview Street. Major runoff will spill overland toward the south and toward Sunview Street.

Stormwater attenuation will be provided on the rooftop using flow control roof drains, with additional attenuation provided underground and on the parking lot surface. Stormwater quality control for parking areas will be provided using a Snout oil/grit separator (OGS) unit. Based on the site layout and available tank separation distance from the parking structure, active infiltration of roof runoff has not been proposed in the design.

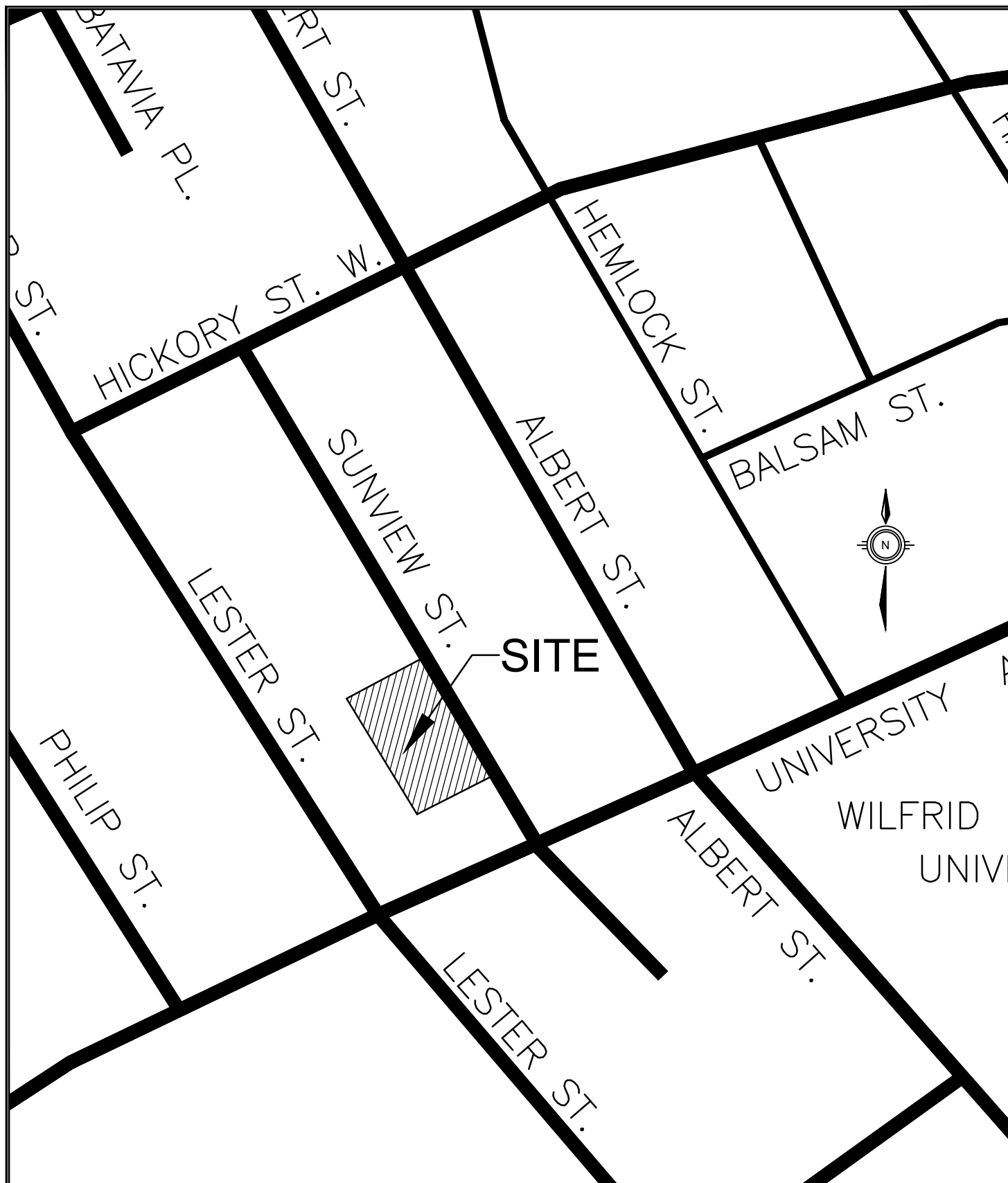


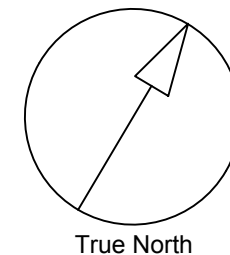
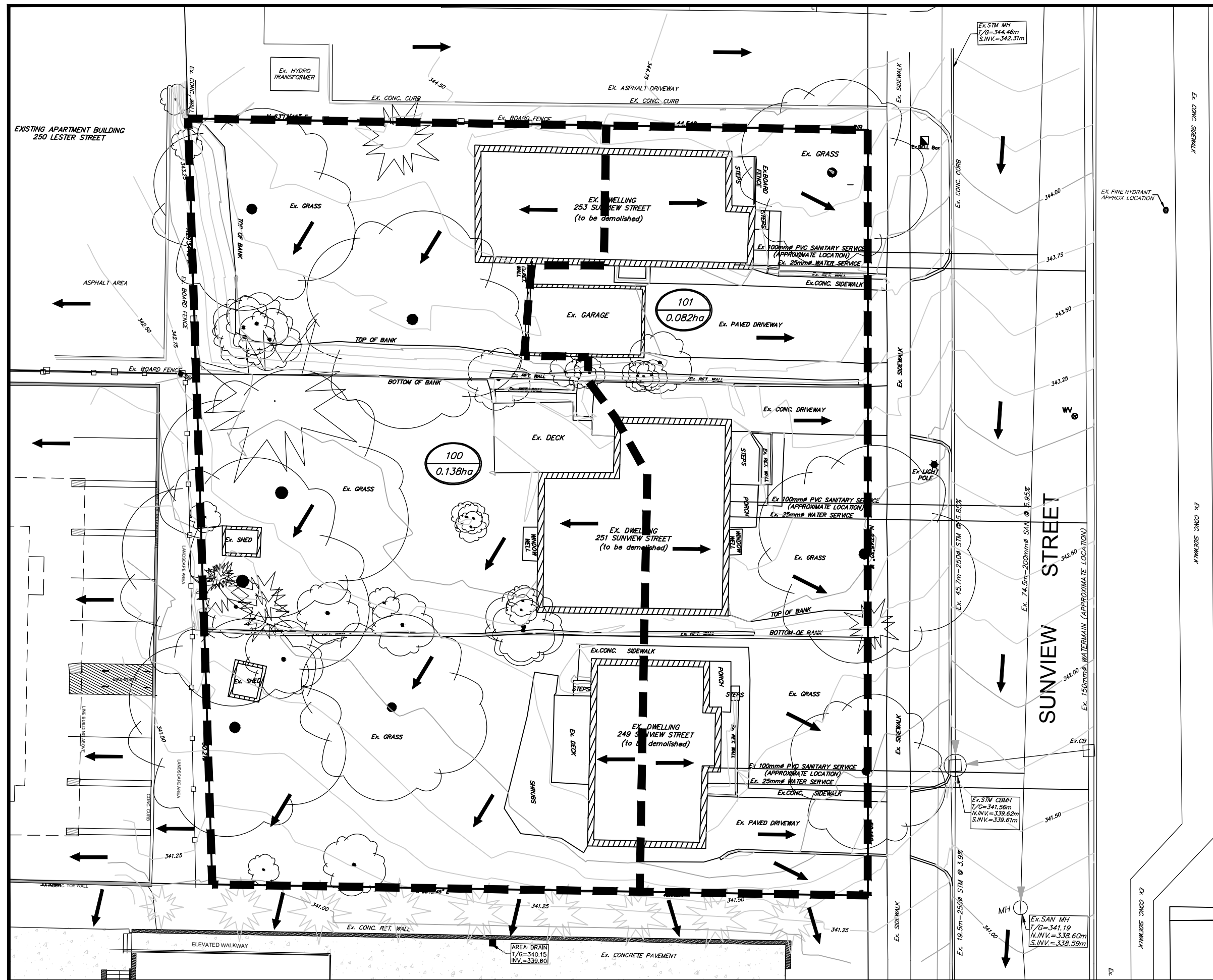
FIGURE 1 SITE LOCATION

249 - 253 SUNVIEW STREET
CITY OF WATERLOO

SCALE NTS
DATE OCTOBER 20, 2023
PROJECT No. 139419



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LEGEND

- EXISTING CATCHMENT BOUNDARIES
- DRAINAGE ARROWS
- EX. CATCHMENT SYMBOL
- CATCHMENT AREA NUMBER
- AREA (ha)

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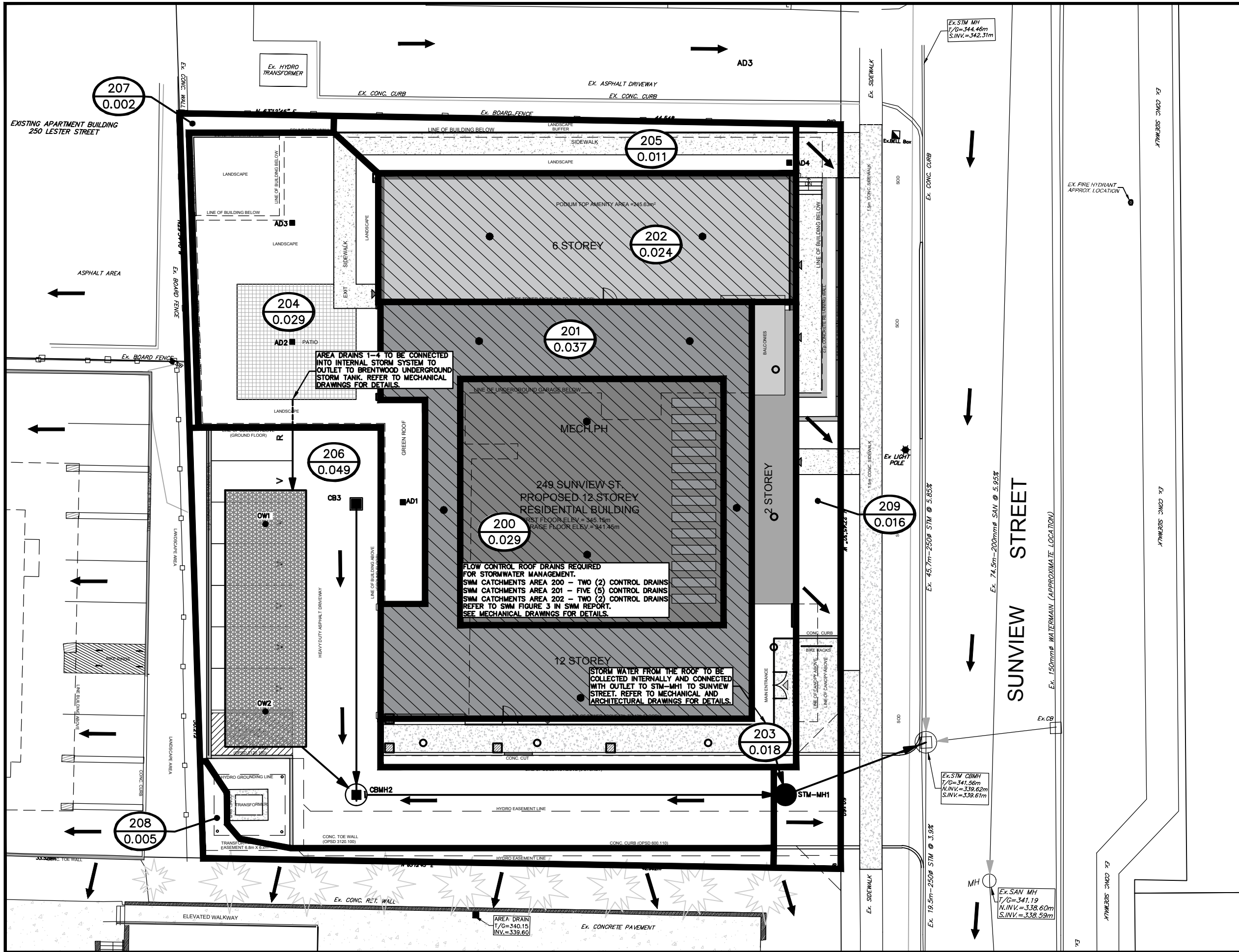
SCALE	1:250
DATE	OCTOBER 20 2023
PROJECT No.	139419

CITY OF WATERLOO
REGIONAL MUNICIPALITY
OF WATERLOO

249-253 SUNVIEW STREET
RESIDENTIAL BUILDING

EXISTING STORM
CATCHMENT AREAS

FIGURE 1



True North

LEGEND

- UNCONTROLLED ROOF DRAIN (approximate location)
- CONTROLLED ROOF DRAIN (approximate location)
- PROPOSED CATCHMENTS BOUNDARIES
- PROPOSED ROOF SWM STORAGE AREA
- DRAINAGE ARROWS
- 200

0.029

 PROP. CATCHMENT SYMBOL
CATCHMENT AREA NUMBER
AREA (ha)

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DATE OCTOBER 20, 2023
PROJECT No. 139419

CITY OF WATERLOO
REGIONAL MUNICIPALITY
OF WATERLOO

249 SUNVIEW STREET
RESIDENTIAL BUILDING

PROPOSED STORM
CATCHMENT AREAS

FIGURE 3

4 STORMWATER MANAGEMENT

The stormwater management criteria for this development are based on the requirements of the City of Waterloo. The requirements include:

- Stormwater quantity controls are required for the site to control the proposed conditions peak flows from the site to the existing conditions levels for 2, 5, and 100 year storm events;
- The 2 year storm volume is to be stored underground to minimize frequent nuisance flooding;
- Active infiltration of rooftop runoff should be provided if soil and groundwater conditions permit; and
- Stormwater quality controls are to be provided for the site.

4.1 Stormwater Quantity Control

Three-hour duration Chicago style storms derived from City of Waterloo IDF curves were used for the stormwater management modelling. The total depths of rainfall for the modelled storms are indicated in Table 1.

Table 1 Rainfall Depths

RETURN EVENT	STORM DURATION (HOURS)	RAINFALL DEPTH (MM)
2 Year	3	32.4
5 Year	3	47.5
100 Year	3	90.0

The existing and proposed conditions have been modelled using MIDUSS, in accordance with City guidelines. Modelling variables are summarized in Table 2.

Table 2: MIDUSS Modelling Variables

CATCHMENT ID	DESCRIPTION	AREA (HA)	LENGTH (M)	GRADIENT (%)	IMPERV. (%)	MANNING 'N'	PERVIOUS CN
EXISTING CONDITIONS							
100	Lots	0.137	20	2	19.9	0.250	66
101	Lots	0.082	15	2	35.3	0.250	66
Total		0.219			25.7		
PROPOSED CONDITIONS							
200	Roof - Controlled	0.029	15	15	100	0.013	98
201	Roof - Controlled	0.037	15	15	100	0.013	98
202	Roof - Controlled	0.024	15	15	100	0.013	98
203	Roof	0.018	15	15	100	0.013	98
204	Patio/Landscaped	0.029	15	15	64.9	0.250	66
205	Landscaped/Walkway	0.011	10	10	53.7	0.250	66
206	Parking/Landscaped	0.049	15	15	82.1	0.250	66
207	Landscaped	0.002	10	10	0	0.250	66
208	Landscaped	0.005	10	10	0	0.250	66
209	Landscaped	0.016	15	15	50.3	0.250	66
Total		0.219			82.2		

Rooftop attenuation will be provided using Zurn Control-Flo roof drains (or approved equivalent) for roof areas 200, 201, and 202, and the roof areas will outlet to the proposed site storm sewer. Rooftop area 203 will drain to the site storm sewer without rooftop attenuation. Additional attenuation will be provided on the parking lot surface at CBMH2 and CB3 and in an underground storage tank, with a 50mm orifice opening at the outlet pipe of CBMH2 providing flow control for Areas 204, 205, and 206.

The site storm sewer will outlet to the existing storm sewer on Sunview Street. An overland flow route will be provided from the parking area to at the south side-yard for major storm events in excess of the 100 year storm at a depth of 0.35m. Note that the total volume generated during the 100 year storm for the areas draining to CBMH2 and CB3 (from Areas 204, 205, and 206 - 890m²) is approximately 80 m³, which would pond to a maximum depth of 0.23m above CBMH2 and CB3. The total available storage at the spill elevation of 341.45m is 159.2 m³, which is approximately twice the total volume generated by the 100 year storm. Note that this assumes that the outlet at CBMH2 is completely blocked with no outflow. A back flow preventer is included at MH2 to prevent potential surcharging from the Sunview Street storm sewer from entering the site.

The rooftop and underground/parking lot stage-storage-discharge calculations are included in Appendix A, and details are provided on the engineering drawings.

The existing and proposed peak flows from the site are summarized in Table 3, and the MIDUSS model output is included in Appendix B.

Table 3: Peak Discharges

RETURN EVENT	EXISTING CONDITIONS	PROPOSED CONDITIONS
	PEAK DISCHARGE (M ³ /S)	PEAK DISCHARGE (M ³ /S)
Draining Toward South		
2 Year	0.013	0.015
5 Year	0.018	0.020
100 Year	0.039	0.032

As indicated in Table 3, the proposed design will result in a slight increase in the 2 and 5 year peak flows from the site, based on a minimum allowable orifice diameter of 50mm at CBMH2. These increases are relatively minor and will not impact the receiving storm sewer on Sunview Street. As summarized in Table 4, events up to the 100 year storm volume (41 m³) will be stored underground to minimize nuisance flooding.

Table 4: Ponding Characteristics

RETURN EVENT	STORAGE VOLUME (M ³)	PONDING DEPTH (M)*	PONDING ELEVATION (M)*
2 Year	11	-	340.00
5 Year	19	-	340.07
100 Year	41	0.00	341.10

* CBMH2 top of grate elevation = 341.10m

4.2 Stormwater Quality Control

A 'Snout' OGS unit will be installed at the outlet of CBMH2 to provide stormwater quality control for flows generated from the parking lot area. The Snout OGS unit is appropriate for this development given the relatively small impervious parking lot Area 206 drainage area (490 m²). Refer to the engineering drawings for locations and details.

The unit should be inspected and cleaned regularly (once every 12 months) as per the manufacturer's specifications.

5 CONCLUSIONS AND RECOMMENDATIONS

This Report demonstrates that stormwater attenuation using rooftop storage, and underground and parking lot surface storage will control peak flows to the required levels for the 2, 5, and 100 year storms. Stormwater quality will be addressed by routing parking areas through Snout OGS units.

We trust the foregoing is satisfactory and will allow you to review and approve the Stormwater Management Report and engineering drawings for this development. If you have any questions or require additional information please contact the undersigned.

All of which is respectfully submitted.

IBI GROUP



Andy Kroess, M.Eng., P.Eng.

Appendix A –Stormwater Calculations

**139419 - 249 Sunview Street, City of Waterloo
Existing and Proposed Drainage Areas**

Existing Areas

Description	Area (ha)	% Impervious
Total Area	0.219	25.7%
Area 100		
Asphalt/Concrete/Building	0.027	
Grass	0.110	
Total	0.137	19.9%
Area 101		
Asphalt/Concrete/Building	0.029	
Grass	0.053	
Total	0.082	35.3%

Proposed Areas

Description	Area (ha)	% Impervious
Total Area	0.219	82.2%
Area 200		
Asphalt/Concrete/Building	0.029	
Grass	0.000	
Total	0.029	100.0%
Area 201		
Asphalt/Concrete/Building	0.037	
Grass	0.000	
Total	0.037	100.0%
Area 202		
Asphalt/Concrete/Building	0.024	
Grass	0.000	
Total	0.024	100.0%
Area 203		
Asphalt/Concrete/Building	0.018	
Grass	0.000	
Total	0.018	100.0%

Area 204		
Asphalt/Concrete/Building	0.019	
Grass	0.010	
Total	0.029	64.9%
Area 205		
Asphalt/Concrete/Building	0.006	
Grass	0.005	
Total	0.011	53.7%
Area 206		
Asphalt/Concrete/Building	0.040	
Grass	0.009	
Total	0.049	82.1%
Area 207		
Asphalt/Concrete/Building	0.000	
Grass	0.002	
Total	0.002	0.0%
Area 208		
Asphalt/Concrete/Building	0.000	
Grass	0.005	
Total	0.005	0.0%
Area 209		
Asphalt/Concrete/Building	0.008	
Grass	0.008	
Total	0.016	50.3%

139419 - 249 Sunview Street, City of Waterloo
Area 200 Roof Stage-Storage-Discharge Relationship

Total Rooftop Area = 294 (m²)
 Number of Roof Drains = 2
 Roof Cell Area = 147.0 (m²)
 The Length of a Cell Side* = 12.12 (m)
 Maximum Ponding Depth = 0.152 (m)
 Total Number of Notches per Drain = 1

Depth	Depth	Base Area	Cell Volume	Total Volume	Notch Discharge**	Total Discharge
(inch)	(m)	(m ²)	(m ³)	(m ³)	(m ³ /s)	(m ³ /s)
0	0.000	0	0.00	0.00	0.00000	0.00000
1	0.025	4.08	0.03	0.07	0.00038	0.00076
2	0.051	16.33	0.28	0.55	0.00076	0.00152
3	0.076	36.75	0.93	1.87	0.00114	0.00228
4	0.102	65.33	2.21	4.43	0.00152	0.00304
5	0.127	102.08	4.32	8.64	0.00190	0.00380
6	0.152	147.00	7.47	14.94	0.00228	0.00456

* - assumed that the cell is square

** - notch discharge given as 0.38 l/s/notch/inch of head

(from Zurn Control-Flo Roof Drainage System Technical Catalogue)

**139419 - 249 Sunview Street, City of Waterloo
Area 201 Roof Stage-Storage-Discharge Relationship**

Total Rooftop Area = 367 (m²)
 Number of Roof Drains = 5
 Roof Cell Area = 73.4 (m²)
 The Length of a Cell Side* = 8.57 (m)
 Maximum Ponding Depth = 0.152 (m)
 Total Number of Notches per Drain = 1

Depth	Depth	Base Area	Cell Volume	Total Volume	Notch Discharge**	Total Discharge
(inch)	(m)	(m ²)	(m ³)	(m ³)	(m ³ /s)	(m ³ /s)
0	0.000	0	0.00	0.00	0.00000	0.00000
1	0.025	2.04	0.02	0.09	0.00038	0.00190
2	0.051	8.16	0.14	0.69	0.00076	0.00380
3	0.076	18.35	0.47	2.33	0.00114	0.00570
4	0.102	32.62	1.10	5.52	0.00152	0.00760
5	0.127	50.97	2.16	10.79	0.00190	0.00950
6	0.152	73.40	3.73	18.64	0.00228	0.01140

* - assumed that the cell is square

** - notch discharge given as 0.38 l/s/notch/inch of head

(from Zurn Control-Flo Roof Drainage System Technical Catalogue)

139419 - 249 Sunview Street, City of Waterloo
Area 202 Roof Stage-Storage-Discharge Relationship

Total Rooftop Area = 244 (m²)
 Number of Roof Drains = 2
 Roof Cell Area = 122.0 (m²)
 The Length of a Cell Side* = 11.05 (m)
 Maximum Ponding Depth = 0.152 (m)
 Total Number of Notches per Drain = 1

Depth	Depth	Base Area	Cell Volume	Total Volume	Notch Discharge**	Total Discharge
(inch)	(m)	(m ²)	(m ³)	(m ³)	(m ³ /s)	(m ³ /s)
0	0.000	0	0.00	0.00	0.00000	0.00000
1	0.025	3.39	0.03	0.06	0.00038	0.00076
2	0.051	13.56	0.23	0.46	0.00076	0.00152
3	0.076	30.50	0.77	1.55	0.00114	0.00228
4	0.102	54.22	1.84	3.67	0.00152	0.00304
5	0.127	84.72	3.59	7.17	0.00190	0.00380
6	0.152	122.00	6.20	12.40	0.00228	0.00456

* - assumed that the cell is square

** - notch discharge given as 0.38 l/s/notch/inch of head

(from Zurn Control-Flo Roof Drainage System Technical Catalogue)

139419 - 249 Sunview Street, City of Waterloo
Area 206 Underground Tank and Surface Stage-Storage-Discharge Relationship

Orifice # 1

Pipe Invert = 339.85 m (@ CBMH2)
 Pipe Radius = 0.0250 m
 Pipe Diameter = 50 mm
 Pipe Centreline = 339.875 m
 Orifice Coefficient = 0.6
 Orifice Area = 0.0019634 m²

Tank # 1 Storage

Tank Invert = 339.87 m
 Tank Obvert = 340.32 m
 Length = 17.29 m
 Width = 5.46 m
 Height = 0.46 m
 Voids = 0.97
 Storage = 91.57 m³/m
 Total Storage = 41.66 m³

L
W
H

Overflow (@ CBMH2 Grate)

Spill Elevation = 341.45 m (spill at property line)
 Weir Length = 2.50 m
 Weir Coefficient = 1.6

Hydraulic Depth (m)	Elevation (m)	Description	Orifice # 1 Flow (m ³ /s)	Weir Flow (m ³ /s)	Total Flow (m ³ /s)	Tank Total Storage (m ³)	Surface Storage (m ³)	Total Storage (m ³)
0.00	339.87	Tank # 1 Invert	0.00000	0.00000	0.00000	0.0	0.0	0.0
0.05	339.92		0.00111	0.00000	0.00111	4.6	0.0	4.6
0.10	339.97		0.00161	0.00000	0.00161	9.2	0.0	9.2
0.15	340.02		0.00199	0.00000	0.00199	13.7	0.0	13.7
0.20	340.07		0.00230	0.00000	0.00230	18.3	0.0	18.3
0.25	340.12		0.00258	0.00000	0.00258	22.9	0.0	22.9
0.30	340.17		0.00283	0.00000	0.00283	27.5	0.0	27.5
0.35	340.22		0.00306	0.00000	0.00306	32.0	0.0	32.0
0.40	340.27		0.00328	0.00000	0.00328	36.6	0.0	36.6
0.45	340.32	Tank #1 Obvert	0.00348	0.00000	0.00348	41.2	0.0	41.2
1.23	341.10	Top of Grate CBMH2 & CB3	0.00577	0.00000	0.00577	41.2	0.0	41.2
1.28	341.15		0.00589	0.00000	0.00589	41.2	0.7	41.9
1.33	341.20		0.00601	0.00000	0.00601	41.2	4.8	46.0
1.38	341.25		0.00612	0.00000	0.00612	41.2	16.9	58.1
1.43	341.30		0.00623	0.00000	0.00623	41.2	36.3	77.5
1.48	341.35		0.00634	0.00000	0.00634	41.2	60.0	101.2
1.53	341.40		0.00644	0.00000	0.00644	41.2	87.6	128.8
1.58	341.45	Spill Elevation	0.00655	0.00000	0.00655	41.2	118.0	159.2
1.63	341.50		0.00665	0.04472	0.05137	41.2	148.9	190.1

Orifice equation: $Q = C_o \times A \times (2 \times g \times h)^{0.5}$

where:

A = orifice area (m²)

g = 9.806 m/s²

h = head above c/l of orifice (m)

L = weir length (m)

H = head above weir (m)

Weir equation: $Q = C_w \times L \times (H)^{3/2}$

Appendix B –MIDUSS Model Output

```

Output File (4.7) 139419R2.OUT opened 2023-10-23 12:45
Units used are defined by G = 9.810
36 960 5.000 are MAXDT MAXHYD & DTMIN values
Licensee: PLANNING INITIATIVES LTD
35 COMMENT
6 line(s) of comment
*****
* 139419 - APARTMENT BUILDING *
* 246 SUNVIEW STREET, CITY OF WATERLOO *
* IBI GROUP *
* OCTOBER 2023 *
*****
35 COMMENT
4 line(s) of comment
*****
* 2 YEAR CHICAGO STORM *
* CITY OF WATERLOO IDF PARAMETERS *
*****
2 STORM
1 1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
1101.000 Coefficient a
9.258 Constant b (min)
.882 Exponent c
.400 Fraction to peak r
180.000 Duration ó 180 min
32.400 mm Total depth
3 IMPERVIOUS
1 Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.013 Manning "n"
98.000 SCS Curve No or C
.100 Ia/S Coefficient
.518 Initial Abstraction
35 COMMENT
3 line(s) of comment
*****
* EXISTING CONDITIONS *
*****
35 COMMENT
3 line(s) of comment
*****
* AREA 101 - EXISTING LOTS DRAINING SOUTH *
*****
4 CATCHMENT
100.000 ID No.ó 99999
.137 Area in hectares
20.000 Length (PERV) metres
2.000 Gradient (%)
19.900 Per cent Impervious
20.000 Length (IMPERV)
.000 %Imp. with Zero Dpth

```

```

        1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
    .250      Manning "n"
66.000      SCS Curve No or C
    .100      Ia/S Coefficient
13.085      Initial Abstraction
        1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
            .006      .000      .000      .000 c.m/s
            .077      .835      .227      C perv/imperv/total
15  ADD RUNOFF
            .006      .006      .000      .000 c.m/s
35  COMMENT
    3      line(s) of comment
    *****
    * AREA 101 - EXISTING LOTS DRAINING SOUTH *
    *****
4  CATCHMENT
101.000      ID No.ó 99999
    .082      Area in hectares
15.000      Length (PERV) metres
    2.000      Gradient (%)
35.300      Per cent Impervious
15.000      Length (IMPERV)
    .000      %Imp. with Zero Dpth
        1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
    .250      Manning "n"
66.000      SCS Curve No or C
    .100      Ia/S Coefficient
13.085      Initial Abstraction
        1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
            .007      .006      .000      .000 c.m/s
            .077      .832      .343      C perv/imperv/total
35  COMMENT
    3      line(s) of comment
    *****
    * TOTAL FLOW SOUTH *
    *****
15  ADD RUNOFF
            .007      .013      .000      .000 c.m/s
14  START
    1      1=Zero; 2=Define
35  COMMENT
    3      line(s) of comment
    *****
    * PROPOSED CONDITIONS *
    *****
35  COMMENT
    3      line(s) of comment
    *****
    * AREA 200 - ROOFTOP AREA *
    *****

```

```

4    CATCHMENT
200.000    ID No.ó 99999
.029      Area in hectares
15.000    Length (PERV) metres
1.000     Gradient (%)
100.000   Per cent Impervious
15.000    Length (IMPERV)
.000      %Imp. with Zero Dpth
1         Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.013      Manning "n"
98.000    SCS Curve No or C
.000      Ia/S Coefficient
.518      Initial Abstraction
1         Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
.006      .000      .000      .000 c.m/s
.835      .835      .835      C perv/imperv/total
15    ADD RUNOFF
.006      .006      .000      .000 c.m/s
35    COMMENT
3        line(s) of comment
*****
* BUILDING ROOFTOP STORAGE *
*****
10    POND
7 Depth - Discharge - Volume sets
.000      .000      .0
.025      .000760      .1
.051      .00152      .6
.076      .00228      1.9
.102      .00304      4.4
.127      .00380      8.6
.152      .00456      14.9
Peak Outflow = .002 c.m/s
Maximum Depth = .083 metres
Maximum Storage = 3. c.m
.006      .006      .002      .000 c.m/s
17    COMBINE
500      Junction Node No.
.006      .006      .002      .002 c.m/s
14    START
1        1=Zero; 2=Define
35    COMMENT
3        line(s) of comment
*****
* AREA 201 - ROOFTOP AREA *
*****
4    CATCHMENT
201.000    ID No.ó 99999
.037      Area in hectares
15.000    Length (PERV) metres

```

```

1.000      Gradient (%)
100.000    Per cent Impervious
15.000     Length (IMPERV)
.000       %Imp. with Zero Dpth
1          Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.013       Manning "n"
98.000     SCS Curve No or C
.000       Ia/S Coefficient
.518       Initial Abstraction
1          Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
.008       .000       .002       .002 c.m/s
.835       .835       .835       C perv/imperv/total
15  ADD RUNOFF
.008       .008       .002       .002 c.m/s
35  COMMENT
3    line(s) of comment
*****
*   BUILDING ROOFTOP STORAGE   *
*****
10  POND
7  Depth - Discharge - Volume sets
.000       .000       .0
.025       .00190     .1
.051       .00380     .7
.076       .00570     2.3
.102       .00760     5.5
.127       .00950     10.8
.152       .0114      18.6
Peak Outflow = .005 c.m/s
Maximum Depth = .066 metres
Maximum Storage = 2. c.m
.008       .008       .005       .002 c.m/s
17  COMBINE
500 Junction Node No.
.008       .008       .005       .007 c.m/s
14  START
1    1=Zero; 2=Define
35  COMMENT
3    line(s) of comment
*****
*   AREA 202 - ROOFTOP AREA   *
*****
4  CATCHMENT
202.000    ID No.ó 99999
.024       Area in hectares
15.000     Length (PERV) metres
1.000      Gradient (%)
100.000    Per cent Impervious
15.000     Length (IMPERV)
.000       %Imp. with Zero Dpth

```

```

1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.013      Manning "n"
98.000      SCS Curve No or C
.000      Ia/S Coefficient
.518      Initial Abstraction
1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
.005      .000      .005      .007 c.m/s
.835      .835      .835      C perv/imperv/total
15      ADD RUNOFF
.005      .005      .005      .007 c.m/s
35      COMMENT
3      line(s) of comment
*****
* BUILDING ROOFTOP STORAGE *
*****
10      POND
7      Depth - Discharge - Volume sets
.000      .000      .0
.025      .000760      .1
.051      .00152      .5
.076      .00228      1.6
.102      .00304      3.7
.127      .00380      7.2
.152      .00456      12.4
Peak Outflow =      .002 c.m/s
Maximum Depth =      .079 metres
Maximum Storage =      2. c.m
.005      .005      .002      .007 c.m/s
17      COMBINE
500      Junction Node No.
.005      .005      .002      .009 c.m/s
14      START
1      1=Zero; 2=Define
35      COMMENT
3      line(s) of comment
*****
* AREA 203 - ROOFTOP AREA *
*****
4      CATCHMENT
203.000      ID No.6 99999
.018      Area in hectares
15.000      Length (PERV) metres
1.000      Gradient (%)
100.000      Per cent Impervious
15.000      Length (IMPERV)
.000      %Imp. with Zero Dpth
1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.013      Manning "n"
98.000      SCS Curve No or C
.000      Ia/S Coefficient

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```

        .518      Initial Abstraction
          1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
            .004      .000      .002      .009 c.m/s
            .835      .835      .835      C perv/imperv/total
15  ADD RUNOFF
            .004      .004      .002      .009 c.m/s
9   ROUTE
            .000      Conduit Length
            .000      No Conduit defined
            .000      Zero lag
            .000      Beta weighting factor
            .000      Routing timestep
            0      No. of sub-reaches
            .004      .004      .004      .009 c.m/s
17  COMBINE
500  Junction Node No.
            .004      .004      .004      .012 c.m/s
14  START
1    1=Zero; 2=Define
35  COMMENT
3    line(s) of comment
    *****
    * AREA 204 *
    *****
4   CATCHMENT
204.000    ID No.ó 99999
    .029    Area in hectares
15.000    Length (PERV) metres
2.000    Gradient (%)
64.900    Per cent Impervious
15.000    Length (IMPERV)
    .000    %Imp. with Zero Dpth
    1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
    .250    Manning "n"
66.000    SCS Curve No or C
    .100    Ia/S Coefficient
13.085    Initial Abstraction
    1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
            .004      .000      .004      .012 c.m/s
            .077      .832      .567      C perv/imperv/total
15  ADD RUNOFF
            .004      .004      .004      .012 c.m/s
35  COMMENT
3    line(s) of comment
    *****
    * AREA 205 *
    *****
4   CATCHMENT
205.000    ID No.ó 99999
    .011    Area in hectares

```

```

10.000    Length (PERV) metres
 2.000    Gradient (%)
53.700    Per cent Impervious
10.000    Length (IMPERV)
 .000     %Imp. with Zero Dpth
   1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
 .250     Manning "n"
66.000    SCS Curve No or C
 .100     Ia/S Coefficient
13.085    Initial Abstraction
   1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
 .001     .004     .004     .012 c.m/s
 .077     .822     .477     C perv/imperv/total
15  ADD RUNOFF
 .001     .006     .004     .012 c.m/s
35  COMMENT
3     line(s) of comment
*****
*   AREA 206   *
*****
4  CATCHMENT
206.000    ID No.ó 99999
 .049     Area in hectares
15.000    Length (PERV) metres
 2.000    Gradient (%)
82.100    Per cent Impervious
15.000    Length (IMPERV)
 .000     %Imp. with Zero Dpth
   1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
 .250     Manning "n"
66.000    SCS Curve No or C
 .100     Ia/S Coefficient
13.085    Initial Abstraction
   1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
 .009     .006     .004     .012 c.m/s
 .077     .832     .697     C perv/imperv/total
15  ADD RUNOFF
 .009     .015     .004     .012 c.m/s
35  COMMENT
3     line(s) of comment
*****
* UNDERGROUND/SURFACE STORAGE *
*****
10  POND
11 Depth - Discharge - Volume sets
 .000     .000     .0
 .100     .00161    9.2
 .200     .00230    18.3
 .300     .00283    27.5
 .450     .00348    41.2

```

	1.230	.00577	41.3	
	1.330	.00601	46.0	
	1.430	.00623	77.5	
	1.530	.00644	128.8	
	1.580	.00655	159.2	
	1.630	.0514	190.1	
	Peak Outflow	=	.002 c.m/s	
	Maximum Depth	=	.125 metres	
	Maximum Storage	=	11. c.m	
	.009	.015	.002	.012 c.m/s
17	COMBINE			
500	Junction Node No.			
	.009	.015	.002	.013 c.m/s
14	START			
	1	1=Zero; 2=Define		
35	COMMENT			
	3	line(s) of comment		

	* AREA 207 *			

4	CATCHMENT			
207.000	ID No.ó	99999		
.002	Area in hectares			
10.000	Length (PERV) metres			
2.000	Gradient (%)			
.000	Per cent Impervious			
10.000	Length (IMPERV)			
.000	%Imp. with Zero Dpth			
1	Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat			
.250	Manning "n"			
66.000	SCS Curve No or C			
.100	Ia/S Coefficient			
13.085	Initial Abstraction			
1	Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv			
.000	.000	.002	.013 c.m/s	
.077	.000	.077	C perv/imperv/total	
15	ADD RUNOFF			
	.000	.000	.002	.013 c.m/s
9	ROUTE			
.000	Conduit Length			
.000	No Conduit defined			
.000	Zero lag			
.000	Beta weighting factor			
.000	Routing timestep			
0	No. of sub-reaches			
.000	.000	.000	.013 c.m/s	
17	COMBINE			
500	Junction Node No.			
	.000	.000	.000	.013 c.m/s
14	START			

```

1      1=Zero; 2=Define
35     COMMENT
3      line(s) of comment
*****
*   AREA 208 *
*****
4      CATCHMENT
208.000    ID No.6 99999
.005      Area in hectares
10.000    Length (PERV) metres
2.000     Gradient (%)
.000      Per cent Impervious
10.000    Length (IMPERV)
.000      %Imp. with Zero Dpth
1         Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.250      Manning "n"
66.000    SCS Curve No or C
.100      Ia/S Coefficient
13.085    Initial Abstraction
1         Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
.000      .000      .000      .013 c.m/s
.077      .000      .077      C perv/imperv/total
15     ADD RUNOFF
.000      .000      .000      .013 c.m/s
9      ROUTE
.000      Conduit Length
.000      No Conduit defined
.000      Zero lag
.000      Beta weighting factor
.000      Routing timestep
0         No. of sub-reaches
.000      .000      .000      .013 c.m/s
17     COMBINE
500      Junction Node No.
.000      .000      .000      .013 c.m/s
35     COMMENT
3      line(s) of comment
*****
*   AREA 209 *
*****
4      CATCHMENT
209.000    ID No.6 99999
.016      Area in hectares
15.000    Length (PERV) metres
2.000     Gradient (%)
50.300    Per cent Impervious
15.000    Length (IMPERV)
.000      %Imp. with Zero Dpth
1         Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.250      Manning "n"

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66.000    SCS Curve No or C
.100      Ia/S Coefficient
13.085    Initial Abstraction
    1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
          .002      .000      .000      .013 c.m/s
          .077      .832      .456      C perv/imperv/total
15  ADD RUNOFF
          .002      .002      .000      .013 c.m/s
    9  ROUTE
          .000      Conduit Length
          .000      No Conduit defined
          .000      Zero lag
          .000      Beta weighting factor
          .000      Routing timestep
          0      No. of sub-reaches
          .002      .002      .002      .013 c.m/s
17  COMBINE
500      Junction Node No.
          .002      .002      .002      .015 c.m/s
35  COMMENT
    3      line(s) of comment
          *****
          * TOTAL FLOW TO SOUTH *
          *****
18  CONFLUENCE
500      Junction Node No.
          .002      .015      .002      .000 c.m/s
14  START
    1      1=Zero; 2=Define
35  COMMENT
    4      line(s) of comment
          *****
          * 5 YEAR CHICAGO STORM *
          * CITY OF WATERLOO IDF PARAMETERS *
          *****
    2  STORM
          1      1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
1755.000  Coefficient a
    12.347  Constant b (min)
          .895  Exponent c
          .400  Fraction to peak r
    180.000  Duration ó 180 min
          47.549 mm Total depth
    3  IMPERVIOUS
          1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
          .013  Manning "n"
    98.000  SCS Curve No or C
          .100  Ia/S Coefficient
          .518  Initial Abstraction
35  COMMENT

```

```

3      line(s) of comment
*****
* EXISTING CONDITIONS *
*****
35    COMMENT
3      line(s) of comment
*****
* AREA 101 - EXISTING LOTS DRAINING SOUTH *
*****
4    CATCHMENT
100.000    ID No.6 99999
   .137    Area in hectares
20.000    Length (PERV) metres
   2.000    Gradient (%)
19.900    Per cent Impervious
20.000    Length (IMPERV)
   .000    %Imp. with Zero Dpth
     1    Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
   .250    Manning "n"
66.000    SCS Curve No or C
   .100    Ia/S Coefficient
13.085    Initial Abstraction
     1    Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
   .009    .000    .002    .000 c.m/s
   .151    .877    .295    C perv/imperv/total
15    ADD RUNOFF
   .009    .009    .002    .000 c.m/s
35    COMMENT
3      line(s) of comment
*****
* AREA 101 - EXISTING LOTS DRAINING SOUTH *
*****
4    CATCHMENT
101.000    ID No.6 99999
   .082    Area in hectares
15.000    Length (PERV) metres
   2.000    Gradient (%)
35.300    Per cent Impervious
15.000    Length (IMPERV)
   .000    %Imp. with Zero Dpth
     1    Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
   .250    Manning "n"
66.000    SCS Curve No or C
   .100    Ia/S Coefficient
13.085    Initial Abstraction
     1    Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
   .009    .009    .002    .000 c.m/s
   .151    .872    .405    C perv/imperv/total
35    COMMENT
3      line(s) of comment

```

```

*****
* TOTAL FLOW SOUTH *
*****
15  ADD RUNOFF
      .009      .018      .002      .000 c.m/s
14  START
1    1=Zero; 2=Define
35  COMMENT
3    line(s) of comment
*****
* PROPOSED CONDITIONS *
*****
35  COMMENT
3    line(s) of comment
*****
* AREA 200 - ROOFTOP AREA *
*****
4    CATCHMENT
200.000 ID No.ó 99999
      .029 Area in hectares
15.000 Length (PERV) metres
1.000 Gradient (%)
100.000 Per cent Impervious
15.000 Length (IMPERV)
      .000 %Imp. with Zero Dpth
1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
      .013 Manning "n"
98.000 SCS Curve No or C
      .000 Ia/S Coefficient
      .518 Initial Abstraction
1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
      .009      .000      .002      .000 c.m/s
      .877      .877      .877      C perv/imperv/total
15  ADD RUNOFF
      .009      .009      .002      .000 c.m/s
35  COMMENT
3    line(s) of comment
*****
* BUILDING ROOFTOP STORAGE *
*****
10  POND
7 Depth - Discharge - Volume sets
      .000      .000      .0
      .025      .000760      .1
      .051      .00152      .6
      .076      .00228      1.9
      .102      .00304      4.4
      .127      .00380      8.6
      .152      .00456      14.9
Peak Outflow = .003 c.m/s

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Maximum Depth = .101 metres
Maximum Storage = 4. c.m
.009 .009 .003 .000 c.m/s
17 COMBINE
500 Junction Node No.
.009 .009 .003 .003 c.m/s
14 START
1 1=Zero; 2=Define
35 COMMENT
3 line(s) of comment
*****
* AREA 201 - ROOFTOP AREA *
*****
4 CATCHMENT
201.000 ID No.ó 99999
.037 Area in hectares
15.000 Length (PERV) metres
1.000 Gradient (%)
100.000 Per cent Impervious
15.000 Length (IMPERV)
.000 %Imp. with Zero Dpth
1 Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.013 Manning "n"
98.000 SCS Curve No or C
.000 Ia/S Coefficient
.518 Initial Abstraction
1 Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
.011 .000 .003 .003 c.m/s
.877 .877 .877 C perv/imperv/total
15 ADD RUNOFF
.011 .011 .003 .003 c.m/s
35 COMMENT
3 line(s) of comment
*****
* BUILDING ROOFTOP STORAGE *
*****
10 POND
7 Depth - Discharge - Volume sets
.000 .000 .0
.025 .00190 .1
.051 .00380 .7
.076 .00570 2.3
.102 .00760 5.5
.127 .00950 10.8
.152 .0114 18.6
Peak Outflow = .006 c.m/s
Maximum Depth = .083 metres
Maximum Storage = 3. c.m
.011 .011 .006 .003 c.m/s
17 COMBINE

```

```

500      Junction Node No.
          .011      .011      .006      .009 c.m/s
14      START
1      1=Zero; 2=Define
35      COMMENT
3      line(s) of comment
          *****
          * AREA 202 - ROOFTOP AREA *
          *****
4      CATCHMENT
202.000      ID No.6 99999
          .024      Area in hectares
15.000      Length (PERV) metres
1.000      Gradient (%)
100.000      Per cent Impervious
15.000      Length (IMPERV)
          .000      %Imp. with Zero Dpth
          1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
          .013      Manning "n"
98.000      SCS Curve No or C
          .000      Ia/S Coefficient
          .518      Initial Abstraction
          1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
          .007      .000      .006      .009 c.m/s
          .877      .877      .877      C perv/imperv/total
15      ADD RUNOFF
          .007      .007      .006      .009 c.m/s
35      COMMENT
3      line(s) of comment
          *****
          * BUILDING ROOFTOP STORAGE *
          *****
10      POND
7 Depth - Discharge - Volume sets
          .000      .000      .0
          .025      .000760      .1
          .051      .00152      .5
          .076      .00228      1.6
          .102      .00304      3.7
          .127      .00380      7.2
          .152      .00456      12.4
          Peak Outflow =      .003 c.m/s
          Maximum Depth =      .096 metres
          Maximum Storage =      3. c.m
          .007      .007      .003      .009 c.m/s
17      COMBINE
500      Junction Node No.
          .007      .007      .003      .012 c.m/s
14      START
1      1=Zero; 2=Define

```

```

35  COMMENT
    3  line(s) of comment
      *****
      *  AREA 203 - ROOFTOP AREA *
      *****
4    CATCHMENT
203.000  ID No.ó 99999
.018    Area in hectares
15.000  Length (PERV) metres
1.000   Gradient (%)
100.000 Per cent Impervious
15.000  Length (IMPERV)
.000    %Imp. with Zero Dpth
1       Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.013    Manning "n"
98.000  SCS Curve No or C
.000    Ia/S Coefficient
.518    Initial Abstraction
1       Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
      .006      .000      .003      .012 c.m/s
      .877      .877      .877      C perv/imperv/total
15  ADD RUNOFF
      .006      .006      .003      .012 c.m/s
9    ROUTE
.000    Conduit Length
.000    No Conduit defined
.000    Zero lag
.000    Beta weighting factor
.000    Routing timestep
0       No. of sub-reaches
      .006      .006      .006      .012 c.m/s
17  COMBINE
500    Junction Node No.
      .006      .006      .006      .016 c.m/s
14  START
1       1=Zero; 2=Define
35  COMMENT
    3  line(s) of comment
      *****
      *  AREA 204 *
      *****
4    CATCHMENT
204.000  ID No.ó 99999
.029    Area in hectares
15.000  Length (PERV) metres
2.000   Gradient (%)
64.900  Per cent Impervious
15.000  Length (IMPERV)
.000    %Imp. with Zero Dpth
1       Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat

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        .250      Manning "n"
66.000      SCS Curve No or C
        .100      Ia/S Coefficient
13.085      Initial Abstraction
        1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
              .006      .000      .006      .016 c.m/s
              .151      .872      .619      C perv/imperv/total
15  ADD RUNOFF
              .006      .006      .006      .016 c.m/s
35  COMMENT
        3      line(s) of comment
        *****
        *   AREA 205   *
        *****
4    CATCHMENT
205.000     ID No.6 99999
        .011     Area in hectares
10.000     Length (PERV) metres
        2.000     Gradient (%)
53.700     Per cent Impervious
10.000     Length (IMPERV)
        .000     %Imp. with Zero Dpth
        1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
        .250     Manning "n"
66.000     SCS Curve No or C
        .100     Ia/S Coefficient
13.085     Initial Abstraction
        1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
              .002      .006      .006      .016 c.m/s
              .151      .858      .530      C perv/imperv/total
15  ADD RUNOFF
              .002      .008      .006      .016 c.m/s
35  COMMENT
        3      line(s) of comment
        *****
        *   AREA 206   *
        *****
4    CATCHMENT
206.000     ID No.6 99999
        .049     Area in hectares
15.000     Length (PERV) metres
        2.000     Gradient (%)
82.100     Per cent Impervious
15.000     Length (IMPERV)
        .000     %Imp. with Zero Dpth
        1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
        .250     Manning "n"
66.000     SCS Curve No or C
        .100     Ia/S Coefficient
13.085     Initial Abstraction

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```

1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
      .013      .008      .006      .016 c.m/s
      .151      .872      .743      C perv/imperv/total
15    ADD RUNOFF
      .013      .020      .006      .016 c.m/s
35    COMMENT
3      line(s) of comment
      *****
      * UNDERGROUND/SURFACE STORAGE *
      *****
10    POND
11    Depth - Discharge - Volume sets
      .000      .000      .0
      .100      .00161      9.2
      .200      .00230      18.3
      .300      .00283      27.5
      .450      .00348      41.2
      1.230      .00577      41.3
      1.330      .00601      46.0
      1.430      .00623      77.5
      1.530      .00644      128.8
      1.580      .00655      159.2
      1.630      .0514      190.1
      Peak Outflow =      .002 c.m/s
      Maximum Depth =      .204 metres
      Maximum Storage =      19. c.m
      .013      .020      .002      .016 c.m/s
17    COMBINE
500    Junction Node No.
      .013      .020      .002      .018 c.m/s
14    START
1      1=Zero; 2=Define
35    COMMENT
3      line(s) of comment
      *****
      * AREA 207 *
      *****
4      CATCHMENT
207.000    ID No.ó 99999
      .002    Area in hectares
10.000    Length (PERV) metres
2.000    Gradient (%)
      .000    Per cent Impervious
10.000    Length (IMPERV)
      .000    %Imp. with Zero Dpth
      1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
      .250    Manning "n"
66.000    SCS Curve No or C
      .100    Ia/S Coefficient
13.085    Initial Abstraction

```

```

1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
      .000      .000      .002      .018 c.m/s
      .151      .000      .151      C perv/imperv/total
15    ADD RUNOFF
      .000      .000      .002      .018 c.m/s
9      ROUTE
      .000      Conduit Length
      .000      No Conduit defined
      .000      Zero lag
      .000      Beta weighting factor
      .000      Routing timestep
      0      No. of sub-reaches
      .000      .000      .000      .018 c.m/s
17    COMBINE
500    Junction Node No.
      .000      .000      .000      .018 c.m/s
14    START
1      1=Zero; 2=Define
35    COMMENT
3      line(s) of comment
      *****
      * AREA 208 *
      *****
4      CATCHMENT
208.000    ID No.6 99999
      .005    Area in hectares
10.000    Length (PERV) metres
2.000    Gradient (%)
      .000    Per cent Impervious
10.000    Length (IMPERV)
      .000    %Imp. with Zero Dpth
      1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
      .250    Manning "n"
66.000    SCS Curve No or C
      .100    Ia/S Coefficient
13.085    Initial Abstraction
      1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
      .000      .000      .000      .018 c.m/s
      .151      .000      .151      C perv/imperv/total
15    ADD RUNOFF
      .000      .000      .000      .018 c.m/s
9      ROUTE
      .000      Conduit Length
      .000      No Conduit defined
      .000      Zero lag
      .000      Beta weighting factor
      .000      Routing timestep
      0      No. of sub-reaches
      .000      .000      .000      .018 c.m/s
17    COMBINE

```

```

500      Junction Node No.
          .000      .000      .000      .018 c.m/s
35      COMMENT
          3      line(s) of comment
          *****
          *      AREA 209      *
          *****
4      CATCHMENT
209.000      ID No.6 99999
          .016      Area in hectares
15.000      Length (PERV) metres
          2.000      Gradient (%)
50.300      Per cent Impervious
15.000      Length (IMPERV)
          .000      %Imp. with Zero Dpth
          1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
          .250      Manning "n"
66.000      SCS Curve No or C
          .100      Ia/S Coefficient
13.085      Initial Abstraction
          1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
          .003      .000      .000      .018 c.m/s
          .151      .872      .514      C perv/imperv/total
15      ADD RUNOFF
          .003      .003      .000      .018 c.m/s
9      ROUTE
          .000      Conduit Length
          .000      No Conduit defined
          .000      Zero lag
          .000      Beta weighting factor
          .000      Routing timestep
          0      No. of sub-reaches
          .003      .003      .003      .018 c.m/s
17      COMBINE
500      Junction Node No.
          .003      .003      .003      .020 c.m/s
35      COMMENT
          3      line(s) of comment
          *****
          *      TOTAL FLOW TO SOUTH      *
          *****
18      CONFLUENCE
500      Junction Node No.
          .003      .020      .003      .000 c.m/s
14      START
          1      1=Zero; 2=Define
35      COMMENT
          4      line(s) of comment
          *****
          *      100 YEAR CHICAGO STORM      *

```

```

* CITY OF WATERLOO IDF PARAMETERS *
*****

2  STORM
    1      1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
4692.000  Coefficient a
17.437    Constant b (min)
.956      Exponent c
.400      Fraction to peak r
180.000   Duration ó 180 min
          89.960 mm      Total depth

3  IMPERVIOUS
    1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.013      Manning "n"
98.000    SCS Curve No or C
.100      Ia/S Coefficient
.518      Initial Abstraction

35 COMMENT
3  line(s) of comment
*****
* EXISTING CONDITIONS *
*****

35 COMMENT
3  line(s) of comment
*****
* AREA 101 - EXISTING LOTS DRAINING SOUTH *
*****

4  CATCHMENT
100.000   ID No.ó 99999
.137      Area in hectares
20.000    Length (PERV) metres
2.000     Gradient (%)
19.900    Per cent Impervious
20.000    Length (IMPERV)
.000      %Imp. with Zero Dpth
    1      Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.250      Manning "n"
66.000    SCS Curve No or C
.100      Ia/S Coefficient
13.085    Initial Abstraction
    1      Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
          .022      .000      .003      .000 c.m/s
          .316      .917      .435      C perv/imperv/total

15 ADD RUNOFF
          .022      .022      .003      .000 c.m/s

35 COMMENT
3  line(s) of comment
*****
* AREA 101 - EXISTING LOTS DRAINING SOUTH *
*****

4  CATCHMENT

```

```

101.000    ID No.ó 99999
.082      Area in hectares
15.000    Length (PERV) metres
2.000     Gradient (%)
35.300    Per cent Impervious
15.000    Length (IMPERV)
.000      %Imp. with Zero Dpth
1         Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.250      Manning "n"
66.000    SCS Curve No or C
.100      Ia/S Coefficient
13.085    Initial Abstraction
1         Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
.019      .022      .003      .000 c.m/s
.314      .906      .523      C perv/imperv/total
35  COMMENT
3         line(s) of comment
*****
* TOTAL FLOW SOUTH *
*****
15  ADD RUNOFF
.019      .039      .003      .000 c.m/s
14  START
1         1=Zero; 2=Define
35  COMMENT
3         line(s) of comment
*****
* PROPOSED CONDITIONS *
*****
35  COMMENT
3         line(s) of comment
*****
* AREA 200 - ROOFTOP AREA *
*****
4  CATCHMENT
200.000    ID No.ó 99999
.029      Area in hectares
15.000    Length (PERV) metres
1.000     Gradient (%)
100.000    Per cent Impervious
15.000    Length (IMPERV)
.000      %Imp. with Zero Dpth
1         Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.013      Manning "n"
98.000    SCS Curve No or C
.000      Ia/S Coefficient
.518      Initial Abstraction
1         Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
.017      .000      .003      .000 c.m/s
.919      .919      .919      C perv/imperv/total

```

```

15  ADD RUNOFF
    .017      .017      .003      .000 c.m/s
35  COMMENT
3    line(s) of comment
    *****
    * BUILDING ROOFTOP STORAGE *
    *****
10  POND
7  Depth - Discharge - Volume sets
    .000      .000      .0
    .025      .000760    .1
    .051      .00152    .6
    .076      .00228    1.9
    .102      .00304    4.4
    .127      .00380    8.6
    .152      .00456    14.9
    Peak Outflow =      .004 c.m/s
    Maximum Depth =      .136 metres
    Maximum Storage =      11. c.m
    .017      .017      .004      .000 c.m/s
17  COMBINE
500 Junction Node No.
    .017      .017      .004      .004 c.m/s
14  START
1    1=Zero; 2=Define
35  COMMENT
3    line(s) of comment
    *****
    * AREA 201 - ROOFTOP AREA *
    *****
4  CATCHMENT
201.000 ID No.6 99999
    .037 Area in hectares
15.000 Length (PERV) metres
1.000 Gradient (%)
100.000 Per cent Impervious
15.000 Length (IMPERV)
    .000 %Imp. with Zero Dpth
    1 Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
    .013 Manning "n"
98.000 SCS Curve No or C
    .000 Ia/S Coefficient
    .518 Initial Abstraction
    1 Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
    .021      .000      .004      .004 c.m/s
    .919      .919      .919      C perv/imperv/total
15  ADD RUNOFF
    .021      .021      .004      .004 c.m/s
35  COMMENT
3    line(s) of comment

```

```

*****
* BUILDING ROOFTOP STORAGE *
*****

10  POND
    7 Depth - Discharge - Volume sets
      .000      .000      .0
      .025      .00190    .1
      .051      .00380    .7
      .076      .00570    2.3
      .102      .00760    5.5
      .127      .00950   10.8
      .152      .0114    18.6
    Peak Outflow =      .009 c.m/s
    Maximum Depth =     .118 metres
    Maximum Storage =      9. c.m
      .021      .021      .009      .004 c.m/s

17  COMBINE
    500 Junction Node No.
      .021      .021      .009      .013 c.m/s

14  START
    1 1=Zero; 2=Define
35  COMMENT
    3 line(s) of comment
      *****
      * AREA 202 - ROOFTOP AREA *
      *****

4  CATCHMENT
    202.000 ID No.6 99999
      .024 Area in hectares
    15.000 Length (PERV) metres
      1.000 Gradient (%)
    100.000 Per cent Impervious
      15.000 Length (IMPERV)
      .000 %Imp. with Zero Dpth
      1 Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
      .013 Manning "n"
    98.000 SCS Curve No or C
      .000 Ia/S Coefficient
      .518 Initial Abstraction
      1 Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
      .014      .000      .009      .013 c.m/s
      .919      .919      .919      C perv/imperv/total

15  ADD RUNOFF
      .014      .014      .009      .013 c.m/s

35  COMMENT
    3 line(s) of comment
      *****
      * BUILDING ROOFTOP STORAGE *
      *****

10  POND

```

```

7 Depth - Discharge - Volume sets
    .000      .000      .0
    .025      .000760    .1
    .051      .00152     .5
    .076      .00228     1.6
    .102      .00304     3.7
    .127      .00380     7.2
    .152      .00456    12.4
Peak Outflow      =      .004 c.m/s
Maximum Depth      =      .132 metres
Maximum Storage    =      8. c.m
    .014      .014      .004      .013 c.m/s
17  COMBINE
500  Junction Node No.
    .014      .014      .004      .017 c.m/s
14  START
1    1=Zero; 2=Define
35  COMMENT
3    line(s) of comment
*****
*   AREA 203 - ROOFTOP AREA *
*****
4    CATCHMENT
203.000    ID No.ó 99999
    .018    Area in hectares
15.000    Length (PERV) metres
1.000    Gradient (%)
100.000    Per cent Impervious
15.000    Length (IMPERV)
    .000    %Imp. with Zero Dpth
    1    Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
    .013    Manning "n"
98.000    SCS Curve No or C
    .000    Ia/S Coefficient
    .518    Initial Abstraction
    1    Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
    .010      .000      .004      .017 c.m/s
    .919      .919      .919      C perv/imperv/total
15  ADD RUNOFF
    .010      .010      .004      .017 c.m/s
9    ROUTE
    .000    Conduit Length
    .000    No Conduit defined
    .000    Zero lag
    .000    Beta weighting factor
    .000    Routing timestep
    0    No. of sub-reaches
    .010      .010      .010      .017 c.m/s
17  COMBINE
500  Junction Node No.

```

```

      .010      .010      .010      .023 c.m/s
14  START
1    1=Zero; 2=Define
35  COMMENT
3    line(s) of comment
      *****
      * AREA 204 *
      *****
4    CATCHMENT
204.000    ID No.ó 99999
      .029    Area in hectares
15.000    Length (PERV) metres
2.000    Gradient (%)
64.900    Per cent Impervious
15.000    Length (IMPERV)
      .000    %Imp. with Zero Dpth
      1    Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
      .250    Manning "n"
66.000    SCS Curve No or C
      .100    Ia/S Coefficient
13.085    Initial Abstraction
      1    Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
      .011      .000      .010      .023 c.m/s
      .314      .906      .698      C perv/imperv/total
15  ADD RUNOFF
      .011      .011      .010      .023 c.m/s
35  COMMENT
3    line(s) of comment
      *****
      * AREA 205 *
      *****
4    CATCHMENT
205.000    ID No.ó 99999
      .011    Area in hectares
10.000    Length (PERV) metres
2.000    Gradient (%)
53.700    Per cent Impervious
10.000    Length (IMPERV)
      .000    %Imp. with Zero Dpth
      1    Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
      .250    Manning "n"
66.000    SCS Curve No or C
      .100    Ia/S Coefficient
13.085    Initial Abstraction
      1    Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
      .004      .011      .010      .023 c.m/s
      .314      .884      .620      C perv/imperv/total
15  ADD RUNOFF
      .004      .015      .010      .023 c.m/s
35  COMMENT

```

```

3      line(s) of comment
*****
*   AREA 206   *
*****
4      CATCHMENT
206.000      ID No.6 99999
.049         Area in hectares
15.000       Length (PERV) metres
2.000        Gradient (%)
82.100       Per cent Impervious
15.000       Length (IMPERV)
.000         %Imp. with Zero Dpth
1           Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.250         Manning "n"
66.000       SCS Curve No or C
.100         Ia/S Coefficient
13.085       Initial Abstraction
1           Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
.024         .015         .010         .023 c.m/s
.314         .906         .800         C perv/imperv/total
15      ADD RUNOFF
.024         .038         .010         .023 c.m/s
35      COMMENT
3      line(s) of comment
*****
*   UNDERGROUND/SURFACE STORAGE   *
*****
10      POND
11      Depth - Discharge - Volume sets
.000         .000         .0
.100         .00161        9.2
.200         .00230       18.3
.300         .00283       27.5
.450         .00348       41.2
1.230        .00577       41.3
1.330        .00601       46.0
1.430        .00623       77.5
1.530        .00644      128.8
1.580        .00655      159.2
1.630        .0514       190.1
Peak Outflow   =         .006 c.m/s
Maximum Depth  =         1.232 metres
Maximum Storage =         41. c.m
.024         .038         .006         .023 c.m/s
17      COMBINE
500      Junction Node No.
.024         .038         .006         .026 c.m/s
14      START
1         1=Zero; 2=Define
35      COMMENT

```

```

3      line(s) of comment
*****
*   AREA 207 *
*****
4      CATCHMENT
207.000      ID No.6 99999
.002         Area in hectares
10.000       Length (PERV) metres
2.000        Gradient (%)
.000         Per cent Impervious
10.000       Length (IMPERV)
.000         %Imp. with Zero Dpth
1           Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.250         Manning "n"
66.000       SCS Curve No or C
.100         Ia/S Coefficient
13.085       Initial Abstraction
1           Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
.000         .000         .006         .026 c.m/s
.314         .000         .314         C perv/imperv/total
15      ADD RUNOFF
.000         .000         .006         .026 c.m/s
9      ROUTE
.000         Conduit Length
.000         No Conduit defined
.000         Zero lag
.000         Beta weighting factor
.000         Routing timestep
0           No. of sub-reaches
.000         .000         .000         .026 c.m/s
17     COMBINE
500       Junction Node No.
.000         .000         .000         .026 c.m/s
14     START
1         1=Zero; 2=Define
35     COMMENT
3      line(s) of comment
*****
*   AREA 208 *
*****
4      CATCHMENT
208.000      ID No.6 99999
.005         Area in hectares
10.000       Length (PERV) metres
2.000        Gradient (%)
.000         Per cent Impervious
10.000       Length (IMPERV)
.000         %Imp. with Zero Dpth
1           Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
.250         Manning "n"

```

	66.000	SCS Curve No or C		
	.100	Ia/S Coefficient		
	13.085	Initial Abstraction		
	1	Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv		
		.001	.000	.000 .026 c.m/s
		.314	.000	.314 C perv/imperv/total
15	ADD RUNOFF			
		.001	.001	.000 .026 c.m/s
9	ROUTE			
	.000	Conduit Length		
	.000	No Conduit defined		
	.000	Zero lag		
	.000	Beta weighting factor		
	.000	Routing timestep		
	0	No. of sub-reaches		
		.001	.001	.001 .026 c.m/s
17	COMBINE			
	500	Junction Node No.		
		.001	.001	.001 .027 c.m/s
35	COMMENT			
	3	line(s) of comment		

		* AREA 209 *		

4	CATCHMENT			
	209.000	ID No.ó 99999		
	.016	Area in hectares		
	15.000	Length (PERV) metres		
	2.000	Gradient (%)		
	50.300	Per cent Impervious		
	15.000	Length (IMPERV)		
	.000	%Imp. with Zero Dpth		
	1	Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat		
	.250	Manning "n"		
	66.000	SCS Curve No or C		
	.100	Ia/S Coefficient		
	13.085	Initial Abstraction		
	1	Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv		
		.005	.001	.001 .027 c.m/s
		.314	.906	.612 C perv/imperv/total
15	ADD RUNOFF			
		.005	.005	.001 .027 c.m/s
9	ROUTE			
	.000	Conduit Length		
	.000	No Conduit defined		
	.000	Zero lag		
	.000	Beta weighting factor		
	.000	Routing timestep		
	0	No. of sub-reaches		
		.005	.005	.005 .027 c.m/s

17	COMBINE				
	500	Junction Node No.			
		.005	.005	.005	.032 c.m/s
35	COMMENT				
	3	line(s) of comment			

		* TOTAL FLOW TO SOUTH *			

18	CONFLUENCE				
	500	Junction Node No.			
		.005	.032	.005	.000 c.m/s
20	MANUAL				

Appendix C – Geotechnical Investigation



CHUNG & VANDER DOELEN
ENGINEERING LTD.

GEOTECHNICAL INVESTIGATION
PROPOSED TWELVE - STOREY APARTMENT BUILDING
249, 251 and 253 SUNVIEW STREET
WATERLOO, ONTARIO

Submitted to:
SAC Developments
802 Cedar Bend Place
Waterloo, Ontario
N2V 2R7

Attention:
Mr. Jim Gao



**CHUNG & VANDER DOELEN
ENGINEERING LTD.**

311 VICTORIA STREET NORTH
KITCHENER / ONTARIO / N2H 5E1
519-742-8979

November 27, 2015

FILE NO.: G15182

SAC Developments
802 Cedar Bend Place
Waterloo, Ontario
N2V 2R7

Attention: Mr. Jim Gao

**Re: GEOTECHNICAL INVESTIGATION
PROPOSED 12-STOREY APARTMENT BUILDING
249, 251 and 253 SUNVIEW STREET
WATERLOO, ONTARIO**

We take pleasure in enclosing two (2) copies of our Geotechnical Investigation Report carried out at the above-referenced Site.

If you have any questions or clarifications are required, please contact the undersigned at your convenience. We thank you for giving us this opportunity to be of service to you.

Yours truly,
CHUNG & VANDER DOELEN ENGINEERING LTD.

Eric Y. Chung, M. Eng., P. Eng.
Principal Engineer

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LIST OF ENCLOSURES

Appendix "A"	Statement of Limitations
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Drawing No. 1	Borehole Location Plan



1.0 INTRODUCTION

CHUNG & VANDER DOELEN ENGINEERING LTD. (CVD) has been retained by SAC Developments to conduct a geotechnical investigation for a proposed 12-Storey Apartment Building at 249, 251 and 253 Sunview Street, Waterloo, Ontario.

The ±0.21 ha site is located on the west side of Sunview Street and consists of three (3) residences which are presently used for student housing. It is understood that the proposed development will consist of a twelve (12)-storey apartment building to be constructed with a slab on grade that will include at grade parking spots. Site grading and finished floor levels of the building were not established at the time of reporting.

The purpose of the investigation was to determine the subsurface conditions at the site and, based on the findings, make geotechnical recommendations for the design and construction of the foundations, excavation, asphalt pavement and floor slabs areas. Estimates of infiltration rates of the various soil deposits encountered at the site for the potential design of storm water management features are also provided.

2.0 FIELD WORK

Seven (7) boreholes were drilled and sampled to depths between 3.5 and 9.6 m below existing grades in order to investigate the subsurface conditions at the site. The locations of the boreholes are shown on Drawing No. 1, appended.

The field work for this project was conducted on November 23 and 24, 2015 under the supervision of a member of our engineering staff who logged the boreholes in the field, effected the subsurface sampling and monitored the groundwater conditions.

The boreholes were advanced to the sampling depths using a power auger drilling rig equipped with continuous flight augers and standard soil sampling equipment. Standard penetration tests (SPTs) in accordance with ASTM Specification D1586, were carried out at frequent intervals of depth, and the results are shown on the Borehole Logs as Penetration Resistance or "N"-values. Dynamic Cone penetration tests were conducted at Borehole 3 to confirm the compactness condition of the silty sand stratum. The compactness condition or consistency of the soil strata has been inferred from these test results.



Soil samples obtained from the in situ tests were examined in the field and subsequently brought to our laboratory for tactile examination. Moisture content determination of all retrieved samples occurred. In addition, three (3) grain size distribution analyses were carried out on representative soil samples of the major soil deposits to establish the physical properties.

Four (4) soil samples were submitted to ALS Laboratory Group of Waterloo, Ontario. Two (2) of the soil samples were submitted for analysis of selected metals and two (2) of the samples were submitted for analysis of petroleum hydrocarbons (PHCs F2 - F4). This testing was conducted to assess the environmental quality of excess soils which may be removed off-site during construction. This will be reported on separately, when results are available.

The groundwater condition was monitored during and at completion of the sampling of each borehole. The boreholes were backfilled in accordance with Ontario Regulation 903 at completion of the field work program.

The locations of the boreholes were established in the field by CVD. The ground surface elevations at the boreholes were surveyed by CVD and were referenced to a temporary benchmark (TBM) which is shown on Drawing No. 1 and described below:

TBM: Top of Manhole on Sunview Street, as illustrated on Drawing No. 1
Elevation: 341.17 m (Geodetic)

3.0 EXISTING SITE CONDITIONS

The ±0.21 ha site is located on the west side of Sunview Street and consists of the three (3) residences. These three residences have asphalt driveways and are landscaped with trees, bushes, grass and concrete patios. Apartment buildings have been constructed on the properties to the north and south of the site.

The site has a topographical relief in the order of 3.0 m, but each property is relatively flat from front to rear. Elevations at the borehole locations vary between 344.63 and 341.63 m. Elevations were higher at the northeast corner and lower along the south edge of the property. Front yard drainage is from the houses to the Sunview Street property line.



4.0 SUBSURFACE CONDITIONS

The subsurface conditions encountered at the boreholes are detailed on the Borehole Log Sheets, Enclosures 1 to 7. The following notes are intended to amplify and comment on the subsurface data.

4.1 Topsoil, Fill

Topsoil was encountered at the boreholes with measured thicknesses varying between 150 and 200 mm.

Fill materials that generally comprised brown to dark brown silt to silt and sand with traces of gravel and topsoil, were encountered at Boreholes 1 to 5 and extended to depths of 1.50 m to 2.29 m below existing grades.

Standard Penetration testing within the fill yielded "N"-values from 3 to 18 blows per 300 mm, indicating a variable very loose to compact compactness condition. Natural moisture contents were measured in the range of 4 to 22%, indicative of a damp to moist moisture condition.

4.2 Sandy Silt to Sand and Silt

At Boreholes 1, 6 and 7, a layer of sandy silt to sand and silt soil was encountered to depths of 2.13 to 5.80 m depth. Two (2) grain size distribution analyses were conducted on representative samples obtained from Boreholes 1 and 6, and the results are graphically illustrated on Enclosure 8 of this report.

Standard penetration testing within the sand deposit yielded "N"-values of 3 to 48 blows per 300 mm, thus indicating variable very loose to dense compactness condition. Natural moisture content was measured at 2 to 13%, indicative of damp to moist moisture conditions.

4.3 Silty Sand

The above described soils were underlain by a major deposit of silty sand which extended to the full extent of the investigation at the boreholes. The silty sand also contained occasional silt seams. One (1) grain size distribution analysis was conducted on a representative sample obtained from Borehole 7 and the results are graphically illustrated on Enclosure 8 of this report.

Standard penetration testing and dynamic cone penetration testing within the silty sand yielded "N"-values between 5 and 56 blows per 300 mm, thus indicating generally compact to dense compactness



conditions. Loose layers were encountered in the upper stratum at Boreholes 3 and 4 and extended to depths of 5.0 (338.17 m) and 3.5 m (elevation 338.13 m), respectively.

Natural moisture content was measured between 26 and 23%, indicative of damp to saturated moisture conditions.

4.4 Groundwater Condition

The groundwater conditions were monitored during and following completion of the borehole sampling. Boreholes 1, 2, 3, 4 and 5 reported water level at completion of sampling at depths between 6.9 and 8.5 m (elevations of 334.73 to 336.49 m).

There were no free water and cave-in on removal of augers from the shallower Boreholes 6 and 7. Tactile examination and the natural moisture contents of the retrieved soil samples indicate that the silty sand deposit became wet at depths between 4.5 and 6.0 m.

Based on the above observations, the groundwater table is considered to lie at depths greater than 6 m below ground surface.

It should be cautioned that the groundwater table will fluctuate in response to major weather events. Seasonal fluctuations of the groundwater table are to be expected.



5.0 DISCUSSION AND RECOMMENDATIONS

It is understood that the proposed development will consist of a twelve (12)-storey apartment building to be constructed with a slab on grade that will include at grade parking spots. Site grading and finished floor levels of the building were not established at the time of reporting.

5.1 Foundations

The native compact to dense sandy silt to silty sand deposits are considered competent to support the proposed development with conventional spread and strip footing foundations.

The footings can be designed using a Geotechnical Reaction at SLS of 200 kPa (4,000 psf). The SLS value given above is based on a maximum settlement of 25 mm. The Factored Geotechnical Resistance at ULS is 300 kPa (6,000 psf). These soil bearing pressures can be achieved provided that the founding subgrade is undisturbed during construction. The majority of the settlements will take place during construction and the first loading cycle of the building.

The following table summarizes the recommended highest footing founding depth and elevation at each borehole location:

Borehole No.	Elevation of Borehole (m)	Highest Depth Below Existing Grade (m)	Highest Bearing Elevation (m)
1	344.39	1.99	342.40
2	344.63	2.73	341.90
3	343.17	5.07	338.10
4	341.63	3.63	338.00
5	342.23	1.73	340.50

Footings must be founded below the existing building foundations, trench backfill, any existing fill and loose native soils. Spacing between adjacent footing steps should not be steeper than 10 horizontal to 7 vertical.

Footings in unheated portions of the building should be provided with a soil cover of not less than 1.2 m or equivalent synthetic thermal insulation for adequate frost protection. The subgrade soils must be protected from frost penetration during winter construction.



It is recommended that the footing excavations be inspected by the geotechnical engineer to ensure adequate soil bearing and proper subgrade preparation.

5.2 Engineered Fill

Deeper/thicker fill and loose native silty sand layers were encountered at the boreholes. The basements of the existing homes may be deeper than the proposed underside of footings of the proposed 12- storey apartment building.

Removal of all fill and any loose native soil and constructing engineered fill could prove to be an effective and economical method to repair poor bearing soil areas to provide suitable bearing at more desirable elevations. The engineered fill would require to be monitored during its construction.

The engineered fill is to be constructed in accordance with the following procedures in order to support the future building structures:

1. All existing topsoil, fill, previous structure remnants and otherwise deleterious materials are to be excavated/removed to expose the underlying native sand subgrade soils;
2. The exposed subgrade surface is to be thoroughly recompactd by large heavy compaction equipment (10 tonne recommended) and inspected by qualified geotechnical personnel. Any loose or soft areas identified should be excavated to the level of competent soil;
3. The required grades can then be achieved by placing approved on-site excavated soil or imported granular materials (OPSS Granular "B") in maximum 300 mm thick lifts and compacted to no less than 100% Standard Proctor maximum dry density (SPMDD);
4. Engineered fill must be placed such that the fill pad extends horizontally outwards from all footings/foundation at least the same distance as how thick the engineered fill pad will exist between the underside of future footings and the approved native subgrade;
5. All fill placement and compaction operations must be supervised on a full-time basis by qualified geotechnical personnel to approve fill material and ensure the specified degree of compaction has been achieved.

Foundations supported on approved engineered fill constructed in accordance with the procedures given above can be designed to 200 kPa at SLS and 300 kPa at ULS.



5.2 Earthquake Consideration

In accordance with The Ontario Building Code 2012 (OBC), the proposed structure should be designed to resist earthquake load and effects as per OBC Subsection 4.1.8.

Based on the soils condition encountered at the boreholes and our experience with the top 30 m of soil condition in the general area of the site, the site can be classified as a Site Class D as per OBC Table 4.1.8.4.A (Page B24).

5.3 Construction and Groundwater Control

Excavation across the site is anticipated to extend to depth of 3 to 5 m below existing ground surface. Locally deeper excavation at elevator pits are anticipated. The excavations can generally be carried out using open cut with side slopes of 1H :1V throughout.

The excavations will penetrate the very loose to compact fill and loose to compact sands or silts. These soils are considered to be Type 3 Soils in accordance with the latest Occupational Health and Safety Act.

Excavations in the Type 3 soils are expected to remain stable during the construction period provided that side slopes are cut to 1H : 1V throughout and the groundwater is adequately controlled. The slope surface should be suitably protected from erosion processes.

Groundwater is not expected to be encountered within the anticipated depth of excavations. However, minor seepage possibly from perched water within the upper fill materials can occur randomly across the site. Any surface water runoff and minor seepage into the excavations may be handled by conventional sump pumping techniques, as and where required. The sump pits should be filtered.

5.4 Floor Slab Construction

The floor slab(s) for the proposed building structure can be constructed as conventional slab-on-grade. The boreholes indicate that soils exposed at the subgrade elevation level could be very loose to compact fill composed of native sands and silts. Very loose fill with topsoil or materials which have become overly wet are not considered suitable subgrade materials for the support of slab-on-grade concrete floor and should be removed, then replaced with granular fill which should be compacted to at least 95% SPMDD.

The footing excavations and any trenches can be backfilled with selected excavated materials (sands and silts) which should be placed in thin lifts (200 mm thick) and compacted to at least 95% SPMDD.



The exposed subgrade should be proof-rolled with a heavy roller in conjunction with an inspection by the geotechnical engineer at the time of floor slab construction. Any soft and/or unstable areas detected should be replaced with granular fill which should be compacted to at least 95% SPMDD.

Following the proof-rolling of the subgrade, it is recommended that a minimum 150 mm thick layer of OPSS Granular "A" be placed and compacted to at least 100% SPMDD beneath the concrete floor slabs to provide uniform support. Alternatively, suitably densified 19 mm clear crushed stone can be used.

A modulus of subgrade reaction (k_s) of 40 MN/m³ may be used for the design of the floor slabs, assuming a sandy silt subgrade.

The floor slabs should be separated structurally from the columns and foundation walls. Sawcut control joints should be provided at regular spacing (less than 30 times the concrete slab thickness) and to depths between one-third to one-quarter of the slab thickness.

Installation of footing drains, damp-proofing or water-proofing the below grade foundation walls are recommended.

5.5 Lateral Earth Pressure

The below grade walls and any other soil retaining structures should be designed to resist the lateral earth pressure acting against these walls. The following formula may be used to calculate the unfactored earth pressure distribution. The factored resistance can be calculated by using a factor of 0.8.

$$P = K(\gamma H + q)$$

where:

P =	lateral earth pressure	kPa
K =	earth pressure coefficient, 0.5 for non-yielding foundation wall earth pressure coefficient, 0.3 for yielding retaining wall	
γ =	unit weight of granular backfill, compacted to 95% SPMDD	21 kN/m ³
H =	unbalanced height of wall	m
q =	surcharge load at ground surface	kPa



The backfill for the foundation walls and retaining walls should be free-draining granular materials which should have less than 8% silt particles (OPSS Granular "B" Type 1). The backfill should be placed in thin layers and compacted to 95% SPMDD. Over-compaction should be avoided. Weeping tiles or weep holes should be installed to effect drainage behind the retaining wall.

The sliding resistance of the footings should be checked. The unfactored horizontal resistance against sliding between concrete and the undisturbed native sands and silts can be calculated using a friction coefficient of 0.35. The unit weight of the native sands and silts deposit is 20 kN/m^3 , and a unit weight of 21 kN/m^3 for the granular backfill compacted to 95% SPMDD.

5.6 Pavement Design and Construction

Based on the results of the field work, the predominant subgrade material at the site is expected to consist of sandy silt materials. The following flexible pavement structures are recommended based on assumed CBR values, groundwater table, frost susceptibility of subgrade soils and traffic volume.

Component	Light Duty Pavement (mm)	Heavy Duty Pavement (mm)
Asphaltic Concrete		
HL3	40	40
HL8	40	50
Granular "A" Base	150	150
Granular "B" Sub-base	250	300

The pavement design considers that pavement construction will be carried out during the drier time of the year and that the subgrade is stable, not heaving under construction equipment traffic. If the subgrade is wet or unstable, additional granular sub-base may be required.

The base and sub-base materials should be produced in accordance with the current OPSS specifications, and placed and uniformly compacted to at least 100% SPMDD. The asphaltic concrete should be placed and compacted in accordance with OPSS Form 310 and to at least 92% of the Marshall Density (MRD). Frequent in situ density testing by this office should be carried out to verify that the specified degree of compaction is being achieved and maintained.



It should be noted that even well compacted trench backfill could settle for a period of time after construction. In this regard, the surface course of the asphaltic concrete should be placed at least one (1) year after trench backfill is completed so as to allow any minor settlements to occur within the trench backfill. The incomplete pavement structure may not be capable of supporting construction traffic. Consequently, minor repairs of the sub-base, base and asphaltic concrete may be required prior to paving with the base course and/or the surface course asphaltic concrete.

The prepared earth subgrade and final pavement surfaces should be graded to direct water runoff away from buildings, sidewalks and other similar pertinent structures. Positive drainage outlets should be provided at all low points of the prepared earth subgrade, such as stub drains extended from the catch-basins.

5.7 Infiltration Rates of Soils

Infiltration galleries for at-source infiltration of storm and roof waters may be required for the proposed development. It is noted that infiltration galleries should have the base located at least 1.0 m above the high groundwater table, and that a minimum infiltration rate of 15 mm/hr is required.

Based on the laboratory results and our past experience, the coefficient of permeability and infiltration rate of the various non-saturated soils encountered across the site are estimated and provided in the following table and may be used for stormwater management purposes:

MATERIAL	PERMEABILITY (K) (cm/sec)	INFILTRATION RATE (mm/hr)
Sandy Silt	5×10^{-4}	10
Sand and Silt	2×10^{-3}	20
Silty Sand	4×10^{-3}	30

The deposit of silty sand is relatively pervious and is considered suitable for infiltration. It is also noted that the groundwater table is expected to lie at depths of greater than 6 m below ground surface.



6.0 CLOSURE

The Limitations of Report, as quoted in Appendix "A", is an integral part of this report.

We trust that the information presented in this report is complete within our terms of reference. If there are any further questions concerning this report, please do not hesitate to contact our office.

Yours truly,
CHUNG & VANDER DOELEN ENGINEERING LTD.



Hans Dworatzek, P.Eng., CET.
Project Engineer



Eric Y. Chung, M. Eng., P. Eng.
Principal Engineer



APPENDIX “A”

Statement of Limitations



APPENDIX "A"

LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the testhole locations. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Soils Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

The benchmark and elevations mentioned in this report were obtained strictly for use in the geotechnical design of the project and by this office only, and should not be used by any other parties for any other purposes.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. CHUNG & VANDER DOELEN ENGINEERING LIMITED accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

This report does not reflect the environmental issues or concerns unless otherwise stated in the report. The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.



Enclosures



FILE No: G15182

BOREHOLE No. 1

Enclosure No.: 1

Sheet 1 of 1



Client: SAC Developments

Project: Proposed 12 Storey Apartment Building

Location: 249, 251 & 253 Sunview Street

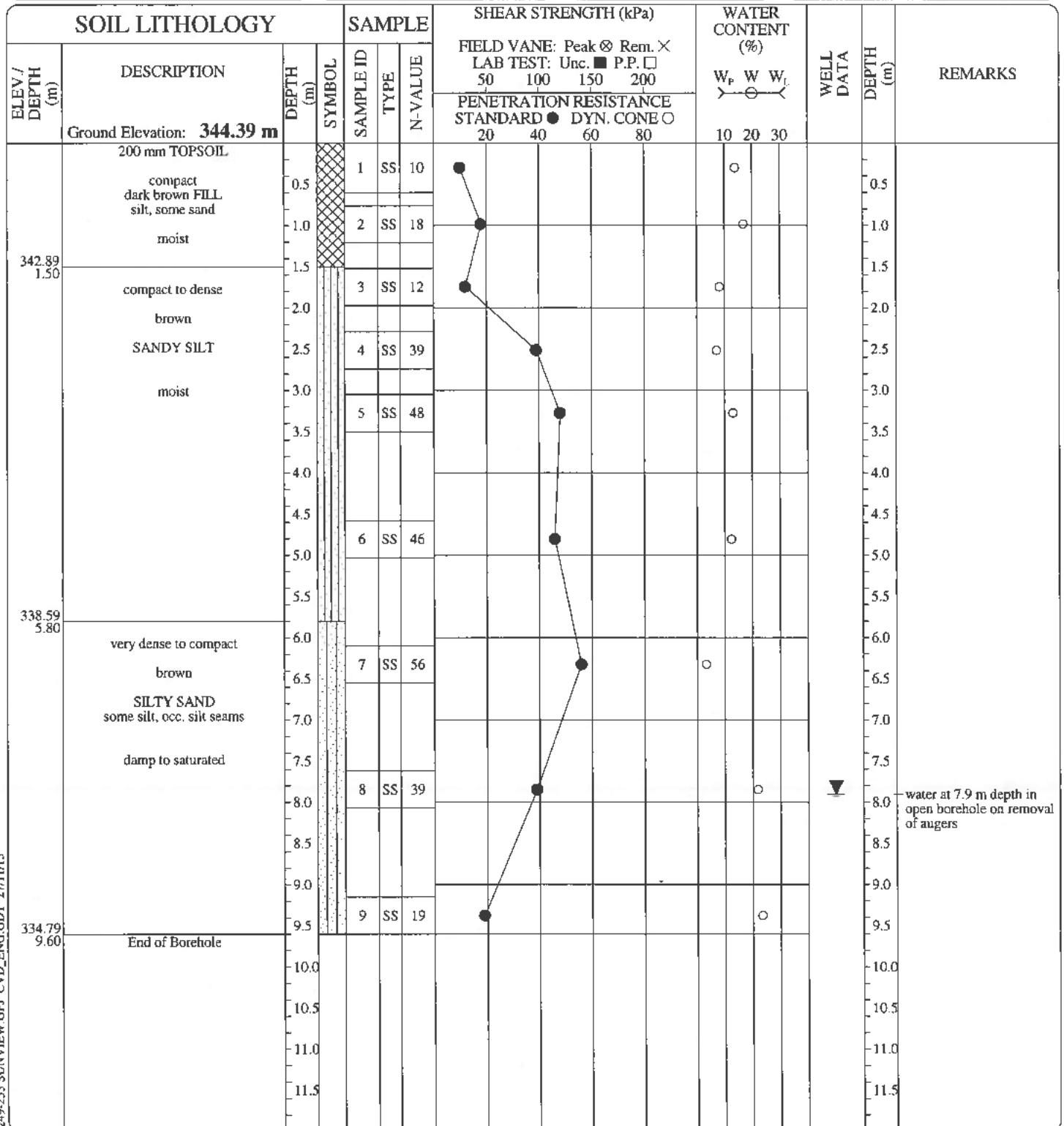
EQUIPMENT DATA

Machine: Geoprobe

Method: Hollow Stem Auger

Size: 83 mm I.D.

Date: Nov 23 / 15 TO Nov 23 / 15



PROJECT MANAGER: EYC

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CVD BOREHOLE G15182 249-253 SUNVIEW GPJ CVD_ENG.GDT 27/11/15

FILE No: G15182

BOREHOLE No. 2

Enclosure No.: 2

Sheet 1 of 1



Client: SAC Developments

Project: Proposed 12 Storey Apartment Building

Location: 249, 251 & 253 Sunview Street

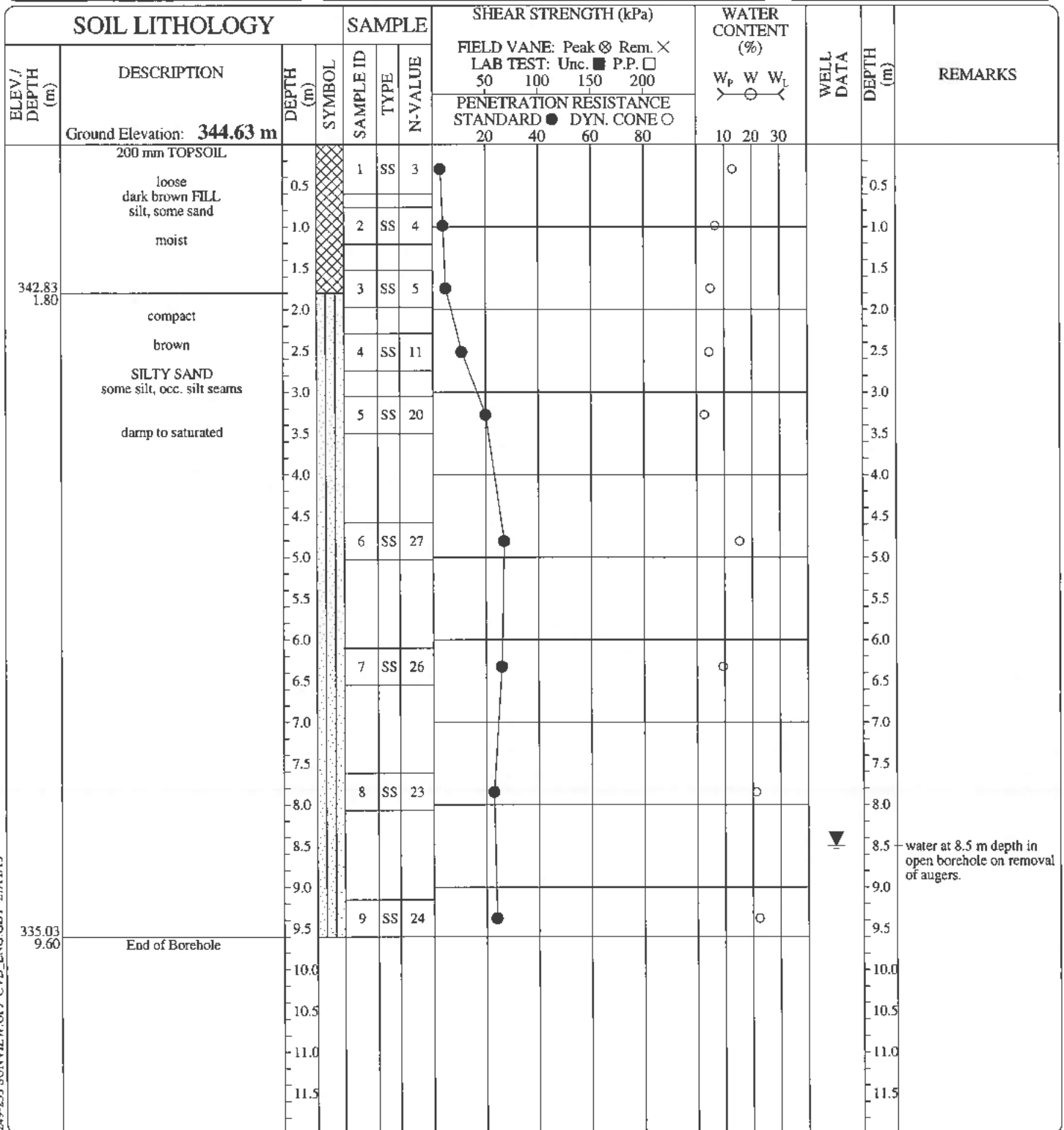
EQUIPMENT DATA

Machine: Geoprobe

Method: Hollow Stem Auger

Size: 83 mm I.D.

Date: Nov 23 / 15 TO Nov 23 / 15



CVD BOREHOLE: G15182 249-253 SUNVIEW.CP CVD ENG GDT 27/11/15

PROJECT MANAGER: EYC

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FILE No: G15182

BOREHOLE No. 3

Enclosure No.: 3

Sheet 1 of 1



Client: SAC Developments

Project: Proposed 12 Storey Apartment Building

Location: 249, 251 & 253 Sunview Street

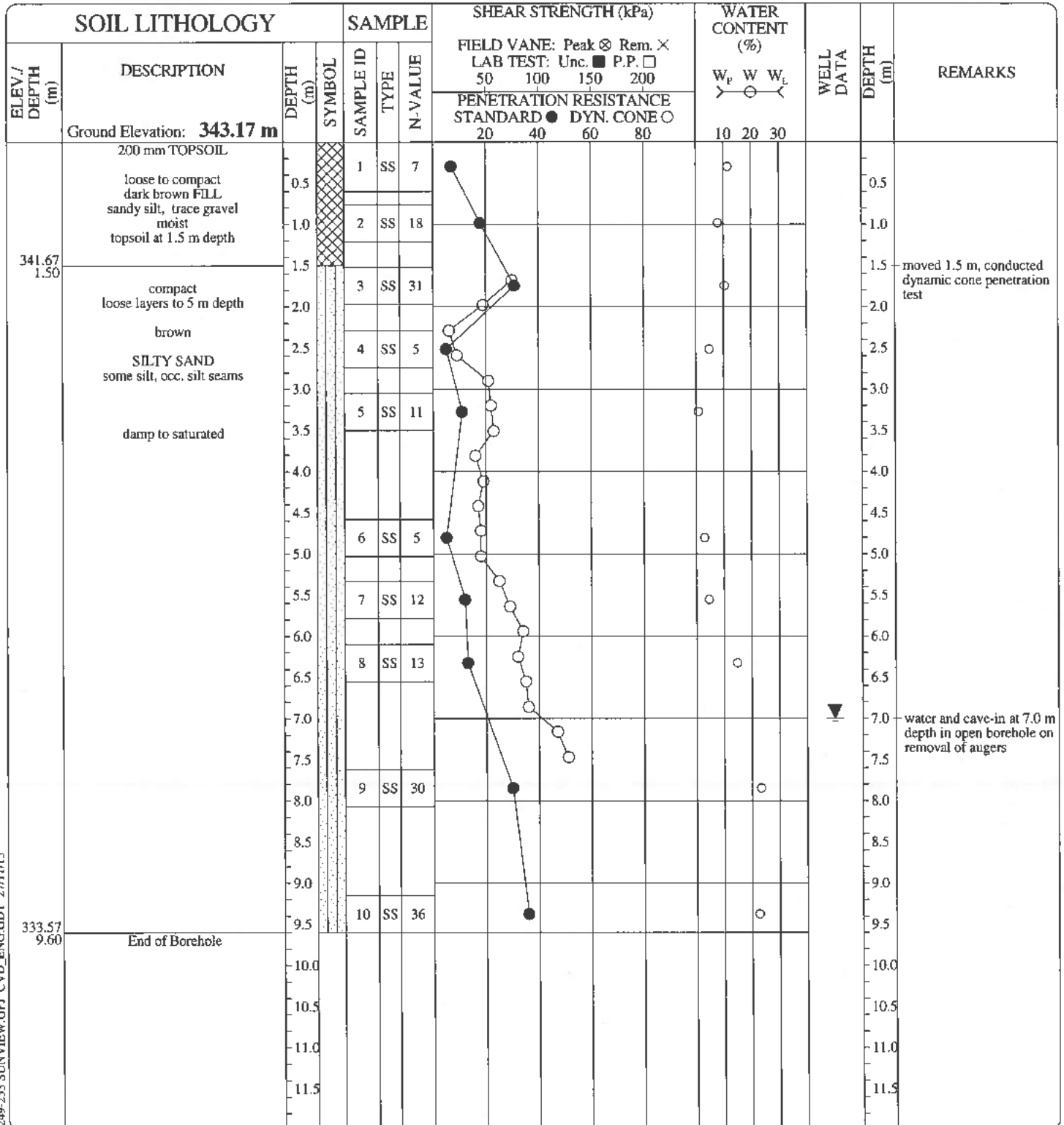
EQUIPMENT DATA

Machine: Geoprobe

Method: Hollow Stem Auger

Size: 83 mm I.D.

Date: Nov 24 / 15 TO Nov 24 / 15



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PROJECT MANAGER: EYC

CVD BOREHOLE G15182 249-253 SUNVIEW GPI CVD-ENG-GDT 27/11/15

FILE No: G15182

BOREHOLE No. 4

Enclosure No.: 4

Sheet 1 of 1



Client: SAC Developments

Project: Proposed 12 Storey Apartment Building

Location: 249, 251 & 253 Sunview Street

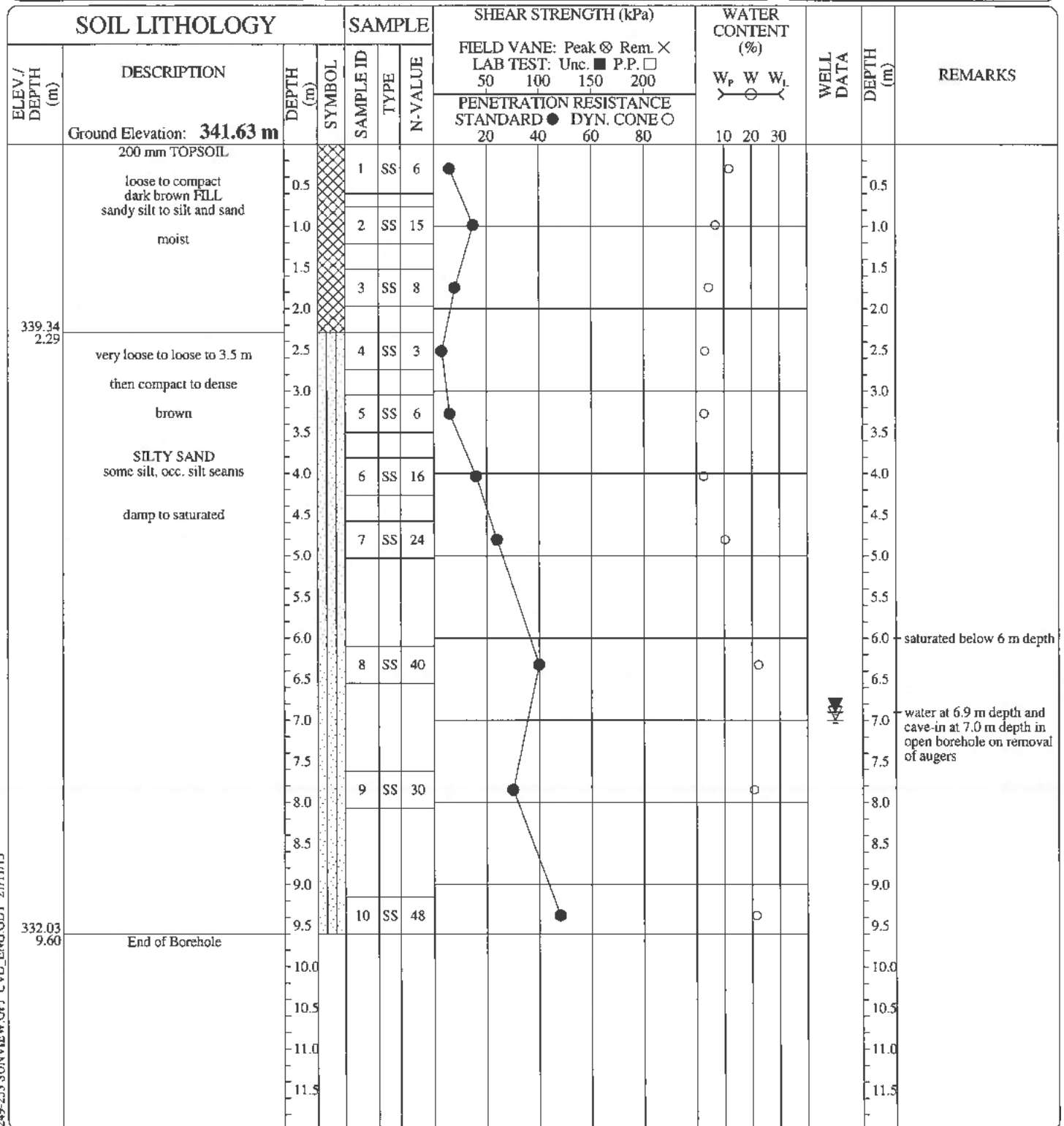
EQUIPMENT DATA

Machine: Geoprobe

Method: Hollow Stem Auger

Size: 83 mm I.D.

Date: Nov 24 / 15 TO Nov 24 / 15



PROJECT MANAGER: EYC

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CVD BOREHOLE G15182 249-253 SUNVIEW.OPI CVD_ENG.GDT 27/11/15

FILE No: G15182

BOREHOLE No. 5



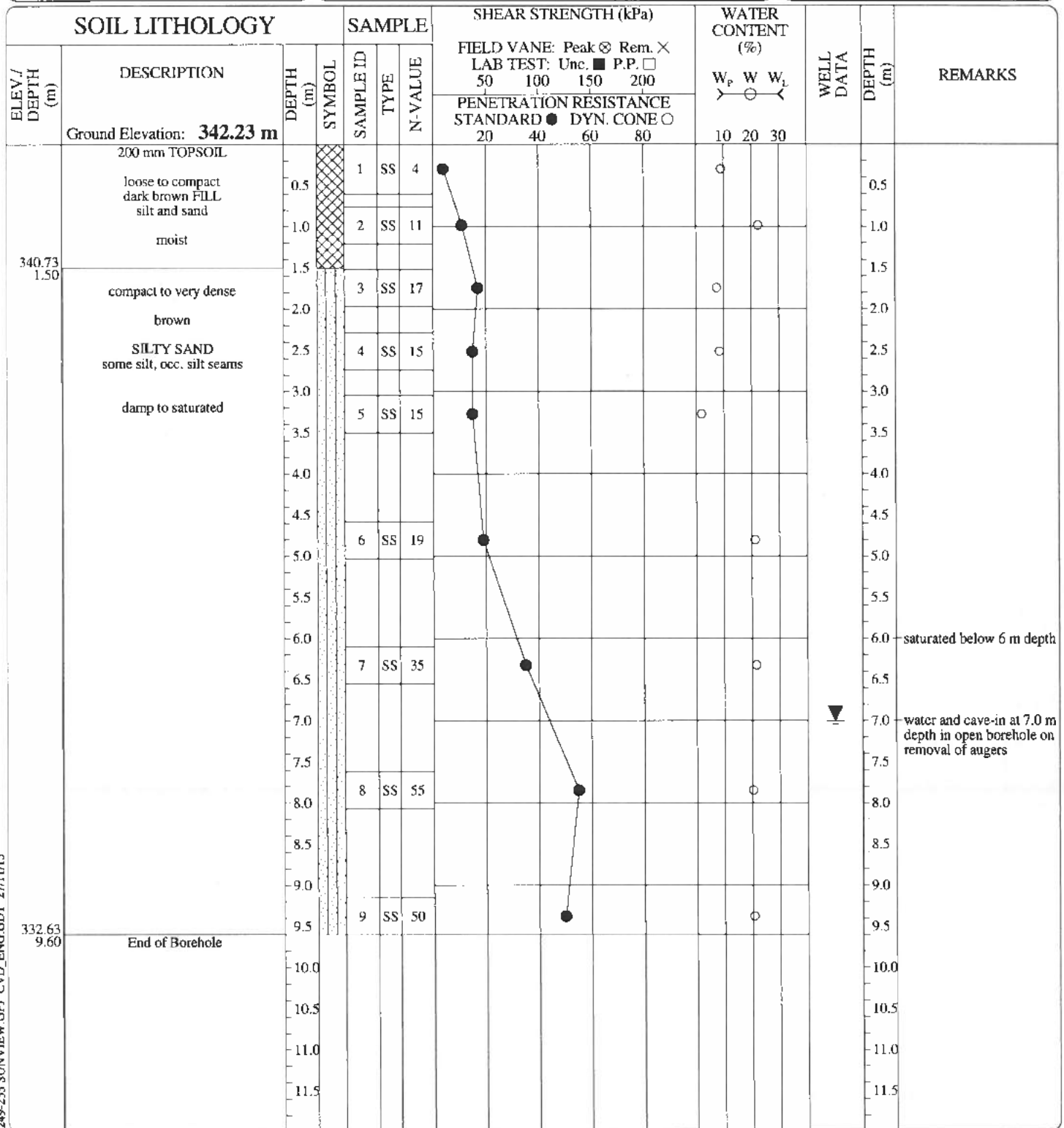
Client: SAC Developments

Project: Proposed 12 Storey Apartment Building

Location: 249, 251 & 253 Sunview Street

EQUIPMENT DATA

Machine: Geoprobe
Method: Hollow Stem Auger
Size: 83 mm I.D.
Date: Nov 23 / 15 TO Nov 23 / 15



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PROJECT MANAGER: EYC

FILE No: G15182

BOREHOLE No. 6

Enclosure No.: 6

Sheet 1 of 1



Client: SAC Developments

Project: Proposed 12 Storey Apartment Building

Location: 249, 251 & 253 Sunview Street

EQUIPMENT DATA

Machine: Geoprobe

Method: Hollow Stem Auger

Size: 83 mm I.D.

Date: Nov 24 / 15 TO Nov 24 / 15

SOIL LITHOLOGY				SAMPLE			SHEAR STRENGTH (kPa)				WATER CONTENT (%)			WELL DATA	DEPTH (m)	REMARKS	
ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE	FIELD VANE: Peak ⊗ Rem. × LAB TEST: Unc. ■ P.P. □ 50 100 150 200				W _p —○— W _L						
							PENETRATION RESISTANCE										
							STANDARD ● DYN. CONE ○ 20 40 60 80				10 20 30						
Ground Elevation: 344.19 m																	
342.06 2.13	150 mm Topsoil	0.5		1	SS	3	●						○			No free water in open borehole on removal of augers	
	very loose to compact brown																
	SANDY SILT, trace gravel	1.0		2	SS	20	●						○				
	moist	1.5															
		2.0		3	SS	15	●						○				
340.69 3.50	compact, brown	2.5		4	SS	20	●						○				
	SAND AND SILT	3.0															
	damp	3.5		5	SS	26	●						○				
	End of Borehole	3.5															
		4.0															
		4.5															
		5.0															
		5.5															
		6.0															
		6.5															
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		9.5															
		10.0															
		10.5															
		11.0															
		11.5															

PROJECT MANAGER: EYC

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FILE No: G15182

BOREHOLE No. 7

Enclosure No.: 7

Sheet 1 of 1



Client: SAC Developments

Project: Proposed 12 Storey Apartment Building

Location: 249, 251 & 253 Sunview Street

EQUIPMENT DATA

Machine: Geoprobe

Method: Hollow Stem Auger

Size: 83 mm I.D.

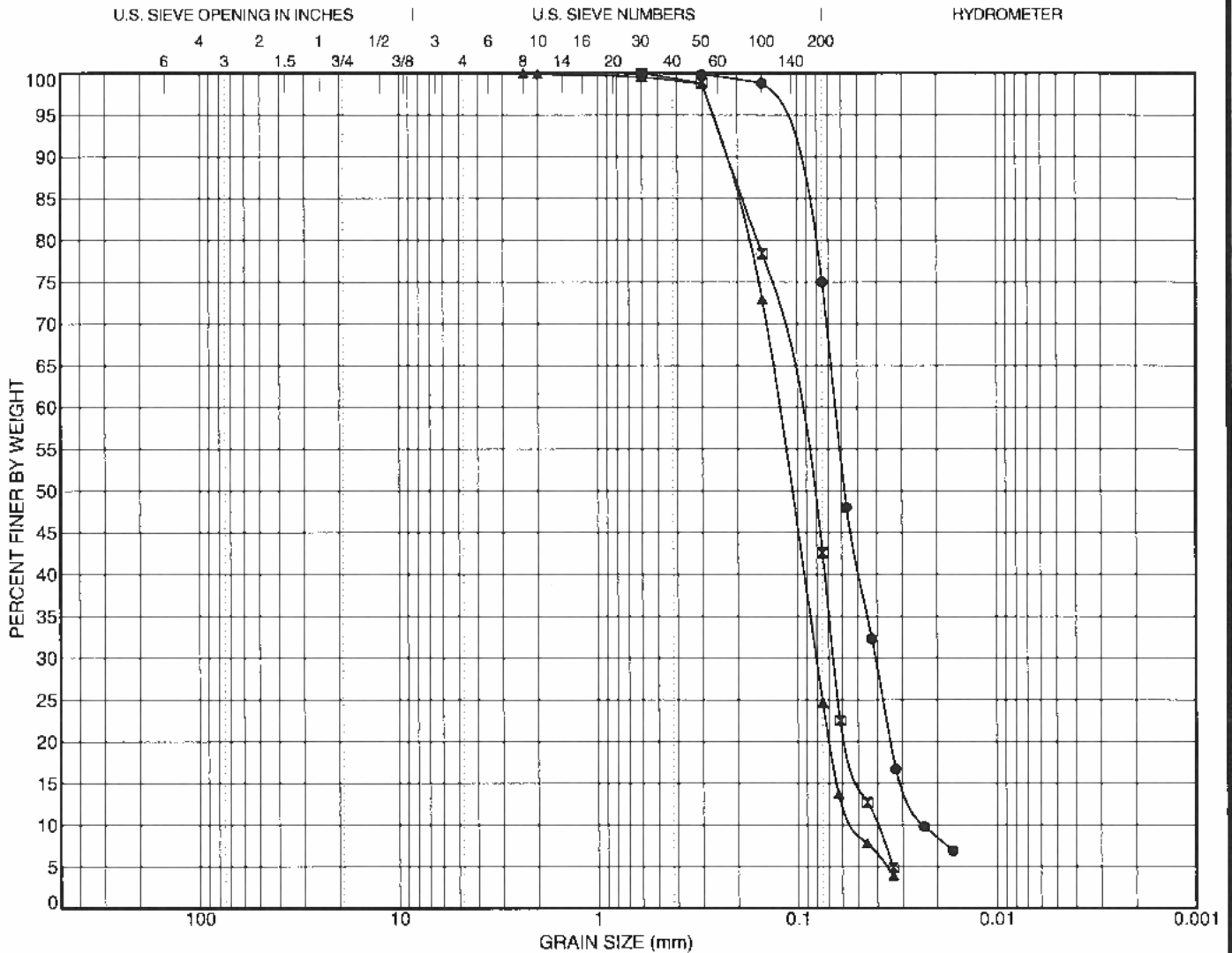
Date: Nov 24 / 15 TO Nov 24 / 15

SOIL LITHOLOGY				SAMPLE			SHEAR STRENGTH (kPa)				WATER CONTENT (%)			WELL DATA	DEPTH (m)	REMARKS	
ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE	FIELD VANE: Peak ⊗ Rem. × LAB TEST: Unc. ■ P.P. □ 50 100 150 200				W _p W W _L —○—						
							PENETRATION RESISTANCE STANDARD ● DYN. CONE ○ 20 40 60 80										
339.58 2.13	200 mm Topsoil	0.5		1	SS	18	●						○			0.5	
	compact, brown	1.0		2	SS	20	●						○				
	SANDY SILT, trace gravel	1.5															
	moist	2.0		3	SS	26							○				
	338.21 3.50	loose to compact, brown		2.5	4	SS	9	●						○			
SILTY SAND some silt, occ. silt seams		3.0															
damp		3.5	5	SS	15	●						○					
	End of Borehole	3.5														No free water in open borehole on removal of augers	
		4.0															
		4.5															
		5.0															
		5.5															
		6.0															
		6.5															
		7.0															
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		9.0															
		9.5															
		10.0															
		10.5															
		11.0															
		11.5															

No free water in open borehole on removal of augers

PROJECT MANAGER: EYC

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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Test Hole No.	Sample No.	Depth (m)	Soil Description				LL	PL	PI	Cc	Cu
●	1 - 6	4.6	Sandy Silt							1.10	2.73
■	6 - 4	2.3	Sand and Silt							1.03	2.59
▲	7 - 5	3.0	Silty Sand							1.03	2.44
Test Hole No.	Sample No.	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay		
●	1 - 6	0.6	0.064	0.041	0.024	0.0	25.0	75.0			
■	6 - 4	0.6	0.105	0.066	0.041	0.0	57.4	42.6			
▲	7 - 5	2.36	0.125	0.081	0.051	0.0	75.4	24.6			



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e-mail: info@cvdengineering.com

GRAIN SIZE DISTRIBUTION

Project: Proposed 12 Storey Apartment Building

Location: 249, 251 & 253 Sunview Street

File No.: G15182

Enclosure No.:



KEY PLAN



LEGEND

- TBM: Top of existing Manhole**
Elevation: 341.170 m
- Borehole Location**

BOREHOLE LOCATION PLAN

Proposed 12 Story Apartment
249 to 253 Sunview Street
Waterloo, Ontario



CHUNG & VANDER DOELEN
ENGINEERING LTD.

311 VICTORIA STREET NORTH
KITCHENER / ONTARIO / N2H 5E1 / 519-742-8979

Drawn by: DVF	Date: November, 2015	File No.: G15182
Checked by: EYC	Scale: As Shown	Drawing No.: 1