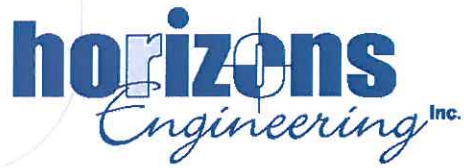




# **DRAINAGE REPORT**

**BMR JAMAICA WIND LIMITED  
MUNRO EXPANSION PROJECT  
SAINT ELIZABETH, JAMAICA**



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**DRAINAGE REPORT  
FOR  
BMP JAMAICA WIND LIMITED  
MUNRO EXPANSION PROJECT  
SAINT ELIZABETH, JAMAICA**

**JANUARY 2014**

**PROJECT NUMBER 13218**

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## **1.0 PROJECT INFORMATION NARRATIVE**



## **1.1 Project Narrative**

### **1.1.1 Project Summary**

BMR Jamaica Wind Limited has been selected to expand the Munro Wind Project in Saint Elizabeth, Jamaica. The site currently has four turbines located in a north-south string. The proposal is to take advantage of an excellent wind resource and expand the project to 18 new Vestas turbines located along four new access roads, totaling approximately 4,170 meters of roadway. Additionally a laydown area, an operations and maintenance building, an electrical substation, electrical transmission mains (other buried and overhead) are proposed.

### **1.1.2 Existing Site Conditions**

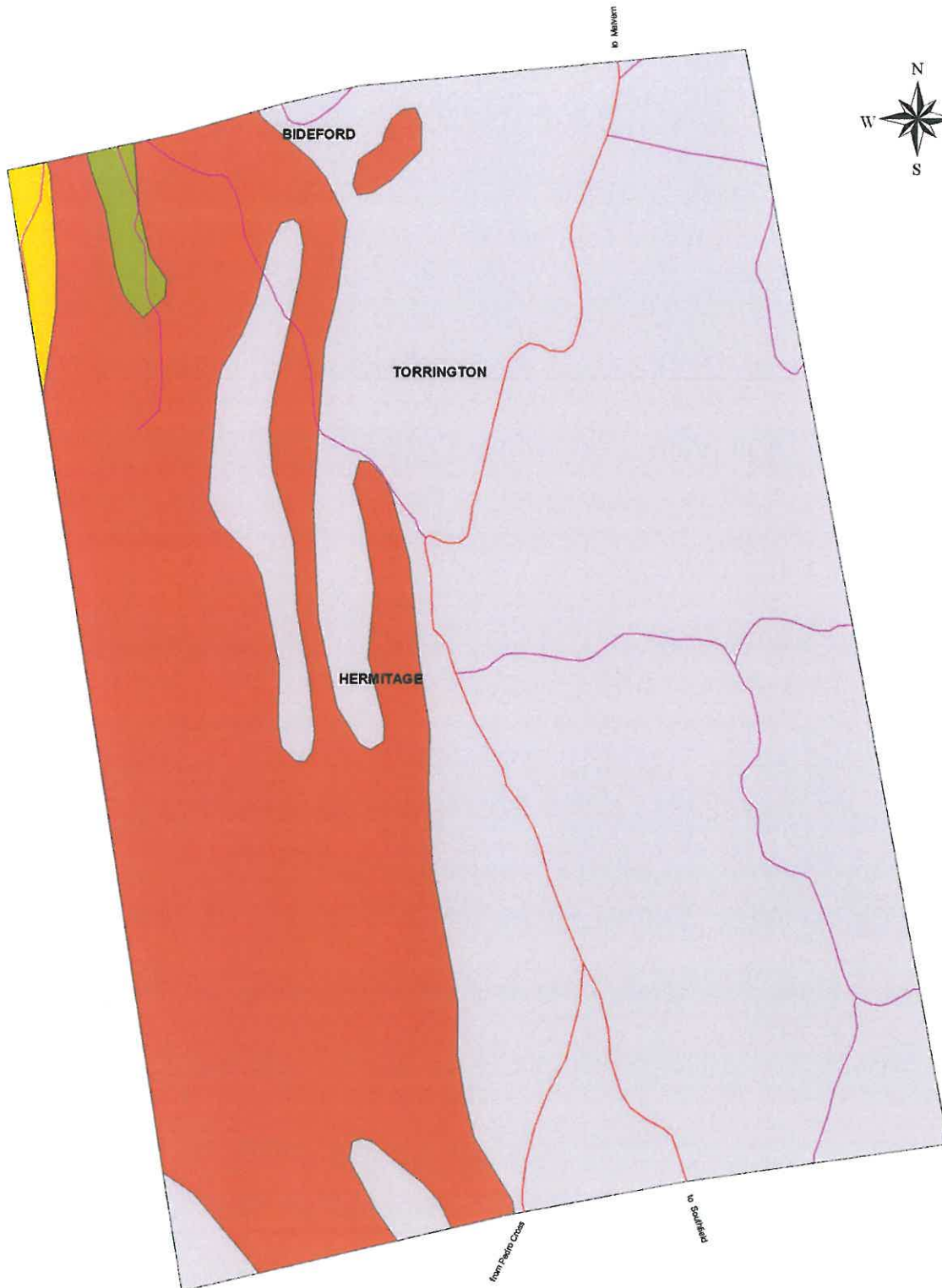
The Munro Wind Project expansion is located on the edge of a plateau near Potsdam, Saint Elizabeth. The elevation in the area of the project is relatively level at around 700 meters above sea level. The project site is rural in character with a mix of forested and grassed areas. There are a number of sinkholes, which can be attributed to the karstic nature of the underlying Newport formation limestone. To the west the forested terrain falls away quickly to an elevation of around 45 meters at an average slope between 30% and 50%.

#### **1.1.2.1 Soils Information**

Scale 1:5,500

# SOIL MAP - HERMITAGE & ENVIRONS

St. Elizabeth



0.2 0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 Kilometers

- Bonnygate Stony Loam
- Bonnygate Stony Loam + St Ann Clay Loam
- St Ann Clay Loam
- St Ann Clay Loam + Bonnygate Stony Loam

- Main Road
- Other Roads



Rural Physical Planning Division  
Hope Gardens  
Kingston 6  
January 2014

#### **1.1.2.2 Site Photographs**

The following photos are included to provide a general overview of existing conditions on the project site.



Looking southeast toward existing turbines #1 and #2 from near existing turbine #3



Photo characteristic of onsite vegetation and topography, near proposed turbine #14



Looking northward at existing turbines #1 - #4 from near proposed turbine #17



Looking southwest over forested slope





Looking south at existing turbines #1 and #2, from near proposed substation

### 1.1.3 Proposed Site Conditions & Disturbances

Approximately 248,985 square meters of earth disturbance will be required for construction of turbine pads, roads, and other infrastructure on the site. This work will include installing an electrical substation, operations and maintenance building, temporary material laydown pad, and electrical transmission lines (both above and below ground). The design intent is that culverts and ditches be sized for the 25 year storm event, and detention structures have at least 15cm freeboard during the 50 year event.

The impacts to water quality during site development will be minimized using temporary treatment devices and erosion control measures. Frequent site inspections during construction are required during or directly following rainfall events to ensure erosion control devices are working properly.

### 1.1.4 Rainfall Data

Using SCS TR-20, run under HydroCAD Version 9.1, pre- and post-development cover types and drainage paths were modeled to generate peak discharge rates. Type II and Type III-24 hour rainfall events were considered. Type II storms demonstrate intense short duration rainfall and were chosen for this project as they result in higher (more conservative) runoff rates...

**Table 1.1 –Comparison of Type II and Type III Storms for 10, 50 Year Events (Pre-development)**

Watershed Area Discharge Point	Type II 10 Yr Flow Rate (cms)	Type III 10 Yr Flow Rate (cms)	Type II 50 Yr Flow Rate (cms)	Type III 50 Yr Flow Rate (cms)
W	6.702	6.423	60.141	56.876
X	0.251	0.233	2.775	2.416
Y	0.353	0.336	3.026	2.813
Z	0.549	0.559	4.293	4.191

Depth of rainfall for various return periods was provided by the National Meteorological Service, Jamaica from a rain gage located in Potsdam, St. Elizabeth, approximately 2.5 kilometers from the center of the project site. These data are provided below in **Table 1.2**.

**Table 1.2 - Type II, 24 Hour Rainfall Depths for Potsdam, St. Elizabeth**

Rainfall Event	Depth*
2-Year	84.6 mm
5-Year	158.1 mm
10-Year	228.1 mm
25-Year	335.2 mm
50-Year	425.5 mm
100-Year	522.8 mm

*\*Data provided by Meteorological Service of Jamaica, Climate Branch*

### 1.1.5 Peak Runoff Summary

**Table 1.3** summarizes the stormwater runoff peak flow rate for the 2, 10 and 50 year storm events. With the exception of the 50 year storm at discharge point Z, all discharge points peak flow rates either decrease for the all storm events. The increase shown at discharge point Z for the 50 year event is approximately 3.4%. This increase does not take into account any infiltration of stormwater.

**Table 1.3 – 2, 10 and 50 Year Comparison**

Watershed Area Discharge Point	Pre 2 Yr Flow Rate (cms)	Post 2 Yr Flow Rate (cms)	Pre 10 Yr Flow Rate (cms)	Post 10 Yr Flow Rate (cms)	Pre 50 Yr Flow Rate (cms)	Post 50 Yr Flow Rate (cms)
W	0.000	0.000	6.702	6.645	60.141	60.367
X	0.000	0.000	0.251	0.250	2.775	2.765
Y	0.000	0.000	0.353	0.334	3.026	2.864
Z	0.000	0.000	0.549	0.540	4.293	4.435

## **2.0 - DRAINAGE CALCULATIONS, ANALYSIS & DESIGN**

## **2.1 Pre-development Analysis**

## 2.1 Pre-development Analysis

Based on topography, four pre-development drainage areas have been identified on the project site to accommodate all areas disturbed by the project. These areas drain to points designated as W, X, Y, and Z throughout the drainage analysis and drainage report, as well as in the HydroCAD Model. The total watershed to be analyzed is 816.84 hectares.

Drainage area Pr1 is located on the west and south of the project site, draining west to discharge point W, a point where all flow off the western side of the project area is concentrated. Limits of available topography prevent this point from being precisely located for this study. This drainage area is primarily located on a steep, forested hillside. In the southeast of this drainage area is a portion of Munro College. Three of the four existing wind turbines (to be removed) are included in this area. This drainage area encompasses the majority of the project site, and is approximately 713.35 hectares.

Drainage area Pr2 is located in the northeast of the project site and encompasses a primarily open area with moderate hills. This area drains to discharge point X in the northeast of the drainage area. There is an existing road which runs along the top of the watershed on the west side. This drainage area is approximately 16.57 hectares.

Drainage area Pr3 is located in the center of the east of the project site, and drains to discharge point Y in the northeast of the drainage area. The area is gently sloping, and is primarily open. As with area Pr2, there are some existing roadways within this drainage area. One of the existing wind turbines (to be removed) is included in this drainage area. Pr3 is approximately 27.38 hectares.

Drainage area Pr4 is located in the center of the east of the project site, and drains to discharge point Z in the northeast of the drainage area. The area is hilly near the top of the watershed, and flatter near the bottom. The drainage area is a mix of open and forested areas. There are some existing roadways within this drainage area. This drainage area is approximately 59.53 hectares.

Information on soils in the area was obtained from the Rural Physical Planning Division of the Ministry of Agriculture. This information can be found in **Section 1.1.2.1** of this report. Soils on this site have been identified as Bonnygate Stony Loam, and a complex of St. Ann Clay Loam and Bonnygate Stony Loam. Soil types are described in the ‘Soil Technical Guide Sheets’ published by the Rural Physical Planning Division, 2004.

**Table 2.1 – Soil Types and Drainage Description**

Soil ID	Soil Name	Internal Drainage Description
77	Bonnygate	Very Rapid
78	St. Ann	Extremely Rapid

The ‘Soil Technical Guide Sheets’ advise that rapid internal drainage is defined by permeability rates of greater than 5.0 inches per hour. The United States Department of Agriculture Natural Resources Conservation Service defines Hydrologic Soil Group (HSG) A as soils that “have low runoff potential and high infiltration rates ... and have a high rate of water transmission (greater than 0.30 in/hr)”. As such, all soils in the watershed have been interpreted to be HSG A. The watershed areas and drainage paths can be found in **Section 3**.

### **2.1.1 Pre-Development Node Listing 2, 10 and 50 - Year Storm Event**



## PRE\_DRAINAGE

Type II 24-hr 2-Year Rainfall=85 mm

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Page 1

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=SCS

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**SubcatchmentPr1: Drainage Area**      Runoff Area=7,133,532.7 m<sup>2</sup>   0.78% Impervious   Runoff Depth=0 mm  
Flow Length=3,573.8 m   Tc=118.8 min   CN=31   Runoff=0.000 m<sup>3</sup>/s   0.000 MI

**SubcatchmentPr2: Drainage Area**      Runoff Area=165,704.3 m<sup>2</sup>   0.81% Impervious   Runoff Depth=0 mm  
Flow Length=581.1 m   Tc=47.4 min   CN=31   Runoff=0.000 m<sup>3</sup>/s   0.000 MI

**SubcatchmentPr3: Drainage Area**      Runoff Area=273,843.1 m<sup>2</sup>   2.40% Impervious   Runoff Depth=0 mm  
Flow Length=1,029.1 m   Tc=91.9 min   CN=32   Runoff=0.000 m<sup>3</sup>/s   0.000 MI

**SubcatchmentPr4: Drainage Area**      Runoff Area=595,274.4 m<sup>2</sup>   2.32% Impervious   Runoff Depth=0 mm  
Flow Length=2,751.8 m   Tc=158.7 min   CN=32   Runoff=0.000 m<sup>3</sup>/s   0.000 MI

**Link W: Drainage Point**

Inflow=0.000 m<sup>3</sup>/s   0.000 MI  
Primary=0.000 m<sup>3</sup>/s   0.000 MI

**Link X: Drainage Point**

Inflow=0.000 m<sup>3</sup>/s   0.000 MI  
Primary=0.000 m<sup>3</sup>/s   0.000 MI

**Link Y: Drainage Point**

Inflow=0.000 m<sup>3</sup>/s   0.000 MI  
Primary=0.000 m<sup>3</sup>/s   0.000 MI

**Link Z: Drainage Point**

Inflow=0.000 m<sup>3</sup>/s   0.000 MI  
Primary=0.000 m<sup>3</sup>/s   0.000 MI

**Total Runoff Area = 816.8355 ha   Runoff Volume = 0.000 MI   Average Runoff Depth = 0 mm**  
**99.05% Pervious = 809.0954 ha   0.95% Impervious = 7.7401 ha**

## PRE\_DRAINAGE

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Type II 24-hr 10-Year Rainfall=228 mm

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=SCS

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment Pr1: Drainage Area** Runoff Area=7,133,532.7 m<sup>2</sup> 0.78% Impervious Runoff Depth>14 mm  
Flow Length=3,573.8 m Tc=118.8 min CN=31 Runoff=6.702 m<sup>3</sup>/s 102.326 MI

**Subcatchment Pr2: Drainage Area** Runoff Area=165,704.3 m<sup>2</sup> 0.81% Impervious Runoff Depth>16 mm  
Flow Length=581.1 m Tc=47.4 min CN=31 Runoff=0.251 m<sup>3</sup>/s 2.570 MI

**Subcatchment Pr3: Drainage Area** Runoff Area=273,843.1 m<sup>2</sup> 2.40% Impervious Runoff Depth>17 mm  
Flow Length=1,029.1 m Tc=91.9 min CN=32 Runoff=0.353 m<sup>3</sup>/s 4.626 MI

**Subcatchment Pr4: Drainage Area** Runoff Area=595,274.4 m<sup>2</sup> 2.32% Impervious Runoff Depth>16 mm  
Flow Length=2,751.8 m Tc=158.7 min CN=32 Runoff=0.549 m<sup>3</sup>/s 9.280 MI

**Link W: Drainage Point**

Inflow=6.702 m<sup>3</sup>/s 102.326 MI  
Primary=6.702 m<sup>3</sup>/s 102.326 MI

**Link X: Drainage Point**

Inflow=0.251 m<sup>3</sup>/s 2.570 MI  
Primary=0.251 m<sup>3</sup>/s 2.570 MI

**Link Y: Drainage Point**

Inflow=0.353 m<sup>3</sup>/s 4.626 MI  
Primary=0.353 m<sup>3</sup>/s 4.626 MI

**Link Z: Drainage Point**

Inflow=0.549 m<sup>3</sup>/s 9.280 MI  
Primary=0.549 m<sup>3</sup>/s 9.280 MI

**Total Runoff Area = 816.8355 ha Runoff Volume = 118.802 MI Average Runoff Depth = 15 mm**  
**99.05% Pervious = 809.0954 ha 0.95% Impervious = 7.7401 ha**

## PRE\_DRAINAGE

Type II 24-hr 50-Year Rainfall=426 mm

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=SCS

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment Pr1: Drainage Area**      Runoff Area=7,133,532.7 m<sup>2</sup>   0.78% Impervious   Runoff Depth>93 mm  
Flow Length=3,573.8 m   Tc=118.8 min   CN=31   Runoff=60.141 m<sup>3</sup>/s   662.847 MI

**Subcatchment Pr2: Drainage Area**      Runoff Area=165,704.3 m<sup>2</sup>   0.81% Impervious   Runoff Depth>97 mm  
Flow Length=581.1 m   Tc=47.4 min   CN=31   Runoff=2.775 m<sup>3</sup>/s   16.128 MI

**Subcatchment Pr3: Drainage Area**      Runoff Area=273,843.1 m<sup>2</sup>   2.40% Impervious   Runoff Depth>101 mm  
Flow Length=1,029.1 m   Tc=91.9 min   CN=32   Runoff=3.026 m<sup>3</sup>/s   27.537 MI

**Subcatchment Pr4: Drainage Area**      Runoff Area=595,274.4 m<sup>2</sup>   2.32% Impervious   Runoff Depth>96 mm  
Flow Length=2,751.8 m   Tc=158.7 min   CN=32   Runoff=4.293 m<sup>3</sup>/s   56.970 MI

**Link W: Drainage Point**

Inflow=60.141 m<sup>3</sup>/s   662.847 MI  
Primary=60.141 m<sup>3</sup>/s   662.847 MI

**Link X: Drainage Point**

Inflow=2.775 m<sup>3</sup>/s   16.128 MI  
Primary=2.775 m<sup>3</sup>/s   16.128 MI

**Link Y: Drainage Point**

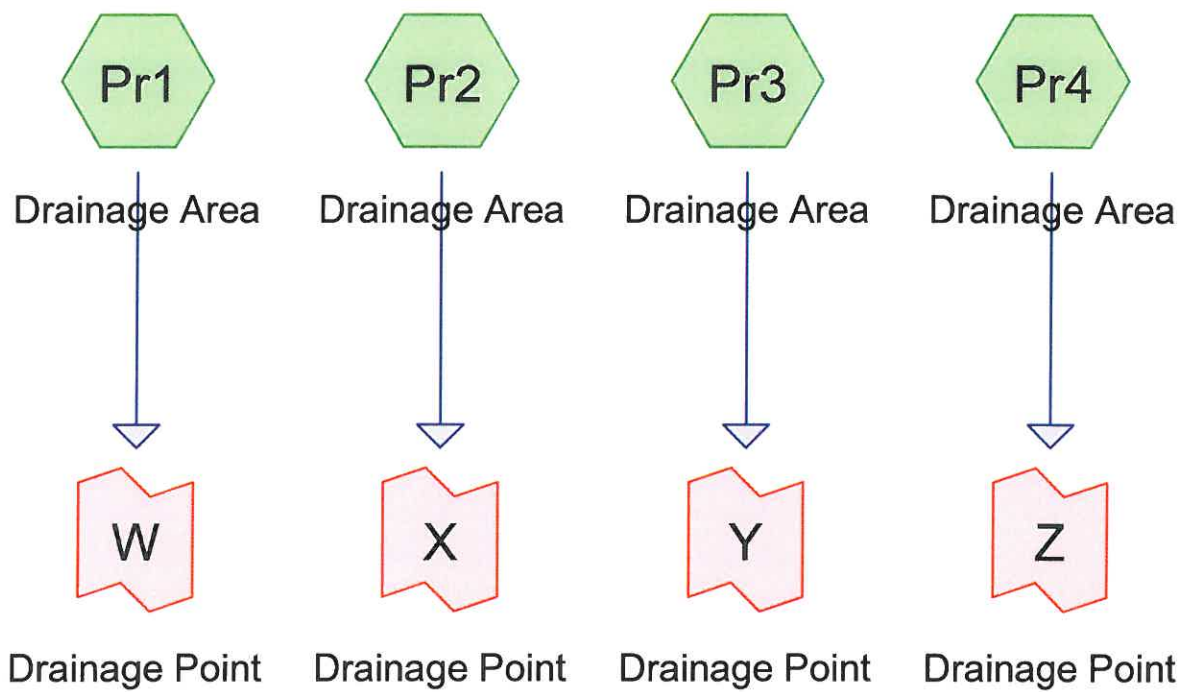
Inflow=3.026 m<sup>3</sup>/s   27.537 MI  
Primary=3.026 m<sup>3</sup>/s   27.537 MI

**Link Z: Drainage Point**

Inflow=4.293 m<sup>3</sup>/s   56.970 MI  
Primary=4.293 m<sup>3</sup>/s   56.970 MI

**Total Runoff Area = 816.8355 ha   Runoff Volume = 763.482 MI   Average Runoff Depth = 93 mm**  
**99.05% Pervious = 809.0954 ha   0.95% Impervious = 7.7401 ha**

**2.1.2 Pre-Development Full Summary and Diagram  
10 - Year Storm Event**



## PRE\_DRAINAGE

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### Area Listing (all nodes)

Area (hectares)	CN	Description (subcatchment-numbers)
242.6291	30	Meadow, non-grazed, HSG A (Pr1, Pr2, Pr3, Pr4)
566.4663	30	Woods, Good, HSG A (Pr1, Pr2, Pr4)
1.0845	98	xBUILDING (Pr1)
6.6556	98	xROAD (Pr1, Pr2, Pr3, Pr4)
<b>816.8355</b>	<b>31</b>	<b>TOTAL AREA</b>

## PRE\_DRAINAGE

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### Soil Listing (all nodes)

Area (hectares)	Soil Group	Subcatchment Numbers
809.0954	HSG A	Pr1, Pr2, Pr3, Pr4
0.0000	HSG B	
0.0000	HSG C	
0.0000	HSG D	
7.7401	Other	Pr1, Pr2, Pr3, Pr4
<b>816.8355</b>		<b>TOTAL AREA</b>



## PRE\_DRAINAGE

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Type II 24-hr 10-Year Rainfall=228 mm

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=SCS

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment Pr1: Drainage Area** Runoff Area=7,133,532.7 m<sup>2</sup> 0.78% Impervious Runoff Depth>14 mm  
Flow Length=3,573.8 m Tc=118.8 min CN=31 Runoff=6.702 m<sup>3</sup>/s 102.326 MI

**Subcatchment Pr2: Drainage Area** Runoff Area=165,704.3 m<sup>2</sup> 0.81% Impervious Runoff Depth>16 mm  
Flow Length=581.1 m Tc=47.4 min CN=31 Runoff=0.251 m<sup>3</sup>/s 2.570 MI

**Subcatchment Pr3: Drainage Area** Runoff Area=273,843.1 m<sup>2</sup> 2.40% Impervious Runoff Depth>17 mm  
Flow Length=1,029.1 m Tc=91.9 min CN=32 Runoff=0.353 m<sup>3</sup>/s 4.626 MI

**Subcatchment Pr4: Drainage Area** Runoff Area=595,274.4 m<sup>2</sup> 2.32% Impervious Runoff Depth>16 mm  
Flow Length=2,751.8 m Tc=158.7 min CN=32 Runoff=0.549 m<sup>3</sup>/s 9.280 MI

**Link W: Drainage Point**

Inflow=6.702 m<sup>3</sup>/s 102.326 MI  
Primary=6.702 m<sup>3</sup>/s 102.326 MI

**Link X: Drainage Point**

Inflow=0.251 m<sup>3</sup>/s 2.570 MI  
Primary=0.251 m<sup>3</sup>/s 2.570 MI

**Link Y: Drainage Point**

Inflow=0.353 m<sup>3</sup>/s 4.626 MI  
Primary=0.353 m<sup>3</sup>/s 4.626 MI

**Link Z: Drainage Point**

Inflow=0.549 m<sup>3</sup>/s 9.280 MI  
Primary=0.549 m<sup>3</sup>/s 9.280 MI

**Total Runoff Area = 816.8355 ha Runoff Volume = 118.802 MI Average Runoff Depth = 15 mm**  
**99.05% Pervious = 809.0954 ha 0.95% Impervious = 7.7401 ha**

**PRE\_DRAINAGE**

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Type II 24-hr 10-Year Rainfall=228 mm

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**Summary for Subcatchment Pr1: Drainage Area**Runoff = 6.702 m<sup>3</sup>/s @ 13.93 hrs, Volume= 102.326 MI, Depth> 14 mmRunoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type II 24-hr 10-Year Rainfall=228 mm

	Area (m <sup>2</sup> )	CN	Description
	5,535,684.0	30	Woods, Good, HSG A
*	44,796.9	98	xROAD
*	10,844.7	98	xBUILDING
	1,542,207.1	30	Meadow, non-grazed, HSG A
	7,133,532.7	31	Weighted Average
	7,077,891.1		99.22% Pervious Area
	55,641.6		0.78% Impervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m <sup>3</sup> /s)	Description
28.6	31.0	0.0100	0.02		<b>Sheet Flow, Pr1-A</b> Grass: Bermuda n= 0.410 P2= 85 mm
19.7	581.0	0.1048	0.49		<b>Shallow Concentrated Flow, Pr1-B</b> Woodland Kv= 1.52 m/s
19.5	697.5	0.0781	0.60		<b>Shallow Concentrated Flow, Pr1-C</b> Short Grass Pasture Kv= 2.13 m/s
11.6	767.9	0.5307	1.11		<b>Shallow Concentrated Flow, Pr1-D</b> Woodland Kv= 1.52 m/s
7.2	355.3	0.1511	0.83		<b>Shallow Concentrated Flow, Pr1-E</b> Short Grass Pasture Kv= 2.13 m/s
32.2	1,141.1	0.1514	0.59		<b>Shallow Concentrated Flow, Pr1-F</b> Woodland Kv= 1.52 m/s
118.8	3,573.8	Total			

## PRE\_DRAINAGE

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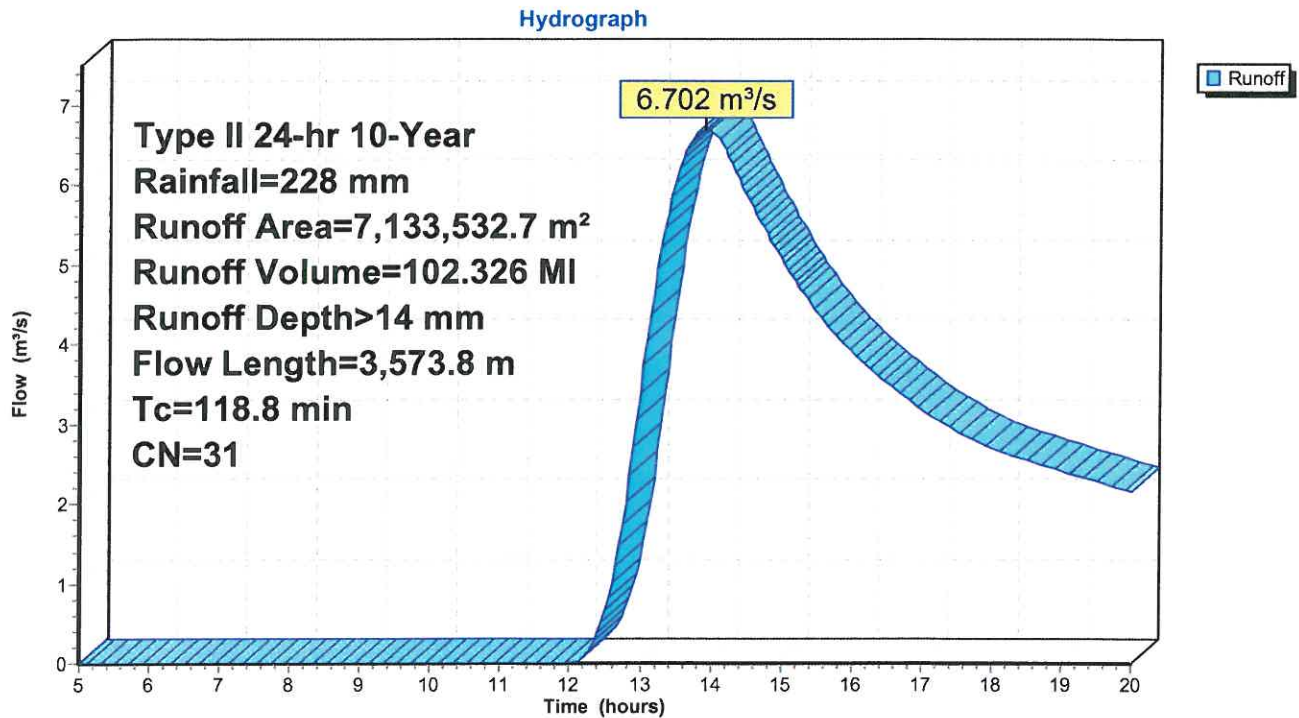
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Type II 24-hr 10-Year Rainfall=228 mm

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### Subcatchment Pr1: Drainage Area



## PRE\_DRAINAGE

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Type II 24-hr 10-Year Rainfall=228 mm

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### Summary for Subcatchment Pr2: Drainage Area

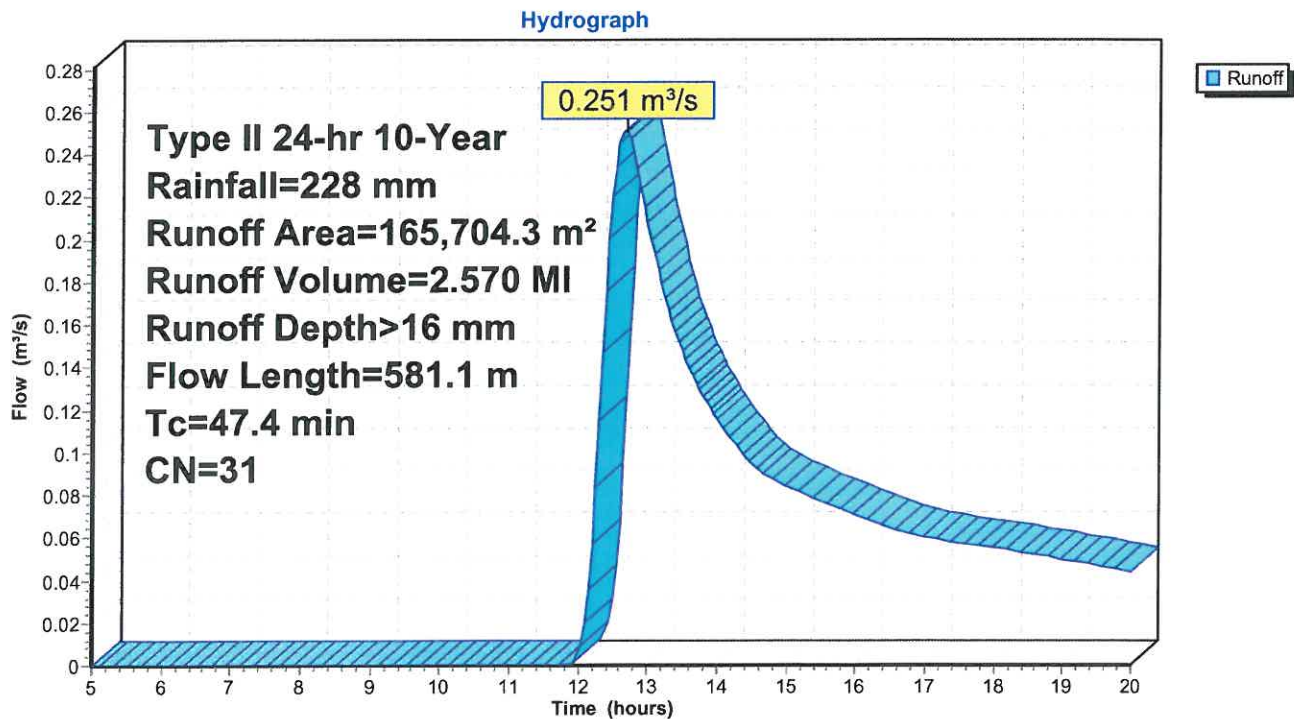
Runoff = 0.251 m<sup>3</sup>/s @ 12.69 hrs, Volume= 2.570 MI, Depth> 16 mm

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type II 24-hr 10-Year Rainfall=228 mm

	Area (m <sup>2</sup> )	CN	Description
	45,455.7	30	Woods, Good, HSG A
*	1,336.4	98	xROAD
*	0.0	98	xBUILDING
	118,912.2	30	Meadow, non-grazed, HSG A
	165,704.3	31	Weighted Average
	164,367.9		99.19% Pervious Area
	1,336.4		0.81% Impervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m <sup>3</sup> /s)	Description
21.3	31.0	0.0200	0.02		<b>Sheet Flow, Pr2-A</b> Woods: Light underbrush n= 0.400 P2= 85 mm
26.1	550.1	0.0273	0.35		<b>Shallow Concentrated Flow, Pr2-B</b> Short Grass Pasture Kv= 2.13 m/s
47.4	581.1	Total			

### Subcatchment Pr2: Drainage Area



## PRE\_DRAINAGE

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Type II 24-hr 10-Year Rainfall=228 mm

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### Summary for Subcatchment Pr3: Drainage Area

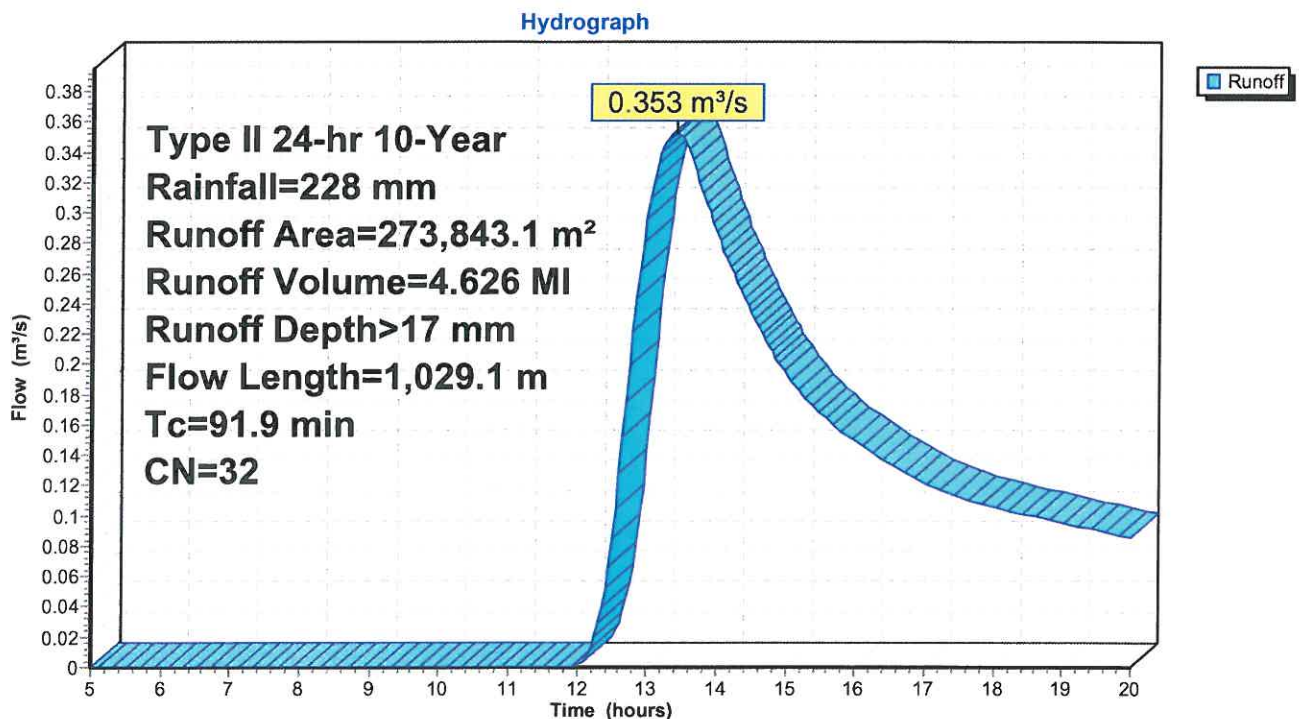
Runoff = 0.353 m<sup>3</sup>/s @ 13.41 hrs, Volume= 4.626 MI, Depth> 17 mm

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type II 24-hr 10-Year Rainfall=228 mm

Area (m <sup>2</sup> )	CN	Description
0.0	30	Woods, Good, HSG A
* 6,584.9	98	xROAD
* 0.0	98	xBUILDING
267,258.2	30	Meadow, non-grazed, HSG A
273,843.1	32	Weighted Average
267,258.2		97.60% Pervious Area
6,584.9		2.40% Impervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m <sup>3</sup> /s)	Description
28.6	31.0	0.0100	0.02		<b>Sheet Flow, Pr3-A</b>
					Grass: Bermuda n= 0.410 P2= 85 mm
63.3	998.1	0.0152	0.26		<b>Shallow Concentrated Flow, Pr3-B</b>
					Short Grass Pasture Kv= 2.13 m/s
91.9	1,029.1	Total			

### Subcatchment Pr3: Drainage Area





## PRE\_DRAINAGE

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Type II 24-hr 10-Year Rainfall=228 mm

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### Summary for Subcatchment Pr4: Drainage Area

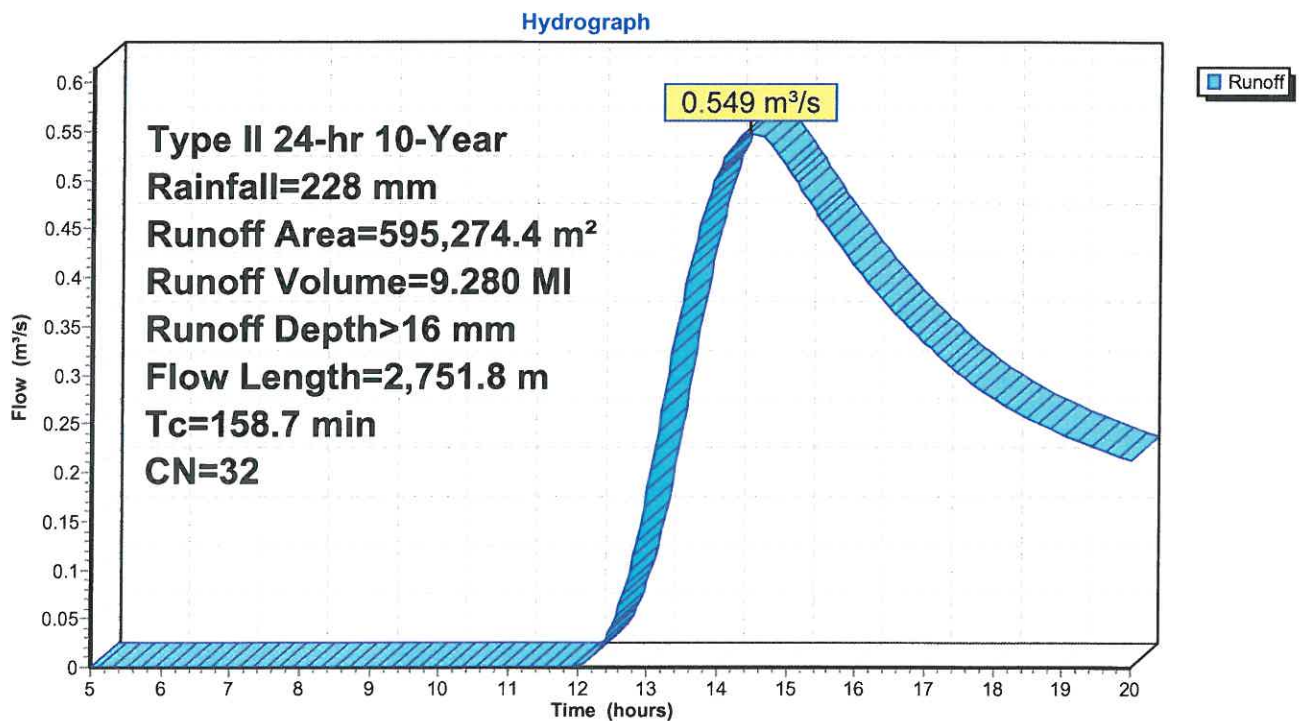
Runoff = 0.549 m<sup>3</sup>/s @ 14.47 hrs, Volume= 9.280 MI, Depth> 16 mm

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type II 24-hr 10-Year Rainfall=228 mm

	Area (m <sup>2</sup> )	CN	Description
	83,523.1	30	Woods, Good, HSG A
*	13,837.6	98	xROAD
*	0.0	98	xBUILDING
	497,913.7	30	Meadow, non-grazed, HSG A
	595,274.4	32	Weighted Average
	581,436.8		97.68% Pervious Area
	13,837.6		2.32% Impervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m <sup>3</sup> /s)	Description
12.5	31.0	0.0757	0.04		<b>Sheet Flow, Pr4-A</b> Woods: Light underbrush n= 0.400 P2= 85 mm
146.2	2,720.8	0.0212	0.31		<b>Shallow Concentrated Flow, Pr4-B</b> Short Grass Pasture Kv= 2.13 m/s
158.7	2,751.8	Total			

### Subcatchment Pr4: Drainage Area



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Type II 24-hr 10-Year Rainfall=228 mm

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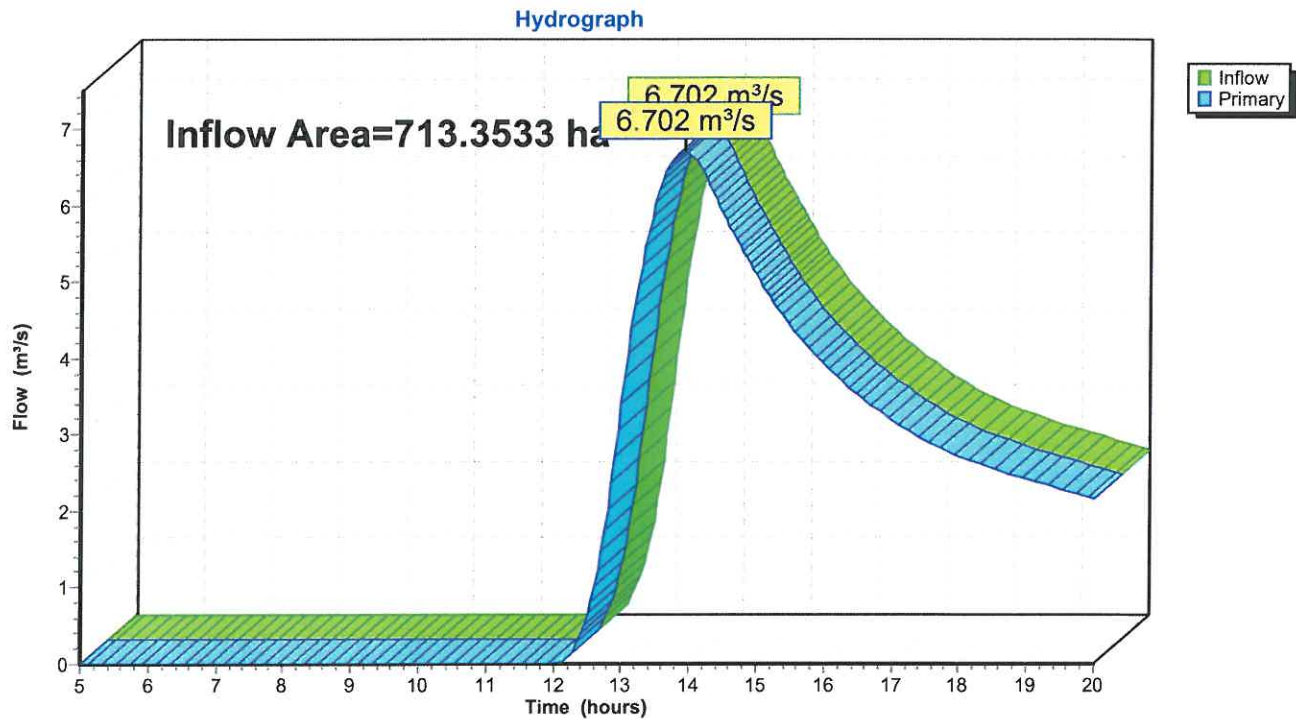
Page 10

### Summary for Link W: Drainage Point

Inflow Area = 713.3533 ha, 0.78% Impervious, Inflow Depth > 14 mm for 10-Year event  
Inflow = 6.702 m<sup>3</sup>/s @ 13.93 hrs, Volume= 102.326 MI  
Primary = 6.702 m<sup>3</sup>/s @ 13.93 hrs, Volume= 102.326 MI, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

### Link W: Drainage Point





## PRE\_DRAINAGE

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Type II 24-hr 10-Year Rainfall=228 mm

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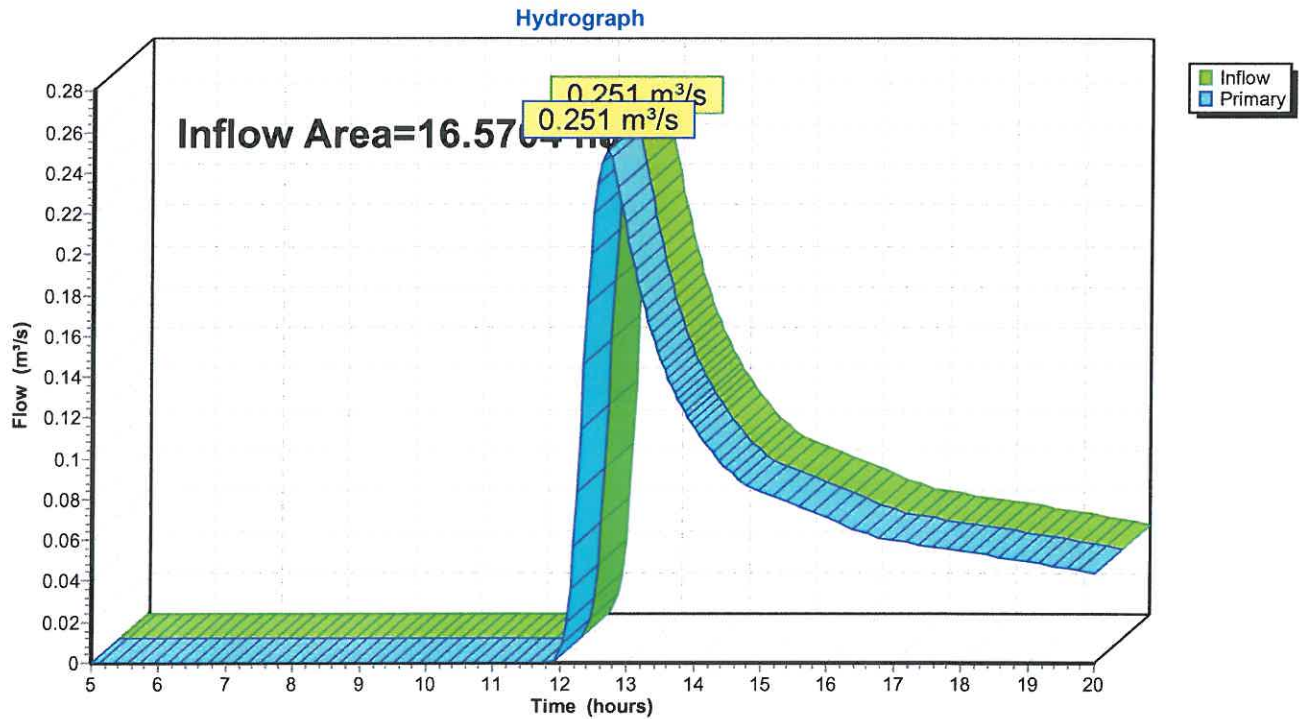
Page 11

### Summary for Link X: Drainage Point

Inflow Area = 16.5704 ha, 0.81% Impervious, Inflow Depth > 16 mm for 10-Year event  
Inflow = 0.251 m<sup>3</sup>/s @ 12.69 hrs, Volume= 2.570 MI  
Primary = 0.251 m<sup>3</sup>/s @ 12.69 hrs, Volume= 2.570 MI, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

### Link X: Drainage Point



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Type II 24-hr 10-Year Rainfall=228 mm

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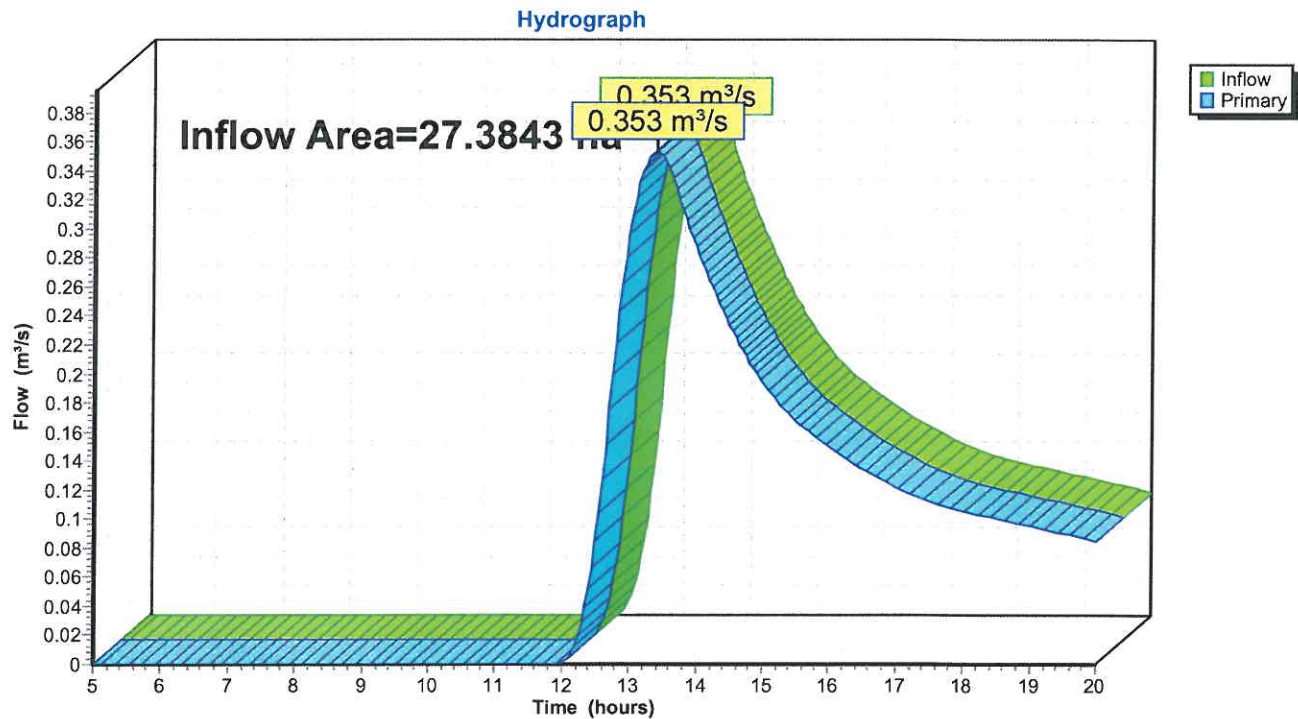
Page 12

### Summary for Link Y: Drainage Point

Inflow Area = 27.3843 ha, 2.40% Impervious, Inflow Depth > 17 mm for 10-Year event  
Inflow = 0.353 m<sup>3</sup>/s @ 13.41 hrs, Volume= 4.626 MI  
Primary = 0.353 m<sup>3</sup>/s @ 13.41 hrs, Volume= 4.626 MI, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

### Link Y: Drainage Point



## PRE\_DRAINAGE

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Type II 24-hr 10-Year Rainfall=228 mm

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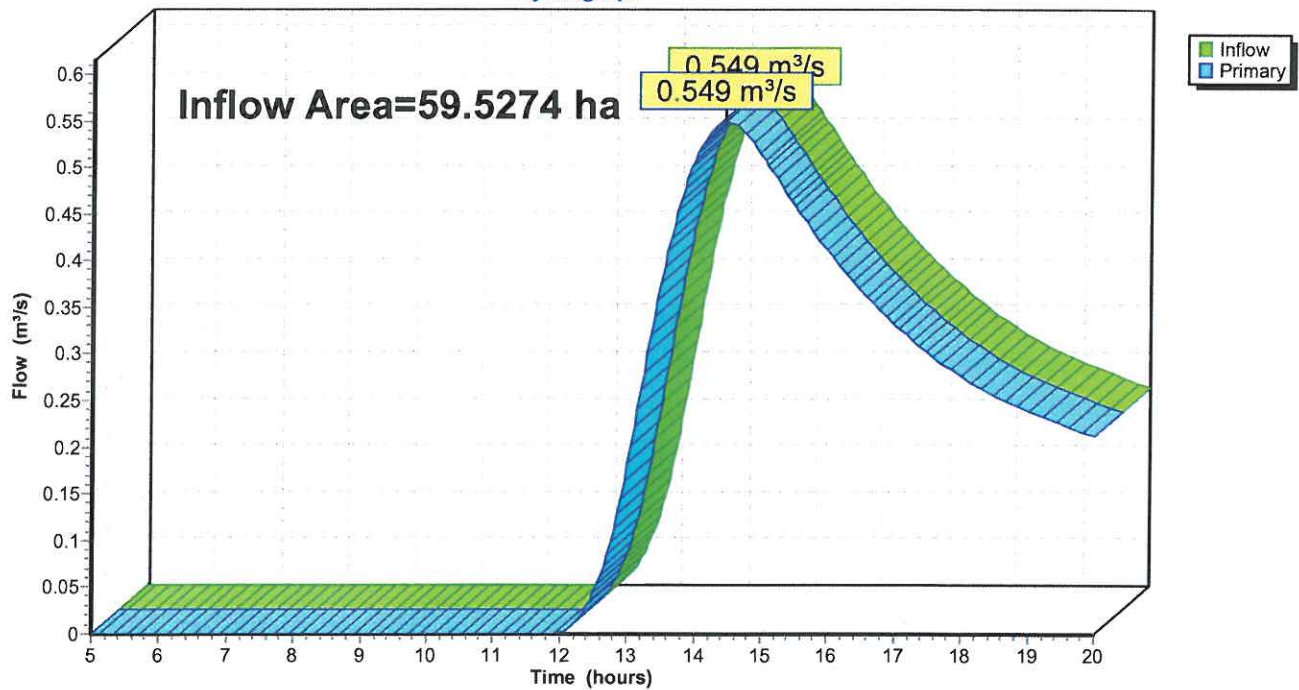
### Summary for Link Z: Drainage Point

Inflow Area = 59.5274 ha, 2.32% Impervious, Inflow Depth > 16 mm for 10-Year event  
Inflow = 0.549 m<sup>3</sup>/s @ 14.47 hrs, Volume= 9.280 MI  
Primary = 0.549 m<sup>3</sup>/s @ 14.47 hrs, Volume= 9.280 MI, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

### Link Z: Drainage Point

Hydrograph



## **2.2 Post-Development Analysis**

## 2.2 Post-development Analysis

As in the pre-development analysis, the total watershed area is 816.84 hectares. Pre-development area boundaries remained virtually unchanged in the post-development analysis, and are similarly identified as Po1, Po2, Po3, and Po4. A smaller subcatchment exists within Po4, and has been identified in the model as Po4a.

Boundaries of drainage area Po1 are very similar to those of Pr1. External boundaries are entirely unchanged, while internal boundary with Po2 and Po4 are slightly modified by grading associated with the project. Twelve of the new turbines proposed for the project are contained within Po1. Additionally approximately 2300 meters of new road are proposed. Post construction all but a 5 meter gravel travelled way will be reclaimed. Runoff leaves this area at drainage analysis point W.

Drainage area Po2 is the same basic area as Pr2 with the southwestern boundary slightly modified by the addition of a proposed turbine and road. One proposed turbine and approximately 64 meters of roadway are contained within this drainage area. Runoff leaves this area at drainage analysis point X.

Drainage area Po3 is the same area as Pr3, with boundaries unchanged from the pre-development model. Two proposed turbines and approximately 536 meters of roadway are contained within this drainage area. Runoff leaves this area at drainage analysis point Y.

Drainage area Po4 is the same area as Pr4 with the southwestern boundary slightly modified by the addition of a proposed turbine and road. Three proposed turbines and approximately 371 meters of roadway are contained within this drainage area. The electrical substation, operations and maintenance area, and a laydown yard are located within Po4, draining to a sinkhole/pond. Drainage to this pond has been identified as a unique subcatchment, Po4a. Runoff leaves Po4 at drainage analysis point Z.

For more detailed information on post-developed areas, see attached drainage plans found in **Section 3** and the HydroCAD area listings found in **Section 2.2.2**. A pre- versus post-development comparison flow rate table for the 2, 10, and 50 year storm events can be found in **Table 1.3** in **Section 1.1.5**.

### **2.2.1 Post-Development 2, 10, and 50 - Year Storm**

## POST\_DRAINAGE

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Type II 24-hr 2-Year Rainfall=85 mm

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=SCS

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment Po1: Drainage Area** Runoff Area=7,096,962.6 m<sup>2</sup> 1.02% Impervious Runoff Depth=0 mm  
Flow Length=3,573.8 m Tc=118.8 min CN=31 Runoff=0.000 m<sup>3</sup>/s 0.000 MI

**Subcatchment Po2: Drainage Area** Runoff Area=164,097.8 m<sup>2</sup> 1.24% Impervious Runoff Depth=0 mm  
Flow Length=581.1 m Tc=47.4 min CN=31 Runoff=0.000 m<sup>3</sup>/s 0.000 MI

**Subcatchment Po3: Drainage Area** Runoff Area=273,851.4 m<sup>2</sup> 3.62% Impervious Runoff Depth=0 mm  
Flow Length=1,033.9 m Tc=98.1 min CN=32 Runoff=0.000 m<sup>3</sup>/s 0.000 MI

**Subcatchment Po4: Drainage Area** Runoff Area=584,719.0 m<sup>2</sup> 2.90% Impervious Runoff Depth=0 mm  
Flow Length=2,751.8 m Tc=158.7 min CN=32 Runoff=0.000 m<sup>3</sup>/s 0.000 MI

**Subcatchment Po4a: Drainage Area** Runoff Area=48,731.9 m<sup>2</sup> 13.53% Impervious Runoff Depth>0 mm  
Flow Length=480.2 m Slope=0.0200 m/m Tc=46.2 min CN=39 Runoff=0.000 m<sup>3</sup>/s 0.000 MI

**Pond SH: Sinkhole/Pond** Peak Elev=683.000 m Storage=0.1 m<sup>3</sup> Inflow=0.000 m<sup>3</sup>/s 0.000 MI  
Outflow=0.000 m<sup>3</sup>/s 0.000 MI

**Link W: Drainage Point** Inflow=0.000 m<sup>3</sup>/s 0.000 MI  
Primary=0.000 m<sup>3</sup>/s 0.000 MI

**Link X: Drainage Point** Inflow=0.000 m<sup>3</sup>/s 0.000 MI  
Primary=0.000 m<sup>3</sup>/s 0.000 MI

**Link Y: Drainage Point** Inflow=0.000 m<sup>3</sup>/s 0.000 MI  
Primary=0.000 m<sup>3</sup>/s 0.000 MI

**Link Z: Drainage Point** Inflow=0.000 m<sup>3</sup>/s 0.000 MI  
Primary=0.000 m<sup>3</sup>/s 0.000 MI

**Total Runoff Area = 816.8363 ha Runoff Volume = 0.000 MI Average Runoff Depth = 0 mm**  
**98.68% Pervious = 806.0445 ha 1.32% Impervious = 10.7918 ha**

## POST\_DRAINAGE

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Type II 24-hr 10-Year Rainfall=228 mm

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=SCS

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment Po1: Drainage Area** Runoff Area=7,096,962.6 m<sup>2</sup> 1.02% Impervious Runoff Depth>14 mm  
Flow Length=3,573.8 m Tc=118.8 min CN=31 Runoff=6.667 m<sup>3</sup>/s 101.801 MI

**Subcatchment Po2: Drainage Area** Runoff Area=164,097.8 m<sup>2</sup> 1.24% Impervious Runoff Depth>16 mm  
Flow Length=581.1 m Tc=47.4 min CN=31 Runoff=0.249 m<sup>3</sup>/s 2.545 MI

**Subcatchment Po3: Drainage Area** Runoff Area=273,851.4 m<sup>2</sup> 3.62% Impervious Runoff Depth>17 mm  
Flow Length=1,033.9 m Tc=98.1 min CN=32 Runoff=0.333 m<sup>3</sup>/s 4.596 MI

**Subcatchment Po4: Drainage Area** Runoff Area=584,719.0 m<sup>2</sup> 2.90% Impervious Runoff Depth>16 mm  
Flow Length=2,751.8 m Tc=158.7 min CN=32 Runoff=0.539 m<sup>3</sup>/s 9.115 MI

**Subcatchment Po4a: Drainage Area** Runoff Area=48,731.9 m<sup>2</sup> 13.53% Impervious Runoff Depth>34 mm  
Flow Length=480.2 m Slope=0.0200 m/m Tc=46.2 min CN=39 Runoff=0.254 m<sup>3</sup>/s 1.677 MI

**Pond SH: Sinkhole/Pond** Peak Elev=685.013 m Storage=1,451.5 m<sup>3</sup> Inflow=0.254 m<sup>3</sup>/s 1.677 MI  
Outflow=0.026 m<sup>3</sup>/s 0.229 MI

**Link W: Drainage Point** Inflow=6.667 m<sup>3</sup>/s 101.801 MI  
Primary=6.667 m<sup>3</sup>/s 101.801 MI

**Link X: Drainage Point** Inflow=0.249 m<sup>3</sup>/s 2.545 MI  
Primary=0.249 m<sup>3</sup>/s 2.545 MI

**Link Y: Drainage Point** Inflow=0.333 m<sup>3</sup>/s 4.596 MI  
Primary=0.333 m<sup>3</sup>/s 4.596 MI

**Link Z: Drainage Point** Inflow=0.539 m<sup>3</sup>/s 9.344 MI  
Primary=0.539 m<sup>3</sup>/s 9.344 MI

**Total Runoff Area = 816.8363 ha Runoff Volume = 119.734 MI Average Runoff Depth = 15 mm**  
**98.68% Pervious = 806.0445 ha 1.32% Impervious = 10.7918 ha**



## POST\_DRAINAGE

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Type II 24-hr 50-Year Rainfall=426 mm

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=SCS

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment Po1: Drainage Area** Runoff Area=7,096,962.6 m<sup>2</sup> 1.02% Impervious Runoff Depth>93 mm  
Flow Length=3,573.8 m Tc=118.8 min CN=31 Runoff=59.832 m<sup>3</sup>/s 659.449 MI

**Subcatchment Po2: Drainage Area** Runoff Area=164,097.8 m<sup>2</sup> 1.24% Impervious Runoff Depth>97 mm  
Flow Length=581.1 m Tc=47.4 min CN=31 Runoff=2.748 m<sup>3</sup>/s 15.972 MI

**Subcatchment Po3: Drainage Area** Runoff Area=273,851.4 m<sup>2</sup> 3.62% Impervious Runoff Depth>100 mm  
Flow Length=1,033.9 m Tc=98.1 min CN=32 Runoff=2.878 m<sup>3</sup>/s 27.426 MI

**Subcatchment Po4: Drainage Area** Runoff Area=584,719.0 m<sup>2</sup> 2.90% Impervious Runoff Depth>96 mm  
Flow Length=2,751.8 m Tc=158.7 min CN=32 Runoff=4.216 m<sup>3</sup>/s 55.960 MI

**Subcatchment Po4a: Drainage Area** Runoff Area=48,731.9 m<sup>2</sup> 13.53% Impervious Runoff Depth>144 mm  
Flow Length=480.2 m Slope=0.0200 m/m Tc=46.2 min CN=39 Runoff=1.330 m<sup>3</sup>/s 7.024 MI

**Pond SH: Sinkhole/Pond** Peak Elev=685.196 m Storage=1,672.5 m<sup>3</sup> Inflow=1.330 m<sup>3</sup>/s 7.024 MI  
Outflow=1.292 m<sup>3</sup>/s 5.555 MI

**Link W: Drainage Point** Inflow=59.832 m<sup>3</sup>/s 659.449 MI  
Primary=59.832 m<sup>3</sup>/s 659.449 MI

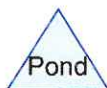
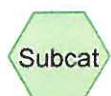
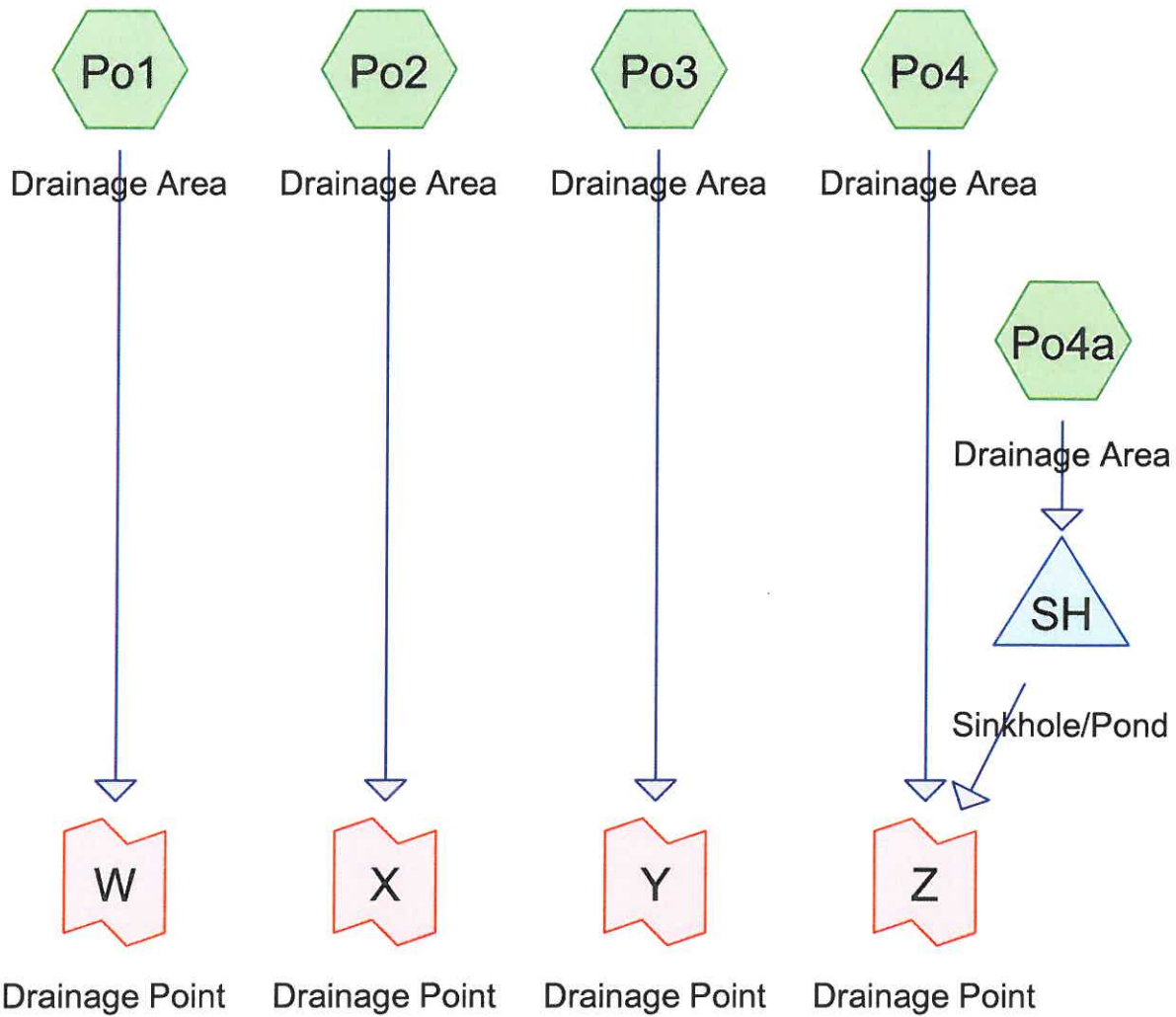
**Link X: Drainage Point** Inflow=2.748 m<sup>3</sup>/s 15.972 MI  
Primary=2.748 m<sup>3</sup>/s 15.972 MI

**Link Y: Drainage Point** Inflow=2.878 m<sup>3</sup>/s 27.426 MI  
Primary=2.878 m<sup>3</sup>/s 27.426 MI

**Link Z: Drainage Point** Inflow=4.445 m<sup>3</sup>/s 61.515 MI  
Primary=4.445 m<sup>3</sup>/s 61.515 MI

**Total Runoff Area = 816.8363 ha Runoff Volume = 765.830 MI Average Runoff Depth = 94 mm**  
**98.68% Pervious = 806.0445 ha 1.32% Impervious = 10.7918 ha**

**2.2.2 Post-Development Full Summary Diagram  
10 - Year Storm Event**



## POST\_DRAINAGE

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### Area Listing (all nodes)

Area (hectares)	CN	Description (subcatchment-numbers)
234.0845	30	Meadow, non-grazed, HSG A (Po1, Po2, Po3, Po4, Po4a)
16.8781	30	Meadow, non-grazed, PROJECT, HSG A (Po1, Po2, Po3, Po4, Po4a)
555.0460	30	Woods, Good, HSG A (Po1, Po2, Po3, Po4, Po4a)
3.5885	98	Gravel-Project Road/Pads, 99% imp, HSG A (Po1, Po2, Po3, Po4, Po4a)
0.0669	98	Roofs, HSG A (Po1, Po2, Po3, Po4, Po4a)
1.0845	98	xBUILDING (Po1)
6.0879	98	xROAD (Po1, Po2, Po3, Po4)
<b>816.8363</b>	<b>31</b>	<b>TOTAL AREA</b>

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### Soil Listing (all nodes)

Area (hectares)	Soil Group	Subcatchment Numbers
809.6640	HSG A	Po1, Po2, Po3, Po4, Po4a
0.0000	HSG B	
0.0000	HSG C	
0.0000	HSG D	
7.1723	Other	Po1, Po2, Po3, Po4
<b>816.8363</b>		<b>TOTAL AREA</b>

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### Pipe Listing (all nodes)

Line#	Node Number	In-Invert (meters)	Out-Invert (meters)	Length (meters)	Slope (m/m)	n	Diam/Width (mm)	Height (mm)	Fill (mm)
1	Po3	0.000	0.000	45.00	0.0889	0.013	457	0	0

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=SCS

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment Po1: Drainage Area** Runoff Area=7,096,962.6 m<sup>2</sup> 1.02% Impervious Runoff Depth>14 mm  
Flow Length=3,573.8 m Tc=118.8 min CN=31 Runoff=6.667 m<sup>3</sup>/s 101.801 MI

**Subcatchment Po2: Drainage Area** Runoff Area=164,097.8 m<sup>2</sup> 1.24% Impervious Runoff Depth>16 mm  
Flow Length=581.1 m Tc=47.4 min CN=31 Runoff=0.249 m<sup>3</sup>/s 2.545 MI

**Subcatchment Po3: Drainage Area** Runoff Area=273,851.4 m<sup>2</sup> 3.62% Impervious Runoff Depth>17 mm  
Flow Length=1,033.9 m Tc=98.1 min CN=32 Runoff=0.333 m<sup>3</sup>/s 4.596 MI

**Subcatchment Po4: Drainage Area** Runoff Area=584,719.0 m<sup>2</sup> 2.90% Impervious Runoff Depth>16 mm  
Flow Length=2,751.8 m Tc=158.7 min CN=32 Runoff=0.539 m<sup>3</sup>/s 9.115 MI

**Subcatchment Po4a: Drainage Area** Runoff Area=48,731.9 m<sup>2</sup> 13.53% Impervious Runoff Depth>34 mm  
Flow Length=480.2 m Slope=0.0200 m/m Tc=46.2 min CN=39 Runoff=0.254 m<sup>3</sup>/s 1.677 MI

**Pond SH: Sinkhole/Pond** Peak Elev=685.013 m Storage=1,451.5 m<sup>3</sup> Inflow=0.254 m<sup>3</sup>/s 1.677 MI  
Outflow=0.026 m<sup>3</sup>/s 0.229 MI

**Link W: Drainage Point** Inflow=6.667 m<sup>3</sup>/s 101.801 MI  
Primary=6.667 m<sup>3</sup>/s 101.801 MI

**Link X: Drainage Point** Inflow=0.249 m<sup>3</sup>/s 2.545 MI  
Primary=0.249 m<sup>3</sup>/s 2.545 MI

**Link Y: Drainage Point** Inflow=0.333 m<sup>3</sup>/s 4.596 MI  
Primary=0.333 m<sup>3</sup>/s 4.596 MI

**Link Z: Drainage Point** Inflow=0.539 m<sup>3</sup>/s 9.344 MI  
Primary=0.539 m<sup>3</sup>/s 9.344 MI

**Total Runoff Area = 816.8363 ha Runoff Volume = 119.734 MI Average Runoff Depth = 15 mm**  
**98.68% Pervious = 806.0445 ha 1.32% Impervious = 10.7918 ha**

**POST\_DRAINAGE**

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Type II 24-hr 10-Year Rainfall=228 mm

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**Summary for Subcatchment Po1: Drainage Area**Runoff = 6.667 m<sup>3</sup>/s @ 13.93 hrs, Volume= 101.801 MI, Depth> 14 mm

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Type II 24-hr 10-Year Rainfall=228 mm

Area (m <sup>2</sup> )	CN	Description
5,420,293.8	30	Woods, Good, HSG A
* 44,666.0	98	xROAD
* 10,844.6	98	xBUILDING
1,513,866.9	30	Meadow, non-grazed, HSG A
* 16,940.2	98	Gravel-Project Road/Pads, 99% imp, HSG A
90,214.2	30	Meadow, non-grazed, PROJECT, HSG A
136.9	98	Roofs, HSG A
7,096,962.6	31	Weighted Average
7,024,544.3		98.98% Pervious Area
72,418.3		1.02% Impervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m <sup>3</sup> /s)	Description
28.6	31.0	0.0100	0.02		<b>Sheet Flow, Po1-A</b> Grass: Bermuda n= 0.410 P2= 85 mm
19.7	581.0	0.1048	0.49		<b>Shallow Concentrated Flow, Po1-B</b> Woodland Kv= 1.52 m/s
19.5	697.5	0.0781	0.60		<b>Shallow Concentrated Flow, Po1-C</b> Short Grass Pasture Kv= 2.13 m/s
11.6	767.9	0.5307	1.11		<b>Shallow Concentrated Flow, Po1-D</b> Woodland Kv= 1.52 m/s
7.2	355.3	0.1511	0.83		<b>Shallow Concentrated Flow, Po1-E</b> Short Grass Pasture Kv= 2.13 m/s
32.2	1,141.1	0.1514	0.59		<b>Shallow Concentrated Flow, Po1-F</b> Woodland Kv= 1.52 m/s
118.8	3,573.8	Total			



## POST\_DRAINAGE

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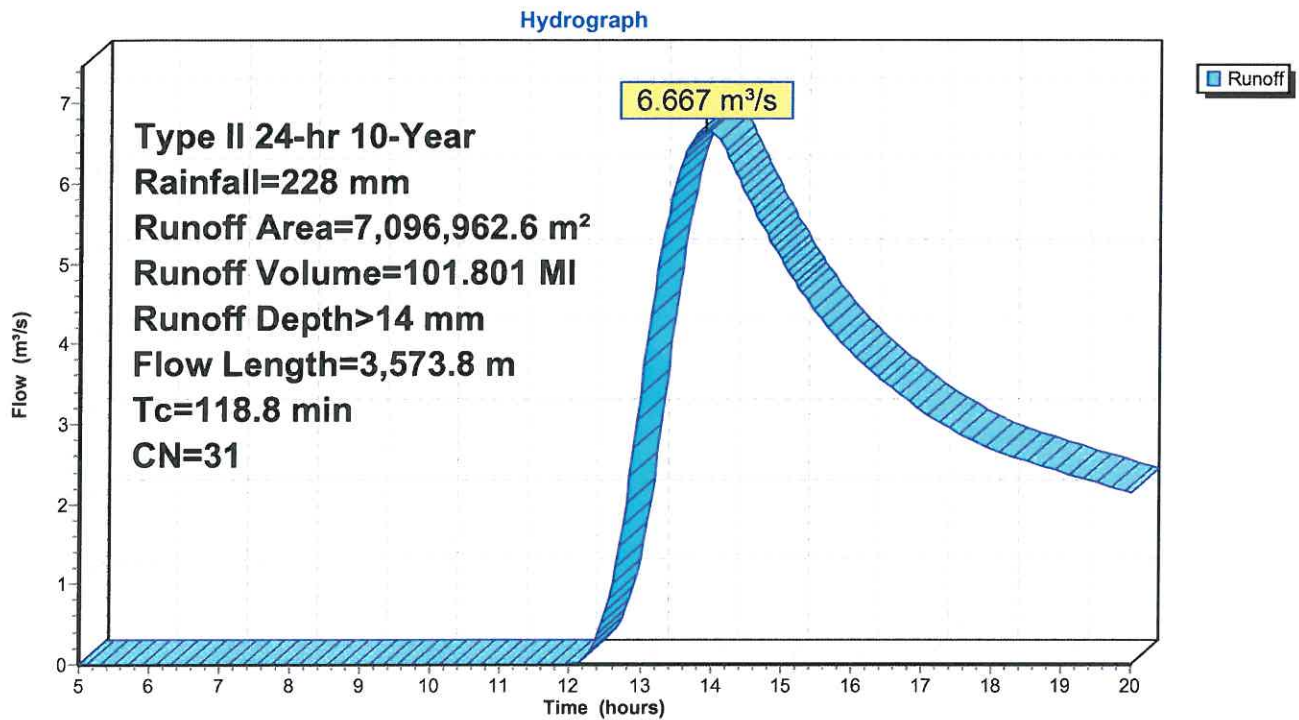
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Type II 24-hr 10-Year Rainfall=228 mm

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### Subcatchment Po1: Drainage Area



## POST\_DRAINAGE

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### Summary for Subcatchment Po2: Drainage Area

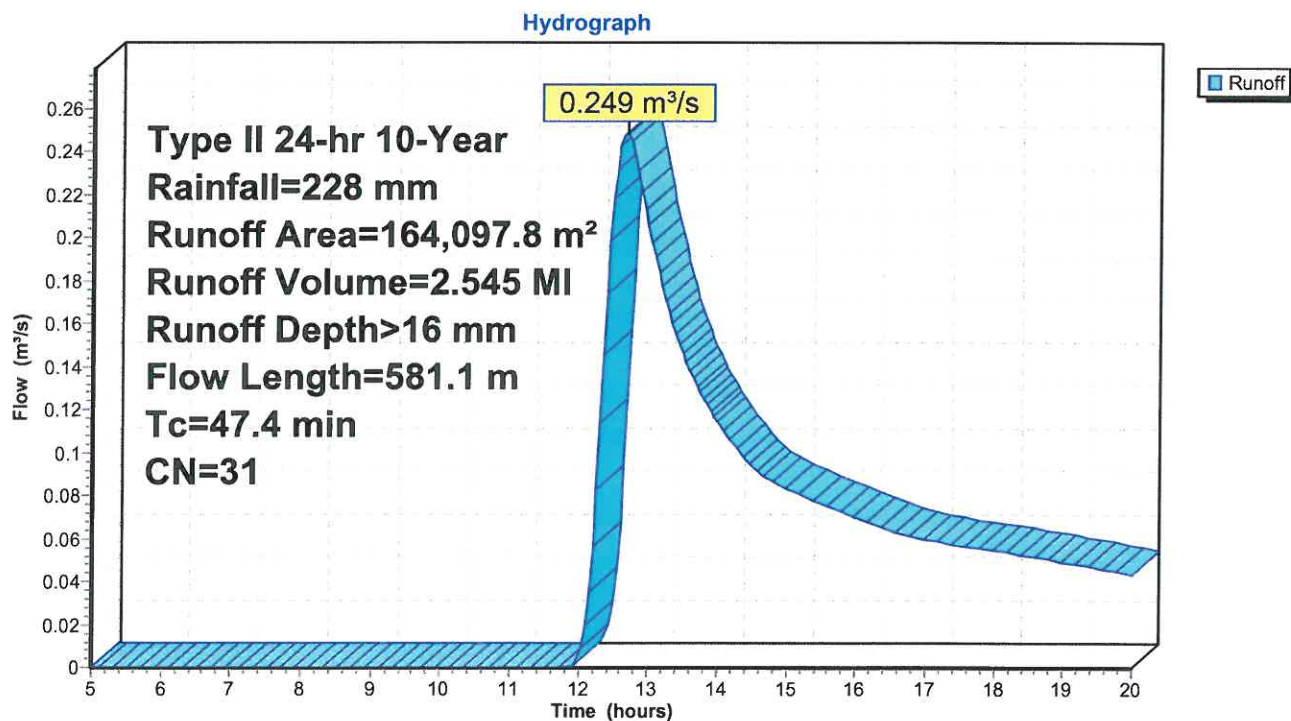
Runoff = 0.249 m<sup>3</sup>/s @ 12.69 hrs, Volume= 2.545 MI, Depth> 16 mm

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type II 24-hr 10-Year Rainfall=228 mm

Area (m <sup>2</sup> )	CN	Description
44,734.9	30	Woods, Good, HSG A
* 1,336.4	98	xROAD
* 0.0	98	xBUILDING
114,185.0	30	Meadow, non-grazed, HSG A
* 687.5	98	Gravel-Project Road/Pads, 99% imp, HSG A
3,141.5	30	Meadow, non-grazed, PROJECT, HSG A
12.5	98	Roofs, HSG A
164,097.8	31	Weighted Average
162,068.3		98.76% Pervious Area
2,029.5		1.24% Impervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m <sup>3</sup> /s)	Description
21.3	31.0	0.0200	0.02		<b>Sheet Flow, Po2-A</b> Woods: Light underbrush n= 0.400 P2= 85 mm
26.1	550.1	0.0273	0.35		<b>Shallow Concentrated Flow, Po2-B</b> Short Grass Pasture Kv= 2.13 m/s
47.4	581.1	Total			

### Subcatchment Po2: Drainage Area



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**Summary for Subcatchment Po3: Drainage Area**Runoff = 0.333 m<sup>3</sup>/s @ 13.50 hrs, Volume= 4.596 MI, Depth> 17 mm

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Type II 24-hr 10-Year Rainfall=228 mm

Area (m <sup>2</sup> )	CN	Description
635.7	30	Woods, Good, HSG A
* 5,472.0	98	xROAD
* 0.0	98	xBUILDING
244,591.7	30	Meadow, non-grazed, HSG A
* 4,452.3	98	Gravel-Project Road/Pads, 99% imp, HSG A
18,674.8	30	Meadow, non-grazed, PROJECT, HSG A
24.9	98	Roofs, HSG A
273,851.4	32	Weighted Average
263,946.7		96.38% Pervious Area
9,904.7		3.62% Impervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m <sup>3</sup> /s)	Description
28.6	31.0	0.0100	0.02		<b>Sheet Flow, Po3-A</b> Grass: Bermuda n= 0.410 P2= 85 mm
43.6	618.1	0.0123	0.24		<b>Shallow Concentrated Flow, Po3-B</b> Short Grass Pasture Kv= 2.13 m/s
0.1	45.0	0.0889	5.40	0.8858	<b>Pipe Channel, Po3-C</b> 457 mm Round Area= 0.16 m <sup>2</sup> Perim= 1.44 m r= 0.11 m n= 0.013 Corrugated PE, smooth interior
25.8	339.8	0.0106	0.22		<b>Shallow Concentrated Flow, Po3-D</b> Short Grass Pasture Kv= 2.13 m/s
98.1	1,033.9	Total			

## POST\_DRAINAGE

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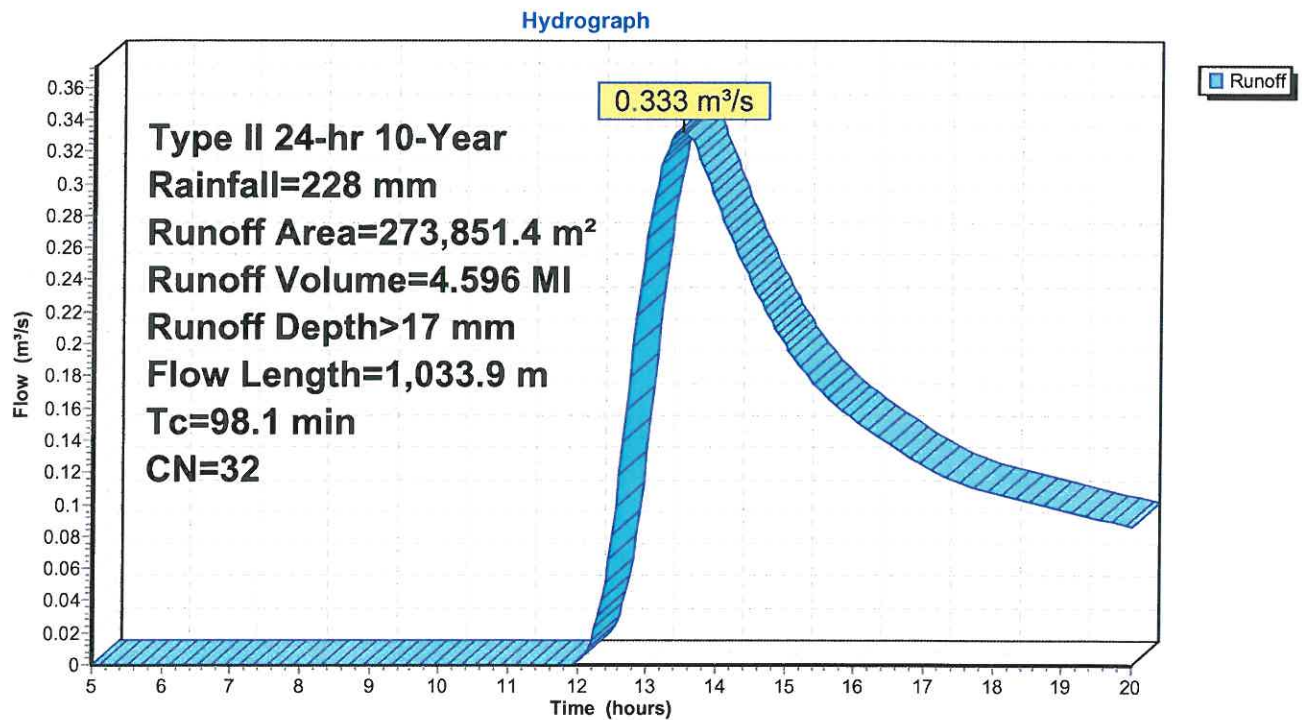
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### Subcatchment Po3: Drainage Area





## POST\_DRAINAGE

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### Summary for Subcatchment Po4: Drainage Area

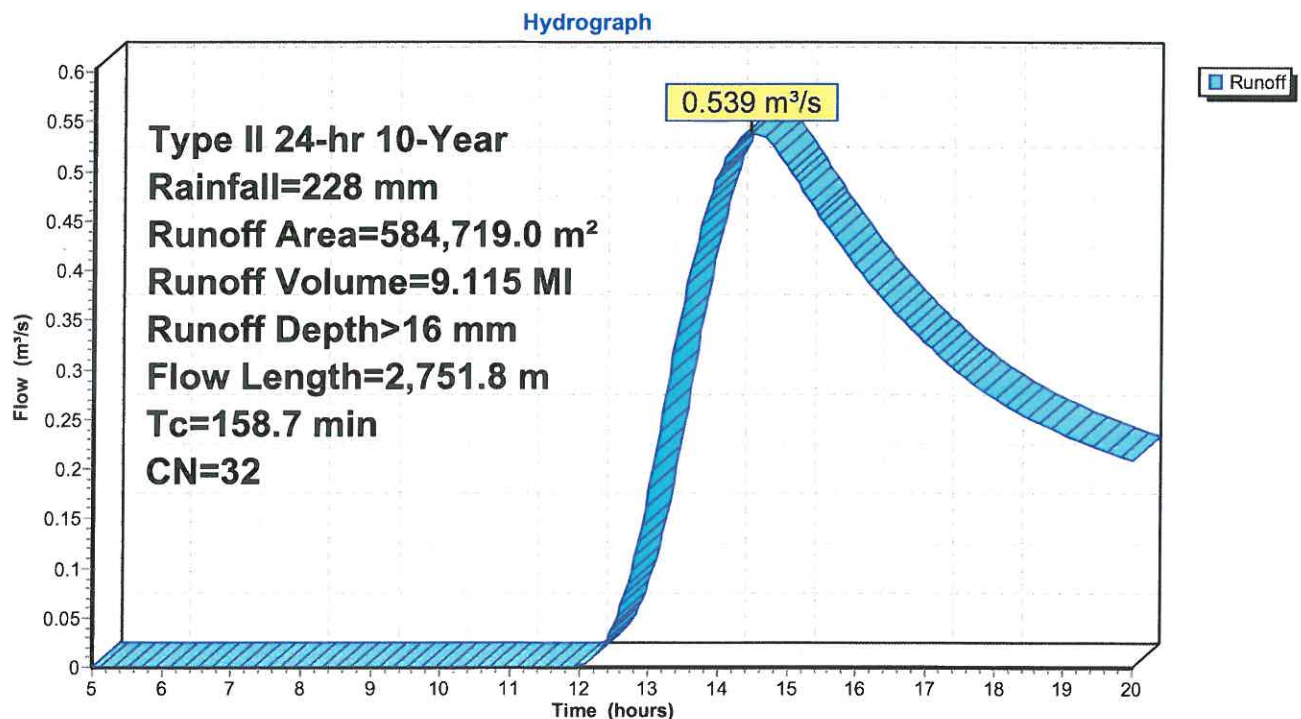
Runoff = 0.539 m<sup>3</sup>/s @ 14.47 hrs, Volume= 9.115 MI, Depth> 16 mm

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type II 24-hr 10-Year Rainfall=228 mm

Area (m <sup>2</sup> )	CN	Description
81,838.2	30	Woods, Good, HSG A
* 9,404.2	98	xROAD
* 0.0	98	xBUILDING
455,264.0	30	Meadow, non-grazed, HSG A
* 7,606.7	98	Gravel-Project Road/Pads, 99% imp, HSG A
30,568.6	30	Meadow, non-grazed, PROJECT, HSG A
37.3	98	Roofs, HSG A
584,719.0	32	Weighted Average
567,746.9		97.10% Pervious Area
16,972.1		2.90% Impervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m <sup>3</sup> /s)	Description
12.5	31.0	0.0757	0.04		<b>Sheet Flow, Po4-A</b> Woods: Light underbrush n= 0.400 P2= 85 mm
146.2	2,720.8	0.0212	0.31		<b>Shallow Concentrated Flow, Po4-B</b> Short Grass Pasture Kv= 2.13 m/s
158.7	2,751.8	Total			

### Subcatchment Po4: Drainage Area



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### Summary for Subcatchment Po4a: Drainage Area

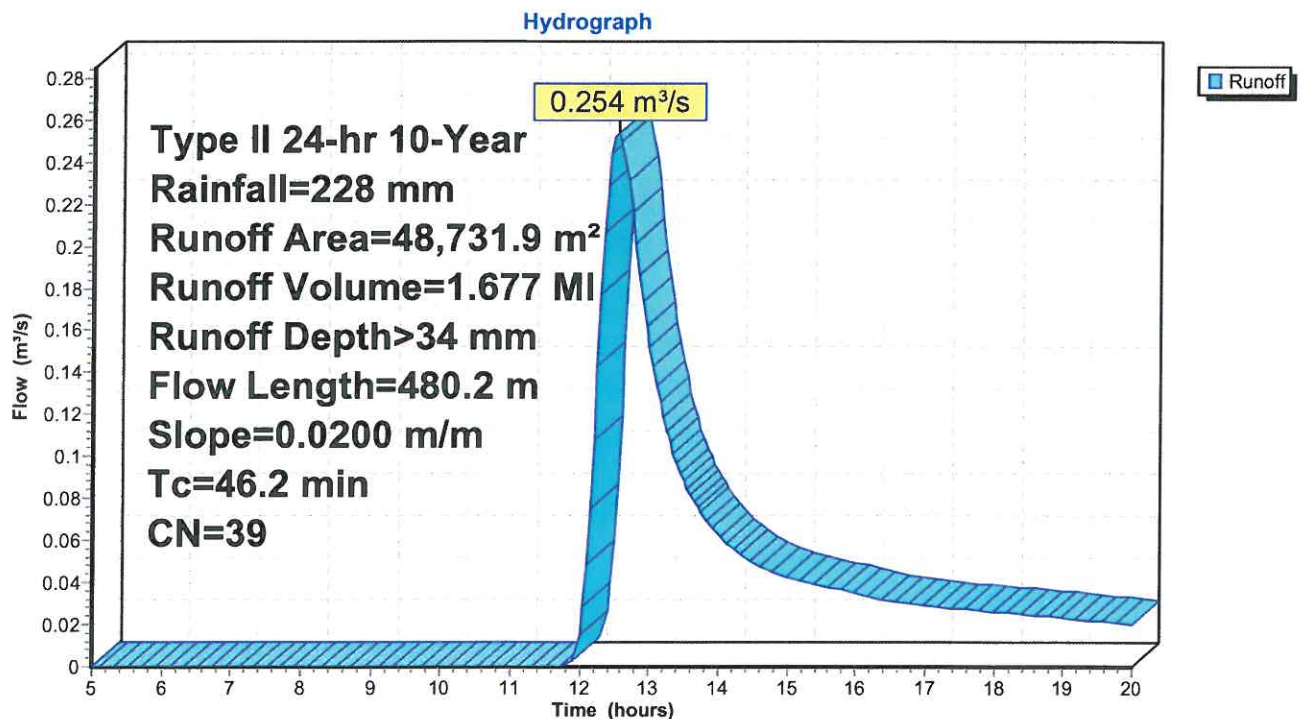
Runoff = 0.254 m<sup>3</sup>/s @ 12.54 hrs, Volume= 1.677 MI, Depth> 34 mm

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type II 24-hr 10-Year Rainfall=228 mm

	Area (m <sup>2</sup> )	CN	Description
	2,957.6	30	Woods, Good, HSG A
*	0.0	98	xROAD
*	0.0	98	xBUILDING
	12,937.3	30	Meadow, non-grazed, HSG A
*	6,198.0	98	Gravel-Project Road/Pads, 99% imp, HSG A
	26,181.5	30	Meadow, non-grazed, PROJECT, HSG A
	457.5	98	Roofs, HSG A
	48,731.9	39	Weighted Average
	42,138.4		86.47% Pervious Area
	6,593.5		13.53% Impervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m <sup>3</sup> /s)	Description
21.3	31.0	0.0200	0.02		<b>Sheet Flow, Po4a-A</b>
					Woods: Light underbrush n= 0.400 P2= 85 mm
24.9	449.2	0.0200	0.30		<b>Shallow Concentrated Flow, Po4a-B</b>
					Short Grass Pasture Kv= 2.13 m/s
46.2	480.2	Total			

### Subcatchment Po4a: Drainage Area



**POST\_DRAINAGE**

Type II 24-hr 10-Year Rainfall=228 mm

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**Summary for Pond SH: Sinkhole/Pond**

Inflow Area = 4.8732 ha, 13.53% Impervious, Inflow Depth > 34 mm for 10-Year event  
 Inflow = 0.254 m<sup>3</sup>/s @ 12.54 hrs, Volume= 1.677 MI  
 Outflow = 0.026 m<sup>3</sup>/s @ 17.92 hrs, Volume= 0.229 MI, Atten= 90%, Lag= 322.5 min  
 Primary = 0.026 m<sup>3</sup>/s @ 17.92 hrs, Volume= 0.229 MI

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
 Peak Elev= 685.013 m @ 17.92 hrs Surf.Area= 1,158.2 m<sup>2</sup> Storage= 1,451.5 m<sup>3</sup>

Plug-Flow detention time= 379.8 min calculated for 0.228 MI (14% of inflow)  
 Center-of-Mass det. time= 256.0 min ( 1,119.3 - 863.3 )

Volume	Invert	Avail.Storage	Storage Description
#1	683.000 m	2,075.0 m <sup>3</sup>	<b>Custom Stage Data (Prismatic)</b> Listed below (Recalc)

Elevation (meters)	Surf.Area (sq-meters)	Inc.Store (cubic-meters)	Cum.Store (cubic-meters)
683.000	336.0	0.0	0.0
684.000	693.0	514.5	514.5
685.000	1,152.0	922.5	1,437.0
685.500	1,400.0	638.0	2,075.0

Device	Routing	Invert	Outlet Devices
#1	Primary	685.000 m	<b>10.00 m long x 2.00 m breadth Broad-Crested Rectangular Weir</b> Head (meters) 0.061 0.122 0.183 0.244 0.305 0.366 0.427 0.488 0.549 0.610 0.762 0.914 1.067 1.219 1.372 1.524 1.676 Coef. (Metric) 1.32 1.39 1.49 1.48 1.48 1.47 1.47 1.46 1.46 1.46 1.47 1.47 1.47 1.48 1.50 1.51 1.55

**Primary OutFlow** Max=0.019 m<sup>3</sup>/s @ 17.92 hrs HW=685.013 m (Free Discharge)  
 ↑1=**Broad-Crested Rectangular Weir** (Weir Controls 0.019 m<sup>3</sup>/s @ 0.15 m/s)

## POST\_DRAINAGE

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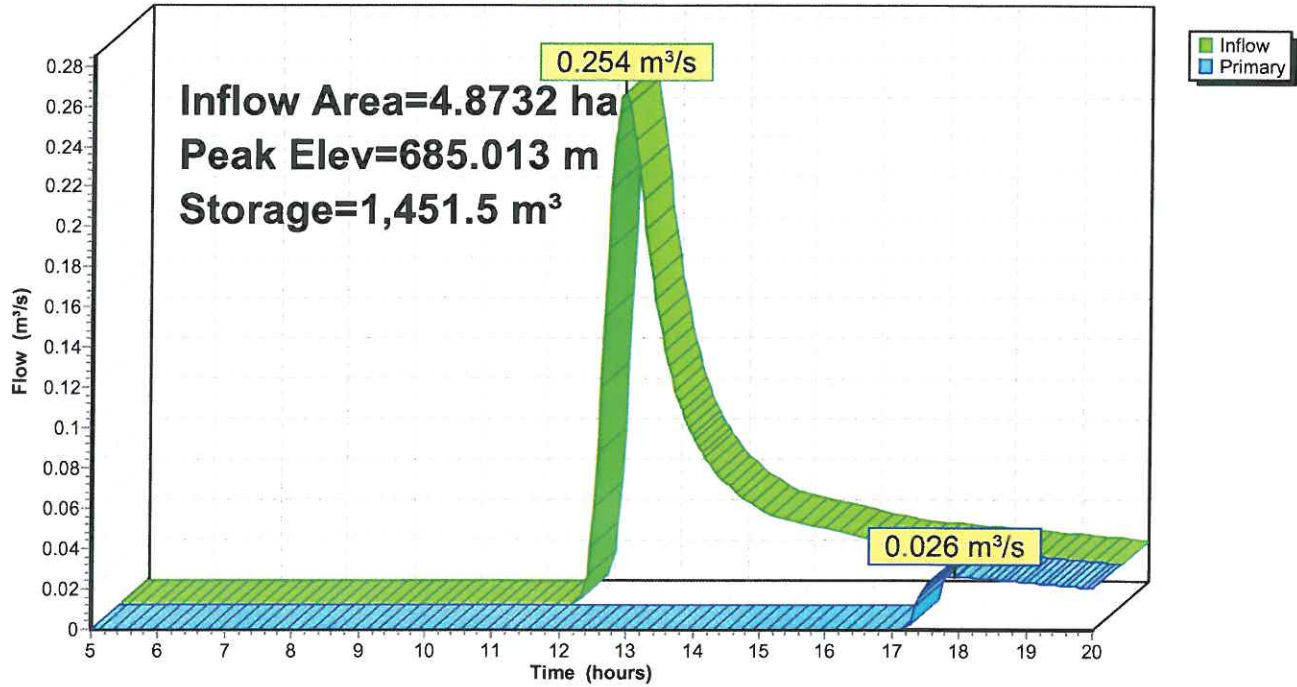
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### Pond SH: Sinkhole/Pond

Hydrograph





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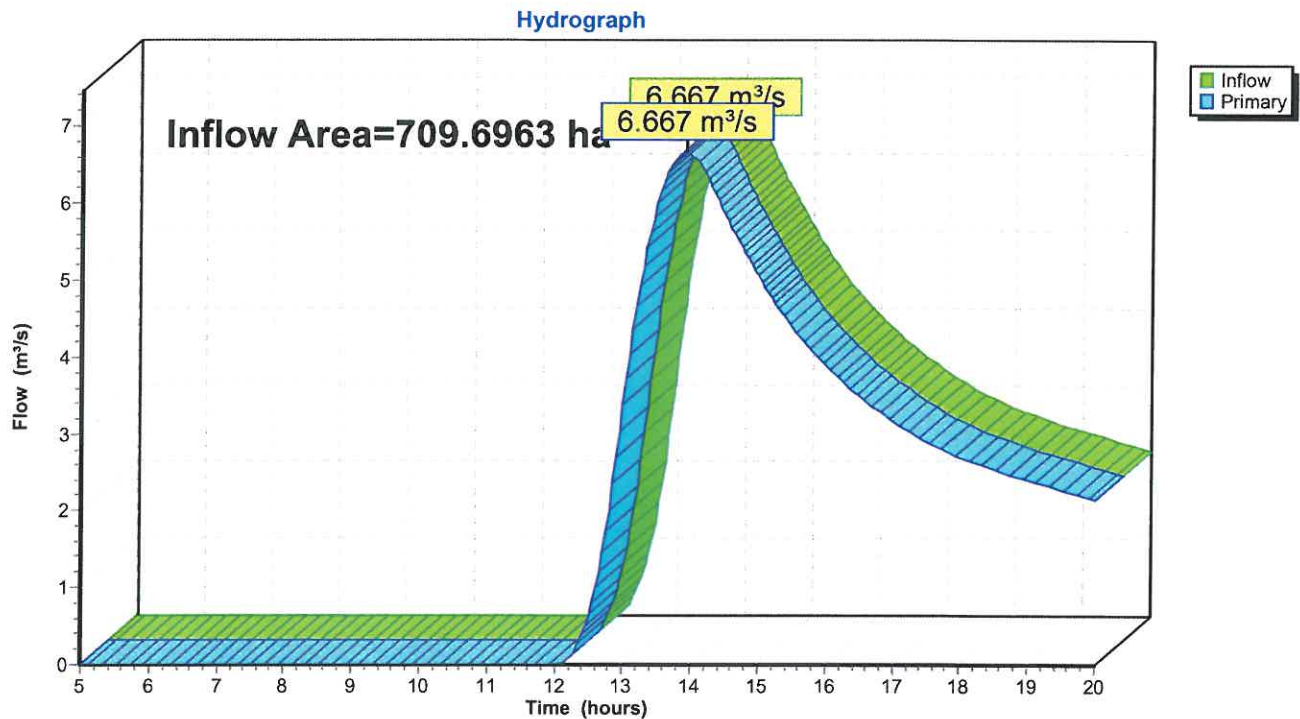
Page 15

### Summary for Link W: Drainage Point

Inflow Area = 709.6963 ha, 1.02% Impervious, Inflow Depth > 14 mm for 10-Year event  
Inflow = 6.667 m<sup>3</sup>/s @ 13.93 hrs, Volume= 101.801 MI  
Primary = 6.667 m<sup>3</sup>/s @ 13.93 hrs, Volume= 101.801 MI, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

### Link W: Drainage Point



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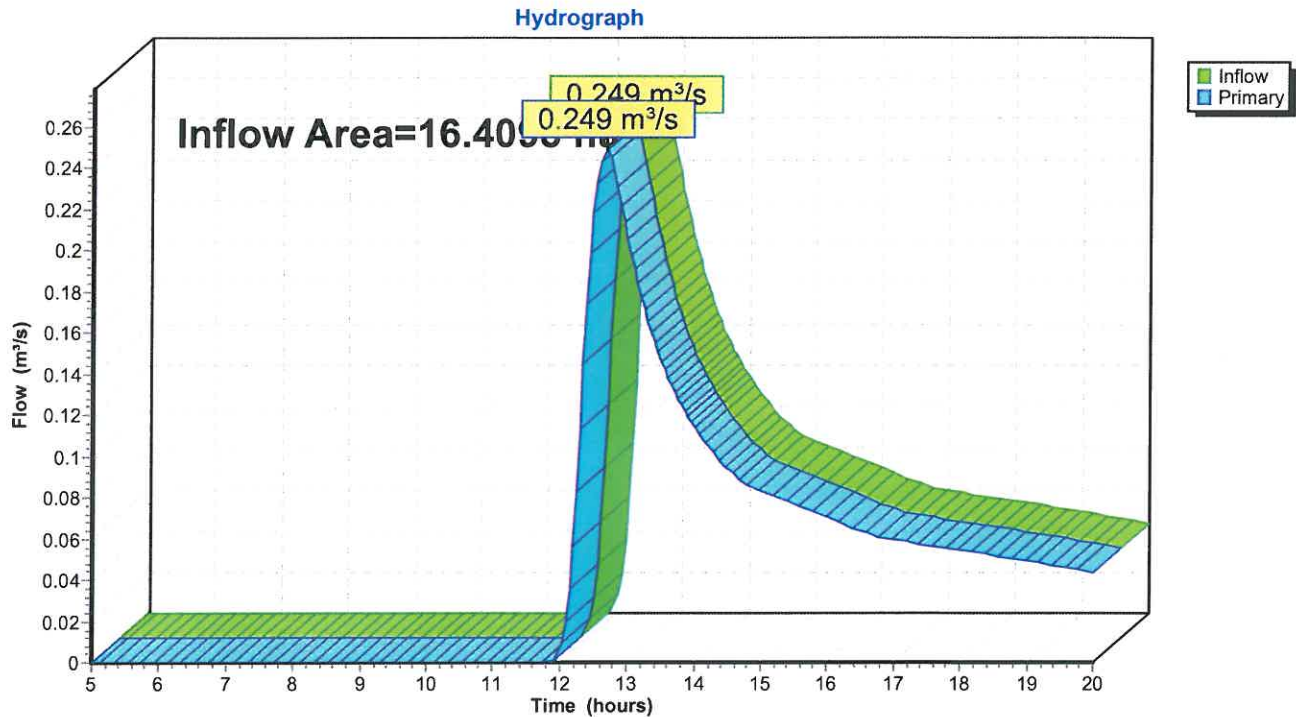
Page 16

### Summary for Link X: Drainage Point

Inflow Area = 16.4098 ha, 1.24% Impervious, Inflow Depth > 16 mm for 10-Year event  
Inflow = 0.249 m<sup>3</sup>/s @ 12.69 hrs, Volume= 2.545 MI  
Primary = 0.249 m<sup>3</sup>/s @ 12.69 hrs, Volume= 2.545 MI, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

### Link X: Drainage Point



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### Summary for Link Y: Drainage Point

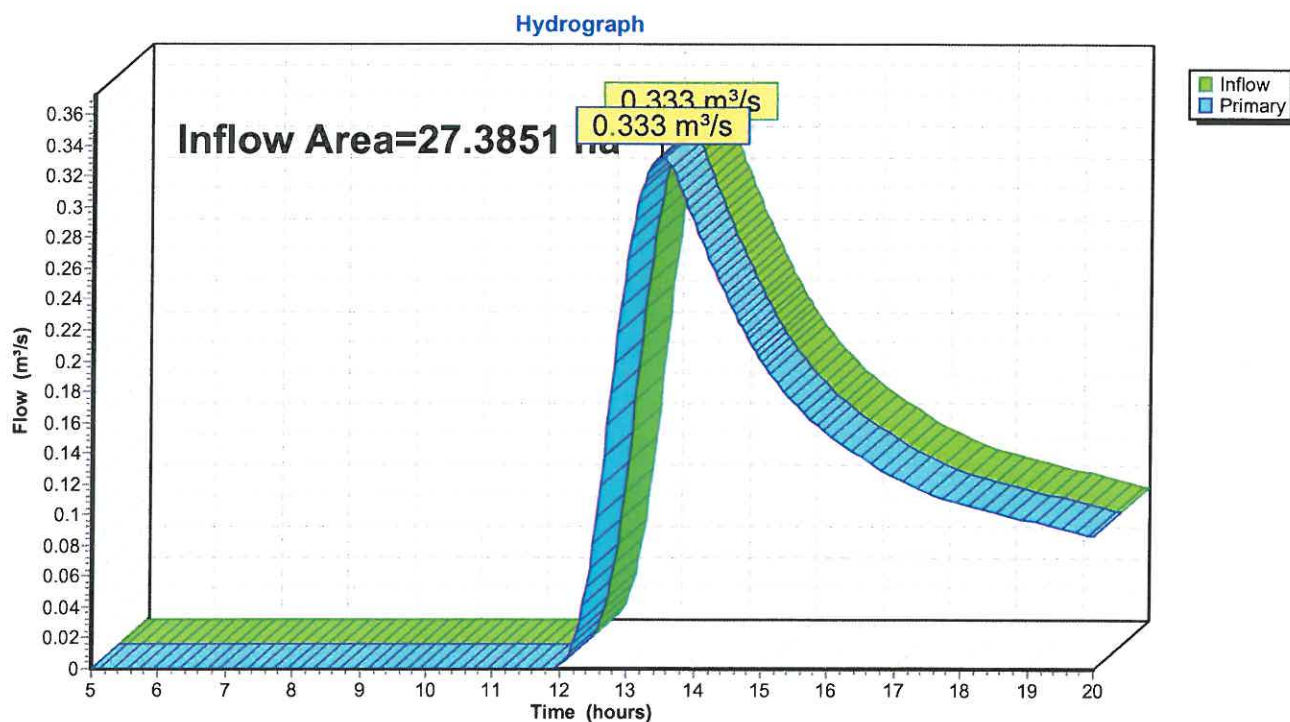
Inflow Area = 27.3851 ha, 3.62% Impervious, Inflow Depth > 17 mm for 10-Year event

Inflow = 0.333 m<sup>3</sup>/s @ 13.50 hrs, Volume= 4.596 MI

Primary = 0.333 m<sup>3</sup>/s @ 13.50 hrs, Volume= 4.596 MI, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

### Link Y: Drainage Point



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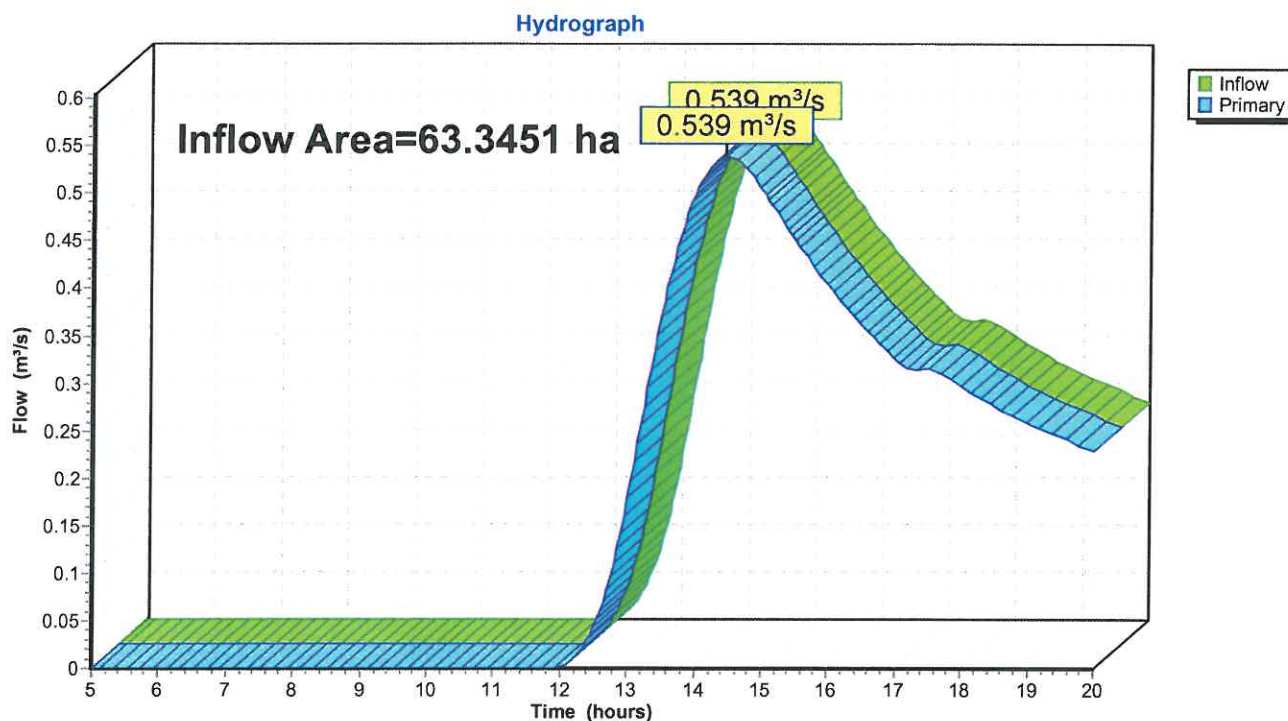
Page 18

### Summary for Link Z: Drainage Point

Inflow Area = 63.3451 ha, 3.72% Impervious, Inflow Depth > 15 mm for 10-Year event  
Inflow = 0.539 m<sup>3</sup>/s @ 14.47 hrs, Volume= 9.344 MI  
Primary = 0.539 m<sup>3</sup>/s @ 14.47 hrs, Volume= 9.344 MI, Atten= 0%, Lag= 0.0 min

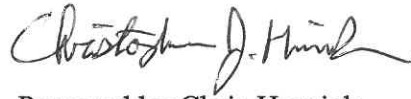
Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

### Link Z: Drainage Point



**2.3 References**  
**Preparer's Certification**  
**Reviewer's Certification**

**PREPARER'S CERTIFICATION**

A handwritten signature in black ink, appearing to read "Christopher J. Hernick". The signature is fluid and cursive, with the first name "Christopher" and last name "Hernick" clearly legible, and a middle initial "J." in between.

Prepared by Chris Hernick

**REVIEWER'S CERTIFICATION**

Reviewed by Steve LaFrance, P.Eng.

### **3.0 – PLANS**

### **3.1 Design Plans**

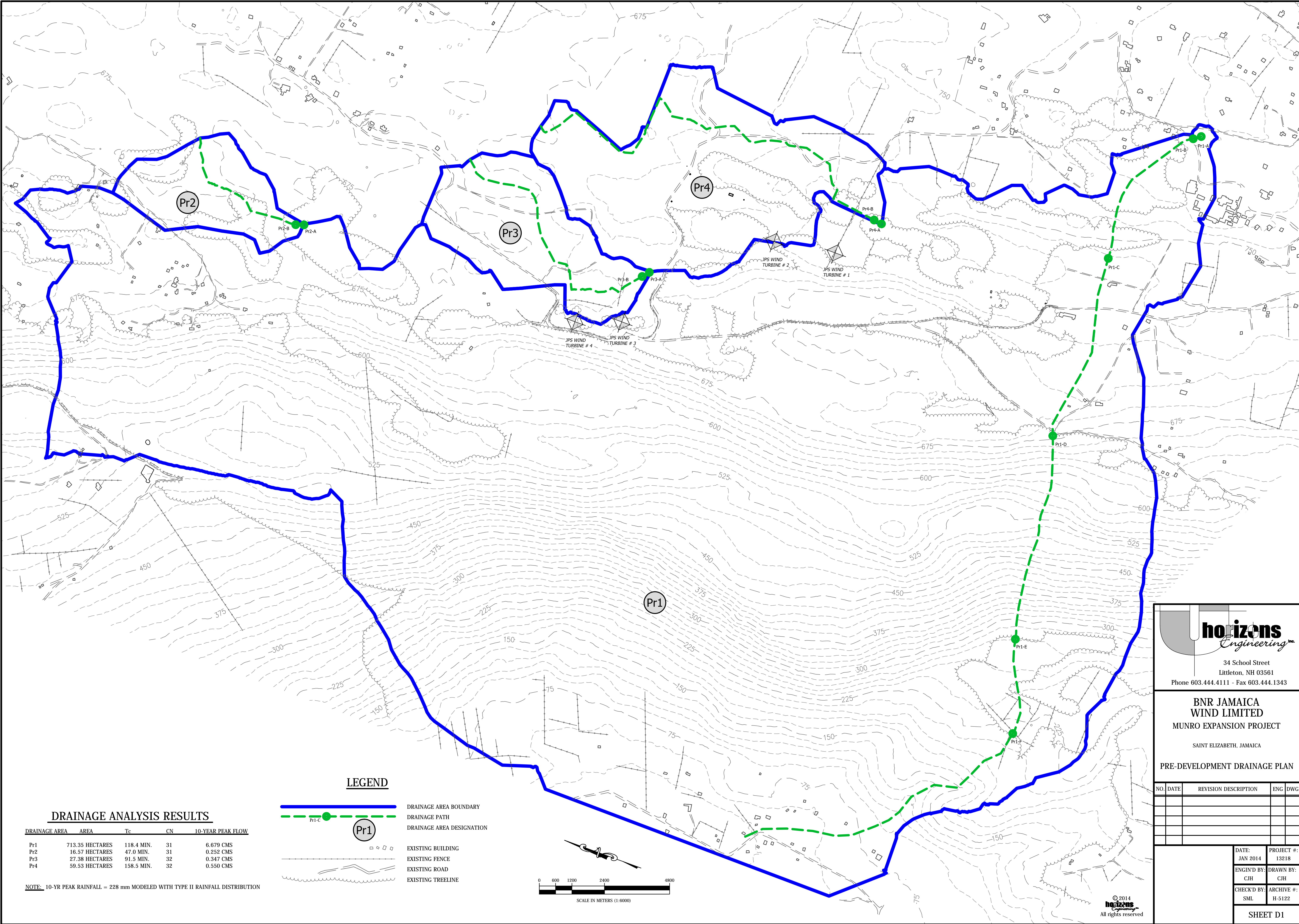


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(Plans Bound Separately)**

## **3.2 Pre- & Post-Development Drainage Area Plans**



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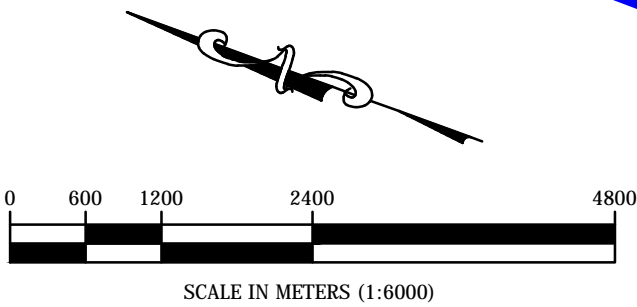
DRAINAGE ANALYSIS RESULTS

DRAINAGE AREA	AREA	Tc	CN	10-YEAR PEAK FLOW
Pr1	713.35 HECTARES	118.4 MIN.	31	6.679 CMS
Pr2	16.57 HECTARES	47.0 MIN.	31	0.252 CMS
Pr3	27.38 HECTARES	91.5 MIN.	32	0.347 CMS
Pr4	59.53 HECTARES	158.5 MIN.	32	0.550 CMS

NOTE: 10-YR PEAK RAINFALL = 228 mm MODELED WITH TYPE II RAINFALL DISTRIBUTION

LEGEND

- DRAINAGE AREA BOUNDARY
- - - DRAINAGE PATH
- Pr1 DRAINAGE AREA DESIGNATION
- □ □ EXISTING BUILDING
- - - EXISTING FENCE
- EXISTING ROAD
- ~ EXISTING TREELINE





34 School Street  
Littleton, NH 03561  
Phone 603.444.4111 - Fax 603.444.1343

BNR JAMAICA  
WIND LIMITED  
MUNRO EXPANSION PROJECT

SAINT ELIZABETH, JAMAICA

PRE-DEVELOPMENT DRAINAGE PLAN

NO.	DATE	REVISION DESCRIPTION	ENG	DWG

DATE:  
JAN 2014

ENGINE'D BY:  
CJH

CHECK'D BY:  
SML

PROJECT #:  
13218

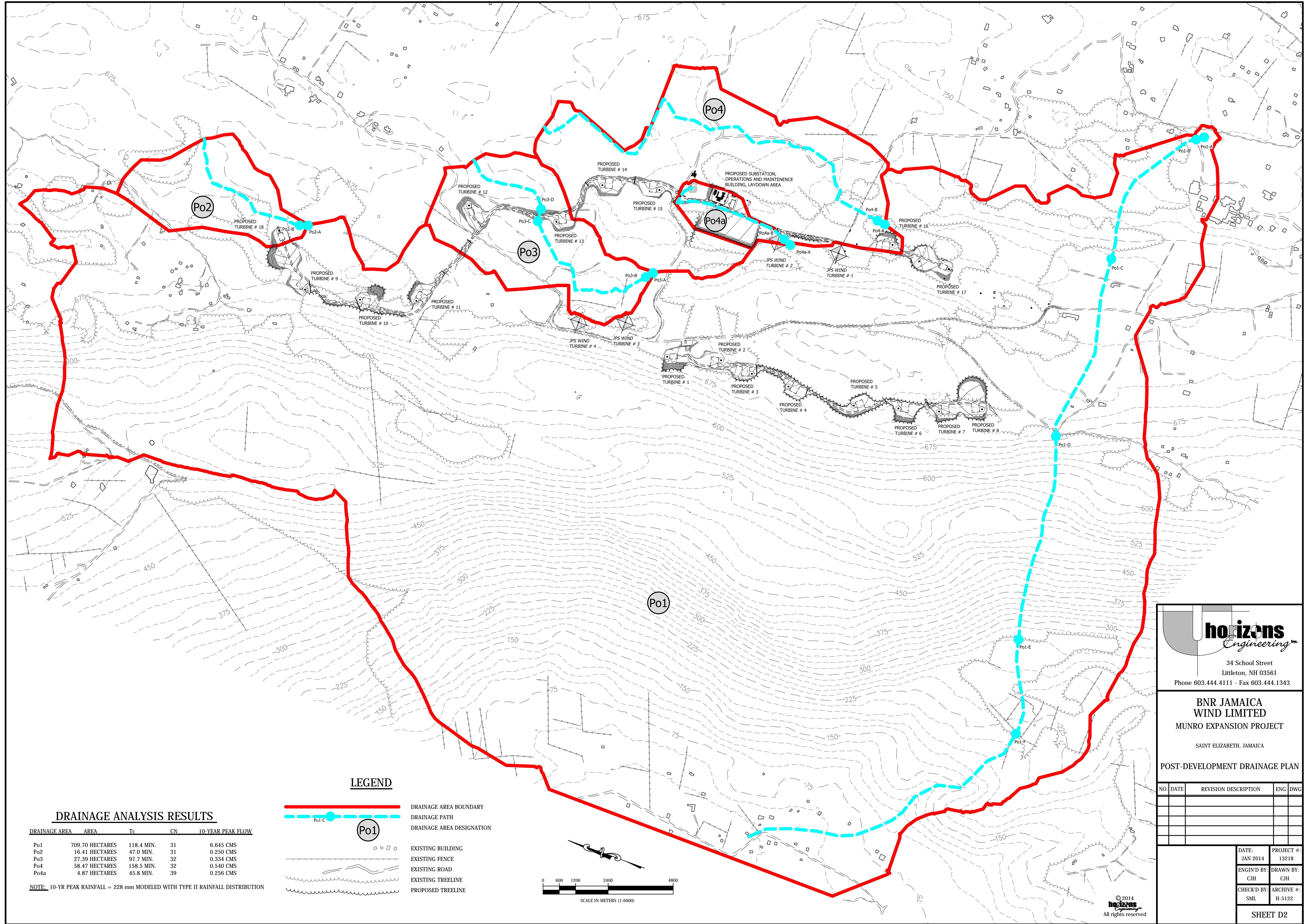
DRAWN BY:  
CJH

ARCHIVE #:  
H-5122

SHEET D1



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**BNR JAMAICA WIND LIMITED**  
**MUNRO EXPANSION PROJECT**  
SAINT ELIZABETH, JAMAICA

**POST-DEVELOPMENT DRAINAGE PLAN**

NO.	DATE	REVISION DESCRIPTION	ENG	DWG

DATE:	PROJECT #:
JAN 2014	13218
ENGINE'D BY:	DRAWN BY:
CJH	CJH
CHECK'D BY:	ARCHIVE #:
SML	H-5122

**SHEET D2**