CLA CONSULTANTS
Consulting Civil/Structural Engineers, Project Managers

RESPONSE TO DA CONDITIONS
STORMWATER
1843 MULLIGAN HIGHWAY
COOKTOWN

REVISION A
OUR REF: 25611

REVISION	DATE	AMENDMENTS
A	21/08/2025	Initial Issue

PO Box 5342 Gold Coast MC Q 9726
ABN 55 079 641 286

Prepared For:	**Mr B Boserio**
Prepared By:	**Campbell Leonard**
Release Date	**21/08/2025**
Job Number:	**25611**
Document Name:	**Response to DA Conditions - Stormwater**
	1843 Mulligan Highway Cooktown
Revision:	**A**

Approved for release by

Campbell Leonard
FIEAust CPEng NER
RPEQ 4293
Director

Contents

1. Introduction

This Stormwater Management Plan has been prepared in response to specific conditions specified in Development Approval for the subdivision of 1843 Mulligan Highway Cooktown (Lot 216 SP137304) referenced DA 4608 dated 29/10/24, issued by Cook Shire Council.

2. Site Information

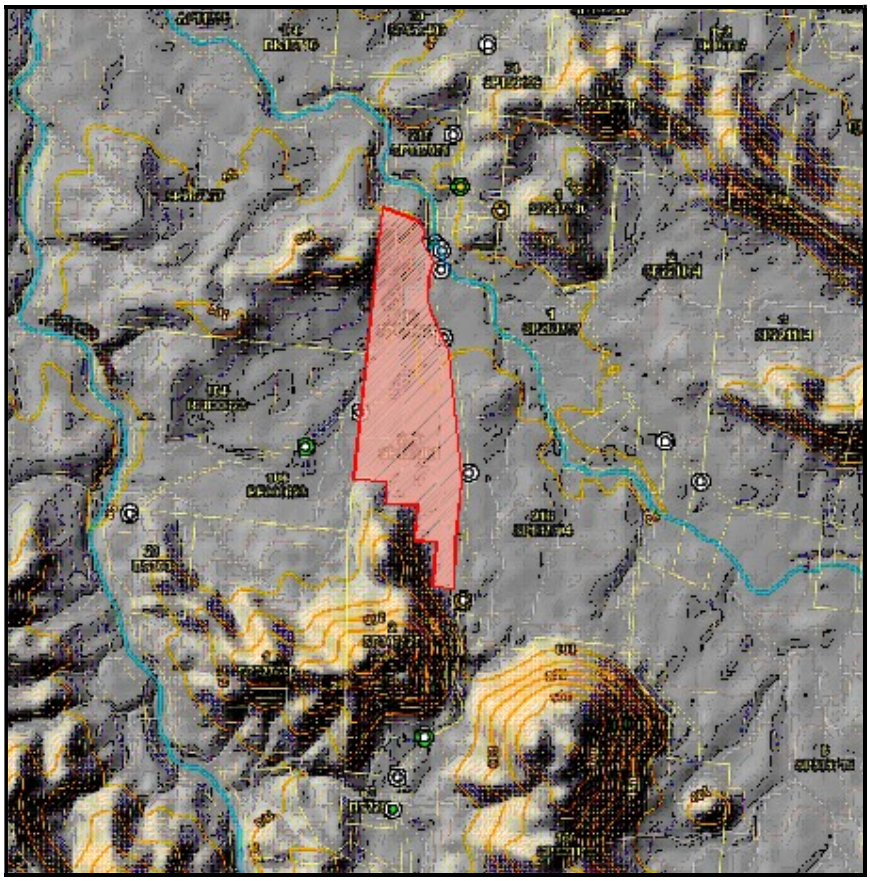


Figure 1
Site Topography

Stage 1 of the development (the stage to which the above referenced DA refers) is located generally along the line of a low spur roughly defined by the alignment of Gampe Drive. Flow from Gampe Drive is generally North and South from Gampe Drive.

General topography in the environs is shown in Fig 1 (Extract from Qld globe)

3. Development Approval Conditions

Development approval conditions are discussed as follows:

3.1 Condition 15

DRAINAGE

15. Undertake a local drainage study / plan of the site to determine the measures required to ensure immunity for the building envelopes. The drainage study / plan must demonstrate the drainage within each allotment and identify the existing creeks and drainage lines. In particular, the study must address the following:

a. The contributing catchment boundaries;

Boundaries of external catchments contributing to the site flow regime are mapped as follows:

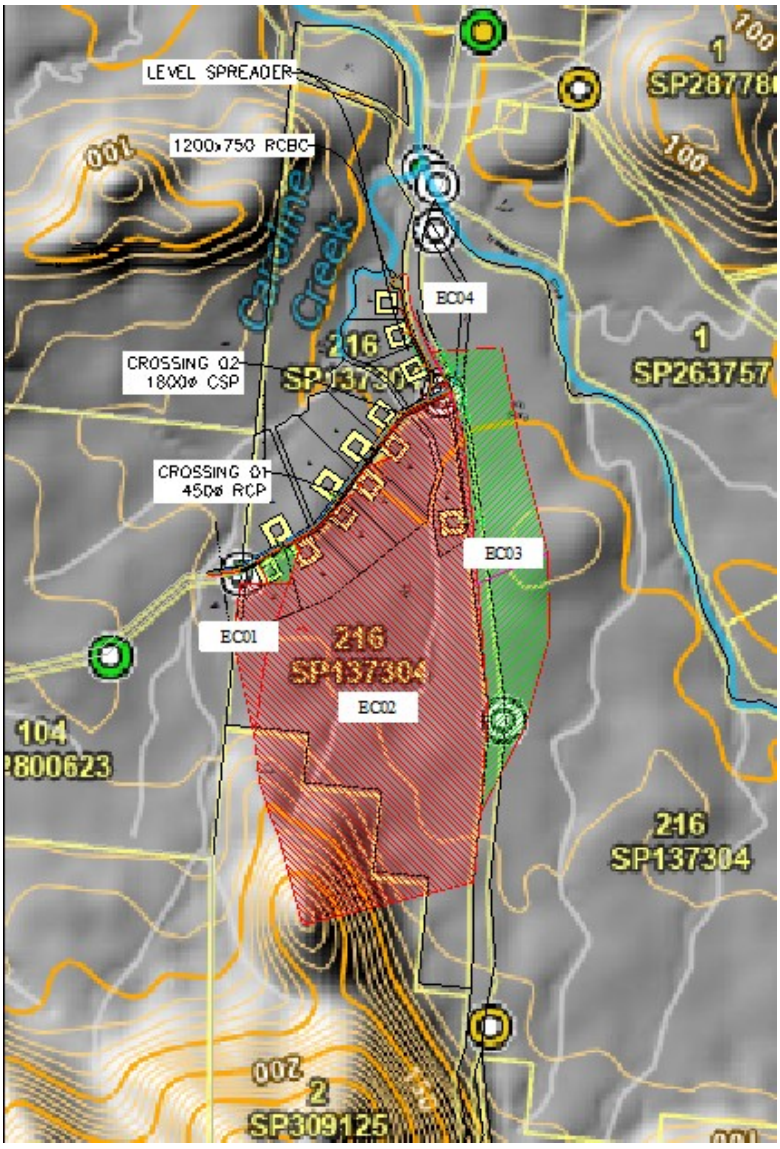


Figure 2
External Catchments

b. The extent of the 100-year ARI flood event in relation to the building envelopes;

i) Caroline Creek

Caroline Creek Invert level immediately upstream of Mulligan Highway is approximately RL30 compared with the existing surface level at Lot 1 (the lowest of the proposed new lots) is of the order of RL42.

It is considered extremely unlikely that flooding of Caroline Creek would affect proposed building envelopes.

ii) Watercourse crossing Gampe Drive (Crossing 02)

Review of the flood hydraulics associated with the existing 1800dia culvert, compared with general levels of the nominated building pad areas are summarised as follows:

Location	Description	RL
Crossing 02 (Gampe Drive)	Q100 Water Surface Level	40.0
Lot 3	General Building Pad Surface	44.0
Lot 4	General Building Pad Surface	43.5
Lot 12	General Building Pad Surface	44.0

The lots are not affected by Q100 ARI flooding.

c. Primary and secondary flow paths through the site, and through each lot relative to the identified building envelopes;

Flow paths affecting the proposed building pads are demonstrated at Attachment A.

Generally, building pad areas are able to be isolated from flow paths by the construction of minor diversion drains constructed upstream of the building pad areas discharging along the contour to regenerate sheet flow.

It is noted however that specific issues relate to Lots 1 and 2.

These lots are affected by significant re-entrants flowing approximately to the North. Refer Fig 3.

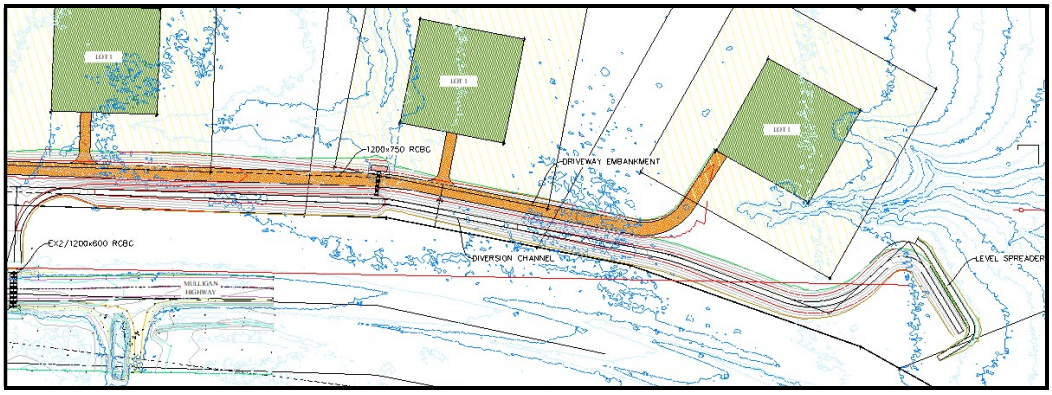


Figure 3
Lots 1 to 3
Works in Mitigation of Development

Mitigation treatment is discussed as follows:

The development approval requires the provision of access to Lots 1 to 3 inclusive from a new laneway from Gampe Drive, rather than from direct access from Mulligan Highway.

The development approval conditions require the building pads and the property accesses to be trafficable at the Q10 ARI event. The decision was made to increase the flood immunity level to the Q100 ARI event in order to reduce the risk of overtopping of the low embankment of the new laneway, seen to be a potential maintenance issue without provision of scour protection to the downstream embankment batter, and to provide control of the overland flow that would otherwise impact the utility of the proposed building pad areas.

Accordingly, the key design parameter for the diversion drain was the requirement to convey the Q100 flows without overtopping. Satisfaction of that requirement necessitated the inclusion of a cross road culvert approximately midway along the length of the laneway.

Discharge from the diversion drain is controlled with the inclusion of a level spreader located at the Northern end of the Drain.

Detailed hydraulic analysis of the system shown at Fig 2 are given at Attachment D.

d. Identify the locations of the watercourses through the site as mapped on State mapping including identifying the location of Caroline Creek and the unnamed southern tributary in relation to the lot layout and lot boundaries;

Watercourse alignments are indicated by contour information at Fig 4.

The survey shows that building envelopes are suitable for construction and use of residential structures.

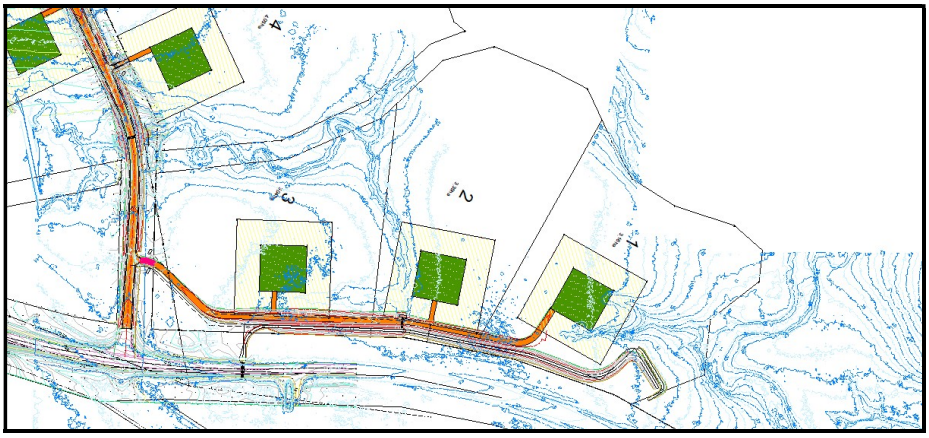


Figure 4
Mapped Creek Alignments

e. Confirm with suitable level data, the location of flow paths that run beside or across Gampe Drive including assessments of existing crossroad drainage infrastructure capacity and any upgrades required to achieve the capacity nominated in the FNQROC Development Manual and the Queensland Urban Drainage manual (minimum 10-year ARI capacity unless otherwise approved by Council);

Base Information

IFD details

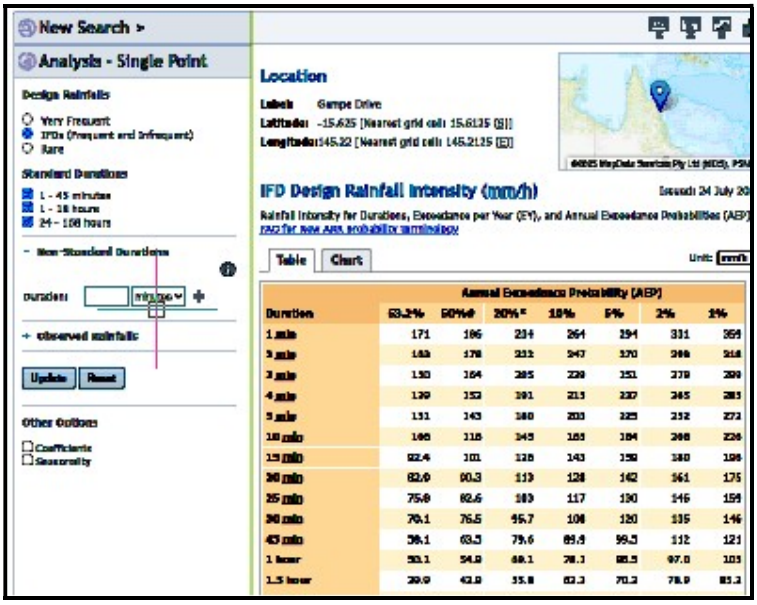


Figure 5

Time of Concentration

Catchment Name		EC01	EC02	EC03	EC04
H1	m	120	180.00	60.00	43.1
H2	m	52	40.00	43.10	41.8
H Change	m	68.00	140.00	16.90	1.30
Main Stream Length	m	0.66	2.16	1.80	0.35
Mainstream Slope	%	10.30	6.48	0.94	0.37
Catchment Area	Ha	1.7	117.00	33.00	1.62
Tine Of Concentration	**min**	**22.77**	**53.55**	**74.53**	**23.58**

Catchment Details are given at Fig 2.

Crossing 01 – Gampe Drive – 450dia RCP

Analys indicates that Crossing 01 is essentially a relief structure, without the capacity to convey catchment flows under the road. Excess flows have previously been diverted along Gampe Drive to discharge at existing Crossing 02.

The advent of the new allotment crossovers results in the necessity to cater for such flows, either with the installation of crossover culverts, such as in the case of Lot 9, or for the discharge of the flows withing the allotments. In the latter cases, diversion channels are discharged along the line of the existing contours in order to generate sheet flow lateral to the line of the contours.

Detailed hydraulic analysis is given at Attachment C

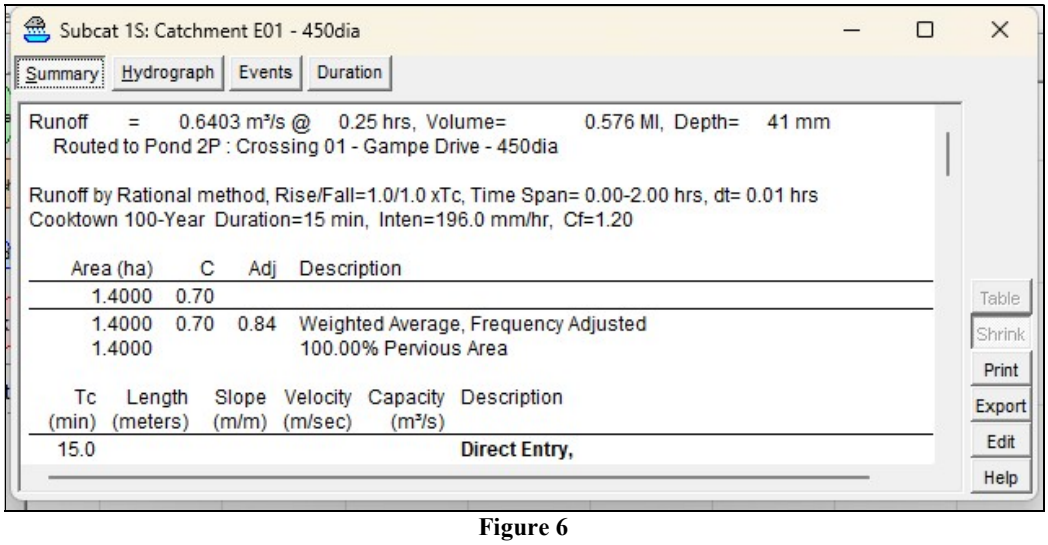


Figure 6

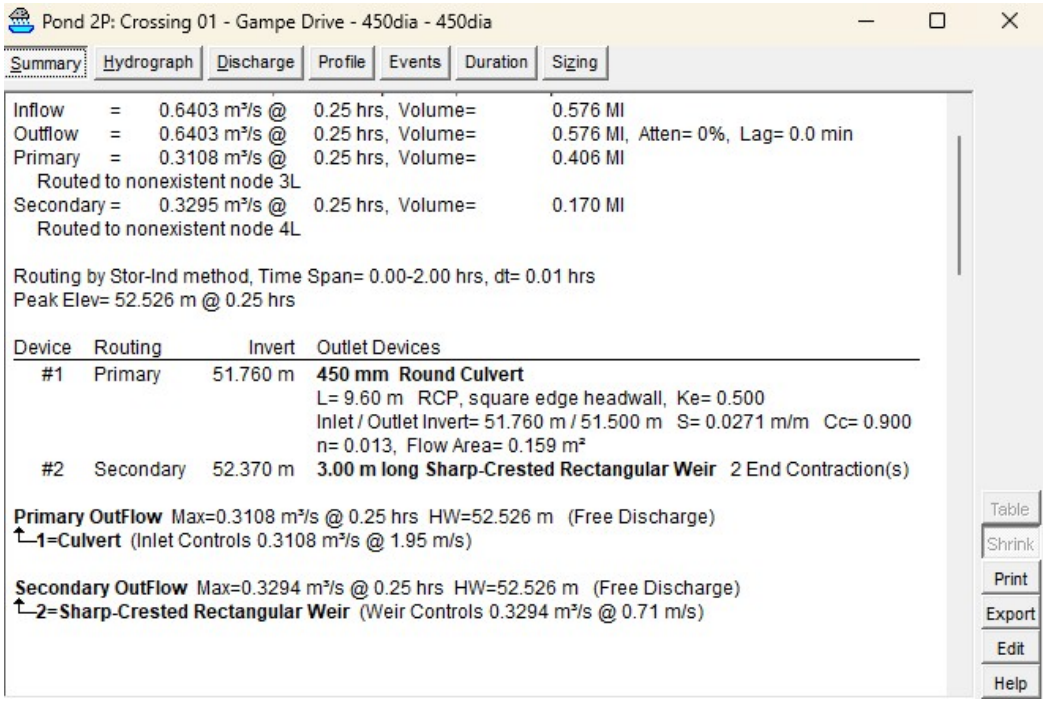


Figure 7

Crossing 02 – Gampe Drive – 1800dia CSP

Crossing conveys significant flows from the upstream catchment. Existing culvert does not have capacity to accommodate flows from Q10 ARI under the road.

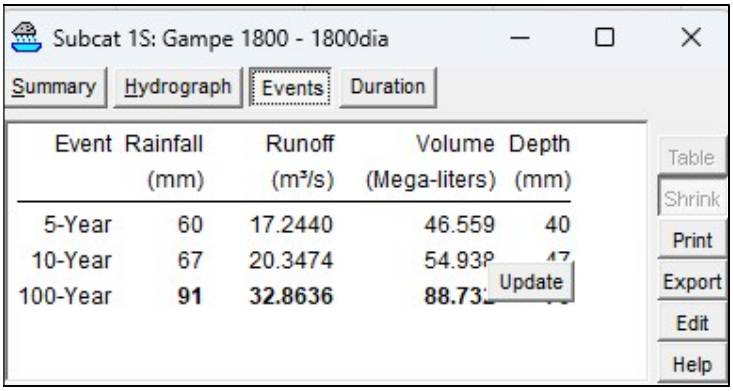


Figure 8

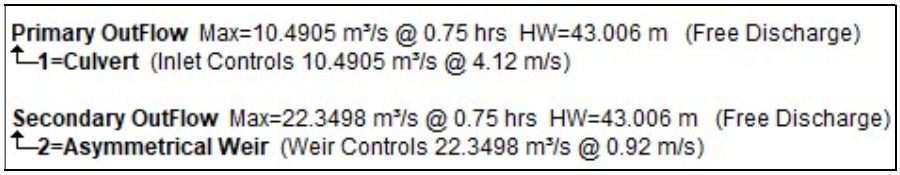


Figure 9

Detailed analysis of the overtopping characteristics are provided at Attachment C however the results can be summarised as follows:

Overtopping Characteristics

ARI	10	100	Year
Floodway Invert	42.62	42.62	m
Water Surface Level	42.9	43	m
Flow Depth	0.28	0.38	m
Flow Velocity	0.74	0.91	m/s
VxD	**0.2072**	**0.3458**	m2/s

The system provides appropriate depth and VxD products at the Q10 ARI event. Flow depth associated with the Q100 ARI is marginally greater than the normally expected maximum, however the VxD product is well within normally expected bounds for both predestrian and vehicular stability.

f. Identify any requirement for drainage easements; and

Development on the proposed lots is controlled by surveyed building envelopes. Additional development control with the use of easements is not seen to be warranted, unless the benefit of such easements is to Cook Shire Council for maintenance purposes.

g. Proposed points of discharge for each lots including where such discharge may include maintaining overland flow across inter-allotment boundaries. The study must be endorsed by Council prior to the issue of a Development Permit for Operational Works. The approved works must be completed and accepted by Council prior to Council approval of the Plan of Survey.

Refer Section 3.4 below

3.2 Condition 16

***16**. Existing watercourse systems and drainage areas within the subject site must be left in their current state, including no channel alterations and no removal of vegetation, unless otherwise approved.*

Existing watercourse systems and drainage areas are generally maintained in their pre-development state, the exception being the water courses flowing West from the Mulligan Highway necessarily diverted by the DA requirement to provide a common access to Lots 1 to 3 inclusive.

Such works are described more fully at Section 3.1 (c) above.

3.3 Condition 17

17. Flow paths through the site must be clearly identified in relation to the lot layout and lot boundaries to confirm that no layout changes are required for access or use of the land for accommodating a Dwelling House with appropriate setbacks to drainage lines. If updates are required to the lot layout based on the location of the bed and banks of Caroline Creek or the unnamed southern tributary these must be provided on an updated dimensioned layout plan. The plan must be provided with the Operational Works Application for Roadworks.

Advice Note - There appears to be a slight misalignment between the state mapping of the watercourse and the actual location of the Gampe Drive cross-road culvert and downstream drainage path. The lot layout boundary of the access leg to the northern balance land (between Lots 3 and 4) appears to have a similar alignment to the State Mapping. These conditions require the drainage path alignment to be reconfirmed on site and the lot layout verified following that site verification.

Flow paths, both existing and proposed, are detailed at Attachment A.

3.4 Condition 18

18. All stormwater from each lot must be directed to a lawful point of discharge or maintained as overland flow based on current site conditions such that it does not adversely affect the building envelopes and access of the proposed lots to the requirements and satisfaction of the Director Infrastructure.

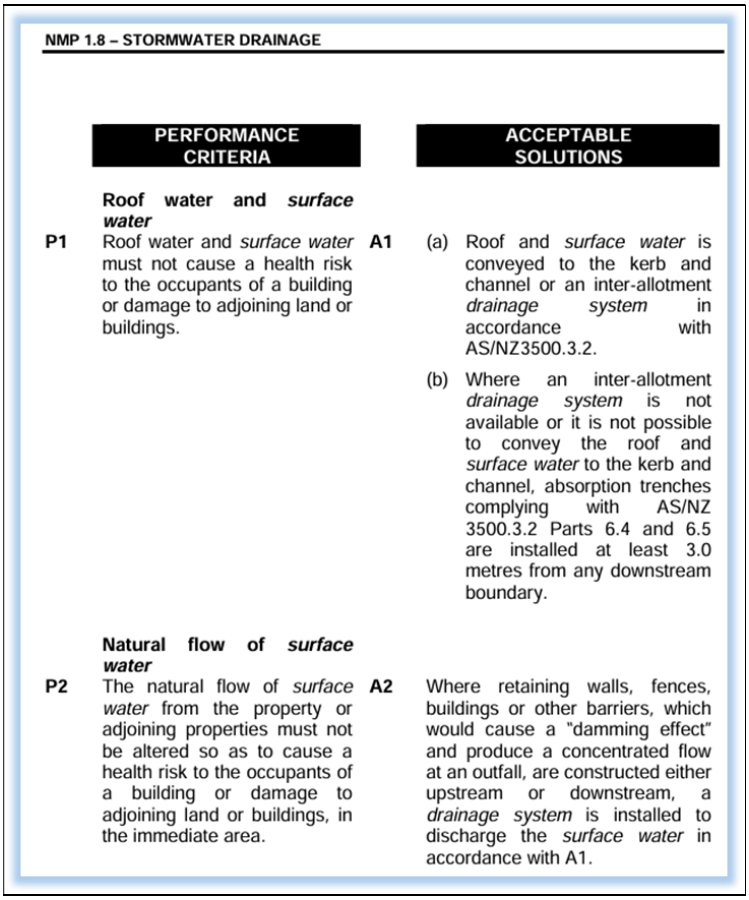
Lawful point of discharge for the site is provided by Caroline Creek, which comprises the Northern boundary of the site.

As to the requirement for the specification of lawful points of discharge for the proposed allotments it is noted that in the main interallotment runoff is provided generally by overland flow. Such flow regime is to be maintained.

It is noted that there is no requirements for the nomination of a lawful point of discharge unless there is a material change to the runoff characteristics, including discharge location and flow rate.

In this instance, it is appropriate to address such determinants with reference to State Development Code, in particular the Acceptable Solutions specified by that Code.

NMP 1.8 defines acceptable solutions as follows:



NMP 1.8 – STORMWATER DRAINAGE

	PERFORMANCE CRITERIA		ACCEPTABLE SOLUTIONS
	Roof water and *surface water*		
P1	Roof water and *surface water* must not cause a health risk to the occupants of a building or damage to adjoining land or buildings.	**A1**	(a) Roof and *surface water* is conveyed to the kerb and channel or an inter-allotment *drainage system* in accordance with AS/NZ3500.3.2. (b) Where an inter-allotment *drainage system* is not available or it is not possible to convey the roof and *surface water* to the kerb and channel, absorption trenches complying with AS/NZ 3500.3.2 Parts 6.4 and 6.5 are installed at least 3.0 metres from any downstream boundary.
	Natural flow of *surface water*		
P2	The natural flow of *surface water* from the property or adjoining properties must not be altered so as to cause a health risk to the occupants of a building or damage to adjoining land or buildings, in the immediate area.	**A2**	Where retaining walls, fences, buildings or other barriers, which would cause a "damming effect" and produce a concentrated flow at an outfall, are constructed either upstream or downstream, a *drainage system* is installed to discharge the *surface water* in accordance with A1.

Figure 10
Extract from NMP 1.8

It is noted that there is no downstream interallotment drainage system and there is no existing (or proposed) kerb and gutter. Consequently alternative A1 (b) is proposed. In this instance absorption trenches are t be located at lease 3.0m upstream of the downstream building pad boundary.

Details of proposed works to be provided in associated with building application.

A2

Where retaining walls, fences, buildings or other barriers, which would cause a "damming effect" and produce a concentrated flow at an outfall, are constructed either upstream or downstream, a drainage system is installed to discharge the surface water in accordance with A1.

Condition P2 is not relevant to this discussion.

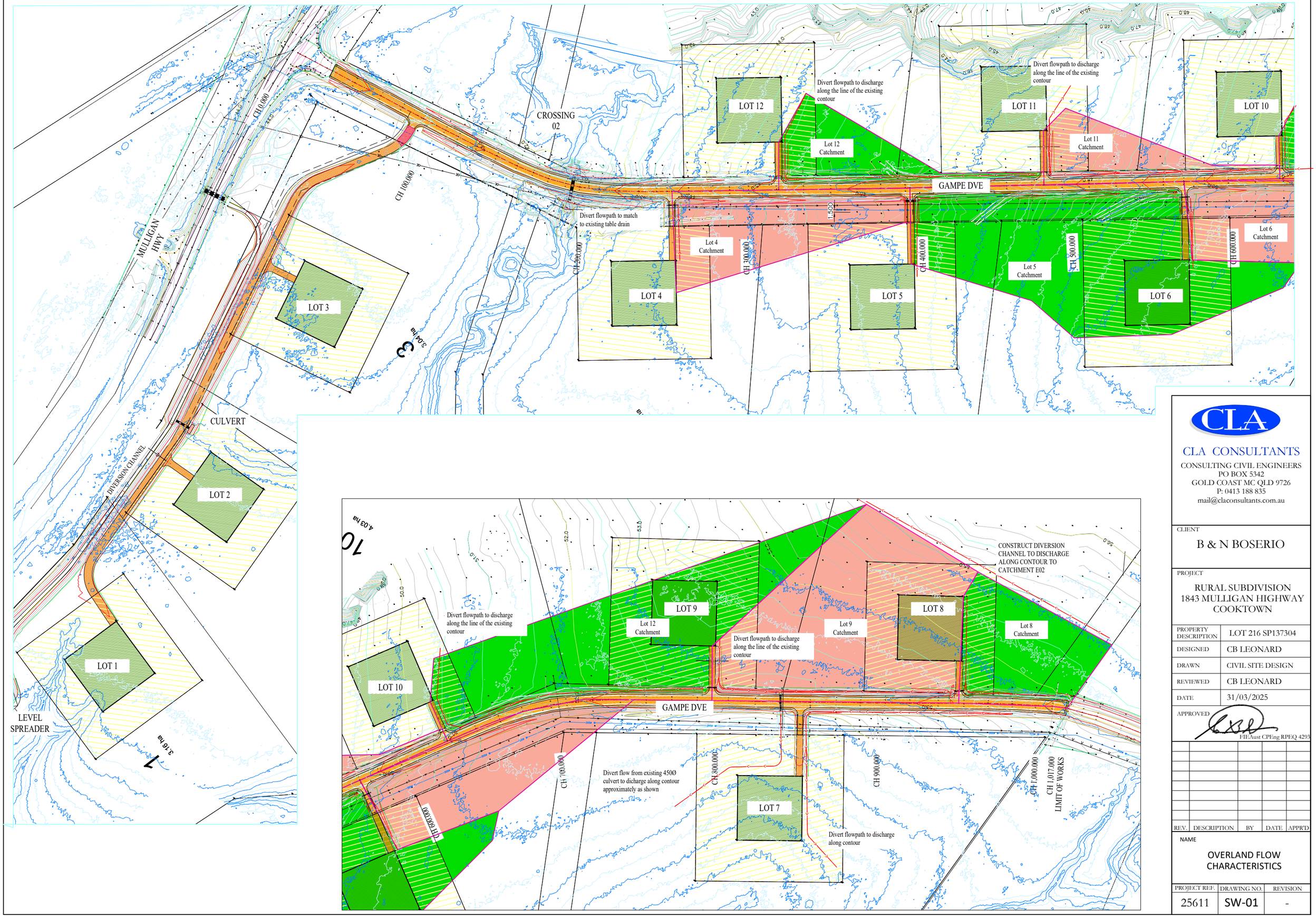
4. Conclusion

This report addresses the requirements of Council's development approval for the subdivision, demonstrating compliance with the conditions or providing an appropriate rationale approval where compliance is not achievable.

Campbell Leonard
FIEAust CPEng NER RPEQ

Attachment A
Overland Flow Characteristics

21/08/2025



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CLIENT

B & N BOSERIO

PROJECT

RURAL SUBDIVISION
1843 MULLIGAN HIGHWAY
COOKTOWN

PROPERTY DESCRIPTION	LOT 216 SP137304
DESIGNED	CB LEONARD
DRAWN	CIVIL SITE DESIGN
REVIEWED	CB LEONARD
DATE	31/03/2025

APPROVED

FIEAust CPEng RPEQ 4293

REV.	DESCRIPTION	BY	DATE	APPR'D

NAME

OVERLAND FLOW CHARACTERISTICS

PROJECT REF.	DRAWING NO.	REVISION
25611	SW-01	-

Attachment B

Hydraulic Analysis
Crossing 01
Gampe Drive
450dia Culvert

Catchment E01

Crossing 01 - Gampe Drive - 450dia

Subcat Reach Pond Link

Routing Diagram for 450dia

Prepared by HydroCAD SAMPLER 1-800-927-7246 www.hydrocad.net, Printed 20/08/2025
HydroCAD® 10.20-7a Sampler s/n S26069

Area Listing (all nodes)

Area (hectares)	C	Description (subcatchment-numbers)
1.4000	0.70	(1S)
1.4000	**0.70**	**TOTAL AREA**

Time span=0.00-2.00 hrs, dt=0.01 hrs, 201 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Catchment E01 Runoff Area=1.4000 ha 0.00% Impervious Runoff Depth=25 mm
Tc=15.0 min C=0.70 Runoff=0.3893 m³/s 0.350 Ml

Pond 2P: Crossing 01 - Gampe Drive - 450dia Peak Elev=52.442 m Inflow=0.3893 m³/s 0.350 Ml
Primary=0.2856 m³/s 0.321 Ml Secondary=0.1036 m³/s 0.029 Ml Outflow=0.3893 m³/s 0.350 Ml

Total Runoff Area = 1.4000 ha Runoff Volume = 0.350 Ml Average Runoff Depth = 25 mm
100.00% Pervious = 1.4000 ha 0.00% Impervious = 0.0000 ha

Summary for Subcatchment 1S: Catchment E01

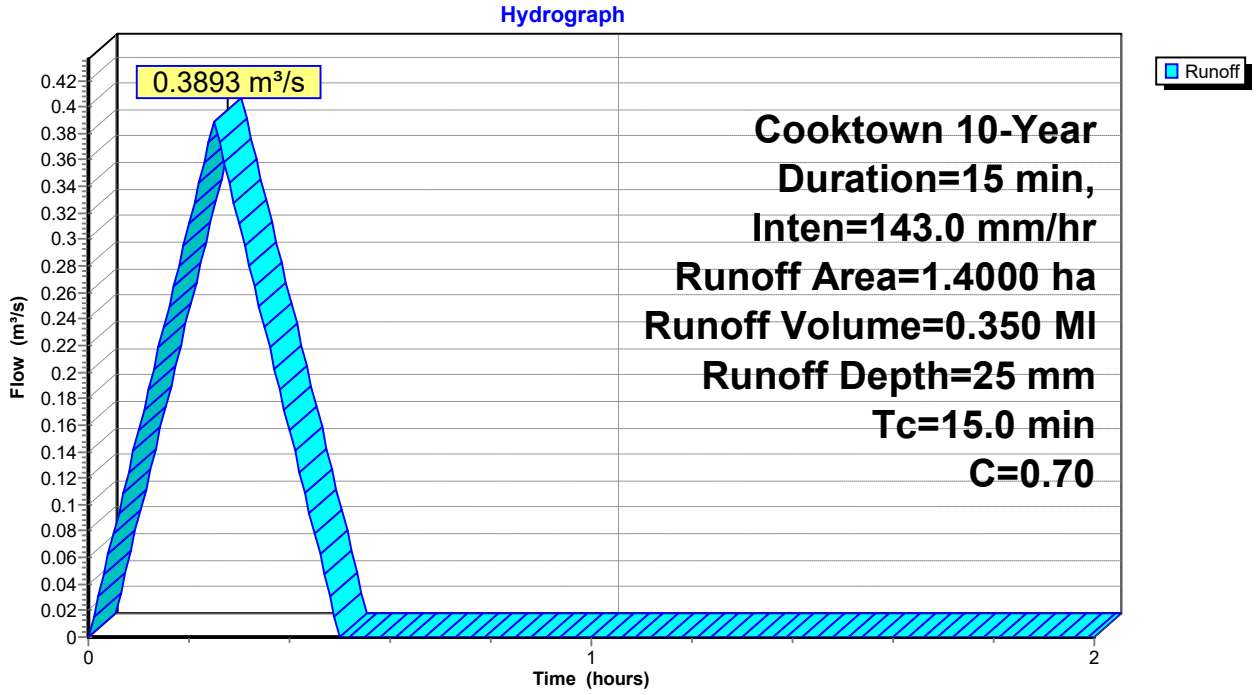
Runoff = 0.3893 m³/s @ 0.25 hrs, Volume= 0.350 Ml, Depth= 25 mm
Routed to Pond 2P : Crossing 01 - Gampe Drive - 450dia

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-2.00 hrs, dt= 0.01 hrs
Cooktown 10-Year Duration=15 min, Inten=143.0 mm/hr

Area (ha)	C	Description
1.4000	0.70	
1.4000		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
15.0					**Direct Entry,**

Subcatchment 1S: Catchment E01



Summary for Pond 2P: Crossing 01 - Gampe Drive - 450dia

Inflow Area = 1.4000 ha, 0.00% Impervious, Inflow Depth = 25 mm for 10-Year event
Inflow = 0.3893 m³/s @ 0.25 hrs, Volume= 0.350 Ml
Outflow = 0.3893 m³/s @ 0.25 hrs, Volume= 0.350 Ml, Atten= 0%, Lag= 0.0 min
Primary = 0.2856 m³/s @ 0.25 hrs, Volume= 0.321 Ml
Routed to nonexistent node 3L
Secondary = 0.1036 m³/s @ 0.25 hrs, Volume= 0.029 Ml
Routed to nonexistent node 4L

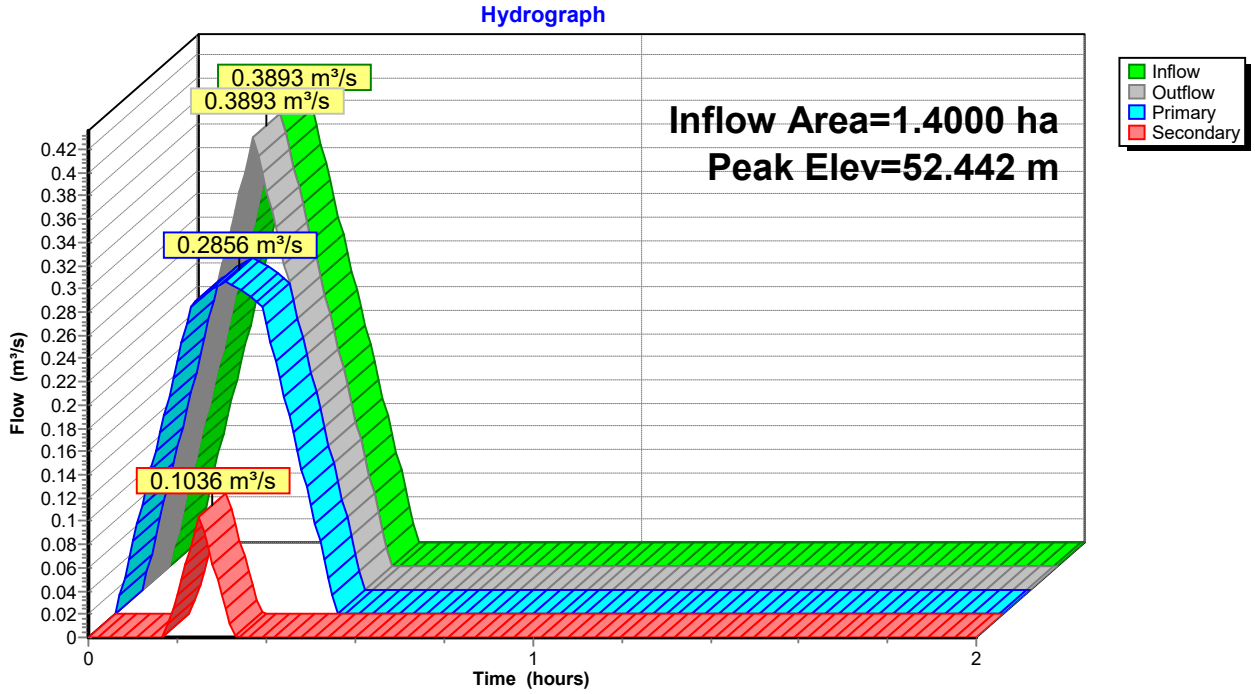
Routing by Stor-Ind method, Time Span= 0.00-2.00 hrs, dt= 0.01 hrs
Peak Elev= 52.442 m @ 0.25 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	51.760 m	**450 mm Round Culvert** L= 9.60 m RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 51.760 m / 51.500 m S= 0.0271 m/m Cc= 0.900 n= 0.013, Flow Area= 0.159 m²
#2	Secondary	52.370 m	**3.00 m long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=0.2857 m³/s @ 0.25 hrs HW=52.442 m (Free Discharge)
↑—**1=Culvert** (Inlet Controls 0.2857 m³/s @ 1.80 m/s)

Secondary OutFlow Max=0.1036 m³/s @ 0.25 hrs HW=52.442 m (Free Discharge)
↑—**2=Sharp-Crested Rectangular Weir** (Weir Controls 0.1036 m³/s @ 0.48 m/s)

Pond 2P: Crossing 01 - Gampe Drive - 450dia



Time span=0.00-2.00 hrs, dt=0.01 hrs, 201 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Catchment E01 Runoff Area=1.4000 ha 0.00% Impervious Runoff Depth=41 mm
Tc=15.0 min Frequency Adjusted C=0.84 Runoff=0.6403 m³/s 0.576 Ml

Pond 2P: Crossing 01 - Gampe Drive - 450dia Peak Elev=52.526 m Inflow=0.6403 m³/s 0.576 Ml
Primary=0.3108 m³/s 0.406 Ml Secondary=0.3295 m³/s 0.170 Ml Outflow=0.6403 m³/s 0.576 Ml

Total Runoff Area = 1.4000 ha Runoff Volume = 0.576 Ml Average Runoff Depth = 41 mm
100.00% Pervious = 1.4000 ha 0.00% Impervious = 0.0000 ha

Summary for Subcatchment 1S: Catchment E01

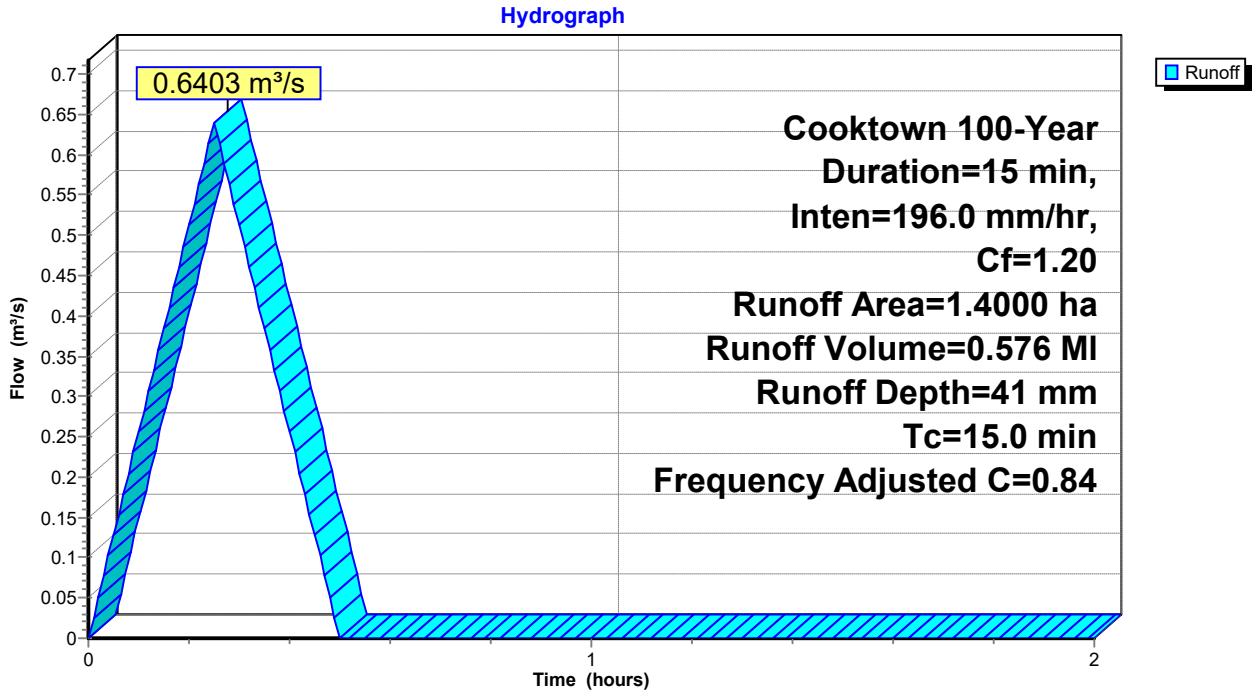
Runoff = 0.6403 m³/s @ 0.25 hrs, Volume= 0.576 Ml, Depth= 41 mm
Routed to Pond 2P : Crossing 01 - Gampe Drive - 450dia

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-2.00 hrs, dt= 0.01 hrs
Cooktown 100-Year Duration=15 min, Inten=196.0 mm/hr, Cf=1.20

Area (ha)	C	Adj	Description
1.4000	0.70		
1.4000	0.70	0.84	Weighted Average, Frequency Adjusted
1.4000			100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
15.0					**Direct Entry,**

Subcatchment 1S: Catchment E01



Summary for Pond 2P: Crossing 01 - Gampe Drive - 450dia

Inflow Area = 1.4000 ha, 0.00% Impervious, Inflow Depth = 41 mm for 100-Year event
Inflow = 0.6403 m³/s @ 0.25 hrs, Volume= 0.576 Ml
Outflow = 0.6403 m³/s @ 0.25 hrs, Volume= 0.576 Ml, Atten= 0%, Lag= 0.0 min
Primary = 0.3108 m³/s @ 0.25 hrs, Volume= 0.406 Ml
Routed to nonexistent node 3L
Secondary = 0.3295 m³/s @ 0.25 hrs, Volume= 0.170 Ml
Routed to nonexistent node 4L

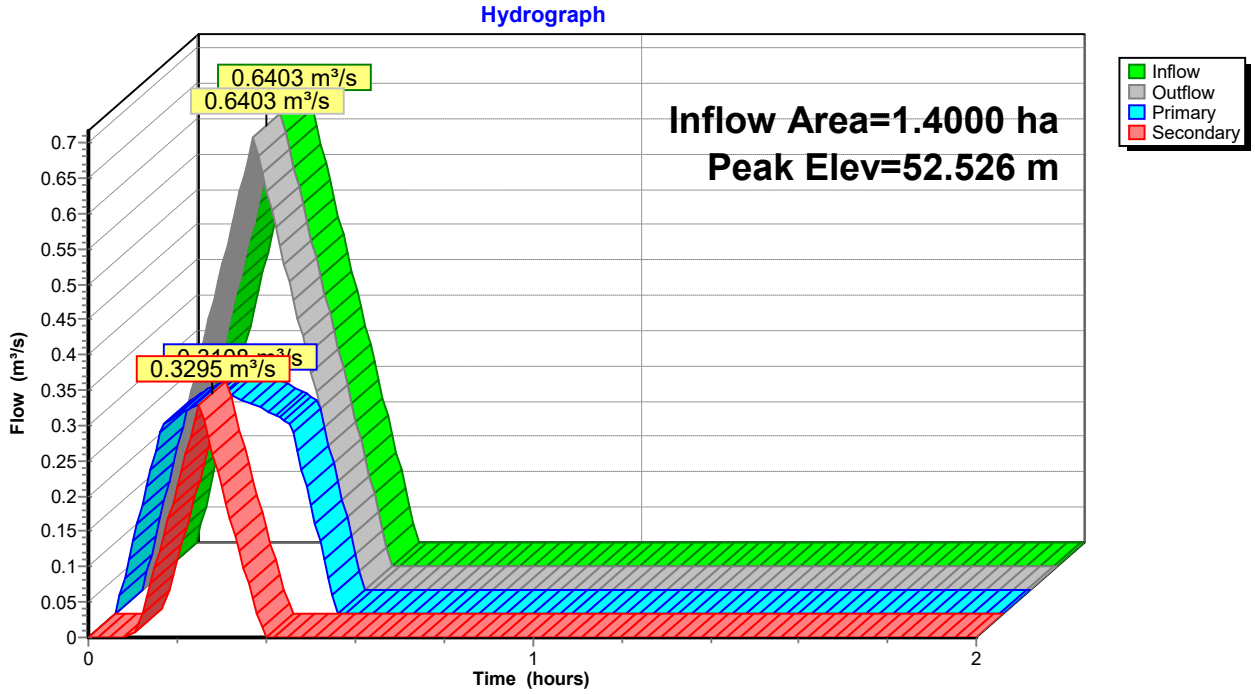
Routing by Stor-Ind method, Time Span= 0.00-2.00 hrs, dt= 0.01 hrs
Peak Elev= 52.526 m @ 0.25 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	51.760 m	**450 mm Round Culvert** L= 9.60 m RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 51.760 m / 51.500 m S= 0.0271 m/m Cc= 0.900 n= 0.013, Flow Area= 0.159 m²
#2	Secondary	52.370 m	**3.00 m long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=0.3108 m³/s @ 0.25 hrs HW=52.526 m (Free Discharge)
1=Culvert (Inlet Controls 0.3108 m³/s @ 1.95 m/s)

Secondary OutFlow Max=0.3294 m³/s @ 0.25 hrs HW=52.526 m (Free Discharge)
2=Sharp-Crested Rectangular Weir (Weir Controls 0.3294 m³/s @ 0.71 m/s)

Pond 2P: Crossing 01 - Gampe Drive - 450dia



Events for Subcatchment 1S: Catchment E01

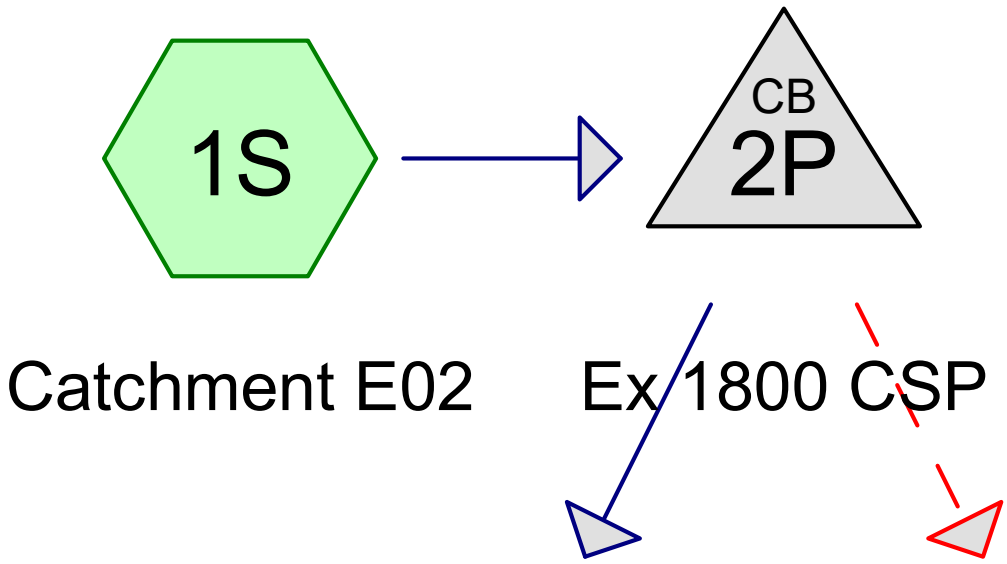
Event	Rainfall (mm)	Runoff (m^3/s)	Volume (Mega-liters)	Depth (mm)
10-Year	36	0.3893	0.350	25
100-Year	**49**	**0.6403**	**0.576**	**41**

Events for Pond 2P: Crossing 01 - Gampe Drive - 450dia

Event	Inflow (m^3/s)	Outflow (m^3/s)	Primary (m^3/s)	Secondary (m^3/s)	Elevation (meters)	Storage (Mega-liters)
10-Year	0.3893	0.3893	0.2856	0.1036	52.442	**0.000**
100-Year	**0.6403**	**0.6403**	**0.3108**	**0.3295**	**52.526**	0.000

Attachment C

Hydraulic Analysis
Crossing 02
Gampe Drive
1800dia Culvert



Subcat Reach Pond Link

Routing Diagram for 1800dia

Prepared by HydroCAD SAMPLER 1-800-927-7246 www.hydrocad.net, Printed 19/08/2025

Summary for Subcatchment 1S: Catchment E02

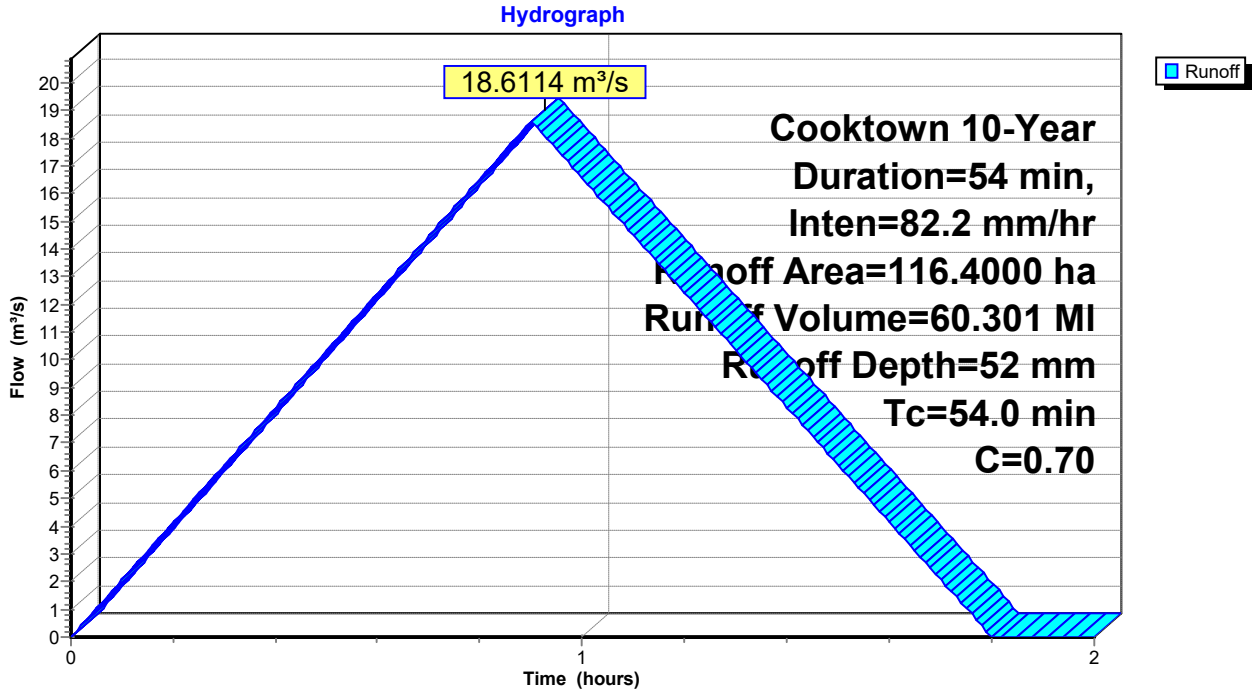
Runoff = 18.6114 m³/s @ 0.90 hrs, Volume= 60.301 Ml, Depth= 52 mm
Routed to Pond 2P : Ex 1800 CSP

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-2.00 hrs, dt= 0.01 hrs
Cooktown 10-Year Duration=54 min, Inten=82.2 mm/hr

Area (ha)	C	Description
116.4000	0.70	
116.4000		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
54.0					**Direct Entry,**

Subcatchment 1S: Catchment E02



Summary for Pond 2P: Ex 1800 CSP

Inflow Area = 116.4000 ha, 0.00% Impervious, Inflow Depth = 52 mm for 10-Year event
Inflow = 18.6114 m³/s @ 0.90 hrs, Volume= 60.301 Ml
Outflow = 18.6114 m³/s @ 0.90 hrs, Volume= 60.301 Ml, Atten= 0%, Lag= 0.0 min
Primary = 9.8828 m³/s @ 0.90 hrs, Volume= 45.966 Ml
Routed to Link 3L : 1800Dia CSP
Secondary = 8.7286 m³/s @ 0.90 hrs, Volume= 14.336 Ml
Routed to Link 4L : Floodway

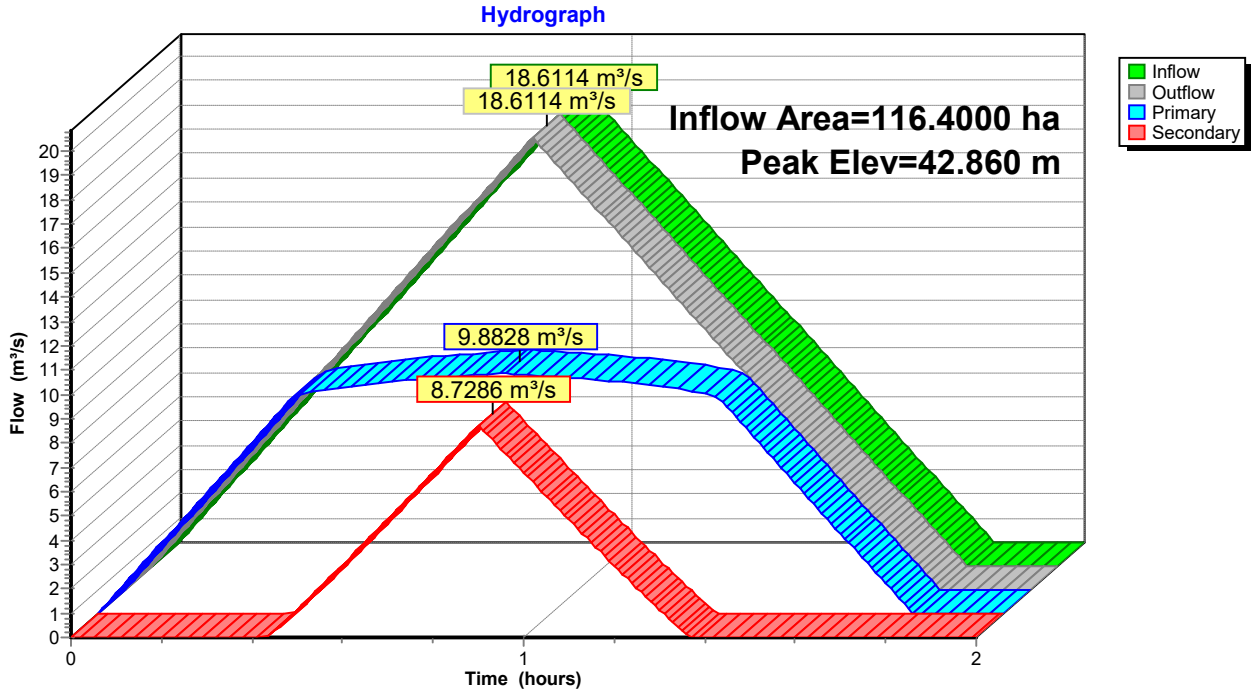
Routing by Stor-Ind method, Time Span= 0.00-2.00 hrs, dt= 0.01 hrs
Peak Elev= 42.860 m @ 0.90 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	40.010 m	**1,800 mm Round Culvert** L= 10.00 m Box, 30-75° wingwalls, square crown, Ke= 0.400 Inlet / Outlet Invert= 40.010 m / 39.910 m S= 0.0100 m/m Cc= 0.900 n= 0.013, Flow Area= 2.545 m²
#2	Secondary	42.620 m	**Asymmetrical Weir, C= 1.81** Offset (meters) 50.000 55.000 60.000 65.000 70.000 75.000 80.000 85.000 90.000 95.000 100.000 105.000 110.000 115.000 120.000 125.000 130.000 135.000 140.000 145.000 150.000 155.000 160.000 165.000 170.000 175.000 180.000 185.000 190.000 195.000 200.000 205.000 210.000 215.000 220.000 225.000 230.000 235.000 240.000 245.000 250.000 255.000 260.000 Height (meters) 1.43 1.34 1.30 1.25 1.21 1.17 1.12 1.06 1.01 0.94 0.87 0.80 0.73 0.65 0.58 0.52 0.44 0.35 0.25 0.18 0.13 0.07 0.05 0.04 0.03 0.01 0.01 0.00 0.02 0.07 0.12 0.18 0.23 0.32 0.41 0.50 0.61 0.72 0.86 0.99 1.19 1.31 1.43

Primary OutFlow Max=9.8832 m³/s @ 0.90 hrs HW=42.860 m (Free Discharge)
└**1=Culvert** (Barrel Controls 9.8832 m³/s @ 3.88 m/s)

Secondary OutFlow Max=8.6672 m³/s @ 0.90 hrs HW=42.860 m (Free Discharge)
└**2=Asymmetrical Weir** (Weir Controls 8.6672 m³/s @ 0.71 m/s)

Pond 2P: Ex 1800 CSP



Summary for Subcatchment 1S: Catchment E02

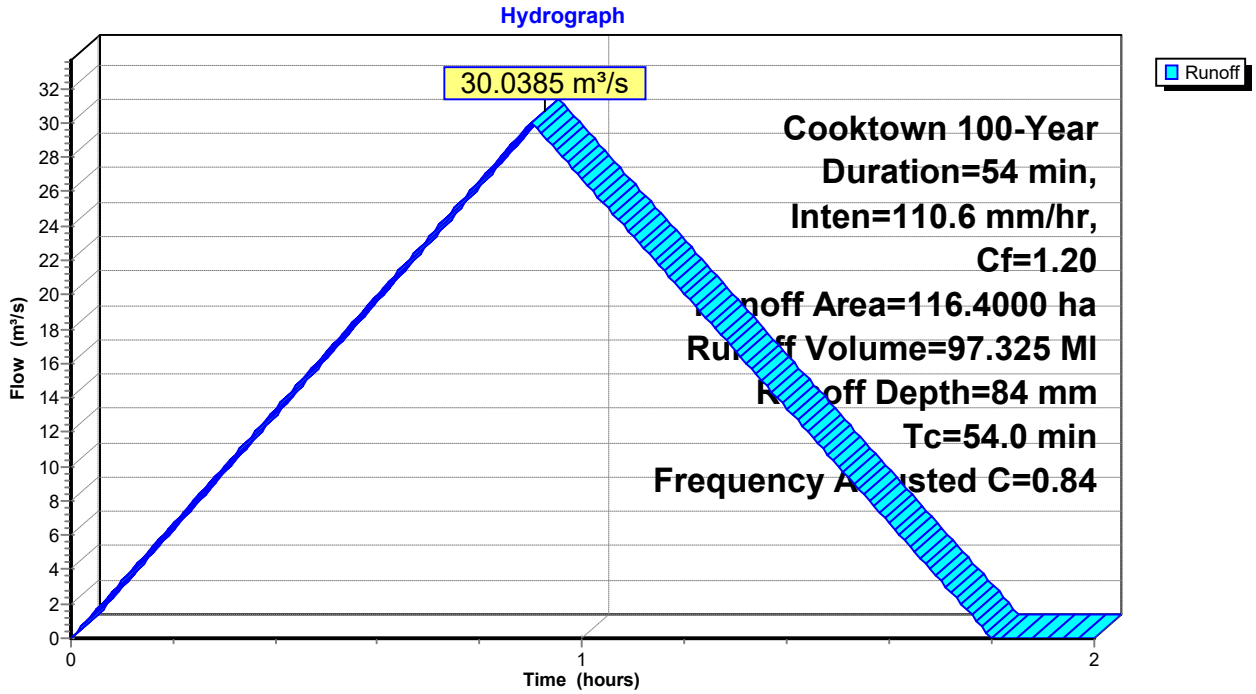
Runoff = 30.0385 m³/s @ 0.90 hrs, Volume= 97.325 Ml, Depth= 84 mm
Routed to Pond 2P : Ex 1800 CSP

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-2.00 hrs, dt= 0.01 hrs
Cooktown 100-Year Duration=54 min, Inten=110.6 mm/hr, Cf=1.20

Area (ha)	C	Adj	Description
116.4000	0.70		
116.4000	0.70	0.84	Weighted Average, Frequency Adjusted
116.4000			100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
54.0					**Direct Entry,**

Subcatchment 1S: Catchment E02



Summary for Pond 2P: Ex 1800 CSP

Inflow Area = 116.4000 ha, 0.00% Impervious, Inflow Depth = 84 mm for 100-Year event
Inflow = 30.0385 m³/s @ 0.90 hrs, Volume= 97.325 Ml
Outflow = 30.0385 m³/s @ 0.90 hrs, Volume= 97.325 Ml, Atten= 0%, Lag= 0.0 min
Primary = 10.3894 m³/s @ 0.90 hrs, Volume= 53.510 Ml
Routed to Link 3L : 1800Dia CSP
Secondary = 19.6490 m³/s @ 0.90 hrs, Volume= 43.815 Ml
Routed to Link 4L : Floodway

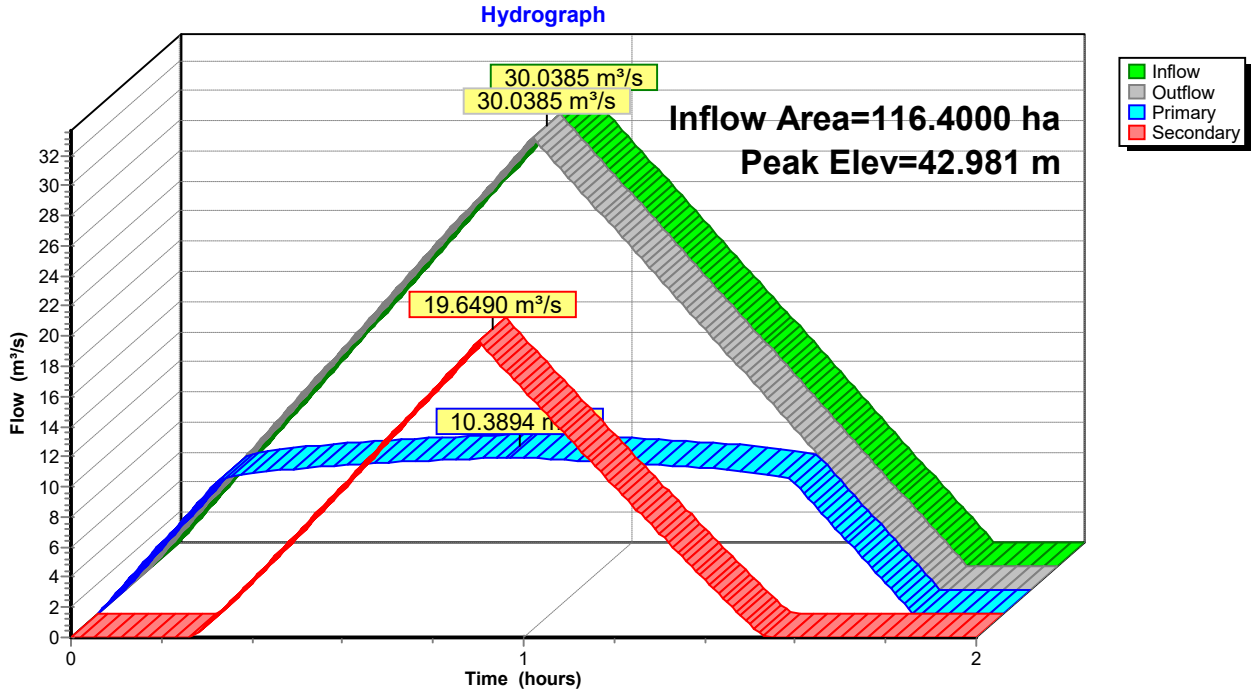
Routing by Stor-Ind method, Time Span= 0.00-2.00 hrs, dt= 0.01 hrs
Peak Elev= 42.981 m @ 0.90 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	40.010 m	**1,800 mm Round Culvert** L= 10.00 m Box, 30-75° wingwalls, square crown, Ke= 0.400 Inlet / Outlet Invert= 40.010 m / 39.910 m S= 0.0100 m/m Cc= 0.900 n= 0.013, Flow Area= 2.545 m²
#2	Secondary	42.620 m	**Asymmetrical Weir, C= 1.81** Offset (meters) 50.000 55.000 60.000 65.000 70.000 75.000 80.000 85.000 90.000 95.000 100.000 105.000 110.000 115.000 120.000 125.000 130.000 135.000 140.000 145.000 150.000 155.000 160.000 165.000 170.000 175.000 180.000 185.000 190.000 195.000 200.000 205.000 210.000 215.000 220.000 225.000 230.000 235.000 240.000 245.000 250.000 255.000 260.000 Height (meters) 1.43 1.34 1.30 1.25 1.21 1.17 1.12 1.06 1.01 0.94 0.87 0.80 0.73 0.65 0.58 0.52 0.44 0.35 0.25 0.18 0.13 0.07 0.05 0.04 0.03 0.01 0.01 0.00 0.02 0.07 0.12 0.18 0.23 0.32 0.41 0.50 0.61 0.72 0.86 0.99 1.19 1.31 1.43

Primary OutFlow Max=10.3898 m³/s @ 0.90 hrs HW=42.981 m (Free Discharge)
1=Culvert (Barrel Controls 10.3898 m³/s @ 4.08 m/s)

Secondary OutFlow Max=19.5910 m³/s @ 0.90 hrs HW=42.981 m (Free Discharge)
2=Asymmetrical Weir (Weir Controls 19.5910 m³/s @ 0.89 m/s)

Pond 2P: Ex 1800 CSP



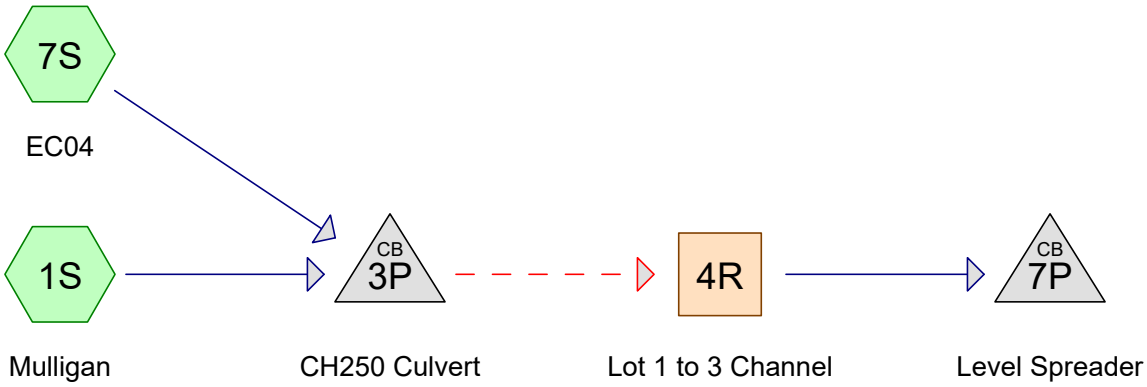
Events for Subcatchment 1S: Catchment E02

Event	Rainfall (mm)	Runoff (m^3/s)	Volume (Mega-liters)	Depth (mm)
10-Year	74	18.6114	60.301	52
100-Year	**100**	**30.0385**	**97.325**	**84**

Events for Pond 2P: Ex 1800 CSP

Event	Inflow (m^3/s)	Outflow (m^3/s)	Primary (m^3/s)	Secondary (m^3/s)	Elevation (meters)	Storage (Mega-liters)
10-Year	18.6114	18.6114	9.8828	8.7286	42.860	**0.000**
100-Year	**30.0385**	**30.0385**	**10.3894**	**19.6490**	**42.981**	0.000

Attachment D
Hydraulic Analysis
Diversion Drainage
Lots 1 to 3 Access



Subcat Reach Pond Link

Routing Diagram for Level Spreader

Prepared by HydroCAD SAMPLER 1-800-927-7246 www.hydrocad.net, Printed 19/08/2025

Area Listing (all nodes)

Area (hectares)	C	Description (subcatchment-numbers)
32.3000	0.70	(1S)
1.6000	0.70	(7S)
33.9000	**0.70**	**TOTAL AREA**

Time span=0.00-3.00 hrs, dt=0.01 hrs, 301 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Mulligan Runoff Area=32.3000 ha 0.00% Impervious Runoff Depth=63 mm
Tc=75.0 min C=0.70 Runoff=4.2258 m³/s 20.284 Ml

Subcatchment 7S: EC04 Runoff Area=1.6000 ha 0.00% Impervious Runoff Depth=63 mm
Tc=19.0 min C=0.70 Runoff=0.2093 m³/s 1.005 Ml

Reach 4R: Lot 1 to 3 Channel Avg. Flow Depth=0.92 m Max Vel=0.50 m/s Inflow=2.6907 m³/s 8.827 Ml
n=0.100 L=200.00 m S=0.0055 m/m Capacity=15.6280 m³/s Outflow=2.6019 m³/s 8.801 Ml

Pond 3P: CH250 Culvert Peak Elev=42.815 m Inflow=4.4351 m³/s 21.289 Ml
Primary=1.7444 m³/s 12.461 Ml Secondary=2.6907 m³/s 8.827 Ml Outflow=4.4351 m³/s 21.289 Ml

Pond 7P: Level Spreader Peak Elev=41.885 m Inflow=2.6019 m³/s 8.801 Ml
Outflow=2.6019 m³/s 8.801 Ml

Total Runoff Area = 33.9000 ha Runoff Volume = 21.289 Ml Average Runoff Depth = 63 mm
100.00% Pervious = 33.9000 ha 0.00% Impervious = 0.0000 ha

Summary for Subcatchment 1S: Mulligan

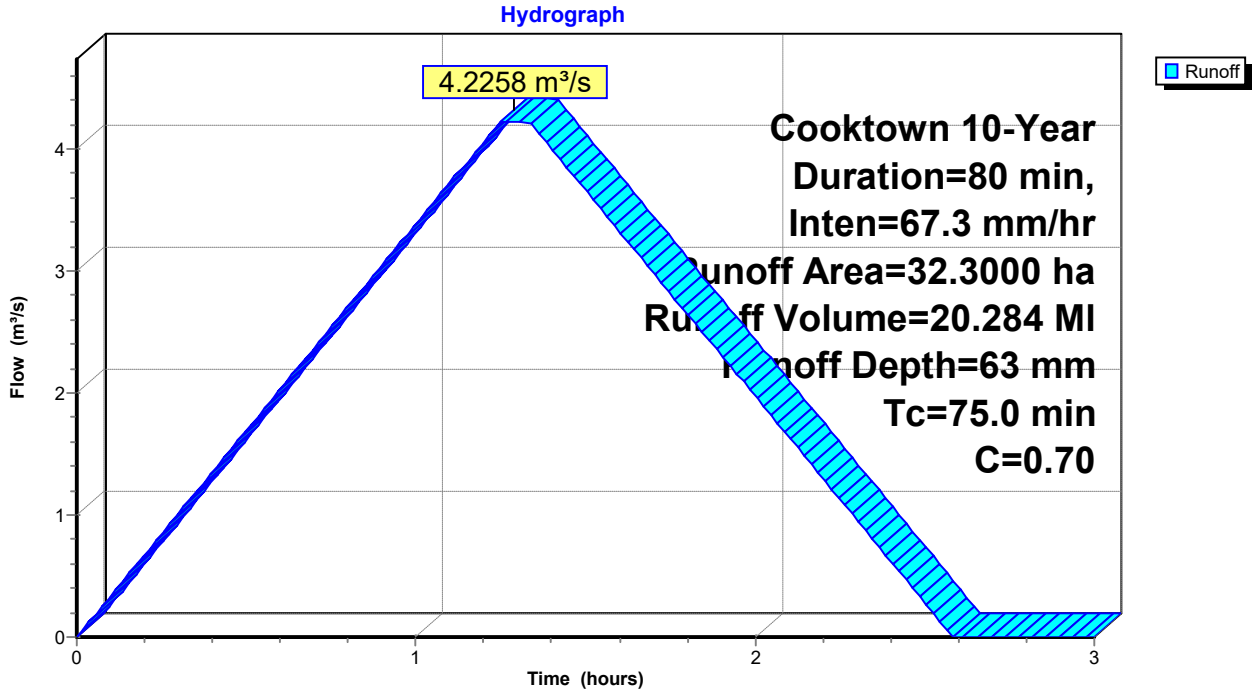
Runoff = 4.2258 m³/s @ 1.25 hrs, Volume= 20.284 Ml, Depth= 63 mm
Routed to Pond 3P : CH250 Culvert

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Cooktown 10-Year Duration=80 min, Inten=67.3 mm/hr

Area (ha)	C	Description
32.3000	0.70	
32.3000		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
75.0					**Direct Entry,**

Subcatchment 1S: Mulligan



Summary for Subcatchment 7S: EC04

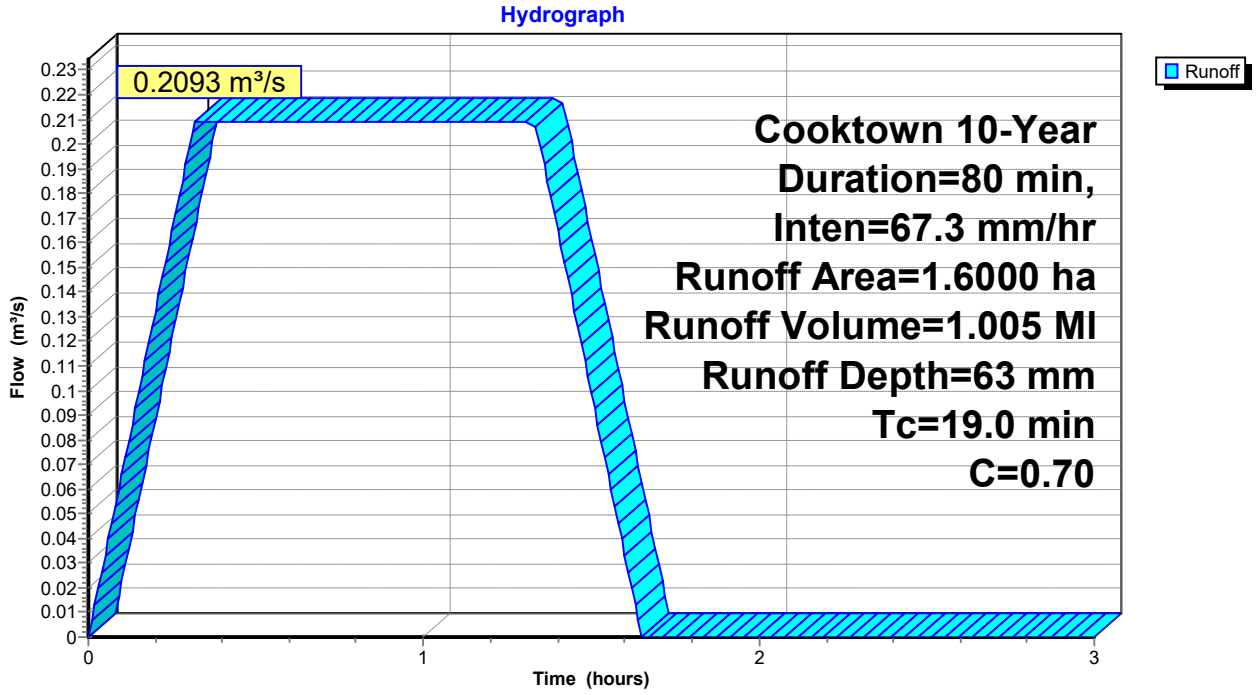
Runoff = 0.2093 m³/s @ 0.32 hrs, Volume= 1.005 Ml, Depth= 63 mm
Routed to Pond 3P : CH250 Culvert

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Cooktown 10-Year Duration=80 min, Inten=67.3 mm/hr

Area (ha)	C	Description
1.6000	0.70	
1.6000		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
19.0					**Direct Entry,**

Subcatchment 7S: EC04



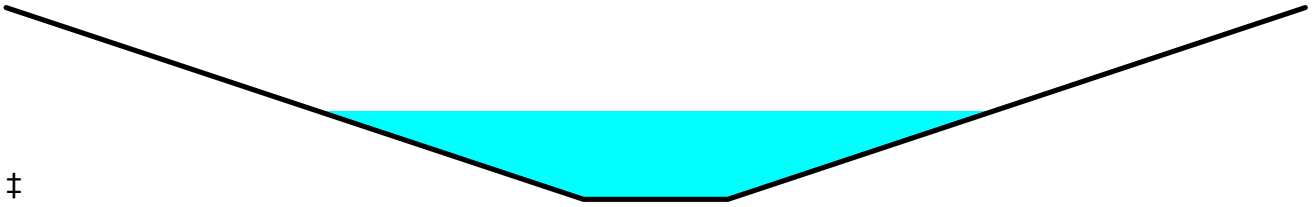
Summary for Reach 4R: Lot 1 to 3 Channel

Inflow = 2.6907 m³/s @ 1.26 hrs, Volume= 8.827 Ml
Outflow = 2.6019 m³/s @ 1.47 hrs, Volume= 8.801 Ml, Atten= 3%, Lag= 12.6 min
Routed to Pond 7P : Level Spreader

Routing by Stor-Ind+Trans method, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.50 m/s, Min. Travel Time= 6.7 min
Avg. Velocity = 0.31 m/s, Avg. Travel Time= 10.7 min

Peak Storage= 1,050.0 m³ @ 1.36 hrs
Average Depth at Peak Storage= 0.92 m , Surface Width= 9.38 m
Bank-Full Depth= 2.00 m Flow Area= 20.00 m², Capacity= 15.6280 m³/s

2.00 m x 2.00 m deep channel, n= 0.100
Side Slope Z-value= 4.0 m/m Top Width= 18.00 m
Length= 200.00 m Slope= 0.0055 m/m
Inlet Invert= 42.250 m, Outlet Invert= 41.150 m



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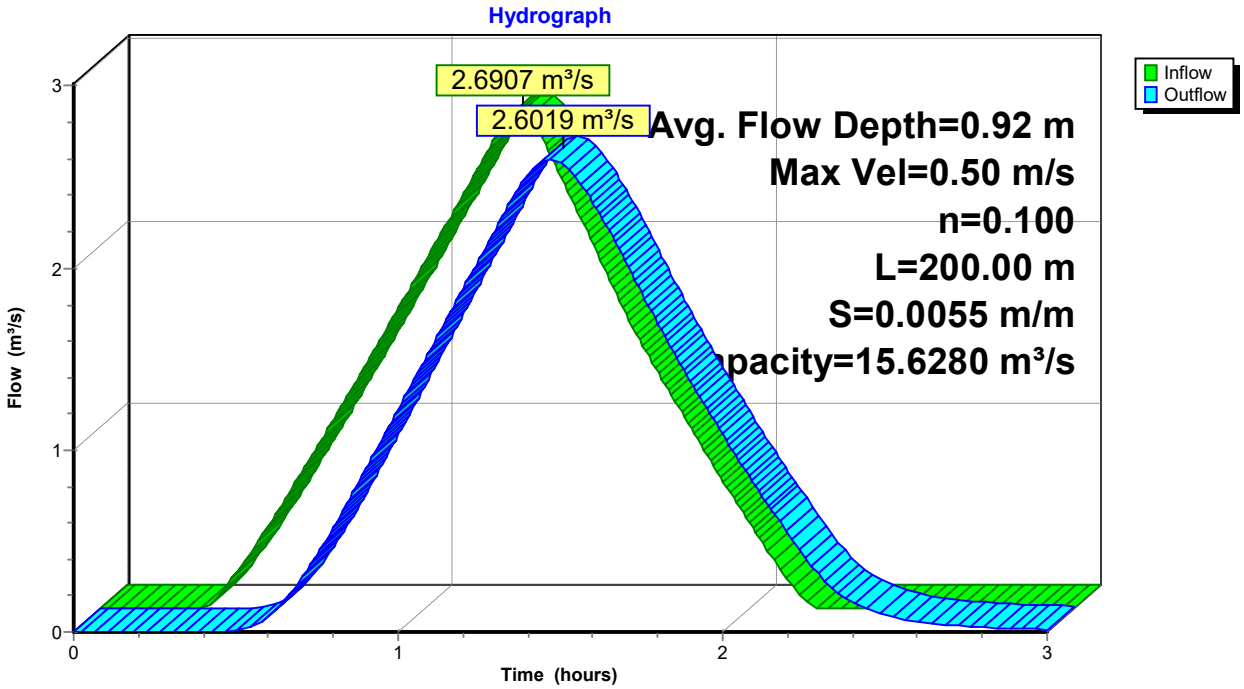
Reach 4R: Lot 1 to 3 Channel



Summary for Pond 3P: CH250 Culvert

Inflow Area = 33.9000 ha, 0.00% Impervious, Inflow Depth = 63 mm for 10-Year event
Inflow = 4.4351 m³/s @ 1.25 hrs, Volume= 21.289 Ml
Outflow = 4.4351 m³/s @ 1.26 hrs, Volume= 21.289 Ml, Atten= 0%, Lag= 0.6 min
Primary = 1.7444 m³/s @ 1.26 hrs, Volume= 12.461 Ml
Routed to nonexistent node 5L
Secondary = 2.6907 m³/s @ 1.26 hrs, Volume= 8.827 Ml
Routed to Reach 4R : Lot 1 to 3 Channel

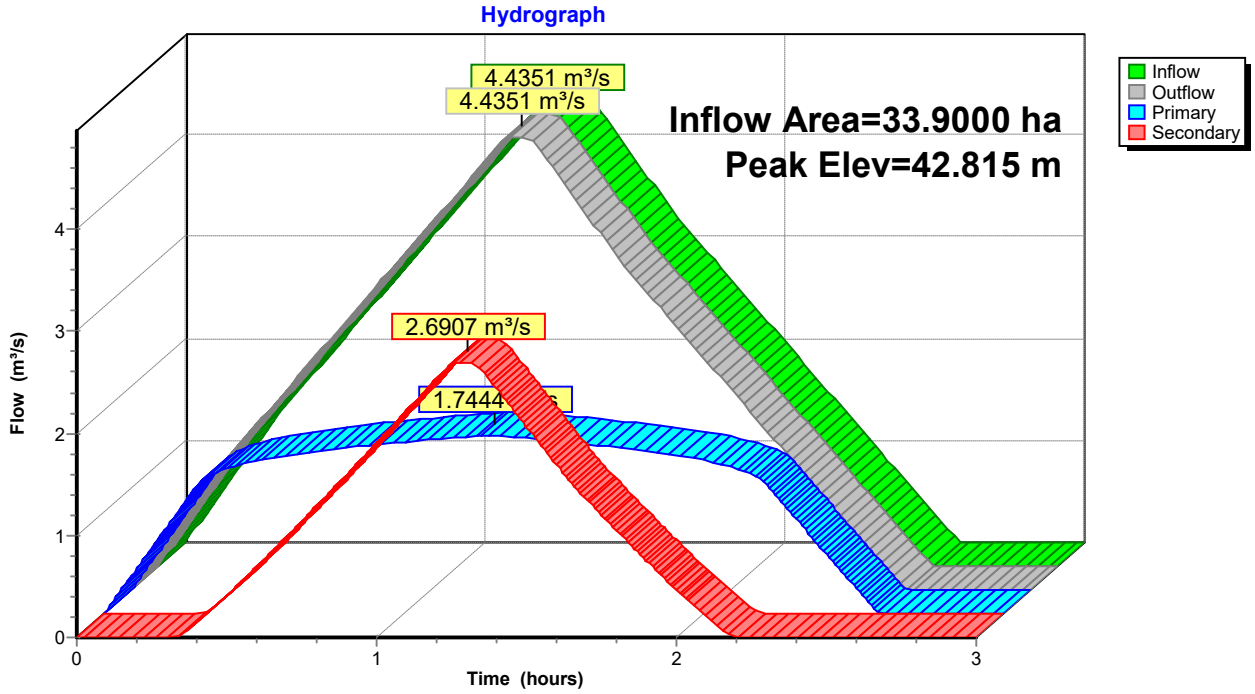
Routing by Stor-Ind method, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Peak Elev= 42.815 m @ 1.25 hrs

Device	Routing	Invert	Outlet Devices
#1	Secondary	42.250 m	**2.00 m long + 4.0 m/m SideZ x 0.50 m breadth Broad-Crested Rectangular W** 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 Coef. (Metric) 1.43 1.45 1.45 1.47 1.50 1.55 1.59 1.67 1.67 1.64 1.78 1.81 1.83
#2	Primary	41.300 m	**1,200 mm W x 450 mm H Box Culvert** L= 9.60 m Box, 30-75° wingwalls, square crown, Ke= 0.400 Inlet / Outlet Invert= 41.300 m / 41.100 m S= 0.0208 m/m Cc= 0.900 n= 0.013, Flow Area= 0.540 m²

Primary OutFlow Max=1.7444 m³/s @ 1.26 hrs HW=42.815 m (Free Discharge)
└**2=Culvert** (Inlet Controls 1.7444 m³/s @ 3.23 m/s)

Secondary OutFlow Max=2.6906 m³/s @ 1.26 hrs HW=42.815 m (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Weir Controls 2.6906 m³/s @ 1.12 m/s)

Pond 3P: CH250 Culvert



Summary for Pond 7P: Level Spreader

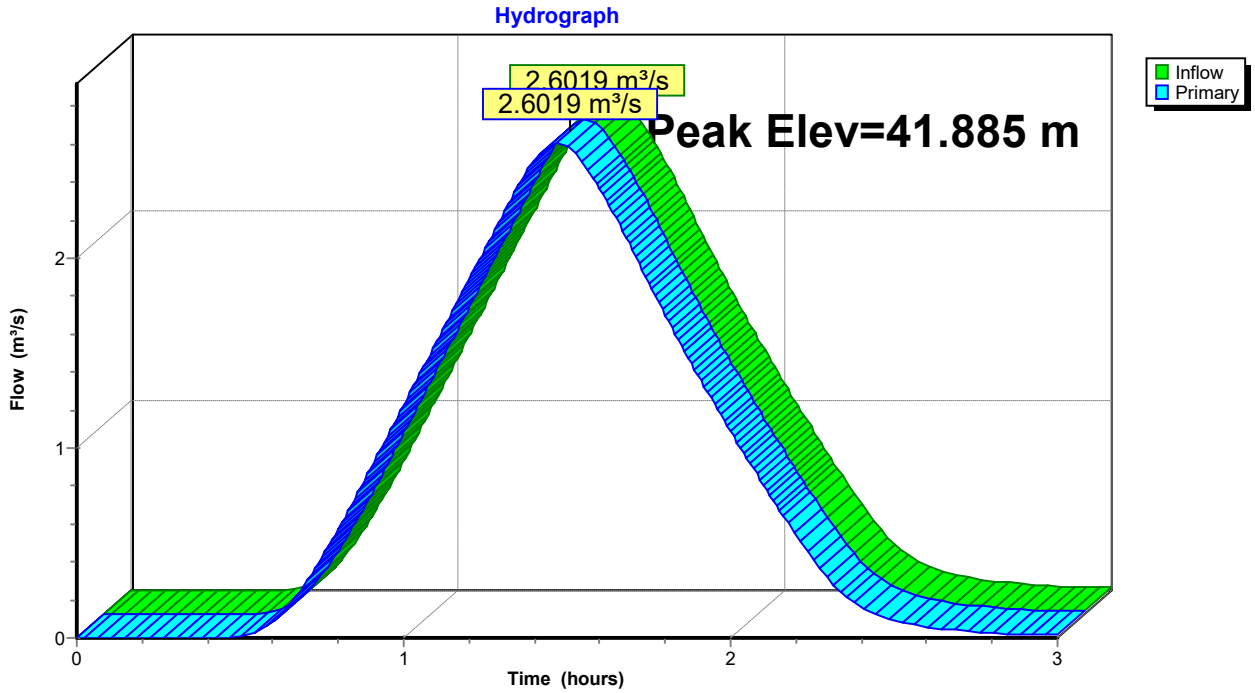
Inflow	=	2.6019 m³/s @	1.47 hrs,	Volume=	8.801 Ml
Outflow	=	2.6019 m³/s @	1.47 hrs,	Volume=	8.801 Ml, Atten= 0%, Lag= 0.0 min
Primary	=	2.6019 m³/s @	1.47 hrs,	Volume=	8.801 Ml

Routing by Stor-Ind method, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Peak Elev= 41.885 m @ 1.47 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	41.800 m	**55.00 m long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 0.20 m Crest Height

Primary OutFlow Max=2.6017 m³/s @ 1.47 hrs HW=41.885 m (Free Discharge)
1=Sharp-Crested Rectangular Weir (Weir Controls 2.6017 m³/s @ 0.56 m/s)

Pond 7P: Level Spreader



Time span=0.00-3.00 hrs, dt=0.01 hrs, 301 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Mulligan Runoff Area=32.3000 ha 0.00% Impervious Runoff Depth=101 mm
Tc=75.0 min Frequency Adjusted C=0.84 Runoff=6.8231 m³/s 32.751 Ml

Subcatchment 7S: EC04 Runoff Area=1.6000 ha 0.00% Impervious Runoff Depth=101 mm
Tc=19.0 min Frequency Adjusted C=0.84 Runoff=0.3380 m³/s 1.622 Ml

Reach 4R: Lot 1 to 3 Channel Avg. Flow Depth=1.25 m Max Vel=0.59 m/s Inflow=5.2864 m³/s 20.179 Ml
n=0.100 L=200.00 m S=0.0055 m/m Capacity=15.6280 m³/s Outflow=5.1813 m³/s 20.141 Ml

Pond 3P: CH250 Culvert Peak Elev=43.014 m Inflow=7.1611 m³/s 34.373 Ml
Primary=1.8747 m³/s 14.194 Ml Secondary=5.2864 m³/s 20.179 Ml Outflow=7.1611 m³/s 34.373 Ml

Pond 7P: Level Spreader Peak Elev=41.933 m Inflow=5.1813 m³/s 20.141 Ml
Outflow=5.1813 m³/s 20.141 Ml

Total Runoff Area = 33.9000 ha Runoff Volume = 34.373 Ml Average Runoff Depth = 101 mm
100.00% Pervious = 33.9000 ha 0.00% Impervious = 0.0000 ha

Summary for Subcatchment 1S: Mulligan

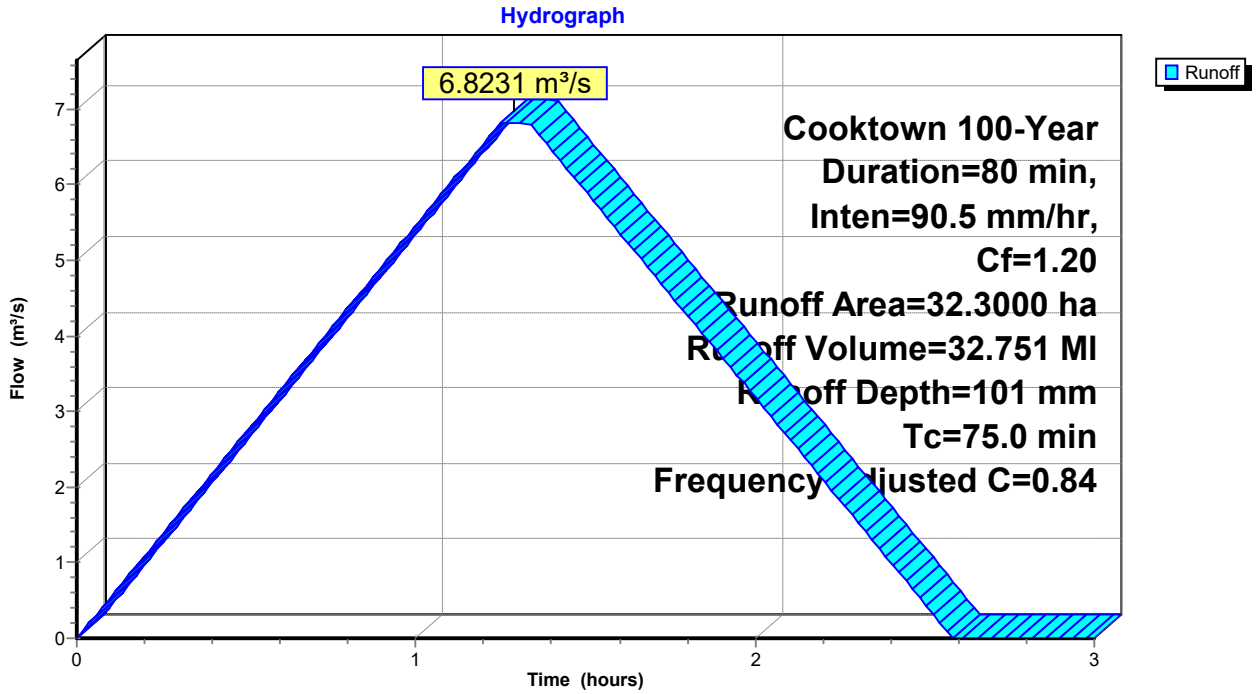
Runoff = 6.8231 m³/s @ 1.25 hrs, Volume= 32.751 Ml, Depth= 101 mm
Routed to Pond 3P : CH250 Culvert

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Cooktown 100-Year Duration=80 min, Inten=90.5 mm/hr, Cf=1.20

Area (ha)	C	Adj	Description
32.3000	0.70		
32.3000	0.70	0.84	Weighted Average, Frequency Adjusted
32.3000			100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
75.0					**Direct Entry,**

Subcatchment 1S: Mulligan



Summary for Subcatchment 7S: EC04

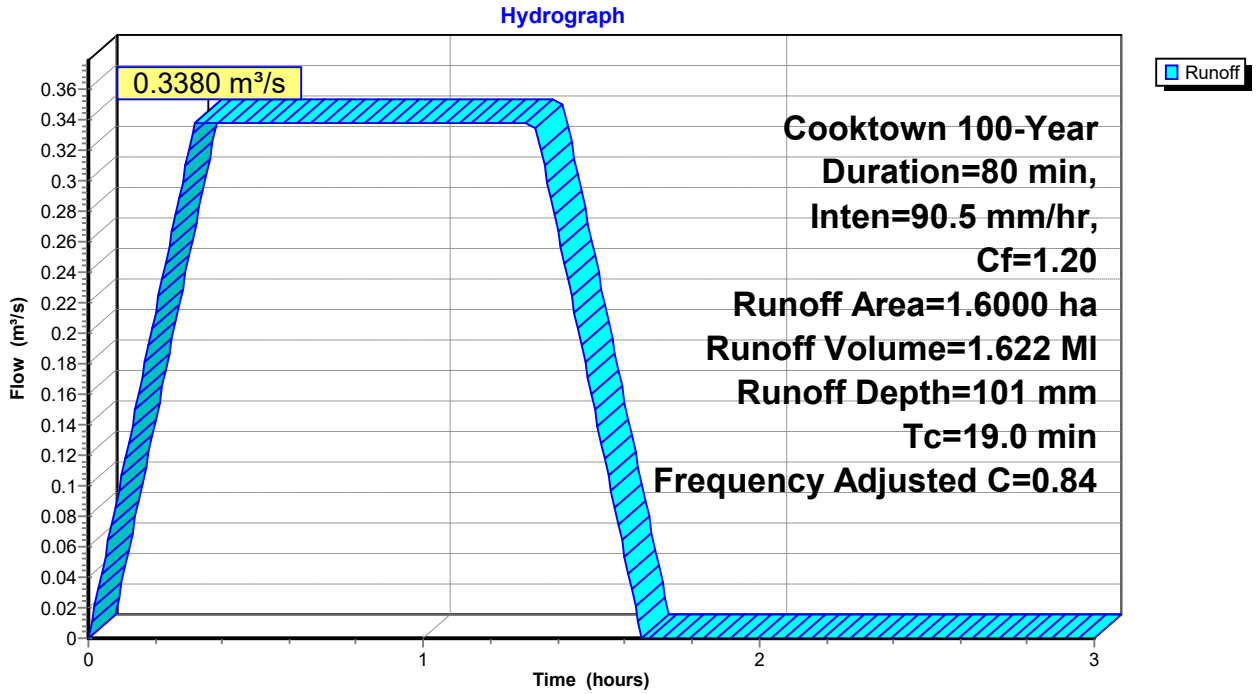
Runoff = 0.3380 m³/s @ 0.32 hrs, Volume= 1.622 Ml, Depth= 101 mm
Routed to Pond 3P : CH250 Culvert

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Cooktown 100-Year Duration=80 min, Inten=90.5 mm/hr, Cf=1.20

Area (ha)	C	Adj	Description
1.6000	0.70		
1.6000	0.70	0.84	Weighted Average, Frequency Adjusted
1.6000			100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
19.0					**Direct Entry,**

Subcatchment 7S: EC04



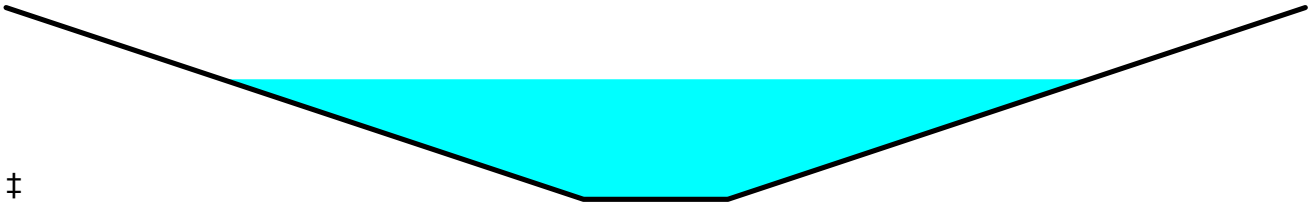
Summary for Reach 4R: Lot 1 to 3 Channel

Inflow = 5.2864 m³/s @ 1.26 hrs, Volume= 20.179 Ml
Outflow = 5.1813 m³/s @ 1.44 hrs, Volume= 20.141 Ml, Atten= 2%, Lag= 11.1 min
Routed to Pond 7P : Level Spreader

Routing by Stor-Ind+Trans method, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.59 m/s, Min. Travel Time= 5.6 min
Avg. Velocity = 0.40 m/s, Avg. Travel Time= 8.4 min

Peak Storage= 1,753.3 m³ @ 1.35 hrs
Average Depth at Peak Storage= 1.25 m , Surface Width= 12.01 m
Bank-Full Depth= 2.00 m Flow Area= 20.00 m², Capacity= 15.6280 m³/s

2.00 m x 2.00 m deep channel, n= 0.100
Side Slope Z-value= 4.0 m/m Top Width= 18.00 m
Length= 200.00 m Slope= 0.0055 m/m
Inlet Invert= 42.250 m, Outlet Invert= 41.150 m



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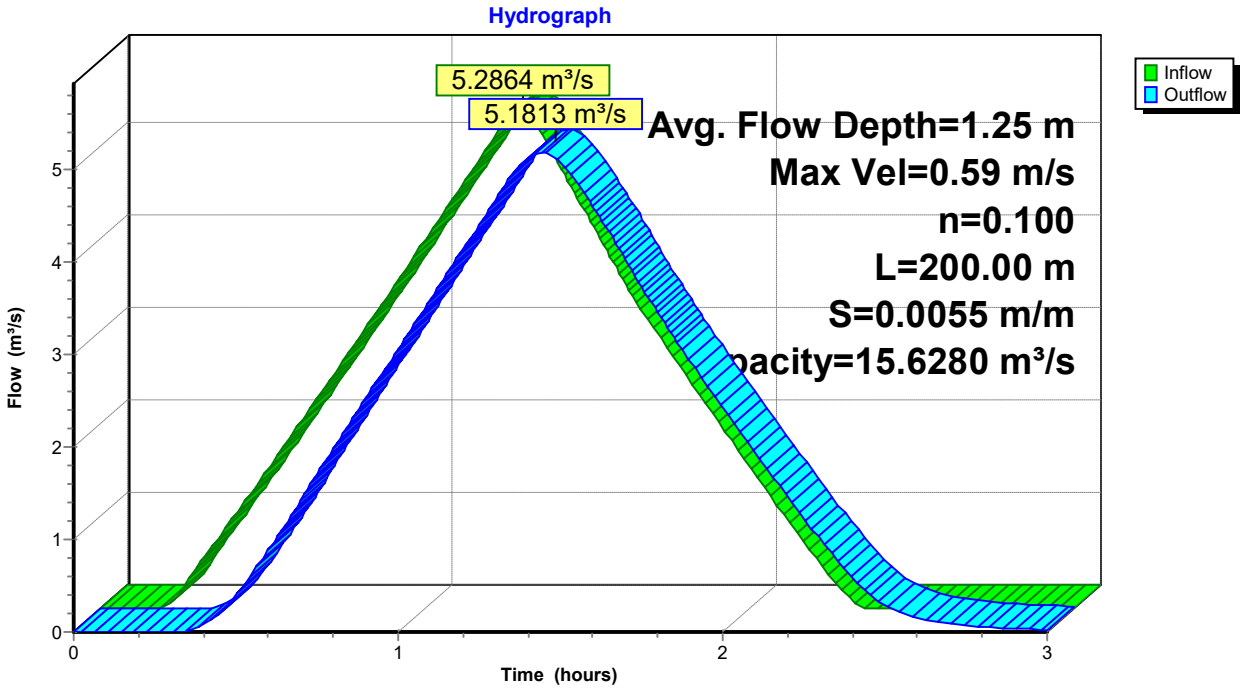
Reach 4R: Lot 1 to 3 Channel



Summary for Pond 3P: CH250 Culvert

Inflow Area = 33.9000 ha, 0.00% Impervious, Inflow Depth = 101 mm for 100-Year event
Inflow = 7.1611 m³/s @ 1.25 hrs, Volume= 34.373 Ml
Outflow = 7.1611 m³/s @ 1.26 hrs, Volume= 34.373 Ml, Atten= 0%, Lag= 0.6 min
Primary = 1.8747 m³/s @ 1.25 hrs, Volume= 14.194 Ml
Routed to nonexistent node 5L
Secondary = 5.2864 m³/s @ 1.26 hrs, Volume= 20.179 Ml
Routed to Reach 4R : Lot 1 to 3 Channel

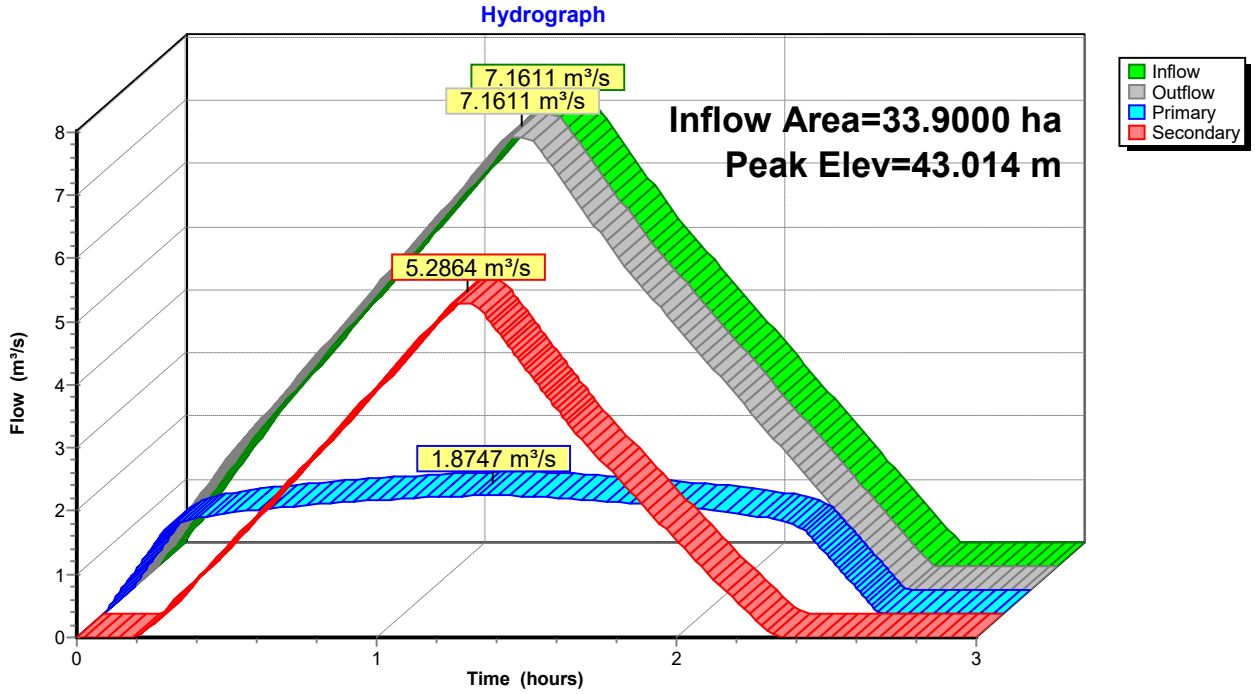
Routing by Stor-Ind method, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Peak Elev= 43.014 m @ 1.25 hrs

Device	Routing	Invert	Outlet Devices
#1	Secondary	42.250 m	**2.00 m long + 4.0 m/m SideZ x 0.50 m breadth Broad-Crested Rectangular W** 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 Coef. (Metric) 1.43 1.45 1.45 1.47 1.50 1.55 1.59 1.67 1.67 1.64 1.78 1.81 1.83
#2	Primary	41.300 m	**1,200 mm W x 450 mm H Box Culvert** L= 9.60 m Box, 30-75° wingwalls, square crown, Ke= 0.400 Inlet / Outlet Invert= 41.300 m / 41.100 m S= 0.0208 m/m Cc= 0.900 n= 0.013, Flow Area= 0.540 m²

Primary OutFlow Max=1.8747 m³/s @ 1.25 hrs HW=43.014 m (Free Discharge)
2=Culvert (Inlet Controls 1.8747 m³/s @ 3.47 m/s)

Secondary OutFlow Max=5.2885 m³/s @ 1.26 hrs HW=43.014 m (Free Discharge)
1=Broad-Crested Rectangular Weir (Weir Controls 5.2885 m³/s @ 1.37 m/s)

Pond 3P: CH250 Culvert



Summary for Pond 7P: Level Spreader

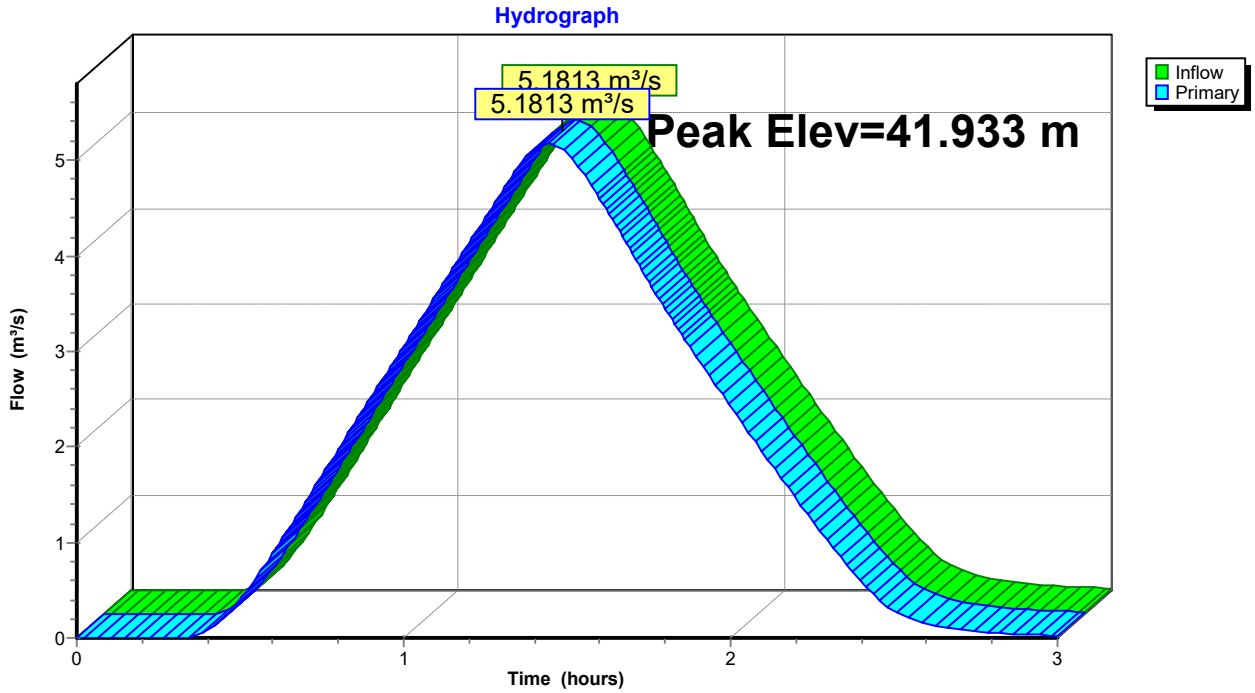
Inflow	=	5.1813 m³/s @	1.44 hrs,	Volume=	20.141 Ml
Outflow	=	5.1813 m³/s @	1.44 hrs,	Volume=	20.141 Ml, Atten= 0%, Lag= 0.0 min
Primary	=	5.1813 m³/s @	1.44 hrs,	Volume=	20.141 Ml

Routing by Stor-Ind method, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Peak Elev= 41.933 m @ 1.44 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	41.800 m	**55.00 m long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 0.20 m Crest Height

Primary OutFlow Max=5.1799 m³/s @ 1.44 hrs HW=41.933 m (Free Discharge)
└**1=Sharp-Crested Rectangular Weir** (Weir Controls 5.1799 m³/s @ 0.71 m/s)

Pond 7P: Level Spreader



Events for Subcatchment 1S: Mulligan

Event	Rainfall (mm)	Runoff (m^3/s)	Volume (Mega-liters)	Depth (mm)
10-Year	90	4.2258	20.284	63
100-Year	**121**	**6.8231**	**32.751**	**101**

Events for Subcatchment 7S: EC04

Event	Rainfall (mm)	Runoff (m^3/s)	Volume (Mega-liters)	Depth (mm)
10-Year	90	0.2093	1.005	63
100-Year	**121**	**0.3380**	**1.622**	**101**

Events for Reach 4R: Lot 1 to 3 Channel

Event	Inflow (m^3/s)	Outflow (m^3/s)	Elevation (meters)	Storage (cubic-meters)
10-Year	2.6907	2.6019	43.173	1,050.0
100-Year	**5.2864**	**5.1813**	**43.501**	**1,753.3**

Events for Pond 3P: CH250 Culvert

Event	Inflow (m^3/s)	Outflow (m^3/s)	Primary (m^3/s)	Secondary (m^3/s)	Elevation (meters)	Storage (Mega-liters)
10-Year	4.4351	4.4351	1.7444	2.6907	42.815	**0.000**
100-Year	**7.1611**	**7.1611**	**1.8747**	**5.2864**	**43.014**	0.000

Events for Pond 7P: Level Spreader

Event	Inflow (m^3/s)	Primary (m^3/s)	Elevation (meters)	Storage (Mega-liters)
10-Year	2.6019	2.6019	41.885	**0.000**
100-Year	**5.1813**	**5.1813**	**41.933**	0.000