REPORT

Stormwater Runoff Assessment

Mission Special Character Zone

Prepared for
Marist Holdings (Greenmeadows) Limited

Prepared by
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Date
April 2018

Job Number
1002680

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Document Control

Title: Stormwater Runoff Assessment					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
July 2017	1	MSCZ Stormwater Runoff Assessment	HSMI	JRR	ADP
Sept' 2017	2	Updated to include downstream flood assessment	HSMI	JRR	ADP
Mar 2018	3	Updated based on consultation with HBRC	HSMI	JRR	ADP
April 2018	4	Updated with additional figures	HSMI		

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Executive summary

The Mission Special Character Zone (MSCZ) is a proposed residential development for approximately 570 residential properties located near Napier. The 246 ha site is currently owned by Marist Holdings (Greenmeadows) Ltd.

T+T were engaged to carry out a stormwater effects assessment for the development and identify necessary flood mitigation works to support a discharge consent application and a plan change to the Operative City of Napier District Plan ('Plan Change 12').

The proposed development will increase impervious coverage by approximately 43 ha for land draining west to the Turirau Stream and by 3.4 ha for land draining east to the Taipo Stream. However, runoff to the east will be mitigated through landscape planting, which is expected to reduce runoff volume and peak flows.

The increase in impervious surface for land draining to the west represents approximately 2.5% of the Turirau catchment area (~1,720 ha) and 3% of the catchment upstream of a farmland area which is known to flood (~1,345 ha). Irrespective of the mitigation works at the Mission Special Character Zone site, the farmland will continue to flood to a similar extent to what has been experienced.

In order to mitigate the downstream effects of the development, a series of stormwater ponds are proposed to meet water quality and water quantity performance objectives. The proposed ponds are located in the natural contours of the major gullies and will be formed by constructing an earth embankment at the downstream end of the gulley, through which an outlet will be constructed. It may be possible in subsequent design stages to change the stormwater management ponds into wetlands through appropriate vegetation selection and topographic contouring.

It has been demonstrated that the proposed stormwater ponds will reduce peak discharges from the developed catchment by between 6% and 77% for all ARIs and event durations considered.

Overall we conclude that with the proposed mitigation measures there will be no negative effect caused by the development to downstream areas. The concept design included in this report is likely to cause a small reduction in downstream flood levels.

1 Introduction

The Mission Special Character Zone (MSCZ) is a proposed residential development for approximately 570 residential properties located near Napier. The 246 ha site is currently owned by Marist Holdings (Greenmeadows) Ltd.

Marist Holdings (Greenmeadows) Ltd have engaged T+T to carry out a stormwater effects assessment for the development to support a discharge consent application and a plan change to the Operative City of Napier District Plan ('Plan Change 12').

1.1 Scope

The primary goal of this assessment is to demonstrate the effects of the proposed development and the nature of flood mitigation works. The assessment will consider whether the proposed development can meet the goals outlined in Hawke's Bay Regional Council Stormwater Management Guidelines (HBRC SMG) and the standards set out in Rule 43 of the Hawkes Bay Regional Resource Management Plan.

In discussions with HBRC the following performance objectives and clarifications were agreed:

1. The post-development peak discharge should not exceed the 48 hour pre-development peak discharge for storm events with average recurrence intervals of 2 years, 10 year and 50 years.
2. Attenuate and treat stormwater runoff from the water quality storm over 24 hour period
3. The erosion control design criteria is to store 1.2 times the water quality volume which will be provided as live pond storage.

With regards item 1, we have agreed with HBRC that post-development peak discharges for storm durations of 3 hour, 6 hour, 12 hour, 24 hour and 48 hour should not exceed the peak discharge from a pre-development 48 hour duration storm event. A 100 year ARI design storm has also been considered, which is a larger storm event than was agreed with HBRC.

1.2 Proposed development

The proposed layout of the development and the direction of drainage within the sub-catchments are shown in Figure 1-1. The residential areas are shown in grey, and proposed vegetative cover in green. The direction of drainage is indicated by blue arrows. The site to the left of the orange dashed line drains westwards towards the Turirau Stream, and to the right drains eastwards towards the Taipo Stream. The yellow dashed lines indicate sub catchment divides of the westwards draining catchments.

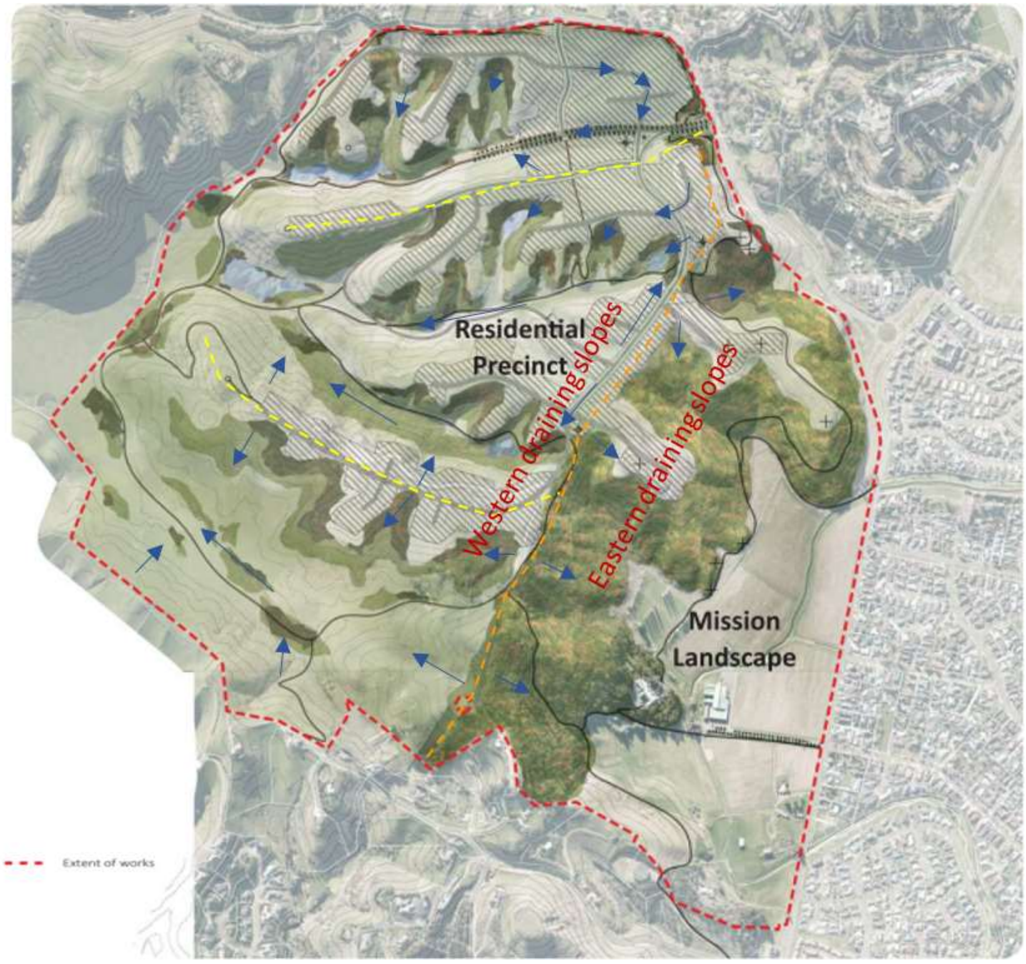

Figure 1-1: Proposed development plan with runoff flow directions indicated

The percentage of impervious area for residential lot areas has been estimated at 75%, which is similar to nearby developments in Napier.

The total impervious area for the entire development including roads and residential lots will be approximately 20%. This is significantly lower than nearby developments in Napier. The 20% increase represents a 43 ha increase in imperviousness draining west and 3.4 ha increase draining east. The distribution of impervious area in the proposed development is shown in Table 1-1.

On the eastward draining slopes a significant amount of landscape planting is proposed with a small area covered by residential lots.

Table 1-1: Impervious area in sub-catchments in proposed development

Sub Catchments[1]	Area (ha)	% Area Impervious Post-Development
C1	76	6%
C2	73	23%
C3	45	48%
C4	18	4%

[1] See Figure 1-3 for sub-catchment locations

Sub Catchments[1]	Area (ha)	% Area Impervious Post-Development
C5	22	10%
C6	11	4%

The Plan Change documents include a Structure Plan which identify this area as East Hill Face Woodland (reproduced in Appendix A). Furthermore Plan Change 12 Design Outcome 16 requires that the area *"is to be planted with trees established prior to subdivision of the Residential Precinct and is to be retained as a woodland to achieve the following specific outcomes:*

- *A high amenity landscape comprising a mix of deciduous and evergreen species.*
- *A green skyline and backdrop to the Mission landscape when viewed from Church Road.*
- *The screening of houses in the Residential Precinct when viewed from Church Road.*
- *Provision for paths and 'art cabins' within the woodland (see Design Outcome 19).*
- *Long term retention of the woodland backdrop while providing for individual trees to be selectively harvested on an on-going basis. Such harvesting is not to apply to trees on the upper slopes so that the skyline retains a permanent screening function and is to be undertaken so that the green woodland backdrop is maintained."*

A detailed vegetation plan will be available at subsequent design stages, however on the basis of the Structure Plan (Appendix A) and the existing land use (as shown below in Figure 1-2) we believe that there will be an overall decrease in CN for the east facing slopes (refer Section 3).

Figure 1-2: Existing and proposed land cover for eastern-draining slopes

In the eastward draining sub-catchments extensive planting proposed (more details provided later) that may result in reduced runoff, both quantity and peak discharge and likely water quality improvement.

1.3 Wider catchment context

Approximately 80% (194 ha) of the proposed development drains westwards to the Turirau Stream (a tributary of the Tutaekuri River) and 20% (52 ha) drains east towards the Mission Estate Vineyard and Taipo Stream. The total area of the Turirau Stream upstream of the confluence with the Tutaekuri is approximately 1,720 ha.

Figure 1-3 shows the sub-catchments for the proposed development. Sub-catchments C1 to C3 drain to the west and sub-catchments C4 to C6 drain to the east. The entire Turirau Stream catchment is shown in Figure 1-5.

Land use on the westward draining catchments primarily comprises dry land cattle farming with a pine plantation covering most of catchment C1 (Figure 1-3). The forest cover is cyclic and after harvesting the area may be used for pasture instead of forest, which will increase runoff from the catchment. In the analyses land use has been modelled as pasture.

Runoff from the western catchments flows to farmland that was historically formed by draining swampland. The low-lying area drains through a series of manmade channels and culverts before flowing into the Tutaekuri River, as shown in Figure 1-4. The total upstream area of the farmland is approximately 1,345ha, noting that due to the flat topography some downstream catchments may also influence flooding in this area.

Land use on the eastern side of the site (sub-catchments C4, C5, and C6) is currently dry land cattle farming. The catchments drain east towards the Mission Estate Vineyard before flowing into the Taipo Stream, which discharges into the Main Outfall Channel (Figure 1-4). The Taipo Stream and Main Outfall Channel are urban streams that have been modified from their natural state.

The eastward draining catchments are much steeper than the westwards draining catchment and therefore have a much more flashy hydrological response.

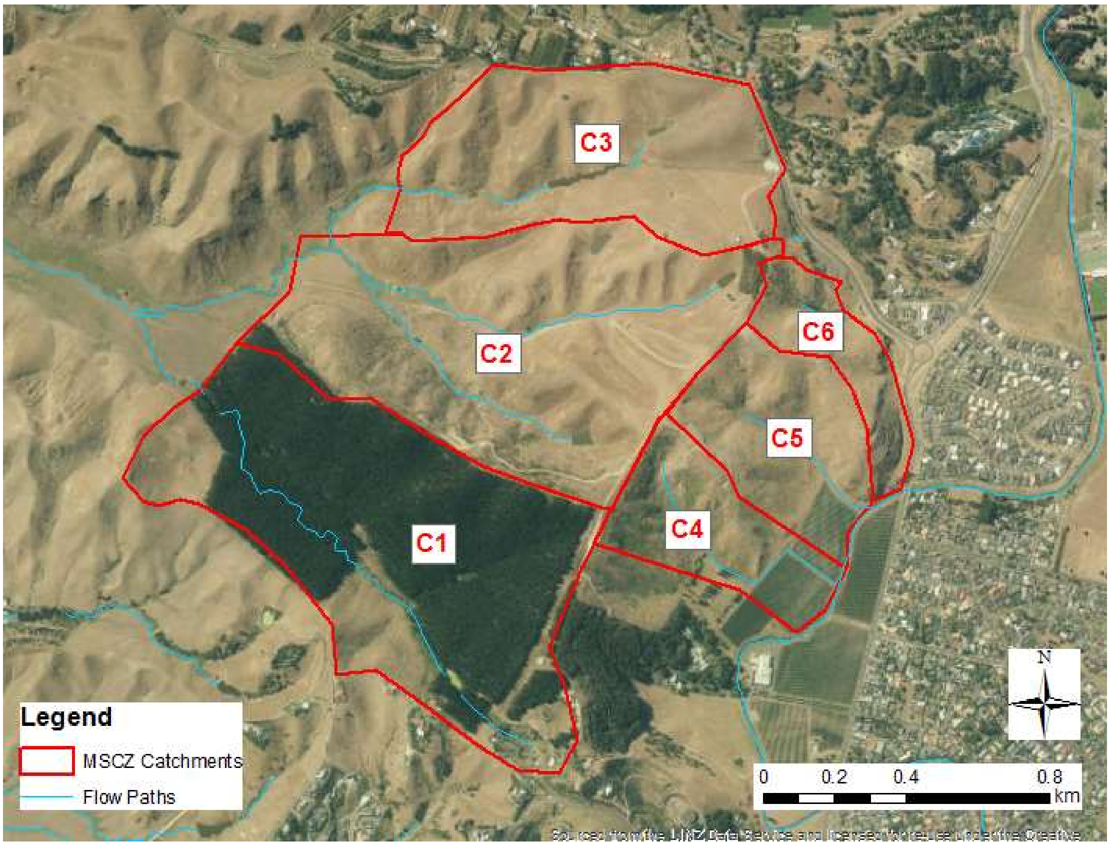

Figure 1-3: Aerial photograph showing the proposed development area and sub-catchments

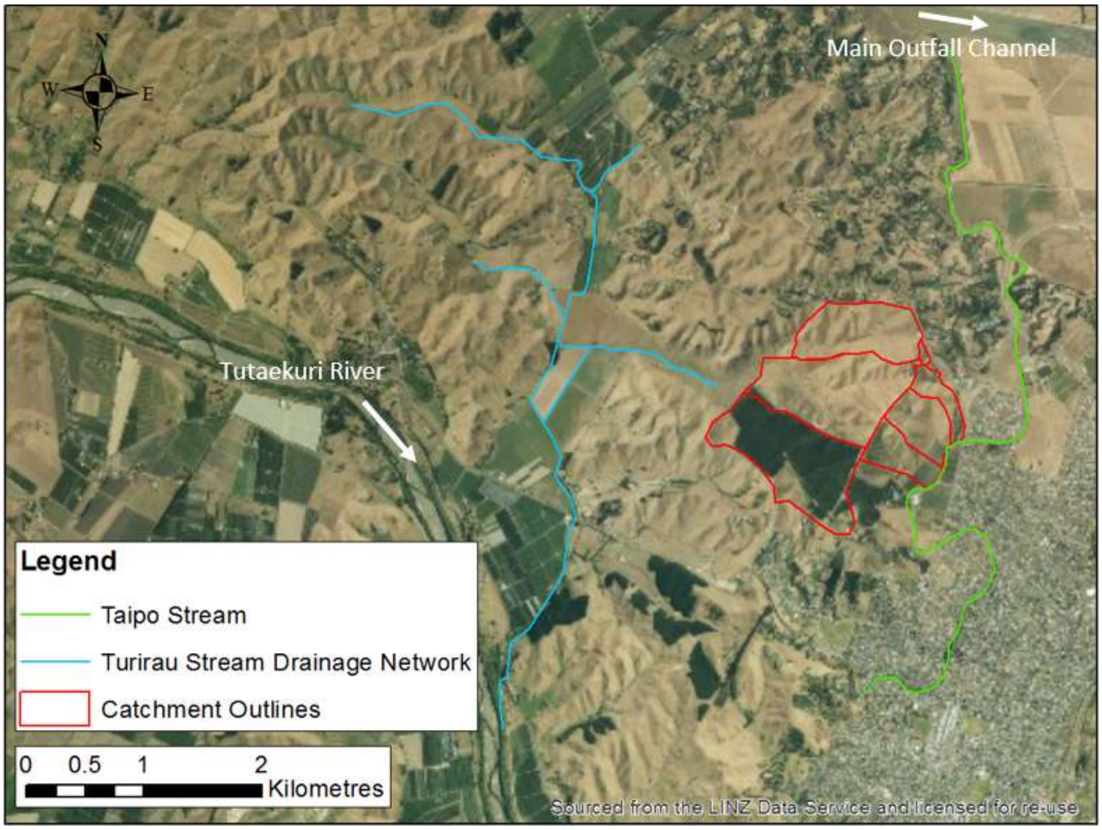

Figure 1-4: Location of development sub-catchments with respect to receiving environments

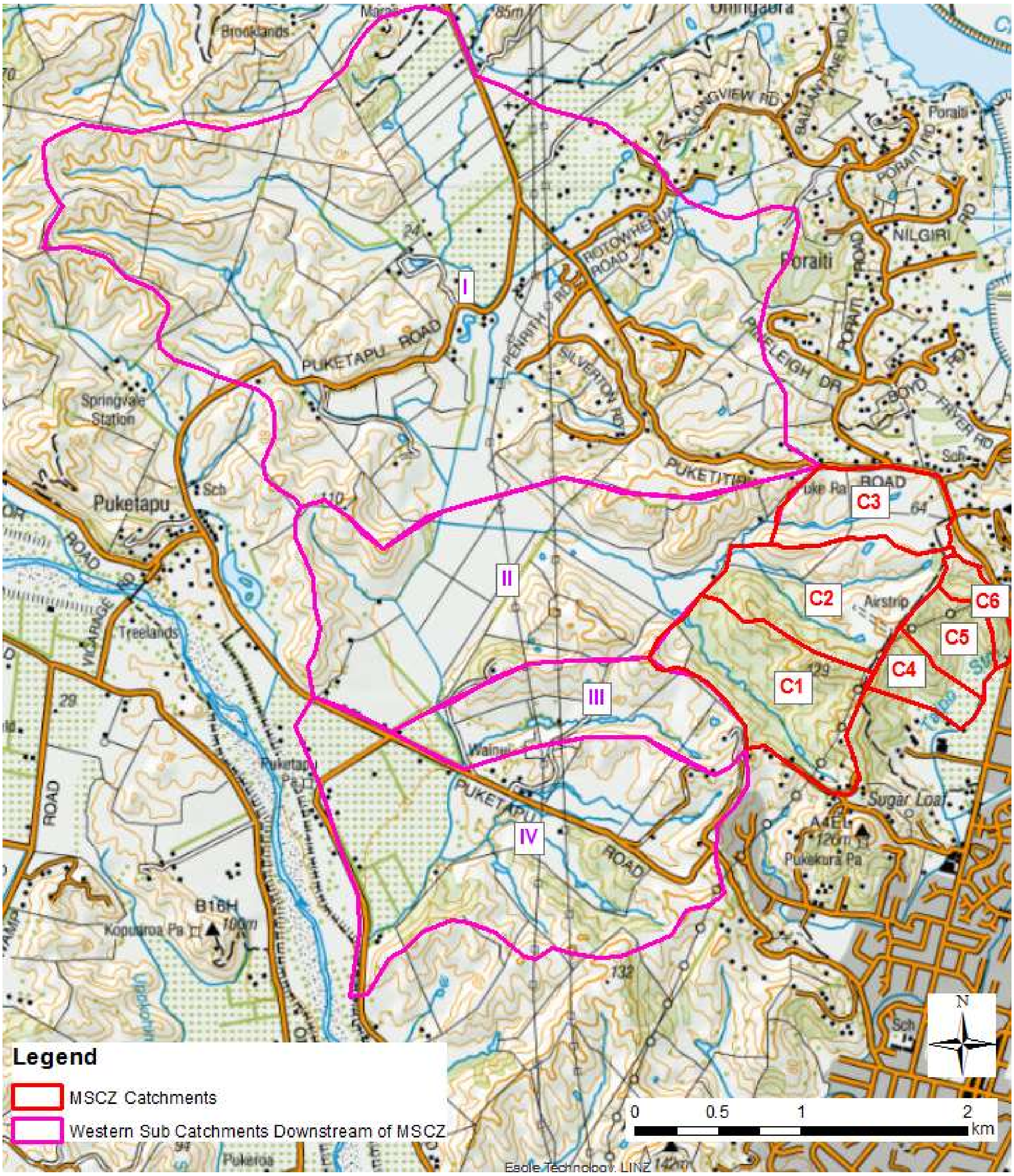

Figure 1-5: Topographic map of MSCZ catchments and western downstream catchment area

1.4 Description of potential effects without mitigation

Without mitigation, the proposed development and the resulting change in land use from predominantly dairy cattle to a residential site with an increased impervious area, will produce increased runoff volume, higher peak flows, shorter hydrological response times and may have an effect on water quality (more urban contaminants, less agricultural) when compared to the current situation. Increased peak flows can also lead to increased erosion, which can cause loss of land, downstream sedimentation and higher turbidity in streams and watercourses.

2 Methodology

This section describes the methodology used to generate design hydrographs for the sub-catchments to assess the effect of the proposed development.

The hydrological analysis includes the proposed development areas draining to the west (sub-catchments C1, C2 and C3) and to the east (sub-catchments C4, C5 and C6), as shown in Figure 2-1.

The four downstream sub-catchments (I, II, III and IV) for the west draining catchments, are also shown in Figure 2-1. These sub-catchments were also analysed to contextualise the contribution of the development area to downstream runoff and potential flooding.

Catchment runoff was simulated using the SCS unit hydrograph method as implemented in HEC-HMS. Losses were modelled using the SCS curve number (CN) method with CN values estimated based on land use and soil group and initial losses (Ia) as 20% of the soil storage parameter (S) in accordance with the guidance provided in the SCS literature.

Soil group were based on the Landcare Research soil permeability map shown in Figure 2-1.

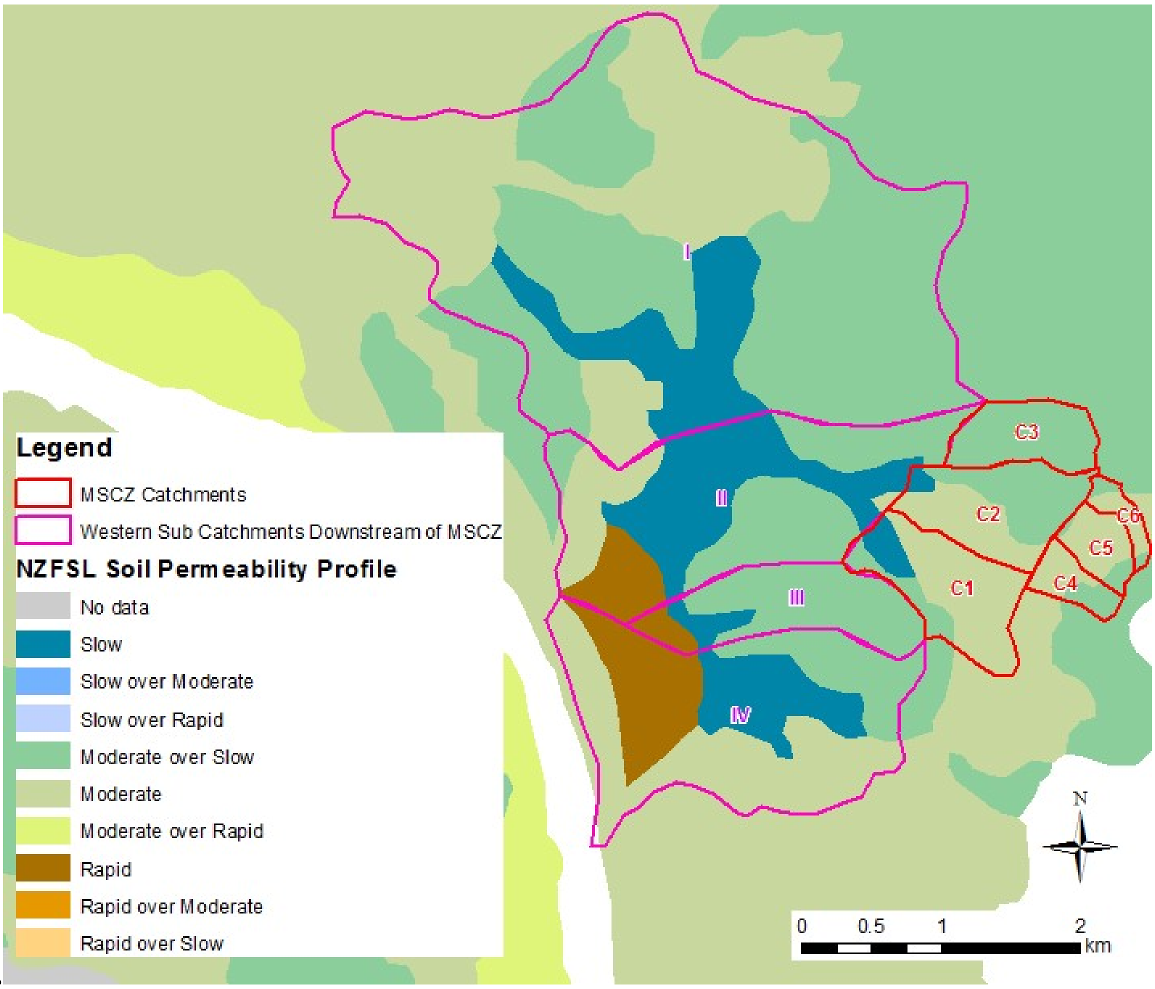

Figure 2-1: Landcare Research Soil Permeability Map

2.1 Design rainfall

Design rainfall depths for a range of storm durations were sourced from NIWA's HIRDs V3 database and are listed in Table 2-1. HIRDs V3 data is preferred because it is based on more up to date rainfall data than that used for Section 6.1.3 of the HBRC SMG. We note that the depths from the two tables are within 5% of each other.

Table 2-1: HIRDs V3 Rainfall Depths for the development site – shaded values were used as design values in this assessment

	Storm depth (mm) for storm duration (hours)							
ARI (y)	0.25h	1h	2h	3h	6h	12h	24h	48h
1.58	7.4	16.0	22.2	26.8	37.2	51.5	71.4	87.9
2	8.2	17.8	24.6	29.6	40.9	56.4	77.7	95.6
5	11.6	25.0	33.9	40.5	54.9	74.4	100.9	124.1
10	14.4	31.2	41.9	49.7	66.6	89.4	119.8	147.4
20	17.9	38.7	51.3	60.6	80.3	106.5	141.3	173.9
30	20.2	43.7	57.7	67.8	89.4	117.9	155.4	191.2
40	22.1	47.7	62.6	73.5	96.4	126.6	166.2	204.5
50	23.6	51.0	66.8	78.1	102.2	133.8	175.1	215.3
60	25.0	53.9	70.3	82.2	107.2	139.9	182.6	224.6
80	27.2	58.7	76.3	88.9	115.6	150.2	195.2	240.1
100	29.1	62.8	81.3	94.6	122.5	158.7	205.5	252.8

Hyetographs were generated for storm durations from 3 hours to 48 hours so that the peak discharge from the sub-catchments under present day and proposed development conditions could be determined. A nested approach with central peak rainfall intensity limited to approximately 3 times the average rainfall intensity was followed to generate the design hyetographs.

Rainfall hyetographs for the range of design events, with hourly aggregation are presented in Appendix B. These hyetographs show the depth of rainfall in each hour of storm for the design storms used in the runoff model. Shorter duration rainfall events have higher peak rainfall intensities (typically expressed as mm per hour), whereas the longer duration events typically have lower peak intensities.

The water quality storm rainfall hyetograph was estimated using 30mm depth rainfall event as recommended in Section 6.3.3 of the HBRC SWMG.

2.2 Runoff model

A HEC-HMS model was used to calculate runoff from the catchments for both pre-development and post-development scenarios. The model included routing of the post development flows through detention storage so that peak discharges could be controlled.

Table 2-2 shows the hydrological model parameters for the sub-catchments shown in Figure 1-5 for both pre and post development scenarios.

Time of concentration was calculated using the time of concentration formula in the Auckland Council Stormwater guideline (TP108).

Table 2-2: Comparison of pre-development and post-development hydrological parameters

Catchment	Area (ha)	Stream length (km)	Slope (m/m)	Pre development				Post development			
				CN	Ia	Tc (hours)	Lag (minutes)	CN	Ia	Tc (hours)	Lag (minutes)
C1	76	1.56	0.019	62	31	0.86	34	69	23	0.79	32
C2	73	1.41	0.025	62	31	0.74	30	63	29	0.73	29
C3 pre	44.3	1.49	0.018	61	32	0.86	34				
C3 post	44.7							72	19	0.74	30
C4	18	0.94	0.13	61	32	0.36	14	54	43	0.39	16
C5	22	0.65	0.13	61	32	0.28	11	56	40	0.30	12
C6	11	0.32	0.17	61	32	0.17	7	54	44	0.18	7
I	878	4.55	0.006	74	18	2.13	85				
II	273	3.12	0.001	65	27	3.17	127				
III	91	2.01	0.017	60	34	1.08	43				
IV	284	3.43	0.005	60	34	2.22	89				

3 Unmitigated results

This section provides a summary of the hydrological simulation results without any stormwater mitigation for the MSCZ catchments.

The peak discharges for catchments draining to the west and to the east are summarised in Table 3-1 and Table 3-2 respectively. The highest peak for each ARI is shown in bold. The three hour storm durations were simulated for the post-development scenario to ensure that the critical storm duration for peak discharge was identified.

Figure 3-1 and Figure 3-2 show examples of simulated discharge from the C1-C3 catchments for the pre-development and post-development scenarios respectively. The plots show how peak discharge varies with storm duration and that there is a critical storm duration that generates the largest peak discharge.

Table 3-1: Simulated sub-catchment peak discharge for west draining areas (sub-catchments C1, C2 and C3)

ARI (years)	**2**	**10**	**50**	**100**	**2**	**10**	**50**	**100**
Storm duration	**Pre-development**				**Post-development**			
	Simulated peak discharge (m^3/s)							
Area C1								
3 hour	Not simulated				0.07	0.69	2.84	4.55
6 hour	0.07	0.59	2.49	3.95	0.18	1.26	3.82	**5.61**
12 hour	0.16	1.07	2.97	**4.24**	0.45	1.68	**3.91**	5.33
24 hour	0.39	**1.37**	**3.06**	4.14	**0.68**	**1.85**	3.72	4.87
48 hour	**0.46**	1.19	2.41	3.13	0.66	1.48	2.77	3.51
Area C2								
3 hour	Not simulated				0.00	0.34	1.85	3.23
6 hour	0.07	0.60	2.53	4.01	0.09	0.73	2.79	4.34
12 hour	0.16	1.07	2.93	**4.17**	0.21	1.18	**3.10**	**4.37**
24 hour	0.39	**1.34**	**2.98**	4.02	0.44	**1.42**	3.09	4.15
48 hour	**0.44**	1.15	2.33	3.02	**0.48**	1.20	2.39	3.08
Area C3								
3 hour	Not simulated				0.10	0.64	2.19	3.36
6 hour	0.03	0.31	1.36	2.18	0.20	1.02	**2.72**	**3.88**
12 hour	0.08	0.58	1.65	2.38	0.39	1.19	2.59	3.46
24 hour	0.21	0.76	1.72	2.34	**0.50**	**1.23**	2.38	3.07
48 hour	**0.25**	0.67	1.37	1.78	0.45	0.95	1.73	2.17

Table 3-2: Simulated sub-catchment peak discharge for east draining areas (sub-catchments C4, C5, C6)

ARI (years)	2	10	50	100	2	10	50	100
Storm duration	Pre-development				Post-development			
	Simulated peak discharge (m^3/s)							
Area C4								
3 hour	0.0	0.1	0.5	0.9	0.00	0.02	0.19	0.44
6 hour	0.0	0.2	0.7	1.2	0.00	0.04	0.42	0.76
12 hour	0.0	0.3	0.8	1.1	0.01	0.14	0.54	0.82
24 hour	0.0	0.3	0.7	1.0	0.03	0.22	0.58	0.82
48 hour	0.1	0.3	0.6	0.7	0.06	0.21	0.48	0.64
Area C5								
3 hour	0.00	0.08	0.65	1.22	0.03	0.09	0.32	0.73
6 hour	0.02	0.24	0.97	1.52	0.00	0.08	0.66	1.13
12 hour	0.05	0.36	0.95	1.35	0.00	0.23	0.75	1.12
24 hour	0.12	0.42	0.92	1.24	0.02	0.32	0.78	1.08
48 hour	0.13	0.35	0.70	0.91	0.06	0.28	0.62	0.82
Area C6								
3 hour	0.00	0.04	0.38	0.72	0.00	0.01	0.13	0.34
6 hour	0.01	0.14	0.53	0.81	0.00	0.03	0.32	0.55
12 hour	0.03	0.19	0.49	0.81	0.01	0.10	0.35	0.53
24 hour	0.06	0.21	0.47	0.63	0.02	0.14	0.37	0.52
48 hour	0.07	0.17	0.35	0.46	0.04	0.13	0.29	0.39

Table 3-2 shows that for the catchments draining to the east there will be a reduction in runoff volume and peak discharge based on the proposed planting in comparison with the existing land use.

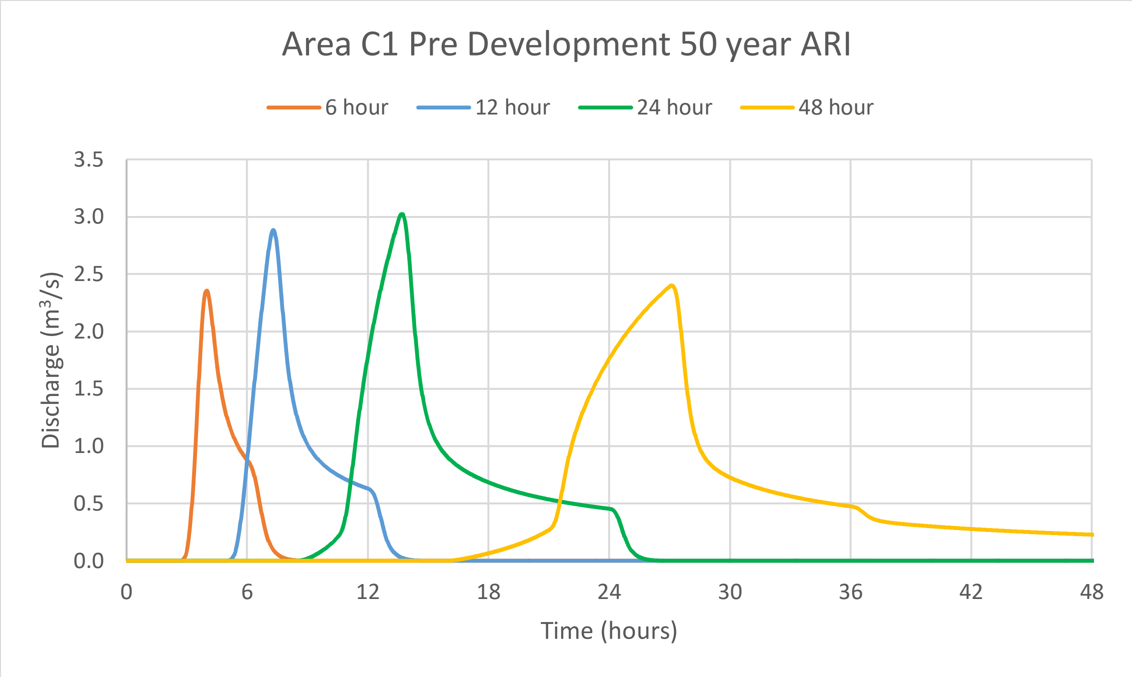

Figure 3-1: Discharge hydrographs for Area C1 pre-development case

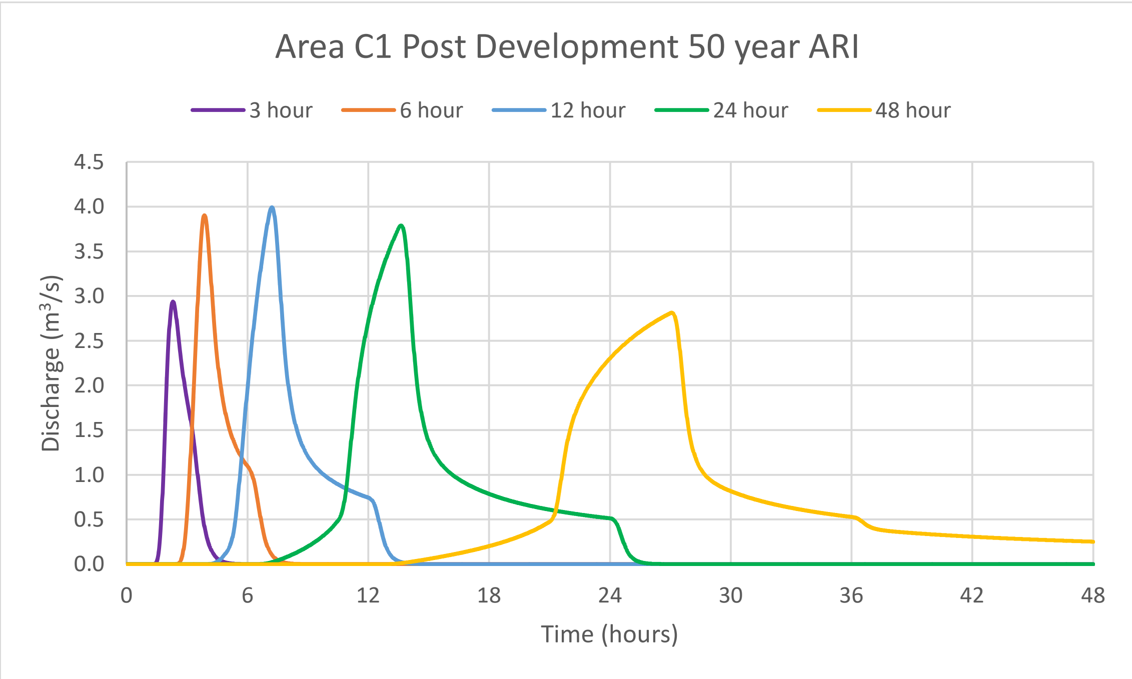

Figure 3-2: Discharge hydrographs for Area C1 post-development case

Peak discharges calculated from the HEC-HMS model for the Turirau catchments are shown in Table 3-3. Comparison to flows from catchments I, II, III and IV. Where the MSCZ catchments flow into the Turirau catchments, the results indicate that for a 50 year 48 hour event the MSCZ catchments contribute around 15% of the peak discharge to this area, and a similar proportion of the total storm volume.

Table 3-3: Simulated peak catchment discharges Turirau Catchments I, II, III, and IV

ARI (years)	**2**	**10**	**50**	**100**
Storm duration	**Pre-development**			
	Simulated peak discharge (m^3/s)			
Turirau I				
3 hour	1.9	9.5	26.4	38.4
6 hour	3.8	13.9	34.3	48.0
12 hour	6.3	18.6	40.1	53.7
24 hour	**8.9**	**21.8**	**42.0**	**54.2**
48 hour	8.8	18.5	33.3	41.8
Turirau II				
3 hour	0.1	0.9	3.5	5.6
6 hour	0.3	1.8	5.3	7.9
12 hour	0.7	2.8	7.1	10.1
24 hour	1.2	3.9	**8.7**	**11.8**
48 hour	**1.6**	**4.1**	8.2	10.6
Turirau III				
3 hour	0.0	0.3	1.4	2.5
6 hour	0.1	0.5	2.2	3.6
12 hour	0.1	1.0	3.0	4.3
24 hour	0.4	**1.4**	**3.3**	**4.5**
48 hour	**0.5**	1.3	2.7	3.6
Turirau IV				
3 hour	0.1	0.7	3.5	6.0
6 hour	0.2	1.4	5.3	8.5
12 hour	0.4	2.5	7.5	11.0
24 hour	1.0	**3.8**	**9.1**	**12.5**
48 hour	**1.4**	3.8	8.1	10.7

4 Mitigation of effects

It is proposed to use stormwater ponds to provide the water quality and water quantity performance objectives identified in Section 1.1 of this report for catchment draining to the west. Water quality and water quantity mitigation for the eastward draining catchments is also discussed in the relevant Sections 4.1 and 4.2 respectively.

Figure 4-1 identifies the pond locations and indicative 50 year ARI pond surface area. The proposed ponds are located in the natural contours in each of the major gullies. The ponds will be formed by constructing an earth embankment at the downstream end of the gulley, through which an outlet will be configured to meet the water quality and water quantity objectives (as discussed in the following subsections).

The method for passing stormwater flows to the ponds will be confirmed in subsequent stages of design and are likely comprise conventional curb and channel collection and routing of stormwater. Storm runoff will be piped to the base of the gulley and flow into the pond. Energy dissipation will probably be required where the stormwater discharges into the natural gullies.

For concept design, the ponds were sized to minimise their impounded height (keeping below 3m depth of water during the most extreme event modelled), and generally conform to the sites existing contours in the gullies with some modifications to balance cut fill and shape the ponds to a desirable geometry.

All ponds will have a sediment forebay, a permanently stored volume (that may dry out during extended periods of dry weather), an extended detention outlet pipe inside a debris catcher (such as a scruffy dome) and a broad crested weir spillway. The extended detention volume, permanent wet (water quality) volumes, and sediment forebay will all be sized in accordance with the Guidance set out in the HBRC SMG.

Permanent water storage volume and sediment storage can be created by excavating below existing ground level, without adding to the height of impounded water behind the embankment.

The outlet configuration modelled in HEC-HMS involves a broad crested weir description. The pond design may use a manhole rise (acting as a circular sharp crested weir) connected to an outlet pipe. These details will be confirmed during detailed design and the discharge characteristics of the proposed arrangement will need to be compared against the concept design.

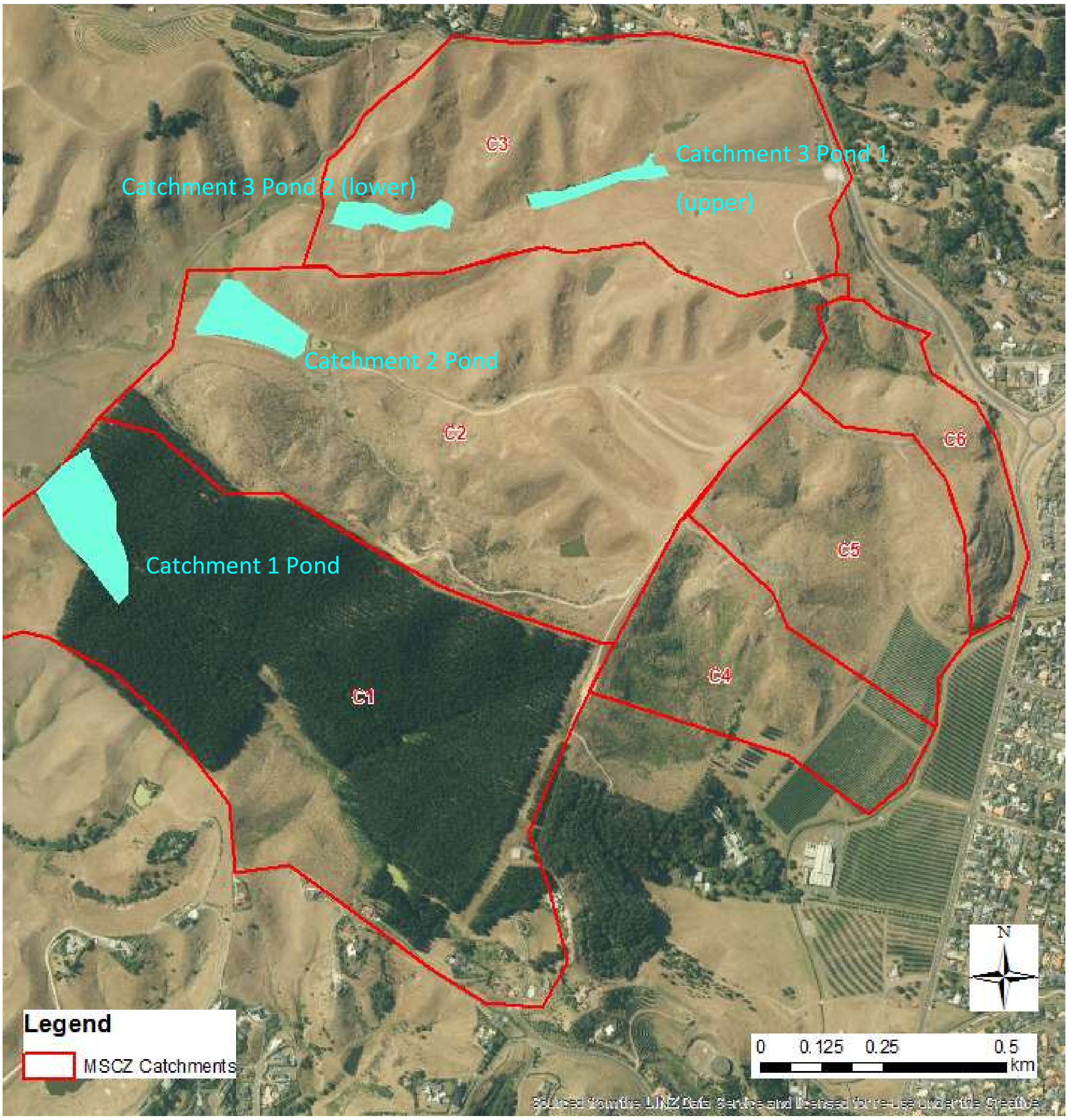

Figure 4-1: Proposed conceptual locations of stormwater management ponds in west draining sub-catchments

4.1 Water quality

Stormwater ponds provide water quality treatment through the capture of sediment, and associated contaminants. Through appropriate vegetation selection and topographic contouring it may be possible in subsequent design stages to change the stormwater management ponds into wetlands, or add wetland pond elements to them. Both wetlands and ponds promote sedimentation, however wetlands also promote biological uptake of contaminants for water quality treatment. The choice of vegetation that can withstand both long, dry periods and also relatively deep inundation depths and multiple day flood durations will require input from appropriate specialists.

Both stormwater management ponds and stormwater wetlands are consistent with the Low Impact Design guidelines in the Hawke's Bay Waterway Guidelines.

The stormwater quality approach builds on the stormwater quantity approach by utilising the ponds in the western draining catchments for quality treatment as well as quantity control. The drivers for the ponds were determined from the HBRC SMG, notably:

- Water quality control volume based on 30mm of runoff from catchment impervious surfaces.
- 50% of the water quality volume allocated to permanent pond storage.
- 1.2 times the water quality volume released as extended detention over 24 hours.
- Removal of 75% of total suspended solids

The ponds have been designed so that the extended detention volume (EDV) is released gradually over 24 hours through a small diameter orifice. Flood discharges beyond the extended detention storage volume in the ponds will be released through an overflow (typically arranged as a wider opening cut through a manhole riser and into a piped outlet through the downstream embankment). An emergency overflow should be incorporated into the outlet design to cover larger storm events and to allow for a secondary flowpath in the event of a blockage.

Table 4-1 provides a summary of the key pond requirements for water quality treatment including the diameter of the outlets and peak live storage water depth for each pond.

Table 4-1: Pond key parameters for water quality treatment

	C1 Pond	C2 Pond	C3 Pond 1	C3 Pond 2
Pond bed level (m RL)	36	36	54	43
ED Outlet Level (m RL)	36.5	36.5	54.5	43.79
ED Outlet Size (diameter)	125 mm	175 mm	175 mm	125mm
Primary Outlet Level (m RL)	36.85	37.5	55.53	45.22
Primary Outlet Size	0.65m weir	1m weir	1.2m weir	0.7m weir
Water Quality Volume (m^3)	1368	5037	4277	2203
Sediment forebay volume (m^3)	205	756	642	330
Permanent Storage (min) 50% WQV (m^3)	684	2519	2138	1102
Extended Detention Volume (m^3)	1642	6044	5132	2644
Extended Detention Volume + 50% WQV – Volume below primary outlet (m^3)	2326	8563	7271	3745

Further design consideration regarding sediment forebay design, planting and access requirements for the ponds will be considered further at the detailed design. There are no fundamental problems with any of these based on the concept proposed in this report.

Stormwater runoff from the eastward sloping catchment should be collected via a curb and channel collection. Runoff should be passed through a gross pollutant trap and coarse filtration before being discharged via a level spreader onto the proposed planting areas. The level spreader is intended to reduce the potential for erosion and increase the area of planting that the stormwater discharge is exposed to. Downstream of the level spreader, the proposed planting will continue to treat stormwater contaminants through a combination of biological processes and filtration. No further treatment is considered necessary.

Figure 4-2 provides an example schematisation of how pond outlets can be configured, and how the different components of volume make up the total pond volume.

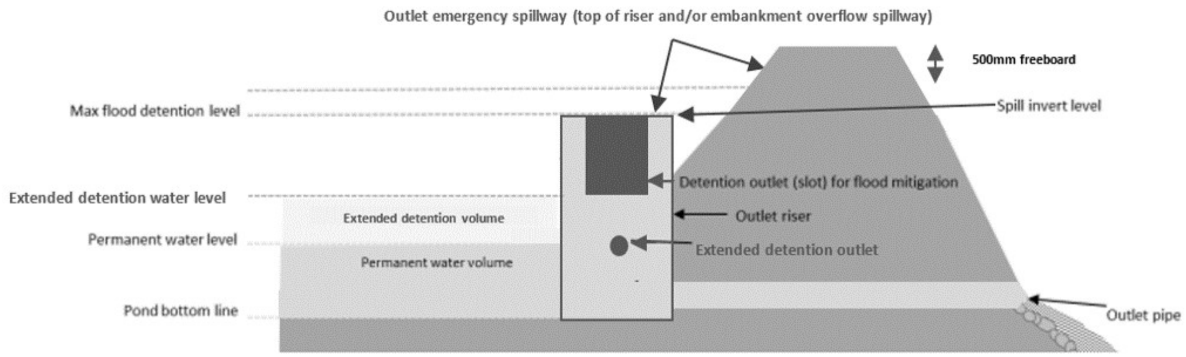

Figure 4-2: example schematisation of how pond outlets can be configured, and components of pond volume

4.2 Water quantity

The stormwater quantity controls discussed in this section relate only to the catchments draining to the west. This is because there are reductions in peak flows and runoff volume from the catchments draining to the east due to the proposed planting of these catchments.

If the amount of planting on these eastwards discharging catchments is reduced from that shown on the concept plans, then further analysis of these catchments will be required to assess the need for mitigation measures.

The performance objective of the pond storage and outlet configuration is that post-development peak discharges for storm durations of 3 hour, 6 hour, 12 hour, 24 hour and 48 hour do not exceed the peak discharge from a pre-development 48 hour duration storm event. A 100 year ARI design storm has also been considered.

The pond size and outlet configuration was determined through an iterative process to achieve the performance objectives laid out above. Table 4-2 provides a summary of the proposed outlet and pond characteristics. Each pond will have an additional emergency spillway to safely discharge water in events exceeding those it is designed for, or if the outlet becomes blocked.

Table 4-2: Proposed stormwater mitigation pond key design parameters

	C1 Pond	C2 Pond	C3 Pond 1	C3 Pond 2
Pond bed level (m RL)	36	36	54	43
50y ARI 48h level	38.59	38.8	56.3	45.86
50y ARI 48h Storage Depth (m)	2.59	2.8	2.2	2.86
50y ARI 48h Storage Area (m^2)	12,740	7,810	15,500	5,530
50y ARI 48h Storage Volume (m^3)	28,520	18,000	20,530	7,410
Primary Outlet Size	0.65m weir	1m weir	0.7m weir	1.3m weir

4.2.1 Mitigated water quantity results

Table 4-3 presents simulated peak discharges calculated using the HEC-HMS model for the post development mitigated case for the west flowing MSCZ catchments routed through the proposed stormwater management ponds.

Table 4-3: Simulated sub-catchment peak discharges for areas, C1, C2 and C3 from stormwater ponds

ARI (years)	2	10	50	100	2	10	50	100
Storm duration	**Pre-development**				**Post-development mitigated**			
	Simulated peak discharge (m^3/s)							
Area C1								
3 hour	Not simulated				0.01	0.03	0.61	1.18
6 hour	0.07	0.59	2.49	3.95	0.02	0.26	1.11	1.79
12 hour	0.16	1.07	2.97	**4.24**	0.08	0.86	1.67	2.57
24 hour	0.39	**1.37**	**3.06**	4.14	0.20	0.86	2.36	3.33
48 hour	**0.46**	1.19	2.41	3.13	**0.31**	**1.12**	**2.40**	**3.14**
Area C2								
3 hour	Not simulated				0.00	0.03	0.83	0.88
6 hour	0.07	0.60	2.53	4.01	0.01	0.04	0.83	1.56
12 hour	0.16	1.07	2.93	**4.17**	0.03	0.31	1.48	2.56
24 hour	0.39	**1.34**	**2.98**	4.02	0.08	0.59	2.29	3.30
48 hour	**0.44**	1.15	2.33	3.02	**0.15**	**0.96**	**2.16**	**2.82**
Area C3								
3 hour	Not simulated				0.03	0.03	0.05	0.17
6 hour	0.03	0.31	1.36	2.18	0.02	0.05	0.24	0.53
12 hour	0.08	0.58	1.65	**2.38**	0.04	0.08	0.46	0.88
24 hour	**0.21**	**0.76**	**1.72**	2.34	**0.05**	**0.20**	**0.85**	**1.38**
48 hour	**0.25**	0.67	1.37	1.78	**0.06**	**0.31**	**1.11**	**1.53**

The peak outflows from all stormwater ponds are less than the pre-developed scenarios for each individual catchment.

This is demonstrated in Table 4-4, which demonstrates that there is a reduction in peak discharge of between 6% and 77% for all event scenarios considered as a result of the mitigation proposed.

Appendix C presents a comparison of pre development and post development sub-catchment discharge hydrographs for the western flowing catchments for the range of storm frequency and duration scenarios modelled. The mitigated post development discharge hydrographs represent the outflow from the stormwater ponds.

The range of storm durations presented in each figure demonstrate that the critical storm duration (which produces the highest peak discharge) varies by return period, and between the pre and post development cases for each recurrence interval event.

The discharge hydrographs demonstrate that for the range of different recurrence intervals and duration events examined in the runoff assessment, the ponds are able to store runoff for the duration of a storm event and release it over a greater period, thus reducing peak discharges, despite the increase in impervious area due to the proposed development.

Table 4-4: Change in peak discharge from all catchments

Storm Dur.	ARI (years)			
	2	**10**	**50**	**100**
3 hour	**N/A**	**N/A**	**N/A**	**N/A**
6 hour	-66%	-77%	-66%	-62%
12 hour	-62%	-54%	-52%	-44%
24 hour	-66%	-52%	-29%	-24%
48 hour	-55%	-21%	-7%	-6%

Based on this it is reasonable to assume that flooding is suitably mitigated in the post development scenario, and the proposed stormwater ponds meet the required performance objectives for peak discharge.

5 Conclusions

The development proposes to increase impervious surface across the site, which if unmitigated, has the potential to increase runoff volume and peak discharge as well as decrease hydrological response times compared to the current situation. Unmitigated, this increases the potential for downstream flooding and increased erosion. Increased erosion can cause downstream sedimentation and turbidity problems in the watercourses.

The proposed development will increase impervious coverage by approximately 43 ha for land draining west to the Turirau Stream and by 3.4 ha for land draining east to the Taipo Stream. However, runoff to the east will be mitigated through landscape planting, which is expected to reduce runoff volume and peak flows.

The increase in impervious surface for land draining to the west represents approximately 2.5% of the Turirau catchment area (~1,720 ha) and 3% of the catchment upstream of a farmland area which is known to flood (~1,345 ha). Irrespective of the mitigation works at the Mission Special Character Zone site, the farmland will continue to flood to a similar extent to what has been experienced.

To be consistent with HBRC SMG requirements for areas upstream of floodplains, flood mitigation options have been considered to reduce the downstream effects and to attenuate post-development peak flows.

The concept developed to meet these requirements was to develop a series of stormwater management ponds which will capture runoff from each of the gullies, attenuate peak flows and reduce the volume of runoff at critical times, thereby delaying the hydraulic response times downstream.

Overall we conclude that with the proposed mitigation measures there will be no negative effect caused by the development to downstream areas. The concept design included in this report is likely to cause a small reduction in downstream flood levels.

The stormwater ponds have been designed with appropriate outlet configurations and storage volume to provide water quality treatment that meets the HBRC SMG.

It has been demonstrated that the proposed stormwater ponds will reduce peak discharges from the developed catchment by between 6% and 77% for all ARIs and event durations considered.

Through appropriate vegetation selection and topographic contouring it may be possible to change the stormwater management ponds into wetlands, or add wetland pond elements to them. Both wetlands and ponds promote sedimentation, however wetlands also promote biological uptake of contaminants for water quality treatment. The choice of vegetation which can withstand both long, dry periods and also relatively deep inundation depths and multiple day flood durations will require advice from an appropriate expert.

During the detailed design stages of this project, there may be opportunities to refine and optimise the stormwater design, however based on the assessment and recommendations from this report, Marist Holdings (Greenmeadows) Ltd should be confident that the proposed development can be carried out in a manner that does not cause negative downstream effects from flooding and does not create adverse water quality effects.

6 References

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7 Applicability

This report has been prepared for the exclusive use of our client Marist Holdings (Greenmeadows) Limited, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

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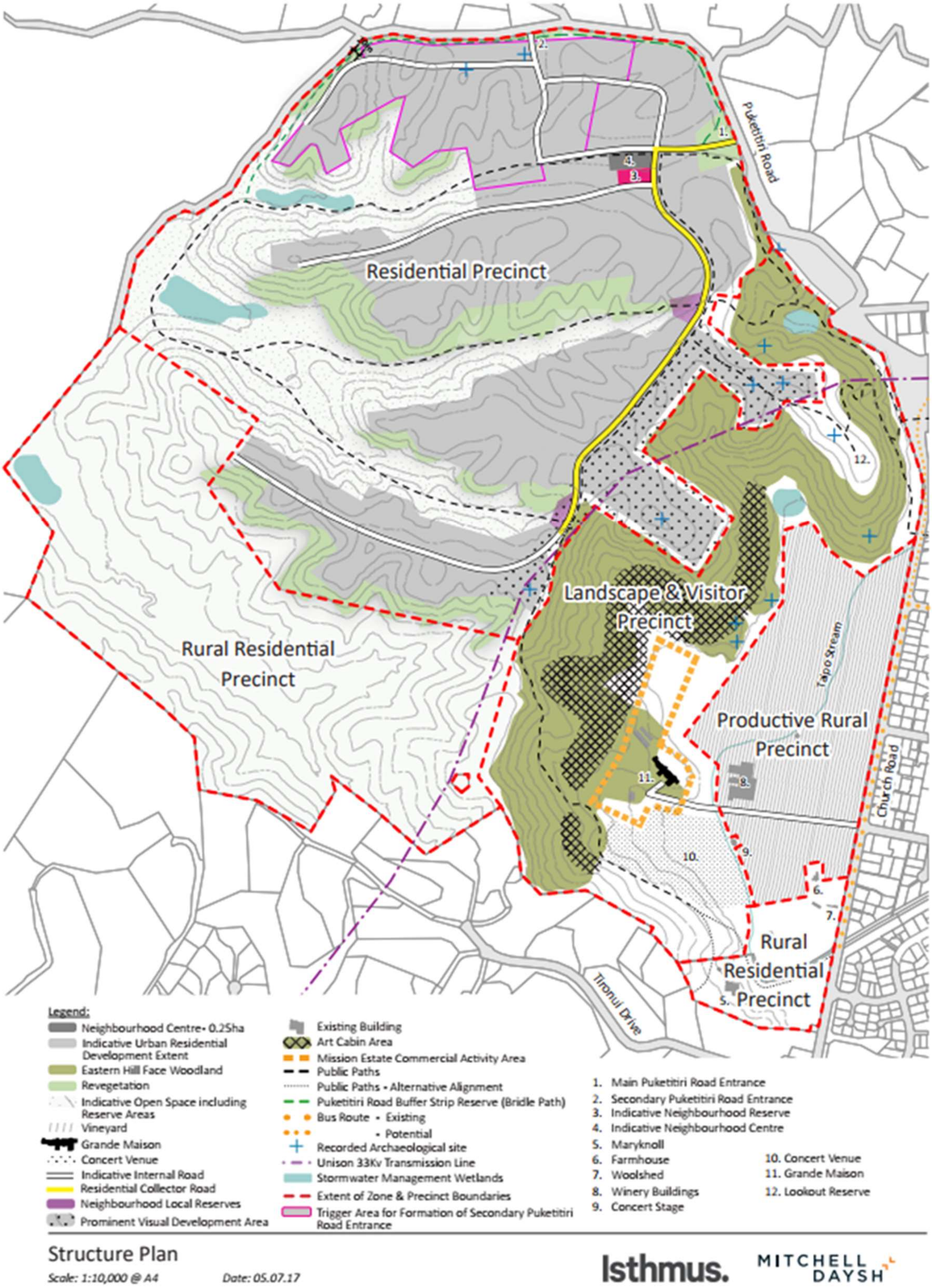
Appendix A: Structure Plan Vegetation East Hill Face Woodland



Appendix B: Rainfall Hyetographs

This appendix presents rainfall hyetographs used in the runoff model to generate the runoff hydrographs. The rainfall hyetographs were generated using HEC HMS's built-in frequency storm function, with the inputs adjusted to provide peak intensity between 3 & 4 times the average intensity. Hyetographs are provided in hourly aggregation. HEC HMS outputs the results in 1 minute durations. Hyetographs are presented here for the range of duration storms modelled, with the hyetographs grouped into recurrence intervals for each figure.

The Hyetographs show shorter storm durations have higher intensity rainfall compared to longer duration events for the same recurrence interval.

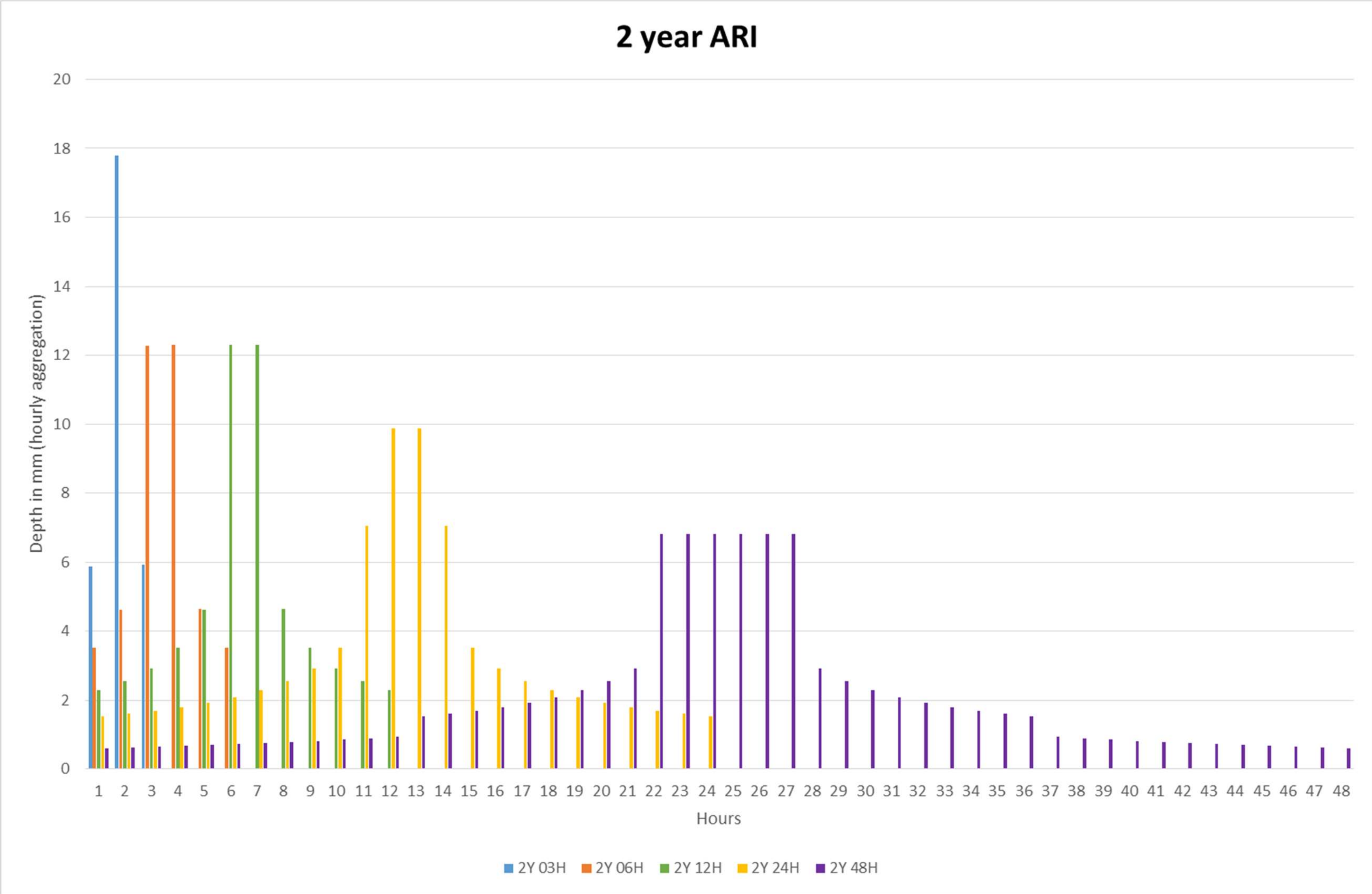


Figure B-1: 2 year ARI design rainfall hyetographs with hourly rainfall depth aggregation for a range of storm durations

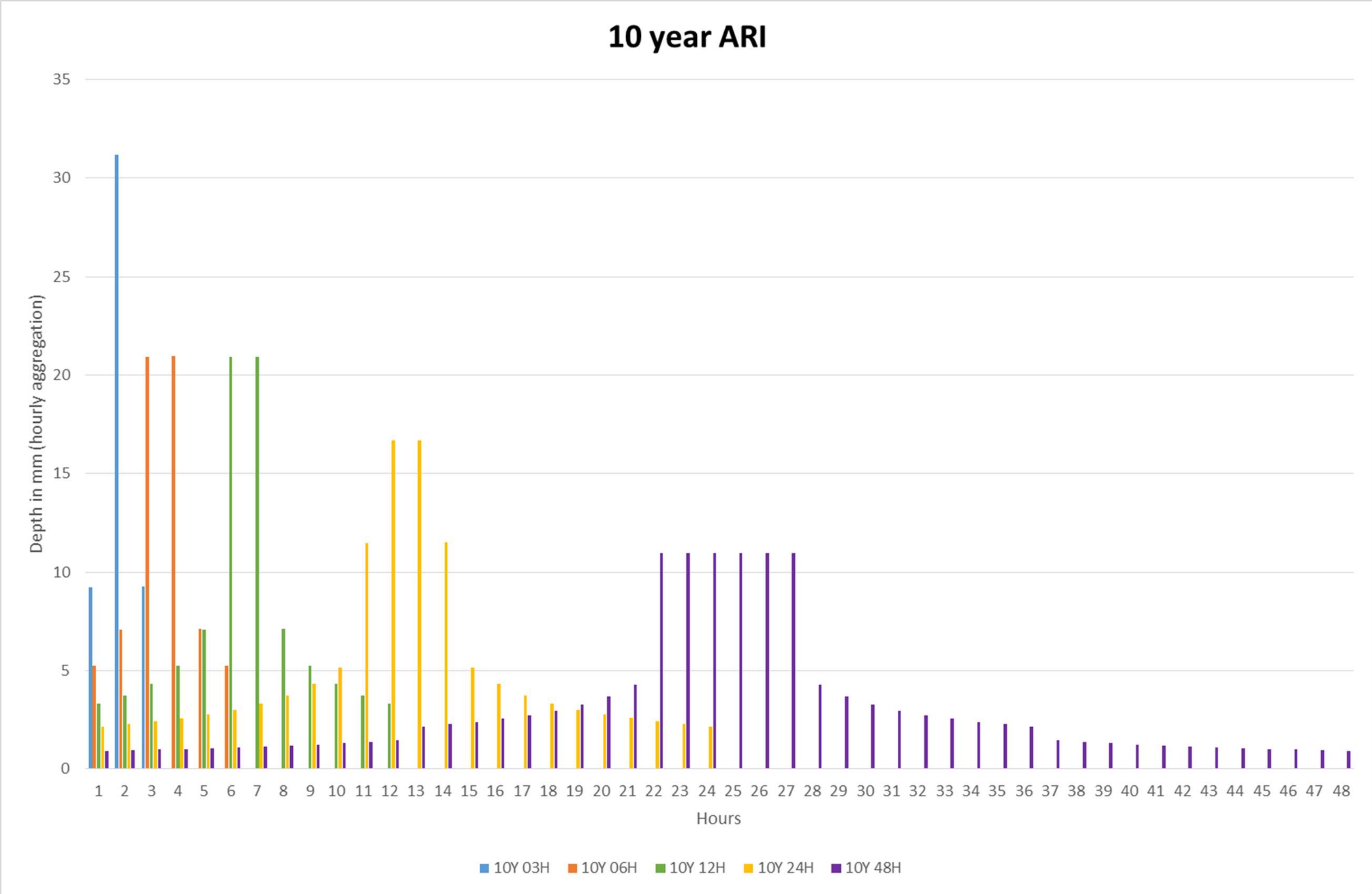


Figure B-2: 10 year ARI design rainfall hyetographs with hourly rainfall depth aggregation for a range of storm durations

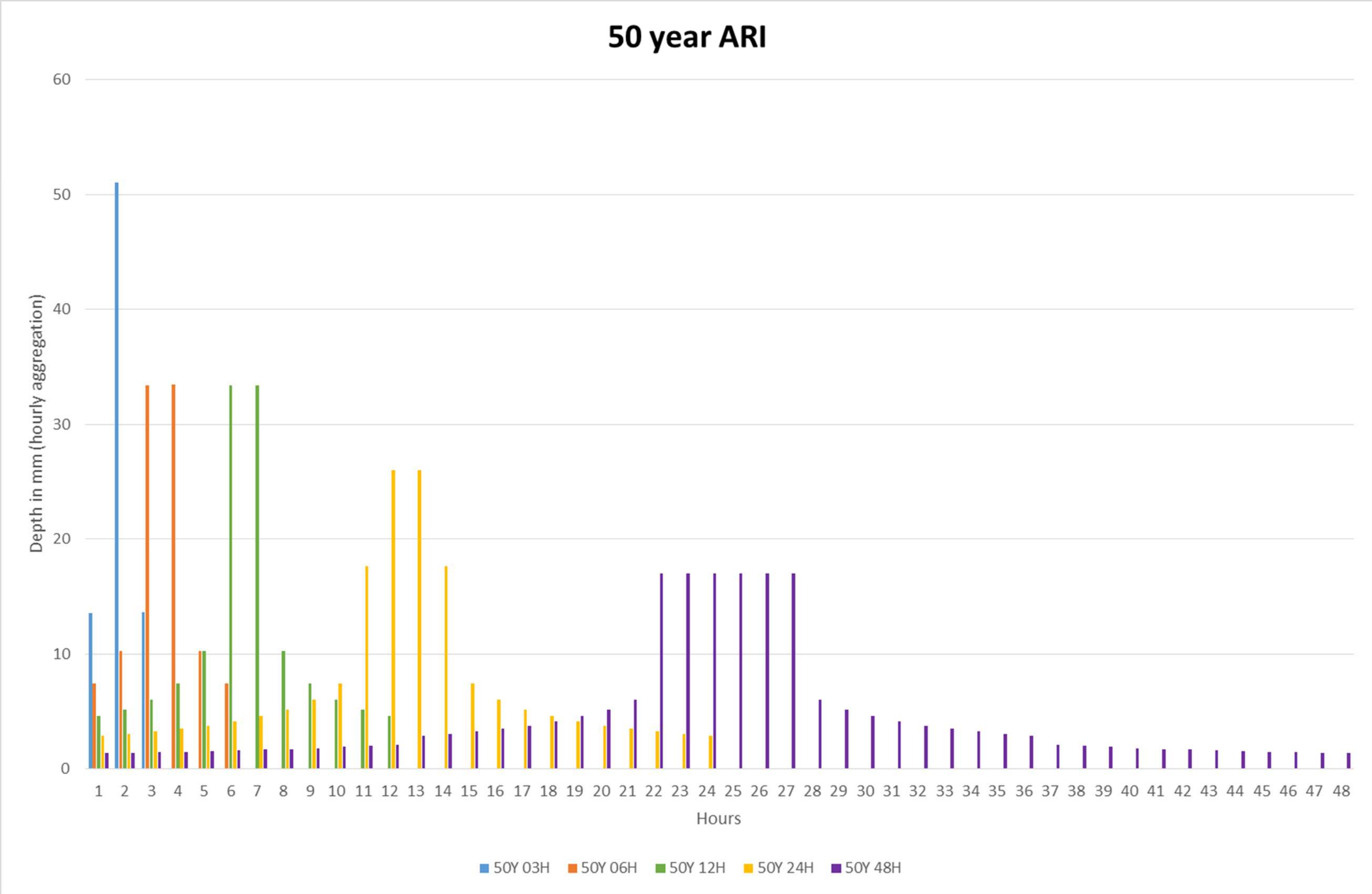


Figure B-3: 50 year ARI design rainfall hyetographs with hourly rainfall depth aggregation for a range of storm durations

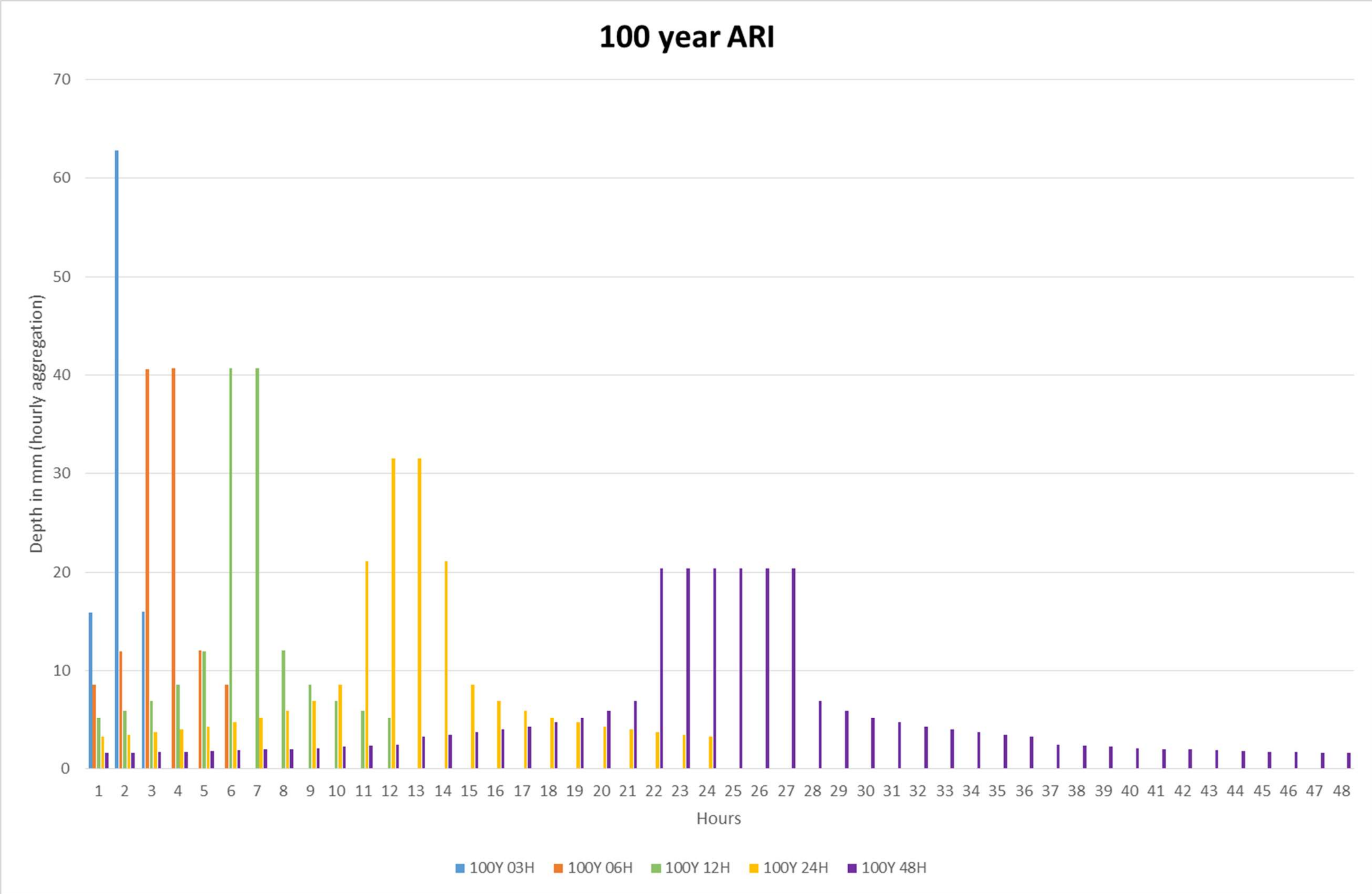


Figure B-4: 100 year ARI design rainfall hyetographs with hourly rainfall depth aggregation for a range of storm durations

Appendix C: Western flowing MSCZ catchment discharge hydrographs for pre and post development scenarios

Outflow hydrographs for the 2, 10, 50 and 100 year ARI events are provided for the sub-catchment areas C1, C2, and C3 as described in Figure 1-3.

Outflow hydrographs are grouped into figures by sub-catchment (C1, C2 or C3) and recurrence interval, and each show a range of storm durations. The pre development outflows (**shown in solid lines in the plots**) are the outflows into the areas where ponds are proposed to be located, and the post development mitigated outflows are the outflows out of the stormwater ponds (**shown as dashed lines in the plots**).

The range of storm durations presented in each figure demonstrate that the critical storm duration – that which produces the largest peak discharge varies for return period, and between the pre and post development cases for each recurrence interval event. This is reflective of the runoff model's representation of rainfall losses.

The hydrographs demonstrate that the ponds are able to reduce peak outflows from the sub-catchment areas in all of the cases presented here to less than the pre-development discharges.

The total volume of runoff produced is stored in the ponds and released over a longer duration which is how the ponds enable reduction in peak discharge in the post development mitigated case, despite the increase in impervious area due to the development.

Sub-catchment Area ‘C1’ discharge hydrographs

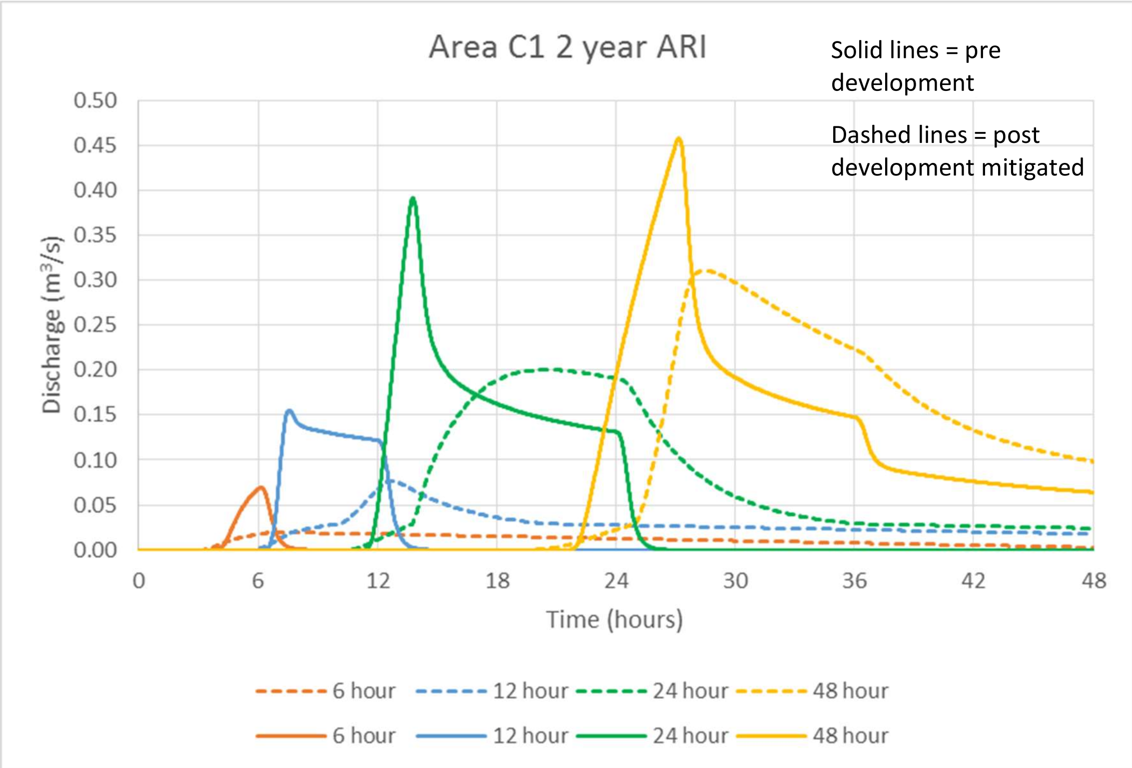


Figure C-1: 2 year ARI runoff from sub-catchment area C1 for a range of storm durations

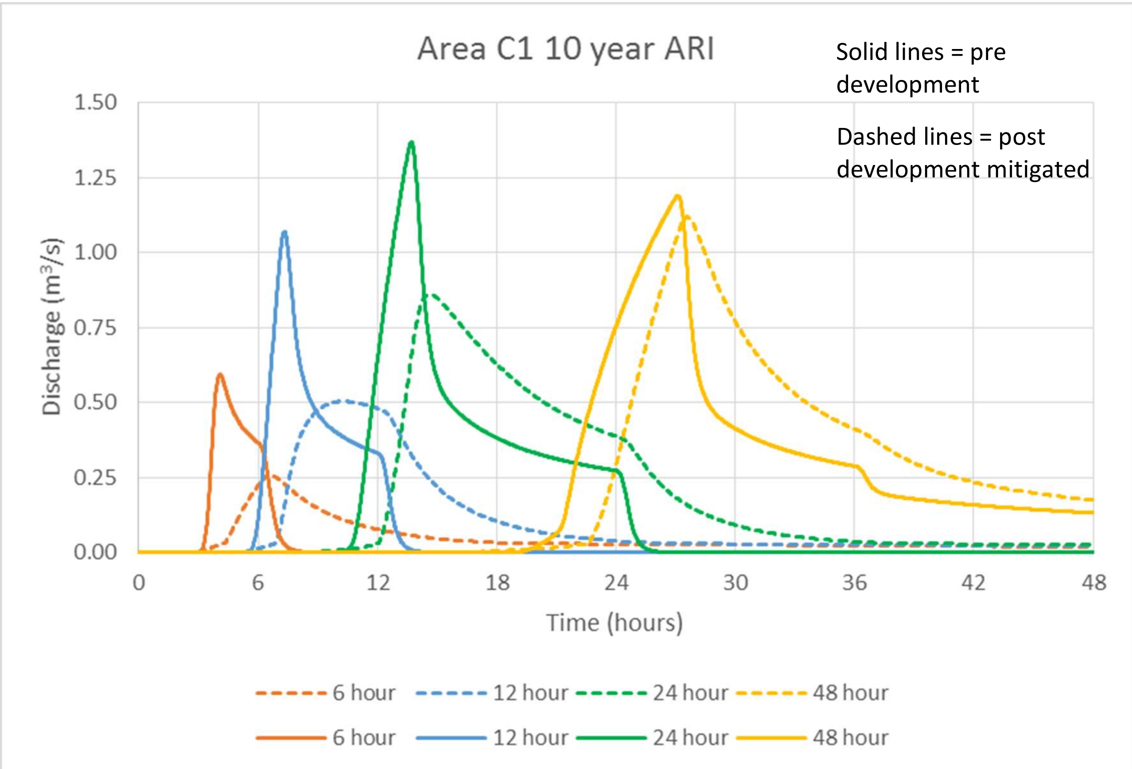


Figure C-2: 10 year ARI runoff from sub-catchment area C1 for a range of storm durations

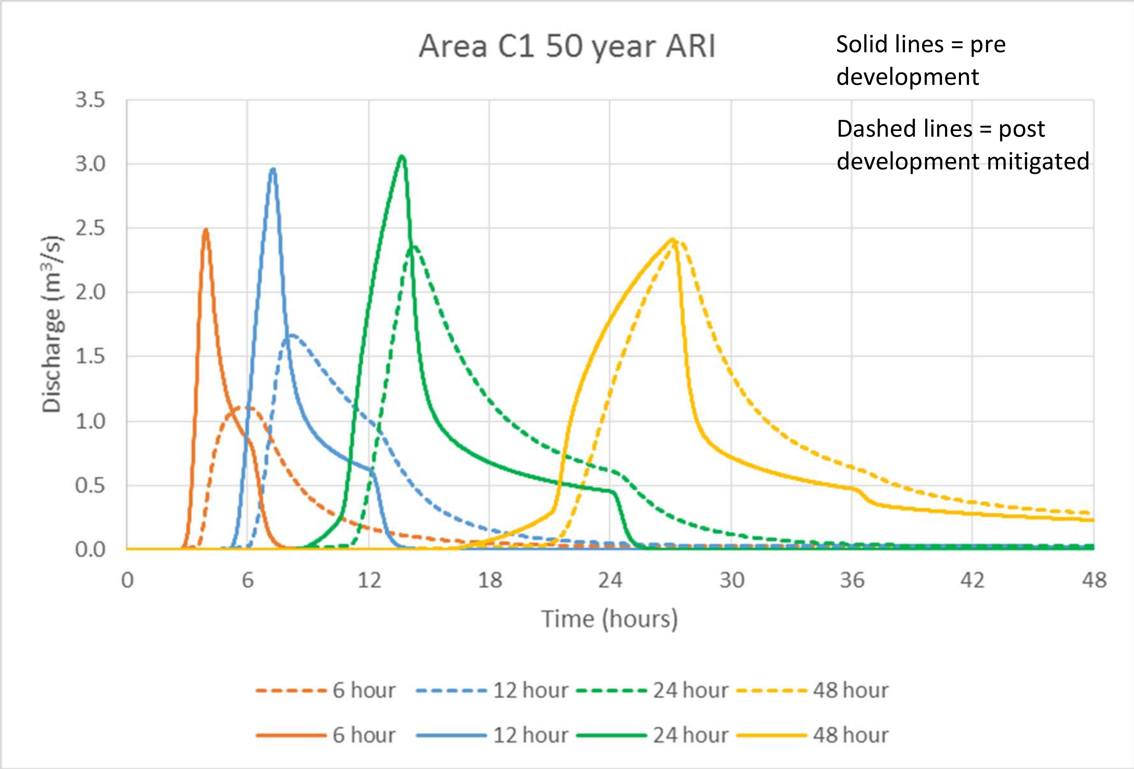


Figure C-3: 50 year ARI runoff from sub-catchment area C1 for a range of storm durations

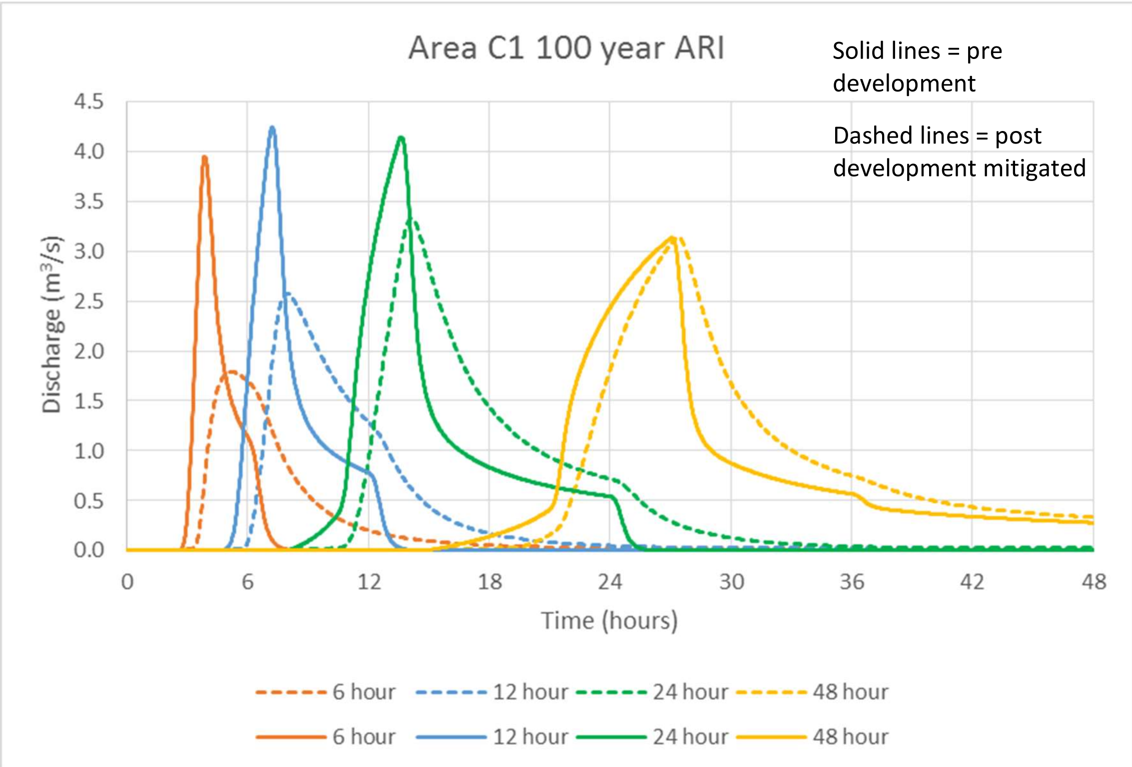


Figure C-4: 100 year ARI runoff from sub-catchment area C1 for a range of storm durations

Sub-catchment Area ‘C2’ discharge hydrographs

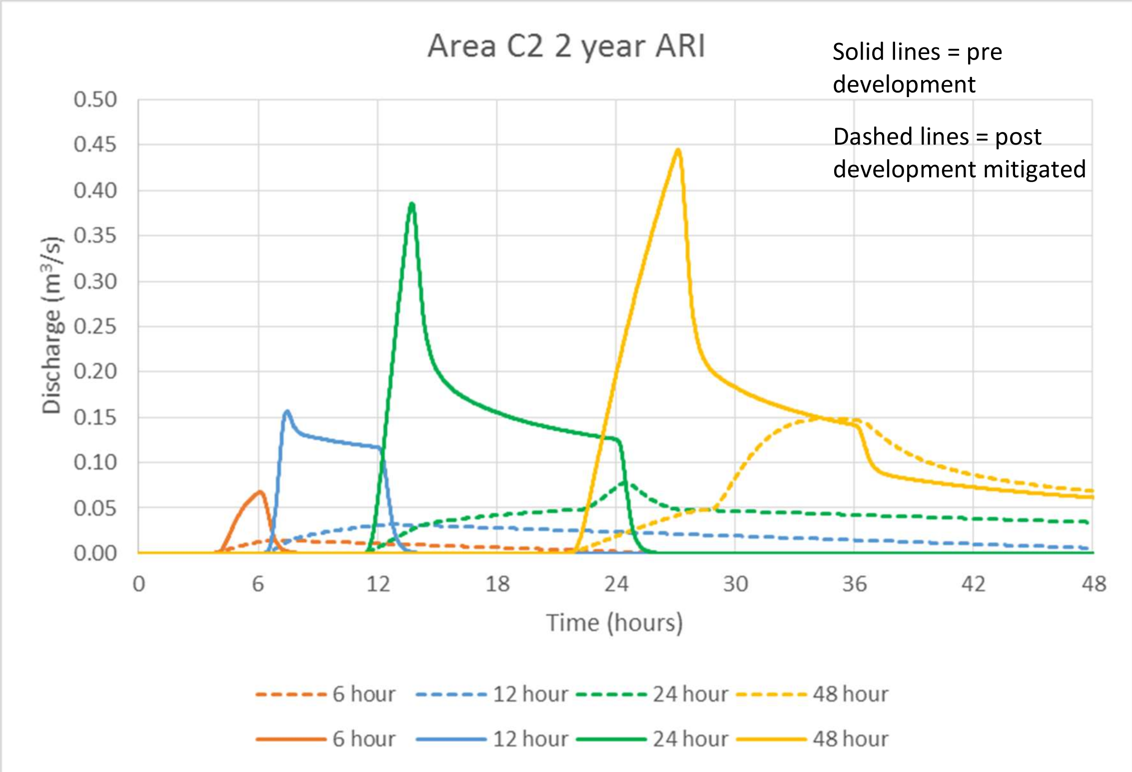


Figure C-5: 2 year ARI runoff from sub-catchment area C2 for a range of storm durations

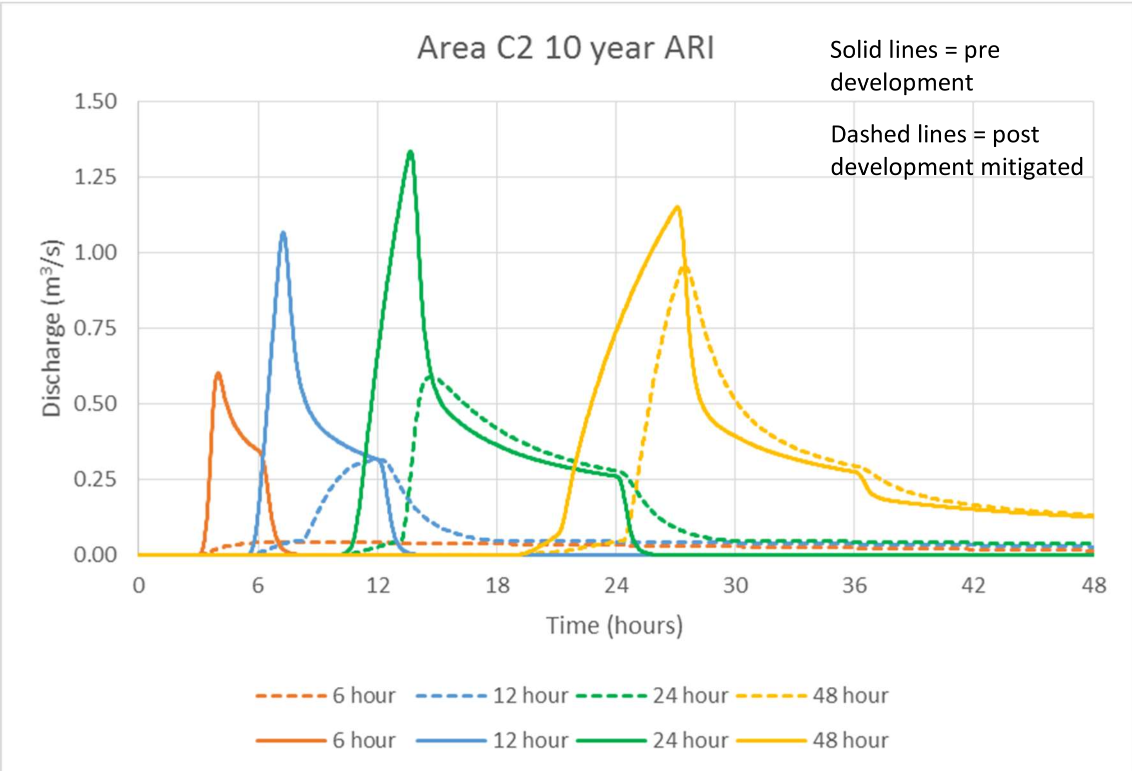


Figure C-6: 10 year ARI runoff from sub-catchment area C2 for a range of storm durations

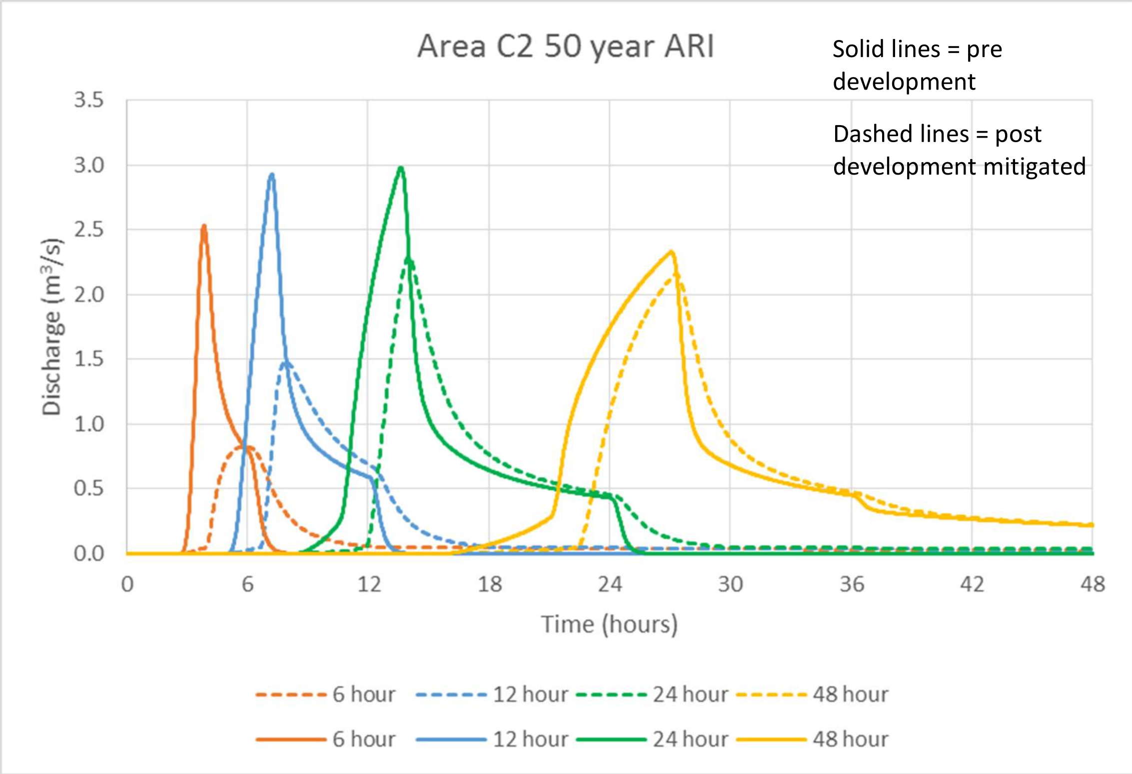


Figure C-7: 50 year ARI runoff from sub-catchment area C2 for a range of storm durations

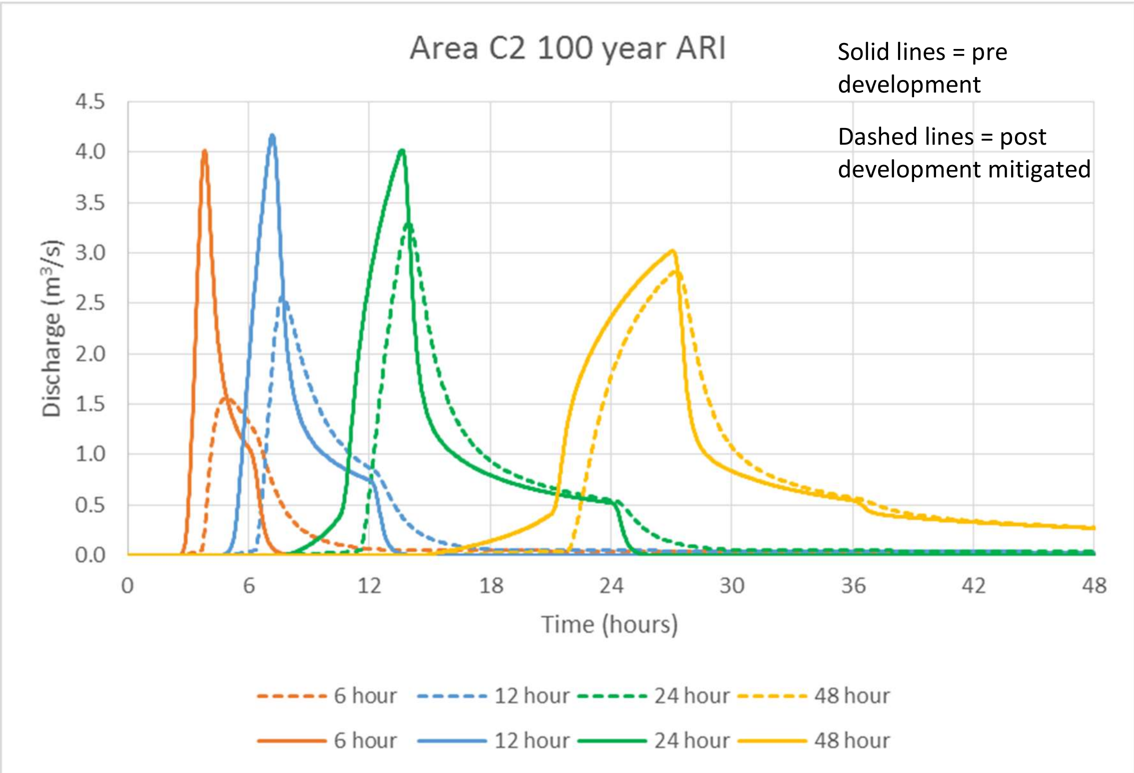


Figure C-8: 100 year ARI runoff from sub-catchment area C2 for a range of storm durations

Sub-catchment Area 'C3' discharge hydrographs

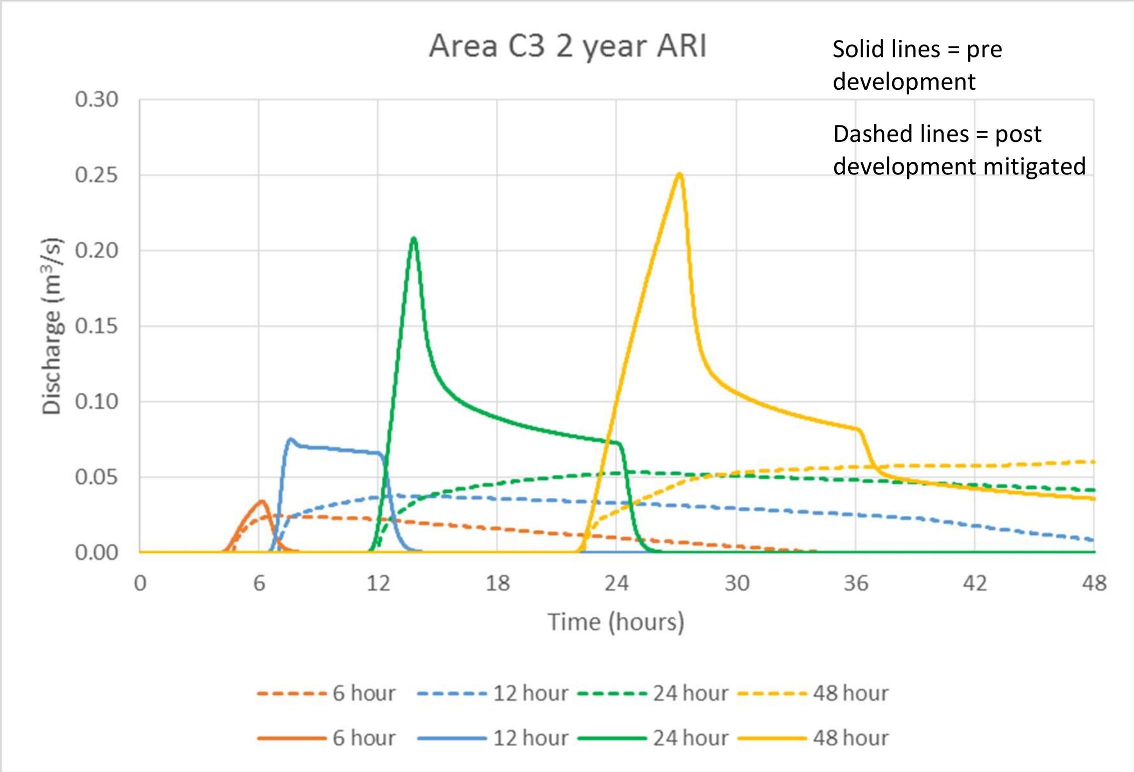


Figure C-9: 2 year ARI runoff from sub-catchment area C3 for a range of storm durations

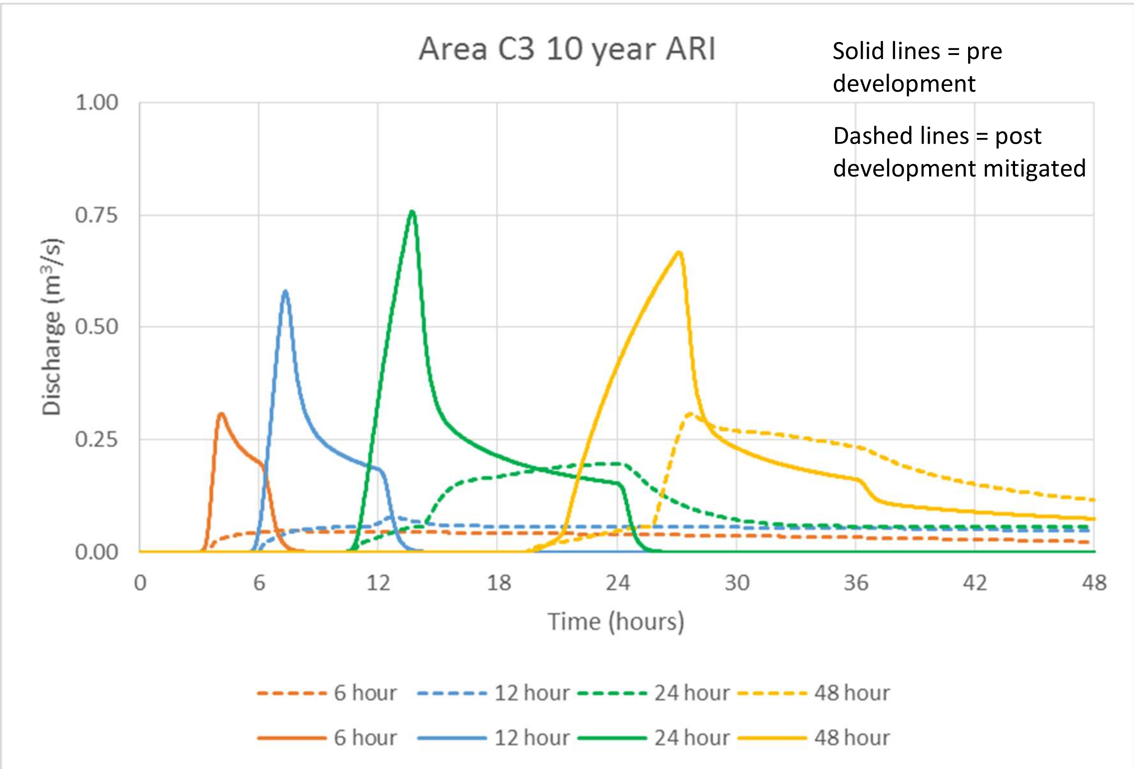


Figure C-10: 10 year ARI runoff from sub-catchment area C3 for a range of storm durations

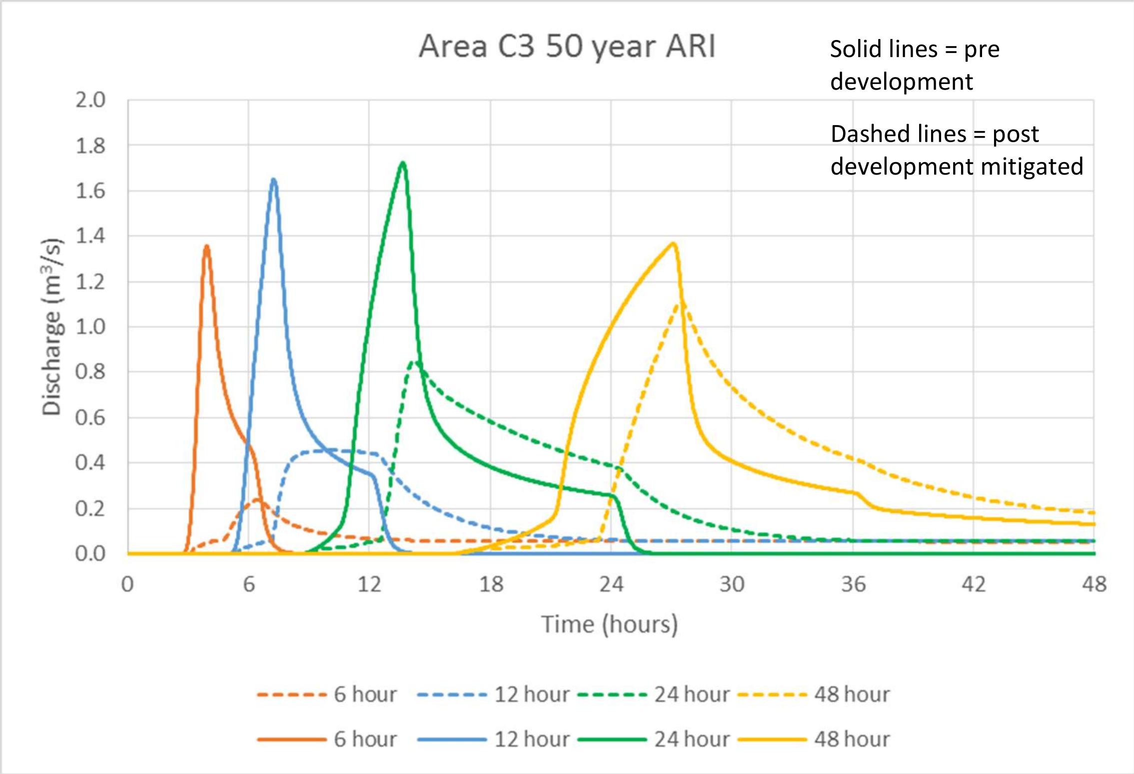


Figure C-11: 50 year ARI runoff from sub-catchment area C3 for a range of storm durations

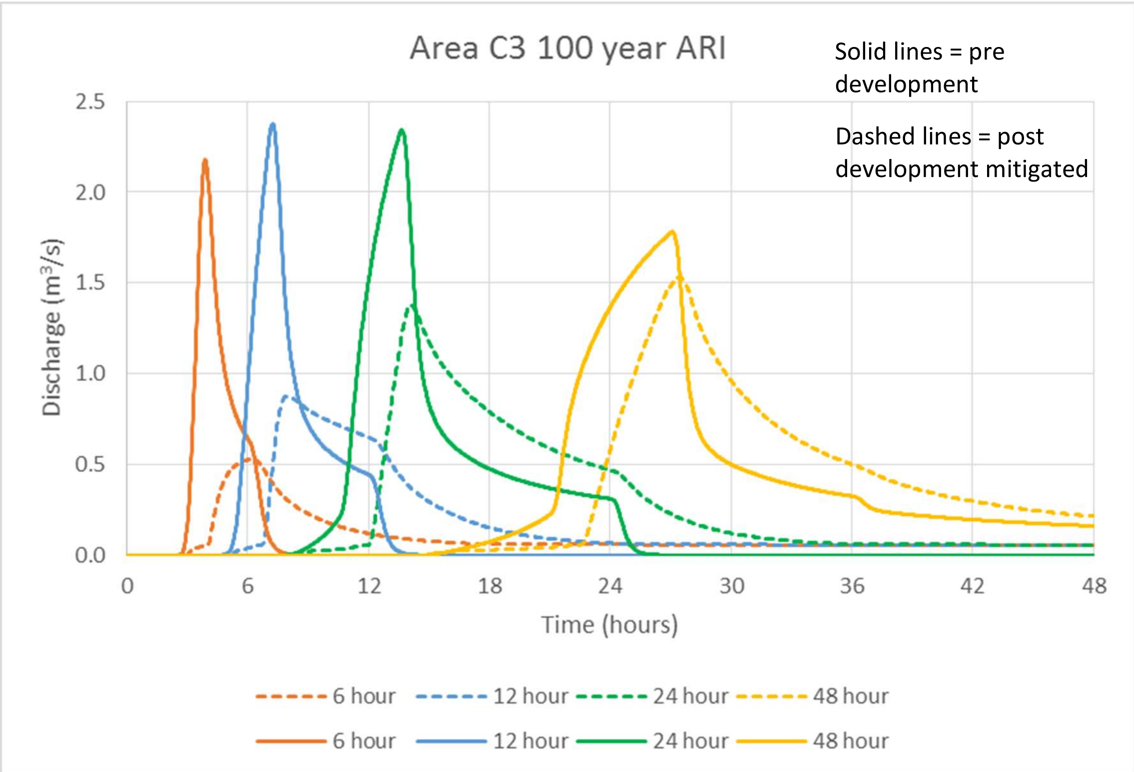


Figure C-12: 100 year ARI runoff from sub-catchment area C3 for a range of storm durations

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