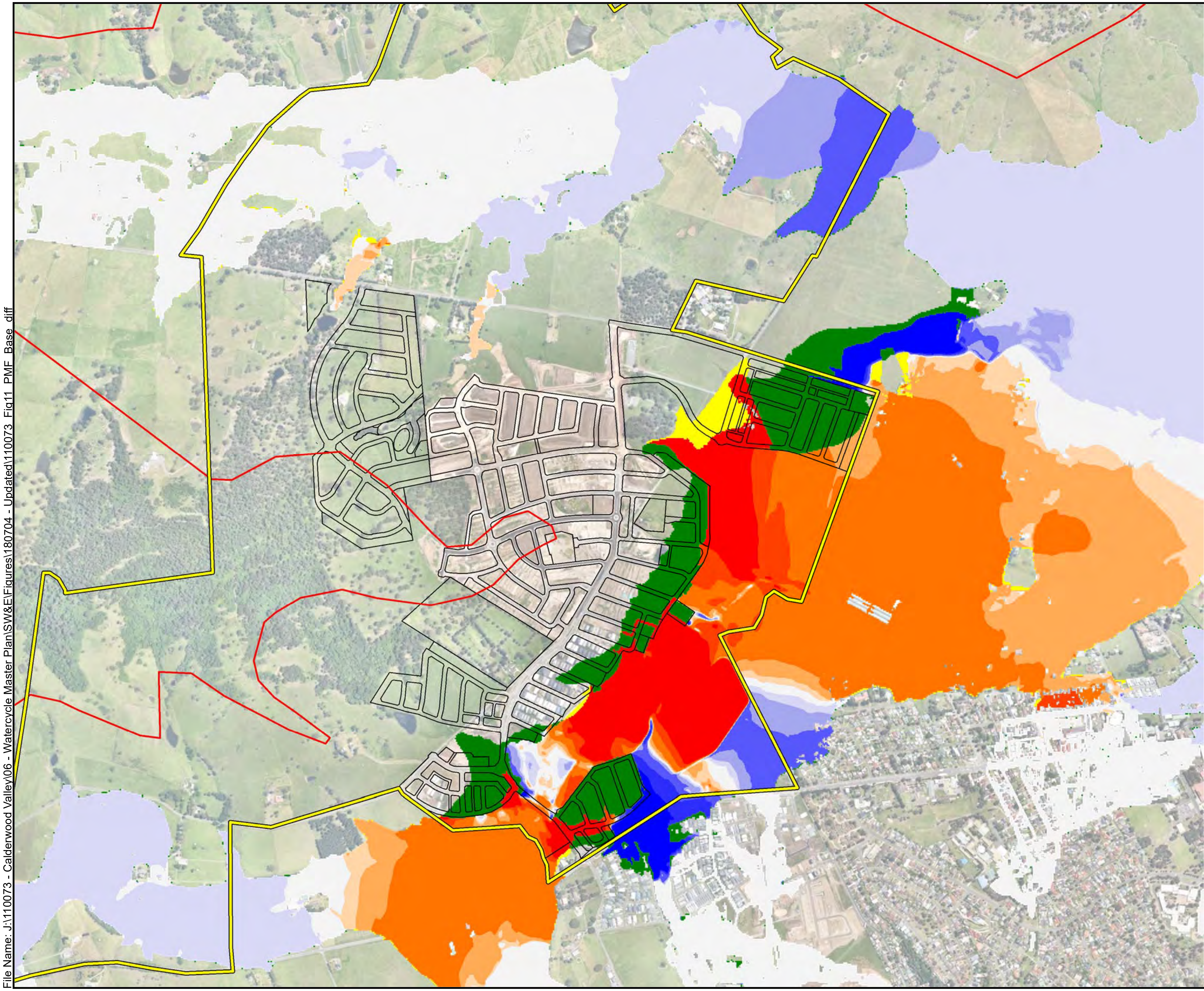


J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
P 02 4720 3300 www.jwprince.com.au

LEGEND

- Site Boundary
- TUFLOW Boundary
- Site Layout

Increase in Flood Levels (m)

-0.40+	0.02
-0.25	0.05
-0.10	0.10
-0.05	0.25
-0.02	0.40+
-0.02 to 0.02	

- Area Now Flood Free in Modelled Event
- Area Now Flood Affected in Modelled Event

N

0 500 meters

Scale 1:12,500 @ A3

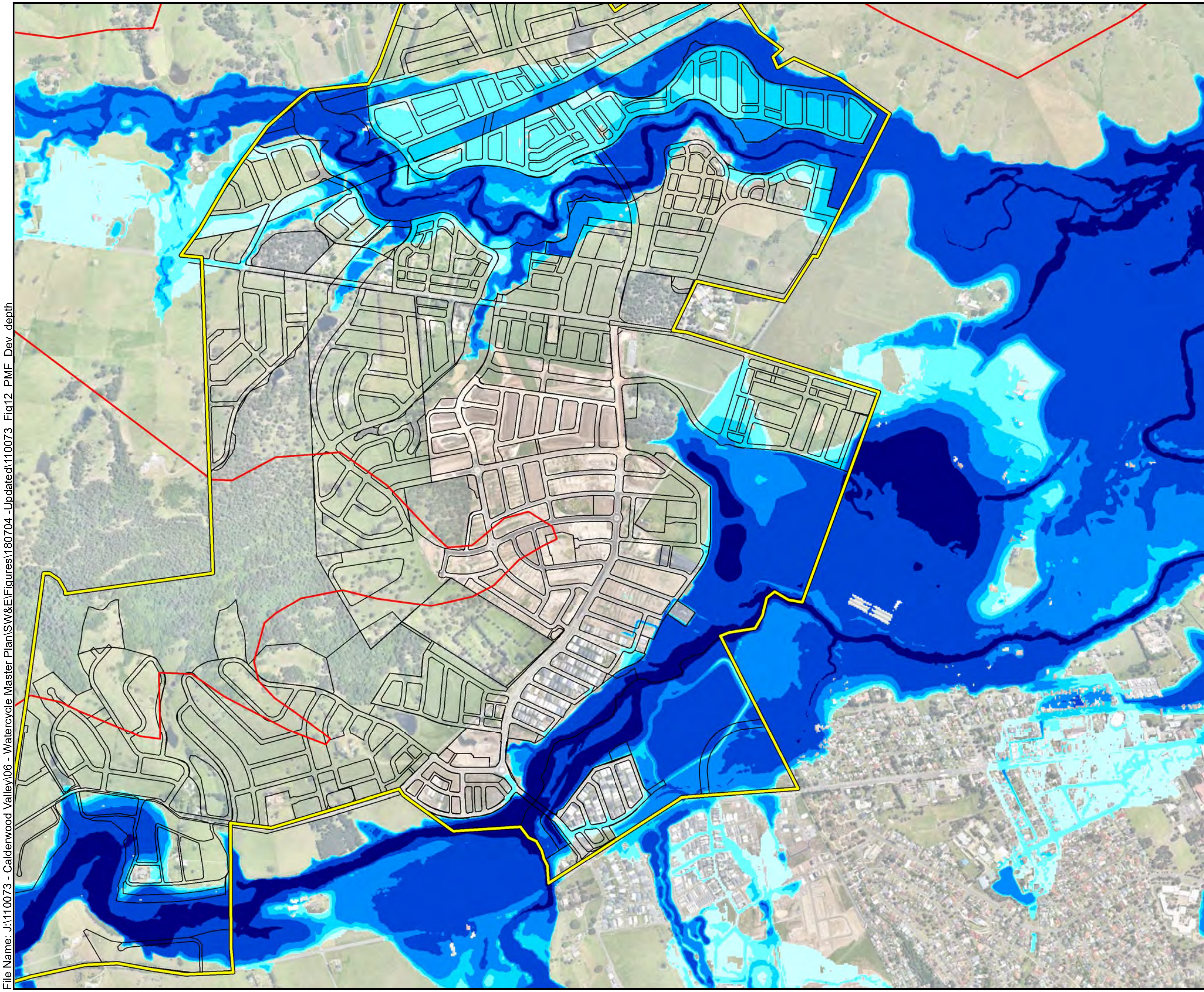
Projection: GDA 1994 MGA Zone 56

Figure 11

Calderwood Urban Development Project

PMF Event
Flood Difference
Approved Development - Existing

Date: 4/07/2018 Issue: A



J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
P 02 4720 3300 www.jwprince.com.au

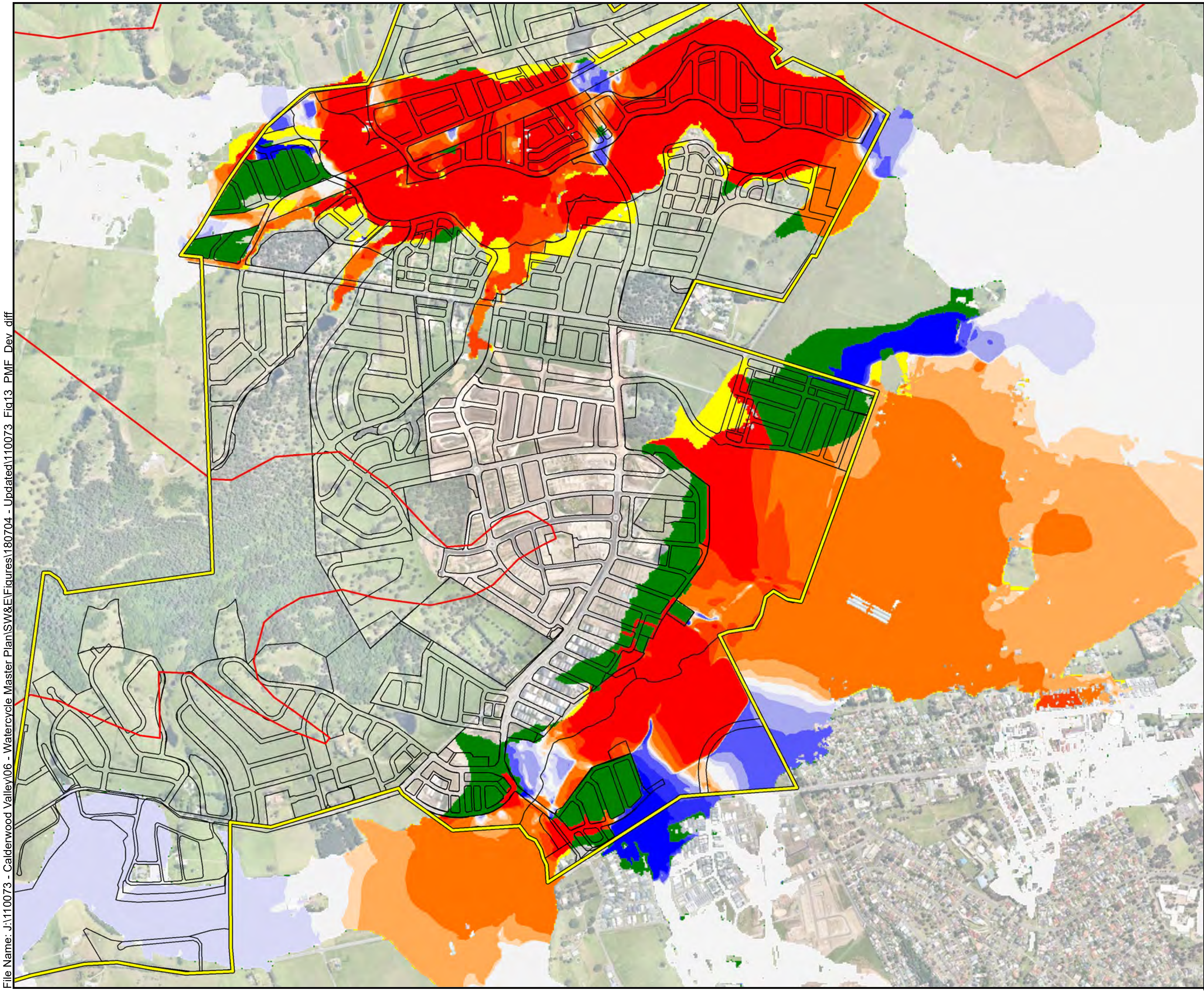
Figure 12

Calderwood Urban Development Project

PMF Event
Flood Depth
Proposed Development

Date: 4/07/2018 Issue: A

File Name: J:\110073 - Calderwood Valley\06 - Watercycle Master Plan\SW&E\Figures\180704 -Updated\110073_Fig12_PMF_Dev_depth



J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
P 02 4720 3300 www.jwprince.com.au

LEGEND

- Site Boundary
- TUFLOW Boundary
- Site Layout

Increase in Flood Levels (m)

-0.40+	0.02
-0.25	0.05
-0.10	0.10
-0.05	0.25
-0.02	0.40+
-0.02 to 0.02	

- Area Now Flood Free in Modelled Event
- Area Now Flood Affected in Modelled Event

N
0 500
meters
Scale 1:12,500 @ A3

Projection: GDA 1994 MGA Zone 56

Figure 13

Calderwood Urban Development Project

PMF Event
Flood Difference
Proposed Development - Existing

Date: 4/07/2018 Issue: A

File Name: J:\110073 - Calderwood Valley\06 - Watercycle Master Plan\SW&E\Figures\180704 - Updated\110073_Fig13_PMF_Dev_diff

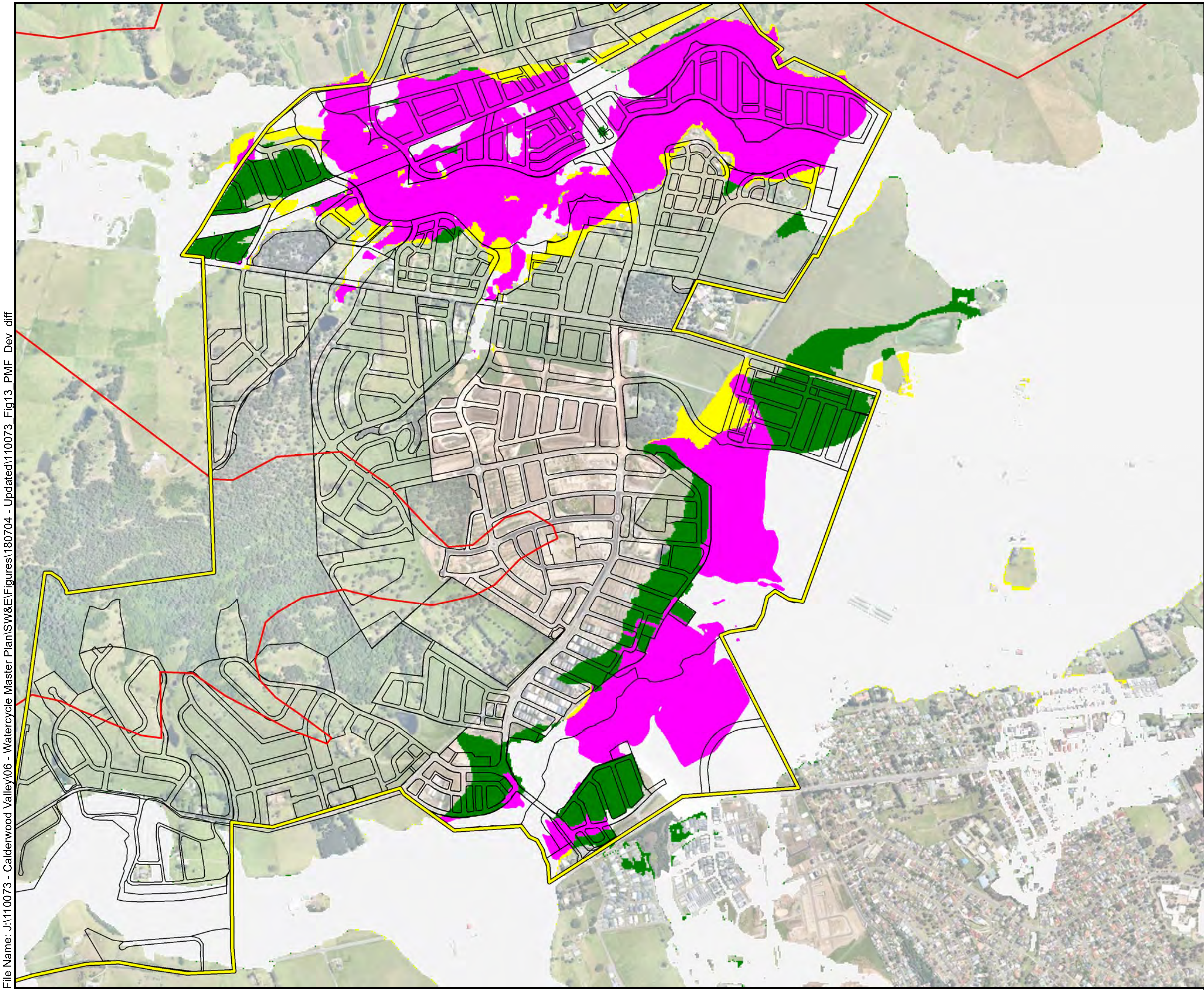


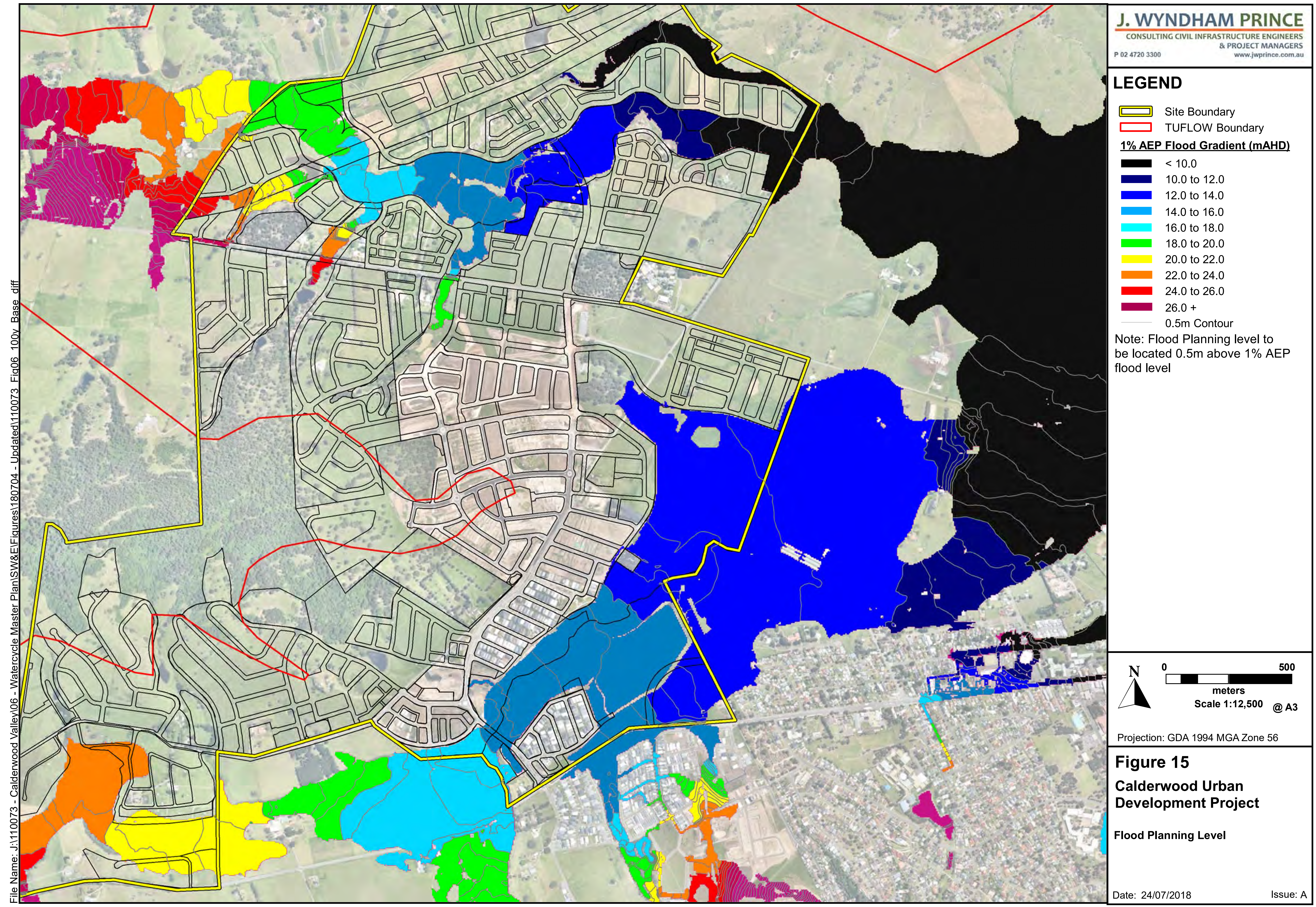
Figure 14

Calderwood Urban Development Project

PMF Event
Flood Difference
Proposed Development - Existing

Date: 5/07/2018

Issue: A


J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS
P 02 4720 3300
www.jwprince.com.au
LEGEND
Site Boundary
TUFLOW Boundary
1% AEP Flood Gradient (mAHD)
< 10.0
10.0 to 12.0
12.0 to 14.0
14.0 to 16.0
16.0 to 18.0
18.0 to 20.0
20.0 to 22.0
22.0 to 24.0
24.0 to 26.0
26.0 +
0.5m Contour
Note: Flood Planning level to be located 0.5m above 1% AEP flood level
N
0
500
meters
Scale 1:12,500
@ A3
Projection: GDA 1994 MGA Zone 56
Figure 15
Calderwood Urban Development Project
Flood Planning Level
Date: 24/07/2018
Issue: A
File Name: J:\110073 - Calderwood Valley\06 - Watercycle Master Plan\SW&E\Figures\180704 - Updated\110073_Fig06_100y_Base_diff

APPENDIX B – MUSIC MODELLING

MUSIC MODELLING WORKSHEET

Calderwood

Treatment Device		Catchment		Total Catchment Area (ha)	Not required to be treated-Farmland	Not required to be treated-ESL	R1 Lot Area (ha) 60%	R1 No. Lots	Avg Lot Size (m²)	R2 Lot Area (ha) 75%	R2 No. Lots	Avg Lot Size (m²)	non core/ Heritage 60%	R3 Lot Area (Retirement) (ha) 90%	R3 No. Lots	Avg Lot Size (m²)	Commercial	Substation	Road Reserve Area (ha)	School	Active Open Space	Passive Open Space/RG		Road and driveways (ha)	Roof	Roof Bypass	Comm. Roof Bypass (ha)	Other Impervious (ha)	Pervious Areas (ha)
				Catchment Division																				Catchment Split Road/Roof/Impervious/Pervious					
	MMC	3A1	8.343	8.359						5.503									2.840					3.106	1.376	1.376		0.825	1.660
	MR	A	0	25.467																									
	MR	B	0	40.094																									
	MR	C	0	34.231																									
12.775	MMC	D1	34.116	34.275		21.500				7.558	170	445							3.750	1.308			12.616	4.131	1.889	1.889		1.788	2.918
20.920	MMC	D2	24.3784	24.520	4.933	3.600				8.461	190	445							5.695	1.689				5.972	2.115	2.115		2.114	3.529
	MR	F	0.2249	25.043															0.225					0.202					0.022
4.952	MMC	G1	4.923	4.952						2.770	92	301							2.153					2.215	0.693	0.693		0.416	0.908
0.260	MMC	G2	1.369	1.380		1.120													0.249					0.224					0.025
6.452	MMC	H1	6.4526	6.452										3.776	130	290			2.353		0.324			2.495	1.133	1.133		0.917	0.775
3.104	MMC	H2	3.1	3.104										2.194	98	224			0.906					1.035	0.658	0.658		0.439	0.310
	MR	H3	6.4792	6.479										4.373	136	322			1.684		0.422			1.953	1.312	1.312		1.086	0.817
23.224	MMC	H4	27.293	27.400		4.176				4.510	137	329		2.710	97	279	4.825		7.698		3.374			8.133	1.941	1.941	3.860	3.147	4.097
17.389	MMC	I	17.3907	17.389						1.363	32	426	1.004	9.876				0.499	3.482		0.503	0.664		4.358	3.504	3.504		3.097	2.927
16.700	MMC	J	15.5447	16.700						8.496	236	360							5.764		1.285			6.037	2.124	2.124		1.917	3.343
10.020	MMC	J1	9.9781	10.020						4.608	125	369	1.025						4.096		0.249			4.250	1.357	1.357		0.918	2.096
16.640	MMC	K	16.637	16.640	3.556		2.143	21	1020	4.431	88	504	2.426						3.856		0.225			4.263	2.022	2.022		1.020	2.576
35.630	MMC	L	35.578	35.630	8.995		13.070	36	3631	5.901	139	425	0.833						6.779					7.428	4.256	4.256		0.968	2.486
23.391	MMC	M	23.3914	23.391									23.391												4.678	4.678		2.339	9.357
18.359	MMC	N	18.3586	18.359									18.359												3.672	3.672		1.836	7.343
8.016	MMC	O	8.903	8.016						4.294	149	288	1.059						3.550					3.730	1.285	1.285		0.750	1.852
	MR	P	0	11.067																									

APPENDIX C – WATER TREATMENT DEVICES

WETLAND

Wetlands are shallow water body systems, densely vegetated with emergent aquatic macrophytes. Wetlands are effective in trapping suspended solids, as well as chemical and biological uptake of pollutants. Constructed wetlands can take the form of either a surface or sub surface system.

- **Surface** – Conventional wetlands
- **Sub Surface** – Gravel filled shallow wetland.

Biological Floating Wetlands are a proprietary option which can either be implemented within a proposed body of water or retrofitted to existing ponds. The suspended media is self-cleaning, which makes it sustainable, with significant savings on cost of life. It uses biological elements, as opposed to chemicals that negatively impact the environment, and has consistently achieved all the necessary bacteria counts and oxygen levels in independent scientific trials and over numerous installation sites.

Floating wetlands have a very low capital investment compared to traditional systems with no operation energy costs and low maintenance costs. Other benefits also include improvement to water quality, self-cleaning, and an increased abundance of wildlife. A typical floating wetland arrangement is shown on Plate C-1.

Plate C-1 – Typical Floating Wetland Arrangement

Comment: Wetlands are effective in removing sediment and nutrient loads typically generated from urban development. Wetlands do require a reasonable amount of maintenance, however can be managed to minimise potential algal blooms via recirculation systems.

Floating Wetlands are proposed within the overall Water Cycle Management Strategy for the CUDP. Where the is appropriate land take available, they are the preferred option to provide "end of line" treatment prior to discharge to Marshall Mount Creek and Macquarie Rivulet. They will enhance the natural elements of the site and provide an attractive solution.

BIO-RETENTION RAINGARDEN SYSTEMS

Bio-retention raingarden systems consist of a filtration bed with either gravel or sandy loam media and an extended detention zone typically from 100-300 mm deep designed to detain and treat first flush flows from the upstream catchment. They typically take the form of an irregular bed (raingarden) or a linear swale (bio-swale) and are located within the verge area of a road reserve or extend within the bushland corridors or other open space areas. The surface of the bio-retention system can be grassed or mass planted with water tolerant species. Filtration beds of bio-retention systems are typically 0.4 to 0.6 metres deep. For an example of an established bio-retention raingarden, refer to Plate C-2.

Plate C-2 – Typical Bioretention Raingarden

Comment: Bio-retention systems are an effective and efficient means of treating pollutants from urban development when part of an overall treatment train. Bio-retention systems do however require a reasonable amount of maintenance during the vegetation establishment phase. Within the CUDP, there are opportunities for many of these raingarden devices to be located, which minimises landtake and provides easy access for maintenance (i.e. if located adjacent to a perimeter road or footpaths).

Bio-retention "raingardens" are proposed as a viable alternative to Wetlands within the overall Water Cycle Management Strategy for the CUDP where they will provide "end of line" treatment prior to discharge to the Macquarie Rivulet or Marshall Mount Creek and minimise land take.

VEGETATED SWALES AND BUFFERS

Swales are formed, vegetated depressions that are used for the conveyance of stormwater runoff from impervious areas. They provide a number of functions including:

- Removing sediments by filtration through the vegetated surface.
- Reducing runoff volumes (by promoting some infiltration to the sub-soils).
- Delaying runoff peaks by reducing flow velocities.

Swales are typically linear, shallow, wide, vegetation lined channels. They are often used as an alternative to kerb and gutter along roadways but can also be used to convey stormwater flows in recreation areas and car parks. A typical vegetated swale arrangement is shown on Plate C-3.

Plate C-3 – Typical Vegetated Swale Arrangement

Comment: The grade of the land within certain portions of Calderwood Valley is suitable for swales and buffers (< 3%). However, changes proposed to the land surrounding the edges of the development will be changed in order to improve flood conveyancing. Swales and buffers within urban residential streets are not recommended due to the large number of culvert crossings required for driveways, safety concerns, increased number of GPT's required and significant maintenance requirements.

However, in the right location, away from residential streets, swales are suitable as a supplement for other devices, as they provide an effective means of removing pollutants, particularly Total Suspended Solids (TSS) while minimising land take. They are therefore suggested as a secondary treatment mechanism within the CUDP.

SAND FILTERS

Sand filters typically include a bed of filter media through which stormwater is passed prior to discharging to the downstream stormwater system. The filter media is usually sand, but can also contain gravel and peat/organic mixtures. Sand filters provide several functions including:

- Removing fine to coarse sediments and attached pollutants by infiltration through a sand media layer.
- Delaying runoff peaks by providing retention capacity and reducing flow velocities.

Sand filters can be constructed as either small or large scale devices. Small scale units are usually located in below ground concrete pits (at residential/lot level) comprising of a preliminary sediment trap chamber with a secondary filtration chamber. Larger scale units may comprise of a preliminary sedimentation basin with a downstream sand filter basin-type arrangement. For an example of a typical sand filter, refer to **Plate C-4**.

Plate C-4 – Typical Sand Filter Arrangement

Comment: Sand filters are suited to confined spaces and where vegetation cannot be sustained (such as underground) and are particularly useful in heavily built-up areas. They are inefficient when compared to bio-retention systems and require frequent maintenance. Sand filters are therefore not included as part of the Watercycle Management Strategy for the CUDP.

PERMEABLE PAVEMENT

Permeable pavements, which are an alternative to typical impermeable pavements, allow runoff to percolate through hard surfaces to an underlying granular sub-base reservoir for temporary storage until the water either infiltrates into the ground or discharges to a stormwater outlet. They provide several functions including:

- Removing some sediments and attached pollutants by infiltration through an underlying sand/gravel media layer.
- Reducing runoff volumes (by infiltration to the sub-soils).
- Delaying runoff peaks by providing retention/detention storage capacity and reducing flow velocities.

Commercially available permeable pavements include pervious/open-graded asphalt, no fines concrete, modular concrete blocks and modular flexible block pavements.

There are two (2) main functional types of permeable pavements:

- Infiltration (or retention) systems – temporarily holding surface water for a sufficient period to allow percolation into the underlying soils.
- Detention systems – temporarily holding surface water for short periods to reduce peak flows and later releasing into the stormwater system.

For an example of a permeable pavement, refer to **Plate C-5**.

Plate C-5 – Typical Permeable Pavement Arrangement

Comment: Permeable pavements are generally a more 'at source' solution and best suited as an 'on lot' approach or for small roadway catchments. Permeable pavers may possibly be considered at the development application stage for on lot treatment or for areas draining small catchment areas with low sediment loads and low vehicle weights. These systems are also prone to clogging and are not suitable in saline soils similar to those located close to the precinct and therefore not recommended for the CUDP.

INFILTRATION TRENCHES

Infiltration trenches temporarily hold stormwater runoff in a sub-surface trench prior to infiltrating into the surrounding soils. Infiltration trenches provide the following main functions:

- Removing sediments and attached pollutants by infiltration through the sub-soils.
- Reducing runoff volumes (by infiltration to the sub-soils).
- Delaying runoff peaks by providing detention storage capacity and reducing flow velocities.

Infiltration trenches typically comprise of a shallow, excavated trench filled with reservoir storage aggregate. The aggregate is typically gravel or cobbles but can also comprise modular plastic cells (similar to a milk crate). Runoff entering the system is stored in the void space of the aggregate material or modular cells prior to percolating into the surrounding soils. Overflow from the trench is usually to downstream drainage system. Infiltration trenches are similar in concept to infiltration basins; however, trenches store runoff water below ground in a pit and tank system, whereas basins utilise above ground storage. For an example of an infiltration trench, refer to **Plate C-6**

Plate C-6 – Typical Infiltration Trench Arrangement

Comment: Infiltration trenches and basins are not appropriate for clay soils or where there is potential for salinity issues. They are inefficient when compared to swales and require frequent maintenance. Infiltration Trenches are not recommended as a proposed solution for the CUDP.

PONDS

Ponds are usually deep (>1.5 m) artificial bodies of open water. Many ponds have a small range of water level fluctuation because they are formed by a simple dam wall with a weir outlet structure. Newer systems may have riser-style outlets allowing for extended detention and temporary storage of inflows. Emergent aquatic macrophytes are normally restricted to the pond surrounds because of water depth, although submerged plants may occur in the open water zone.

Water quality improvement in ponds are promoted by a complex array of physical, chemical and biological actions. Whilst not as effective in the removal of pollutants as wetlands, they do still provide benefit an effective means of intercepting pollutants from stored sediments. For an example of a pond arrangement, refer to **Plate C-7**

Plate C-7 – Typical Pond Arrangement

Comment: Ponds and Wetlands are effective in removing sediment and nutrient loads typically generated from urban development. However, ponds generally require large landtake to ensure the pollutant treatment capacity of the pond achieves the requires water quality objectives. Where there is sufficient land take available, ponds are proposed to house the floating wetlands to provide additional pollutant removal as well as to provide an attractive focal design point for the development.

CARTRIDGE FILTER SYSTEMS

Cartridge filtration systems are underground pollution control devices that treat first flush flows. The unit consists of a vault containing a number of cartridges each loaded with media that targets specific pollutants. Each cartridge has a maximum treatable flowrate of approximately 1 - 1.5 litres per second. For an example of a typical cartridge filter system arrangement, refer to **Plate C-8**

Plate C-8 – Typical Cartridge Filter System (During Construction)

Comment: Cartridge filtration systems are an efficient means of treating pollutants from urban development, as they are typically located underground and therefore do not require additional land take. As cartridge systems have a low treatable flow rate, additional 'buffer' storage is usually provided to keep the capital costs down. Cartridge filtration systems also need to be supplemented with additional treatment devices to achieve pollutant reduction targets. There is a need to provide significant height differences between the inlet to the filtration system and the discharge point from the supplementary system. It also generally results in expensive capital and ongoing maintenance costs.

Cartridge Filter systems are not typically suited for large scale developments. However, given the town centre envisaged for the CUDP, cartridge filters are considered as a possible solution for highly dense land uses.

INLET PIT FILTER INSERTS AND GROSS POLLUTANT TRAPS (GPTS)

GPT devices are typically provided at the outlet of stormwater drainage lines. These systems operate as a primary treatment to remove litter, vegetative matter, free oils and grease and coarse sediments prior to discharge to downstream (Secondary and Tertiary) treatment devices. They can take the form of trash screens or litter control pits, pit filter inserts and wet sump gross pollutant traps.

In theory, inlet pit filter inserts have several advantages over end of pipe GPT's, such as providing a dry, at source collection of litter, vegetative matter and sediment as well as allowing for staged construction works without having to provide additional / temporary GPT units. Pit filter inserts will provide an at source mechanism for treatment of gross pollutants as development proceeds throughout the site. However, GPTs provide a lower maintenance burden than inlet pit filter inserts, as the location for maintenance is generally in one (1) location within the catchment, rather than at every pit. For an example of a Vortex Style GPT unit, refer to **Plate C-9**

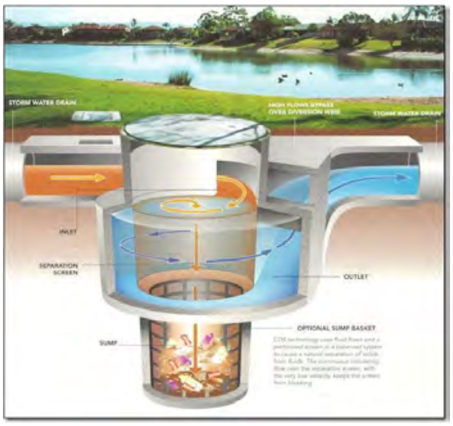


Plate C-9 – Vortex Style GPT Unit

Comment: Gross Pollutant Traps are effective in removing gross pollutants from stormwater runoff generated from large urbanised catchments. They provide a single point of maintenance, which is beneficial to the long-term viability and cost effectiveness of the water quality treatment system. Therefore, Gross Pollutant Traps are included within the proposed Water Cycle Management Strategy for the CUDP.

RAINWATER TANKS

Rainwater tanks are sealed tanks designed to contain rainwater collected from roofs.

Rainwater tanks provide the following main functions:

- Allow the reuse of collected rainwater as a substitute for mains water supply, for use for toilet flushing, laundry, or garden watering.
- When designed with additional storage capacity above the overflow, provide some on-site detention, thus reducing peak flows and reducing downstream velocities.

The water collected can be reused as a substitute for mains water supply either indoors (toilet flushing) or outdoors (garden watering). Rainwater tanks can be either above ground or underground. Above ground tanks can be placed on stands to prevent the need of installing a pump to distribute the water. Such systems are referred to as gravity systems. Pressure systems require a pump and can be either above or below ground tanks.

Tanks can be constructed of various materials such as Colorbond™, galvanised iron, polymer or concrete.

Plate C-10 – Rainwater Tank

Comment: Rainwater tanks are effective in removing suspended solids and a small amount of nutrient pollutants. They are also effective in reducing overall runoff volumes. The effectiveness of rainwater tanks is also increased when plumbed in for internal use.

Rainwater tanks are recommended within the CUDP for all low-medium development areas. For the purposes of modelling, rainwater tanks are conservatively excluded from medium density residential and commercial.