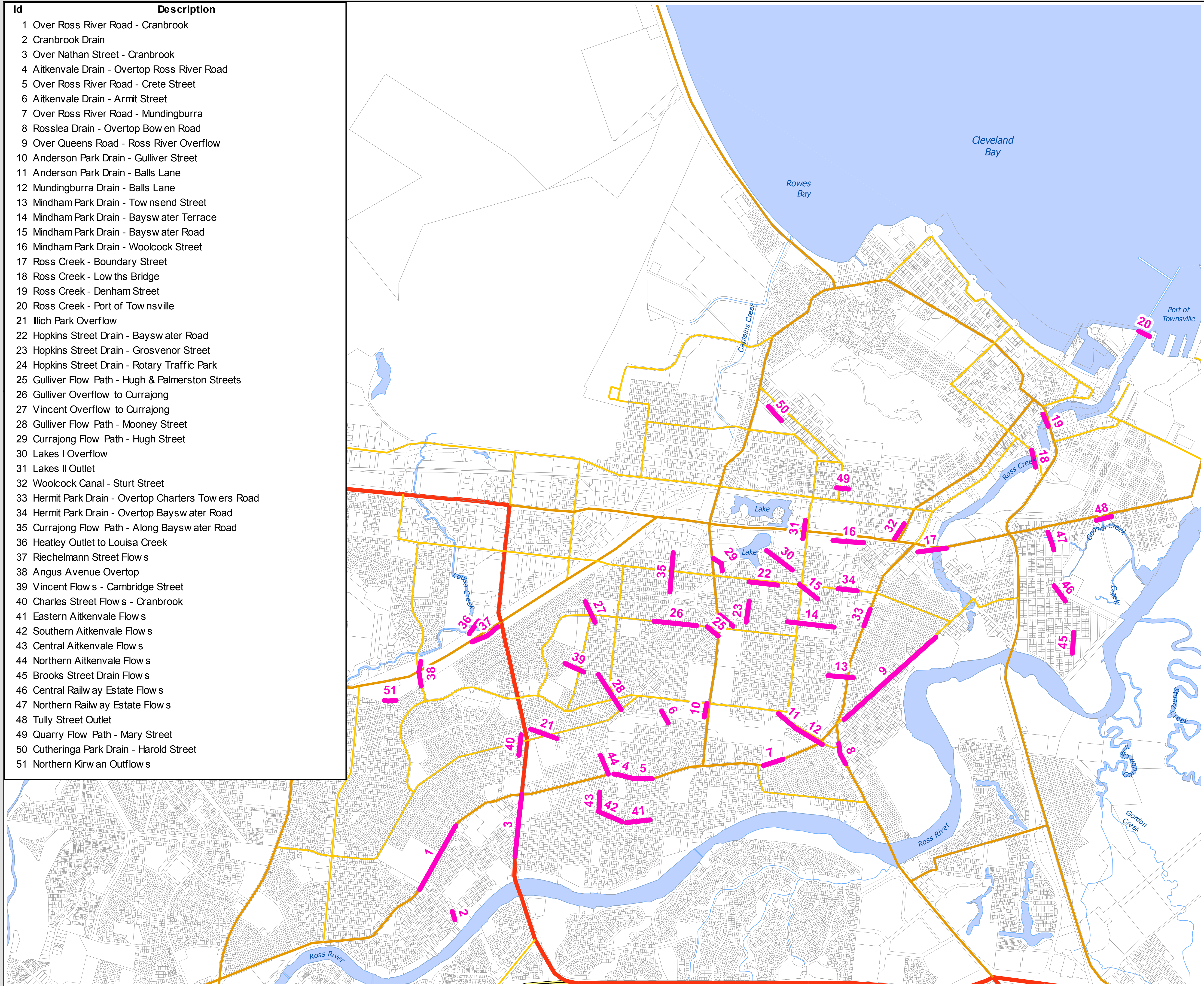
Id	Description
1	Over Ross River Road - Cranbrook
2	Cranbrook Drain
3	Over Nathan Street - Cranbrook
4	Aitkenvale Drain - Overtop Ross River Road
5	Over Ross River Road - Crete Street
6	Aitkenvale Drain - Armit Street
7	Over Ross River Road - Mundingburra
8	Rosslea Drain - Overtop Bow en Road
9	Over Queens Road - Ross River Overflow
10	Anderson Park Drain - Gulliver Street
11	Anderson Park Drain - Balls Lane
12	Mundingburra Drain - Balls Lane
13	Mindham Park Drain - Tow nsend Street
14	Mindham Park Drain - Baysw ater Terrace
15	Mindham Park Drain - Baysw ater Road
16	Mindham Park Drain - Woolcock Street
17	Ross Creek - Boundary Street
18	Ross Creek - Low ths Bridge
19	Ross Creek - Denham Street
20	Ross Creek - Port of Tow nsville
21	Illich Park Overflow
22	Hopkins Street Drain - Baysw ater Road
23	Hopkins Street Drain - Grosvenor Street
24	Hopkins Street Drain - Rotary Traffic Park
25	Gulliver Flow Path - Hugh & Palmerston Streets
26	Gulliver Overflow to Currajong
27	Vincent Overflow to Currajong
28	Gulliver Flow Path - Mooney Street
29	Currajong Flow Path - Hugh Street
30	Lakes I Overflow
31	Lakes II Outlet
32	Woolcock Canal - Sturt Street
33	Hermit Park Drain - Overtop Charters Tow ers Road
34	Hermit Park Drain - Overtop Baysw ater Road
35	Currajong Flow Path - Along Baysw ater Road
36	Heatley Outlet to Louisa Creek
37	Riechelmann Street Flow s
38	Angus Avenue Overtop
39	Vincent Flow s - Cambridge Street
40	Charles Street Flow s - Cranbrook
41	Eastern Aitkenvale Flow s
42	Southern Aitkenvale Flow s
43	Central Aitkenvale Flow s
44	Northern Aitkenvale Flow s
45	Brooks Street Drain Flow s
46	Central Railw ay Estate Flow s
47	Northern Railw ay Estate Flow s
48	Tully Street Outlet
49	Quarry Flow Path - Mary Street
50	Cutheringa Park Drain - Harold Street
51	Northern Kirw an Outflow s



ROSS CREEK FLOOD STUDY FLOW LOCATIONS

Figure 5-10

LEGEND

Flow Result Locations

City of Townsville

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400 200 0 400 800 Metres

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5.4 Impact on Residential Properties

A summary of the numbers of residential properties impacted by flooding within the suburbs of the Study Area is provided in **Table 5-10**. The numbers of inundated residential properties are on the basis of 0.20 m water depth within the lot, which does not mean floor levels are exceeded (though in some cases they may be when floor levels are less 0.20 m above the ground). To undertake a comparison with respect to floor levels would require survey of all floor levels within the study area.

Table 5-10 Summary of Inundate Residential Properties

Suburb	Number of Impacted Properties								
	2 Y	**5 Y**	**10 Y**	**20 Y**	**50 Y**	**100 Y**	**200 Y**	**500 Y**	**PMF**
Cranbrook	10	75	120	175	235	290	330	415	1080
Aitkenvale	45	75	105	165	215	270	325	410	1285
Mundingburra	150	185	205	235	275	320	350	400	940
Rosslea	5	6	10	20	25	50	70	195	345
Mysterton	35	55	65	75	85	100	115	130	240
Hermit Park	40	100	130	200	240	295	355	470	1065
Railway Estate#	45	60	75	100	125	140	165	425	1110
South Townsville#	40	80	95	110	130	150	165	190	510
Heatley	50	80	120	160	195	220	245	290	730
Vincent	40	50	65	90	110	125	150	190	575
Gulliver	8	15	40	80	125	195	270	385	1165
Currajong	45	60	75	90	110	155	200	260	1000
Pimlico	20	40	50	65	90	100	120	140	490
Hyde Park	15	35	45	60	80	100	125	165	420
West End*	35	55	60	70	80	95	115	135	435
Total	**583**	**971**	**1260**	**1695**	**2120**	**2605**	**3100**	**4200**	**11390**

Note:
There is likely to be additional properties inundated by storm tide
* May not represent total inundation within the suburb as flooding in parts is also the result of Captains Creek inundation

5.5 Floodplain Hazard

The safety of people and potential for damage to property is dependent on both the depth of inundation and the velocity of the flood waters. Floodwaters that flow deep and swift are obviously more hazardous than those areas where flows are shallow and slow.

The degree of hazard varies across the floodplain in response to:

- flood severity;
- floodwater depth and velocity;
- rate of rise of floodwater;
- duration of flooding;
- evacuation capacity;
- population at risk;
- land-use;
- flood awareness; and
- warning time.

To assist with floodplain management it is necessary to determine the hazard and ensure land uses are suitably aligned. *Floodplain Management in Australia: Best practices and principles (CSIRO, 2000)* identifies four degrees of hazard:

- **Low** – no significant evacuation problems; children and elderly could wade to safety with little difficulty; maximum flood depths and velocities along evacuation routes are low; evacuation distances are short; evacuation is possible by sedan-type motor vehicle; there is ample time for flood forecasting, flood warning and evacuation; evacuation routes remain trafficable for at least twice as long as the time required for evacuation.

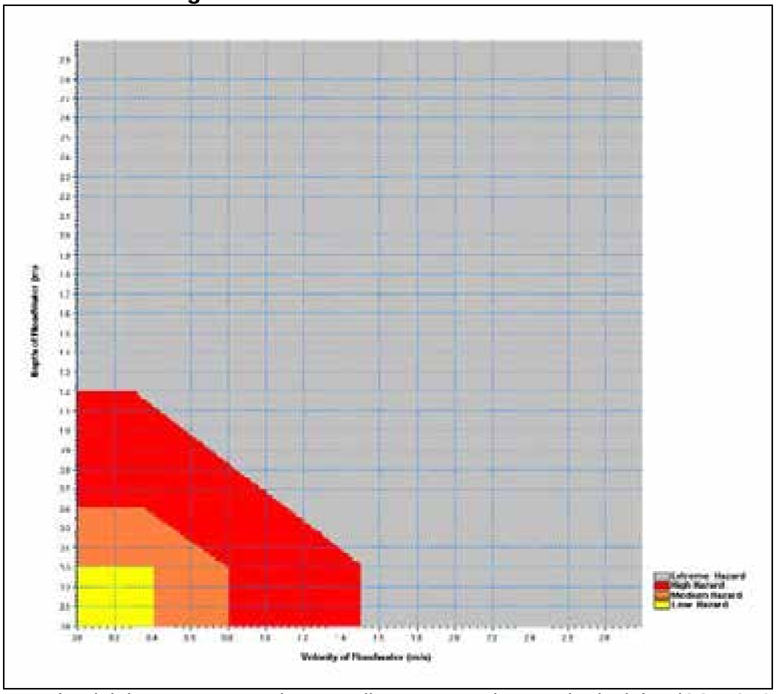
- **Medium** – Fit adults can wade to safety, but children and the elderly may have difficulty; evacuation routes are longer; maximum flood depths and velocities are greater; evacuation by sedan type motor vehicle is possible in the early stages of flooding, after which 4WD vehicles or trucks are required; evacuation routes remain trafficable for at least 1.5 times as long as the necessary evacuation time.

- **High** – fit adults have difficulty wading to safety; wading evacuation routes are longer again; maximum flood depths and velocities are greater (up 1.0 m and 1.5 m/s respectively); motor vehicle evacuation is possible only by 4WD vehicles or trucks in the early stages of flooding; boats and helicopters may be required; evacuation routes remain trafficable only up to the minimum evacuation time.

- **Extreme** – boats or helicopters are required for evacuation; wading is not an option because of the rate of rise and/or the depth and velocity of the floodwaters; maximum flood depths and velocities are over 1.0 m and 1.5 m/s respectively.

Prior to detailed assessment of floodplain hazard based on all the factors influencing hazard, preliminary assessment is often undertaken based on flood depth and velocity. **Figure 5-11** provides the basis for defining hazard as a function of depth and velocity as provided in *Floodplain Management in Australia: Best practices and principles (CSIRO, 2000)*.

Figure 5-11 Estimation of Flood Hazard



Source: Floodplain Management in Australia: Best practices and principles (CSIRO, 2000)

On the basis of the flood model results floodplain hazard has been mapped for the following events:

- **100 Year ARI** – representing the level of risk the *State Planning Policy - Mitigating the Adverse Impacts of Flood, Bushfire and Landslide (SPP 1/03)* requires for the Defined Flood Event,;

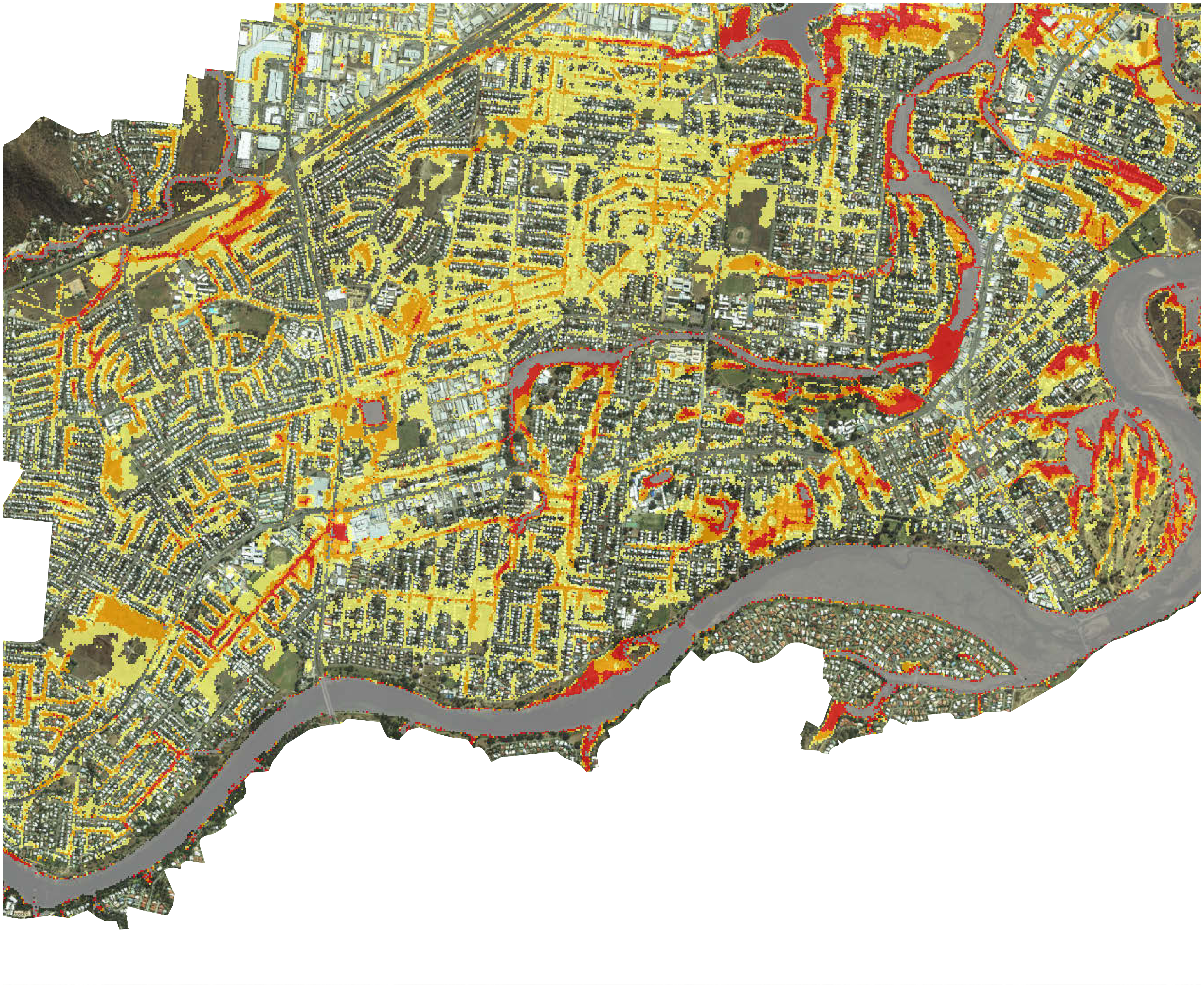
- **500 Year ARI** – representing a rare event that is often used for design for critical infrastructure, and also the first event with significant overflow from Ross River;

- **Probable Maximum Flood** – representing the extreme upper limit of flood hazard within the Ross River floodplain.

Figures 5-12, **5-13** and **5-14** show the resulting floodplain hazard maps for the 100 Year ARI, 500 Year ARI and Probable Maximum Floods respectively. A summary of the number of residential properties within the given hazard areas of the floodplain are provided in **Table 5-11**.

Table 5-11 Floodplain Hazard Summary

Event	Number of Residential Properties			
	Low Hazard	Medium Hazard	High Hazard	Extreme Hazard
100 Year ARI	1145	785	245	30
500 Year ARI	1375	1130	650	185
PMF	1545	3625	3560	2475



ROSS CREEK FLOOD STUDY 100 YEAR ARI HAZARD

Figure 5-12a

LEGEND

- Low Hazard
- Medium Hazard
- High Hazard
- Extreme Hazard

N

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ROSS CREEK FLOOD STUDY 100 YEAR ARI HAZARD

Figure 5-12b

LEGEND

- Low Hazard
- Medium Hazard
- High Hazard
- Extreme Hazard

N

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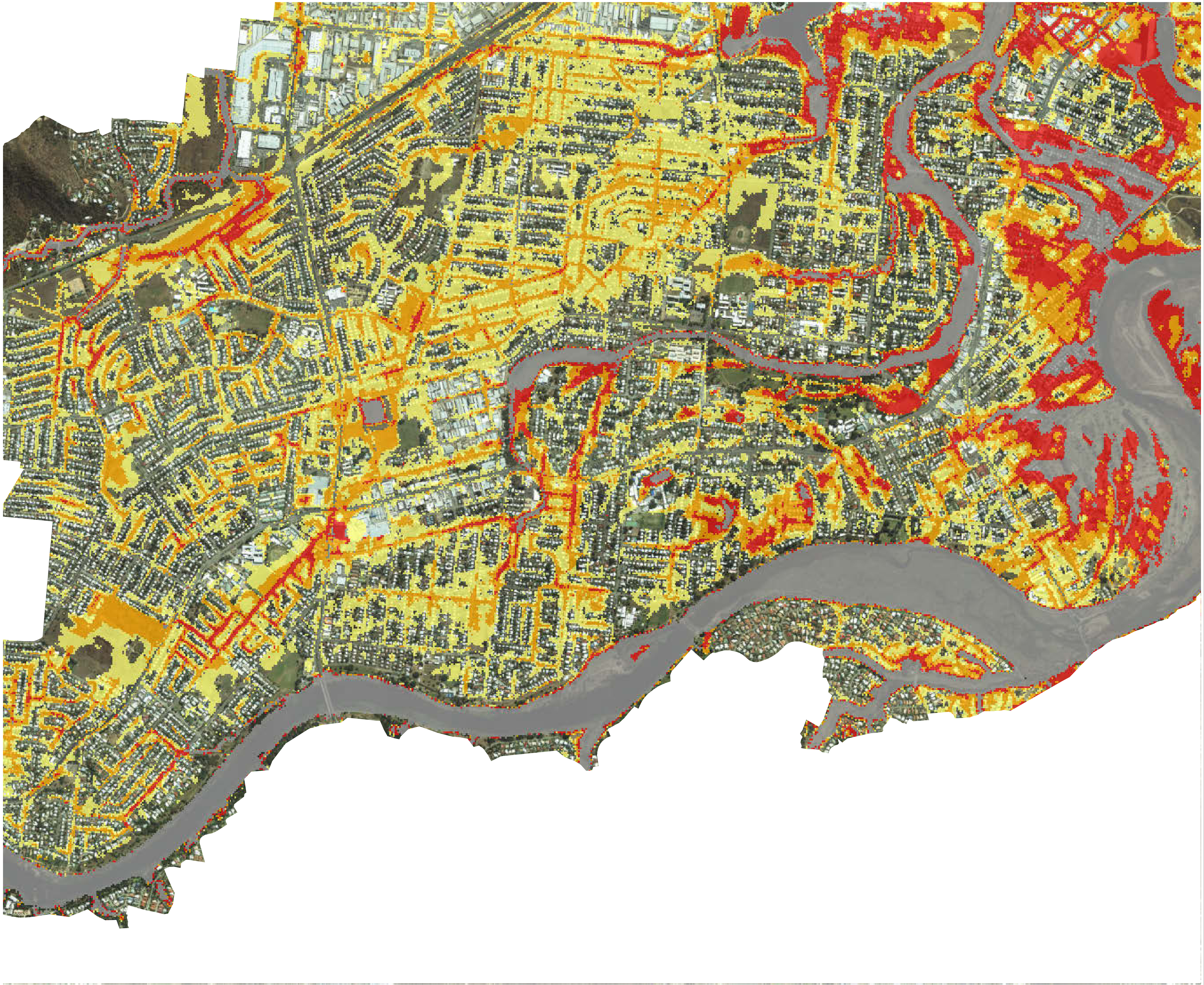

ROSS CREEK FLOOD STUDY 500 YEAR ARI HAZARD

Figure 5-13a

LEGEND

- Low Hazard
- Medium Hazard
- High Hazard
- Extreme Hazard

N

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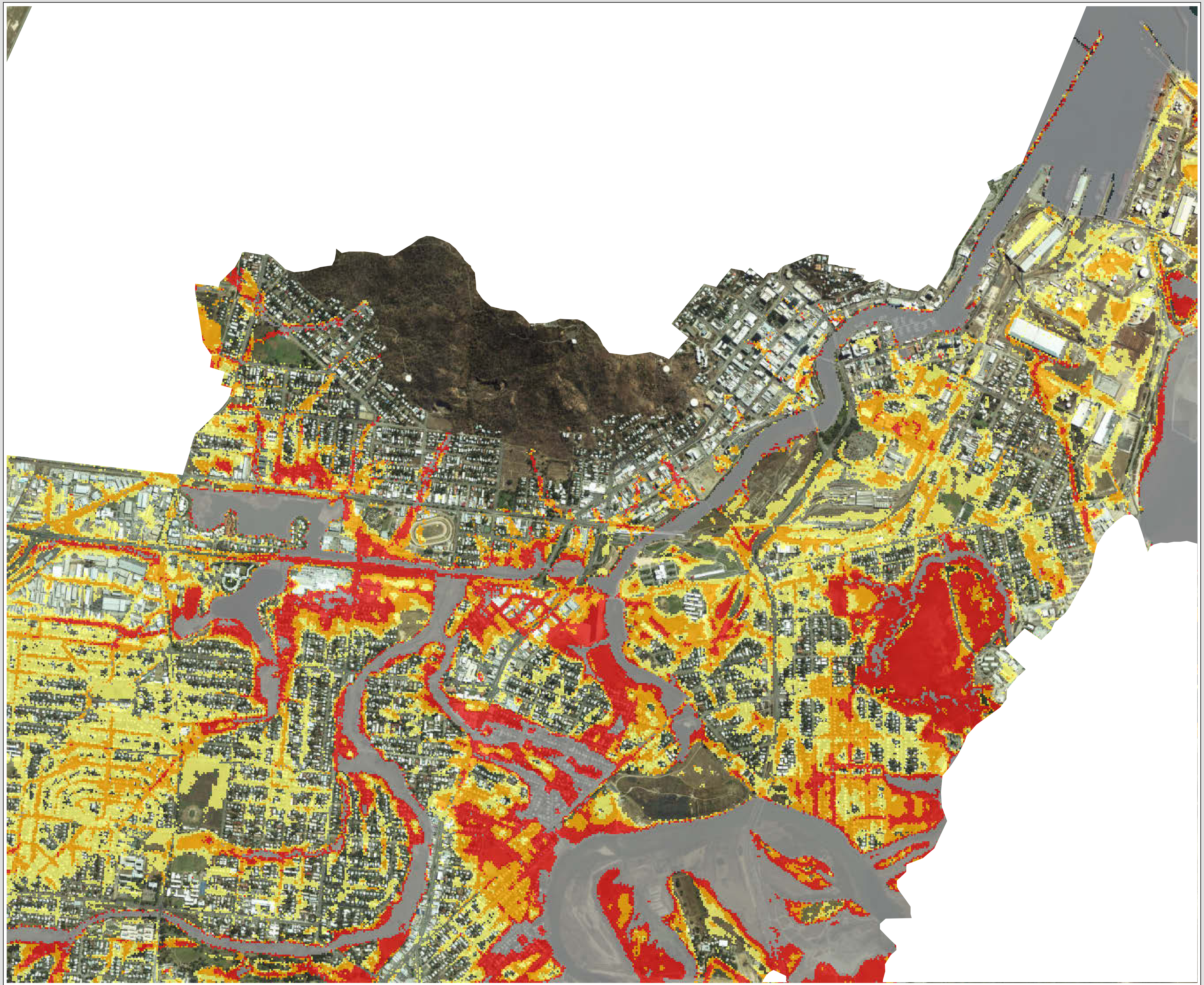

ROSS CREEK FLOOD STUDY 500 YEAR ARI HAZARD

Figure 5-13b

LEGEND

- Low Hazard
- Medium Hazard
- High Hazard
- Extreme Hazard

N

City of Townsville

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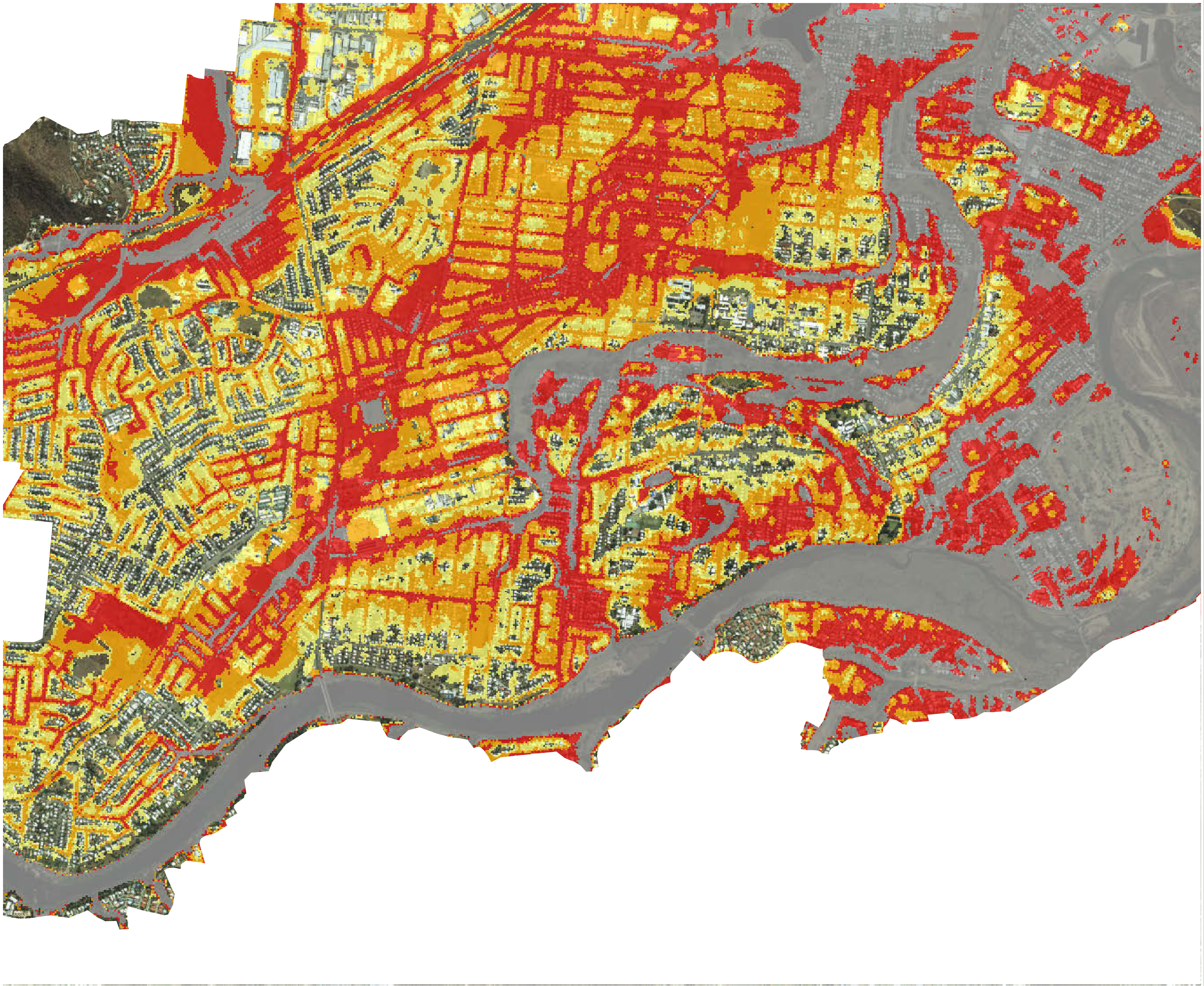

ROSS CREEK FLOOD STUDY PMP HAZARD

Figure 5-14a

LEGEND

- Low Hazard
- Medium Hazard
- High Hazard
- Extreme Hazard

N

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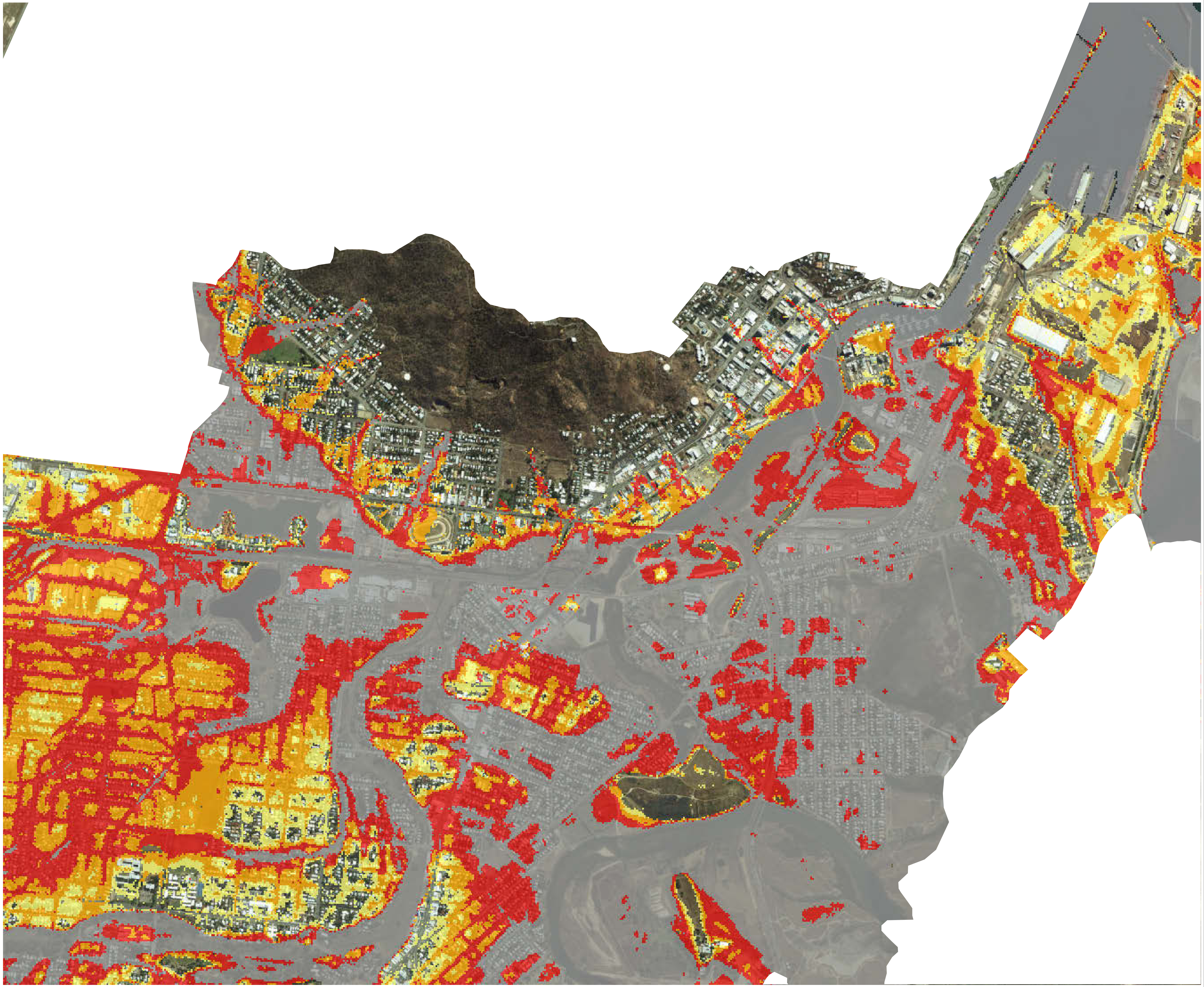

ROSS CREEK FLOOD STUDY PMP HAZARD

Figure 5-14b

LEGEND

- Low Hazard
- Medium Hazard
- High Hazard
- Extreme Hazard

N

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5.6 Floodplain Planning Considerations

Flood Hazard Overlay Mapping

The new City Plan for Townsville City Council is presently being drafted. The 100 Year ARI (1 % AEP) flood has been chosen as the Defined Flood Event (DFE) for establishing floor levels. Maps for the Flood Hazard Overlay have utilised different zones for the overlay comprising:

- **Low flood hazard** – areas of residual flood risk beyond the 100 Year ARI;
- **Medium flood hazard** – areas of shallower and slower moving flood waters in the 100 Year ARI as per the criteria in **Figure 5-15**;
- **High flood Hazard** – areas of deeper and faster moving flood waters in the 100 Year ARI as per the criteria in **Figure 5-15.**

These hazard areas should not be confused with those provided in **Section 5.5**, which indicate the hazardous nature of the areas of the floodplain for specific probability floods.

Figure 5-15 – Flood Hazard Overlay Definitions (Medium and High Hazard)

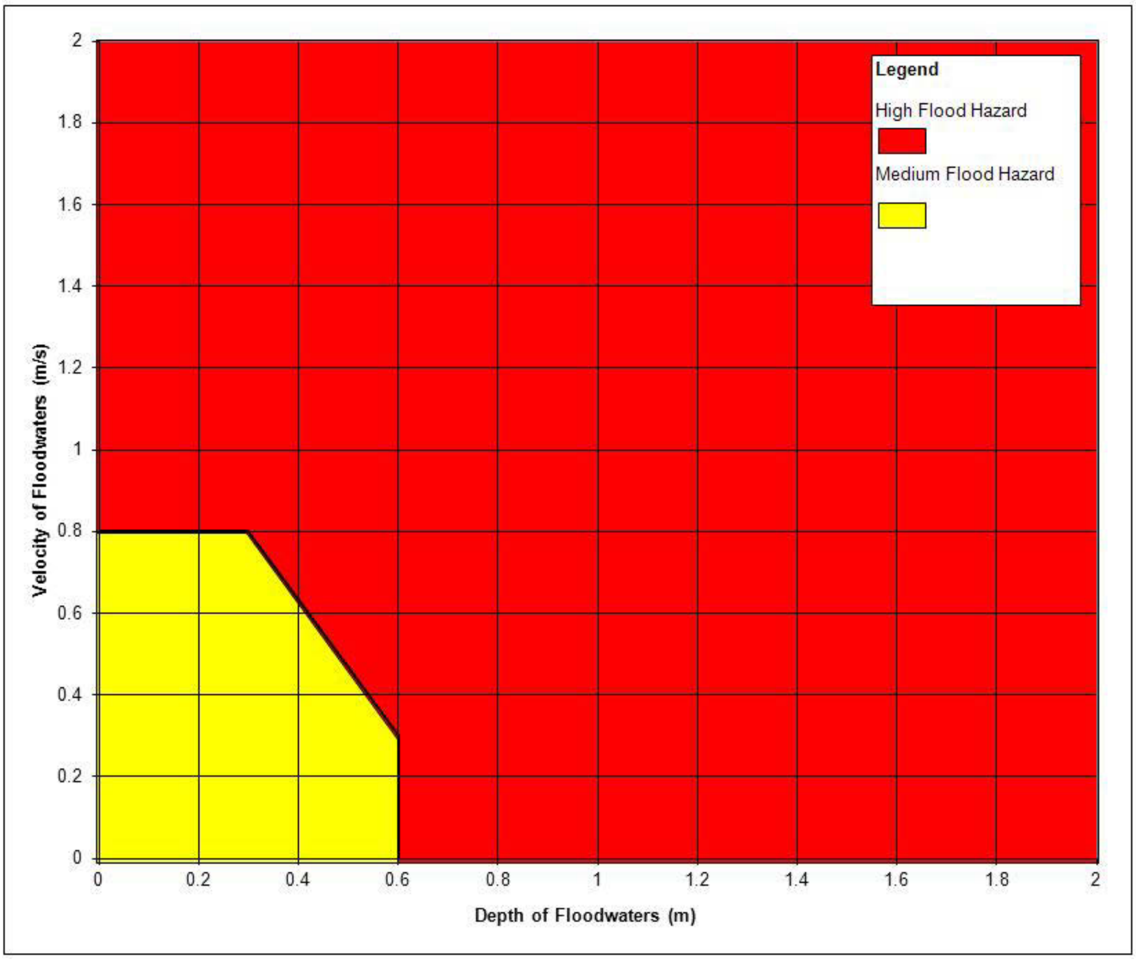
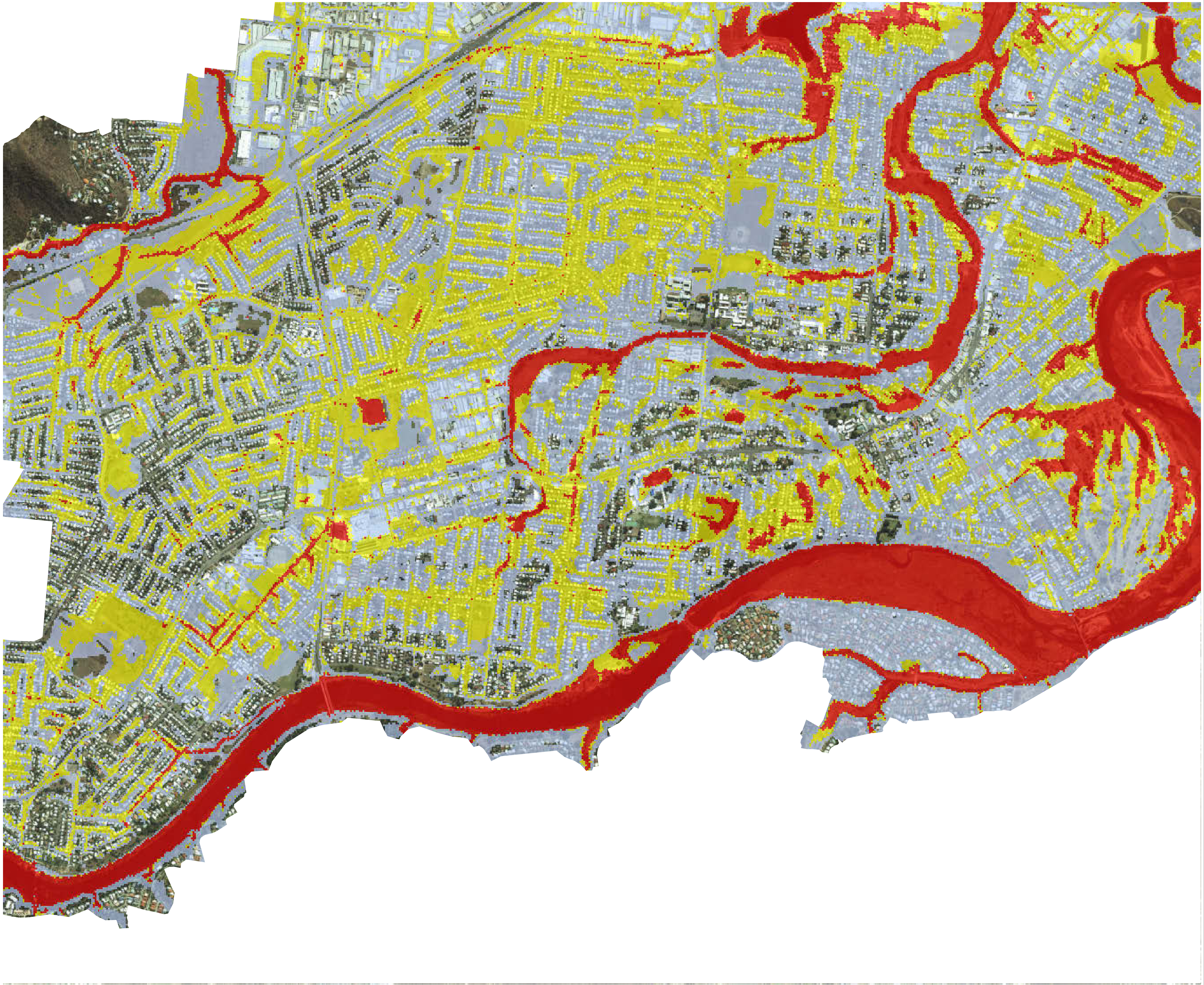


Figure 5-16 shows the proposed flood hazard overlay map for the Ross Creek Study area based on the criteria above.



ROSS CREEK FLOOD STUDY PROPOSED FLOOD HAZARD OVERLAY

Figure 5-16a

LEGEND

Hazard Overlay

- Low Hazard
- Medium Hazard
- High Hazard

N

SCALE: 1:20,000 @A3

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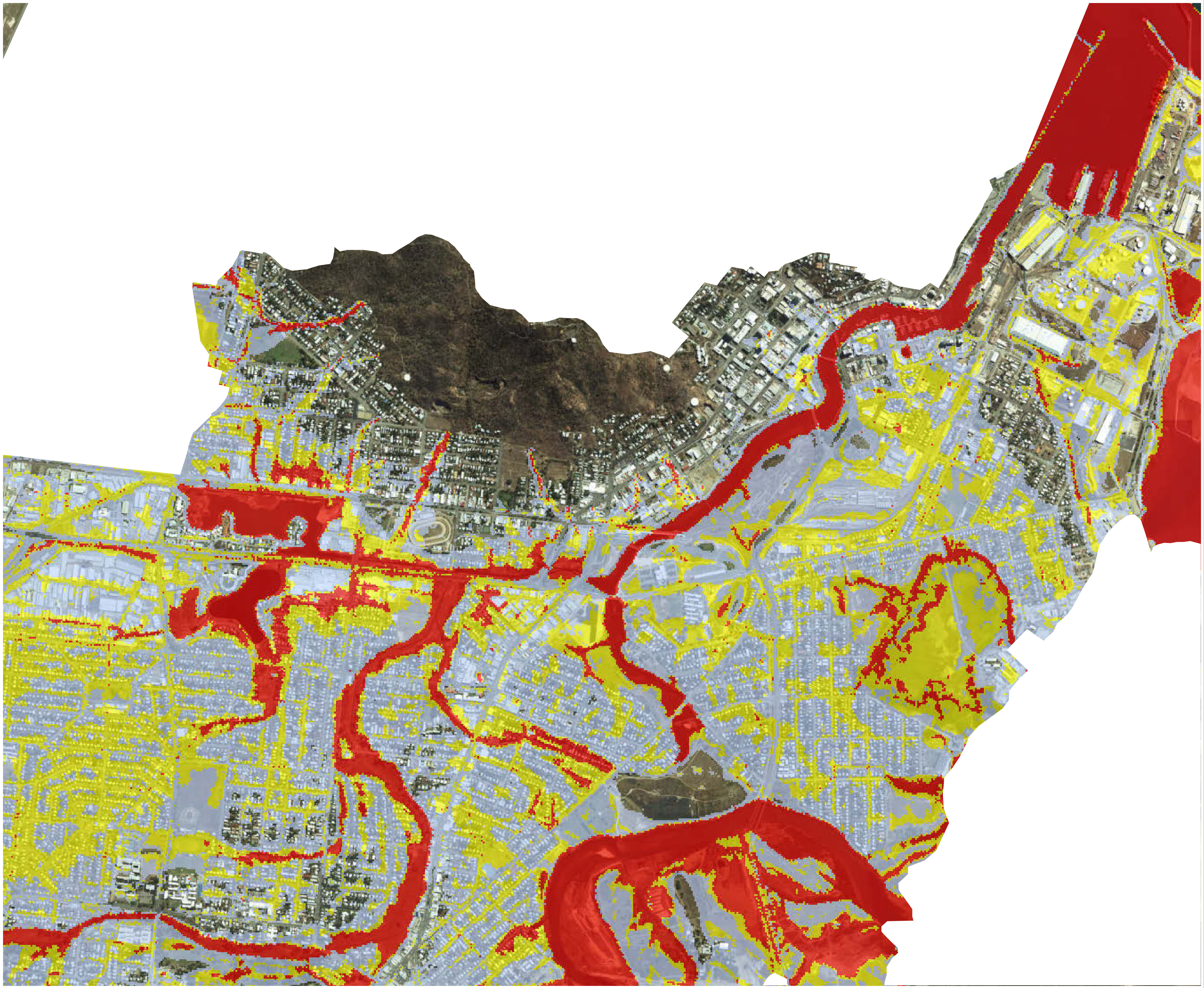
ROSS CREEK FLOOD STUDY PROPOSED FLOOD HAZARD OVERLAY

Figure 5-16b



LEGEND

Hazard Overlay

- Low Hazard
- Medium Hazard
- High Hazard

N

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DIGITAL FILE: RossCreek_Fig5-16_Overlay

5.7 Emergency Management Considerations

Flood Warning and Prediction

The Ross Creek flood model is presently not suitable for use as a real-time prediction flood model, because of long run-times and complex set-up. There is however a significant amount of GIS flood layers that have been developed from the study which could be imported into a post processing software package such as WaterRide to support flood extent prediction as part of emergency management planning.

Flood extent prediction will still require an understanding of what flood levels are expected at key locations in the Ross Creek catchment based on Bureau of Meteorology rainfall predictions. The Bureau of Meteorology does not presently make any flood level estimates in the Ross Creek catchment, as the catchment is much smaller than the typical river basin scale examined by the Bureau of Meteorology flood forecasting unit.

There is still significant work required to enable reasonable flood level prediction within the Ross Creek catchment for input to emergency planning, including:

- commissioning additional flood level alert gauges on key water courses in the Ross Creek catchment;
- re-calibrating the Ross Creek hydraulic model against observed flood events at the new flood level alert gauges;
- developing suitable rating curves for locations corresponding to flood level alert gauges in the Ross Creek catchment;
- calibrating the Ross Creek hydrological model to observed flood events at the flood level alert gauges using the developed rating curves; and
- configuring the Ross Creek hydrological model to be used as a flood forecasting tool with rainfall advice provided by the Bureau of Meteorology.

Evacuation Route Closures

There are numerous major evacuation routes within the extent of the Ross Creek Flood study. Many of the evacuation routes are potentially closed from flooding. Because of limitations with flood warning and prediction identified above, it is difficult to provide any predictions of road closures based on rainfall predictions; however, the flood immunity of evacuation routes has been examined for the design flood events from the flood study.

Figure 5-17 shows the locations where the major evacuation routes are closed. Based on the flood study results the flood immunity of the evacuation routes is provided in **Table 5-12**.

The evacuation route closure results indicate that there are numerous locations where roads are closed in the events as small as a 2 Year ARI. In some locations this water over road is a result of localised stormwater or backwater through pipe networks and there little increase in water level up to much larger flood events. These locations include:

- Railway Avenue - Ninth Street;
- Railway Avenue - Doorey Street;
- Bowen Road – Rosslea Drain;
- Hugh Street – Woolcock Street; and

- Nathan Street – Domain Central.

Conversely, some of the other locations with flood immunities as low as the 2 Year ARI, are subject to broader-scale flooding and flood depths get significantly greater with increasing flood magnitude, such as:

- Woolcock Street – Kings Road;
- Woolcock Street – Pilkington Street;
- Ross River Road – Vale Hotel;
- Nathan Street – Albert Street; and
- Nathan Street – Charles Street.

Woolcock Street has significant vulnerability to flooding. Given that Woolcock Street is the main north/west bound evacuation route from the City, it potentially has a substantial role in evacuations for flood and storm tide events. Given that Ingham Road in the same area is largely unaffected by flooding, it is recommended that Ingham Road be included as a major evacuation route.

Location	Description
1	Railway Ave - Ninth St
2	Railway Ave - Doorey St
3	Railway Ave - Seventh St
4	Flinders St - Morris St
5	Charters Towers Rd - Boundary St
6	Charters Towers Rd - Yeatman St
7	Charters Towers Rd - Hermit Park Drain
8	Bowen Rd - Rosslea Drain
9	Bowen Rd - Benson St
10	Woolcock St - Mindham Park Drain
11	Woolcock St - Kings Rd
12	Woolcock St - Lakes 1
13	Hugh St - Woolcock St
14	Percy St - Ralston St
15	Percy St - Harold St
16	Woolcock St - Pilkington St
17	Dalrymple Rd - North Heatley
18	Ross River Rd - Wood St
19	Ross River Rd - Cathedral School
20	Ross River Rd - Crete St
21	Ross River Rd - Vale Hotel
22	Ross River Rd - Nathan St
23	Nathan St - Albert St
24	Ross River Rd - Indigineous Reserve
25	Nathan St - Charles St
26	Nathan St - Domain Central

ROSS CREEK FLOOD STUDY EVACUATION ROUTES

Figure 5-17

LEGEND

- Closure Locations
- Major Evacuation Routes

N

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Table 5-12 Major Evacuation Route Flood Immunity

Location	Description	Depth over Road (m) 2 Year ARI	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI	200 Year ARI	500 Year ARI	PMP
1	Railway Ave - Ninth St	0.22	0.23	0.24	0.26	0.26	0.27	0.28	0.31	1.48
2	Railway Ave - Doorey St	0.21	0.23	0.24	0.25	0.26	0.28	0.31	0.4	1.39
3	Railway Ave - Seventh St	-	-	-	-	-	-	-	-	1.38
4	Flinders St - Morris St	-	-	0.15	0.2	0.23	0.29	0.28	0.3	0.5
5	Charters Towers Rd - Boundary St	-	-	-	-	-	0.13	0.26	0.47	1.81
6	Charters Towers Rd - Yeatman St	-	-	-	-	-	-	-	0.11	1.46
7	Charters Towers Rd - Hermit Park Drain	-	-	-	0.16	0.31	0.45	0.57	1.17	1.91
8	Bowen Rd - Rosslea Drain	0.12	0.14	0.16	0.17	0.19	0.2	0.22	0.57	1.21
9	Bowen Rd - Benson St	-	-	-	-	-	-	-	0.14	0.86
10	Woolcock St - Mindham Park Drain	-	-	-	-	0.22	0.37	0.49	0.64	1.86
11	Woolcock St - Kings Rd	0.23	0.33	0.38	0.45	0.52	0.61	0.7	0.83	2.04
12	Woolcock St - Lakes 1	-	-	0.13	0.2	0.28	0.37	0.46	0.58	1.8
13	Hugh St - Woolcock St	0.12	0.13	0.14	0.15	0.16	0.18	0.19	0.21	0.88
14	Percy St - Ralston St	-	-	-	-	-	-	0.11	0.18	1.53
15	Percy St - Harold St	-	-	-	-	0.1	0.12	0.12	0.14	0.23
16	Woolcock St - Pilkington St	0.14	0.25	0.31	0.36	0.39	0.43	0.46	0.49	0.86
17	Dalrymple Rd - North Heatley	-	-	0.18	0.32	0.35	0.4	0.45	0.52	1.19
18	Ross River Rd - Wood St	-	-	-	-	-	-	0.12	0.16	0.7
19	Ross River Rd - Cathedral School	-	-	-	-	-	-	-	-	0.29
20	Ross River Rd - Crete St	-	-	0.11	0.17	0.21	0.25	0.29	0.34	0.88
21	Ross River Rd - Vale Hotel	0.15	0.25	0.29	0.33	0.35	0.39	0.42	0.47	1.01
22	Ross River Rd - Nathan St	-	-	-	0.1	0.12	0.14	0.15	0.17	0.44
23	Nathan St - Albert St	0.24	0.3	0.34	0.39	0.43	0.47	0.5	0.55	0.96
24	Ross River Rd - Indigenous Reserve	-	0.15	0.18	0.21	0.23	0.25	0.27	0.29	0.57
25	Nathan St - Charles St	0.1	0.23	0.3	0.35	0.39	0.42	0.44	0.47	0.86
26	Nathan St - Domain Central	0.12	0.13	0.14	0.16	0.18	0.2	0.22	0.25	0.5

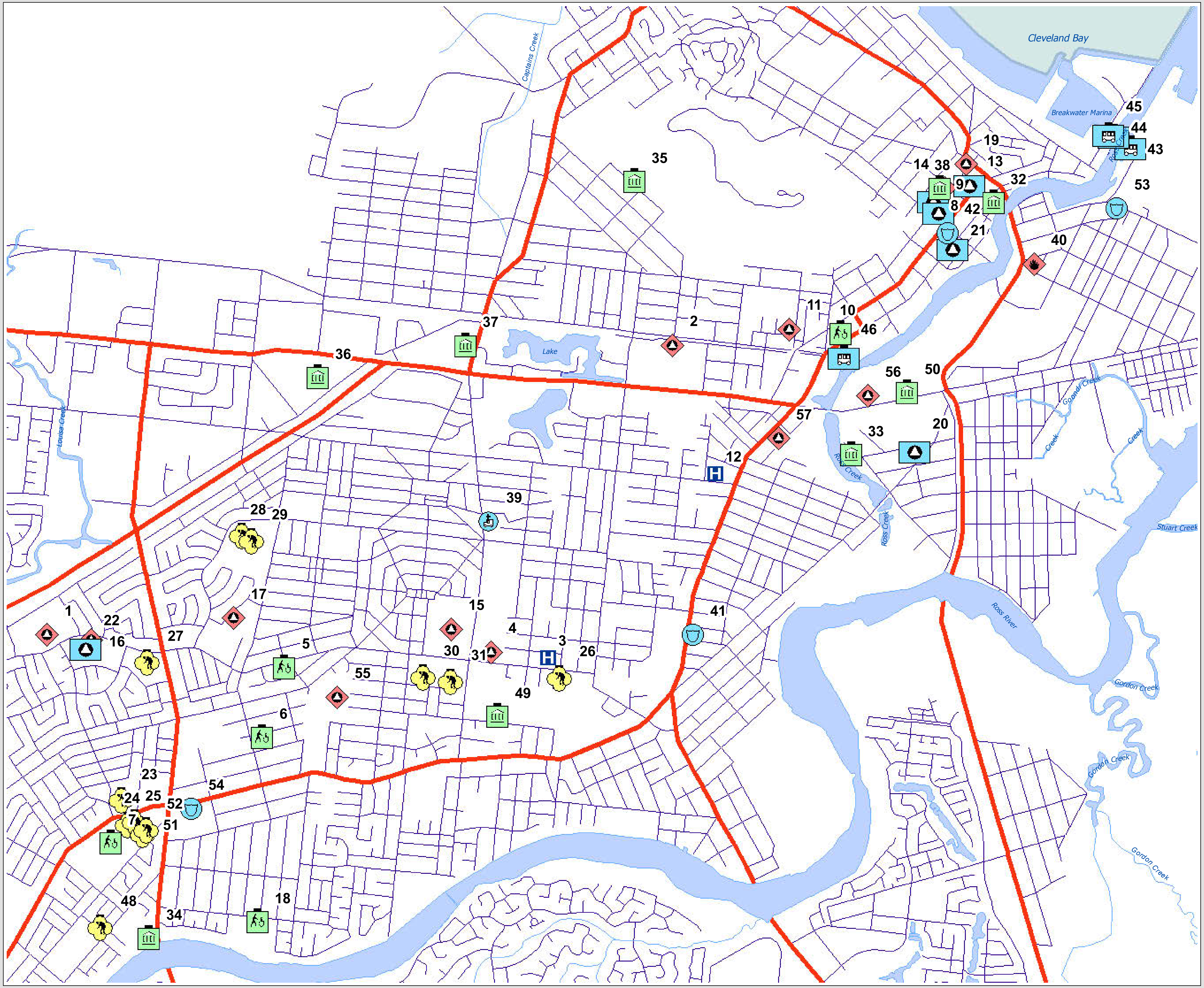
Emergency Management Facilities
There are numerous facilities within the study area that are important from an emergency management perspective, where flooding has the potential to impact on the function of the facility. Such facilities include:

- Medical facilities;
- Emergency services facilities (police, fire and ambulance);
- Council depots and offices;
- Major public transport and
- Evacuation facilities (event, recovery and special needs);

Figure 5-18 shows the potential emergency management facilities within the study area. **Table 5-13** shows the flood depths at the emergency management facilities for the given design flood events. Given the flood depths indicated are only depths relative to lot levels, they may not necessarily indicate whether the facilities themselves are inoperable as result of flooding. It is worth noting this assessment of depths of inundation only examines terrestrial flooding and does not consider the potential for inundation due to Storm Tide.

The results demonstrate:

- most facilities with a major role in disaster management remain unaffected up to the large flood events (greater than 100 Year ARI);
- There are some aged care facilities with low levels of flood immunity and ideally early evacuation of these centres should be part of the Local Disaster Management Plan – Evacuation Sub-plan; and
- The Railway Estate Community Centre has low flood immunity and ideally should be part of any evacuation arrangements.



ROSS CREEK FLOOD STUDY - DISASTER MANAGEMENT

Figure 5-18

LEGEND

- AGED CARE
- AMBULANCE
- COUNCIL DEPOT
- FIRE & RESCUE
- MEDICAL
- POLICE
- POST IMPACT
- PRE IMPACT
- SPECIAL GROUP
- TRANSPORT

N

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Table 5-13 Emergency Management Facility Flooding

Location	Description	Facility Type	Water Depth (m) 2 Year ARI	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI	200 Year ARI	500 Year ARI	PMP
1	HEATLEY SECONDARY COLLEGE	POST IMPACT	-	-	-	-	-	-	-	-	-
2	TOWNSVILLE SHOWGROUNDS	POST IMPACT	-	-	-	-	-	-	-	0.1	0.25
3	MATER HOSPITAL	MEDICAL	-	-	-	-	-	-	-	-	-
4	PIMLICO STATE HIGH SCHOOL AND ARTS CENTRE	POST IMPACT	-	-	-	-	-	-	-	-	-
5	CHURCH OF JESUS CHRIST OF LATTER DAY SAINTS (MORMON COMMUNITY)	SPECIAL GROUP	-	-	-	-	0.12	0.15	0.17	0.2	0.61
6	TOWNSVILLE ITALO AND AUSTRALIAN SPORTING ASSOCIATION (ITALIAN COMMUNITY)	SPECIAL GROUP	-	-	-	-	-	-	-	-	-
7	IGNATIUS PARK COLLEGE - ASSEMBLY HALL	SPECIAL GROUP	-	-	-	-	-	-	-	-	0.2
8	COMMONWEALTH GOVERNMENT OFFICES - UNDERGROUND CARPARK	PRE IMPACT	-	-	-	-	-	-	-	-	-
9	STATE GOVERNMENT OFFICE - UNDERGROUND CARPARK	PRE IMPACT	-	-	-	-	-	-	-	-	-
10	GREEK COMMUNITY CENTRE (GREEK COMMUNITY)	SPECIAL GROUP	-	-	-	-	-	-	-	-	-
11	TOWNSVILLE WEST STATE SCHOOL	POST IMPACT	-	-	-	-	-	-	-	-	-
12	WESLEY PARK HAVEN HOSPITAL	MEDICAL	-	-	-	-	-	-	-	-	0.22
13	SUNCORP METWAY BUILDING - UNDERGROUND CARPARK	PRE IMPACT	-	-	-	-	-	-	-	-	-
14	TOWNSVILLE CITY COUNCIL - RECEPTION ROOM	POST IMPACT	-	-	-	-	-	-	-	-	-
15	BARRIER REEF PIMLICO TAFE	POST IMPACT	-	-	-	-	-	-	-	-	-
16	MT LOUISA SUBURBS KINDERGARTEN & PRESCHOOL	POST IMPACT	-	-	-	-	-	-	-	-	-
17	WORINDA OCCASIONAL CARE	POST IMPACT	-	-	-	-	-	-	-	-	-
18	SEVENTH-DAY ADVENTIST CHURCH	SPECIAL GROUP	-	-	-	-	-	-	-	-	-
19	CWA HALL	POST IMPACT	-	-	-	-	-	-	-	-	-
20	RAILWAY ESTATE COMMUNITY CENTRE	PRE IMPACT	0.1	0.17	0.23	0.29	0.34	0.36	0.39	0.56	1.77
21	POWERHOUSE CENTRE	PRE IMPACT	-	-	-	-	-	-	-	-	-
22	HEATLEY COMMUNITY CENTRE	PRE IMPACT	-	-	-	-	-	-	-	-	-
23	BROOKLEA LIFESTYLE VILLAGE	AGED CARE	-	-	-	-	-	-	-	-	-
24	CRANBRAE NO 1 RETIREMENT VILLAGE	AGED CARE	-	-	-	-	-	-	0.1	0.11	0.31
25	CRANBRAE NO 2 RETIREMENT VILLAGE	AGED CARE	-	-	-	-	-	-	-	-	0.25
26	LORETO HOME FOR THE AGED	AGED CARE	-	-	-	-	-	-	-	-	-
27	ST JAMES RETIREMENT VILLAGE	AGED CARE	-	-	-	-	-	-	-	-	-
28	TOWNSVILLE NURSING HOME	AGED CARE	-	-	-	-	-	-	-	-	-
29	TOWNSVILLE NURSING HOME (MENTAL HEALTH)	AGED CARE	0.13	0.15	0.17	0.18	0.19	0.21	0.22	0.24	0.4
30	VILLA MCAULAY RETIREMENT VILLAGE	AGED CARE	-	-	0.1	0.11	0.12	0.13	0.13	0.14	1.18
31	VILLA VINCENT NURSING HOME	AGED CARE	-	-	-	-	-	-	-	-	0.47
32	NORTH TOWN	COUNCIL DEPOT	-	-	-	-	-	-	-	-	-
33	PARKS SERVICES	COUNCIL DEPOT	-	-	-	-	-	-	-	-	1.15
34	PARKS DEPOT	COUNCIL DEPOT	-	-	-	-	-	-	-	-	-
35	SES BUILDING	COUNCIL DEPOT	-	-	-	-	-	-	-	-	-
36	INFRASTRUCTURE SERVICES DEPOT	COUNCIL DEPOT	-	-	-	-	-	-	-	-	0.11
37	GARBUTT OPERATIONS CENTRE	COUNCIL DEPOT	-	-	-	-	-	-	-	-	0.34
38	TOWNSVILLE CITY COUNCIL - ADMINISTRATION BUILDING	COUNCIL DEPOT	-	-	-	-	-	-	-	-	-
39	CURRAJONG AMBULANCE STATION	AMBULANCE	-	-	-	-	-	-	-	-	0.4

Location	Description	Facility Type	Water Depth (m) 2 Year ARI	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI	200 Year ARI	500 Year ARI	PMP
40	FIRE RESCUE AND OPERATIONS CENTRE	FIRE & RESCUE	-	-	-	-	-	-	-	0.1	1.1
41	MUNDINGBURRA POLICE STATION	POLICE	-	-	-	-	-	-	-	-	-
42	TOWNSVILLE POLICE DISTRICT HEADQUARTERS	POLICE	-	-	-	-	-	-	-	-	-
43	FANTASEA CAR BARGE	TRANSPORT	-	-	-	-	-	-	-	-	-
44	SUNFERRIES PTY LTD	TRANSPORT	-	-	-	-	-	-	-	-	-
45	GREYHOUND BUSES	TRANSPORT	-	-	-	-	-	-	-	-	-
46	TOWNSVILLE RAILWAY STATION	TRANSPORT	-	-	-	-	0.11	0.15	0.14	0.16	0.39
47	TOWNSVILLE WATER POLICE	POLICE	-	-	-	-	-	0.13	0.18	0.23	0.53
48	CRANBROOK SUITES RETIREMENT VILLAGE	AGED CARE	-	-	-	-	-	-	-	-	0.17
49	WELLINGTON STREET DEPOT	COUNCIL DEPOT	-	-	-	-	-	-	-	-	0.87
50	REID PARK	COUNCIL DEPOT	-	-	-	-	-	-	-	-	0.69
51	CRANBRAE NO 3 RETIREMENT VILLAGE	AGED CARE	-	-	-	-	-	-	0.13	0.18	0.7
52	CRANBRAE NO 4 RETIREMENT VILLAGE	AGED CARE	-	-	-	-	-	0.11	0.15	0.2	0.67
53	SOUTH TOWNSVILLE NEIGHBOURHOOD POLICE BEAT	POLICE	-	-	-	-	-	-	-	-	-
54	STOCKLAND POLICE BEAT SHOPFRONT	POLICE	-	-	-	-	-	-	-	-	0.26
55	AITKENVALE PCYC	POST IMPACT	-	-	-	-	-	-	-	-	1.09
56	CIVIC THEATRE	POST IMPACT	-	-	-	-	-	-	-	-	0.24
57	FIT FOR LIFE	POST IMPACT	-	-	-	-	-	-	-	-	1

5.8 Tailwater Conditions

For all the design storm events the MIKE FLOOD hydraulic model has adopted a fixed tail water condition at the MHWS tidal level (1.254 m AHD). This is considered somewhat conservative as most in reality a flood is likely to coincide with a combination low and high tides across a tidal cycle.

There has also been an evaluation of adopting the Highest Astronomical Tide (HAT) level (2.25 m AHD) as the tail water condition for the model. The 50 Year ARI and 100 Year ARI, 24 hour floods were both run with a tail water condition equal to HAT. It should be noted that combining HAT with a design flood of a given frequency does not maintain the exceedance probability of the flood. Accordingly HAT in combination with a 50 Year ARI flood, should have a lower frequency (higher ARI). This issue of joint probability with respect to flooding and coastal processes is the subject of review within the forthcoming revision of *Australian Rainfall and Runoff*, due in 2014.

Figure 5-19 and **5-20** show changes in flood levels for the 50 and 100 Year ARI floods as a result of the HAT tail water condition.

For the 50 Year ARI, the results show increases in flood levels of greater than 0.5 m in the entire length of Ross Creek, and up Woolcock Canal to upstream of Sturt Street. In Mindham Park Drain, increases in flood levels of over 0.1m are observed back to Townsend Street and within the Hermit Park Drain. Any increase in flood level within Mindham Park Drain is washed out by Balls Lane. Increases between 0.01 to 0.05 m are observed up the Pimlico Drain to Diprose Street. Areas around Castletown and The Lakes have flood level increases between 0.05 and 0.1 m, with the exception of the Ingham Road sump, where increase are above 0.1 m.

For the 100 Year ARI, the results show increases in flood levels of greater than 0.5 m in the entire length of Ross Creek, and up Woolcock Canal to downstream of Sturt Street. In Mindham Park Drain, increases in flood levels of over 0.1 m are observed back to Bayswater Road and within the Hermit Park Drain, while increases of up to 0.05 m are observed back to Townsend Street. Any increase in flood level within Mindham Park Drain is washed out by Balls Lane. Increases between 0.01 to 0.05 m are observed up the Pimlico Drain to Diprose Street. Areas around Castletown and The Lakes have flood level increases between 0.05 and 0.1 m.

ROSS CREEK FLOOD STUDY SENSITIVITY - 50 Y ARI & HAT

Figure 5-19a

LEGEND

Water Level Difference (m)

- Previously Inundated
- < -1
- -1 - -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- > 1
- Now Inundated

N

City of Townsville

SCALE: 1:20,000 @A3

200 100 0 200 400 600 Metres

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ROSS CREEK FLOOD STUDY SENSITIVITY - 50 Y ARI & HAT

Figure 5-19b

LEGEND

Water Level Difference (m)

- Previously Inundated
- < -1
- -1 - -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- > 1
- Now Inundated

City of Townsville

SCALE: 1:20,000 @A3

200 100 0 200 400 600 Metres

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ROSS CREEK FLOOD STUDY SENSITIVITY - 100 Y ARI & HAT

Figure 5-20a

LEGEND

Water Level Difference (m)

- Previously Inundated
- < -1
- -1 - -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- > 1
- Now Inundated

N

SCALE: 1:20,000 @A3

200 100 0 200 400 600 Metres

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ROSS CREEK FLOOD STUDY SENSITIVITY - 100 Y ARI & HAT

Figure 5-20b

LEGEND

Water Level Difference (m)

- Previously Inundated
- < -1
- -1 - -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- > 1
- Now Inundated

N

City of Townsville

SCALE: 1:20,000 @A3

200 100 0 200 400 600 Metres

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DIGITAL FILE: RossCreek_Fig5-20_100yHAT

6.0 Impact of Climate Change on Flooding

An evaluation of the potential impact on flooding of climate change has been undertaken. The two primary mechanisms where climate change could impact on Ross Creek flooding are sea level rise and changes in extreme rainfall intensities. A single climate change scenario has been assessed incorporating both sea level rise and increased intensity of extreme rainfall.

To assess the potential impact of sea-level rise on Ross Creek flooding, the tail water level of MIKE FLOOD model was updated to include the sea level rise value. The sea-level rise specified within the *Queensland Coastal Plan* of 0.8 m to allow for conditions in 2100 was adopted. This value is consistent with advice from *the IPCC Fourth Assessment Report: Climate Change* (2007) and within the range of projections within *Climate Change Projections for the Townsville Region* (Hennessy et al, 2008).

While there is considerable consensus on the likelihood of sea-level rise resulting from climate change, the impacts on extreme rainfall is more contentious. The Queensland Department of Environment and Resource Management (DERM) has released some interim guidance on the changes in extreme rainfall.

In a joint project between, DERM, the Department of Infrastructure and Planning (DoIP) and the Local Government Association of Queensland (LGAQ), a review of the potential for climate change to alter extreme rainfall intensities has been completed. *Increasing Queensland's resilience to inland flooding in a changing climate* (DERM, 2010) provides recommendation for extreme rainfall intensities in the interim until a new revision of *Australian Rainfall and Runoff* addresses the issue. The Scientific Advisory Group (SAG) agreed that:

- an increase in rainfall intensity is likely;
- the available scientific literature indicates this increased rainfall intensity to be in the range of 3–10% per degree of global warming; and
- in the interim the SAG would consider a figure of a 5% increase in rainfall intensity per degree of global warming reasonable for informing policy development in the interim.

To evaluate the impact of sea-level rise and changes in extreme rainfall intensities on Ross Creek flooding, the modelling was updated by:

- increasing rainfall intensities by 15% allowing for a 3ºC rise in temperature to 2100;
- re-calculating catchment runoff based on the new rainfall intensities;
- updating the rain on grid data based on the new rainfall intensities;
- applying the revised flows as boundary conditions and source points to the MIKE FLOOD model; and
- updating the tail water level to account for a 0.8 m rise in sea level to 2100.

Assessing the change in rainfall intensities relative to existing IFD data presented in **Table 3-3** suggest that:

- the climate change 50 Year ARI, 24 hour intensity of 20.31mm/h is just above the existing 100 Year ARI, 24 hour intensity; and

- the climate change 100 Year ARI, 24 hour intensity of 23.03mm/h is between the existing 200 and 500 Year ARI, 24 hour intensities.

It should be noted that the following assumptions are implied in this methodology:

- initial and continuing rainfall losses remain unchanged from present conditions;
- rainfall temporal patterns remain unchanged from present conditions;
- catchment surface retardances remain unchanged from present conditions;
- channel and floodplain hydraulic roughness remains unchanged from present conditions; and
- fraction impervious remains unchanged from present conditions.

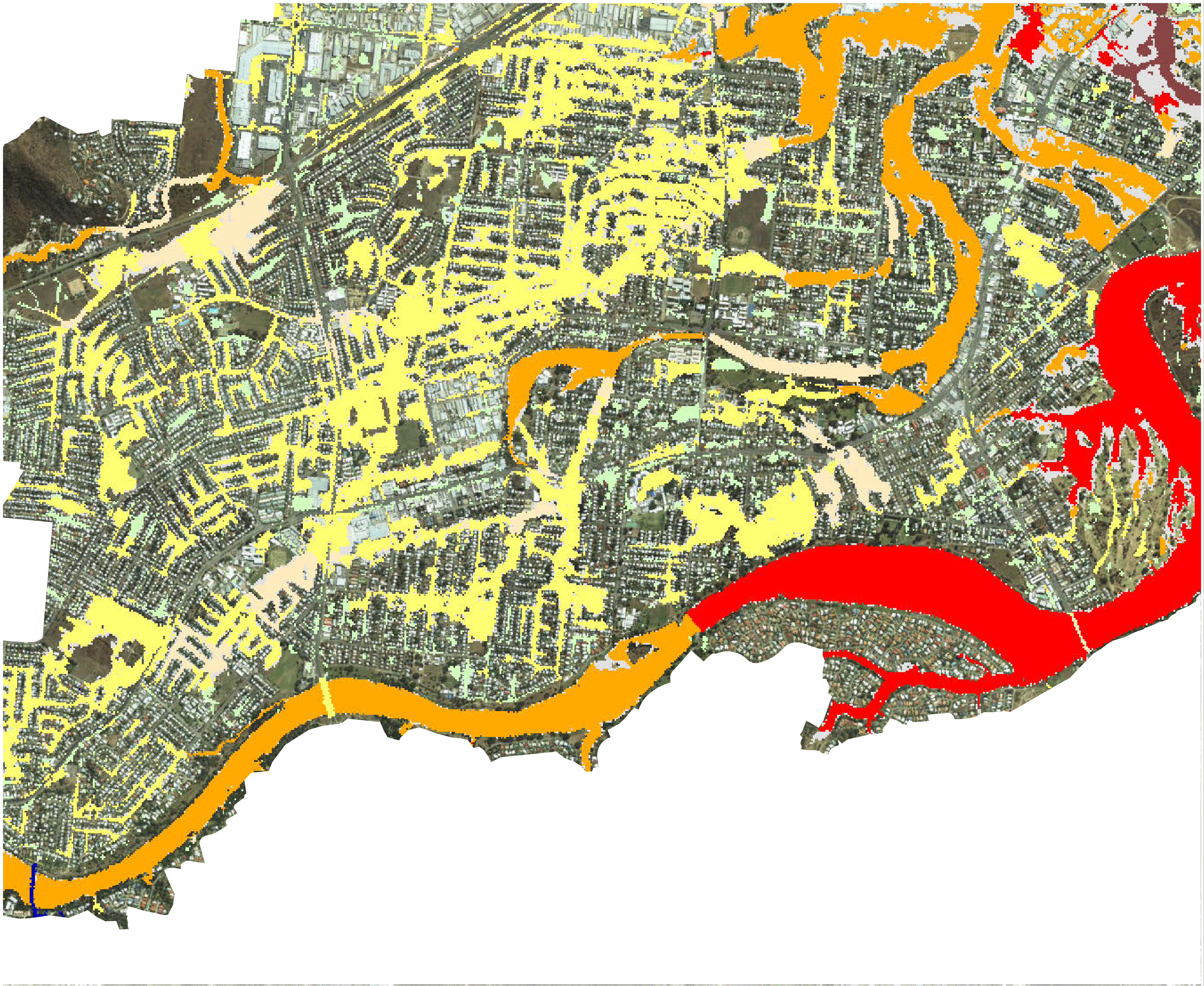
Both the 50 Year ARI and 100 Year ARI, 24 hour design event floods were evaluated for the sea level rise and increased rainfall intensity condition. **Figures 6-1** and **6-2** show the changes in flood levels for the 50 Year ARI and 100 Year ARI floods respectively.

For the 50 Year ARI:

- flood level increases through a majority of the urban area are generally under 50 mm;
- areas downstream of Balls Lane in Mindham Park Drain, Gerard Street in Hopkins Street Drain and within Hermit Park drain have flood level increases in excess of 100 mm; and
- there are increases in extent of inundation within Rosslea, Hermit Park, Railway Estate, northern Pimlico and northern Hyde Park.

For the 100 Year ARI:

- flood level increases through a majority of the urban area are in the order of 50 mm;
- areas downstream of Balls Lane in Mindham Park Drain and Hopkins Street in Hopkins Street Drain have flood level increases in excess of 100 mm;
- areas downstream of Townsend Street in Mindham Park Drain and within the Hermit Park Drain area have flood level increases in excess of 300 mm;
- there are significant increases in extent of inundation within Rosslea, Hermit Park, Railway Estate, northern Pimlico and northern Hyde Park.



ROSS CREEK FLOOD STUDY 50 Y ARI & CLIMATE CHANGE

Figure 6-1a

LEGEND

Water Level Difference (m)

- Previously Inundated
- < -1
- -1 - -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- > 1
- Now Inundated

2100 Climate Change includes 0.8m sea level rise & 15% increase in rainfall intensity

N

City of Townsville

SCALE: 1:20,000 @A3

200 100 0 200 400 600 Metres

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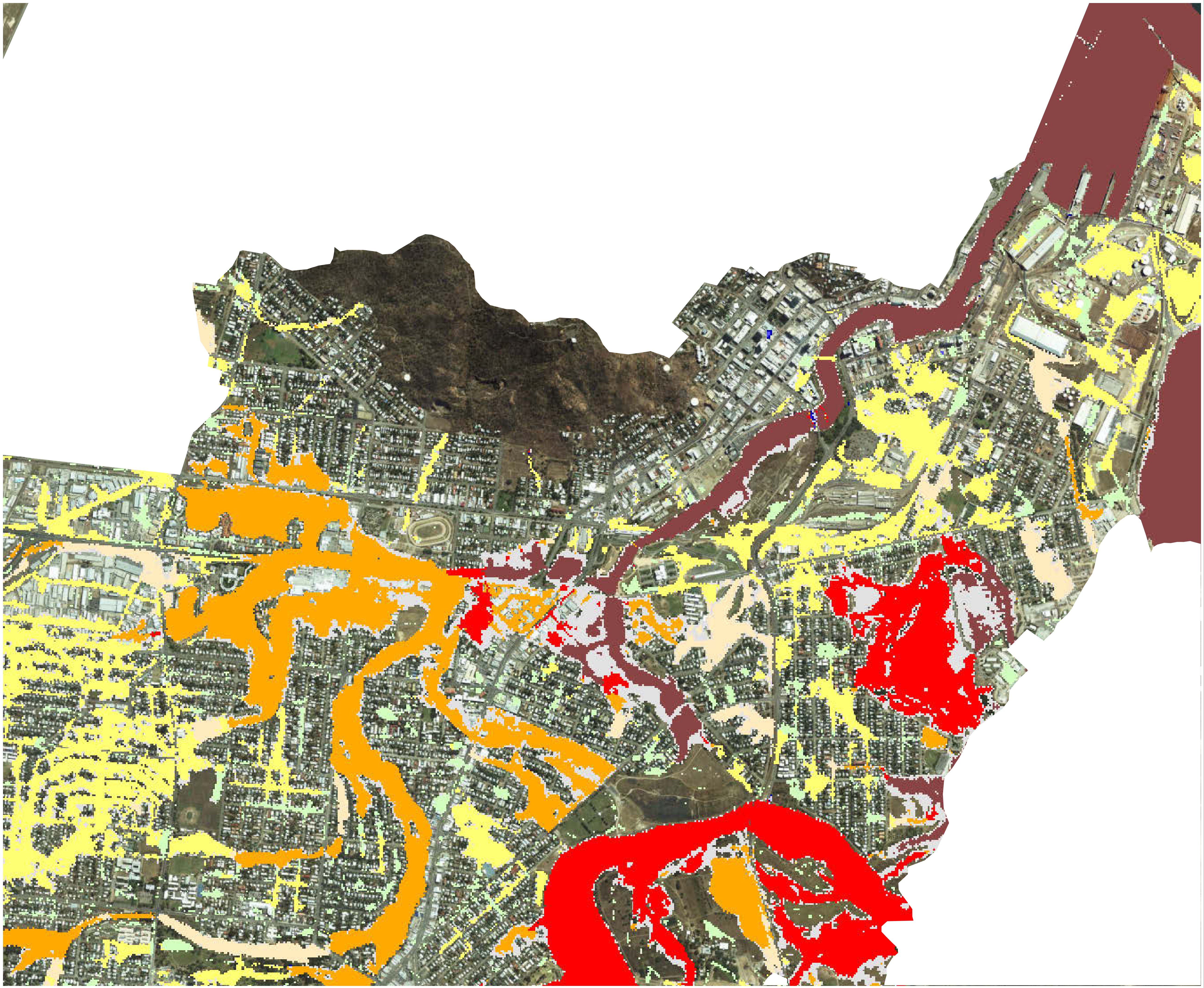
ROSS CREEK FLOOD STUDY 50 Y ARI & CLIMATE CHANGE

Figure 6-1b



LEGEND

Water Level Difference (m)

- Previously Inundated
- < -1
- -1 - -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- > 1
- Now Inundated

2100 Climate Change includes 0.8m sea level rise & 15% increase in rainfall intensity

N

City of Townsville

SCALE: 1:20,000 @A3

200 100 0 200 400 600 Metres

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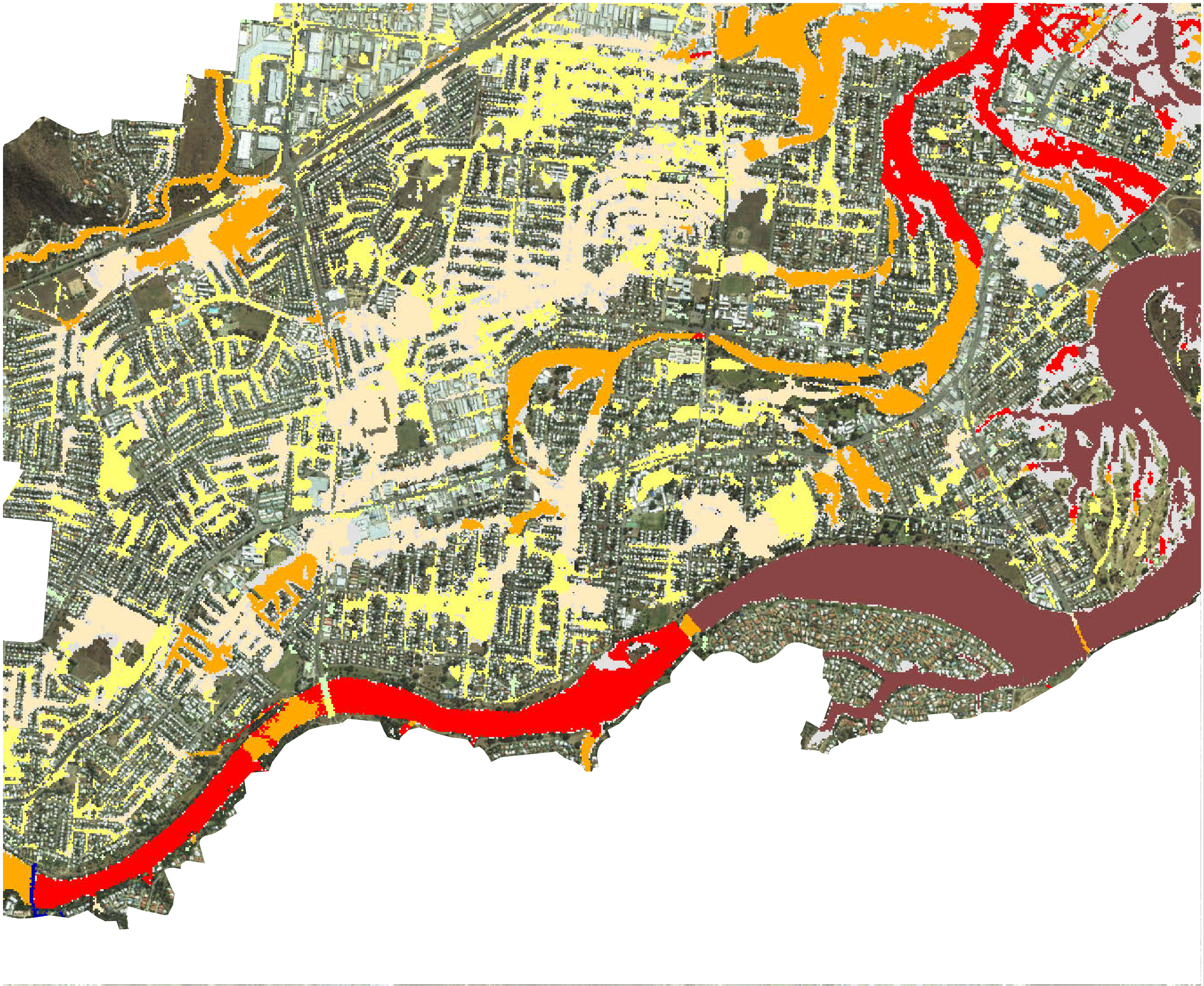

ROSS CREEK FLOOD STUDY 100 Y ARI & CLIMATE CHANGE

Figure 6-2a

LEGEND

Water Level Difference (m)

- Previously Inundated
- < -1
- -1 - -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- > 1
- Now Inundated

2100 Climate Change includes 0.8m sea level rise & 15% increase in rainfall intensity

N

City of Townsville

SCALE: 1:20,000 @A3

200 100 0 200 400 600 Metres

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