10. SENSITIVITY ANALYSIS

10.1. Overview

A number of sensitivity analyses were undertaken to establish the variation in design flood levels and flows that may occur if different parameter assumptions were made. These sensitivity scenarios are summarised in Table 19.

Table 19: Overview of Sensitivity Analyses

Scenario	Description
Catchment Lag Factor, "C"	The catchment lag factor value was increased and decreased by 20%
Rainfall Losses	The rainfall initial and continuing losses were increased and decreased by 10 mm and 1 mm/h, respectively.
Mannings "n"	The hydraulic roughness values were increased and decreased by 20%
Pit Blockages	Sensitivity to blockage of pits was assessed for 0% and 50% blockage.
Culvert and Bridge Blockage	Sensitivity to blockage of culverts and bridges on open channel sections was assessed for: • 0% blockage for all bridges and culverts; • 10% increased blockage for all bridges and 50% blockage for culverts; and • 20% increased blockage for all bridges and 75% blockage for culverts.
Energy Losses	The energy loss (K parameter) at bridges was increased by 0.2
Initial Water Level	The initial water level in the lagoon was increased and decreased by 0.2 m.

The sensitivity scenario results were analysed for the 1% AEP event and for the 5% AEP for some scenarios. A summary of peak flood level and peak flow differences at various locations are provided in:

- Table 20 for variations in the catchment lag factor (C);
- Table 21 for variations in rainfall losses;
- Table 22 for variations in roughness;
- Table 24 for variations in structure blockage;
- Table 26 for variations in energy losses; and
- Table 27 for variations in initial water level; and

10.2. Catchment Lag Parameter

The catchment lag parameter was increased and decreased by 20%. The increase in the lag factor results in a slight decrease and delay in peak flows, while a decrease in the lag factor generally slightly increases and speeds up the peak catchment flows. This does not necessarily occur immediately in the vicinity of the Curl Curl Lagoon berm since peak flows at this location are dependent on lagoon opening conditions. Changing the lag parameter changes the timing of the overtopping and flow through the breakout compared to the timing of the catchment runoff.

The results of the catchment lag parameter sensitivity analysis are provided in Table 20. The results indicate peak flows are relatively insensitive to the lag parameter assumption in comparison to other key inputs such as rainfall intensity.

Table 20: Sensitivity of 1% AEP Peak Flow (m^3/s) to the Lag Factor

ID	Location	1% AEP Peak Flow (m^3/s)	1% AEP (-20% C)	1% AEP (+20% C)
Q01	Upstream of The Kilns (West)	5.7	0.2	-0.1
Q02	Upstream of The Kilns (East)	2.0	0.1	-0.1
Q03	Upstream Consul Road	10.0	0.4	-0.6
Q04	Consul Road	4.7	0.3	-0.4
Q05	Gulliver Street	9.4	0.2	-0.3
Q06	Downstream Winbourne Road	10.1	0.1	-0.1
Q07	Upstream Harbord Road	24.1	0.2	-0.2
Q08	Downstream Harbord Road	30.2	0.2	-0.2
Q09	Upstream Western Footbridge	33.7	0.1	-0.1
Q10	Upstream Eastern Footbridge	41.9	0.1	-0.1
Q11	Downstream Rock Weir	50.7	0.0	-0.1
Q12	Downstream Griffin Road	73.4	0.0	-0.3
Q13	Curl Curl Lagoon Berm	90.0	6.5	-9.6
Q14	Adams Street	1.6	0.0	0.0
Q15	Bennett Street	2.4	0.0	0.0
Q16	Manuela Place	0.3	0.0	0.0
Q17	Pitt Road	1.4	0.0	0.0
Q18	Abbott Road	5.9	0.2	-0.2
Q19	Upstream Community Centre (Abbott Road)	1.7	0.0	-0.1
Q20	Upstream Reub Hudson Oval (Abbott Road)	1.2	0.1	0.1
Q21	Downstream Northern Beaches Secondary College	0.3	0.0	0.0

10.3. Rainfall Losses

The sensitivity of peak flows to initial loss was investigated by increasing and decreasing the initial loss by 10 mm and continuing loss by 1 mm/hr. It was found that flows were relatively insensitive to these rainfall loss variations. Decreasing the initial loss or continuing loss typically resulted in a slight increase in peak flows, while increasing the initial loss typically resulted in a slight decrease in peak flows. This does not necessarily occur immediately upstream of the berm where outflows are dominated by the timing of the entrance breakout.

The results of the rainfall losses sensitivity analysis are shown in Table 21.

Table 21: Sensitivity of 1% AEP peak flows (m^3/s) to rainfall losses

ID	Location	1% AEP Flows (m^3/s)	1% AEP (-10 mm IL)	1% AEP (+10 mm IL)	1% AEP (- 1 mm/hr CL)	1% AEP (+1 mm/hr CL)
Q01	Upstream of The Kilns (West)	5.7	0.1	-0.4	0.0	0.0
Q02	Upstream of The Kilns (East)	2.0	0.1	-0.3	0.0	0.0
Q03	Upstream Consul Road	10.0	0.4	-1.3	0.0	0.0
Q04	Consul Road	4.7	0.3	-1.4	0.0	0.0
Q05	Gulliver Street	9.4	0.6	-1.6	0.1	-0.1
Q06	Downstream Winbourne Road	10.1	0.2	-0.4	0.0	-0.1
Q07	Upstream Harbord Road	24.1	0.6	-1.0	0.0	-0.1
Q08	Downstream Harbord Road	30.2	0.9	-1.6	0.1	-0.1
Q09	Upstream Western Footbridge	33.7	0.8	-1.6	0.1	-0.1
Q10	Upstream Eastern Footbridge	41.9	0.9	-1.8	0.1	-0.1
Q11	Downstream Rock Weir	50.7	0.8	-1.6	0.1	-0.1
Q12	Downstream Griffin Road	73.4	0.0	-2.5	0.1	-0.1
Q13	Curl Curl Lagoon Berm	90.0	9.0	-7.9	1.4	-1.9
Q14	Adams Street	1.6	0.0	-0.1	0.0	0.0
Q15	Bennett Street	2.4	0.0	-0.2	0.0	0.0
Q16	Manuela Place	0.3	0.0	0.0	0.0	0.0
Q17	Pitt Road	1.4	0.0	-0.1	0.0	0.0
Q18	Abbott Road	5.9	0.3	-0.8	0.0	-0.1
Q19	Upstream Community Centre (Abbott Road)	1.7	0.0	-0.1	0.0	0.0
Q20	Upstream Reub Hudson Oval (Abbott Road)	1.2	0.1	0.0	0.0	0.0
Q21	Downstream Northern Beaches Secondary College	0.3	0.0	-0.1	0.0	0.0

10.4. Roughness Variations

Overall peak flood level results were shown to be relatively insensitive to +/-20% variations in the roughness parameter. Varying the Mannings 'n' by 20% typically resulted in a peak flood height difference within ± 0.1 m. The greatest changes occurred in the Greendale Creek channel between Harbord Road and the western footbridge. Shallow overland flow areas are relatively insensitive to roughness variations as shown in Table 22.

Table 22: Roughness Sensitivity Analysis – Change in Peak Flood Level (m)

ID	Location	5% AEP Level (mAHD)	5% AEP -20% Roughness	5% AEP +20% Roughness	1% AEP Level (mAHD)	1% AEP -20% Roughness	1% AEP +20% Roughness
H01	McKillop Road	129.14	0.00	0.00	129.28	0.00	0.00
H02	Upstream 44 Consul Road	30.87	-0.01	0.01	31.03	0.00	-0.01
H03	Consul Road	30.59	0.00	0.00	30.75	-0.02	0.01
H04	Gulliver Street	26.35	-0.01	0.01	26.45	-0.02	0.01
H05	West of Brookvale Oval (Pittwater Road)	22.71	-0.01	0.01	22.78	0.00	0.01
H06	Pittwater Road	19.16	0.00	0.00	19.26	-0.01	0.01
H07	Winbourne Road	15.72	-0.01	0.00	15.75	0.00	0.01
H08	Upstream Chard Road	11.91	0.06	-0.07	12.39	-0.02	-0.01
H09	Ethel Avenue	6.46	-0.04	0.03	6.69	-0.04	0.03
H10	Upstream Harbord Road	6.05	-0.01	0.00	6.32	-0.01	0.01
H11	Harbord Road	5.06	0.01	0.00	5.20	0.00	0.00
H12	Downstream Harbord Road	4.13	-0.15	0.13	4.37	-0.14	0.12
H13	Downstream Harbord Road GPT (Gross Pollutant Trap)	4.03	-0.16	0.13	4.27	-0.15	0.13
H14	Downstream Rock Weir	2.76	0.01	-0.03	2.86	0.03	0.00
H15	Upstream Griffin Road	2.71	-0.01	0.01	2.82	-0.01	0.00
H16	Downstream Griffin Road	2.67	0.01	0.04	2.79	-0.03	0.03
H17	Upstream Berm	2.64	-0.01	-0.04	2.71	0.03	-0.04
H18	Bennett Street	9.43	0.00	0.00	9.47	0.00	0.00
H19	Mitchell Road	10.23	0.00	0.00	10.37	-0.01	0.01
H20	Pitt Road	13.40	0.00	0.01	13.46	-0.01	0.01
H21	Abbott Road	4.11	-0.01	0.00	4.15	0.00	0.01
H22	Upstream Curl Curl Youth and Community Centre (Abbott Road)	3.74	0.00	0.00	3.75	-0.01	0.01
H23	Upstream Reub Hudson Oval (Abbott Road)	10.45	0.00	0.00	10.59	0.00	0.00
H24	Downstream Northern Beaches Secondary College	10.45	0.00	0.00	10.60	0.00	0.00
H25	Manuela Place	5.33	-0.01	0.01	5.35	0.00	0.01
H26	Upstream Western Footbridge	3.61	-0.13	0.10	3.82	-0.11	0.10
H27	Downstream Western Footbridge	3.60	-0.12	0.10	3.80	-0.11	0.10
H28	Upstream Eastern Footbridge	2.80	0.03	0.00	2.93	0.03	0.02
H29	Downstream Eastern Footbridge	2.77	0.02	-0.01	2.86	0.04	0.02

10.5. Blockage Variations

The adopted pit blockage was 25%. A sensitivity analysis was undertaken to see the effect of 0% blockage and 50% blockage. The change in peak flood levels is shown in Table 23. The results indicate that peak flood levels are relatively insensitive to pit blockage assumptions.

Table 23: Pit Blockage Sensitivity Analysis – Change in Peak Flood Level (m)

ID	Location	5% AEP Level (mAHD)	5% AEP 0% Blockage	5% AEP 50% Blockage	1% AEP Level (mAHD)	1% AEP 0% Blockage	1% AEP 50% Blockage
H01	McKillop Road	129.14	0.00	0.00	129.28	0.00	0.00
H02	Upstream 44 Consul Road	30.87	-0.01	-0.01	31.03	-0.01	-0.01
H03	Consul Road	30.59	-0.04	-0.04	30.75	-0.02	-0.02
H04	Gulliver Street	26.35	0.00	0.00	26.45	-0.01	-0.01
H05	West of Brookvale Oval (Pittwater Road)	22.71	0.01	0.01	22.78	0.00	0.00
H06	Pittwater Road	19.16	0.00	0.00	19.26	0.00	0.00
H07	Winbourne Road	15.72	0.00	0.00	15.75	0.00	0.00
H08	Upstream Chard Road	11.91	0.00	0.00	12.39	-0.02	-0.02
H09	Ethel Avenue	6.46	0.02	0.02	6.69	0.02	0.02
H10	Upstream Harbord Road	6.05	0.02	0.02	6.32	0.02	0.02
H11	Harbord Road	5.06	0.01	0.01	5.20	0.01	0.01
H12	Downstream Harbord Road	4.13	0.01	0.01	4.37	0.02	0.02
H13	Downstream Harbord Road GPT (Gross Pollutant Trap)	4.03	0.01	0.01	4.27	0.02	0.02
H14	Downstream Rock Weir	2.76	0.01	0.01	2.86	0.01	0.01
H15	Upstream Griffin Road	2.71	0.00	0.00	2.82	0.00	0.00
H16	Downstream Griffin Road	2.67	-0.01	-0.01	2.79	-0.01	-0.01
H17	Upstream Berm	2.64	0.01	0.01	2.71	0.01	0.01
H18	Bennett Street	9.43	0.00	0.00	9.47	0.00	0.00
H19	Mitchell Road	10.23	-0.02	-0.02	10.37	-0.01	-0.01
H20	Pitt Road	13.40	-0.01	-0.01	13.46	-0.01	-0.01
H21	Abbott Road	4.11	0.00	0.00	4.15	0.00	0.00
H22	Upstream Curl Curl Youth and Community Centre (Abbott Road)	3.74	0.00	0.00	3.75	0.00	0.00
H23	Upstream Reub Hudson Oval (Abbott Road)	10.45	-0.01	-0.01	10.59	-0.01	-0.01
H24	Downstream Northern Beaches Secondary College	10.45	-0.01	-0.01	10.60	0.00	0.00
H25	Manuela Place	5.33	0.00	0.00	5.35	0.00	0.00
H26	Upstream Western Footbridge	3.61	0.01	0.01	3.82	0.02	0.02
H27	Downstream Western Footbridge	3.60	0.01	0.01	3.80	0.01	0.01
H28	Upstream Eastern Footbridge	2.80	0.01	0.01	2.93	0.00	0.00
H29	Downstream Eastern Footbridge	2.77	0.01	0.01	2.86	0.01	0.01

Culvert and bridge blockages typically have a significant impact on peak flood levels upstream and downstream of hydraulic structures. The greatest impact on peak flood levels occurs around Consul Road, Chard Road and Harbord Road, with peak flood level increases of up to 0.7 m. These impacts are relatively localised to the immediate vicinity of the structures that are

potentially subject to blockage. The culvert and bridge blockage sensitivity results are shown in Table 24 (5% AEP) and Table 25 (1% AEP).

Table 24: Culvert / Bridge Blockage Sensitivity – 5% AEP Change in Peak Flood Level (m)

ID	Location	5% AEP Level (mAHD)	0% Blockage	+10% Bridge 50% Culvert Blockage	+20% Bridge 75% Culvert Blockage
H01	McKillop Road	129.14	0.00	0.00	0.00
H02	Upstream 44 Consul Road	30.87	-0.03	0.07	0.19
H03	Consul Road	30.59	-0.01	0.02	0.12
H04	Gulliver Street	26.35	0.00	0.01	0.02
H05	West of Brookvale Oval (Pittwater Road)	22.71	0.00	0.00	0.00
H06	Pittwater Road	19.16	0.00	0.00	0.00
H07	Winbourne Road	15.72	0.00	0.00	-0.01
H08	Upstream Chard Road	11.91	-0.15	0.32	0.73
H09	Ethel Avenue	6.46	-0.06	0.10	0.24
H10	Upstream Harbord Road	6.05	-0.42	0.30	0.52
H11	Harbord Road	5.06	0.00	0.12	0.24
H12	Downstream Harbord Road	4.13	0.02	-0.02	-0.03
H13	Downstream Harbord Road GPT (Gross Pollutant Trap)	4.03	0.02	-0.02	-0.03
H14	Downstream Rock Weir	2.76	0.00	-0.01	-0.03
H15	Upstream Griffin Road	2.71	0.00	0.00	0.01
H16	Downstream Griffin Road	2.67	0.00	0.00	0.03
H17	Upstream Berm	2.64	0.00	-0.01	-0.03
H18	Bennett Street	9.43	0.00	0.00	0.00
H19	Mitchell Road	10.23	0.00	0.01	0.01
H20	Pitt Road	13.40	0.00	0.01	0.00
H21	Abbott Road	4.11	0.00	0.00	0.00
H22	Upstream Curl Curl Youth and Community Centre (Abbott Road)	3.74	0.00	0.00	0.00
H23	Upstream Reub Hudson Oval (Abbott Road)	10.45	0.00	0.00	0.00
H24	Downstream Northern Beaches Secondary College	10.45	0.00	0.00	0.00
H25	Manuela Place	5.33	0.00	0.00	0.00
H26	Upstream Western Footbridge	3.61	0.02	-0.02	-0.02
H27	Downstream Western Footbridge	3.60	0.02	-0.02	-0.03
H28	Upstream Eastern Footbridge	2.80	0.00	-0.01	-0.01
H29	Downstream Eastern Footbridge	2.77	0.00	-0.01	-0.03

Table 25: Culvert / Bridge Blockage Sensitivity – 1% AEP Change in Peak Flood Level (m)

ID	Location	1% AEP Level (mAHD)	0% Blockage	+10% Bridge 50% Culvert Blockage	+20% Bridge 75% Culvert Blockage
H01	McKillop Road	129.28	0.00	0.00	0.00
H02	Upstream 44 Consul Road	31.03	-0.01	0.01	0.13
H03	Consul Road	30.75	0.00	0.01	0.05
H04	Gulliver Street	26.45	0.00	0.00	0.00
H05	West of Brookvale Oval (Pittwater Road)	22.78	0.00	0.00	0.00
H06	Pittwater Road	19.26	0.00	0.00	0.00
H07	Winbourne Road	15.75	0.00	0.00	0.00
H08	Upstream Chard Road	12.39	-0.07	0.14	0.44
H09	Ethel Avenue	6.69	-0.06	0.09	0.18
H10	Upstream Harbord Road	6.32	-0.24	0.21	0.38
H11	Harbord Road	5.20	-0.08	0.09	0.18
H12	Downstream Harbord Road	4.37	0.01	-0.01	-0.01
H13	Downstream Harbord Road GPT (Gross Pollutant Trap)	4.27	0.01	-0.01	-0.01
H14	Downstream Rock Weir	2.86	0.00	-0.01	-0.01
H15	Upstream Griffin Road	2.82	0.00	0.00	0.00
H16	Downstream Griffin Road	2.79	0.00	0.01	0.02
H17	Upstream Berm	2.71	0.00	-0.01	-0.03
H18	Bennett Street	9.47	0.00	0.00	0.00
H19	Mitchell Road	10.37	0.00	0.00	0.00
H20	Pitt Road	13.46	0.00	0.00	0.00
H21	Abbott Road	4.15	0.00	0.00	0.00
H22	Upstream Curl Curl Youth and Community Centre (Abbott Road)	3.75	0.00	0.00	0.00
H23	Upstream Reub Hudson Oval (Abbott Road)	10.59	0.00	0.00	0.00
H24	Downstream Northern Beaches Secondary College	10.60	0.00	0.00	0.00
H25	Manuela Place	5.35	0.00	0.00	0.00
H26	Upstream Western Footbridge	3.82	0.02	0.00	0.00
H27	Downstream Western Footbridge	3.80	0.02	-0.01	-0.01
H28	Upstream Eastern Footbridge	2.93	0.01	0.01	0.02
H29	Downstream Eastern Footbridge	2.86	0.00	0.00	0.00

10.6. Energy Loss Variations

The results of the energy losses sensitivity analysis indicate that increasing the energy losses due to piers at hydraulic structures typically results in peak flood level increases of no more than 0.01 m upstream and downstream of the structure. Results are insensitive to these assumptions as shown in Table 26.

Table 26: Bridge Energy Loss Sensitivity Analysis – Change in Peak Flood Level (m)

ID	Location	5% AEP Level (mAHD)	5% AEP Increased Energy Losses	1% AEP Level (mAHD)	1% AEP Increased Energy Losses
H01	McKillop Road	129.14	0.00	129.28	0.00
H02	Upstream 44 Consul Road	30.87	0.00	31.03	-0.01
H03	Consul Road	30.59	0.00	30.75	0.00
H04	Gulliver Street	26.35	0.00	26.45	0.00
H05	West of Brookvale Oval (Pittwater Road)	22.71	0.00	22.78	0.00
H06	Pittwater Road	19.16	0.00	19.26	0.00
H07	Winbourne Road	15.72	0.00	15.75	0.00
H08	Upstream Chard Road	11.91	0.00	12.39	0.00
H09	Ethel Avenue	6.46	0.00	6.69	0.00
H10	Upstream Harbord Road	6.05	0.00	6.32	0.00
H11	Harbord Road	5.06	0.00	5.20	0.00
H12	Downstream Harbord Road	4.13	0.00	4.37	0.00
H13	Downstream Harbord Road GPT (Gross Pollutant Trap)	4.03	0.00	4.27	0.00
H14	Downstream Rock Weir	2.76	0.00	2.86	0.00
H15	Upstream Griffin Road	2.71	0.00	2.82	0.00
H16	Downstream Griffin Road	2.67	0.00	2.79	0.00
H17	Upstream Berm	2.64	0.00	2.71	0.00
H18	Bennett Street	9.43	0.00	9.47	0.00
H19	Mitchell Road	10.23	0.00	10.37	0.00
H20	Pitt Road	13.40	0.00	13.46	0.00
H21	Abbott Road	4.11	0.00	4.15	0.00
H22	Upstream Curl Curl Youth and Community Centre (Abbott Road)	3.74	0.00	3.75	0.00
H23	Upstream Reub Hudson Oval (Abbott Road)	10.45	0.00	10.59	0.00
H24	Downstream Northern Beaches Secondary College	10.45	0.00	10.60	0.00
H25	Manuela Place	5.33	0.00	5.35	0.00
H26	Upstream Western Footbridge	3.61	0.00	3.82	0.00
H27	Downstream Western Footbridge	3.60	0.00	3.80	0.00
H28	Upstream Eastern Footbridge	2.80	0.01	2.93	0.01
H29	Downstream Eastern Footbridge	2.77	0.00	2.86	0.00
H01	McKillop Road	129.14	0.00	129.28	0.00
H02	Upstream 44 Consul Road	30.87	0.00	31.03	-0.01
H03	Consul Road	30.59	0.00	30.75	0.00
H04	Gulliver Street	26.35	0.00	26.45	0.00
H05	West of Brookvale Oval (Pittwater Road)	22.71	0.00	22.78	0.00
H06	Pittwater Road	19.16	0.00	19.26	0.00
H07	Winbourne Road	15.72	0.00	15.75	0.00

10.7. Initial Water Level Variations

The results of the sensitivity analysis indicate that reducing the initial water level by 0.2 m typically results in peak water level decreases of less than 0.1 m, while increasing the initial water level typically results in peak water level increases of less than 0.1 m. This is because peak flood levels in the lower catchment are dominated by entrance conditions and inflows rather than initial water level as shown in Table 27.

Table 27: Initial Water Level Sensitivity Analysis – Change in Peak Flood Level (m)

ID	Location	5% AEP Level (mAHD)	5% AEP -0.2 m IWL	5% AEP - +0.2 m IWL	1% AEP Level (mAHD)	1% AEP -0.2 m IWL	1% AEP +0.2 m IWL
H01	McKillop Road	129.14	0.00	0.00	129.28	0.00	0.00
H02	Upstream 44 Consul Road	30.87	0.00	0.00	31.03	-0.01	0.00
H03	Consul Road	30.59	0.00	0.00	30.75	0.00	0.00
H04	Gulliver Street	26.35	0.00	0.00	26.45	0.00	0.00
H05	West of Brookvale Oval (Pittwater Road)	22.71	0.00	0.00	22.78	0.00	0.00
H06	Pittwater Road	19.16	0.00	0.00	19.26	0.00	0.00
H07	Winbourne Road	15.72	0.00	0.00	15.75	0.00	0.00
H08	Upstream Chard Road	11.91	0.00	0.00	12.39	0.00	0.00
H09	Ethel Avenue	6.46	0.00	0.00	6.69	0.00	0.00
H10	Upstream Harbord Road	6.05	0.00	0.00	6.32	0.00	0.00
H11	Harbord Road	5.06	0.00	0.00	5.20	0.00	0.00
H12	Downstream Harbord Road	4.13	-0.01	0.01	4.37	-0.01	0.01
H13	Downstream Harbord Road GPT (Gross Pollutant Trap)	4.03	-0.01	0.00	4.27	-0.01	0.01
H14	Downstream Rock Weir	2.76	-0.04	0.01	2.86	-0.02	0.02
H15	Upstream Griffin Road	2.71	0.00	-0.01	2.82	0.00	-0.01
H16	Downstream Griffin Road	2.67	0.04	0.02	2.79	0.01	-0.03
H17	Upstream Berm	2.64	-0.04	-0.05	2.71	-0.01	0.03
H18	Bennett Street	9.43	0.00	0.00	9.47	0.00	0.00
H19	Mitchell Road	10.23	0.00	0.00	10.37	0.00	0.00
H20	Pitt Road	13.40	0.01	0.00	13.46	0.00	0.00
H21	Abbott Road	4.11	0.00	0.00	4.15	0.00	0.00
H22	Upstream Curl Curl Youth and Community Centre (Abbott Road)	3.74	0.00	0.00	3.75	0.00	0.00
H23	Upstream Reub Hudson Oval (Abbott Road)	10.45	0.00	0.00	10.59	0.00	0.00
H24	Downstream Northern Beaches Secondary College	10.45	0.00	0.00	10.60	0.00	0.00
H25	Manuela Place	5.33	0.00	0.00	5.35	0.00	0.00
H26	Upstream Western Footbridge	3.61	-0.01	0.00	3.82	-0.01	0.01
H27	Downstream Western Footbridge	3.60	-0.01	0.00	3.80	-0.01	0.00
H28	Upstream Eastern Footbridge	2.80	-0.01	0.03	2.93	0.00	-0.01
H29	Downstream Eastern Footbridge	2.77	-0.02	0.02	2.86	-0.01	0.02

11. CLIMATE CHANGE IMPACTS

Climate change is expected to increase sea levels and also short duration rainfall intensities from east coast convective storm events. It is typical practice in catchment flood studies under the NSW flood program to model scenarios incorporating the effects of these impacts from climate change to understand the potential changes in flood behaviour.

Various projections of the likely increases to sea levels are available. In 2009 the NSW government published guideline for incorporating sea level rise benchmarks in coastal flood risk assessments (Reference 20), which provides a consistent set of sea level rise scenarios for undertaking land use planning for 2050 (0.4 m increase over 1990 levels) and 2100 (0.9 m increase over 1990 levels).

Any increase in design flood rainfall intensities will increase the frequency, depth and extent of inundation across the catchment. The design rainfall information currently provided by the Bureau of Meteorology is based on historical climate data and does not currently include any allowance for likely increases to convective storm rainfall intensity. Australian Rainfall and Runoff 2019 (Reference 1, Book 1 Chapter 6) provides some guidance about consideration of the impacts of climate change on design rainfall intensities. It suggests assuming that rainfall intensities can be assumed to scale up by about 5% per degree of average surface warming. For this study, Council requested that a scenario be modelled with a 10% rainfall intensity increase, corresponding to approximately 2 degrees warming.

It has also been suggested that the cyclone belt may move further southwards. The possible impacts of this outcome on design rainfalls cannot be ascertained at this time as there is insufficient information about the mechanisms that determine the movement of cyclones under future climate scenarios.

Projected increases to evaporation are also an important consideration because increased evaporation would lead to generally drier catchment conditions, resulting in lower runoff from rainfall. Mean annual rainfall is projected to decrease, which will also result in generally dryer catchment conditions. This is a consideration for the Greendale Creek catchment where the initial water level in Curl Curl Lagoon is an important determinant on whether flooding will occur in the lower catchment. Under drier conditions, Curl Curl Lagoon will be less full on average when rain occurs, and a larger proportion of the initial rain will be collected in the lagoon. However the sensitivity analysis has indicated that flooding in the lower catchment is relatively insensitive to initial water levels in Curl Curl Lagoon.

The current NSW State Government's advice recommends sensitivity analysis on flood modelling should be undertaken to develop an understanding of the effect of various levels of change in the hydrologic regime on the project at hand (Reference 14). Specifically, it is suggested that rainfall intensity and sea level rise increase scenarios should be considered. The following climate change scenarios were assessed for this study:

- Comparison of the current 0.5% AEP and 0.2% AEP rainfall intensity with the 1% AEP rainfall intensity (per the relevant guideline, Reference 14). These events provide an

indication of how 1% AEP flood levels would change if the rainfall intensity increases to the point that it matches either the current 0.5% AEP (a 7.8% increase in intensity) or 0.2% AEP (a 23% increase in intensity).

- Comparison of the 0.4 m and 0.9 m sea level rise benchmarks against current conditions (per the guidance in Reference 20). These scenarios assumed that the typical sand berm height at the lagoon entrance would rise by an amount equivalent to the sea level rise.
- Combined scenarios with both rainfall increase and sea level rise, assuming a 10% increase in rainfall intensity (corresponding to approximately 2 degrees of average surface temperature increases per guidance in Reference 1) and the 0.4 m and 0.9 m sea level rise benchmarks.

The climate change impact results are shown in Table 28, with maps provided in Appendix G.

The results indicate that there would be widespread impact from changes to design rainfalls relative to other design storm assumptions from Section 10. Increases in rainfall would result in an increase in peak flood levels at most of the locations analysed. The largest variations in flood levels are in ponded areas and in the lower catchment with modelled peak flood levels up to 0.2 m higher in the 0.2% AEP event (23% intensity increase relative to the 1% AEP event).

Peak flood levels in the lower catchment are substantially higher in the sea level rise scenarios while flood levels in overland flow areas in the upper catchment are typically unaffected. Peak flood levels just downstream of Griffin Road Bridge are up to 0.4 m and 0.8 m higher for the sea level rise scenarios of 0.4 m and 0.9 m, respectively.