SOUTH DUNEDIN FUTURES EFFICACY MODELLING

HYDRAULIC MODELLING REPORT

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HYDRAULIC MODELLING REPORT

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A	4/12/2025	For Review
B	20/02/2026	Draft Final
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EXECUTIVE SUMMARY

This report addresses the hydraulic modelling undertaken to assess the efficacy of the three directions for the future for flood management ("Futures") in the South Dunedin catchment for the South Dunedin Future (SDF) project covering:

- Futures and time horizons modelled
- Model build and inputs
- Results, including performance and the required upgrades for each Future.

The South Dunedin model was updated during the Integrated Catchment Model (ICM) project, a part of the 3 Waters Integrated System Plan programme of works in 2024, and forms the basis for all future scenario runs. This updated model includes the "quick win options" proposed by Dunedin City Council (DCC) form the baseline (Status quo) model. The status quo model was then adapted to the Short Term (2025), Medium Term (2060), and Long Term (2100) time horizons, considering climate change and sea level rise.

The three proposed Futures assessed are:

Future 3 – Protect: Focus on elevating land and pumping water, with upgrades to pipe and pump networks, land raising, new storage facilities, and a seawall along Portsmouth Drive to protect the catchment from rising sea levels and coastal flood events.

Future 4 – Restore: Utilizes open waterways for drainage, supported by storage basins, pump stations, and a seawall along Portsmouth Drive.

Future 5 – Reshape: Combines open waterways with land raising, storage basins, pump stations, and a seawall along Otaki Street, with designated floodable areas.

For each proposed Future, the modelling incorporates both upgrades and new infrastructure such as pipes, pump stations, and storage areas, along with land use changes. Infrastructure was scaled to meet increasing rainfall and tidal boundary conditions due to climate change. The Short-term time horizon amalgamates common infrastructure upgrades and is the same across all three proposed Futures, while medium- and long -term horizons for each Future introduce further enhancements and land use adjustments. The design level of service for the pipe network and pump stations was a 6 hour (critical duration) 10-year ARI event for the relevant period and for storage and open channels, the design level of service was a 6 hour 50-year ARI event. The design level of service included allowance for flooding on roads of up to 150mm in depth. This is consistent with 2025 engagement results from questions related to acceptable return periods of flooding.

Infrastructure additions for each of the three proposed Futures were conceptualised based on the applicable strategic approach (i.e. utilising waterways, including greenspace, and/or raising land), balancing infrastructure scale against flood reduction performance, and technical feasibility. Proposed locations of interventions were chosen to integrate as much as possible with the existing network to minimise disruption and enhance cost effectiveness. Optimisation of the exact layouts was not undertaken in this stage and will the subject of future work.

Key infrastructure additions to the network and findings of the modelling assessment are:

- The Catchment was split into smaller portions to decrease the scale of infrastructure required and relieve pressure on the Portobello Road pump station and outfall.

- Storage basins (Forbury Park, Tonga Park, and Bathgate Park across all three proposed Futures, and Culling Park in Future 4 – Restore and Future 5 – Reshape) to attenuate flood flows during the storm peaks and then release water when the network has sufficient capacity to receive it.
- Newly installed and upgraded pump station upgrades are proposed to manage increased flows and sea level rise, particularly at key outfalls.
- Open channels were added to the catchment for Future 4 – Restore and Future 5 – Reshape along alignments where the existing pipe network is shallow and more readily modified, with Future 3 – Protect relying on more extensive pipe upgrades.
- All Futures reduce flood hazard compared to the existing network, with significant reductions in property flooding for 10-year and 50-year rainfall events.
- Sensitivity analysis of duration show that longer duration rainfall events result in less surface flooding but greater storage basin volumes. Testing of RCP 4.5 climate change allowance, in comparison to RCP 8.5 used for the design runs, resulted in less flooding throughout the catchment.

Electronic model results and a summary of infrastructure upgrades were delivered to enable the completion of cost estimates and residual risk assessments for each of the three proposed Futures, supporting decision-making for long-term flood management in South Dunedin. Modelling indicates that the futures perform generally well, with fewer than 10% of properties with above floor flooding in the 100yr event.

1 BACKGROUND

Hydraulic modelling was completed to test the efficacy of the three potential directions for the future of flood management for South Dunedin, referred to as "Futures". This report provides an overview of the modelling inputs and approach, along with the modelling outcomes for the three proposed Futures.

Beca previously completed the *South Dunedin Catchment Stormwater System Performance Report*[1], which investigated the current performance of the system and corresponding flooding. The general level of service for the South Dunedin catchment appeared to be that of a 1 in 5-year ARI rainfall event (with some areas having a lower level of service). This modelling included current and future conditions (varying flood events, land use, and climate parameters) and predicted widespread flooding in Forbury, South Dunedin, St Kilda, and Caversham.

The model inputs developed for that project were carried through to this South Dunedin Futures efficacy modelling.

The three proposed Futures were:

- Future 3 – Protect
- Future 4 – Restore
- Future 5 – Reshape

The three Futures were split into the following time horizons:

- Short Term
- Medium Term – 2060
- Long Term – 2100

For each proposed Future the model assumes that the option is fully developed in the 2100 horizon, with the two preceding timeframes including upgrades to work towards that goal.

For this work, the three Futures were amalgamated for the Short Term time scale with common infrastructure that would then be carried through to the Medium and Long Term for each Future. No upgrades were added to the Short Term model that would then be removed in the Medium and Long Term in any Future.

The aim of this modelling is to demonstrate the efficacy of the three proposed Futures, while providing inputs for further comparison through cost estimates (completed by WSP) and residual risk assessments (completed by Tonkin+Taylor).

[1] (South Dunedin Catchment Stormwater System Performance Report, Beca 2025)

2 MODELLING INPUTS

2.1 EXISTING NETWORK SUMMARY

A summary of the existing hydraulic model and the model update completed in 2024 is contained in the *South Dunedin Catchment Stormwater System Performance Report*. Further changes and additions made to the base model for this work are detailed below.

The South Dunedin hydraulic model utilised for the SDF efficacy modelling includes four main component catchments:

- Portsmouth Drive in the northeast,
- South Dunedin throughout the central and southeast, and
- St Clair in the southwest.
- Orari in the northwest.

The first three of these catchments were included in the model utilised for the system performance modelling. The Orari catchment was added for the SDF efficacy modelling to account for upstream flows into the Wilkie Road Conduit (which conveys flows from the Orari catchment to its discharge location in the Otago harbour), as a new pump station proposed in this modelling discharges to this pipeline.

The upgrades proposed as Quick Wins, which are currently being implemented by DCC, were included in the base model. Some of these upgrades were altered (from the inputs supplied by DCC) or upsized in the efficacy modelling options. These Quick Wins were:

- Upgrade of the Forbury Road aqueduct
- Hillside Road main pump station discharging via a new main to the Orari Street outfall
- Portobello Road pipe bypassing the Portobello Road pump station

For more detailed information on the Quick Wins and the basis for their selection, refer to the DCC paper *South Dunedin Flood Alleviation – Short-term Options* (28th January 2025). This Council Paper is available on the DCC website.

Most model inputs (catchments, hydraulic roughness, infiltration rates etc) were developed during the system performance modelling and are detailed in the *South Dunedin Catchment Stormwater System Performance Report (Beca, 2025)*. An overview of the model inputs particular to this work is provided in Section 2.3 of this report, along with details on the approaches used to represent the upgrades.

2.2 MODELLED FUTURES

The components of the three proposed Futures are described at a high level below:

- Future 3 – Protect:
    - The principal of this Future is to utilise an upgraded network of pipes and pumps to drain South Dunedin, while also increasing resilience by raising and redeveloping land in the west of the catchment. Storage facilities would also be included to provide flow attenuation and reduce the required scale of conveyance infrastructure.

    - This is accompanied by new development areas in the east of the catchment and greenspaces to provide infiltration areas and reduce runoff.
    - A seawall along Portsmouth Drive, to protect the catchment from rising sea levels and coastal flood events.
- Future 4 – Restore:
    - The principal of this Future is to utilise waterways to provide large drainage capacity. Storage facilities would also be included to provide flow attenuation and increase overall system capacity. Pump stations and network upgrades would be required to support this infrastructure.
    - This is accompanied by new development areas in the east of the catchment proposed in the long term to provide areas for managed relocation and greenspaces to provide infiltration areas and reduce runoff.
    - A seawall along Portsmouth Drive, to protect the catchment from rising sea levels and coastal flood events.
- Future 5 – Reshape:
    - The principal of this Future is to utilise waterways to provide large conveyance capacity and Storage facilities would also be included to provide flow attenuation and increase overall system capacity, while also increasing resilience by raising and redeveloping land in the west of the catchment. Pump stations and network upgrades would be required to support this infrastructure.
    - This is accompanied by new development areas in the east of the catchment and greenspaces to provide infiltration areas and reduce runoff.
    - A seawall along Otaki Street, to protect the catchment from rising sea levels and coastal flood events. The area between Otaki Street and Portsmouth Drive could be redesignated to have floodable first floors or become a greenspace.

These descriptions are based on the Futures as defined for the multi-criteria analysis and shortlisting process. Details on the MCA process are contained in the report to DCC titled *South Dunedin Futures – Shortlist of Potential Adaption Futures*, which can be accessed on the DCC website. The three proposed Futures were further developed to enable them to be input into the model.

Additionally, the three proposed Futures were amalgamated into a single solution for the Short Term time horizon, with each future then modelled separately for the Medium Term and Long Term time horizons.

2.3 INPUTS

2.3.1 DESIGN RAINFALL CONDITIONS

The *South Dunedin Catchment Stormwater System Performance Report* states that the critical duration (rainfall duration that created the greatest depth of flooding) was the 6-hour event. A long duration event (24 hours) was tested in sensitivity runs.

The rainfall return periods to be tested were:

- 10-year ARI – Used to size the pipe network. The network was sized allowing for approximately 150mm (or less if deemed suitable) of water to remain on roads to reduce the cost and extent of the network upgrades.
- 50-year ARI – This was used as the level of service for open channels, storage, and land raising options. Flooding on the roads in this return period may be greater than 150mm.
- 100-year ARI – This is the model that provided results for the residual risk assessment. The model contains infrastructure sized in the 10yr and 50yr ARI events.

2.3.2 CLIMATE CHANGE

Each rainfall event had a climate change allowance added to match the horizon of each Future. This was RCP 8.5 to 2025 for Short Term, RCP 8.5 to 2060 for Medium Term, and RCP 8.5 to 2100 for Long Term.

For the long duration 24-hour sensitivity runs, 10-year ARI and 50-year ARI RCP 8.5 2100 were used. For the 6-hour critical duration sensitivity run, 100-year ARI RCP 4.5 2100 was used.

2.3.3 TIDAL BOUNDARY CONDITIONS

A fixed tide level using the Mean High Water Springs (MHWS) was applied on the critical duration runs as a conservative approach. Allowances for sea level rise (SLR) were included in the medium and long term (0.5m and 1.1m respectively)

- Short Term – Current MHWS
- Medium Term – Current MHWS + 0.5m SLR
- Long Term – Current MHWS + 1.1m SLR

The tide was applied as a sinusoidal time series in the long duration sensitivity runs.

2.3.4 GROUND WATER

The calibrated groundwater parameters developed during the system performance project, which were based on the groundwater levels provided by GNS, were used for the current modelling assessment. For storage areas, it was initially assumed that localised groundwater controls would be implemented to lower existing groundwater levels represented as fixed inflows. However, these fixed inflow values were not available at the time of modelling.

As presented in the *South Dunedin Future Groundwater Drainage Options Assessment*[2], the average day to day groundwater inflows into the system is approximately 21 L/s under present day conditions increasing to 35 L/s with 1.1 m sea level rise. This increases up to a maximum of 65L/s (Future 4 – Protect with 1.1m sea level rise). These values represent the entire South Dunedin catchment therefore the inflow values at the proposed storage areas are expected to be considerably smaller. The groundwater inflows were therefore not applied to the model as they would be orders of magnitude smaller than the runoff flows during a storm event.

2.3.5 DESIGN LEVEL OF SERVICE

The design level of service for the pipe network and pump stations was a 6 hour 10-year ARI event for the relevant period per Section 2.3.1. The 6-hour event was selected as the critical storm

[2](South Dunedin Future Groundwater Drainage Options Assessment, WSP 2025)

duration as noted in Section 2.3.1, and a 10-year return period level of service aligns with the design requirements for primary stormwater infrastructure in new developments per the DCC Code of Subdivision[3],

For storage and open channels, the design level of service was a 6 hour 50-year ARI event. The design level of service included allowance for flooding on roads of up to 150mm in depth. This aligns with the height of kerb and channel per the DCC Code of Subdivision, with the underlying assumption being that water depths of 150mm or less would stay within the road corridor and not flood the surrounding properties. This allowance was included to reduce the scale of upgrades required to meet the level of service targets in order to improve the overall feasibility of the proposed upgrades.

This aligns well with (and typically exceeds) community feedback during the 2025 engagement period. Specifically, when asked about how frequently flooding was tolerable, responses generally indicated that the following was acceptable:

- In homes: every 50-years, or less frequently
- In workplaces and businesses: every 5- to 10years
- On roads and footpaths: between a few times per year to once every 1- to 5years
- On lawns and in fields: up to a few times per year.

2.3.6 EXISTING INFRASTRUCTURE

It is assumed that existing infrastructure that is not explicitly replaced, altered, or upgraded in the modelled Futures would remain as is throughout the time scales examined, with ongoing asset management and maintenance assumed to occur.

2.3.7 NEW PIPES AND SUMPS

New pipes were sized based on typical available pipes sizes, for both circular and rectangular pipes. Alignments generally followed the existing network and road corridors to minimise disruption.

Minimum grade of 1/pipe DN and cover of 750mm on new pipes was followed were possible, but this was often not achievable within the constraints of the existing network. The headloss coefficients were updated based on the inference tool in the ICM.

Megapits were added to the model in some locations to capture more flows. The head discharge table for these were sourced from the *Wellington Water Regional Stormwater Hydraulic Modelling Specification Guide*[4].

2.3.8 NEW STORAGE AND CHANNELS

Storage basins were modelled in 2D with a mesh level zone used to lower the mesh surface to the proposed basin depth. Storage basins have been modelled to be wet only during rain events, however, this configuration may result in basin storage being utilised in more frequent events than those that have been modelled. The model assumes that groundwater management will be in place for the storage basins and channels to maintain groundwater levels below the invert.

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[3] (Dunedin Code of Subdivision and Development, DCC 2010)

[4] (Regional Stormwater Hydraulic Modelling Specifications, Welling Water 2013)

Where pipes discharge to the basins these were connected with a flap gate upstream to prevent backflow from the basins into the upstream network. Channels discharging to basins were represented with large culverts and no flap gates to simulate a direct connection to the basin. The waterways are set along existing roads and alignments were selected to integrate with the existing network where these were low-lying shallow trunk mains.

Channels were modelled as river reaches with the cross section shown in Figure 2-1. Sumps that intercept the proposed channels were relocated to outside the channel to still capture their sub-catchments. The associated sump leads were relocated with invert levels and pipe dimensions kept as-is, but now draining to the new channel. Sub-catchments that intersected with the new channels were trimmed to remove the area now occupied by the channel. 100% impervious sub-catchments were included in the area occupied by the new channels to account for the rainfall directly on them. Mannings roughness coefficient of 0.03 was assumed for all the sections.

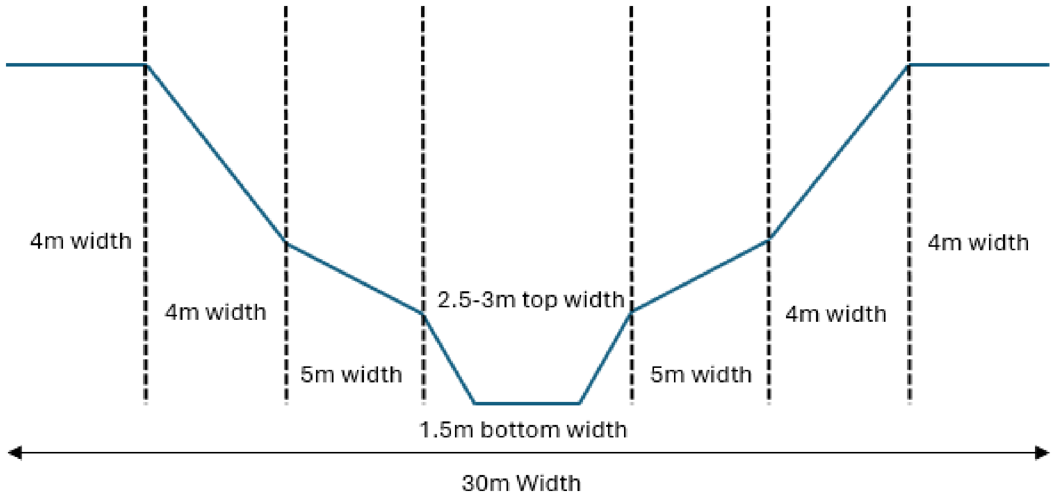

Figure 2-1: Channel cross section as modelled

As a simplification and due to the unknowns around pipe discharge conditions to the channels, pipes in the model were connected directly to river reach break nodes. This does not account for outlet headloss and extends pipe lengths, however, the maximum hydraulic grade in the pipes upstream of the channels is largely dictated by the water level in the channel itself. This is because of the limited grade available in the catchment and efforts to minimise the required channel depth, which means that the pipes discharge to the channel at a low level and these outlets are submerged as the channel fills during a rain event.

2.3.9 NEW AND UPGRADED PUMP STATIONS

The existing pumps in the base model are modelled as rotodynamic pumps with flow/head discharge curves.

All new and upgraded pumps were modelled as fixed flow pumps to inform the required pump station flow capacity only. The discharge head/lift of new pumps was not considered in this modelling.

2.3.10 RAISED LAND, NEW DEVELOPMENT, AND NEW GREENSPACES

Future 3 – Protect and Future 5 – Reshape included raised land. This was achieved by raising the ground model by 1m in the relevant area. In the medium term these raised land areas are undeveloped, with the areas modelled as 2D infiltration zones with a bund to contain any flooding. This raised land extends areas that are already elevated and near the shops and town centres retaining a compact urban form. This builds up some low-lying areas that would not otherwise be suitable for housing.

New developments were modelled as either medium or high density. Pervious-impervious ratios were provided by DCC and are shown in Table 2-1.

Table 2-1: New development permeability percentages.

Density	Pervious	Impervious
Low	36.2	63.8
Medium	25.2	74.8
High	3.6	96.4

It was assumed that all new developments would include storage for flow attenuation. This has been included in the model such that all of the runoff from a single event (up to a 50-year ARI level of service) can be stored. Flows from this storage are then only released to the downstream network when sufficient capacity is available following a rain event.

While the coastal protection, pipes, pumps, storage areas, and waterways help to reduce flooding, there are some areas where high flood risk remains. Some of these higher flood risk areas, (where it is more technically difficult and likely more costly to reduce flooding to target levels) were proposed to be changed into green space. This would reduce the need to develop more complex/costly solutions for those areas and provide additional flood mitigation benefits for surrounding areas, enabling smaller and less costly interventions in those areas and a better overall solution for South Dunedin. These new greenspaces were modelled as 100% pervious 2D infiltration zones. 0.5m bunds were positioned in certain locations accounting for local ground slopes to prevent water flowing into neighbouring properties while allowing water to enter the greenspaces from the surrounding area.

The existing network (sumps and pipes) was removed from raised land and new greenspaces, except for trunk mains with upstream connections.

Raised land, new development, and new greenspace extents were provided by WSP as shapefiles and integrated into the model. Some changes were made to the extent of new greenspaces as required to meet the level of service targets. There are some differences between futures in the exact extent of greenspaces located in the same areas. These are due to the iterative nature of the modelling, and the different extents will not significantly impact flooding in the adjacent areas,

2.3.11 SEAWALLS

The seawall added in the medium and long term for all three proposed Futures was modelled as an impervious wall of infinite height. The level of service of the seawall was not considered as a part of this work, but a nominal defence level of a 100-year coastal flood event (with wave overtopping included) is assumed through other components of this work.

2.3.12 KERBS

Kerbs were added in targeted locations to contain flooding within road corridors and prevent flow into neighbouring properties.

2.4 METHODOLOGY

Upgrades were developed through an iterative modelling process, starting from the principals outlined in the Modelling Schema Statement (Appendix S of this report).

The overall strategy was to divide the catchment into smaller sub-catchments and provide individual outfalls to Otago Harbour for each. This aimed to decrease the scale of key infrastructure and to reduce the impact of bottlenecks in the system. This division of the catchment required the addition of new or upgrade of existing pump stations along with accompanying discharge pipelines. Water storage facilities and increased greenspaces were implemented to attenuate flow peaks and reduce the scale of conveyance infrastructure. New or enlarged trunk mains, and for Future 4 – Restore and Future 5 – Reshape open waterways, were added to convey water to storage and to outfalls. This large, primary, infrastructure was added to the model first, with sizing and location adjusted based on test runs.

Certain land use changes, to enable land raising and new green spaces, were implemented for all three proposed Futures to differing degrees. After the primary infrastructure and land use changes were finalised for each model, network upgrades and kerbs were added to improve areas of localised flooding, These were targeted based on the initial results from the modelling of the primary infrastructure.

Upgrades for each Future were staged over the three time horizons. Upgrades added in earlier horizons were implemented such that they would be utilised in the ultimate long term time horizon. i.e. trunk mains were not added in the Short Term that would then have to be removed and enlarged in the Long Term.

The Short Term upgrades are summarised in Section 3.2, and Sections 3.3, 3.4, and 3.5 outline Future 3 – Protect, Future 4 – Restore, and Future 5 – Reshape respectively for both the Medium and Long Term time horizons. These further break down the approach for each Future and time horizon. The methodology is also covered in *SDF Stormwater Modelling Schema Statement* (refer Appendix S), however, note that this was issued prior to the commencement of modelling and does not reflect changes that were made to the approach during the modelling process.

Further optimisation has not been included at this stage but is recommended in parallel with design or a programme business case.

2.5 MODEL RUNS

The model runs completed for this work are shown in Table 2-2.

Table 2-2: Model Runs proposed for South Dunedin Futures Efficacy Modelling

Model run #	Rainfall Duration		Scenario			Return Period			Climate Change				Tides				Mapping		
	Critical (6hr)	Long Dur (24hr)	Short Term	Medium Term - 2060	Long Term - 2100	10yr	50yr	100yr	RCP4.5 - 2100	RCP 8.5 - 2025	RCP 8.5 - 2060	RCP 8.5 - 2100	MHWS	MHWS + SLR (0.5m)	MHWS + SLR (0.6m)	MHWS + SLR (1.1m)	Residual Risk	Network Sizing	Sensitivity
SD1a	x		x			x				X			X					X	
SD1b	x			x		x					x			x				X	
SD1c	x				x	x						X				X		X	
SD1d	X		x				X			x			X					X	
SD1e	X			x			X				x			x				X	
SD1f	x				x		X					x				X		X	
SD1g	x		X					x		x			X				X		
SD1h	x			x				X			x			x			X		
SD1i	x				x			X				X				x	X		
SD2a	x				x			x	x						x				x
SD2b		X			x	x						x	X						x
SD2c		x			x		x					x	X						x

3 FUTURE OVERVIEWS

3.1 MODEL OUTPUTS

The model outputs are comprised of maps of the catchment displaying maximum flood depths for each model run. The maps are provided in the Appendices listed below in Table 3-1.

Table 3-1: Model Runs proposed for South Dunedin Futures Efficacy Modelling

Appendix	Map number	Drawing tittle
A	A1	South Dunedin existing network overview
B	B1	South Dunedin Baseline (Status quo) network (existing network + quick wins)
C	C1	South Dunedin Short Term network
D	D1	South Dunedin Future O-3 Medium Term (2060)
D	D2	South Dunedin Future O-3 Long Term (2100)
E	E1	South Dunedin Future O-4 Medium Term (2060)
E	E2	South Dunedin Future O-4 Long Term (2100)
F	F1	South Dunedin Future O-5 Medium Term (2060)
F	F2	South Dunedin Future O-5 Long Term (2100)
G	G1	Maximum flood depth map for Baseline (Status quo) network 10-year ARI RCP 8.5 2025-MHWS
G	G2	Maximum flood depth map for Baseline(Status quo) network 50-year ARI RCP 8.5 2025-MHWS
G	G3	Maximum flood depth map for Baseline (Status quo) network 100-year ARI RCP 8.5 2025-MHWS
H	H1	Maximum flood depth map for Short Term 10-year RCP 8.5 2025-MHWS
H	H2	Maximum flood depth map for Short Term 50-year RCP 8.5 2025-MHWS
H	H3	Maximum flood depth map for Short Term 100-year RCP 8.5 2025-MHWS

Appendix	Map number	Drawing tittle
I	I1	Flood Depth Difference between Short Term and Base- 10 yr design storm
I	I2	Flood Depth Difference between Short Term and Base- 50 yr design storm
I	I3	Flood Depth Difference between Short Term and Base- 100 yr design storm
J	J1	Maximum flood depth map for O-3 10 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
J	J2	Maximum flood depth map for O-3 50 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
J	J3	Maximum flood depth map for O-3 100 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
J	J4	Maximum flood depth map for O-3 (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
J	J5	Maximum flood depth map for O-3 50 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
J	J6	Maximum flood depth map for O-3 100 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
K	K1	Flood Depth Difference between O-3 (LT) and Base- 10 yr design storm
K	K2	Flood Depth Difference between O-3 (LT) and Base- 50 yr design storm
K	K3	Flood Depth Difference between O-3 (LT) and Base- 100 yr design storm
L	L1	Maximum flood depth map for O-4 10 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
L	L2	Maximum flood depth map for O-4 50 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
L	L3	Maximum flood depth map for O-4 100 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
L	L4	Maximum flood depth map for 10 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR

Appendix	Map number	Drawing tittle
L	L5	Maximum flood depth map for O-4 50 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
L	L6	Maximum flood depth map for O-4 100 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
M	M1	Flood Depth Difference between O-4 (LT) and Base- 10 yr design storm
M	M2	Flood Depth Difference between O-4 (LT) and Base- 50 yr design storm
M	M3	Flood Depth Difference between O-4 (LT) and Base- 100 yr design storm
N	N1	Maximum flood depth map for O-5 10-year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
N	N2	Maximum flood depth map for O-5 50-year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
N	N3	Maximum flood depth map for O-5 100-year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
N	N4	Maximum flood depth map for O-5 10-year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
N	N5	Maximum flood depth map for O-5 50-year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
N	N6	Maximum flood depth map for O-5 100 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
O	O1	Flood Depth Difference between O-5 (LT) and Base- 10 yr design storm
O	O2	Flood Depth Difference between O-5 (LT) and Base- 50 yr design storm
O	O3	Flood Depth Difference between O-5 (LT) and Base- 100 yr design storm
P	P1	Sensitivity run 1- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 10 year RCP 8.5 2100 MHWS for O-3 (LT)
P	P2	Sensitivity run 2- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 50 year RCP 8.5 2100 MHWS for O-3 (LT)

Appendix	Map number	Drawing tittle
P	P3	Sensitivity run 3- Flood depth difference between 100 year RCP 4.5 2100 MHWS + 0.6 m SLR and 100 year RCP 8.5 2100 MHWS + 1.1 m SLR for O-3 (LT)
Q	Q1	Sensitivity run 1- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 10 year RCP 8.5 2100 MHWS for O-4 (LT)
Q	Q2	Sensitivity run 2- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 50 year RCP 8.5 2100 MHWS for O-4
Q	Q3	Sensitivity run 3- Flood depth difference between 100 year RCP 4.5 2100 MHWS + 0.6 m SLR and 100 year RCP 8.5 2100 MHWS + 1.1 m SLR for future O-4 (LT)
R	R1	Sensitivity run 1- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 10 year RCP 8.5 2100 MHWS for O-5 (LT)
R	R2	Sensitivity run 2- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 50 year RCP 8.5 2100 MHWS for O-5 (LT)
R	R3	Sensitivity run 3- Flood depth difference between 100 year RCP 4.5 2100 MHWS + 0.6 m SLR and 100 year RCP 8.5 2100 MHWS + 1.1 m SLR for O-5 (LT)

The upgrades for each Future and time horizon are summarised in Table 4-1, Table 4-2, Table 4-3, Table 4-4 covering pipes, channels, pump stations, storage, and manholes/sumps.

3.2 SHORT TERM (2025 - 2060)

3.2.1 UPGRADES

Short Term upgrades included new pipes, new and upgraded pump stations, and new storage basins. The Short Term upgrade model is common to all three Futures being considered. The infrastructure upgrades for the Short Term horizon are shown in Appendix C Map C1.

The approach taken was to split the South Dunedin Catchment into smaller portions to decrease the scale of infrastructure required and relieve pressure on the Portobello Road pump station and outfall:

- New pump stations and discharge mains from the catchment to the harbour were added to capture flows from the lower Hillside Road and MacAndrew Road trunk mains. These were located on existing outfalls from the Portsmouth Drive Catchment but would require outfall upgrades. The Tainui pump station is also proposed to be upgraded.
- The new and upgraded pump stations are all proposed to utilise rising mains for discharge, with new rising mains on Midland Street, Orari Street, and Royal Crescent.
- A new pump station located at the Hillside Road – Burns Street intersection and accompanying rising main discharging to the Wilkie Road Conduit would service the Forbury Corner area. This would split the Hillside Road trunk main and frees up capacity in

the trunk main downstream of the new pump station. The discharge to the Wilkie Road Conduit would require raising the hydraulic grade in this main, downstream of the connection, to above ground level.

- The new pump stations and outfalls are supported by trunk main upgrades on Bay View Road, Marlow Street, and upper Hillside Road in Forbury Corner. A new trunk main on Kirkcaldy Street has also been included, to divert flows from the MacAndrew Road Main and leverage the upgraded Bay View Road main.
- The network in the Rona Street area and between Queens Drive and Royal Crescent that previously discharged to the Royal Crescent trunk main was diverted to upstream of the Tainui Pump Station to facilitate this trunk main being converted to a rising main.
- The Forbury Aqueduct is twinned from the Forbury Road – Bay View Road intersection through to the ocean outfall.
- Forbury Park is proposed as a large new storage basin. A new trunk main on Council Street to service the area around De Carle Park is also proposed, to leverage the Forbury Park storage and relieve capacity on the Bellona Street trunk main
- A small basin in Tonga Park to capture overflows from the Forbury Road Aqueduct is also proposed, with an overflow and main located on Wycolla Avenue.
- Various network upgrades, including mains, sump leads, and megapits were included to further alleviate flooding. These have been developed to effectively utilise the proposed and existing larger infrastructure, such as capacity freed up on the MacAndrew Bay Road main as a result of the new trunk main on Kirkcaldy Street.

3.2.2 PERFORMANCE

The Short Term maps are contained in Appendix H Maps H1-H3.

The upgrades modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

Areas where some flooding remains on properties in a 10-year ARI event include Tainui and the Surrey Street – Nicholson Street intersection. There is also some more significant ponding along Portsmouth Drive. Streets throughout the catchment have flood depths up to 150mm.

3.3 FUTURE 3 - PROTECT

3.3.1 MEDIUM TERM (2060 - 2100)

3.3.1.1 UPGRADES

The previous Short Term works were maintained, with no further splitting of the catchment. The infrastructure upgrades for Future 3 – Protect Medium Term are shown in Appendix D Map D1. Additional storage and trunk mains were added along with land raising:

- A new storage basin at Bathgate Park was added along with a pump station to drain it. The Tonga Park storage added in the Short Term model was also enlarged and a pump station added. This provides further flow attenuation and decreases the required scale of downstream infrastructure.
- New trunk mains were added on Coughtrey Street, eastern MacAndrew Road, and Prince Albert Road.

- A further Forbury Road Aqueduct overflow was added at the Coughtrey Street – Forbury Road intersection, discharging to the new trunk main proposed on Coughtrey Street. This in turn connects to the Forbury Park storage, and alleviates pressure on the Forbury Road Aqueduct while limiting impacts on the South Dunedin network by utilising this attenuation.
- Further network upgrades, including mains, sump leads, and megapits were also included to further alleviate flooding and to facilitate delivery of stormwater to the open channels and storage.
- The discharge main from the Portobello Road Pump Station would have the hydraulic grade raised above ground level, in part due to the higher tail water condition at the outfall with sea level rise. To facilitate this, network downstream of the pump station has been diverted directly to the harbour via a new outfall pipe or to upstream of the pump station.
- A seawall was added along Portsmouth Drive in this Future.
- Raised land was added extending east from Forbury Road to Bathgate and Tonga parks. This was considered as undeveloped in the Medium Term.

3.3.1.2 PERFORMANCE

The Future 3 – Protect Medium Term maps are contained in Appendix J Maps J1-J3.

The upgrades and land use changes modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

Some flooding remains on properties in a 10-year ARI event in Tainui. There is also flooding on the corner of Grosvenor Street and Bridgman Street, adjacent to an NZ Defence Force site. The flooding in the Portsmouth Drive catchment has also worsened, primarily due to sea level rise increasing the tail-water level at the outfalls. Streets throughout the catchment have flood depths up to 150mm.

3.3.2 LONG TERM (2100 ONWARDS)

3.3.2.1 UPGRADES

Changes to Future 3 – Protect in this time horizon were primarily land use changes, with some infrastructure upgrades. The infrastructure upgrades for Future 3 – Protect Long Term is shown in Appendix D Map D2.

- New greenspaces were added in Forbury Corner and in Tainui between Ravelston Street and Magdala Street. These are high risk areas that would require costly solutions to meet the targeted level of service. The development of greenspaces reduces risks whilst also providing flood mitigation benefits for the surrounding areas.
- Medium density developments were added to the raised land, Hancock Park, and Chisholm Links. These are serviced by individual storage basins and downstream network upgrades.
- New pump stations were added at each of the four existing Portsmouth Drive catchment gravity outfalls to allow this water to be discharged against the 1.1m of sea level rise in this time scale
- The Portobello Road Pump Station was upgraded to increase flow capacity.

3.3.2.2 PERFORMANCE

The Future 3 – Protect Long Term maps are contained in Appendix J Maps J4-J6.

The upgrades and land use changes modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

The new greenspaces see significant flooding, but it is largely contained to these areas. In Tainui some flooding on properties remains outside of the large new greenspace. The flooding has also worsened on the corner of Grosvenor Street and Bridgman Street. Flooding in the Portsmouth Drive catchment is greatly reduced from the Medium Term with the addition of pump stations on the outfalls.

3.4 FUTURE 4 – RESTORE

3.4.1 MEDIUM TERM (2060 - 2100)

3.4.1.1 UPGRADES

The previous Short Term works were maintained, with no further splitting of the catchment. The open channels for this Future were developed in this time horizon, along with further storage. The infrastructure upgrades for Future 4 – Restore Medium Term are shown in Appendix E Map E1.

- New storage basins, with pump stations to drain them, at Bathgate Park and Culling Park were added, along with the enlargement of and addition of a pump station to the Tonga Park storage added in the Short Term model. These provide further flow attenuation and decreases the required scale of downstream infrastructure.
- New open channels were added on Bellona Street (from Forbury Park to Culling Park storage), MacAndrew Road, Coughtrey Street, and West Avenue. These provide additional stormwater conveyance capacity to the network and provide an opportunity for a nature based solution.
- A further Forbury Road Aqueduct overflow was added at the Coughtrey Street – Forbury Road intersection, discharging to the new channel proposed on Coughtrey Street. This in turn connects to the Forbury Park storage, and alleviates pressure on the Forbury Road Aqueduct while limiting impacts on the South Dunedin network by utilising this attenuation.
- The discharge main from the Portobello Road Pump Station would have the hydraulic grade raised above ground level, in part due to the higher tail water condition at the outfall with sea level rise. To facilitate this, network downstream of the pump station has been diverted directly to the harbour via a new outfall pipe or to upstream of the pump station.
- Further network upgrades, including mains, sump leads, and Megapits were also included to further alleviate flooding and to facilitate delivery of stormwater to the open channels and storage.
- A seawall was added along Portsmouth Drive in this Future.

3.4.1.2 PERFORMANCE

The Future 4 – Restore Medium Term maps are contained in Appendix L Maps L1-L3.

The upgrades modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

Some flooding remains on properties in a 10-year ARI event in Tainui. There is also flooding on the corner of Grosvenor Street and Bridgman Street, adjacent to an NZ Defence Force site. The flooding in the Portsmouth Drive catchment has also worsened, primarily due to sea level rise increasing the tail-water level at the outfalls. Streets throughout the catchment have flood depths up to 150mm.

3.4.2 LONG TERM (2100 ONWARDS)

3.4.2.1 UPGRADES

Changes to Future 4 – Restore Long Term: In this time horizon were primarily land use changes, with some infrastructure upgrades particularly due to the additional sea level rise. The infrastructure upgrades for the Future 4 – Restore Long Term are shown in Appendix E Map E2.

- New greenspaces were added to the east of Surrey Street and West Avenue, in Forbury Corner, and in Tainui between Ravelston Street and Magdala Street. These are high risk areas that would require costly solutions to meet the targeted level of service, with the development of greenspaces also providing flood mitigation benefits for the surrounding areas.
- High density developments were added to Hancock Park, Tahuna Park, and Chisholm Links. These are serviced by individual storage basins and downstream network upgrades.
- New pump stations were added at each of the four existing Portsmouth Drive catchment gravity outfalls to allow this water to be discharged against the 1.1m of sea level rise in this scenario.
- Some upstream network upgrades, primarily mains (not trunk mains) and sump leads, were added to further alleviate localised flooding.

3.4.2.2 PERFORMANCE

The Future 4 – Restore Long Term maps are contained in Appendix L Maps L4-L6.

The upgrades and land use changes modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

The new greenspaces see significant flooding, but it is largely contained to these areas. In Tainui some flooding on properties remains outside of the large new greenspace. The flooding has also worsened on the corner of Grosvenor Street and Bridgman Street. Flooding in the Portsmouth Drive catchment is greatly reduced from the Medium Term with the addition of pump stations on the outfalls.

3.5 FUTURE 5 – RESHAPE

3.5.1 MEDIUM TERM (2060 - 2100)

3.5.1.1 UPGRADES

The previous Short Term works were maintained, with no further splitting of the catchment. The open channels for this Future were developed in this time horizon, along with further storage and the raising of land. The infrastructure upgrades for Future 5 – Reshape Medium Term are shown in Appendix F Map F1.

- New storage basins, with pump stations to drain them, at Bathgate Park and Culling Park were added, along with an upgrade and addition of a pump station to the Tonga Park storage added in the Short Term model. These provide further flow attenuation and decreases the required scale of downstream infrastructure.
- New open channels were added on Bellona Street (from Forbury Park to Culling Park storage), MacAndrew Road, Coughtrey Street, and West Avenue. These provide additional stormwater conveyance capacity to the network and provide an opportunity for a nature based solution.
- A further Forbury Road Aqueduct overflow was added at the Coughtrey Street – Forbury Road intersection, discharging to the new channel proposed on Coughtrey Street. This in turn connects to the Forbury Park storage, and alleviates pressure on the Forbury Road Aqueduct while limiting impacts on the South Dunedin network by utilising this attenuation.
- The discharge main from the Portobello Road Pump Station would have the hydraulic grade raised above ground level, in part due to the higher tail water condition at the outfall with sea level rise. To facilitate this, network downstream of the pump station has been diverted directly to the harbour via a new outfall pipe or to upstream of the pump station.
- Raised land was added extended east from Forbury Road to Bathgate and Tonga parks, and in Forbury Corner. This was considered as undeveloped in the Medium Term.
- Further network upgrades, including mains, sump leads, and megapits were also included to further alleviate flooding and to facilitate delivery of stormwater to the open channels and storage.
- A seawall was added along Otaki Street in this Future. The properties between the seawall and Portsmouth Drive would have floodable first floors.

3.5.1.2 PERFORMANCE

The Future 5 – Reshape Medium Term maps are contained in Appendix N Maps N1-N3.

The upgrades and land use changes modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

Some flooding remains on properties in a 10-year ARI event in Tainui. There is also flooding on the corner of Grosvenor Street and Bridgman Street, adjacent to an NZ Defence Force site.

There is flooding along Portsmouth Drive, which is outside the seawall that is positioned along Otaki Street in this Future.

3.5.2 LONG TERM (2100 ONWARDS)

3.5.2.1 UPGRADES

Changes to Future 5 – Reshape in this time horizon were primarily land use changes. The infrastructure upgrades for Future 5 – Reshape Long Term are shown in Appendix F Map F2.

- New greenspaces were added extending East from West Avenue and in Tainui between Ravelston Street and Magdala Street. These are high risk areas that would require costly solutions to meet the targeted level of service, with the development of greenspaces also providing flood mitigation benefits for the surrounding areas.

- Medium density developments were added to the raised land, Hancock Park, and Chisholm Links. These are serviced by individual storage basins and downstream network upgrades.
- Some upstream network upgrades, primarily mains (not trunk mains) and sump leads, were added to further alleviate localised flooding.

3.5.2.2 PERFORMANCE

The Future 5 – Reshape Long Term maps are contained in Appendix N Maps N4-N6.

The upgrades and land use changes modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

The new greenspaces see significant flooding, but it is largely contained to these areas. In Tainui some flooding on properties remains outside of the large new greenspace. The flooding has also worsened on the corner of Grosvenor Street and Bridgman Street.

The area between Otaki Street (the location of the seawall in this future) and Portsmouth Drive sees significant flooding.

3.6 SENSITIVITY RUNS

Sensitivity runs were completed for a long duration event for each of the three proposed Futures and time horizons for the 10- and 50-year rainfall return periods. These were undertaken to test the Futures against a longer duration (24-hour) rainfall event which was chosen as previous flood events in South Dunedin have occurred during long duration events. These were run to check sensitivity of the upgrades. Flood depth results from these runs were compared to the respective design run results. Other aspects such storage capacity utilisation were also checked.

For climate change allowance testing, a sensitivity run was completed for RCP 4.5 to 2100 for the 100-year ARI event for each Future. These were undertaken to test the Futures against a less severe climate change model. Flood depth results from these runs were compared to the respective design run results.

Depth difference maps for the long duration runs are shown in:

- Appendix P Maps P1 and P2 for Future 3 – Protect
- Appendix Q Maps Q1 and Q2 for Future 4 – Restore
- Appendix R Maps R1 and R2 for Future 5 – Reshape.

The results showed less flooding in the catchment but a greater volume of water in the storage facilities, due to the lower intensity but longer duration of the modelled rain event.

Depth difference maps for the RCP 4.5 100-year ARI runs are shown in:

- Appendix P Map P3 for Future 3 – Protect,
- Appendix Q Map Q3 for Future 4 – Restore
- Appendix R Map R3 for Future 5 – Reshape.

As expected, the results showed less flooding throughout the catchment.

4 SUMMARY

This section outlines the key differences between the three proposed Futures.

4.1 PIPE NETWORK

- Upgrades to pipes for Future 3 – Protect were proposed primarily in medium-term which primarily includes trunk mains connecting to storage areas.
- Approximately 3.5Km of open channels are proposed for Future 4 – Restore and Future 5 – Reshape primarily along Bellona street and Macandrew Rd along with the pipes discharging to these open channels and other laterals.

Table 4-1: Summary of pipe upgrades (newly upgraded and added pipes only).

Shape	Size (mm)	Length (m)						
		Short Term	Future 3 – Protect		Future 4 – Restore		Future 5 – Reshape	
			Medium Term	Long Term	Medium Term	Long Term	Medium Term	Long Term
Circular	100				40.1		40.1	
	150	86.4			953.6	26.9	745.1	
	200				74.4		74.4	
	225	702.2	65.9		1068.5	57	1012.6	
	250				18.9		18.9	
	300	1554.3	575.3		997.3		1427.9	
	375	1819.3	439.6		652.7	102	259.6	
	450	3500.8	1350.1		711.2	583.7	1635.1	
	525	3228.4	148.7		164.4		871.2	
	600	1488.1	1263.2		453.7	707.4	1160.6	
	675		168.1		17.5		185.6	
	700	667.4	142.2				423.4	
	750	1391.6	295.8		19.3		65.3	
	900	2095.7	456.3		198.6		855.3	
	1050	1074.2	23				23	
	1200	272.9			171.6		5.6	

Shape	Size (mm)	Length (m)						
		Short Term	Future 3 – Protect		Future 4 – Restore		Future 5 – Reshape	
			Medium Term	Long Term	Medium Term	Long Term	Medium Term	Long Term
	1300	591.4						
	1500	2348.7					1.9	
Rectangular	1200x900				134.1		76	
	1200x1000	17.9						
	1500x1000	253.9						
	1500x1300	47.6						
	1800x700	421.1						
	2000x1000	246.6						
	2000x1500	1167.6						
	2100x1000	2095.9						
	2100x1050	284.3						
	3000x1000		445.4					
	3000x1200				56.2		56.2	
Open Channel		-	-	-	3526		3526	

4.2 PUMP STATIONS

- Future 3 – Protect requires upgrading the pump capacities at Hillside and installing new pumps at the proposed storage basins (Tonga Park and Bathgate Park) during the Medium Term. In the Long Term, the Portobello pumps are upgraded and new pump stations are added at each of the four existing Portsmouth Drive catchment gravity outfalls to discharge the water against the 1.1m of sea level rise.
- Future 4 – Restore increases capacity at Orari (3.5 m^3/s) and Hillside (2 m^3/s) installing new pumps at the proposed storage basins (Tonga Park and Bathgate Park) during the Medium Term and introduces four pump stations (0.5 m^3/s each) at the Portsmouth Drive gravity outfalls in the Long Term.

Table 4-2: Summary of pump upgrades.

Pump Station	Capacity (m^3/s)							
	Existing	Short Term	Future 3 – Protect		Future 4 – Restore		Future 5 – Reshape	
			Medium Term	Long Term	Medium Term	Long Term	Medium Term	Long Term
Portobello	6.4	6.4	6.4	8	6.4	6.4	6.4	6.4
Tainui	0.72	3	3	3	3	3	3	3
Orari	N/A	2.5	2.5	2.5	3.5	3.5	2.5	2.5
Hillside	N/A	1.5	2.5	2.5	2	2	2.5	2.5
Midland	N/A	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Forbury Park	N/A	1	1	1	1	1	1	1
Tonga Park	N/A	N/A	0.5	0.5	0.5	0.5	0.5	0.5
Bathgate Park	N/A	N/A	0.5	0.5	0.5	0.5	0.5	0.5
Culling Park	N/A	N/A	N/A	N/A	1	1	1	1
Portsmouth Drive #1	N/A	N/A	N/A	0.5	N/A	0.5	N/A	N/A
Portsmouth Drive #2	N/A	N/A	N/A	0.5	N/A	0.5	N/A	N/A
Portsmouth Drive #3	N/A	N/A	N/A	0.5	N/A	0.5	N/A	N/A
Portsmouth Drive #4	N/A	N/A	N/A	0.5	N/A	0.5	N/A	N/A

4.3 STORAGE AREAS

- All three proposed Futures expand Tonga Park to 3.5 ha and introduce Bathgate Park (1.5 ha) for the Medium and Long Term.
- Future 4 – Restore and Future 5 – Reshape add Culling Park (2 ha), providing further flood storage resilience.

Table 4-3: Summary of storage areas.

Storage	Area (ha)						
	Short Term	Future 3 – Protect		Future 4 – Restore		Future 5 – Reshape	
		Medium Term	Long Term	Medium Term	Long Term	Medium Term	Long Term
Forbury Park	9	9	9	9	9	9	9
Tonga Park	1	3.5	3.5	3.5	3.5	3.5	3.5
Bathgate Park	N/A	1.5	1.5	1.5	1.5	1.5	1.5
Culling Park	N/A	N/A	N/A	2	2	2	2

4.4 MANHOLES AND SUMPS

- Sumps located along the river reaches in Future 4 – Restore and Future 5 – Reshape have been relocated to drain into the proposed river reaches.

Table 4-4: Summary of manholes and sumps

Type	Diameter (m)	Short Term	Future 3 – Protect		Future 4 – Restore		Future 5 – Reshape	
			Medium Term	Long Term	Medium Term	Long Term	Medium Term	Long Term
Manholes	0.8	10	7		5		5	
	0.9	38	40		14		13	
	1	53	10		39	14	92	
	1.2	75	5		15		21	
	1.3	63	24		9		15	
	1.5	32	4		11	9	13	
	1.6	1	7		1		5	
	1.7	14	2					
	1.8	33	10		1		1	
	1.9		1					
	2.2	45	4		10	1	24	
	2.6	20			2	1	3	
	3	17			10		8	
	3.3	2						

Type	Diameter (m)	Short Term	Future 3 – Protect		Future 4 – Restore		Future 5 – Reshape	
			Medium Term	Long Term	Medium Term	Long Term	Medium Term	Long Term
	4	13			1		1	
	5.2				1			
	6	28						
	6.4	29	5		3			
	10		10		1		2	
Sumps	0.6				2		2	
	0.7	6			50	2	39	
	0.8	22	7		62	8	54	
	0.9	3	2		11		12	
	1	1	1					
	1.2						1	
	1.3						1	
	1.7						1	
	3	1	1				1	
Megapits		27			5		6	

APPENDICES A-R: MAPS

APPENDIX S: SCHEMA STATEMENT