Te Puke Stormwater Modelling

Stage 4: Modelling Report and Network Upgrade Costings

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Executive Summary

Opus was commissioned by Western Bay of Plenty District Council (WBOPDC) to augment an existing hydraulic model of the Te Puke stormwater system and to use this to identify limitations in the current system. This information was used to prepare a programme of stormwater system upgrades necessary to allow a 5-year ARI storm to pass without significant surcharging.

This report describes changes made to the existing model and presents results from the modelling of the existing system under 5-year and 50-year ARI storm scenarios. It identifies parts of the network that are under capacity in the 5-year ARI storm, prioritises the upgrading of the network, and presents cost estimates for this work.

The existing model was extended upstream to include new District Plan zones and was supplemented with additional drainage assets supplied by WBOPDC. Four model scenarios were run using MIKE URBAN and MIKE FLOOD.

Significant bottlenecks in the existing system were identified and a procedure was developed to identify and prioritise pipes in need of upgrading. Modelling of the upgraded system under a 5-year ARI storm showed that surcharging was virtually eliminated.

The total cost of upgrading the stormwater network to convey a 5-year ARI storm was estimated at $10.1 million, comprising 10,673 m of pipe and 207 manholes. Upgrading the 12 highest priority bottlenecks was estimated to cost approximately $4.1 million. It is likely these upgrades will also provide significant protection against higher ARI storm events.

Contents

1 Introduction

1.1 Background

In November 2012 Opus produced *Te Puke MIKE URBAN Stormwater Modelling, Stage 2 – Modelling Report* (Opus, 2012) which outlined the construction of a MIKE URBAN hydraulic model for the stormwater system of Te Puke. That report discussed limitations of the existing stormwater system to pass storms of certain frequencies.

At the direction of Western Bay of Plenty District Council (WBOPDC), the Stage 2 model was extended upstream of Te Puke to include new District Plan zones to the south of the previously modelled extent (Figure 1). Supplementary drainage assets were made available by WBOPDC to further augment the existing model. WBOPDC also requested that a programme of infrastructure upgrades be developed and that indicative costs of these upgrades be provided.

This work forms Stage 4 of the modelling programme. The model changes enable updated flood risk estimates to be made and support the development of a programme of drainage infrastructure upgrades.

1.2 Purpose

The purpose of this report is to outline changes made to the Stage 2 MIKE URBAN model and to present the results of the four model scenarios that are based on these revisions. All modelling is for the existing degree of catchment development.

The report also describes the procedure used to identify stormwater pipes and manholes that require upgrading in order to pass a 5-year Average Recurrence Interval (ARI) storm event without surcharging. It provides a list of individual assets requiring upgrading and presents cost estimates for these upgrades.

1.3 Model Scenarios

The revised model serves as the basis of four scenarios, all of which use a 30-minute duration storm. Three of the models use MIKE URBAN alone and one is a full MIKE FLOOD (MIKE URBAN-MIKE21 coupled) model. The scenarios are:

- 50-year ARI, 30-minute storm duration (existing infrastructure) – MIKE URBAN
- 50-year ARI, 30-minute storm duration (existing infrastructure) – MIKE FLOOD
- 5-year ARI, 30-minute storm duration (existing infrastructure) – MIKE URBAN
- 5-year ARI, 30-minute storm duration (upgraded infrastructure) – MIKE URBAN

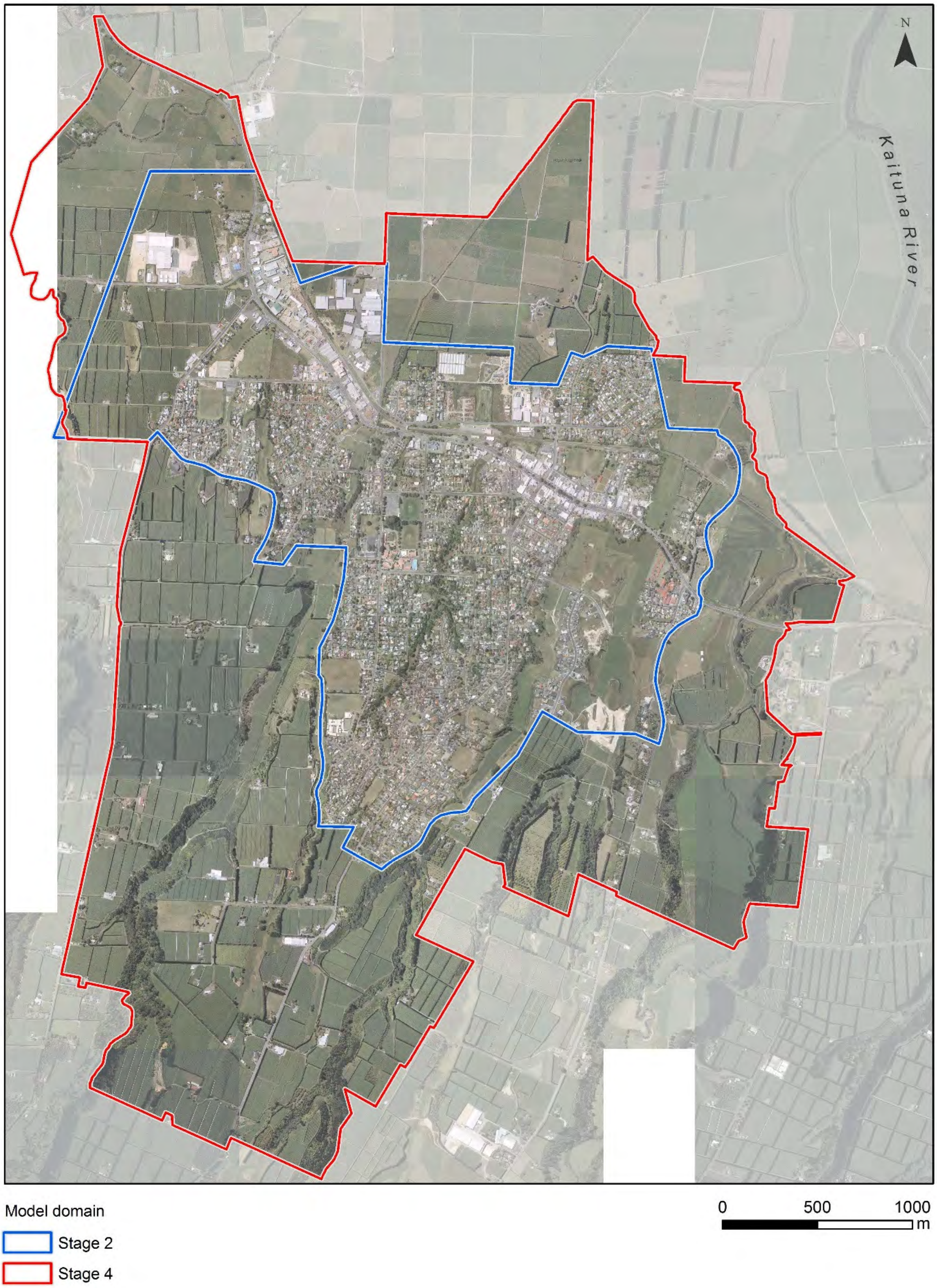

Figure 1 Comparison of model domains between Stages 2 and 4

2 Model Build

2.1 Introduction

The Stage 2 MIKE URBAN model was augmented with additional pipes and open channels to form the Stage 4 model. The resultant model consists of 181 open channels, 7 overland flow paths, 635 pipes and 825 nodes, of which 546 are manholes (i.e., with asset prefix SWMH or SWBX). The Stage 4 model network is shown in Figure 2.

A new 2 m Digital Elevation Model (DEM) was created from LiDAR data supplied by WBOPDC. This formed the bathymetry file in the MIKE FLOOD model and was also used to derive flood water levels by adding modelled water depth to the ground elevations. The DEM was also used to obtain cross-sectional data for the extended open channels and to assign inverts and ground levels for new pipes, manholes and open channels where these were not explicitly stated.

Where the MIKE21 model grid had a 20 degree rotation in the Stage 2 model (to align it roughly with the dominant drainage direction), the Stage 4 model's grid was orientated in a more conventional north-south direction.

2.2 Piped Network

Additional pipes and manholes were supplied in shapefile format by WBOPDC on 19 November 2013 (Figure 3). These were checked for necessary attributes (inverts, lengths etc.) in GIS then imported to MIKE URBAN. Where inverts were not supplied these were inferred from adjacent model elements or interpolated.

A new storage basin (SWCO2907+SWCI0845) was added as part of the network reconfiguration in a depression near the Moehau Street-Norrie Street intersection in which a section of open channel in Stage 2 is now piped (Figure 4). This replaced previous inlet (SWCI0845) and outlet (SWCO2907) nodes. Basin geometry data was extracted from the DEM as depth-varying cross-sectional area and water surface area in 0.2 m depth increments and entered into MIKE URBAN (Table 1). This allowed a depth-storage relationship to be computed in MIKE URBAN following the method described in Opus (2012) (Figure 5).

2.3 Open Channel Network

Existing open channels in MIKE URBAN were extended upstream, and new open channels were added, using the DEM and aerial photographs as a guide (Figure 2). This required subdivision of some of the upstream catchments with consequent changes in the way inflow boundary conditions were allocated. These changes are outlined in Sections 2.4 and 2.5.

Channel cross-sections were extracted from the DEM and used to describe the topography at each end of the channels in MIKE URBAN. Bottom levels for the associated nodes were assigned from the DEM cell in which they fell.

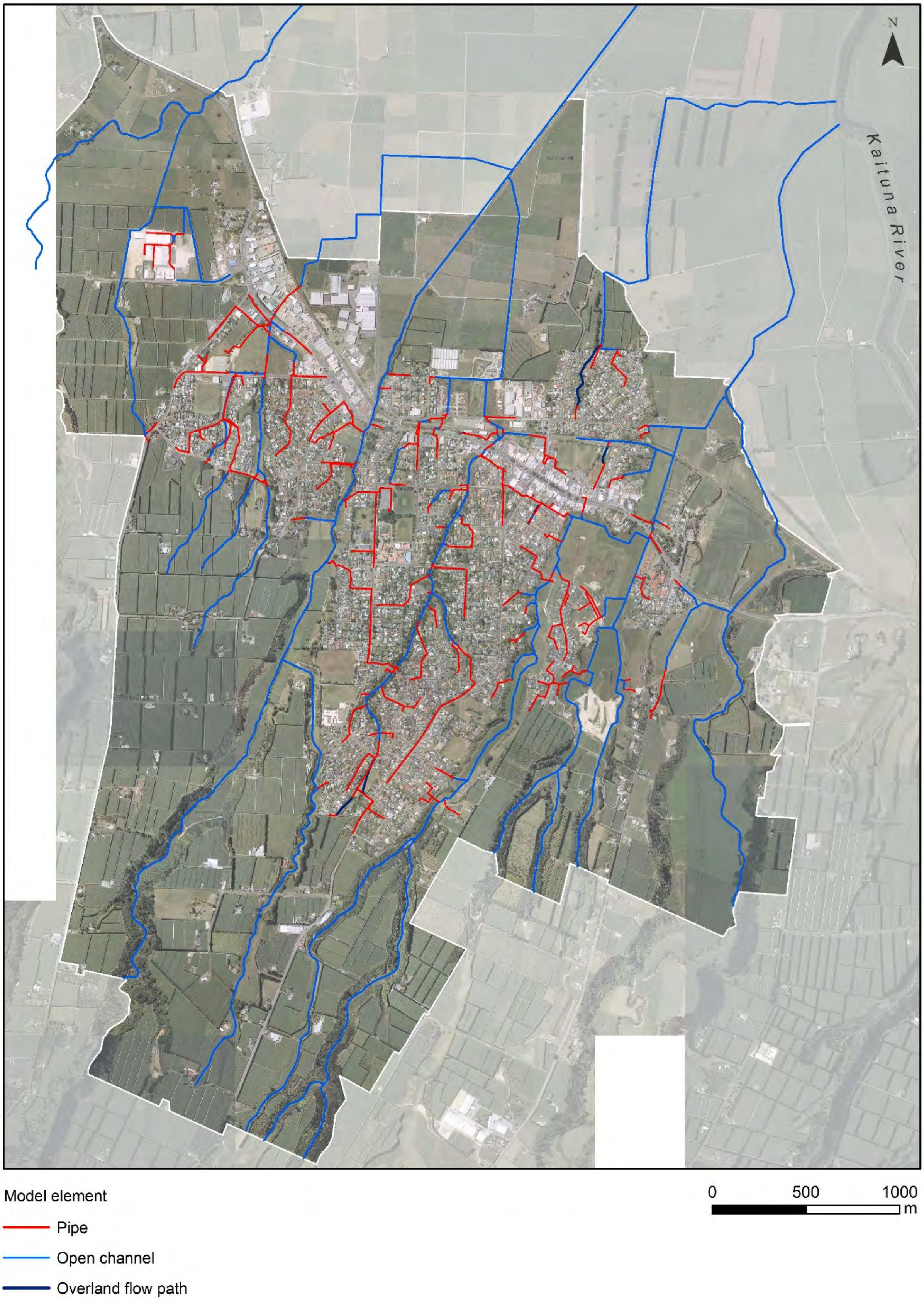

Figure 2 Te Puke stormwater drainage network in the Stage 4 MIKE URBAN model

Figure 3 Network components added to the Stage 4 MIKE URBAN model

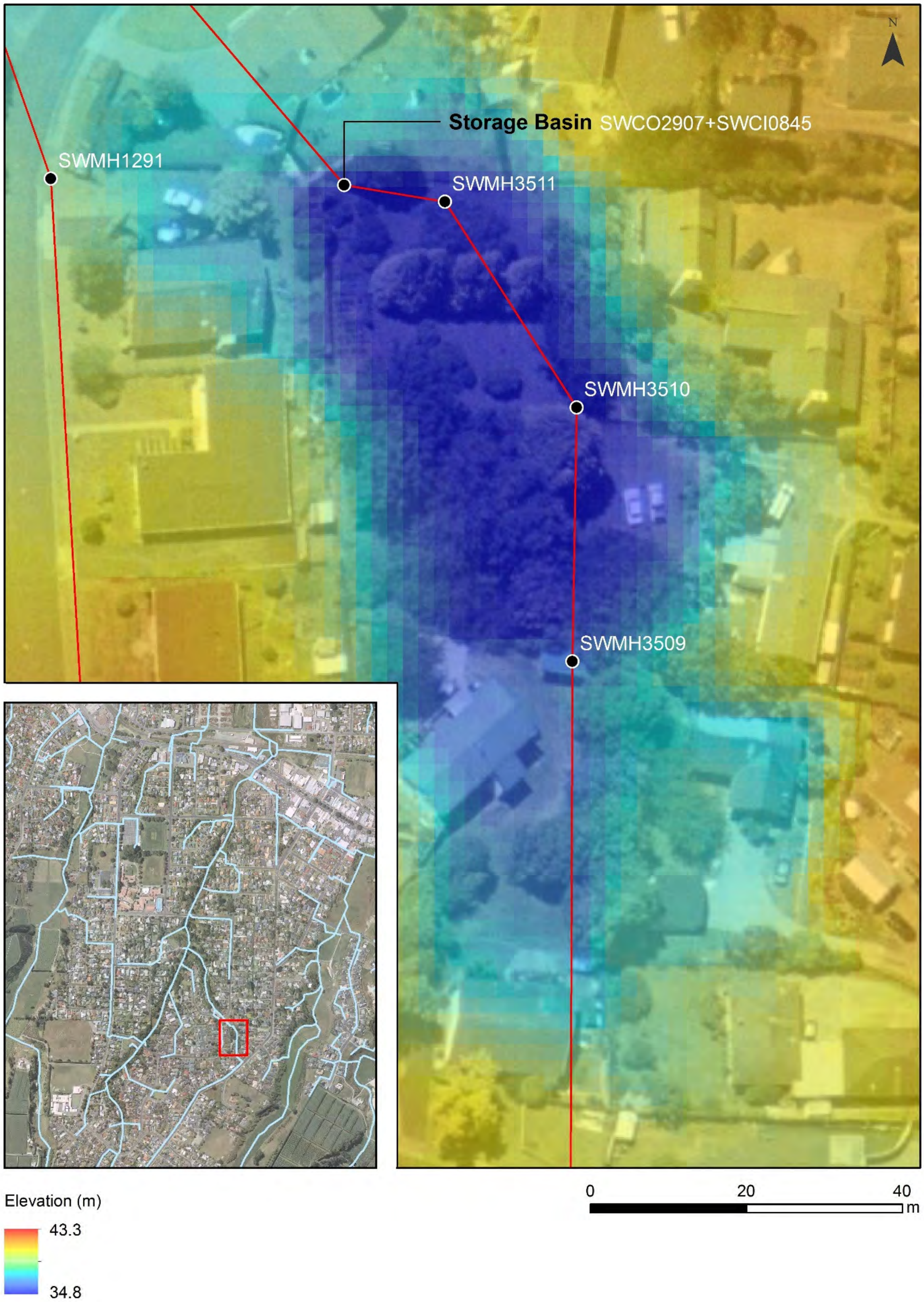

Figure 4 Pipe configuration and surface elevation at the Moehau-Norrie storage basin

Table 1 Geometric data entered into MIKE URBAN for the storage basin

RL (m)	H (m)	Cross-section area (m^2)	Surface area (m^2)
34.8	0.0	0.0	8
34.9	0.1	0.5	176
35.0	0.2	1.9	388
35.2	0.4	6.0	656
35.4	0.6	10.8	952
35.6	0.8	16.0	1232
35.8	1.0	21.5	1492
36.0	1.2	27.3	1648
36.2	1.4	33.3	1788
36.4	1.6	39.5	1928
36.6	1.8	45.9	2228
36.8	2.0	52.5	2496
37.0	2.2	59.4	2768
37.2	2.4	66.5	3008
37.4	2.6	74.1	3296
37.6	2.8	82.4	3592

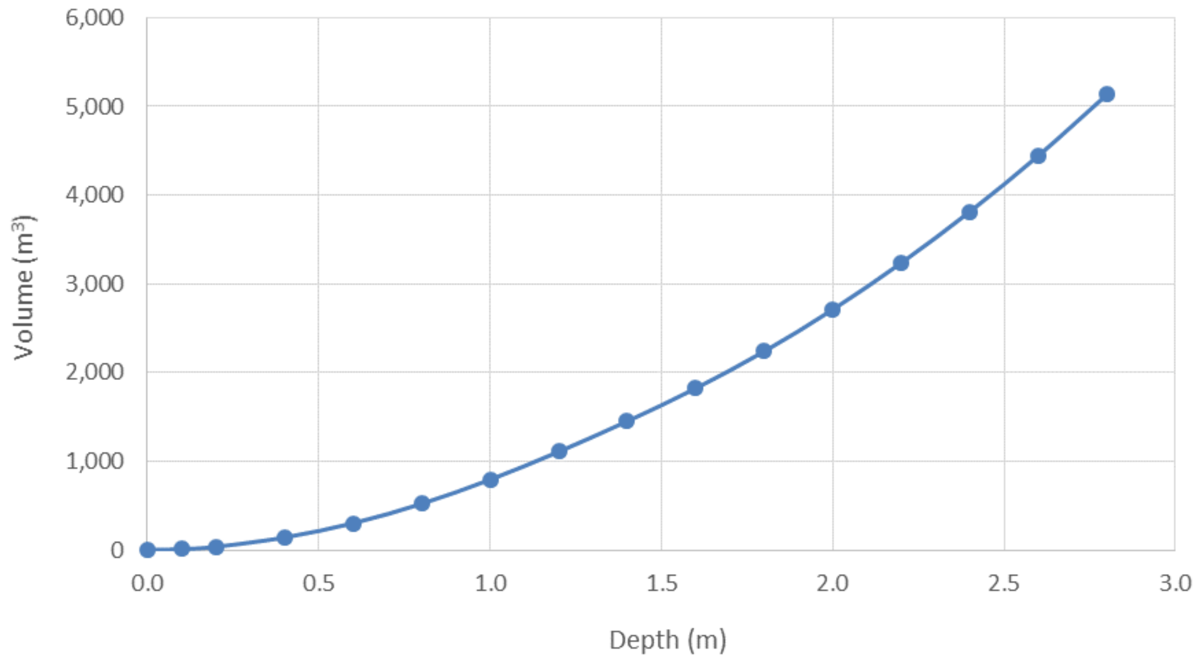

Figure 5 Depth-storage relationship for the storage basin

2.4 Catchments

The addition and rearrangement of piped sections in MIKE URBAN required some catchments to be subdivided and/or to have their rainfall load assigned to different model nodes. These changes are outlined in Table 2.

Table 2 Changes to catchments between Stages 2 and 4

Stage 2 catchment	Stage 4 catchment	Stage 2 node connection	Stage 4 node connection
618	618_1	SWMH2048	SWMH2048
	618_2		SWMH1313
609_2	423_1	FNJN0128	SWMH0041
	423_2		FNJN0128
642	425_1	FNJN0032	SWMH1374
	425_2		FNJN0032
512	430_1	SWMH2156	SWMH2156
	430_2		SWMH3477
504_1	504_1	SWMH1157	SWMH1156
578_1	578_1	SWMH0657	SWCP1078

The MIKE URBAN model uses two types of catchments. These are shown in Figure 6. The MIKE URBAN catchments are those used directly in the model for generating runoff. These cover the existing extent of stormwater infrastructure. The area and imperviousness values of these catchments are used to convert rainfall intensity to runoff volumes which are then assigned to model nodes during the network simulation. The catchments north of the model domain are included since the channels that run through them control the downstream water level boundaries and resultant backwater effects into the model domain.

The second catchment type – Inflow catchments – do not exist explicitly within MIKE URBAN but are instead used to calculate flows which are assigned as boundary conditions to the nodes at the upstream edge of the model domain (Figure 8). The calculated inflows therefore provide the runoff volumes in those parts of the model domain not covered by the MIKE URBAN catchments. Hence, the model considers the full upstream influence of these catchments rather than simply the portion that falls within the model domain.

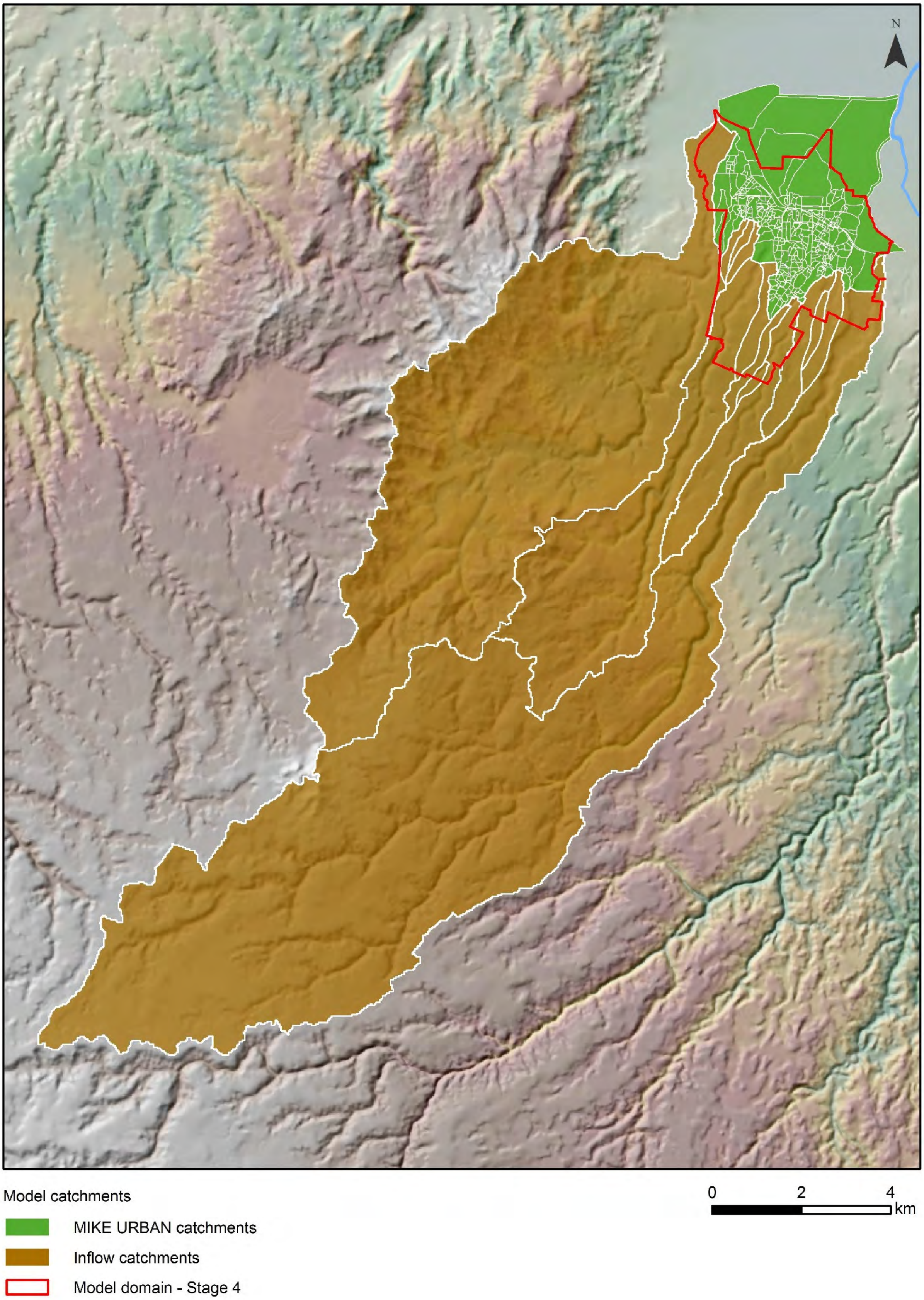

Figure 6 Te Puke catchments

2.5 Boundary Conditions

Boundary conditions were retained from the Stage 2 model with the exception of the upstream inflows. Inflows were recalculated and assigned to different model nodes following changes to the open channels in the model. Peak discharges were retained from the Stage 2 model but were proportionally allocated on the basis of revised catchment areas where the original catchments had been subdivided. The resultant flows, applied as constant network loads, were assigned to 13 new nodes (Figure 8). The values used for the 5-year (ARI 2.33) and 50-year (ARI 20) models are given in Table 3.

Table 3 Estimated peak discharges for the catchments upstream of Te Puke

Name	Stage 2 Node	Stage 4 Node	Proportion of Stage 2 Catchment (%)	Estimated Peak Discharge (m^3/s)	
				ARI 2.33	ARI 20
Raparapahoe River	FNJN0047	FNJN0155	100	49.00	77.45
Raparapahoe Canal Tributary 1	SWCI0836	FNJN0156	100	0.20	0.32
Raparapahoe Canal Tributary 2	SWCI0837	FNJN0157	100	0.15	0.24
Raparapahoe Canal Tributary 3	SWCI0838	FNJN0158	100	0.38	0.61
Ohineangaanga Stream	FNJN0034	FNJN0159	100	15.20	24.00
Ohineangaanga Tributary	SWCO0951	FNJN0160	100	0.94	1.48
Waiari Stream Tributary 1a	N/A	FNJN0162	12.88	0.56	0.88
Waiari Stream Tributary 1b	N/A	FNJN0164	4.37	0.19	0.30
Waiari Stream Tributary 1c	N/A	FNJN0165	82.75	3.57	5.64
Waiari Stream Tributary 1	FNJN0001	N/A	100	4.32	6.82
Waiari Stream Tributary 2a	N/A	FNJN0167	84.47	1.64	2.59
Waiari Stream Tributary 2b	N/A	FNJN0168	15.53	0.30	0.48
Waiari Stream Tributary 2	FNJN0010	N/A	100	1.94	3.07
Waiari Stream Tributary 3	FNJN0011	FNJN0169	100	0.70	1.10
Waiari Stream	FNJN0017	FNJN0170	100	67.89	107.61

2.6 MIKE FLOOD Model Limitations

The MIKE FLOOD model comprises a MIKE URBAN component, which contains the pipe and open channel network, linked with a MIKE21 component, which describes overland flow. Water is exchanged between these models as the simulation proceeds, to generate a final flood depth. The modelling of open channels is more conventionally undertaken using MIKE11 which exchanges water with MIKE21 in a different way to MIKE URBAN. This difference has implications for the flood extent produced for the 50-year ARI scenario in MIKE FLOOD.

In MIKE11, water is able to spill to the MIKE21 surface along the full length of the channel. In MIKE URBAN, water can only spill at the nodes at either end of each channel (Figure 7). This means that in the approach used here, water on the surface in the vicinity of the open channels can only have flowed from the upstream node or backed up the channel from the downstream node. This may over-estimate flood depths at the channel ends and under-estimate flood depths along the channel lengths, or give a false impression of where water exits or enters an open channel.

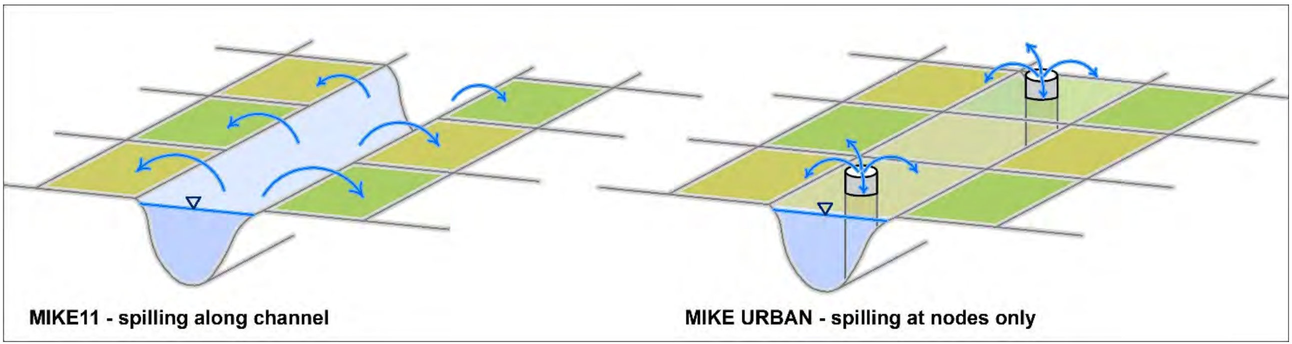

Figure 7 Comparison of water exchange with MIKE21 between MIKE URBAN and MIKE11

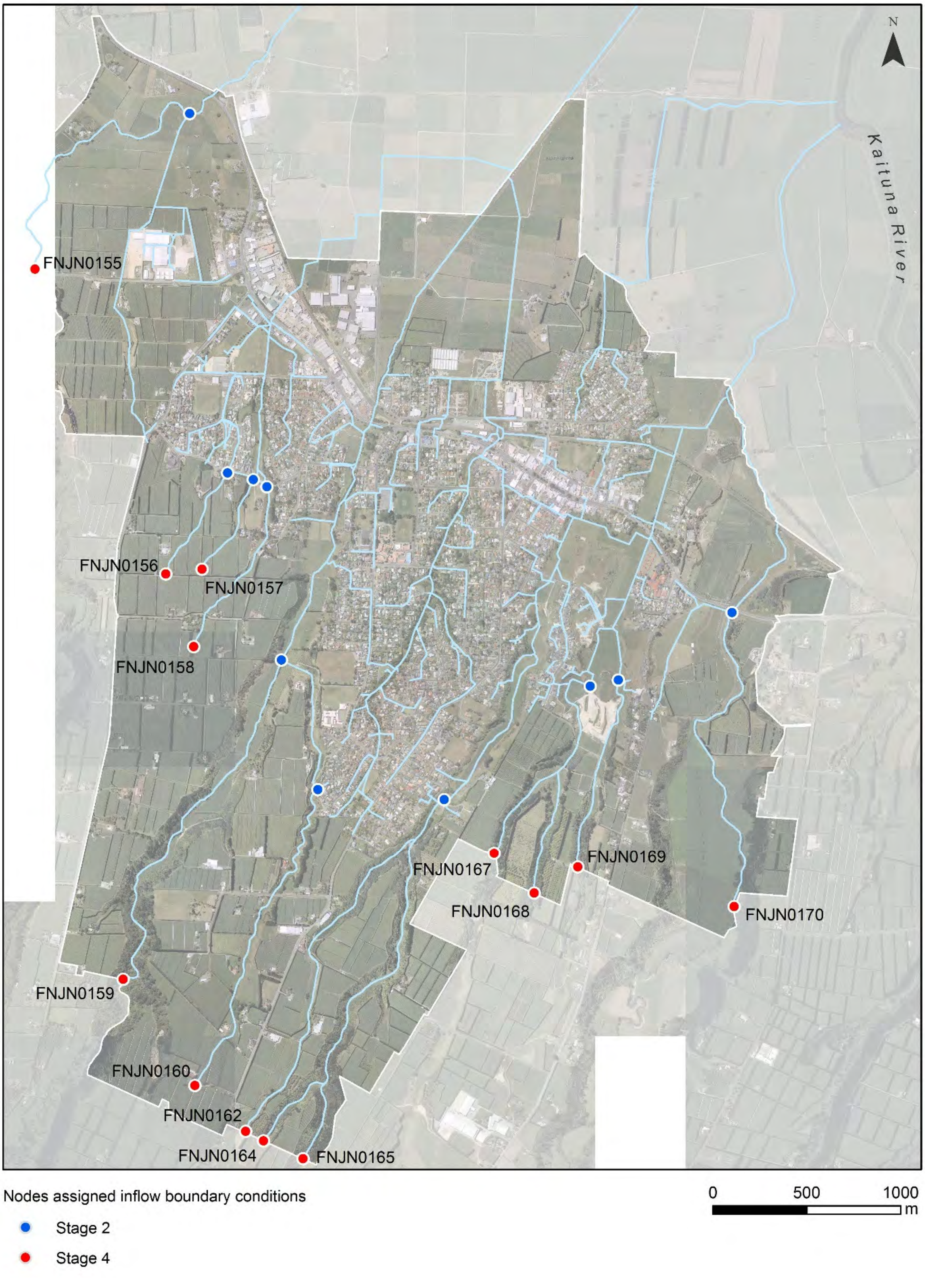

Figure 8 Location of inflow boundary conditions in the Stage 4 MIKE URBAN model

3 Model Results

3.1 Introduction

MIKE URBAN was used to evaluate stormwater system performance under 5-year and 50-year ARI storm events, and to determine infrastructure upgrades necessary to pass a 5-year ARI storm event. MIKE FLOOD was used to model surface flooding that resulted from a 50-year ARI storm with the existing infrastructure in place.

Stormwater system performance was evaluated in terms of the MIKE URBAN parameter $\mathbf{Q_{max} / Q_{Manning}}$, which describes pipe capacity in terms of the ratio of the maximum modelled flow in each pipe to the maximum theoretically possible flow in that pipe (using Manning's equation).

This information was used to assess the capacity of existing pipes and manholes in the 5-year scenario so that those in need of upgraded capacity could be identified (detailed in Section 4).

3.2 Pipe Capacity

Pipe capacity values for the 5-year and 50-year scenarios (existing infrastructure) are shown in Figure 9 and Figure 10, respectively. They show that the capacity of the existing network is exceeded in 216 pipes during a 5-year storm and 277 pipes during a 50-year storm. These results form the basis of the network upgrade programme for the 5-year scenario.

3.3 Flood extent

A flood depth map was produced for the 50-year, 30-minute scenario (existing infrastructure) using MIKE FLOOD (Figure 11). The output from MIKE FLOOD was a grid file of water depth. A water level grid was created from this by adding the depth values to the ground levels of the DEM.

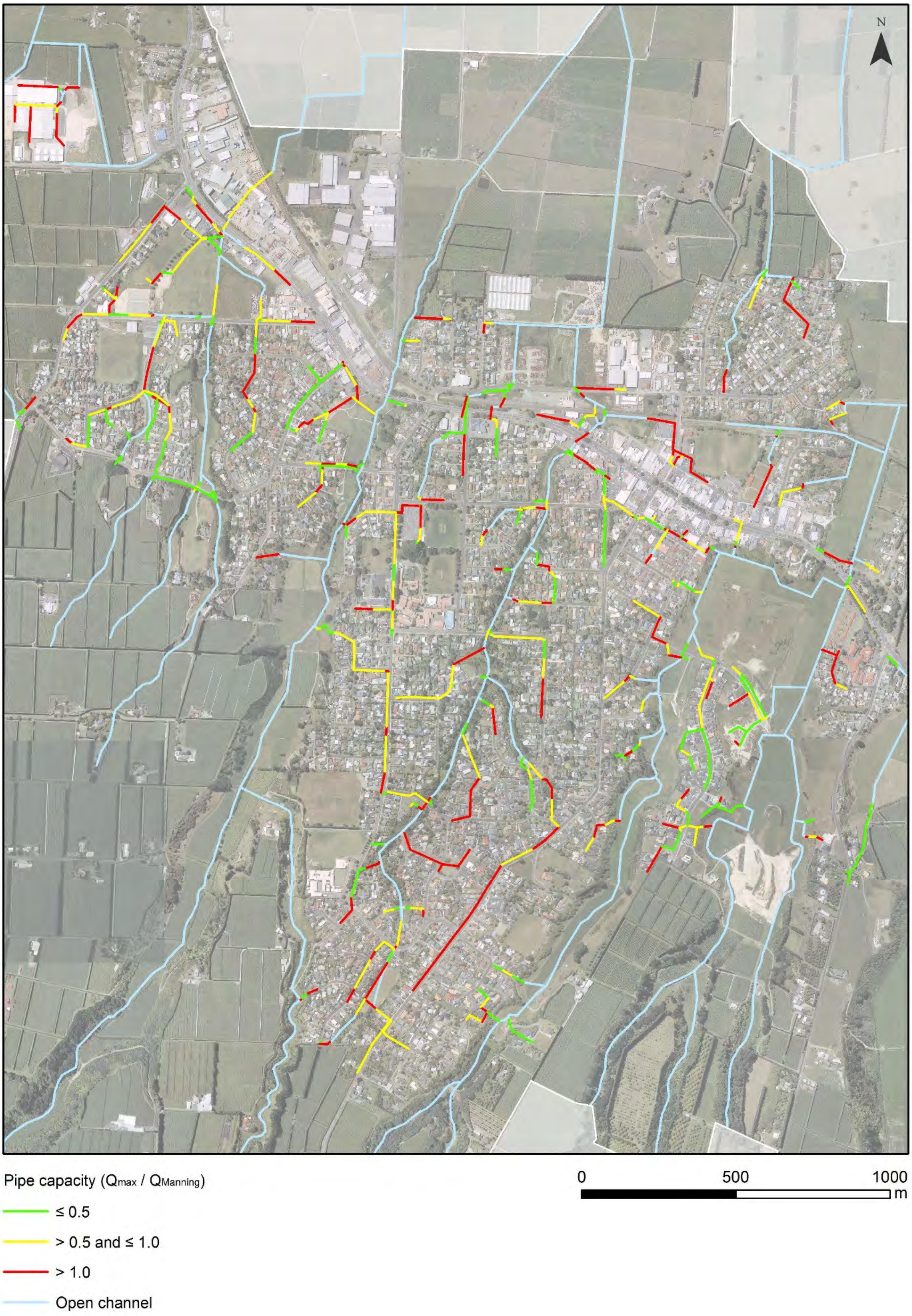

Figure 9 Pipe capacity values ($Q_{max}/Q_{Manning}$) for the 5-year ARI storm (existing infrastructure)

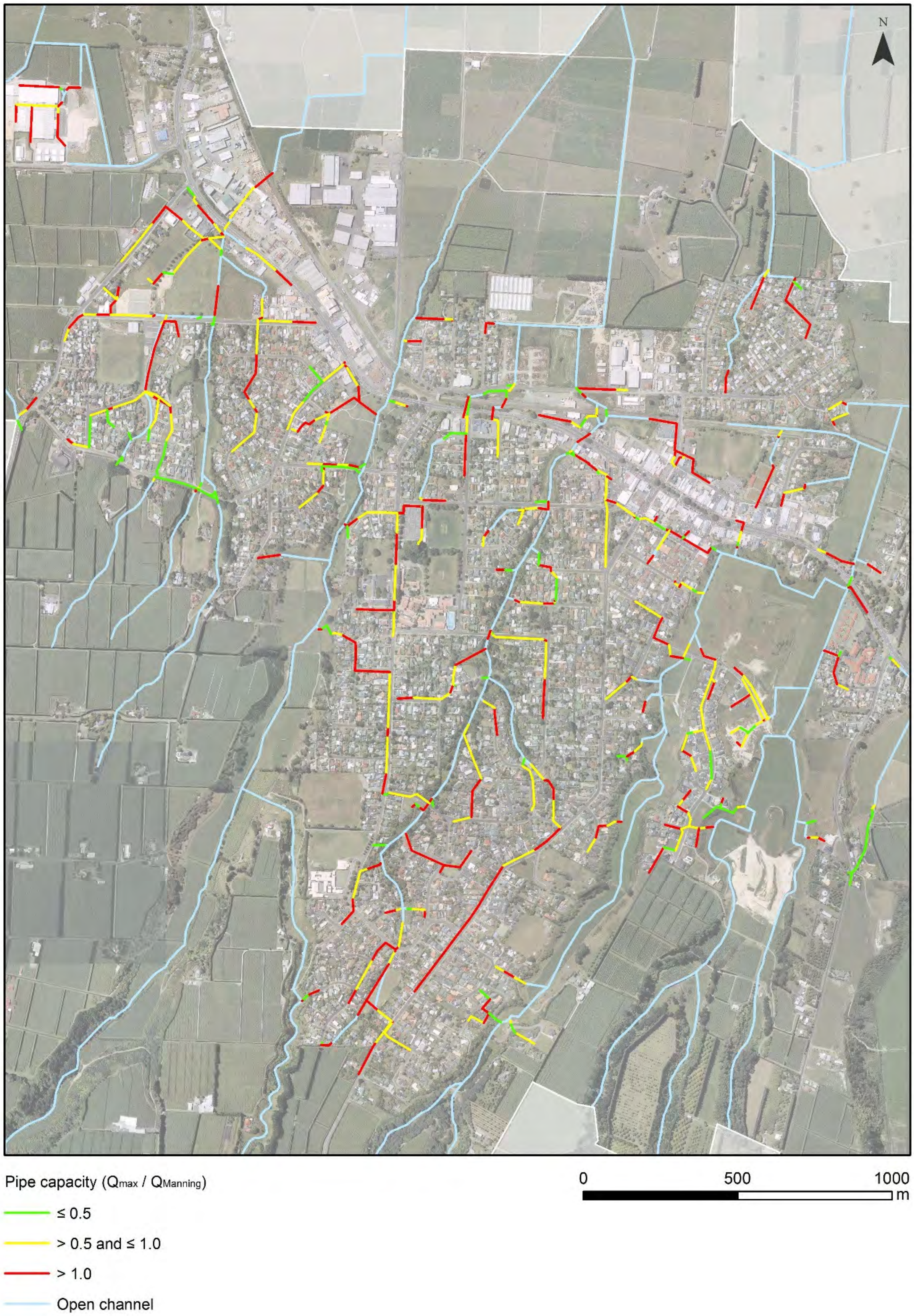

Figure 10 Pipe capacity values ($Q_{max}/Q_{Manning}$) for the 50-year ARI storm (existing infrastructure)

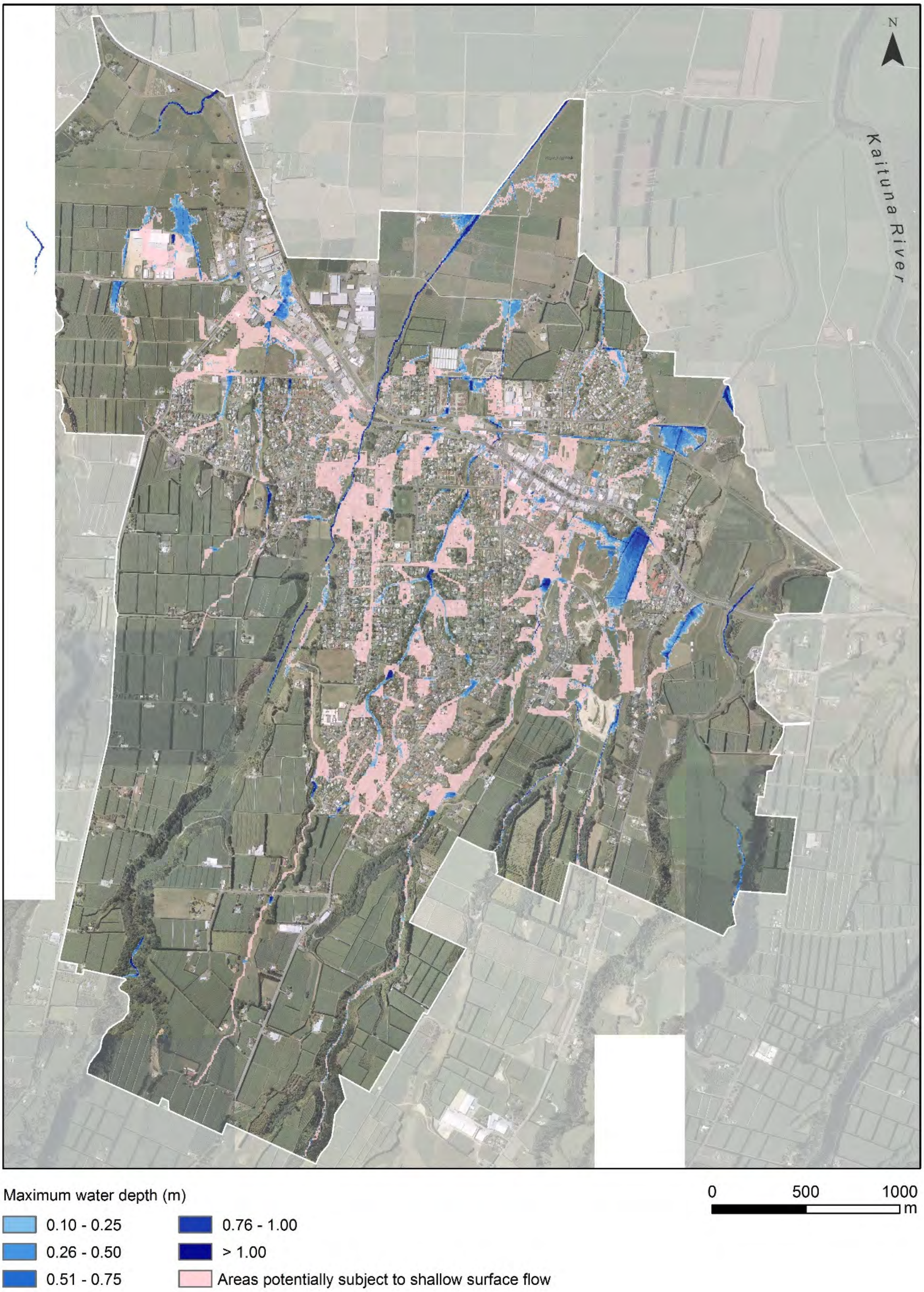

Figure 11 Flood depth for the 50-year ARI, 30-minute duration storm (existing infrastructure)

4 Network Upgrades

4.1 Introduction

Network upgrades were calculated for the 5-year ARI scenario only. Pipes to be upgraded were identified on the basis of the MIKE URBAN pipe capacity parameter (Q_{max} / $Q_{Manning}$) for which a value of greater than 1 was assumed to represent an impediment in the stormwater system. Pipes meeting this criterion were therefore considered to be in need of upgrading. They were assigned an appropriate diameter and cost estimates for the upgrades were prepared. Pipe and manhole upgrade costs were calculated from the 2012 unit rates supplied by WBOPDC (*Appendix A – WBOPDC Stormwater Asset Unit Rates*).

4.2 Pipe Upgrades

The objective of the upgrades procedure was to derive a stormwater network for which all pipes had a Q_{max} / $Q_{Manning}$ value of less than 1 but without creating unnecessarily large pipe diameters to achieve this. A macro was developed in Excel to compare the modelled pipe flow with the theoretical maximum pipe flow and to assign the minimum diameter necessary to allow flow to pass without the system surcharging. Because this was an iterative process, some pipes which initially had a Q_{max} / $Q_{Manning}$ value of less than 1 were subsequently upgraded as increased flow from previously upgraded pipes upstream led to surcharging downstream. Nine iterations of the pipe upgrade process were required to attain two successive simulations without any pipe diameter changes.

A total of 275 pipes were identified for upgrading using this method (Figure 12). These pipes are listed in *Appendix B – Pipe Upgrade Costs* with their existing and upgraded diameters.

Following the upgrades procedure, 96% of pipes were shown to have Q_{max} / $Q_{Manning}$ < 1, indicating the network's ability to pass a storm of that magnitude without surcharging (Figure 13). Of the remaining 26 pipes (Q_{max} / $Q_{Manning}$ range 1.001 – 2.261), 21 are less than 10 m long. In order to allocate a computation point to each model link, MIKE URBAN treats these sections as having a length of 10 m. This creates an artificially flat slope which in turn underestimates the Manning's flow value, thereby yielding a higher-than-actual Q_{max} / $Q_{Manning}$ value. In addition, three pipes had a zero slope such that no increase in diameter would yield Q_{max} / $Q_{Manning}$ < 1.

These pipes were manually inspected in the model to ensure their capacity was adequate and, where they were shown to contribute to surcharging, had their diameter increased. They were otherwise considered to not be in need of upgrading.

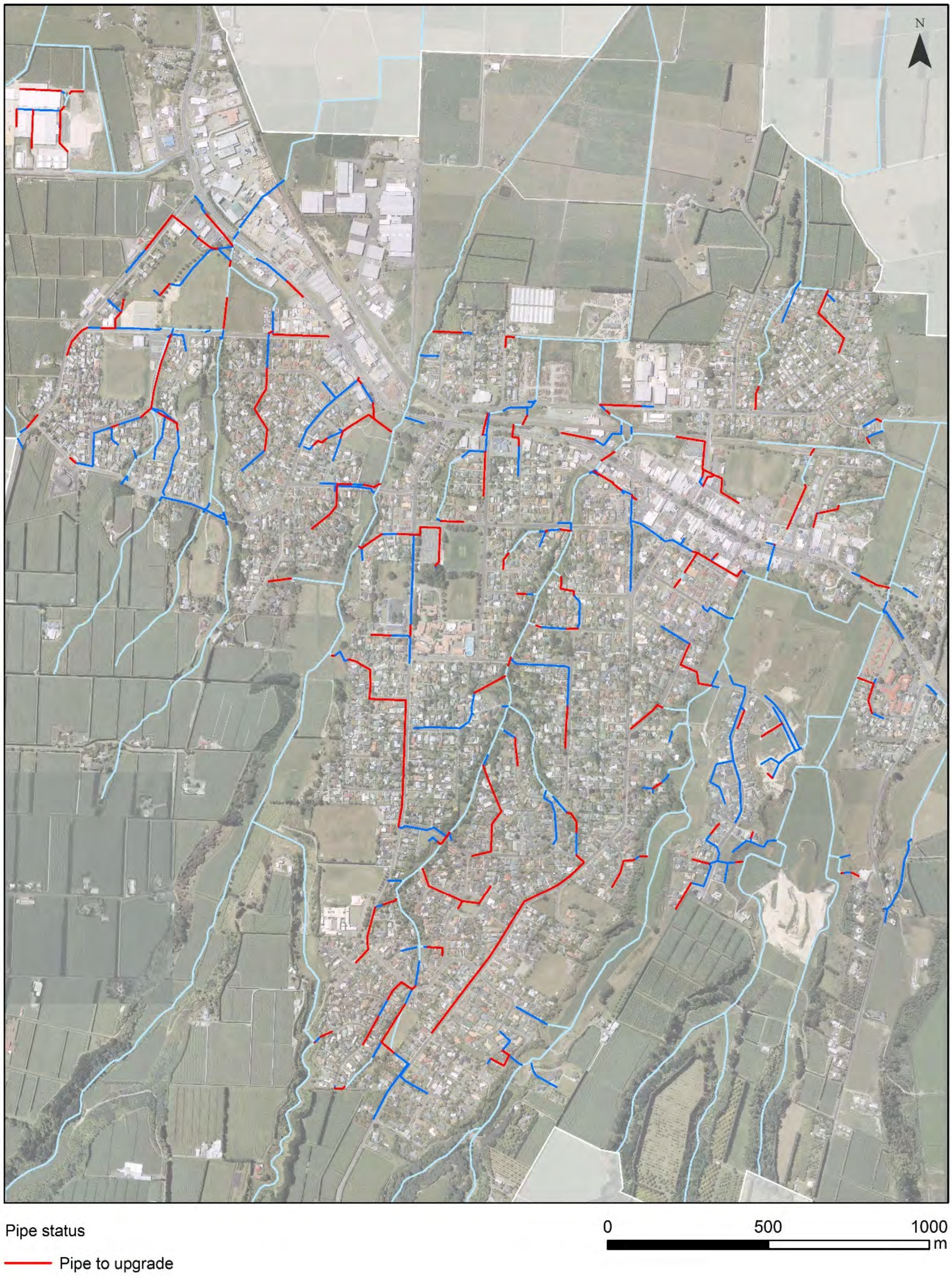

Figure 12 Pipes to be upgraded for the 5-year ARI, 30-minute duration storm

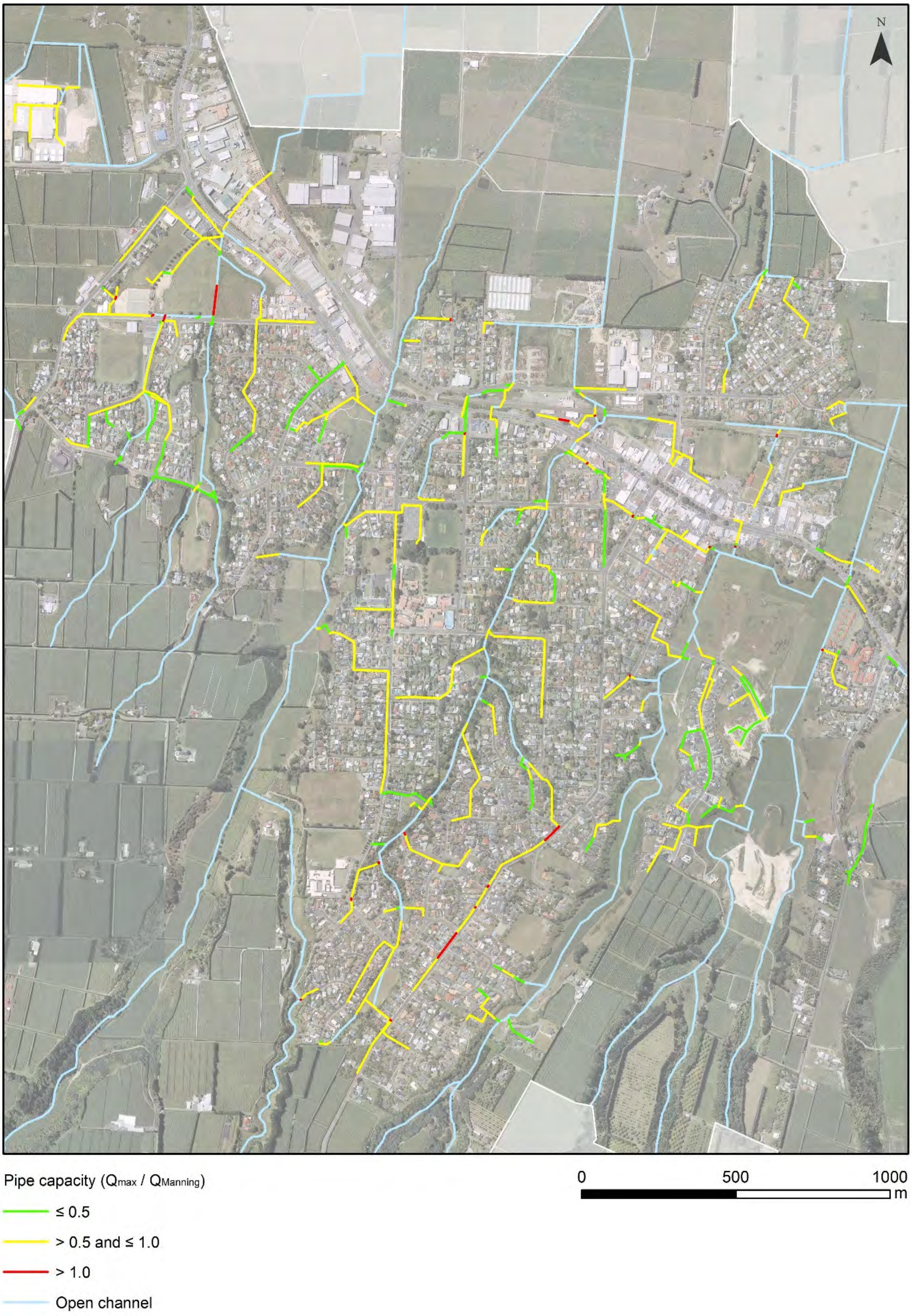

Figure 13 Pipe capacity values ($Q_{max}/Q_{Manning}$) for the 5-year ARI storm (upgraded infrastructure)

4.3 Pipe Upgrade Costs

Estimates of upgrade costs assumed all pipes were concrete, except for 0.15 m diameter pipes which were assumed to be PVC. The 275 pipes identified as requiring upgrading covered 10,673 m with a calculated cost of approximately $9,015,000. A summary of cost by diameter is given in Table 4. Upgrade costs for each pipe are given in *Appendix B – Pipe Upgrade Costs*.

Table 4 Summary of pipe upgrade costs by diameter

Diameter (m)	No. pipes	Length (m)	Cost ($)
0.150	1	25	5,332
0.225	3	53	15,762
0.300	32	1,227	610,117
0.375	62	2,648	1,460,283
0.450	49	1,744	1,188,120
0.525	38	1,580	1,263,433
0.600	32	1,152	1,087,072
0.675	20	796	777,142
0.750	14	675	756,042
0.825	9	314	393,317
0.900	3	90	138,785
1.050	1	14	26,814
1.200	5	150	329,595
1.350	1	28	68,632
1.800	1	95	372,388
1.950	1	17	75,509
2.300	2	22	122,337
3.100	1	43	324,702
Total	**275**	**10,673**	**9,015,382**

4.4 Manhole Upgrades

Model nodes that were connected to a pipe in need of upgrading were identified using a spatial join procedure in GIS. The number of identified nodes was reduced by excluding those which were not manholes (i.e., which did not have the asset prefix SWMH or SWBX). The number was further reduced by excluding manholes that were connected to at least one non-upgraded pipe, where the diameter increase of the upgraded pipe was not sufficient to warrant an increase in manhole diameter. This method assumes that the upgraded pipe could be connected to the existing manhole. A total of 207 manholes were identified for upgrading using this approach (Figure 14).

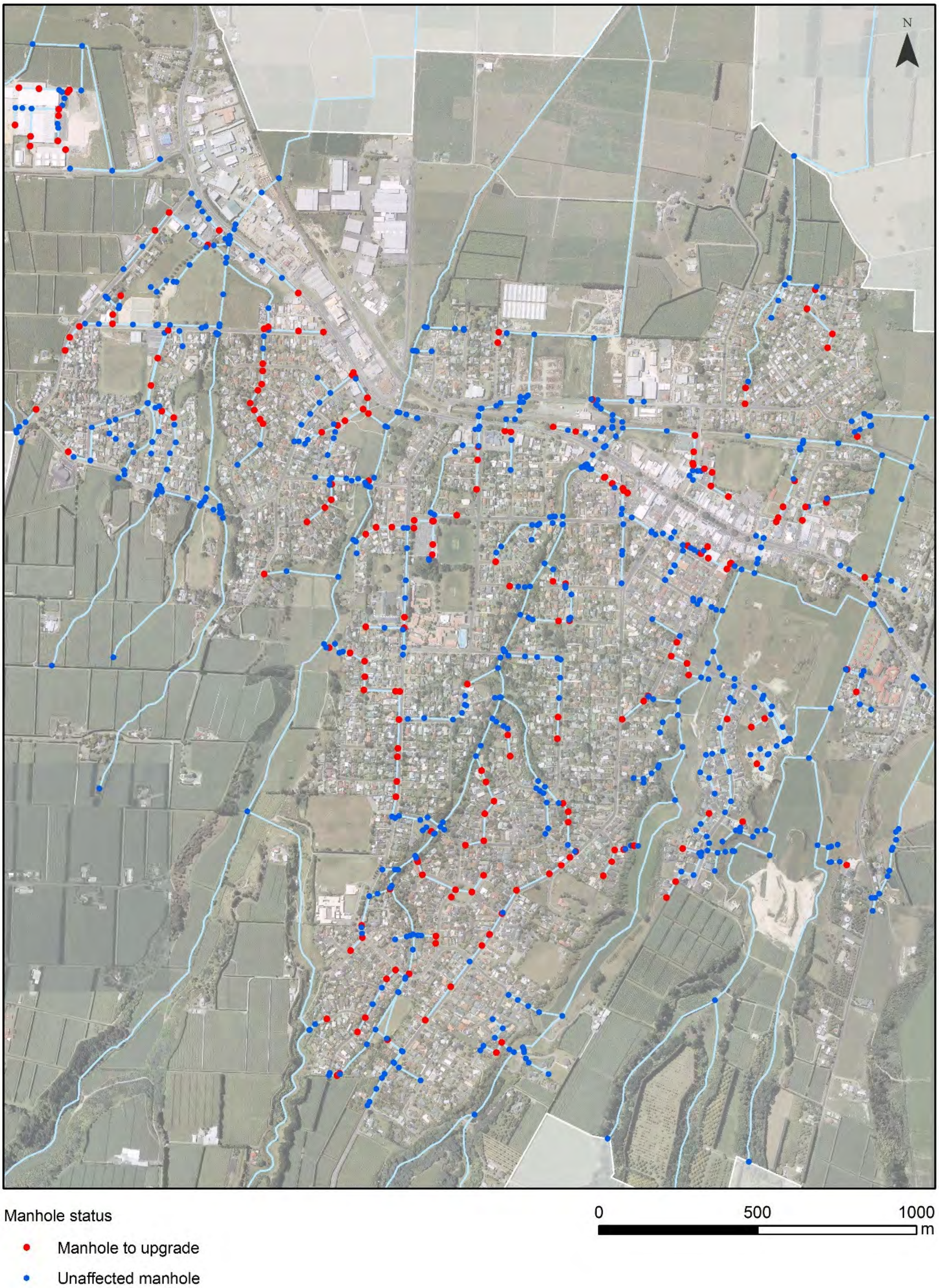

Figure 14 Manholes to be upgraded for the 5-year ARI, 30-minute duration storm

Upgraded manhole diameters were assigned on the basis of the diameters of connected pipes (Table 5).

Table 5 Upgraded pipe diameters and corresponding upgraded manhole diameter

Upgraded pipe diameter (m)	Corresponding manhole diameter (m)
0.150 - 0.600	1.05
0.675 - 0.750	1.20
0.900 - 1.050	1.50
1.200 - 1.350	1.80
≥ 1.950[1]	1.05

4.5 Manhole Upgrade Costs

Manhole upgrade costs were derived from linear depth-cost relationships based on 2012 unit rates supplied by WBOPDC. The relationships are given in Table 6, where y = cost ($) and x = depth (m). Using this method, the 207 manholes identified for upgrade were calculated to cost approximately $1,060,000. A summary of cost by diameter is given in Table 7. A table of upgrade costs for each manhole is given in *Appendix C – Manhole Upgrade Costs*.

Table 6 Cost derivation relationship for manholes to be upgraded

Manhole diameter (m)	Depth-Cost relationship
1.05	y = 1568.5x + 1621.5
1.20	y = 1676.7x + 2302.0
1.50	y = 2288.7x + 2944.8
1.80	y = 3229.5x + 3847.6

Table 7 Summary of manhole upgrades by diameter

Manhole diameter (m)	No. manholes	Cost ($)
1.05	147	621,024
1.20	35	198,879
1.50	21	189,596
1.80	4	50,850
Total	**207**	**1,060,349**

(1) This assumes that the pipe diameter is such that it is more economical and practical to mount standard 1.05 m diameter manhole risers on top of the pipe rather than connecting the pipes to a new, very large manhole.

4.6 Upgrade Prioritisation and Costs

Sections of the stormwater network in which consecutive pipes have insufficient capacity for a particular design storm can be said to constitute bottlenecks in the system if they lead to manholes surcharging. The degree of surcharging associated with bottlenecks under the 5-year ARI storm was used to prioritise network upgrades. The prioritisation uses an index (described below) based on the MIKE URBAN pipe capacity value and the collective pipe length. This method considers hydraulic performance only and takes no account of the effects of any flooding on properties.

Twenty-five bottlenecks were identified from the pipes previously selected for upgrading (Section 4.2). For each pipe a score was calculated by the equation (Q_{max} / $Q_{Manning}$) * Length. The priority index was calculated by Σ_{Score} / Σ_{Length} for bottlenecks in which Σ_{Length} > 280 m [(1)]. Bottlenecks may include pipes which individually have adequate capacity in a 5-year ARI storm (i.e., Q_{max} / $Q_{Manning}$ < 1) but whose upstream or downstream neighbours show pressurised flow. Such pipes are included in the ranking calculation but not in the cost calculation.

Bottlenecks were ranked according to the priority index and the 12 highest priority cases were identified and their upgrade costs estimated (Table 8). The locations of the priority bottlenecks are shown in Figure 15. Upgrading the 12 highest-ranked bottlenecks was estimated to cost approximately $4.1 million. The detailed cost estimates are presented in *Appendix D – Bottleneck Upgrade Costs*.

Table 8 Bottleneck upgrade priority ranking and cost estimates

Bottleneck	Σ Score	Σ Length	Index	Cost ($)[(2)]
1	530	316	1.68	284,704
2	543	353	1.54	401,230
3	555	407	1.36	482,346
4	333	287	1.16	287,014
5	484	438	1.11	303,944
6	644	584	1.10	400,344
7	317	290	1.09	195,403
8	435	410	1.06	370,318
9	954	906	1.05	709,212
10	302	293	1.03	164,576
11	348	348	1.00	266,291
12	301	313	0.96	189,732
				4,055,114

(1) The scoring equation used to prioritise bottlenecks gives high weight to shorter bottlenecks since short pipes tend to individually have the highest values of Q_{max}/$Q_{Manning}$ and because Σ_{Length} is the equation's denominator. The overall bottleneck score can therefore be dominated by local capacity issues which are not necessarily representative of the whole bottleneck. After applying different length thresholds for what constituted a bottleneck, it was found that 280 m gave the most credible representation.

(2) Estimates include costs for upgrading pipes and manholes

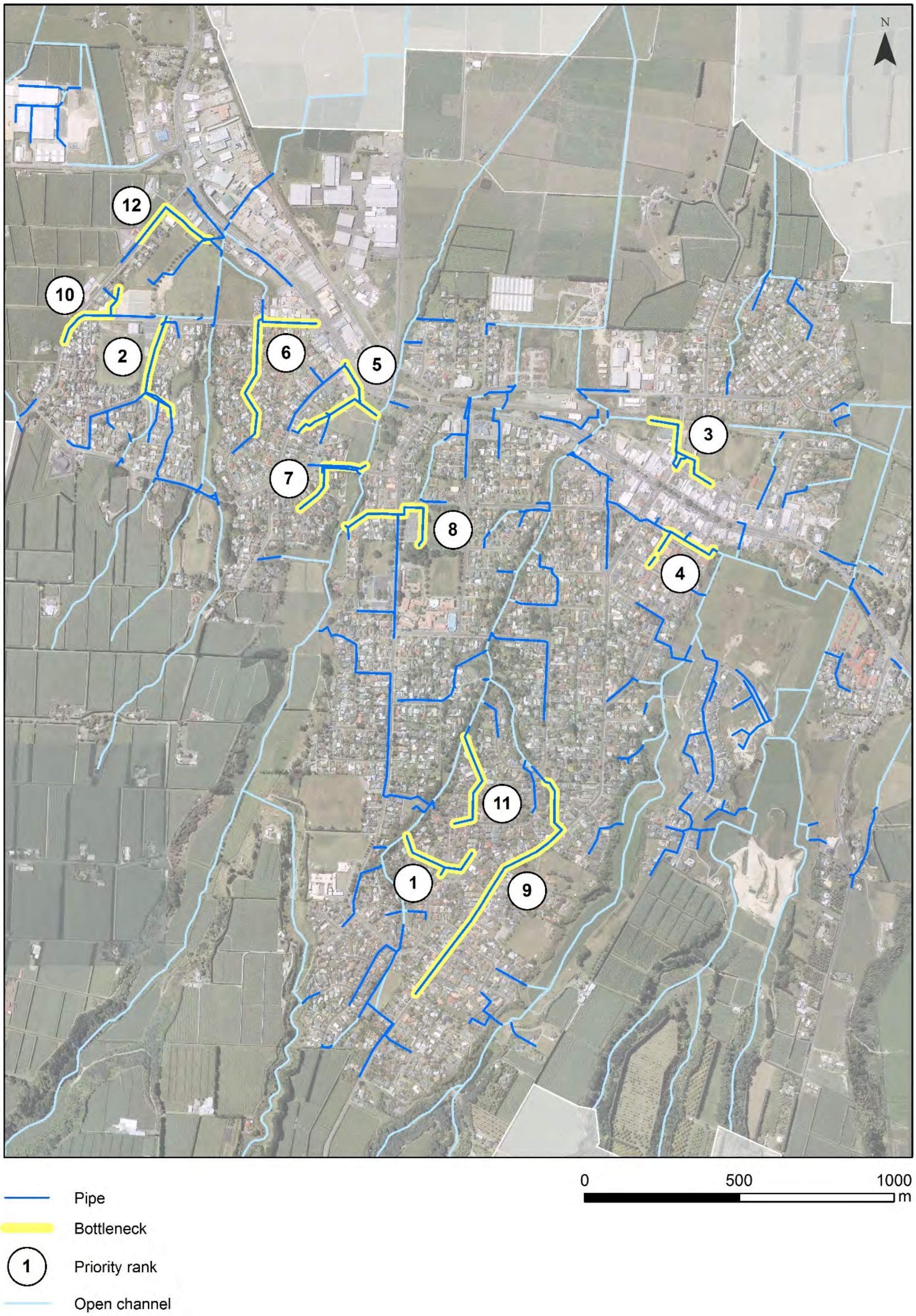

Figure 15 Location and rank of bottlenecks for the 5-year ARI, 30-minute duration storm

5 Conclusions

The Stage 4 modelling shows that the capacity of the Te Puke stormwater system is currently exceeded during a 5-year ARI, 30-minute duration storm event. It is possible to upgrade the network such that a 5-year storm can be passed without network capacity being exceeded. The total cost of upgrading the drainage network to convey the 5-year ARI design event is estimated at $10.1 million. Upgrading the 12 most significant bottlenecks in the system is estimated to cost $4.1 million.

Flood mapping for the 50-year ARI, 30-minute duration storm event shows shallow surface flooding in the vicinity of residential areas, with deeper flooding largely confined to rural areas, park land and open channels. In light of the stormwater system improvements gained by network upgrades for the 5-year ARI event, it is likely that the flood extent and depth would be greatly reduced for a 50-year ARI storm event should the upgrade works be carried out.

6 References

Opus (2012), "*Te Puke MIKE URBAN Stormwater Modelling. Stage 2: Modelling Report*", a report prepared by Opus International Consultants for Western Bay of Plenty District Council, Reference 3-50909.00, November, 2012.

7 Appendices

7.1 Appendix A – WBOPDC Stormwater Asset Unit Rates

Pipes		
Diameter (m)	**Material**	**2012 rate ($/m)**
0.080	PVC	113
0.100	PVC	170
0.150	PVC	214
0.175	PVC	317
0.225	PVC	418
0.250	PVC	540
0.300	PVC	712
0.375	PVC	926
0.400	PVC	1,040
0.450	PVC	1,260
0.475	PVC	1,340
0.525	PVC	1,580
0.600	PVC	1,930
0.675	PVC	2,270
0.700	PVC	2,480
0.750	PVC	2,710
0.900	PVC	3,730
0.225	Concrete	297
0.300	Concrete	496
0.375	Concrete	551
0.450	Concrete	681
0.525	Concrete	801
0.600	Concrete	944
0.675	Concrete	977
0.750	Concrete	1,120
0.825	Concrete	1,250
0.900	Concrete	1,540
1.050	Concrete	1,860
1.200	Concrete	2,200
1.350	Concrete	2,460
1.600	Concrete	3,020
1.800	Concrete	3,910
2.300	Concrete	5,740
3.100	Concrete	7,600

Manholes		
Diameter (m)	**Depth (m)**	**2012 cost ($)**
0.90	1.0	2,590
1.05	0.9	3,100
1.05	1.5	3,800
1.05	2.1	5,050
1.05	3.0	6,300
1.20	1.2	4,300
1.20	2.1	5,800
1.20	3.0	7,420
1.20	3.9	8,790
1.35	1.5	5,450
1.35	2.1	6,820
1.35	3.0	8,320
1.35	3.9	9,820
1.50	1.5	6,300
1.50	2.1	7,800
1.50	3.0	9,920
1.50	3.9	11,790
1.80	1.5	8,660
1.80	2.1	10,540
1.80	3.0	13,800
1.80	3.9	16,300
2.05	3.0	17,000
2.05	3.9	19,800

7.2 Appendix B – Pipe Upgrade Costs

Pipe ID	Length (m)	Existing diameter (m)	Upgraded diameter (m)	Material	Cost ($)
FLPI0164	73	0.300	0.375	Concrete	40,373
SWPI1755	52	0.300	0.375	Concrete	28,388
SWPI1763	44	0.300	0.375	Concrete	24,236
SWPI1765	45	0.300	0.450	Concrete	30,886
SWPI1768	21	0.225	0.300	Concrete	10,493
SWPI1772	43	0.300	0.375	Concrete	23,862
SWPI1776	28	0.225	0.300	Concrete	13,895
SWPI1777	29	0.300	0.450	Concrete	19,790
SWPI1788	71	0.300	0.450	Concrete	48,595
SWPI1792	72	0.300	0.375	Concrete	39,936
SWPI1798	19	0.300	0.375	Concrete	10,681
SWPI1800	16	0.300	0.525	Concrete	12,934
SWPI1807	30	0.300	0.525	Concrete	24,303
SWPI1808	50	0.300	0.450	Concrete	34,022
SWPI1809	32	0.300	0.375	Concrete	17,612
SWPI1817	70	0.225	0.300	Concrete	34,705
SWPI1823	79	0.225	0.375	Concrete	43,496
SWPI1826	94	0.300	0.375	Concrete	51,890
SWPI1829	14	0.750	0.825	Concrete	17,331
SWPI1854	94	0.525	0.675	Concrete	91,677
SWPI1855	88	0.525	0.825	Concrete	110,540
SWPI1857	23	0.225	0.300	Concrete	11,619
SWPI1866	22	0.375	0.450	Concrete	15,000
SWPI1872	42	0.375	0.450	Concrete	28,453
SWPI1873	55	0.525	0.750	Concrete	61,513
SWPI1898	43	0.450	0.825	Concrete	53,374
SWPI1899	22	0.450	0.525	Concrete	17,981
SWPI1921	71	0.250	0.300	Concrete	35,453
SWPI1927	67	0.225	0.300	Concrete	33,194
SWPI1929	16	0.300	0.525	Concrete	12,748
SWPI1931	35	0.300	0.450	Concrete	23,715
SWPI1935	25	0.300	0.600	Concrete	23,616
SWPI1936	47	0.375	0.600	Concrete	44,469
SWPI1939	23	0.375	0.675	Concrete	22,273
SWPI1942	42	0.450	0.675	Concrete	41,162
SWPI1945	23	0.450	0.600	Concrete	21,318
SWPI1970	45	0.300	0.375	Concrete	24,889

Pipe ID	Length (m)	Existing diameter (m)	Upgraded diameter (m)	Material	Cost ($)
SWPI1972	34	0.300	0.525	Concrete	26,893
SWPI1975	20	0.300	0.825	Concrete	25,310
SWPI1980	21	0.300	0.375	Concrete	11,623
SWPI1985	48	0.300	0.375	Concrete	26,697
SWPI1986	32	0.225	0.300	Concrete	15,797
SWPI1990	72	0.225	0.300	Concrete	35,816
SWPI1996	63	0.225	0.300	Concrete	31,234
SWPI2001	78	0.300	0.375	Concrete	42,737
SWPI2007	27	0.300	0.525	Concrete	21,433
SWPI2011	90	0.450	0.600	Concrete	85,163
SWPI2015	89	0.450	0.600	Concrete	83,920
SWPI2018	13	0.600	0.900	Concrete	20,505
SWPI2021	100	0.600	0.750	Concrete	112,134
SWPI2025	42	0.600	0.750	Concrete	46,840
SWPI2027	49	0.600	0.750	Concrete	54,855
SWPI2032	53	0.600	0.675	Concrete	51,459
SWPI2033	22	0.525	0.600	Concrete	21,029
SWPI2037	9	0.600	0.750	Concrete	10,120
SWPI2052	70	0.300	0.375	Concrete	38,595
SWPI2058	58	0.300	0.600	Concrete	54,457
SWPI2060	24	0.300	0.525	Concrete	19,200
SWPI2061	32	0.300	0.525	Concrete	25,618
SWPI2063	38	0.300	0.525	Concrete	30,066
SWPI2070	10	0.400	0.675	Concrete	9,499
SWPI2076	48	0.225	0.300	Concrete	23,867
SWPI2085	40	0.225	0.450	Concrete	27,066
SWPI2089	51	0.225	0.375	Concrete	28,021
SWPI2092	49	0.300	0.375	Concrete	27,249
SWPI2097	31	0.300	0.375	Concrete	16,842
SWPI2098	39	0.300	0.375	Concrete	21,632
SWPI2101	39	0.375	0.450	Concrete	26,592
SWPI2105	14	0.675	1.050	Concrete	26,814
SWPI2115	56	0.225	0.375	Concrete	30,876
SWPI2117	14	0.225	0.450	Concrete	9,439
SWPI2119	19	0.225	0.450	Concrete	13,236
SWPI2121	96	0.375	0.450	Concrete	65,571
SWPI2122	5	0.225	0.450	Concrete	3,596

Pipe ID	Length (m)	Existing diameter (m)	Upgraded diameter (m)	Material	Cost ($)
SWPI2127	41	0.375	0.450	Concrete	28,259
SWPI2128	5	0.375	0.600	Concrete	4,500
SWPI2136	23	0.225	0.525	Concrete	18,622
SWPI2139	46	0.300	0.375	Concrete	25,579
SWPI2146	47	0.300	0.375	Concrete	25,739
SWPI2147	36	0.225	0.300	Concrete	17,978
SWPI2154	26	0.300	0.375	Concrete	14,436
SWPI2173	63	0.300	0.525	Concrete	50,143
SWPI2176	101	0.300	0.450	Concrete	68,451
SWPI2179	132	0.300	0.375	Concrete	72,665
SWPI2183	4	0.300	0.450	Concrete	2,763
SWPI2185	46	0.300	0.525	Concrete	36,695
SWPI2186	138	0.375	0.600	Concrete	130,351
SWPI2203	2	0.300	0.525	Concrete	1,242
SWPI2204	77	0.300	0.525	Concrete	61,355
SWPI2206	5	0.300	0.525	Concrete	3,926
SWPI2208	81	0.300	0.525	Concrete	65,168
SWPI2211	116	0.300	0.525	Concrete	92,771
SWPI2215	46	0.525	0.675	Concrete	45,252
SWPI2217	38	0.525	0.600	Concrete	35,667
SWPI2219	26	0.525	0.600	Concrete	24,362
SWPI2225	1	0.525	0.600	Concrete	1,282
SWPI2226	31	0.525	0.600	Concrete	29,188
SWPI2230	64	0.225	0.525	Concrete	51,425
SWPI2233	53	0.225	0.375	Concrete	28,984
SWPI2237	115	0.375	0.600	Concrete	108,376
SWPI2241	27	0.225	0.375	Concrete	14,608
SWPI2244	43	0.300	0.450	Concrete	29,366
SWPI2245	8	0.450	0.600	Concrete	7,849
SWPI2246	6	0.450	0.600	Concrete	6,017
SWPI2253	43	0.900	1.200	Concrete	94,719
SWPI2260	60	0.300	0.375	Concrete	32,848
SWPI2263	86	0.300	0.450	Concrete	58,311
SWPI2266	49	0.300	0.450	Concrete	33,417
SWPI2267	65	0.375	0.525	Concrete	52,234
SWPI2270	39	0.375	0.450	Concrete	26,253
SWPI2271	50	0.375	0.450	Concrete	33,799

Pipe ID	Length (m)	Existing diameter (m)	Upgraded diameter (m)	Material	Cost ($)
SWPI2288	67	0.300	0.375	Concrete	36,832
SWPI2291	21	0.375	0.450	Concrete	14,121
SWPI2303	109	0.450	0.600	Concrete	103,326
SWPI2307	67	0.300	0.450	Concrete	45,929
SWPI2310	61	0.375	0.450	Concrete	41,440
SWPI2332	28	1.200	1.350	Concrete	68,632
SWPI2339	28	0.225	0.300	Concrete	13,855
SWPI2343	30	0.225	0.300	Concrete	14,837
SWPI2350	7	0.300	0.450	Concrete	4,668
SWPI2354	31	0.300	0.375	Concrete	17,101
SWPI2361	14	0.225	0.375	Concrete	7,854
SWPI2368	7	0.300	0.450	Concrete	4,608
SWPI2369	6	0.300	0.450	Concrete	3,809
SWPI2370	41	0.300	0.600	Concrete	38,342
SWPI2371	38	0.300	0.375	Concrete	20,865
SWPI2383	89	0.300	0.375	Concrete	49,213
SWPI2385	21	0.300	0.450	Concrete	14,392
SWPI2386	1	0.300	0.450	Concrete	883
SWPI2387	17	0.300	0.375	Concrete	9,333
SWPI2399	30	0.225	0.300	Concrete	14,928
SWPI2403	52	0.225	0.300	Concrete	25,838
SWPI2404	38	0.225	0.375	Concrete	20,974
SWPI2409	28	0.225	0.300	Concrete	13,890
SWPI2410	7	0.225	0.300	Concrete	3,444
SWPI2412	10	0.225	0.300	Concrete	5,002
SWPI2413	12	0.300	0.375	Concrete	6,856
SWPI2416	41	0.300	0.525	Concrete	32,507
SWPI2418	2	0.225	0.450	Concrete	1,090
SWPI2421	24	0.225	0.300	Concrete	12,138
SWPI2447	31	0.150	0.300	Concrete	15,522
SWPI2455	93	0.300	0.375	Concrete	51,449
SWPI2459	41	0.300	0.600	Concrete	38,622
SWPI2460	4	0.300	0.600	Concrete	3,500
SWPI2468	42	0.300	0.375	Concrete	23,168
SWPI2469	22	0.300	0.375	Concrete	12,375
SWPI2473	24	0.300	0.450	Concrete	16,628
SWPI2476	20	0.300	0.525	Concrete	15,916

Pipe ID	Length (m)	Existing diameter (m)	Upgraded diameter (m)	Material	Cost ($)
SWPI2477	39	0.300	0.825	Concrete	48,876
SWPI2493	89	0.300	0.525	Concrete	71,359
SWPI2496	33	0.300	0.450	Concrete	22,248
SWPI2497	26	0.300	0.375	Concrete	14,107
SWPI2512	107	0.300	0.375	Concrete	58,802
SWPI2516	17	0.300	0.375	Concrete	9,503
SWPI2518	4	0.300	0.375	Concrete	1,947
SWPI2519	15	2.025	2.300	Concrete	84,470
SWPI2525	52	0.450	0.675	Concrete	50,605
SWPI2527	36	0.450	0.900	Concrete	55,751
SWPI2528	32	0.225	0.450	Concrete	22,119
SWPI2529	11	0.225	0.450	Concrete	7,390
SWPI2530	11	0.225	0.375	Concrete	6,268
SWPI2531	41	0.450	0.900	Concrete	62,529
SWPI2534	27	0.450	0.750	Concrete	30,003
SWPI2535	42	0.375	0.750	Concrete	47,583
SWPI2536	64	0.375	0.675	Concrete	62,678
SWPI2541	90	0.450	0.675	Concrete	87,993
SWPI2584	43	1.800	3.100	Concrete	324,702
SWPI2585	7	1.750	2.300	Concrete	37,867
SWPI2604	113	0.375	0.750	Concrete	126,584
SWPI2605	46	0.300	0.750	Concrete	51,827
SWPI2613	65	0.450	0.825	Concrete	81,795
SWPI2614	10	0.450	0.825	Concrete	12,858
SWPI2619	51	0.225	0.375	Concrete	28,018
SWPI2620	22	0.225	0.450	Concrete	14,793
SWPI2630	16	0.225	0.300	Concrete	8,119
SWPI2634	38	0.300	0.525	Concrete	30,067
SWPI2635	15	0.300	0.450	Concrete	10,229
SWPI2636	89	0.300	0.675	Concrete	87,287
SWPI2637	8	0.300	0.675	Concrete	7,459
SWPI2638	5	0.150	0.375	Concrete	2,645
SWPI2639	17	0.300	0.375	Concrete	9,422
SWPI2651	40	0.300	0.375	Concrete	22,098
SWPI2652	55	0.300	0.375	Concrete	30,560
SWPI2655	49	0.300	0.375	Concrete	27,007
SWPI2656	2	0.300	0.450	Concrete	1,606

Pipe ID	Length (m)	Existing diameter (m)	Upgraded diameter (m)	Material	Cost ($)
SWPI2695	12	0.450	0.600	Concrete	10,974
SWPI2697	15	0.450	0.600	Concrete	14,552
SWPI2699	9	0.450	0.600	Concrete	8,495
SWPI2700	27	0.450	0.675	Concrete	25,976
SWPI2703	18	0.150	0.375	Concrete	9,696
SWPI2706	68	0.525	0.675	Concrete	66,319
SWPI2709	20	0.525	0.825	Concrete	25,000
SWPI2710	3	0.525	0.675	Concrete	3,009
SWPI2717	1	0.300	0.300	Concrete	510
SWPI2725	56	0.225	0.375	Concrete	30,884
SWPI2727	13	0.450	0.600	Concrete	12,719
SWPI2730	31	0.300	0.600	Concrete	29,534
SWPI2734	54	0.225	0.300	Concrete	26,798
SWPI2741	22	0.300	0.375	Concrete	12,156
SWPI2742	41	0.225	0.300	Concrete	20,469
SWPI3504	16	0.225	0.450	Concrete	11,194
SWPI3601	15	0.450	0.825	Concrete	18,233
SWPI3900	38	0.300	0.450	Concrete	25,544
SWPI3901	9	0.300	0.525	Concrete	7,372
SWPI3903	63	0.300	0.450	Concrete	43,199
SWPI3904	63	0.300	0.525	Concrete	50,852
SWPI3907	55	0.375	0.450	Concrete	37,445
SWPI3912	31	0.225	0.525	Concrete	24,566
SWPI3913	89	0.300	0.525	Concrete	70,926
SWPI3916	37	0.375	0.525	Concrete	29,603
SWPI3918	42	0.375	0.450	Concrete	28,399
SWPI3921	38	0.375	0.525	Concrete	30,158
SWPI3923	20	0.450	0.525	Concrete	16,286
SWPI3925	17	0.525	0.675	Concrete	16,764
SWPI3996	27	0.300	0.450	Concrete	18,590
SWPI3999	68	0.300	0.450	Concrete	46,051
SWPI4053	25	0.100	0.150	PVC	5,332
SWPI4054	11	0.100	0.225	Concrete	3,152
SWPI4058	22	0.450	0.600	Concrete	20,400
SWPI4121	59	0.225	0.300	Concrete	29,438
SWPI4131	55	0.300	0.450	Concrete	37,462
SWPI4134	36	0.300	0.375	Concrete	19,950

Pipe ID	Length (m)	Existing diameter (m)	Upgraded diameter (m)	Material	Cost ($)
SWPI4207	41	0.300	0.525	Concrete	32,545
SWPI4296	8	0.225	0.375	Concrete	4,456
SWPI4298	11	0.450	0.675	Concrete	11,233
SWPI4299	4	0.450	0.525	Concrete	3,596
SWPI4347	34	0.375	0.450	Concrete	23,357
SWPI4368	4	0.450	0.750	Concrete	4,129
SWPI4371	74	0.450	0.525	Concrete	59,462
SWPI4373	32	0.450	0.525	Concrete	25,346
SWPI4374	17	0.450	0.525	Concrete	13,448
SWPI4530	50	0.625	0.750	Concrete	55,987
SWPI4531	66	0.675	0.750	Concrete	74,200
SWPI4556	24	0.150	0.225	Concrete	7,135
SWPI4558	5	0.150	0.375	Concrete	3,007
SWPI4698	18	0.150	0.225	Concrete	5,475
SWPI5005	58	0.225	0.300	Concrete	28,905
SWPI5007	37	0.225	0.300	Concrete	18,197
SWPI5150	50	0.225	0.300	Concrete	24,761
SWPI5151	25	0.300	0.375	Concrete	13,800
SWPI5223	11	0.225	0.375	Concrete	5,848
SWPI5301	63	0.300	0.375	Concrete	34,890
SWPI5304	53	0.450	0.525	Concrete	42,531
SWPI5308	39	0.525	0.600	Concrete	36,800
SWPI5309	38	0.525	0.750	Concrete	42,622
SWPI5314	22	0.525	0.675	Concrete	21,268
SWPI5317	2	0.525	0.600	Concrete	1,497
SWPI5606	60	0.375	0.525	Concrete	47,836
SWPI5608	34	0.600	0.750	Concrete	37,645
SWPI5729	20	0.225	0.300	Concrete	10,132
SWPI6010	22	0.375	0.450	Concrete	15,171
SWPI6043	15	0.450	0.600	Concrete	14,157
SWPI6054	7	0.450	0.600	Concrete	6,916
SWPI6057	32	1.050	1.200	Concrete	69,670
SWPI6058	2	1.050	1.200	Concrete	5,170
SWPI6059	50	1.050	1.200	Concrete	109,773
SWPI6061	23	1.050	1.200	Concrete	50,263
SWPI6104	39	0.225	0.375	Concrete	21,550
SWPI6125	43	0.450	0.525	Concrete	34,300

Pipe ID	Length (m)	Existing diameter (m)	Upgraded diameter (m)	Material	Cost ($)
SWPI6129	58	0.300	0.375	Concrete	32,035
SWPI6130	12	0.300	0.375	Concrete	6,406
SWPI6179	23	0.450	0.600	Concrete	21,589
SWPI6180	47	0.450	0.600	Concrete	44,085
SWPI6236	95	1.650	1.800	Concrete	372,388
SWPI6241	31	0.225	0.375	Concrete	17,115
SWPI6248	47	0.225	0.300	Concrete	23,181
SWPI6263	17	1.650	1.950	Concrete	75,509
SWPI6286	56	0.225	0.300	Concrete	27,638
SWPI6397	17	0.225	0.300	Concrete	8,464
SWPI6569	47	0.300	0.450	Concrete	31,973
SWPI6571	25	0.300	0.450	Concrete	17,202
SWPI6573	32	0.300	0.375	Concrete	17,599
SWPI6592	33	0.525	0.675	Concrete	31,850
SWPI6593	31	0.525	0.675	Concrete	30,580
SWPI6594	13	0.525	0.675	Concrete	12,799
TOTAL	**10,673**				**9,015,382**

7.3 Appendix C – Manhole Upgrade Costs

Manhole ID	Assigned manhole diameter (m)	Cost ($)
SWBX0773	1.80	12,535
SWBX0775	1.05	2,312
SWBX0780	1.05	2,798
SWBX0781	1.05	2,563
SWMH0381	1.05	3,378
SWMH0382	1.20	4,700
SWMH0384	1.20	4,968
SWMH0387	1.20	4,649
SWMH0388	1.20	5,488
SWMH0431	1.20	5,907
SWMH0433	1.05	4,711
SWMH0437	1.20	5,873
SWMH0508	1.05	4,649
SWMH0683	1.50	11,230
SWMH0684	1.80	12,567
SWMH0685	1.80	12,696
SWMH0686	1.80	13,052
SWMH0700	1.05	5,417
SWMH0832	1.05	3,849
SWMH0937	1.05	4,210
SWMH0962	1.05	3,676
SWMH1040	1.05	2,798
SWMH1101	1.05	3,268
SWMH1103	1.05	3,519
SWMH1104	1.05	4,178
SWMH1105	1.05	3,268
SWMH1111	1.05	4,272
SWMH1116	1.05	3,974
SWMH1119	1.05	4,994
SWMH1125	1.05	4,523
SWMH1127	1.05	3,504
SWMH1130	1.05	3,974
SWMH1131	1.05	4,068
SWMH1133	1.50	10,703
SWMH1134	1.50	11,619
SWMH1141	1.50	6,424
SWMH1142	1.50	6,515

Manhole ID	Assigned manhole diameter (m)	Cost ($)
SWMH1143	1.05	2,751
SWMH1162	1.50	9,674
SWMH1173	1.05	4,821
SWMH1176	1.05	5,025
SWMH1177	1.05	4,508
SWMH1178	1.05	4,413
SWMH1179	1.05	3,566
SWMH1180	1.20	4,230
SWMH1181	1.20	4,247
SWMH1182	1.20	4,230
SWMH1183	1.20	4,549
SWMH1191	1.50	13,015
SWMH1192	1.05	3,535
SWMH1193	1.05	4,272
SWMH1194	1.05	3,990
SWMH1195	1.05	3,566
SWMH1197	1.05	4,460
SWMH1198	1.05	3,912
SWMH1199	1.05	4,586
SWMH1200	1.05	3,833
SWMH1201	1.50	6,881
SWMH1202	1.50	8,071
SWMH1203	1.20	8,958
SWMH1204	1.20	7,584
SWMH1205	1.20	5,974
SWMH1206	1.20	9,864
SWMH1210	1.20	4,599
SWMH1211	1.05	3,049
SWMH1214	1.05	5,449
SWMH1215	1.05	5,951
SWMH1221	1.05	3,629
SWMH1225	1.05	3,347
SWMH1227	1.05	3,174
SWMH1228	1.05	3,394
SWMH1231	1.05	3,394
SWMH1232	1.05	3,661
SWMH1234	1.50	8,987

Manhole ID	Assigned manhole diameter (m)	Cost ($)
SWMH1237	1.05	3,692
SWMH1238	1.05	3,974
SWMH1239	1.05	4,068
SWMH1243	1.05	3,488
SWMH1244	1.05	3,661
SWMH1248	1.05	3,519
SWMH1250	1.05	5,951
SWMH1256	1.05	2,970
SWMH1257	1.05	3,692
SWMH1265	1.05	3,237
SWMH1266	1.05	3,096
SWMH1267	1.05	3,582
SWMH1268	1.20	4,029
SWMH1269	1.20	4,046
SWMH1270	1.05	3,535
SWMH1271	1.05	4,147
SWMH1273	1.05	4,053
SWMH1274	1.05	6,500
SWMH1275	1.05	5,951
SWMH1276	1.05	4,743
SWMH1277	1.05	6,013
SWMH1278	1.05	6,390
SWMH1279	1.05	4,429
SWMH1283	1.05	4,492
SWMH1284	1.05	4,790
SWMH1285	1.05	4,617
SWMH1286	1.05	4,884
SWMH1287	1.05	5,386
SWMH1288	1.05	5,260
SWMH1294	1.05	3,817
SWMH1295	1.05	4,555
SWMH1304	1.05	3,896
SWMH1305	1.05	3,661
SWMH1315	1.05	3,519
SWMH1317	1.05	2,955
SWMH1326	1.05	4,178
SWMH1327	1.05	4,272

Manhole ID	Assigned manhole diameter (m)	Cost ($)
SWMH1328	1.05	3,378
SWMH1329	1.05	3,566
SWMH1330	1.05	3,017
SWMH1337	1.05	3,770
SWMH1338	1.05	4,272
SWMH1339	1.05	4,759
SWMH1340	1.05	4,680
SWMH1343	1.05	3,739
SWMH1344	1.05	3,990
SWMH1352	1.05	4,727
SWMH1353	1.05	3,347
SWMH1354	1.05	3,519
SWMH1362	1.05	3,676
SWMH1363	1.50	8,712
SWMH1369	1.05	3,692
SWMH1370	1.05	8,774
SWMH1376	1.05	2,970
SWMH1377	1.50	8,209
SWMH1378	1.50	8,392
SWMH1379	1.50	8,209
SWMH1380	1.20	4,582
SWMH1381	1.20	6,075
SWMH1382	1.20	5,203
SWMH1383	1.20	8,757
SWMH1384	1.50	9,399
SWMH1385	1.50	9,880
SWMH1398	1.20	4,918
SWMH1399	1.20	4,649
SWMH1400	1.50	7,339
SWMH1401	1.50	4,593
SWMH1405	1.05	6,531
SWMH1406	1.05	3,268
SWMH1407	1.20	5,957
SWMH1408	1.20	4,063
SWMH1411	1.05	3,519
SWMH1413	1.05	4,084
SWMH1427	1.05	3,504

Manhole ID	Assigned manhole diameter (m)	Cost ($)
SWMH1428	1.20	6,812
SWMH1430	1.05	3,943
SWMH1431	1.20	7,802
SWMH1432	1.50	11,527
SWMH1433	1.50	11,985
SWMH1434	1.20	8,288
SWMH1437	1.05	4,994
SWMH1442	1.05	5,417
SWMH1477	1.05	4,084
SWMH1527	1.05	5,323
SWMH1675	1.05	4,382
SWMH1678	1.05	5,292
SWMH1679	1.05	3,676
SWMH1680	1.05	3,990
SWMH1735	1.20	3,912
SWMH1736	1.20	3,509
SWMH1737	1.05	4,068
SWMH1738	1.05	4,006
SWMH1768	1.05	4,445
SWMH1769	1.05	4,351
SWMH1801	1.05	3,739
SWMH1875	1.05	5,417
SWMH1876	1.05	4,806
SWMH1878	1.05	3,551
SWMH1879	1.05	2,657
SWMH1880	1.05	3,127
SWMH1883	1.05	2,782
SWMH1884	1.05	3,268
SWMH1885	1.20	8,992
SWMH1886	1.05	4,806
SWMH1887	1.05	4,084
SWMH1890	1.05	6,813
SWMH1928	1.05	5,166
SWMH1929	1.05	3,927
SWMH1931	1.05	4,962
SWMH1932	1.05	4,555
SWMH2014	1.05	8,648

Manhole ID	Assigned manhole diameter (m)	Cost ($)
SWMH2015	1.05	3,864
SWMH2016	1.05	3,927
SWMH2048	1.05	4,210
SWMH2087	1.05	6,390
SWMH2146	1.05	4,774
SWMH2285	1.05	3,112
SWMH2286	1.05	3,990
SWMH2357	1.05	4,319
SWMH2358	1.05	3,786
SWMH2407	1.05	3,253
SWMH2440	1.05	4,131
SWMH2444	1.05	7,582
SWMH2445	1.05	7,409
SWMH2446	1.20	7,785
SWMH2449	1.50	8,232
SWMH2452	1.05	3,739
SWMH3466	1.05	3,410
SWMH3498	1.05	4,445
SWMH3499	1.05	4,460
SWMH3509	1.20	5,270
SWMH3510	1.20	4,113
SWMH3511	1.20	4,297
TOTAL		**1,060,349**

7.4 Appendix D – Bottleneck Upgrade Costs

Bottleneck 1		
Asset ID	**Asset type**	**Cost ($)**
SWMH1273	Manhole	4,053
SWPI2230	Pipe	51,425
SWMH1274	Manhole	6,500
SWPI2233	Pipe	28,984
SWMH1275*	Manhole	5,951
SWPI2237	Pipe	108,376
SWMH1277	Manhole	6,013
SWPI2244	Pipe	29,366
SWMH1278	Manhole	6,390
SWPI2245	Pipe	7,849
SWMH1279	Manhole	4,429
SWPI2246	Pipe	6,017
SWMH1276	Manhole	4,743
SWPI2241	Pipe	14,608
	Total	**284,704**

Bottleneck 2		
Asset ID	**Asset type**	**Cost ($)**
SWPI5314	Pipe	21,268
SWMH2449	Manhole	8,232
SWPI1898	Pipe	53,374
SWMH1162	Manhole	9,674
SWPI1899	Pipe	17,981
SWMH1163		
SWPI1900		
SWMH1150		
SWPI5317	Pipe	1,497
SWMH2451		
SWPI1873	Pipe	61,513
SWMH1142	Manhole	6,515
SWPI1855	Pipe	110,540
SWMH1141	Manhole	6,424
SWPI1854	Pipe	91,677
SWBX0773	Manhole	12,535
	Total	**401,230**

* Confluence node in branched bottleneck

Bottleneck 3		
Asset ID	**Asset type**	**Cost ($)**
SWMH1382	Manhole	5,203
SWPI2536	Pipe	62,678
SWMH1381	Manhole	6,075
SWPI2535	Pipe	47,583
SWMH1380	Manhole	4,582
SWPI2534	Pipe	30,003
SWMH1379*	Manhole	8,209
SWPI2531	Pipe	62,529
SWMH1378	Manhole	8,392
SWPI2527	Pipe	55,751
SWMH1377	Manhole	8,209
SWPI2525	Pipe	50,605
SWMH1383	Manhole	8,757
SWPI2541	Pipe	87,993
SWPI2528	Pipe	22,119
SWCP1753		
SWPI2529	Pipe	7,390
SWCP1754		
SWPI2530	Pipe	6,268
	Total	**482,346**

Bottleneck 4		
Asset ID	**Asset type**	**Cost ($)**
SWPI2447	Pipe	15,522
SWCO1025		
FLOD0163		
FNMH0134		
FLPI0164	Pipe	40,373
SWMH1427*	Manhole	3,504
SWPI2695	Pipe	10,974
SWJN0781		
SWPI2727	Pipe	12,719
SWJN0778		
SWPI2697	Pipe	14,552
SWJN0779		
SWPI2699	Pipe	8,495
SWMH1428	Manhole	6,812
SWPI2700	Pipe	25,976
SWMH1431	Manhole	7,802
SWPI2706	Pipe	66,319
SWMH1432	Manhole	11,527
SWPI2709	Pipe	25,000
SWMH1433	Manhole	11,985
SWPI2710	Pipe	3,009
SWMH1434	Manhole	8,288
SWPI6043	Pipe	14,157
	Total	**287,014**

* Confluence node in branched bottleneck

Bottleneck 5		
Asset ID	**Asset type**	**Cost ($)**
SWPI6286	Pipe	27,638
SWMH1929	Manhole	3,927
SWPI3993		
SWMH1928	Manhole	5,166
SWPI3996	Pipe	18,590
SWMH1931	Manhole	4,962
SWPI3999	Pipe	46,051
SWMH1932	Manhole	4,555
SWPI4058	Pipe	20,400
SWMH0388*	Manhole	5,488
SWPI4531	Pipe	74,200
SWMH0381	Manhole	3,378
SWPI4296	Pipe	4,456
SWMH0382	Manhole	4,700
SWPI4298	Pipe	11,233
SWMH0384	Manhole	4,968
SWPI4299	Pipe	3,596
SWMH0386		
SWPI4528		
SWMH0387	Manhole	4,649
SWPI4530	Pipe	55,987
	Total	**303,944**

Bottleneck 6		
Asset ID	**Asset type**	**Cost ($)**
SWPI1927	Pipe	33,194
SWMH1176	Manhole	5,025
SWPI1929	Pipe	12,748
SWMH1177	Manhole	4,508
SWPI1931	Pipe	23,715
SWMH1178	Manhole	4,413
SWPI1935	Pipe	23,616
SWMH1179	Manhole	3,566
SWPI1936	Pipe	44,469
SWMH1180	Manhole	4,230
SWPI1939	Pipe	22,273
SWMH1181	Manhole	4,247
SWPI1942	Pipe	41,162
SWMH1182	Manhole	4,230
SWPI1945	Pipe	21,318
SWMH1183	Manhole	4,549
SWPI1949		
SWMH1136		
SWPI1831		
SWMH1135		
SWPI1830		
SWMH1134	Manhole	11,619
SWPI1829	Pipe	17,331
SWMH1133*	Manhole	10,703
SWMH1130	Manhole	3,974
SWPI1823	Pipe	43,496
SWMH1131	Manhole	4,068
SWPI1826	Pipe	51,890
SWMH1132		
SWPI1827		
	Total	**400,344**

* Confluence node in branched bottleneck

Bottleneck 7		
Asset ID	**Asset type**	**Cost ($)**
SWMH1195	Manhole	3,566
SWPI1990	Pipe	35,816
SWMH1194	Manhole	3,990
SWPI1986	Pipe	15,797
SWMH1193	Manhole	4,272
SWPI1985	Pipe	26,697
SWMH1192	Manhole	3,535
SWPI1980	Pipe	11,623
SWMH1188		
SWPI1970	Pipe	24,889
SWMH1189		
SWPI1971		
SWMH1190		
SWPI1972	Pipe	26,893
SWMH1191	Manhole	13,015
SWPI1975	Pipe	25,310
	Total	**195,403**

Bottleneck 8		
Asset ID	**Asset type**	**Cost ($)**
SWPI4374	Pipe	13,448
SWMH1738	Manhole	4,006
SWPI4373	Pipe	25,346
SWMH1737	Manhole	4,068
SWPI4371	Pipe	59,462
SWMH1736	Manhole	3,509
SWPI4368	Pipe	4,129
SWMH1735	Manhole	3,912
SWPI2058	Pipe	54,457
SWMH1214	Manhole	5,449
SWPI2060	Pipe	19,200
SWMH1215	Manhole	5,951
SWPI2061	Pipe	25,618
SWJN0762		
SWPI2063	Pipe	30,066
SWMH2444	Manhole	7,582
SWPI5307		
SWMH2445	Manhole	7,409
SWPI5308	Pipe	36,800
SWMH2446	Manhole	7,785
SWPI5309	Pipe	42,622
SWMH2447		
SWPI2070	Pipe	9,499
	Total	**370,318**

Bottleneck 9		
Asset ID	**Asset type**	**Cost ($)**
SWMH1257	Manhole	3,692
SWPI2179	Pipe	72,665
SWMH1256	Manhole	2,970
SWPI2176	Pipe	68,451
SWJN0768		
SWPI2173	Pipe	50,143
SWMH1344	Manhole	3,990
SWPI2416	Pipe	32,507
SWCP1554		
SWPI2203	Pipe	1,242
SWMH1265	Manhole	3,237
SWPI2204	Pipe	61,355
SWMH1266	Manhole	3,096
SWPI2206	Pipe	3,926
SWJN0769		
SWPI2208	Pipe	65,168
SWMH1267	Manhole	3,582
SWPI2211	Pipe	92,771
SWMH1268	Manhole	4,029
SWPI2215	Pipe	45,252
SWMH1269	Manhole	4,046
SWPI2217	Pipe	35,667
SWMH1270	Manhole	3,535
SWPI2219	Pipe	24,362
SWMH1271	Manhole	4,147
SWPI2225	Pipe	1,282
SWJN0770		
SWPI2226	Pipe	29,188
SWMH1272		
SWPI2228		
SWMH3509	Manhole	5,270
SWPI6592	Pipe	31,850
SWMH3510	Manhole	4,113
SWPI6593	Pipe	30,580
SWMH3511	Manhole	4,297
SWPI6594	Pipe	12,799
	Total	**709,212**

Bottleneck 10		
Asset ID	**Asset type**	**Cost ($)**
SWMH1103	Manhole	3,519
SWPI1763	Pipe	24,236
SWMH1104	Manhole	4,178
SWPI1765	Pipe	30,886
SWMH1105	Manhole	3,268
SWPI1768	Pipe	10,493
SWMH1106		
SWPI1769		
SWMH1107		
SWPI1772	Pipe	23,862
SWMH2452*	Manhole	3,739
SWMH1527	Manhole	5,323
SWPI6241	Pipe	17,115
SWMH1528		
SWPI6243		
SWMH1110		
SWPI1776	Pipe	13,895
SWMH1111	Manhole	4,272
SWPI1777	Pipe	19,790
	Total	**164,576**

* Confluence node in branched bottleneck

Bottleneck 11		
Asset ID	**Asset type**	**Cost ($)**
SWMH1283	Manhole	4,492
SWPI2260	Pipe	32,848
SWMH1284	Manhole	4,790
SWPI2263	Pipe	58,311
SWMH1285	Manhole	4,617
SWPI2266	Pipe	33,417
SWMH1286	Manhole	4,884
SWPI2267	Pipe	52,234
SWMH1287	Manhole	5,386
SWPI2270	Pipe	26,253
SWMH1288	Manhole	5,260
SWPI2271	Pipe	33,799
	Total	**266,291**

Bottleneck 12		
Asset ID	**Asset type**	**Cost ($)**
SWPI5301	Pipe	34,890
SWMH2440	Manhole	4,131
SWPI1788	Pipe	48,595
SWMH1116	Manhole	3,974
SWPI1792	Pipe	39,936
SWMH1117		
SWPI5303		
SWMH2441		
SWPI5304	Pipe	42,531
SWMH1119	Manhole	4,994
SWPI1798	Pipe	10,681
	Total	**189,732**

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