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Geraldine Stormwater Network – Preliminary Infrastructure Capacity Assessment

Timaru District Council

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Geraldine Stormwater Network – Preliminary Infrastructure Capacity Assessment

Prepared for

Timaru District Council

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Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Timaru District Council and Opus. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

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The analysis provided in this report has been prepared using the best data available at the time. PDP accepts no responsibility for the accuracy of LiDAR and other GIS data collected by others. PDP has assumed the provided data is accurate and fit for the purpose described in this report.

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1.0 Introduction

Timaru District Council (TDC) has engaged Pattle Delamore Partners Ltd (PDP) to assess the capacity of current stormwater infrastructure in and around Geraldine as part of preparation of the Geraldine Stormwater Management Plan (SMP) and associated Stormwater Resource Consent submission to Environment Canterbury (ECan). This report details the methodology applied to assess the capacity of stormwater pipework, outfalls and soak pits to convey stormwater flows. The key findings and recommendations have been prepared from PDP's preliminary capacity assessment. This work references a similar study prepared for TDC by Opus in 2014 (Opus International Consultants Ltd, 2014a) and later updated in 2016 (Opus International Consultants Ltd, 2016).

2.0 Method

2.1 Overview

The method used to assess the hydraulic capacity of Geraldine's stormwater infrastructure involved the following stages:

- Delineated stormwater sub-catchments contributing to piped stormwater outfalls and soakage sumps.
- Identified stormwater overland flow paths and the location of potential ponding areas in the event of the stormwater infrastructure's capacity being exceeded or blockages of the pipes and inlets.
- Estimate peak stormwater flows to key points in the catchment(s) for the appropriate annual exceedance probability (AEP) rainfall event (20% AEP for pipe infrastructure capacity, 10% AEP for soakage infrastructure capacity and 2% AEP capacity for minimum level of protection from flooding).
- Estimate pipe infrastructure capacity at key points based on current pipe sizes and assuming each pipe is free flowing (i.e. ignoring backwater effects).
- Compare the current capacity of infrastructure to the required level of service (LOS) and identify any pipe infrastructure that may be insufficient.
- Estimating the infiltration area required to dispose of peak stormwater flow at points of the catchment(s) that drain through soakaway sumps assuming a nominal soakage rate of 1,000 mm/hr, which is considered appropriate for well-draining alluvial gravels on the Canterbury Plains.

- Analysis of TDC's standard soak pit design, recently used in a soakaway upgrade completed in Williamson Place (Raukaupuka), shows it has an equivalent discharge capacity of approximately 4.6 L/s. The infiltration rate at this one location was measured at only 500 mm/hr.

2.2 Overland Flow Paths and Catchment Areas

In order to quantify stormwater flows at different points in the catchment, overland flow path mapping was undertaken to identify the direction of stormwater flows and surface water catchment boundaries. LiDAR digital elevation model (DEM) data (Environment Canterbury, 2014) was used by GIS software to generate maps of overland flow paths and ponding areas for the natural terrain (i.e. buildings and vegetation removed). The original DEM data (a 1 m grid) was pre-processed into a 2 m grid of average elevations before generating overland flow paths in order to reduce file sizes and processing time. No significant reduction in accuracy in defining the contributing catchments was observed. The threshold for initiation of an overland flow path was set to an arbitrary contributing area of 1,000 m². This threshold also defines the minimum contributing area for catchment delineation. A value of 1000 m² was used (based on prior experience) to ensure adequate visibility of smaller channels.

Overland flow paths for the bare terrain were compared to TDC stormwater infrastructure data obtained from Canterbury Maps (Environment Canterbury). Discrepancies in the direction of overland flow (e.g. due to the presence of a culvert allowing flow under a road) were corrected by imposing open channels and walls into the DEM to represent TDC's pipe infrastructure and flow obstructions, respectively. These additional open channels in the DEM were assumed to have a nominal depth of 300 mm or the diameter of the pipe as defined in the TDC stormwater infrastructure data, whichever was greater. Overland flow paths were regenerated and catchment boundaries defined once flow paths showed consistency with the current stormwater infrastructure. Locations of soakaway sump infrastructure were determined using a combination of TDC stormwater network data and Google Earth Street-view imagery to verify the presence of sump inlets.

2.3 Runoff Estimates

Estimates of peak stormwater flows were obtained using the Rational Method as presented in the WWDG - Waterways, Wetlands and Drainage Guide (Christchurch City Council, 2011). Using this method is consistent with the acceptable solution presented in the Building Code E1/VM1 (Ministry of Business, Innovation and Employment, 2014).

2.3.1 Runoff Coefficients

Runoff coefficients applied for calculation of flows in the Rational Method are shown in Table 1. A map of the different runoff coefficients assumed for areas around Geraldine based on TDC zoning in shown in Figure 9 in Appendix A.

Table 1: Assumed Runoff Coefficients

Timaru District Council Zoning[1]	Description	Runoff Coefficient[2]
Rural Zone - R1	General Rural	0.15 (slopes < 2%) 0.20 (slopes 2-7%) 0.30 (slopes > 7%)
Rural Zone - R2	High Quality Rural	
Rural Zone - R4A	Geraldine Downs	
Open Space Zone - REC2	Urban Recreation	
Open Space Zone - REC3	Rural Recreation	
Residential Zone - RES1	Geraldine Residential	0.40
Residential Zone - RES5	Future Geraldine Residential	
Business Zone - COM1	Geraldine Inner Urban Centre	0.95
Business Zone - INDL	Minor Industrial Activities	0.6

Notes:
1. *Selected designations present in Geraldine taken from the Timaru District Plan* (Timaru District Council, 2016).
2. *Runoff coefficients obtained from Part D 6.5.3.3 of the Timaru District Plan* (Timaru District Council, 2016).

2.3.2 Time of Concentration

Estimates of time of concentration were obtained from the overland flow path mapping using the Bransby-Williams equation as presented in the WWDG (Christchurch City Council, 2011). The time of concentration estimates were assumed to be representative of the critical duration storm for all pipe infrastructure. Design rainfall intensities for soakage infrastructure were obtained assuming a fixed storm of one hour duration in accordance with the Building Code E1/VM1 (Ministry of Business, Innovation and Employment, 2014) requirements.

2.3.3 Design Rainfall Intensities

Corresponding design rainfall intensities that account for 2090 climate change were linearly interpolated from the range of values given in Table 2 (Opus International Consultants Ltd, 2015). The 2090 climate change projection was selected as it is the closest climate change forecast to the expected design life of stormwater infrastructure.

Table 2: Design Rainfall Intensities for Geraldine Including Climate Change (2090)

Duration (min) / AEP (%)	10	20	30	60	120	360
20%	42.0	30.0	28.0	21.0	13.5	8.3
10%	60.0	42.0	34.0	26.0	18.5	10.3
5%	72.0	48.0	44.0	32.0	22.0	12.5
2%	84.0	63.0	54.0	42.0	27.5	15.7
1%	96.0	69.0	62.0	48.0	31.5	17.7

2.4 Level of Service Considerations

The following minimum levels of service requirement have relevance for the Geraldine Stormwater network (in order of increasing level of service):

- 20% AEP (1in 5 year return period) minimum level of service as specified in the TDC Activity Management Plan for Stormwater Services (Timaru District Council, 2015).
- 10% AEP (1 in 10 year return period) minimum level of protection to other property from damage or nuisance as required by E1/VM1 of the Building Code (Ministry of Business, Innovation and Employment, 2014).
- Soakaway performance to provide for 1 hr, 10% AEP (1 in 10 year return period) rainfall event as required for new development by E1/VM1 of the Building Code (Ministry of Business, Innovation and Employment, 2014).
- No flooding of buildings from a 2% AEP (1 in 50 year return period) rainfall event for new development as required by E1/VM1 of the Building Code (Ministry of Business, Innovation and Employment, 2014)
- Timaru District Plan requirements for buildings to be located outside the 0.5% AEP (1 in 200 year return period) flood levels (Timaru District Council, 2016).

2.5 Preliminary Pipe Capacity Assessments

Estimates of current pipe capacity were obtained using the equation presented in Appendix 11 of the WWDG (Christchurch City Council, 2011) and pipe diameters as specified in the TDC stormwater network data. This method assumes the pipes are free-flowing and that local hydraulic losses (e.g. inlets, bends and outlets) are insignificant (i.e. hydraulic gradient can be approximated by the pipe grade). The hydraulic gradient was calculated assuming the pipes were laid parallel to the average ground slope (determined using the supplied 1m DEM) along the length of the pipe. Where pipes discharge to distinct waterway channels visible on the DEM (Such as the Wāhi River floodway), the downstream invert level was approximated with arbitrary height of 0.75 m above the invert of the channel to avoid over estimating the actual hydraulic gradient.

2.6 Soakage Drainage Preliminary Capacity Assessments

Estimates of soakage infrastructure capacity were obtained assuming all soakpits are consistent with TDC's standard design which requires a soakpit area of approximately 9.0 m² to dispose of a 4.6 L/s flow at measured 500 mm/hr infiltration rates. Infiltration rates around Geraldine are understood to be typically 500-1,000 mm/hr, which equates to a maximum contributing area of 1,800-2,200 m^{2}depending on infiltration rate (or one soak pit sump for every 3-4 properties) assuming no functional private soakage works.

For simplicity, this preliminary assessment assumed all soakpits achieve a constant infiltration rate of 1,000 mm/hr without any significant storage effects. Locations where disposing of the runoff generated in the 1-hour 10% AEP storm requires significantly more than TDC's standard soakpit area were identified as under capacity. This was done assuming each soakaway sump indicated is functioning correctly (i.e. downstream sumps do not have to dispose of stormwater runoff that spills over from upstream sumps if they are blocked). It was also conservatively assumed that soakaway sumps must dispose of all runoff from private properties (i.e. runoff from residential roof areas is not being disposed of within the property).

3.0 Data Limitations

3.1 Stormwater Network Asset Data

TDC's stormwater asset does not include reduced levels of pipe inverts, in addition some culvert and pipe diameter sizes are missing. It is recommended that this data be compiled as part of the stormwater management plan and used to verify infrastructure capacity estimates.

3.2 LiDAR Data

Processed LiDAR data was obtained from the ECan 2014 Timaru Rivers Survey (Environment Canterbury, 2014) in the format of a 1 m gridded DEM. This data has a nominal accuracy of ± 0.15 m.

As the accuracy of the DEM is greater than the height of a standard roadside kerb and channel the model may not always correctly identify containment of flows within a kerb and channel or restrictions of the road crown.

Greater inaccuracies are anticipated around buildings and vegetated surfaces, as ground levels have been interpolated by computer algorithms from a smaller number of bare earth LiDAR returns in the area. This interpolation is part of the processing of raw LiDAR data to generate a DEM and is done by the aerial surveyor prior to delivery to the purchaser (ECan).

Consideration of these uncertainties and limitations is essential when interpreting the maps of overland flow paths and catchment boundaries presented in this report. This level of accuracy has been considered sufficient for a preliminary assessment; however more detailed data may be required for subsequent detailed assessments.

4.0 Key Findings

4.1 Outputs

Maps of the overland paths, catchment boundaries and ponding areas for different areas of Geraldine are shown in Figure 1 through Figure 8 in Appendix A.

These maps also include the locations of outlets for different mapped catchments that indicate the areas contributing to specific pipe/soakage infrastructure. Each of these outlets has been colour-coded to indicate whether the infrastructure at that point has sufficient capacity to provide for the appropriate AEP rainfall event. Tables detailing the infrastructure capacity calculations can be found in Appendix B (for pipes and culverts) and Appendix C (for soakage infrastructure).

As the maps illustrate, approximately 45% of pipe infrastructure and 90% of soakage infrastructure are likely to have less capacity than the 20% AEP flow and the 10% AEP 1-hour flow, respectively. In the case of outfalls, it is evident that some areas demonstrate the case where an outlet of insufficient capacity is located immediately upstream of one that has sufficient capacity (e.g. C101 and C102 shown near Tripp Street in Figure 3). In this situation it is likely that the oversized outlet was installed to deal with overflow from the under-sized outlet. The analysis performed has not accounted for these spill-over effects which could affect the indicated capacity of stormwater infrastructure. The analysis has also ignored inconsistencies in the upstream and downstream pipe sizes (i.e. DN225 pipe downstream of DN600) given in the TDC asset database, particularly for culverts along Serpentine Creek.

4.2 Soakage Drainage Issues

4.2.1 Raukapuka

Figure 1 shows that most of the soakage infrastructure in Raukapuka is likely to be undersized for the design 10% AEP 1-hour rainfall. The results also show that there are a large number of overland flow paths that will pass through private properties when no other disposal options are available or the soakage outfalls are blocked or under capacity.

If the conservative assumption that soakaway sumps must dispose of all runoff from private properties (i.e. including all residential roof runoff) is disregarded, allowable contributing areas to soak pits can be increased approximately 10-30% based on an examination of several catchments in Raukapuka (C71, C29, and C54). This corresponds to an equivalent reduction in design flows (and hence required soak pit area) in the order of 20-30%. A reduction of this magnitude still results in many of the soakaway sumps in Raukapuka being undersized for the 10% AEP 1-hour rainfall event.

4.2.2 Geraldine South

The results also indicate that most of the residential areas south of Huffey Street (see Figure 5 and Figure 6) contain very limited stormwater infrastructure. Stormwater flows in this area rely either on Talbot Street kerb and channel and swales having sufficient capacity to carry flows down to Serpentine Creek (i.e. area west of Talbot Street) or on overland flow south across undeveloped land to the confluence of Serpentine Creek and the Waihi River.

Some stormwater soakage drainage has been constructed in this area that provides a low level of service. However, TDC staff have noted that this drainage has limited effectiveness so it has been considered with the assessment of the overland flow paths and piped drainage system capacity below.

4.3 Piped Outfall Capacity and Flooding Mitigation Options Required

Limited areas of potential ponding are identified with overland flow path mapping on Figure 2, Figure 4, Figure 6 and Figure 8.

There are a number of areas where overland flow paths will pass through private properties when the drainage system capacity is exceeded or restricted through blockages.

4.3.1 Raukapuka

The majority of east Geraldine relies on soakage infrastructure however there are several piped outfalls indicated on the TDC asset database (along Orari Station Road and at the ends of Campbell Street and Cascade Place). The preliminary capacity assessment identified some of these pipes as potentially undersized in a 20% AEP event

4.3.2 Serpentine Creek

Opus (2016) identified with the use of an INFOWORKS 2D hydraulic computer model that the main channels of Serpentine Creek had capacity in excess of a

2% AEP level of service. The only overland flow path and flooding identified was in the vicinity of Majors Road and Kennedy Street.

It is noted that the pipe network details in the INFOWORKS model do not match the TDC asset database information and Opus (2016) recommend that the channel and pipe details included in the model be verified as this section of the model was completed by others.

4.3.3 Upper Serpentine Creek

The Hislop Street Branch of Serpentine Creek and the branch between Peel Street and Cox Street are potentially susceptible to ponding to significant depths and flooding private properties in the event of blockages to piped sections of the drain or vegetation build up in the channels.

It is considered particularly critical that both these branches of Serpentine Creek are regularly inspected to ensure excess vegetation is controlled and blockage risks to the culvert are removed from the channels.

4.3.4 Talbot Street

The overland flow path mapping shows drainage from Talbot Street/Geraldine-Winchester road is dependent on the capacity of the kerb and channel and swales running alongside the road. At the northern end of Talbot Street, runoff is anticipated to be collected against the Waihi River Stopbank.

The capacity of the outfalls on Huffey Street and Kennedys Road are limited, even without considering potential adverse effect of elevated water levels in the Waihi River during flood flows.

4.3.5 Geraldine South

The overland flow path mapping indicates that an improvement for stormwater drainage along North Terrace, South Terrace and from the end of Cross Street would be beneficial, specifically to mitigate the risk of overland flows passing through private property and flooding existing culverts in these streets.

4.3.6 Kennedys Road

The overland flow path mapping indicates that Kennedy's Road collects flow from the length of High Street. Some of this flow is directed along the right of way to the rear sections 214a and 218a Talbot Street, then towards Serpentine Creek after crossing at Majors Road.

4.3.7 Kennedys Road - Majors Road

As indicated by Opus (2016), a flow of up to 600 L/s spills from Serpentine Creek upstream of Kennedy Street and flows into Majors Road during a 2% AEP flood event. The area in the immediate vicinity is currently earmarked for low intensity development, so this modelled secondary flow path is likely to present some flooding nuisance. However, it is desirable that this overland flow path is formally defined and directed back to Serpentine Creek prior to further development this area.

4.3.8 Geraldine North

The overland flow path mapping shows some ponding to the east of main North Road and either side of Templer Street. This is consistent with observations of Mr Philip Lees of Environment Canterbury, who advises that water from the western side of Main North Road is diverted to the grounds of No. 26 Main North Road, where its ponds with no natural outlet. This area is located under trees, so was not identified by the overland flow path mapping, which indicated, that flows would spill over Templer Street rather than over Main North Road.

4.4 Network Capacity Issues

Owing to the restrictions of available stormwater network information, assessment of stormwater network assets upstream of outlets is limited. Preliminary estimates show several isolated culverts throughout Geraldine (i.e. not associated with an outlet such as C20 and C147 shown in Figure 3) have insufficient capacity to convey a 20% AEP event. These estimates are based on assuming full-flowing pipes and do not account for any inlet or outlet control to these culverts.

This is generally not an issue for private property flooding as the natural overland flow paths tend to break-out across roads near the location of these culverts anyway. This would result in flow across roads, but no significant flooding to adjacent properties.

It is recommended that detailed capacity assessments of these culverts should be undertaken after confirming culvert sizes, invert levels and inlet and outlet control information.

4.5 Effect of the Waihi Flood Levels

An estimate of the extent of a 1-2% AEP flood experienced in Geraldine in 1986 (Environment Canterbury) is shown in Figure 10. The extent of flooding shows water reaching up to SH79, Waihi Terrace and Talbot Street along the western bank of the Waihi, and that properties between these roads and the Waihi would have been flooded. This indicates that the outlets to the Waihi are likely to be inundated in large floods and cause flooding as stormwater backs up in the stormwater network (i.e. backwater effects).

Capacity checks for the 2% AEP storm (50 year ARI) in Appendix B confirmed that the majority of these outlets to the Waihi River cannot currently meet this level of service.

4.6 Comparison with Flooding Complaints

Despite the potential issues with under-sized infrastructure evident from the assessment, public consultation would suggest the public do not perceive Geraldine has a significant flooding issue(s).

Possible reasons for these perceptions are thought to be related to:

- The nature of the terrain, which falls consistently towards either Serpentine Creek or the Waihi River. There are also a relatively low number of significant ponding areas which intersect with private properties. These factors mean that stormwater flows will most likely drain quickly towards one of the waterways following a rainfall event – even when some pipe infrastructure is under capacity.
- The relative low permeability soils in Geraldine south and in the Raukapuka area favour drainage at lower rainfall intensities; significant runoff is not anticipated from the pervious land in these areas until infrequent heavy rainfall events occur.
- Flooding complaints (Timaru District Council) do not indicate any significant building flooding, which points to “nuisance” flooding effects that cause inconvenience during heavy rainfall events rather than significant damage to private property.

Whilst not considered in this assessment, TDC may also wish to consider the volume of surface water runoff entering the sewerage network, when considering the requirements to upgrade the existing stormwater network.

4.7 Building Control Requirements

Building and infilling of the overland paths should be avoided without provision of the upstream flows and consideration of the estimated depth of flooding. This will require a more detailed assessment with improved survey and stormwater drainage asset data.

The existing level of service of the stormwater network also needs to be considered by TDC as E1/VM1 of the Building Code requires drainage to be provided to protect other property from flooding a rainfall event with a 10% probability of occurring annually. This level of protection is notably greater than the level of service provided by the existing stormwater network.

5.0 Improvement Options

5.1 Geraldine North

The piped drainage installed will require either an outlet to be completed or soakage drainage installed at various points along the road side. Given the likely favourable soakage conditions at this location, installation of soakage collection points along SH 79 is recommended to reduce the risk of downstream flooding of private properties.

5.2 Raukapuka Drainage

Flooding in this area will be further exacerbated by performance issues with the soakpits, particularly as they rely on effective private and public drainage infrastructure maintenance.

Consideration could be made to providing a secondary overflow or a piped primary outflow to the Waihi River through the Raukapuka Recreational Reserve or additional soakage drainage outlets in the streets or within the Reserve. A potential piped outflow to the Waihi River is indicated on Figure 11.

5.3 Geraldine South

Improved stormwater drainage is identified to limit the effects of overland flows being directed to private properties. It is anticipated that this will require drainage upgrades in North Terrace, South Terrace, Cross Street, High Street and Kennedy Street. Potential locations for the pipe upgrades are shown in Figure 12.

These upgrades may include retaining the existing soakage systems as first flush treatment options (see SMP for further details on first flush treatment requirements) or consideration of soakage drainage design, as capacity improvements will increase the discharge of contaminants to receiving waterways

5.4 Kennedy Street and Majors Road

Mitigation of the flood overflows across Kennedy Street into Majors Road could be achieved by lowering Majors Road to provide an overland flow path or upgrading the channel and culverts under and downstream of Kennedys Road. Alternatively, a secondary flow path could be piped along Majors Road and returned to Kennedy's Road. The feasibility of both mitigation options may depend on service constraints (e.g. water, telecommunications and sewer), which will need to be considered in the preliminary design stage.

Opus (2016) also considered options to attenuate flows from the detention dams to further attenuate the discharges from the upstream rural catchments further. However, these investigations showed that such measures are likely to be of limited effectiveness owing the effect of urban runoff between the detention dams and Kennedy Street, and it is understood that throttling the detention dams is not being considered further.

Figure 13 shows a potential upgrade option involving a pipe running along Majors Road.

Alternatively, Majors Road may be lowered to form an overland flow path. Flow depth along the road in the 2% AEP event has been estimated to only be 0.13 m assuming a 4 m wide road cross section with a Manning's roughness coefficient of 0.016.

5.5 Talbot Street Outlets

It is recommended to consider upgrading outlets to the Waihi River at 89 Talbot Street, Hislop Street, Huffey Street and Kennedy Street in addition to providing a new outlet at Cole Street. The locations of these outlets are indicated on Figure 14.

These upgrades may include retaining the existing soakage systems as first flush treatment options (see SMP for further details on first flush treatment requirements) or consideration of soakage drainage design, as capacity improvements will increase the discharge of contaminants to receiving waterways.

5.6 Serpentine Creek

Routine maintenance of the Serpentine Creek Channel, to keep it free of excessive vegetation and blockage risks to the culverts and piped sections, is critical to avoiding significant flooding of private property.

The maintenance of Serpentine Creek is currently completed by ECan as part of the Waihi-Temuka-Opihi Flood Control Scheme on a reactionary basis. However, the maintenance of the channel condition is critical to avoiding adverse effects from the urban stormwater discharges. Therefore, it is recommended that the channel condition should be inspected by ECan at least twice a year, with photographic records maintained for review by TDC staff.

5.7 Asset Database

It is recommended that TDC develop and implement a programme to update its asset database to include all pipes, manholes, sumps and outfalls with details of pipe materials and invert reduced levels.

5.8 Summary of Capital Costs

Based on the issues identified, the following improvement works are have been developed and recommended to limit localised flooding within Geraldine. The recommendations below exclude any works to provide for local drainage and only include those to avoid flooding of properties from overland flow paths.

Table 3 gives rough order cost estimates (-20%/+50%) for pipe upgrade options described in the following sections (see Appendix D for more details of flow/capacity estimates used to derive required pipe sizes). The two different cost estimates reflect the different pipe sizes required to discharge the 20% AEP flow and the 2% AEP flow. Further details of cost estimates calculations (including contingencies and other allowances) are given in Appendix E.

Table 3: Pipe Upgrade Options Rough Order Cost Estimates

Location	Pipeline	Cost Estimate
Raukapuka	Raukapuka Reserve	$1,291,000
Geraldine South	High Street (start) High Street North Terrace Road South Terrace Road to Serpentine South Terrace Road to High Street Cross Street Kennedy Street	$2,314,000
Majors Road	Kennedy Street/Majors Road Overflow pipe[1]	$1,012,000
Talbot Street Outlets	Kennedy Street Outlet Cole Street Outlet Huffey Street Outlet Hislop Street Outlet Talbot Street Outlet	$4,360,000
SH 79	Geraldine North	$81,000
Design and Planning		$1,087,000
Total		**$10,145,000**

6.0 Conclusions

The assessment undertaken in this document has applied a quick and simple approach to estimate peak stormwater flows in order provide a preliminary assessment of the stormwater network capacity and associated potential flooding issues. For any subsequent analysis, more detailed hydraulic modelling and survey data should be conducted to better estimate peak storm flows which should include components such as storage areas, infiltration losses and backwater effects.

The pipe capacity estimates in this analysis were derived using the available data from TDC's stormwater asset database (Environment Canterbury). Pipe diameters should be checked and surveys of invert levels undertaken in order to improve/confirm the pipe capacity estimates. Detailed hydraulic modelling should also be undertaken to confirm the extent that pipe capacities are further limited by backwater effects from flood levels in the Waihi River and Serpentine Creek.

The analysis indicated that there are limited ponding areas which impact private property around Geraldine. Private properties that experience flooding are generally as a result of the property being located along overland flow paths that will cause flooding when the drainage system capacity is exceeded or restricted through blockages.

In areas with soakage infrastructure (mainly East Geraldine), the size of TDC's standard soak-pit design does not appear to provide sufficient capacity for flows generated in the 1-hour 10% AEP rainfall event – even when runoff contributing areas are reduced by up to 30% to account for fully-functioning and effective private drainage system disposing of residential roof runoff. Flooding of private properties in these areas appears to result when upstream soak-pits flood and spill stormwater along natural overland flow paths to downstream private properties.

Some piped outlets to the Waihi, particularly in South Geraldine, have insufficient capacity to discharge flows generated in the target 20% AEP rainfall event. These outlets have also been identified as susceptible to flooding and backwater effects during large floods in the Waihi. These outlets need to be upgraded to meet the target level of service included in TDC's Activity Management Plan (Timaru District Council, 2015). Preliminary rough order cost estimates indicate that a budget of approximately $10M is required to upgrade the Geraldine Stormwater network to provide the level of service required in the TDC Activity Management Plan and as required by the Building Code E1/VM1 (Ministry of Business, Innovation and Employment, 2014) for new developments.

Modelling appears to suggest overland flow paths cross private properties in South Geraldine. Pipe infrastructure requirements to divert flows along High Street have been estimated and preliminary cost estimates provided.

The recorded flooding complaints do not appear to indicate any serious flooding of buildings, and the reduced levels of service would appear to be a 'nuisance' flooding issue. This may allow a reduced urgency in upgrading the network to meet TDC's target if the community is happy with the current level of service, no buildings are located in a secondary flow path, and/or inflows into the wastewater network are not too significant as a result of the stormwater network level of service.

Most of the existing stormwater network is likely to require upgrading to ensure that new development does not cause damage or nuisance to other property.

7.0 Limitations

The analysis provided in this report has been prepared using the best data available at the time. PDP accepts no responsibility for the accuracy of LiDAR and other GIS data (i.e. stormwater network data from asset database) collected by others. PDP has assumed the provided data is accurate and fit for the purpose described in this report.

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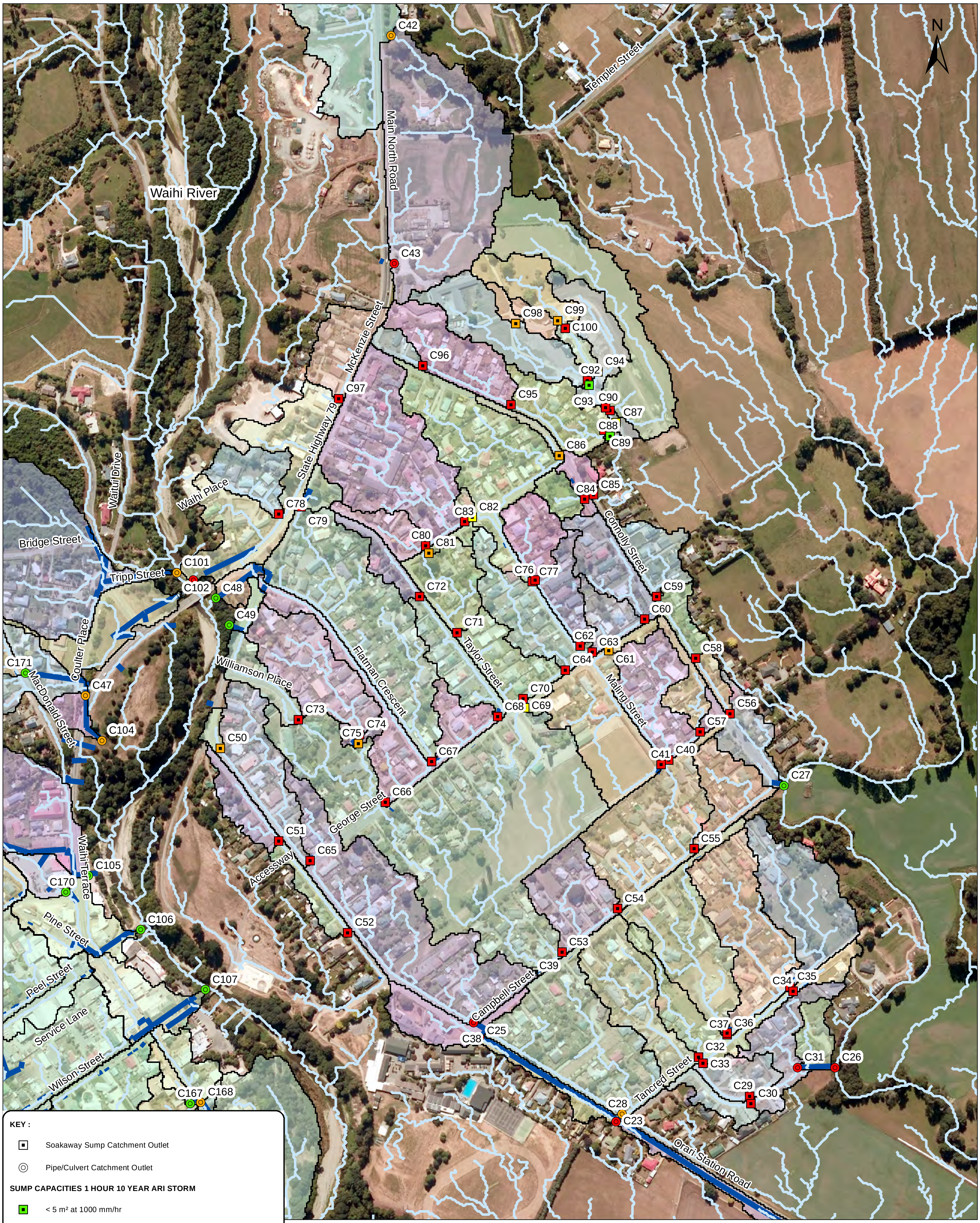

KEY :

- Soakaway Sump Catchment Outlet
- Pipe/Culvert Catchment Outlet

SUMP CAPACITIES 1 HOUR 10 YEAR ARI STORM

- < 5 m² at 1000 mm/hr
- 5 - 10 m² at 1000 mm/hr
- 10 - 20 m² at 1000 mm/hr
- > 20 m² at 1000 mm/hr

PIPE/CULVERT CAPACITIES 5 YEAR ARI STORM

- 0-50%
- 50-100%
- > 100%
- Overland Flow Paths (Natural Terrain)
- Catchment Boundaries
- Stormwater Pipes

DISCLAIMER:
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2. 2014 LIDAR DATA SOURCED FROM TIMARU DISTRICT COUNCIL
3. STORMWATER NEWTORK DATA SOURCED FROM TIMARU DISTRICT COUNCIL (CANTERBURY MAPS)

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NO.	REVISION	DATE	APP.

CLIENT :
TIMARU DISTRICT COUNCIL

PROJECT :
GERALDINE STORMWATER MANAGEMENT PLAN

TITLE :
STORMWATER CATCHMENT BOUNDARIES - EAST GERALDINE

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Auckland Tauranga Wellington Christchurch

SCALE : 1:5,000 (A3)
0 50 100 200
METRES

PROJECT NO. :	FIGURE NO. :	REVISION :
C03489300	1	A

FILED: C03489300Z006_Catchments_East_Geraldine.mxd

KEY :

OVERLAND FLOW PATHS (CULVERTS)

- < 1:500 Slope
- 1:500 - 1:100 Slope
- 1:100 - 1:10 Slope
- > 1:10 Slope

PONDING AREAS

- 0.1 m - 0.2 m
- 0.2 m - 0.4 m
- 0.4 m - 1.0 m
- > 1 m
- Overland Flow Paths (Natural Terrain)
- Stormwater Pipes

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Auckland Tauranga Wellington Christchurch

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0 50 100 200
METRES

PROJECT NO. :	FIGURE NO. :	REVISION :
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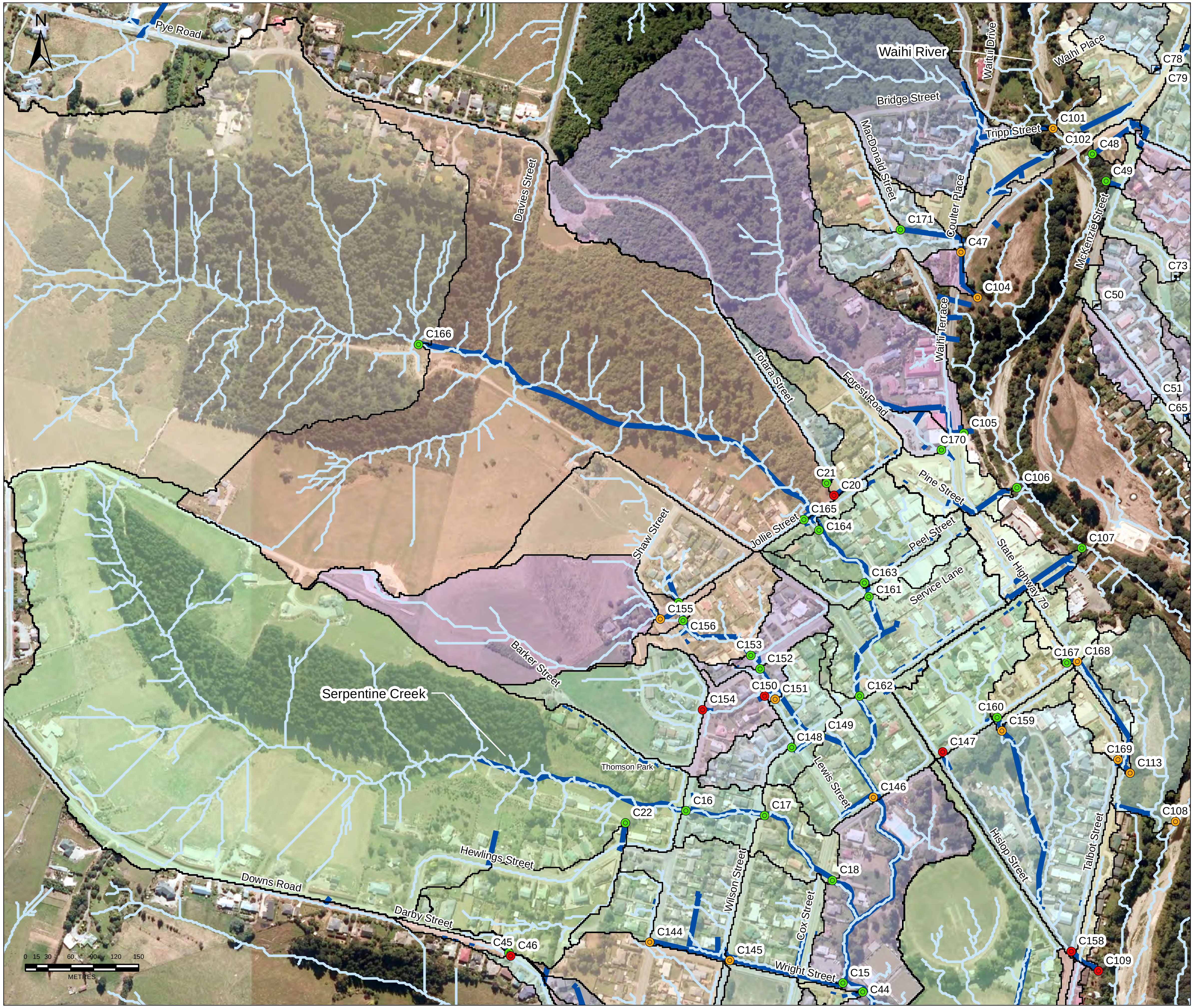

NOTES :

KEY :

Soakaway Sump Catchment Outlet

Pipe/Culvert Catchment Outlet

PIPE/CULVERT CAPACITIES 5 YEAR ARI STORM

0-50%

50-100%

> 100%

Overland Flow Paths (Natural Terrain)

Catchment Boundaries

Stormwater Pipes

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GERALDINE STORMWATER MANAGEMENT PLAN

TITLE :

STORMWATER CATCHMENT BOUNDARIES - NORTH WEST GERALDINE

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PROJECT NO. :	FIGURE NO. :	REVISION :
C03489300	3	A

File: C03489300Z007_Catchments_North_West_Geraldine

NOTES :

KEY :

OVERLAND FLOW PATHS (CULVERTS)

- < 1:500 Slope
- 1:500 - 1:100 Slope
- 1:100 - 1:10 Slope
- > 1:10 Slope

PONDING AREAS

- 0.1 m - 0.2 m
- 0.2 m - 0.4 m
- 0.4 m - 1.0 m
- > 1 m
- Overland Flow Paths (Natural Terrain)
- Stormwater Pipes

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GERALDINE STORMWATER MANAGEMENT PLAN

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OVERLAND FLOW PATHS AND PONDING AREAS - NORTH WEST GERALDINE

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PROJECT NO. :	FIGURE NO. :	REVISION :
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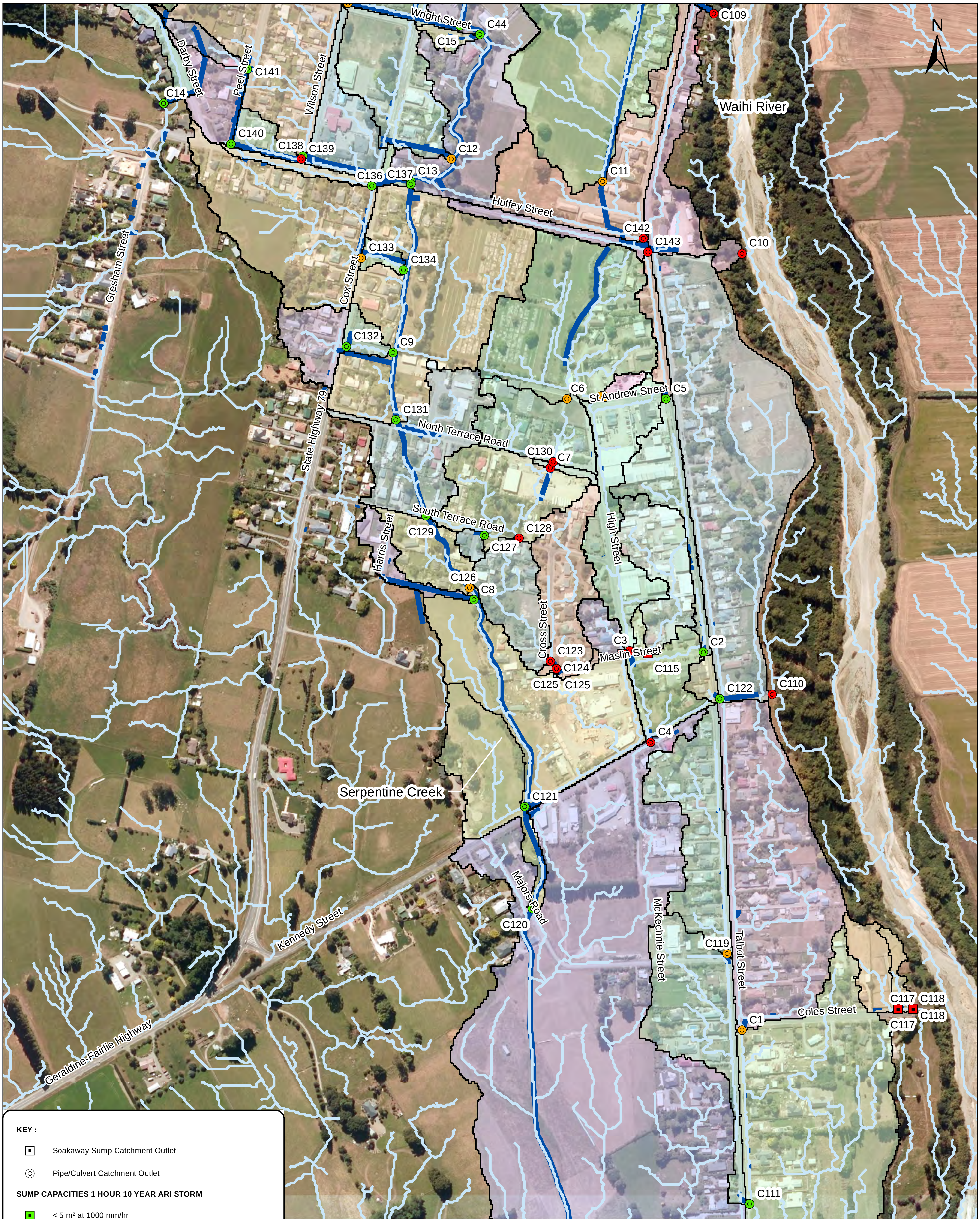

KEY :

- Soakaway Sump Catchment Outlet
- Pipe/Culvert Catchment Outlet

SUMP CAPACITIES 1 HOUR 10 YEAR ARI STORM

- < 5 m² at 1000 mm/hr
- 5 - 10 m² at 1000 mm/hr
- 10 - 20 m² at 1000 mm/hr
- > 20 m² at 1000 mm/hr

PIPE/CULVERT CAPACITIES 5 YEAR ARI STORM

- 0-50%
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GERALDINE STORMWATER MANAGEMENT PLAN

TITLE :
STORMWATER CATCHMENT BOUNDARIES - SOUTH WEST GERALDINE

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METRES

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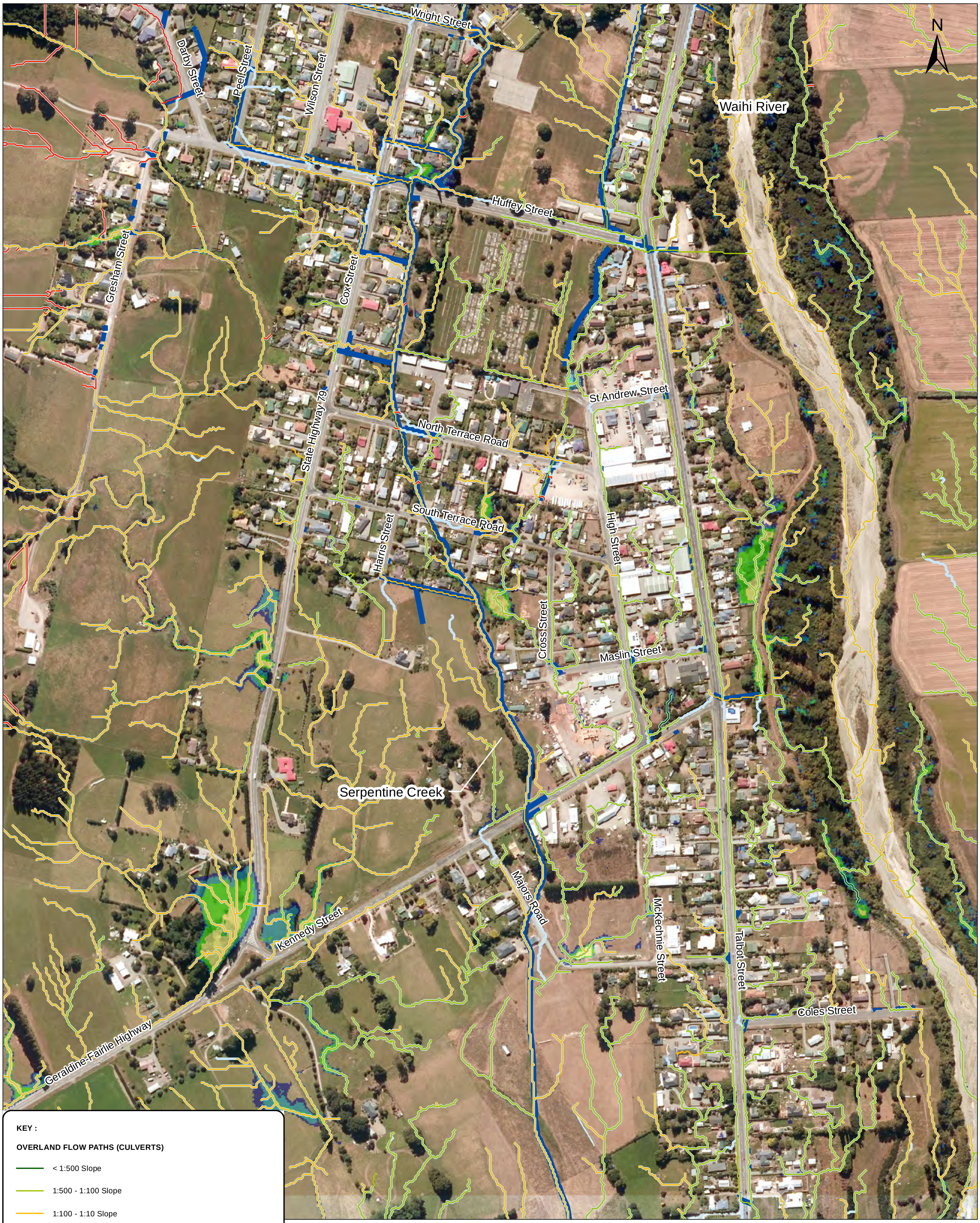

KEY :

OVERLAND FLOW PATHS (CULVERTS)

- < 1:500 Slope
- 1:500 - 1:100 Slope
- 1:100 - 1:10 Slope
- > 1:10 Slope

PONDING AREAS

- 0.1 m - 0.2 m
- 0.2 m - 0.4 m
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0 50 100 200
METRES

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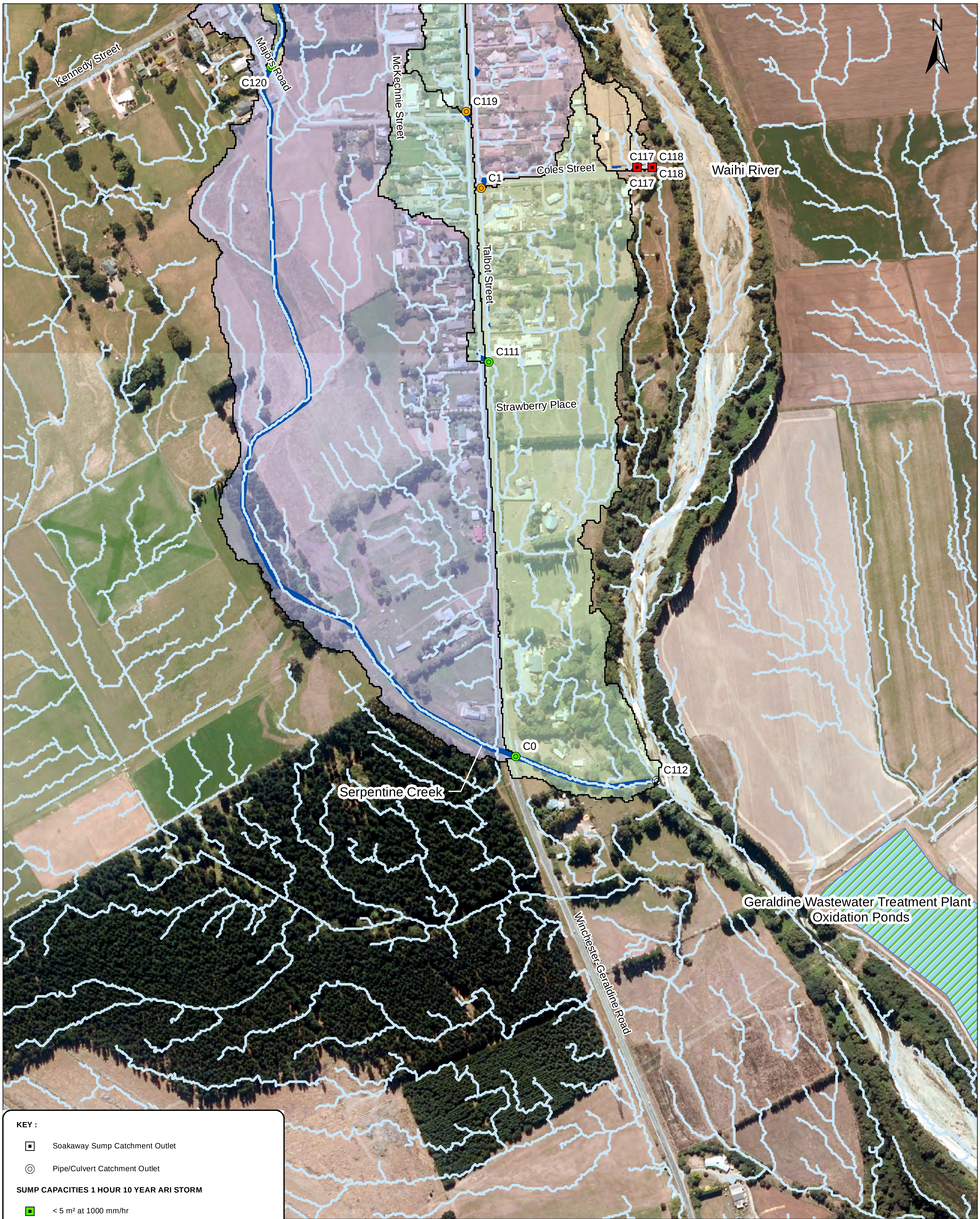

KEY :

- Soakaway Sump Catchment Outlet
- Pipe/Culvert Catchment Outlet

SUMP CAPACITIES 1 HOUR 10 YEAR ARI STORM

- < 5 m² at 1000 mm/hr
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GERALDINE STORMWATER MANAGEMENT PLAN

TITLE :
STORMWATER CATCHMENT BOUNDARIES - SERPENTINE OUTLET

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0 50 100 200
METRES

PROJECT NO. :	FIGURE NO. :	REVISION :
C03489300	7	A

FILED: C03489300Z009_Catchments_Serpentine_Outlet.mxd

KEY :

OVERLAND FLOW PATHS (CULVERTS)

- < 1:500 Slope
- 1:500 - 1:100 Slope
- 1:100 - 1:10 Slope
- > 1:10 Slope

PONDING AREAS

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METRES

PROJECT NO. :	FIGURE NO. :	REVISION :
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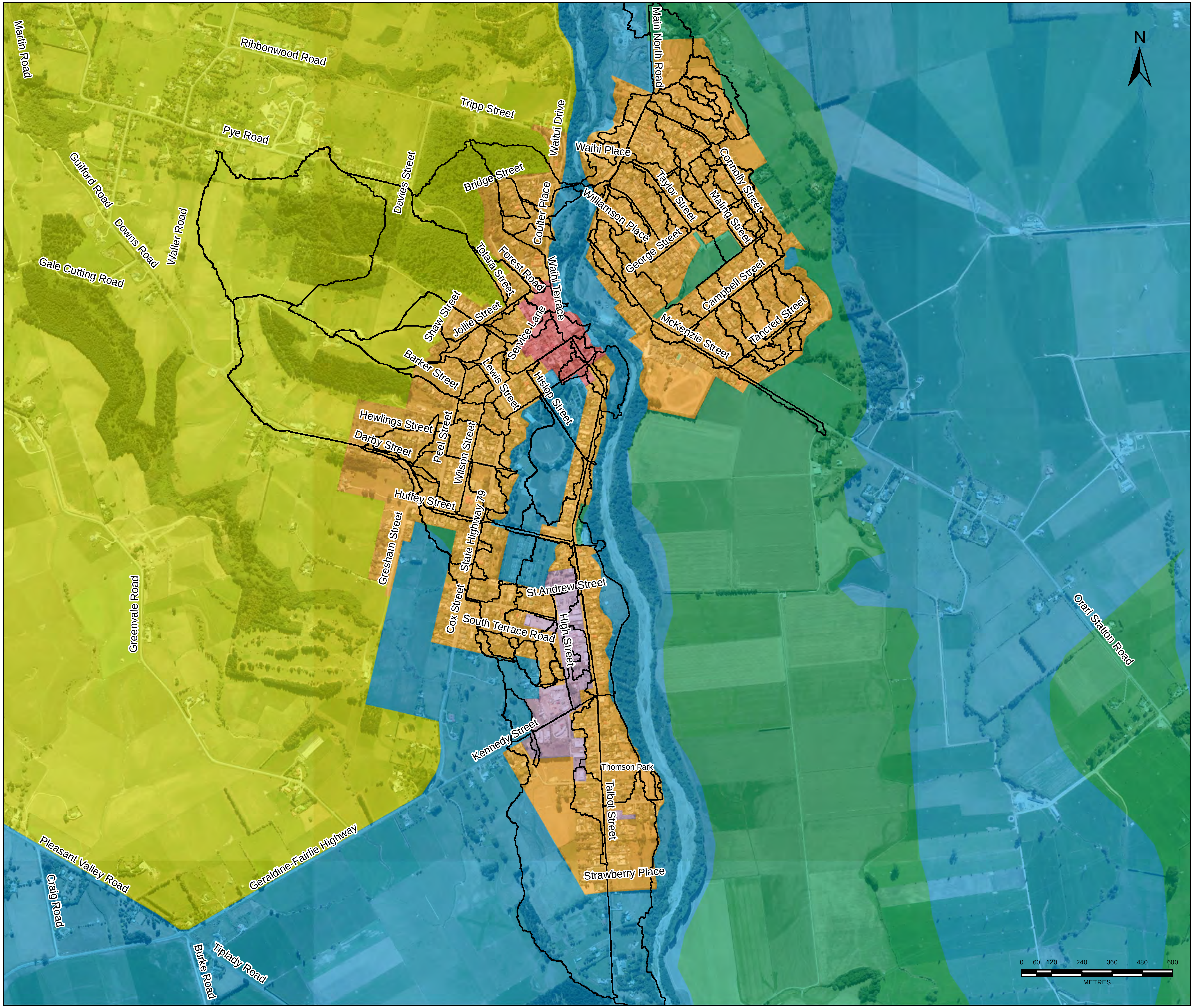

NOTES :

KEY :

Catchment Boundaries

RUNOFF COEFFICIENTS

- 0.15
- 0.2
- 0.3
- 0.4
- 0.6
- 0.95

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GERALDINE STORMWATER MANAGEMENT PLAN

TITLE :

RUNOFF COEFFICIENTS

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PROJECT NO. :	FIGURE NO. :	REVISION :
C03489300	9	A

File: C03489300Z005_Runoff Coefficients

NOTES :

KEY :

SUMP CAPACITIES 1 HOUR 10 YEAR ARI STORM

- < 5 m² at 1000 mm/hr
- 5 - 10 m² at 1000 mm/hr
- 10 - 20 m² at 1000 mm/hr
- > 20 m² at 1000 mm/hr

PIPE/CULVERT CAPACITIES 5 YEAR ARI STORM

- 0-50%
- 50-100%
- > 100%
- Catchment Boundaries
- 1986 Flood Extent

SOURCE:
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GERALDINE STORMWATER MANAGEMENT PLAN

TITLE :

1986 FLOOD EXTENT
(50-100 YEAR ARI)

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PROJECT NO. :	FIGURE NO. :	REVISION :
C03489300	10	A

File: C03489300Z005_Flood Extent

Figure 11: Raukapuka Reserve Diversion

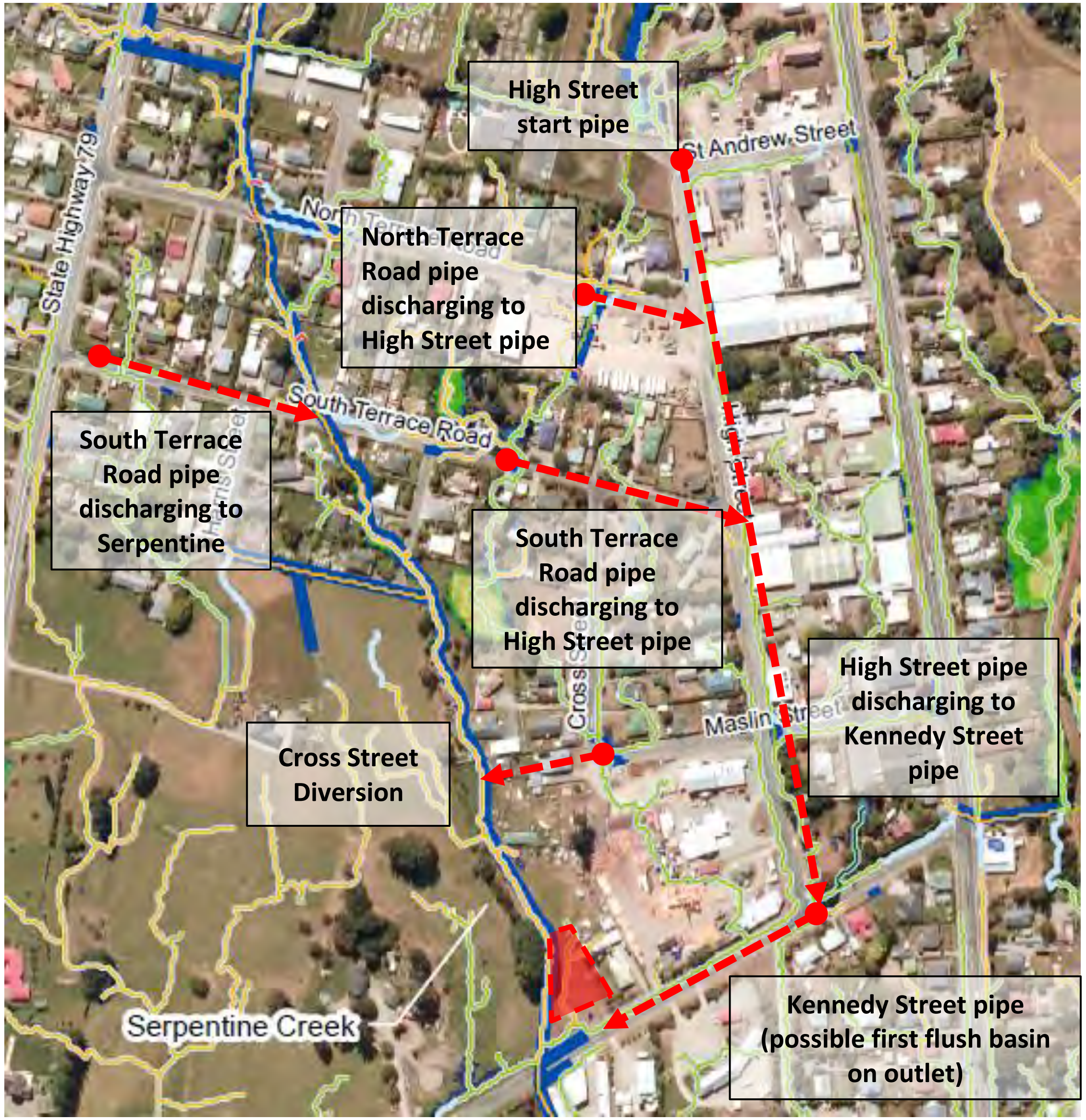

Figure 12: Geraldine South Drainage Upgrades

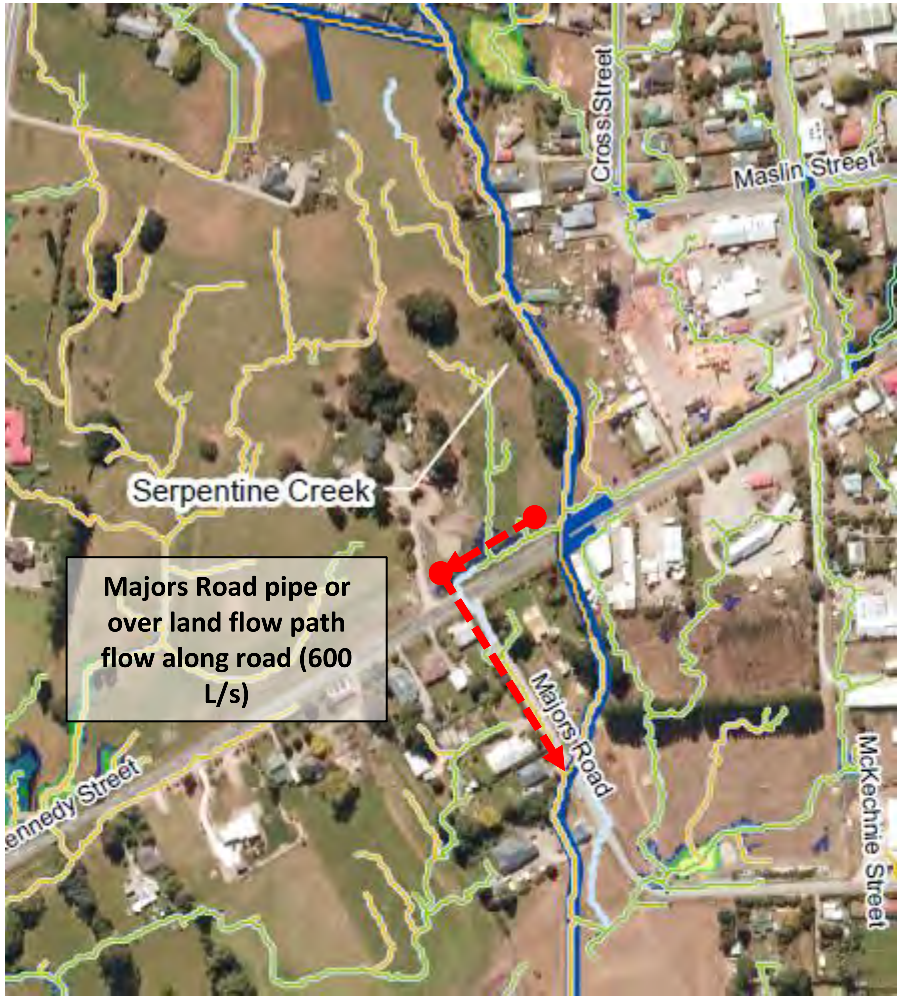

Figure 13: Majors Road Drainage Upgrades

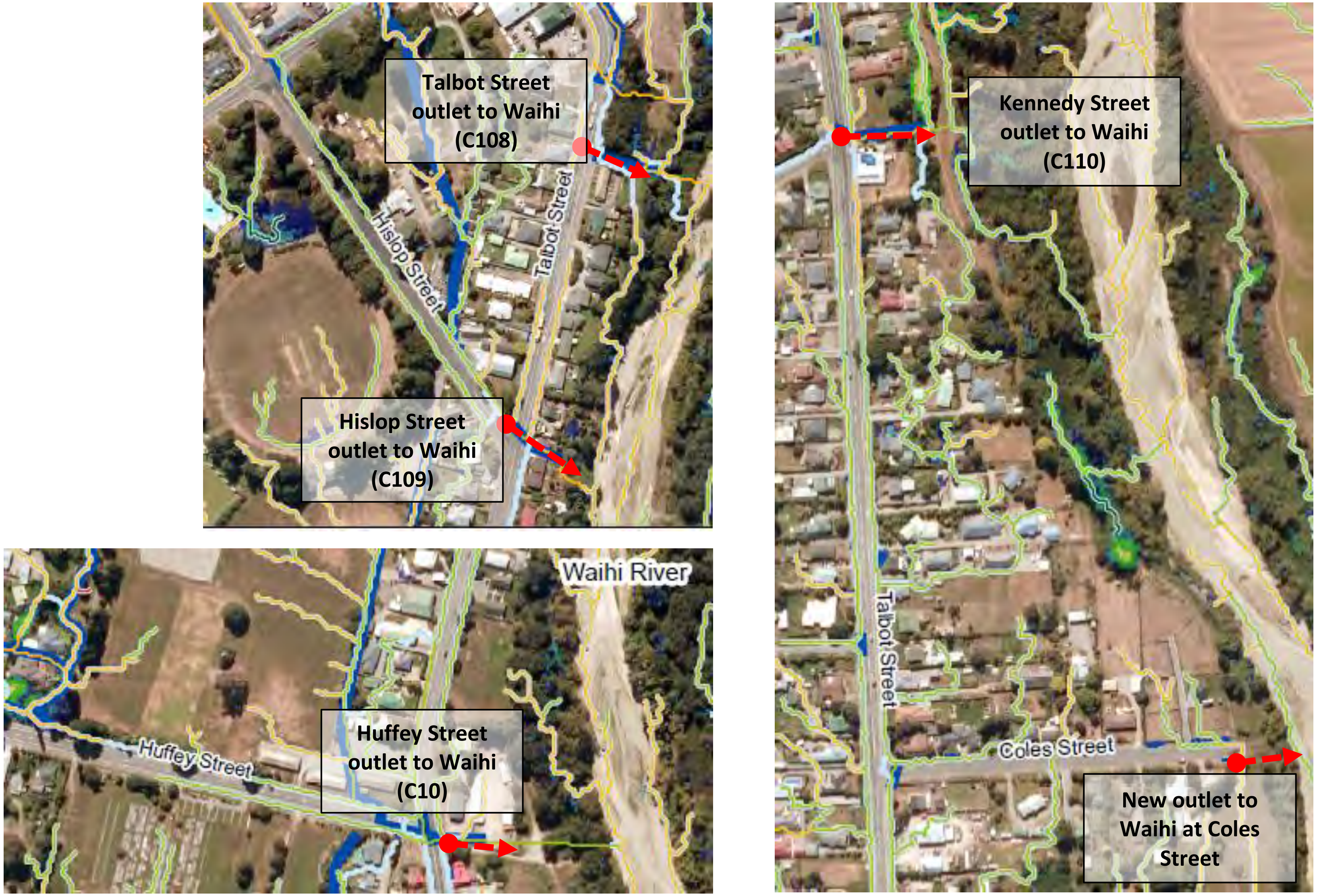

Figure 14: Talbot Street Outlets Upgrade

Appendix B

Pipes and Culverts Capacity Calculations

OUTLET POINT DETAILS								5 YEAR ARI		50 YEAR ARI		PIPE/CULVERT INFASTRUCTURE: PIPE DETAILS				5 YEAR ARI		50 YEAR ARI		
Outlet ID	Description	Location	Contributing Catchment Area	Effective Catchment Area	Weighted Runoff Coefficient	Time of Concentration	Design Storm Duration	Rainfall Intensity	Peak Flow	Rainfall Intensity	Peak Flow	TDC Pipe ID	Pipe Diameter	Pipe Grade	Full Flow Velocity	Pipe Capacity	Pipe Capacity	Pipe Capacity	Pipe Capacity	Notes
			(ha)	*(ha)*		*(min)*	*(min)*	*(mm/hr)*	*(L/s)*	*(mm/hr)*	*(L/s)*		*(mm)*	*(1:x)*	*(m/s)*	*(L/s)*	*(% ARI Flow)*	*(L/s)*	*(% ARI Flow)*	
C0	Culvert	Serpentine Creek	195.8	195.8	0.34	136.3	136.3	13.1	2,468	26.7	5,011	MAJR-OO16421 WINC-SO16549	1,300	85	4.26	3,200	130%	3,200	64%	Checked in Google Earth - culvert present but no size given - assume DN1300. Checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C1	Culvert	Waihi (West)	5.0	5.0	0.40	39.2	39.2	25.8	142	50.3	277	COLS-SM16498 COLS-SO16499	300	85	1.50	106	75%	106	38%	Checked in Google Earth - collection sumps at both end of pipe
C2	Culvert	Serpentine Creek	1.4	1.4	0.50	30.0	30.0	28.0	54	54.0	104	MASN-SM16008 MASN-SO16009	300	66	1.70	120	223%	120	116%	Checked in Google Earth - collection sumps at both end of pipe
C3	Culvert	Serpentine Creek	1.9	1.9	0.56	29.3	29.3	28.1	82	54.6	158	HIGS-SM16011 HIGS-SO16012	225	195	0.82	33	40%	33	21%	Checked in Google Earth - collection sumps at both ends of pipe
C4	Culvert	Serpentine Creek	5.6	5.6	0.56	43.0	43.0	25.0	216	48.8	423	HIGS-SM16006 KEND-SM16007	225	238	0.74	29	14%	29	7%	Checked in Google Earth - collection sumps at both end of pipe
C5	Culvert	Serpentine Creek	0.3	0.3	0.43	10.0	10.0	42.0	16	84.0	32	STAN-SM16043 STAN-SO16044	225	67	1.40	56	347%	56	173%	Checked in Google Earth - collection sumps at both end of pipe
C6	Culvert	Serpentine Creek	3.9	3.9	0.35	16.5	16.5	34.2	130	70.4	268	-	300	69	1.67	118	90%	118	44%	Checked in Google Earth - collection sumps visible - assume DN300 culvert
C7	Culvert	Serpentine Creek	5.3	5.3	0.37	20.7	20.7	29.9	161	62.4	336	NORR-SM16417 NORR-SP16418	300	428	0.67	47	29%	47	14%	Checked in Google Earth - pipe appears to pass under truck yard without receiving more runoff.
C8	Pipe Outlet	Serpentine Creek	0.5	0.5	0.37	16.1	16.1	34.7	16	71.3	33	HRRS-MH16520 FERG-OO16470	300	64	1.73	122	755%	122	368%	Slope calculated assuming downstream invert is 0.75m above receiving channel
C9	Pipe Outlet	Serpentine Creek	1.0	1.0	0.40	12.5	12.5	39.0	43	78.7	86	COXS-SM16451 COXS-SO16452	225	31	2.08	83	194%	83	96%	Checked in Google Earth - collection sump upstream visible. Slope calculated assuming downstream invert is 0.75m above receiving channel
C10	Pipe Outlet	Waihi (West)	10.4	10.4	0.26	44.1	44.1	24.7	186	48.4	364	TALS-MH16051 TALS-SO16053	300	184	1.02	72	39%	72	20%	Slope calculated assuming downstream invert is 0.75m above receiving channel
C11	Culvert	Waihi (West)	6.3	6.3	0.23	32.6	32.6	27.4	110	53.0	213	TALS-SI16045 HUFF-MH16046	300	108	1.33	94	85%	94	44%	Checked in Google Earth - exclude runoff from Huffey Street as there are no collection sumps. Assume it is the same flow to the C10 outlet and that hydraulic grade is the average along the 4 pipes.
C12	Pipe Outlet	Serpentine Creek	1.9	1.9	0.40	17.5	17.5	33.0	70	68.3	145	COXS-MH16460 COXS-SO16461	225	43	1.75	70	99%	70	48%	Slope calculated assuming downstream invert is 0.75m above receiving channel
C13	Pipe Outlet	Serpentine Creek	5.6	5.6	0.40	23.8	23.8	29.2	182	59.6	371	HUFF-MH16059 HUFF-SO16058	375	47	2.64	292	160%	292	79%	-
C14	Pipe Outlet	Serpentine Creek	0.7	0.7	0.40	16.1	16.1	34.6	29	71.1	59	DARB-SM16094 DARB-SO16095	300	17	3.36	238	833%	238	406%	-
C15	Pipe Outlet	Serpentine Creek	3.9	3.9	0.40	20.1	20.1	30.0	132	62.9	276	WRIT-SN16405 WRIT-SO16072	300	8	4.81	340	258%	340	123%	Slope calculated assuming downstream invert is 0.75m above receiving channel
C16	Culvert	Serpentine Creek	33.0	33.0	0.32	37.4	37.4	26.3	783	51.0	1,521	PEEL-SM16213 PEEL-SM16214	900	76	3.58	1,600	204%	1,600	105%	Slope calculated using elevations upstream and downstream of road. Assumed DN900 (OPUS modelling) instead of DN225 as in SW network data. Checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C17	Culvert	Serpentine Creek	33.8	33.8	0.33	40.9	40.9	25.4	781	49.6	1,522	WSON-SN16363 WSON-SN16362	900	38	5.09	1,600	205%	1,600	105%	Slope calculated assuming upstream invert is far enough upstream to exlude apparent ponding area in LiDAR data. Assumed DN900 (OPUS modelling) instead of DN225 as in SW network data. Checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C18	Culvert	Serpentine Creek	34.7	34.7	0.33	45.0	45.0	24.5	777	48.0	1,523	COXS-SI16409 COXS-SO16410	900	79	3.51	1,600	206%	1,600	105%	Checked in Google Earth - waterway visible from road upstream and downstream. Assumed DN900 (OPUS modelling) instead of DN225 as in SW network data. Checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C20	Culvert	Serpentine Creek	1.3	1.3	0.37	15.4	15.4	35.5	47	72.6	96	JOLL-SM16179 JOLL-MH16180	150	72	1.03	18	39%	18	19%	Checked in Google Earth - collection sump upstream visible
C21	Culvert	Serpentine Creek	0.6	0.6	0.35	12.2	12.2	39.4	23	79.4	46	TOTA-SM16304 TOTA-SO16305	225	10	3.63	144	627%	144	311%	Checked in Google Earth - collection sump upstream visible
C22	Pipe Outlet	Serpentine Creek	2.3	2.3	0.40	15.8	15.8	35.0	89	71.8	183	HEWG-SM16309 HEWG-SO16310	300	32	2.45	173	194%	173	95%	Checked in Google Earth - collection sumps upstream visible - also recieves flow from DN300 culvert crossing the road at this point
C23	Culvert	East Geraldine	42.5	42.5	0.38	74.9	74.9	19.1	862	38.4	1,729	MKZE-SN16114 ORIS-SO16115	375	112	1.71	188	22%	188	11%	-
C24	Pipe Outlet	East Geraldine	43.2	43.2	0.38	95.7	95.7	16.5	751	33.4	1,516	ORIS-SI16448 ORIS-SO16449	300	137	1.18	83	11%	83	6%	-
C25	Culvert	East Geraldine	39.6	39.6	0.38	65.4	65.4	20.3	850	40.7	1,703	MKZE-MH16109 MKZE-MH16110	300	174	1.05	74	9%	74	4%	-
C26	Pipe Outlet	East Geraldine	9.7	9.7	0.40	38.6	38.6	26.0	280	50.6	545	CCPL-SM16479 CCPL-SO16480	225	86	1.23	49	17%	49	9%	-

PIPE/CULVERT INFASTRUCTURE																				
OUTLET POINT DETAILS								5 YEAR ARI		50 YEAR ARI		PIPE DETAILS				5 YEAR ARI		50 YEAR ARI		
Outlet ID	Description	Location	Contributing Catchment Area	Effective Catchment Area	Weighted Runoff Coefficient	Time of Concentration	Design Storm Duration	Rainfall Intensity	Peak Flow	Rainfall Intensity	Peak Flow	TDC Pipe ID	Pipe Diameter	Pipe Grade	Full Flow Velocity	Pipe Capacity	Pipe Capacity	Pipe Capacity	Pipe Capacity	Notes
			(ha)	(ha)		(min)	(min)	(mm/hr)	(L/s)	(mm/hr)	(L/s)		(mm)	(1:x)	(m/s)	(L/s)	(% ARI Flow)	(L/s)	(% ARI Flow)	
C27	Pipe Outlet	East Geraldine	1.8	1.8	0.40	26.9	26.9	28.6	57	56.8	114	CONY-SM16230 CONY-SO16231	300	9	4.56	322	563%	322	284%	Slope calculated assuming downstream invert is 0.75m above receiving channel
C28	Culvert	East Geraldine	2.5	2.5	0.40	21.6	21.6	29.7	84	61.5	174	MKZE-SM16112 MKZE-MH16111	225	82	1.26	50	60%	50	29%	-
C31	Pipe Outlet	East Geraldine	9.3	9.3	0.40	37.0	37.0	26.4	273	51.2	530	CCPL-SM16479 CCPL-SO16480	-	-	-	-	-	-	-	Partial area - full area indicated on outlet 26
C38	Culvert	East Geraldine	38.9	38.9	0.38	64.9	64.9	20.4	838	40.8	1,677	MKZE-SM16107 MKZE-SM16108	225	76	1.31	52	6%	52	3%	-
C42	Culvert	Waihi (East)	40.6	40.6	0.15	103.9	103.9	15.5	269	31.4	545	-	300	52	1.93	136	51%	136	25%	Catchment area underestimated due to LiDAR extent. Culvert visible in Google Earth but no pipe size data available - assume DN300
C43	Culvert	Waihi (East)	45.1	45.1	0.17	131.9	131.9	13.2	279	26.9	566	MNRD-SM16261 MNRD-SO16262	225	32	2.04	81	29%	81	14%	Catchment area underestimated due to LiDAR extent
C44	Culvert	Serpentine Creek	0.2	0.2	0.40	10.0	10.0	42.0	7	84.0	14	WRIT-SM16561 WRIT-SO16548	225	17	2.82	112	1616%	112	808%	Slope calculated assuming downstream invert is 0.75m above receiving channel
C45	Culvert	Serpentine Creek	0.2	0.2	0.40	10.0	10.0	42.0	9	84.0	17	DARB-SM16555 DARB-SN16536	225	14	3.07	122	1396%	122	698%	Checked in Google Earth - collection sumps not clear to see but there is evidence on aerial photos
C46	Culvert	Serpentine Creek	0.3	0.3	0.40	10.0	10.0	42.0	16	84.0	33	DARB-SM16555 DARB-SN16536	-	-	-	-	-	-	-	Flow downstream of C46
C47	Culvert	Waihi (West)	2.5	2.5	0.40	13.6	13.6	37.7	104	76.4	211	WAIT-MH16294 WAIT-MH16295	225	31	2.07	82	79%	82	39%	Assume runoff goes downstream to outlet C104
C48	Pipe Outlet	Waihi (East)	0.2	0.2	0.40	10.0	10.0	42.0	10	84.0	20	MKZE-SM16268 MKZE-SO16269	225	48	1.66	66	653%	66	327%	Slope calculated assuming downstream invert is 0.75m above receiving channel
C49	Pipe Outlet	Waihi (East)	0.1	0.1	0.40	10.0	10.0	42.0	6	84.0	12	MKZE-SM16291 MKZE-SO16292	225	27	2.21	88	1410%	88	705%	Slope calculated assuming downstream invert is 0.75m above receiving channel
C101	Pipe Outlet	Waihi (West)	4.9	4.9	0.34	12.9	12.9	38.5	177	77.9	358	WAIT-MH16280 WAIT-SO16281	225	14	3.10	123	70%	123	34%	Slope calculated assuming downstream invert is 0.75m above receiving channel. TDC need to check the culvert actually passes under the embankment.
C102	Pipe Outlet	Waihi (West)	1.0	1.0	0.28	14.1	14.1	37.1	30	75.5	60	WAIT-MH16286 WAIT-SO16287	450	34	3.51	558	1892%	558	931%	Slope calculated assuming downstream invert is 0.75m above receiving channel
C103	Pipe Outlet	Waihi (East)	3.5	3.5	0.40	26.6	26.6	28.7	110	57.0	219	MKZE-SM16377 MKZE-SO16378	225	99	1.15	46	41%	46	21%	Slope calculated assuming downstream invert is 0.75m above receiving channel
C104	Pipe Outlet	Waihi (West)	0.2	2.7	0.40	10.0	10.0	42.0	127	84.0	253	WAIT-MH16295 WAIT-SO16296	225	20	2.56	102	81%	102	40%	Also receiving runoff from outlet C47
C105	Pipe Outlet	Waihi (West)	12.0	12.0	0.34	31.2	31.2	27.7	314	53.5	606	WAIS-SN16170 WAIS-SO16171	760	35	4.77	2,163	689%	2,163	357%	Checked in Google Earth - collection sump upstream visible
C106	Pipe Outlet	Waihi (West)	1.3	1.3	0.81	16.0	16.0	34.8	106	71.3	217	PEEL-MH16318 PEEL-SO16163	225	16	2.88	114	108%	114	53%	TDC need to check the culvert actually passes under the embankment.
C107	Pipe Outlet	Waihi (West)	0.9	0.9	0.92	16.1	16.1	34.7	78	71.3	160	WSON-MH16437 WSON-SO16158	300	35	2.34	166	213%	166	104%	TDC need to check the culvert actually passes under the embankment.
C108	Pipe Outlet	Waihi (West)	3.7	3.7	0.44	22.7	22.7	29.5	134	60.6	275	TALS-SN16367 TALS-SO16368	225	28	2.19	87	65%	87	32%	Checked in Google Earth - collection sump upstream. Slope calculated assuming downstream invert is 0.75m above receiving channel. TDC need to check the culvert actually passes under the embankment.
C109	Pipe Outlet	Waihi (West)	7.3	7.3	0.46	34.2	34.2	27.0	250	52.3	483	TALS-SM16075 TALS-SO16076	300	185	1.02	72	29%	72	15%	Checked in Google Earth - collection sump upstream
C110	Pipe Outlet	Waihi (West)	6.9	6.9	0.33	41.8	41.8	25.3	162	49.3	316	TALS-SM16004 TALS-SO16005	225	98	1.16	46	28%	46	15%	Checked in Google Earth - collection sump upstream. Slope calculated assuming downstream invert is 0.75m above receiving channel. TDC need to check the culvert actually passes under the embankment.
C111	Pipe Outlet	Waihi (West)	4.3	4.3	0.42	40.5	40.5	25.6	127	49.8	248	TALS-SM16105 TALS-SO16106	450	266	1.24	197	155%	197	79%	Checked in Google Earth - collection sumps at upstream end of pipe and discharging to grassy channel
C112	Channel Outlet	Serpentine Outlet	219.6	219.6	0.34	143.3	143.3	13.0	2,736	26.4	5,547	MAJR-OO16421 WINC-SO16549	-	-	-	-	-	-	-	Assume channel discharges to Waihi directly
C113	Pipe Outlet	Waihi (West)	1.3	1.3	0.72	18.0	18.0	32.4	83	67.1	173	TALS-MH16132 TALS-SO16133	225	54	1.56	62	74%	62	36%	Checked in Google Earth - collection sump upstream
C119	Culvert	Serpentine Creek	2.1	2.1	0.41	21.3	21.3	29.7	70	61.8	146	TALS-SI16001 TALS-SO16002	225	148	0.94	37	53%	37	26%	Checked in Google Earth - culvert connecting channels on either side of Majors Road

												PIPE/CULVERT INFASTRUCTURE								
			OUTLET POINT DETAILS					5 YEAR ARI		50 YEAR ARI		PIPE DETAILS				5 YEAR ARI		50 YEAR ARI		
Outlet ID	Description	Location	Contributing Catchment Area	Effective Catchment Area	Weighted Runoff Coefficient	Time of Concentration	Design Storm Duration	Rainfall Intensity	Peak Flow	Rainfall Intensity	Peak Flow	TDC Pipe ID	Pipe Diameter	Pipe Grade	Full Flow Velocity	Pipe Capacity	Pipe Capacity	Pipe Capacity	Pipe Capacity	Notes
			(ha)	*(ha)*		*(min)*	*(min)*	*(mm/hr)*	*(L/s)*	*(mm/hr)*	*(L/s)*		*(mm)*	*(1:x)*	*(m/s)*	*(L/s)*	*(% ARI Flow)*	*(L/s)*	*(% ARI Flow)*	
C120	Culvert	Serpentine Creek	160.7	160.7	0.34	99.6	99.6	16.0	2,471	32.4	4,994	MAJR-OI16420 MAJR-OO16419	1,300	59	5.12	3,200	129%	3,200	64%	Checked in Google Earth - culvert under bridge crossing Majors Road. Assumed DN1300 instead of DN225 as in SW network data. Checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C121	Culvert	Serpentine Creek	159.0	159.0	0.35	94.6	94.6	16.7	2,548	33.6	5,140	KEND-SI16015 KEND-SO16016	1,300	62	4.99	3,200	126%	3,200	62%	Checked in Google Earth - culvert under bridge along Kennedy Street - upstream recieves runoff from one side of Kennedy Street through a sump and pipe. Assumed DN1300 instead of DN225 as in SW network data. Checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C122	Culvert	Waihi (West)	0.2	0.2	0.46	10.0	10.0	42.0	10	84.0	21	TALS-SM16003 TALS-SM16004	150	158	0.69	12	117%	12	59%	Checked in Google Earth - collection sumps at both end of pipe
C123	Culvert	Serpentine Creek	8.3	8.3	0.37	42.7	42.7	25.0	216	48.9	422	CROS-SM16019 CROS-SM16020	225	104	1.12	45	21%	45	11%	Checked in Google Earth - collection sumps at both end of pipe
C124	Culvert	Serpentine Creek	9.7	9.7	0.38	43.0	43.0	25.0	255	48.8	499	CROS-SM16020 MASN-SP16021	225	588	0.47	19	7%	19	4%	Checked in Google Earth - collection sump at upstream end of pipe and soakaway sump at downstream end
C126	Culvert	Serpentine Creek	144.7	144.7	0.34	85.3	85.3	17.8	2,447	35.9	4,923	FERG-SI16306 FERG-SO16307 & FERG-SN16560 FERG-	750	47	4.07	2,000	82%	2,000	41%	Capacity has been doubled to account for double culvert under Fergusson Street. Assumed DN750 for each pipe instead of DN225 as in SW network data. Checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C127	Culvert	Serpentine Creek	0.1	0.1	0.40	10.0	10.0	42.0	6	84.0	12	SOUR-SM16025 SOUR-SO16026	225	32	2.03	81	1328%	81	664%	Checked in Google Earth - collection sumps at both end of pipe
C128	Culvert	Serpentine Creek	7.2	7.2	0.39	13.0	13.0	38.4	297	77.8	602	SOUR-SI16023 SOUR-SO16024	300	53	1.90	134	45%	134	22%	Checked in Google Earth - appears to be small culver discharging to channel on opposite side of South Terrace Road
C129	Culvert	Serpentine Creek	143.9	143.9	0.34	80.5	80.5	18.4	2,512	37.0	5,047	SOUR-SI16027 SOUT-SN16558	1,300	160	3.10	3,200	127%	3,200	63%	Checked in Google Earth - bridge culvert passing under South Terrace Road. Assumed DN1300 instead of DN225 as in SW network data. Checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C130	Culvert	Serpentine Creek	5.2	5.2	0.36	20.7	20.7	29.9	158	62.4	329	NORR-SM16032 NORR-SN16369	300	1060	0.42	30	19%	30	9%	Checked in Google Earth - collection sumps at both end of pipe. TDC to confirm flow direction - have assumed flowing south to truck yard from North Terrace road in contradiction to kerb levels
C131	Culvert	Serpentine Creek	141.9	141.9	0.34	75.8	75.8	19.0	2,550	38.2	5,118	NORR-SI16400 NORR-SO16039	1,300	1212	1.12	3,200	125%	3,200	63%	Checked in Google Earth - appears to be twin culverts under North Terrace Road. TDC to confirm flow direction - have assumed flow goes south of North Terrace road in contradiction to kerb levels. Checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C132	Culvert	Serpentine Creek	0.7	0.7	0.40	10.0	10.0	42.0	34	84.0	67	COXS-SM16450 COXS-SM16451	225	140	0.97	38	114%	38	57%	Checked in Google Earth - collection sumps at both end of pipe
C133	Culvert	Serpentine Creek	3.3	3.3	0.34	17.8	17.8	32.6	102	67.6	212	COXS-SM16482 COXS-SN16484	300	139	1.17	83	81%	83	39%	Checked in Google Earth - collection sumps at both end of pipe
C134	Pipe Outlet	Serpentine Creek	3.5	3.5	0.34	21.0	21.0	29.8	99	62.1	206	COXS-SN16485 COXS-SO16487	300	71	1.64	116	117%	116	56%	-
C135	Culvert	Serpentine Creek	5.2	5.2	0.40	22.2	22.2	29.6	172	61.0	356	COXS-SM16063 HUFF-SM16061	375	224	1.20	133	77%	133	37%	Checked in Google Earth - collection sumps at both end of pipe
C136	Culvert	Serpentine Creek	0.2	0.2	0.40	14.8	14.8	36.3	10	74.0	20	HUFF-SM16060 HUFF-MH16059	225	229	0.76	30	302%	30	148%	Checked in Google Earth - collection sump visible at upstream end
C137	Culvert	Serpentine Creek	132.5	132.5	0.34	66.2	66.2	20.2	2,532	40.5	5,070	HUFF-SI16056 HUFF-SO16057	1,200	55	5.04	3,200	126%	3,200	63%	Checked in Google Earth - bridge culvert visible passing under Huffey Street. Assumed DN1200 instead of DN225 as in SW network data. Checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C138	Culvert	Serpentine Creek	2.8	3.2	0.40	18.6	18.6	31.6	111	65.9	232	WSON-SM16080 HUFF-MH16079	300	63	1.74	123	111%	123	53%	Checked in Google Earth - collection sumps not really visible but it looks like this pipe will take runoff from Huffey Street and Wilson Street
C139	Culvert	Serpentine Creek	1.4	1.4	-	-	-	-	-	-	-	-	-	-	-		-	-	-	Runoff to this point to be added to C138 after removing upstream area at C140
C140	Culvert	Serpentine Creek	1.0	1.0	0.40	15.3	15.3	35.7	41	73.0	84	HUFF-MH16082 HUFF-MH16081	225	34	1.97	78	190%	78	93%	Checked in Google Earth - collection sump upstream is visible. Road runoff along this pipeline to be added to C138.
C141	Culvert	Serpentine Creek	0.3	0.3	0.40	10.0	10.0	42.0	13	84.0	26	PEEL-MH16085 HUFF-MH16082	225	368	0.59	24	183%	24	91%	Checked in Google Earth - collection sump upstream visible
C142	Culvert	Waihi (West)	8.7	8.7	0.26	38.2	38.2	26.1	162	50.7	314	TALS-SM16049 TALS-SM16050	300	167	1.07	76	47%	76	24%	Checked on Google Earth - collection sumps visible upstream and downstream of pipe
C143	Culvert	Waihi (West)	9.0	9.0	0.26	38.8	38.8	25.9	169	50.5	328	TALS-SM16050 TALS-MH16051	225	253	0.72	29	17%	29	9%	Checked in Google Earth - collection sumps at both end of pipe
C144	Culvert	Serpentine Creek	0.6	0.6	0.40	10.0	10.0	42.0	29	84.0	59	PEEL-SM16224 WRIT-SN16226	150	32	1.54	27	93%	27	46%	Checked in Google Earth - upstream sump
C145	Culvert	Serpentine Creek	2.4	2.4	0.40	13.7	13.7	37.6	99	76.3	200	WRIT-MH16078 COXS-MH16071	225	57	1.52	60	61%	60	30%	Checked in Google Earth - sump from lateral connecting pipe at upstream end is visible
C146	Culvert	Serpentine Creek	80.3	80.3	0.34	48.9	48.9	23.6	1,794	46.4	3,532	COXS-SM16146 COXS-SO16148	900	27	6.02	1,600	89%	1,600	45%	Checked in Google Earth - collection sump visible upstream. Assumed DN900 instead of DN225 as in SW network data. Checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.

PIPE/CULVERT INFASTRUCTURE																				
OUTLET POINT DETAILS								5 YEAR ARI		50 YEAR ARI		PIPE DETAILS				5 YEAR ARI		50 YEAR ARI		
Outlet ID	Description	Location	Contributing Catchment Area	Effective Catchment Area	Weighted Runoff Coefficient	Time of Concentration	Design Storm Duration	Rainfall Intensity	Peak Flow	Rainfall Intensity	Peak Flow	TDC Pipe ID	Pipe Diameter	Pipe Grade	Full Flow Velocity	Pipe Capacity	Pipe Capacity	Pipe Capacity	Pipe Capacity	Notes
			(ha)	*(ha)*		*(min)*	*(min)*	*(mm/hr)*	*(L/s)*	*(mm/hr)*	*(L/s)*		*(mm)*	*(1:x)*	*(m/s)*	*(L/s)*	*(% ARI Flow)*	*(L/s)*	*(% ARI Flow)*	
C147	Culvert	Serpentine Creek	1.9	1.9	0.64	20.5	20.5	29.9	100	62.6	210	COXS-SM16143 HISP-SO16144	150	52	1.21	21	21%	21	10%	Checked in Google Earth - collection sump visible upstream
C148	Culvert	Serpentine Creek	0.6	0.6	0.40	10.5	10.5	41.4	29	82.9	58	WSON-SM16194 WSON-SM16195	225	55	1.55	61	212%	61	106%	Checked in Google Earth - collection sumps at both end of pipe
C149	Culvert	Serpentine Creek	15.1	15.1	0.36	29.1	29.1	28.2	425	54.8	827	WSON-SM16361 WSON-SN16359	900	234	2.04	1,600	376%	1,600	193%	Checked in Google Earth - upstream collection sump visible. Checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C150	Culvert	Serpentine Creek	3.0	3.0	0.40	16.3	16.3	34.5	113	70.8	232	LEWS-SM16202 LEWS-SM16203	150	50	1.24	22	19%	22	9%	Checked in Google Earth - collection sumps at both end of pipe
C151	Culvert	Serpentine Creek	13.5	13.5	0.35	25.8	25.8	28.8	383	57.8	767	PEEL-SN16200 WSON-SM16361	600	428	1.17	330	86%	330	43%	Appears to pass through significant ponding area
C152	Culvert	Serpentine Creek	10.2	10.2	0.34	24.8	24.8	29.0	281	58.7	567	PEEL-SM16199 PEEL-SN16200	600	38	3.95	550	196%	550	97%	Unsure of pipe size as this pipe is between two DN600 culverts according to the SW network data. Have assumed DN600 and checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C153	Culvert	Serpentine Creek	9.4	9.4	0.34	23.9	23.9	29.2	257	59.5	523	PEEL-MH16522 PEEL-MH16521	600	121	2.21	550	214%	550	105%	Checked capacity according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C154	Culvert	Serpentine Creek	2.2	2.2	0.39	13.1	13.1	38.3	90	77.5	183	PEEL-SM16209 PEEL-SM16210	150	15	2.30	41	45%	41	22%	Checked in Google Earth - collection sumps at both end of pipe
C155	Culvert	Serpentine Creek	4.7	4.7	0.31	20.2	20.2	30.0	123	62.8	258	SHAS-SN16379 SHAS-SM16217	300	96	1.41	100	81%	100	39%	Checked in Google Earth - upstream collection sump visible
C156	Culvert	Serpentine Creek	8.0	8.0	0.33	20.4	20.4	29.9	217	62.7	455	JOLL-MH16517 JOLL-SO16221	300	6	5.67	401	184%	401	88%	Slope calculated assuming downstream invert is 0.75m above receiving channel
C157	Culvert	Serpentine Creek	3.1	3.1	0.34	15.4	15.4	35.5	103	72.7	210	JOLL-SM16219 JOLL-MH16517	300	55	1.87	132	129%	132	63%	Checked in Google Earth - collection sumps visible at both ends of pipe
C158	Culvert	Waihi (West)	6.9	6.9	0.46	33.6	33.6	27.2	240	52.6	464	TALS-MH16074 TALS-SM16075	300	459	0.64	45	19%	45	10%	Checked in Google Earth - collection sumps at both end of pipe
C159	Culvert	Waihi (West)	0.8	0.8	0.92	11.8	11.8	39.8	79	80.1	159	COXS-MH16136 COXS-MH16137	225	37	1.89	75	95%	75	47%	-
C160	Culvert	Waihi (West)	0.5	0.5	0.95	11.8	11.8	39.8	57	80.1	115	COXS-SM16134 COXS-MH16136	225	63	1.45	58	101%	58	50%	Checked in Google Earth - collection sumps visible at both ends of pipe
C161	Culvert	Serpentine Creek	60.5	60.5	0.32	39.0	39.0	25.9	1,382	50.4	2,689	PEEL-SM16184 PEEL-SN16193	900	37	5.16	1,600	116%	1,600	60%	Checked in Google Earth - upstream collection sump visible. SW database has DN225 so have assumed upstream pipe size of DN900. Capacity checked according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C162	Culvert	Serpentine Creek	62.9	62.9	0.33	44.8	44.8	24.6	1,436	48.1	2,813	WSON-SN16403 WSON-SM16189	1,200	81	4.16	3,200	223%	3,200	114%	Checked in Google Earth - no apparent collection sump for road runoff so have excluded runoff from Wilson Street. Capacity checked according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C163	Culvert	Serpentine Creek	59.7	59.7	0.31	38.6	38.6	26.0	1,348	50.6	2,622	PEEL-SI16182 PEEL-SM16184	900	90	3.30	1,600	119%	1,600	61%	Capacity checked according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C164	Culvert	Serpentine Creek	57.9	57.9	0.30	35.0	35.0	26.8	1,317	52.0	2,553	JOLL-SN16177 JOLL-SO16178	1,100	69	4.26	2,300	175%	2,300	90%	Slope calculated assuming downstream invert is 0.75m above receiving channel. Capacity checked according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C165	Culvert	Serpentine Creek	57.7	57.7	0.30	34.3	34.3	27.0	1,317	52.3	2,550	JOLL-SN16175 JOLL-SN16177	1,100	62	4.50	2,300	175%	2,300	90%	Checked in Google Earth - collection sumps visible for laterals. Capacity checked according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C166	Culvert	Serpentine Creek	32.5	32.5	0.30	25.0	25.0	29.0	785	58.5	1,584	HISP-SI16471 HISP-SO16472	900	24	6.34	1,600	204%	1,600	101%	Culvert visible in aerial photos on Canterbury Maps. Capacity checked according to CPAA Figure 3.3 assuming inlet control with headwater depth of 1.5 x pipe diameter.
C167	Culvert	Waihi (West)	0.2	0.2	0.95	10.0	10.0	42.0	17	84.0	34	TALS-SM16149 TALS-SM16322	225	174	0.87	34	202%	34	101%	Checked in Google Earth - collection sumps visible at both ends of pipe
C168	Culvert	Waihi (West)	0.6	0.6	0.95	10.0	10.0	42.0	64	84.0	129	TALS-SM16322 TALS-SM16323	225	110	1.09	43	67%	43	34%	Checked in Google Earth - collection sumps visible at both ends of pipe
C169	Culvert	Waihi (West)	0.4	0.4	0.55	10.0	10.0	42.0	25	84.0	51	TALS-SM16130 TALS-MH16132	225	464	0.53	21	83%	21	41%	Checked in Google Earth - collection sumps visible at both ends of pipe. TDC to confirm flow direction - have assumed flowing east across Talbot Steet towards Waihi in contradiction to kerb levels
C170	Culvert	Waihi (West)	0.4	0.4	0.72	10.0	10.0	42.0	29	84.0	59	JOLL-SM16512 WAIS-SO16513	225	40	1.80	72	244%	72	122%	Checked in Google Earth - collection sumps visible at both ends of pipe
C171	Culvert	Waihi (West)	1.3	1.3	0.40	10.1	10.1	41.9	60	83.8	121	MDOL-SM16293 WAIT-MH16294	225	6	4.69	187	309%	187	154%	Checked in Google Eath - upstream collection sump visible

Appendix C

Soakage Infrastructure Capacity Calculations

SOAKAWAY SUMP INFASTRUCTURE													
OUTLET POINT DETAILS								10 YEAR ARI		PIPE DETAILS		10 YEAR ARI	
Outlet ID	Description	Location	Contributing Catchment Area	Effective Catchment Area	Weighted Runoff Coefficient	Time of Concentration	Design Storm Duration	Rainfall Intensity	Peak Flow	TDC Pipe ID	Pipe Diameter	Sump Area Required for 1000 mm/hr infiltration	Notes
			(ha)	*(ha)*		*(min)*	*(min)*	*(mm/hr)*	*(L/s)*		*(mm)*	*(m²)*	
C29	Soakaway Sump	East Geraldine	8.2	0.5	0.40	31.8	60.0	26.0	14	CCPL-SM16475 CCPL-SP16476	225	52	Area upstream at C33 removed
C30	Soakaway Sump	East Geraldine	8.5	0.3	0.40	32.4	60.0	26.0	9	CCPL-SM16477 CCPL-SP16478	225	33	Area upstream at C29 removed
C32	Soakaway Sump	East Geraldine	1.4	1.4	0.40	20.2	60.0	26.0	40	TANC-SM16455 TANC-SP16457	225	146	-
C33	Soakaway Sump	East Geraldine	7.7	0.8	0.40	29.9	60.0	26.0	24	TANC-SM16456 TANC-SP16458	225	88	Area upstream at C34, C37 and C32 removed
C34	Soakaway Sump	East Geraldine	1.9	0.2	0.40	20.7	60.0	26.0	7	TANC-SM16550 TANC-SO16564	225	24	Connected to outlet C35 with culvert - assume flow direction is towards C34 and remove upstream area at C35
C35	Soakaway Sump	East Geraldine	1.7	1.7	0.40	20.7	60.0	26.0	48	TANC-SM16550 TANC-SO16564	225	174	Connected to outlet C34 with culvert - assume flow direction is towards C34
C36	Soakaway Sump	East Geraldine	1.7	1.7	0.40	20.3	60.0	26.0	50	-	-	181	-
C37	Soakaway Sump	East Geraldine	3.6	1.8	0.40	22.0	60.0	26.0	53	-	-	191	Area upstream at C36 removed
C39	Soakaway Sump	East Geraldine	34.1	18.8	0.38	60.9	60.0	26.0	513	CAML-SM16124 CAML-SP16125	225	1,848	Area upstream at C53, C66, C69, C73 and C75 removed
C40	Soakaway Sump	East Geraldine	1.6	1.2	0.40	17.1	60.0	26.0	36	MALG-SM16233 MALG-MH16235	300	128	Area upstream at C57 removed
C41	Soakaway Sump	East Geraldine	1.8	1.6	0.29	27.2	60.0	26.0	34	MALG-MH16235 MALG-SP16236	300	123	Area upstream at C61 removed
C50	Soakaway Sump	East Geraldine	0.1	0.1	0.40	10.0	60.0	26.0	3	-	-	12	-
C51	Soakaway Sump	Waihi (East)	0.5	0.5	0.40	10.1	60.0	26.0	13	-	-	48	-
C52	Soakaway Sump	Waihi (East)	0.8	0.4	0.40	20.0	60.0	26.0	10	MKZE-SM16389 MKZE-SP16118	225	37	Area upstream at C51 removed
C53	Soakaway Sump	East Geraldine	7.3	1.1	0.37	44.7	60.0	26.0	29	CAML-SM16326 CAML-SP16127	225	104	Area upstream at C54 removed
C54	Soakaway Sump	East Geraldine	6.2	2.1	0.37	39.7	60.0	26.0	54	CAML-SM16324 CAML-SP16128	225	196	Area upstream at C55, C40 and C41 removed
C55	Soakaway Sump	East Geraldine	0.8	0.8	0.40	20.0	60.0	26.0	23	CAML-SM16398 CAML-SP16103	225	82	-
C56	Soakaway Sump	East Geraldine	1.2	0.2	0.40	26.4	60.0	26.0	6	CONY-SM16386 CONY-SP16228	225	20	Area upstream at C58 removed
C57	Soakaway Sump	East Geraldine	0.4	0.4	0.40	10.0	60.0	26.0	11	MALG-SM16387 MALG-SP16229	225	41	-
C58	Soakaway Sump	East Geraldine	1.0	0.4	0.40	12.4	60.0	26.0	10	CONY-SM16431 CONY-SP16227	225	36	Area upstream at C59 removed
C59	Soakaway Sump	East Geraldine	0.7	0.7	0.39	12.4	60.0	26.0	19	CONY-SM16339 CONY-SP16246	225	67	-
C60	Soakaway Sump	East Geraldine	0.8	0.8	0.40	11.6	60.0	26.0	24	GEOG-SM16340 GEOG-SP16245	225	85	-
C61	Soakaway Sump	East Geraldine	0.1	0.1	0.40	10.0	60.0	26.0	3	GEOG-SM16341 GEOG-SP16244	225	11	-
C62	Soakaway Sump	East Geraldine	1.2	1.0	0.40	18.2	60.0	26.0	29	GEOG-SM16342 GEOG-SP16243	225	104	Area includes catchment outlet C63 as the sump is on the corner. Area upstream at C76 and C60 removed.
C63	Soakaway Sump	East Geraldine	1.3	1.0	0.40	19.7	60.0	26.0	29	GEOG-SM16342 GEOG-SP16243	225	104	Area includes catchment outlet C62 as the sump is on the corner. Area upstream at C76 and C60 removed.
C64	Soakaway Sump	East Geraldine	9.3	1.1	0.40	36.6	60.0	26.0	33	GEOG-SM16343 GEOG-SP16469	225	117	Area upstream at C62, C63 and C77 removed
C65	Soakaway Sump	East Geraldine	1.4	1.3	0.40	23.5	60.0	26.0	37	GEOG-SM16434 GEOG-SP16435	225	133	Area upstream at C50 removed
C66	Soakaway Sump	East Geraldine	5.9	2.5	0.40	34.5	60.0	26.0	73	GEOG-SM16432 GEOG-SP16122	225	264	Area upstream at C67 removed

SOAKAWAY SUMP INFASTRUCTURE														
OUTLET POINT DETAILS								10 YEAR ARI		PIPE DETAILS		10 YEAR ARI	
Outlet ID	Description	Location	Contributing Catchment Area	Effective Catchment Area	Weighted Runoff Coefficient	Time of Concentration	Design Storm Duration	Rainfall Intensity	Peak Flow	TDC Pipe ID	Pipe Diameter	Sump Area Required for 1000 mm/hr infiltration	Notes
			(ha)	*(ha)*		*(min)*	*(min)*	*(mm/hr)*	*(L/s)*		*(mm)*	*(m²)*	
C67	Soakaway Sump	East Geraldine	3.4	3.2	0.40	30.4	60.0	26.0	92	GEOG-SM16348 GEOG-SP16237	225	**331**	Area upstream at C79 removed
C68	Soakaway Sump	East Geraldine	1.1	0.7	0.40	20.9	60.0	26.0	21	GEOG-SM16346 GEOG-SP16239	225	**74**	Area upstream at C72 removed
C69	Soakaway Sump	East Geraldine	11.1	0.1	0.40	40.4	60.0	26.0	2	GEOG-SM16345 GEOG-SP16240	225	8	Area upstream at C70 removed
C70	Soakaway Sump	East Geraldine	11.0	0.8	0.40	40.4	60.0	26.0	25	GEOG-SM16344 GEOG-SP16241	225	**88**	Area upstream at C64 and C71 removed
C71	Soakaway Sump	East Geraldine	0.9	0.8	0.40	15.2	60.0	26.0	23	TLOS-SM16349 TLOS-SP16258	225	**84**	Area upstream at C81 removed
C72	Soakaway Sump	East Geraldine	0.3	0.3	0.40	10.0	60.0	26.0	10	TLOS-SM16350 TLOS-SP16257	225	**36**	-
C73	Soakaway Sump	East Geraldine	0.5	0.5	0.40	12.3	60.0	26.0	15	WILP-SM16384 WILP-SP16271	225	**52**	-
C74	Soakaway Sump	East Geraldine	1.5	1.5	0.40	15.2	60.0	26.0	43	BELL-SM16332 BELL-SP16270	150	**156**	-
C75	Soakaway Sump	East Geraldine	1.6	0.1	0.40	15.2	60.0	26.0	3	BELL-SM16333 BELL-SP16270	100	**11**	Area upstream at C74 removed
C76	Soakaway Sump	East Geraldine	0.6	0.6	0.40	12.2	60.0	26.0	18	MALG-SM16352 MALG-SP16252	225	**64**	-
C77	Soakaway Sump	East Geraldine	5.7	2.3	0.40	30.0	60.0	26.0	68	MALG-SM16353 MALG-SP16253	225	**243**	Area upstream at C82 and C86 removed
C78	Soakaway Sump	Waihi (East)	0.7	0.7	0.40	11.1	60.0	26.0	19	MKZE-SM16330 MKZE-SO16331	225	**69**	-
C79	Soakaway Sump	East Geraldine	0.2	0.2	0.40	10.0	60.0	26.0	6	MKZE-SM16263 MKZE-SO16264	225	**21**	-
C80	Soakaway Sump	East Geraldine	0.4	0.4	0.40	12.1	60.0	26.0	12	LANC-SM16352 LANC-SP16254	225	**43**	-
C81	Soakaway Sump	East Geraldine	0.1	0.1	0.40	10.0	60.0	26.0	3	LANC-SM16353 LANC-SP16255	225	**11**	-
C82	Soakaway Sump	East Geraldine	3.2	0.1	0.40	24.7	60.0	26.0	2	LANC-SM16351 LANC-SP16256	225	8	Area upstream at C83 removed
C83	Soakaway Sump	East Geraldine	3.1	2.7	0.40	21.9	60.0	26.0	79	-	-	**284**	Area upstream at C80 removed
C84	Soakaway Sump	East Geraldine	0.3	0.3	0.40	10.0	60.0	26.0	8	CONY-SM16334 CONY-SP16335	225	**29**	-
C85	Soakaway Sump	East Geraldine	0.5	0.3	0.40	10.0	60.0	26.0	7	CONY-SM16430 CONY-SP16247	225	**27**	Area upstream at C84 removed
C86	Soakaway Sump	East Geraldine	0.1	0.1	0.40	10.0	60.0	26.0	4	CONY-SM16338 CONY-SP16248	225	**15**	-
C87	Soakaway Sump	East Geraldine	5.6	0.1	0.37	34.9	60.0	26.0	2	-	-	8	Area upstream at C90 and C91 removed
C88	Soakaway Sump	East Geraldine	7.8	0.0	0.38	34.5	60.0	26.0	0	-	-	1	Area upstream at C89 removed
C89	Soakaway Sump	East Geraldine	7.8	0.9	0.38	34.5	60.0	26.0	23	-	-	**84**	Area upstream at C87 and C95 removed
C90	Soakaway Sump	East Geraldine	3.2	0.8	0.40	22.0	60.0	26.0	22	-	-	**79**	Area upstream at C93 and C94 removed
C91	Soakaway Sump	East Geraldine	2.4	2.4	0.33	34.5	60.0	26.0	57	-	-	**204**	-
C92	Soakaway Sump	East Geraldine	1.4	1.3	0.40	21.5	60.0	26.0	37	-	-	**134**	Area upstream at C98 removed
C93	Soakaway Sump	East Geraldine	1.4	0.01	0.40	21.5	60.0	26.0	0	-	-	1	Area upstream at C92 removed
C94	Soakaway Sump	East Geraldine	1.0	0.2	0.40	17.1	60.0	26.0	5	-	-	**16**	Area upstream at C100 removed

SOAKAWAY SUMP INFASTRUCTURE														
OUTLET POINT DETAILS								10 YEAR ARI		PIPE DETAILS		10 YEAR ARI	
Outlet ID	**Description**	**Location**	**Contributing Catchment Area**	**Effective Catchment Area**	**Weighted Runoff Coefficient**	**Time of Concentration**	**Design Storm Duration**	**Rainfall Intensity**	**Peak Flow**	**TDC Pipe ID**	**Pipe Diameter**	**Sump Area Required for 1000 mm/hr infiltration**	**Notes**
			(ha)	*(ha)*		*(min)*	*(min)*	*(mm/hr)*	*(L/s)*		*(mm)*	*(m²)*	
C95	Soakaway Sump	East Geraldine	1.3	1.1	0.40	14.2	60.0	26.0	33	CONY-SM16337 CONY-SP16249	225	**117**	Area upstream at C96 removed
C96	Soakaway Sump	East Geraldine	0.2	0.2	0.40	10.0	60.0	26.0	6	CONY-SM16336 CONY-SP16251	225	**21**	-
C97	Soakaway Sump	Waihi (East)	0.8	0.8	0.40	12.1	60.0	26.0	23	MKZE-SM16328 MKZE-SP16329	150	**82**	-
C98	Soakaway Sump	East Geraldine	0.1	0.1	0.40	10.0	60.0	26.0	3	-	-	**11**	-
C99	Soakaway Sump	East Geraldine	0.2	0.2	0.40	10.0	60.0	26.0	5	-	-	**19**	-
C100	Soakaway Sump	East Geraldine	0.8	0.7	0.40	11.6	60.0	26.0	19	-	-	**68**	Area upstream at C99 removed
C114	Soakaway Sump	Serpentine Creek	0.3	0.3	0.41	10.0	60.0	26.0	9	HIGS-SM16013 HIGS-SP16014	225	**33**	Checked in Google Earth - sump present and no culvert so assumed soakaway
C115	Soakaway Sump	Serpentine Creek	1.3	1.3	0.60	23.3	60.0	26.0	56	MASN-SM16441 MASN-SP16010	225	**203**	Checked in Google Earth - sump present and no culvert so assumed soakaway
C116	Soakaway Sump	Serpentine Creek	0.1	0.1	0.60	10.0	60.0	26.0	5	STAN-SM16518 STAN-SP16519	225	**18**	Checked in Google Earth - sump present and no culvert so assumed soakaway
C117	Soakaway Sump	Waihi (West)	0.6	0.6	0.40	13.2	60.0	26.0	16	-	-	**59**	Checked in Google Earth - sump present and no culvert so assumed soakaway
C118	Soakaway Sump	Waihi (West)	0.8	0.2	0.40	13.2	60.0	26.0	6	COLS-SM16500 COLS-SP16501	225	**22**	Checked in Google Earth - sump present and no culvert so assumed soakaway. Area upsteam at C117 removed.
C125	Soakaway Sump	Serpentine Creek	9.8	9.8	0.38	43.0	60.0	26.0	268	MASN-SM16383 MASN-SP16021	225	**964**	Checked in Google Earth

Appendix D

Pipe Upgrade Capacity Calculations

PIPE UPGRADE SIZE ESTIMATES

Location	Pipeline	Catchment Area		Runoff Coefficient	Time of Concentration	Pipe Length	Pipe Grade	5 YEAR ARI Rainfall Intensity	5 YEAR ARI Peak Flow	5 YEAR ARI Pipe Diameter	5 YEAR ARI Full Flow Velocity	5 YEAR ARI Pipe Capacity	50 YEAR ARI Rainfall Intensity	50 YEAR ARI Peak Flow	50 YEAR ARI Pipe Diameter	50 YEAR ARI Full Flow Velocity	50 YEAR ARI Pipe Capacity
		(m²)	*(ha)*		*(min)*	*(m)*	*(1:x)*	*(mm/hr)*	*(L/s)*	*(mm)*	*(m/s)*	*(L/s)*	*(mm/hr)*	*(L/s)*	*(mm)*	*(m/s)*	*(L/s)*
Raukapuka	Raukapuka Reserve	259584	26.0	0.38	57.1	500	310	21.7	593	750	1.58	698	43.2	1,181	975	1.86	1,388
Geraldine South	High Street (start)	38932	3.9	0.35	16.5	40	70	34.2	130	375	2.16	239	70.4	268	450	2.43	386
	High Street	132732	13.3	0.34	43.0	450	140	25.0	311	525	1.89	408	48.8	608	675	2.21	790
	North Terrace Road	14792	1.5	0.40	14.0	75	750	37.2	61	375	0.65	72	75.6	124	525	0.81	175
	South Terrace Road to Serpentine	8324	0.8	0.40	10.0	100	90	42.0	39	225	1.21	48	84.0	78	300	1.46	103
	South Terrace Road to High Street	23000	2.3	0.45	13.0	140	700	38.4	112	450	0.76	121	77.8	226	600	0.91	257
	Cross Street	23400	2.3	0.34	15.0	80	370	36.0	80	375	0.93	103	73.5	164	450	1.05	167
	Kennedy Street	155032	15.5	0.34	43.0	200	740	25.0	364	750	1.02	450	48.8	711	900	1.14	726
Majors Road	Kennedy Street/Majors Road Overflow pipe	-	-	-	-	60	110	-	-	-	-	-	-	600	600	2.32	655
Talbot Street Outlets	Kennedy Street Outlet (upgrade to outlet C110)	69064	6.9	0.33	41.8	60	100	25.2	162	375	1.81	200	49.3	316	450	2.03	322
	Cole Street Outlet	8096	0.8	0.40	13.2	50	30	38.2	34	225	2.10	83	77.4	69	225	2.10	83
	Huffey Street Outlet (upgrade to outlet C10)	103644	10.4	0.26	44.1	120	180	24.7	186	450	1.51	240	48.4	364	600	1.81	511
	Hislop Street Outlet (upgrade to outlet C109)	72992	7.3	0.46	13.2	60	185	38.2	353	525	1.64	355	77.4	714	750	2.05	905
	Talbot Street Outlet (upgrade to outlet C108)	37136	3.7	0.44	22.7	30	30	29.5	134	300	2.53	179	60.6	275	375	3.31	366

Appendix E

Costings

Raukapuka Upgrades **Description**	**Pipe Grade** *(1:x)*	**Pipe Diameter** *(mm)*	**Unit**	**Quantity**	**Rate** *($NZ)*	**Cost Estimate**	
Raukapuka Reserve - Waihi River	310	750	Lin.m	500	$ 1,500.00	$ 1,125,000.00	excludes consideration of soakage area
P&G				10%		$ 112,500.00	
Contigency				25%		$ 281,250.00	
Total						**$ 1,518,750.00**	

Geraldine South Upgrades **Description**	**Pipe Grade** *(1:x)*	**Pipe Diameter** *(mm)*	**Unit**	**Quantity**	**Rate** *($NZ)*	**Cost Estimate**	**Comments**
							Soakage capacity investigations recommended at preliminary design
High Street (start)	70	450	Lin.m	40	$ 825.00	$ 33,000.00	Needs to collect N & S Terrace flows
High Street	140	600	Lin.m	450	$ 1,250.00	$ 562,500.00	
North Terrace Road	750	450	Lin.m	75	$ 825.00	$ 61,875.00	No secondary flow path
South Terrace Road to Serpentine	90	300	Lin.m	100	$ 600.00	$ 60,000.00	No secondary flow path
South Terrace Road to High Street	700	600	Lin.m	140	$ 1,250.00	$ 175,000.00	No secondary flow path
Cross Street	370	450	Lin.m	80	$ 825.00	$ 66,000.00	
Kennedy Street	740	750		200	$ 1,500.00	$ 300,000.00	
First Flush Treatment on outlet - Infiltration basin			ha	7.5	$ 50,000.00	$ 375,000.00	
Land			ha	0.2	$ 600,000.00	$ 120,000.00	
P&G				10%		$ 175,337.50	
Contigency				25%		$ 438,343.75	
Total						**$ 2,367,056.25**	

Majors Road Upgrades **Description**	**Pipe Grade** *(1:x)*	**Pipe Diameter** *(mm)*	**Unit**	**Quantity**	**Rate** *($NZ)*	**Cost Estimate**	**Comments**
							Road Loweringto be considered at Preliminiary Design phase
Kennedy Street/Majors Road Overflow pipe	110	600	Lin.m	60	$ 1,250.00	$ 750,000.00	
P&G				10%		$ 75,000.00	
Contigency				25%		$ 187,500.00	
Total						**$ 1,012,500.00**	

Talbot Street Outlet Upgrades							
Description	**Pipe Grade** *(1:x)*	**Pipe Diameter** *(mm)*	**Unit**	**Quantity**	**Rate** *($NZ)*	**Cost Estimate**	**Comments**
							Road Loweringto be considered at Preliminary Design phase
Kennedy Street Outlet (upgrade to outlet C110)	100	450	Lin.m	60	$ 825.00	$ 371,250.00	
Cole Street Outlet	30	225	Lin.m	50	$ 600.00	$ 135,000.00	
Huffey Street Outlet (upgrade to outlet C10)	180	600	Lin.m	120	$ 1,250.00	$ 750,000.00	
Hislop Street Outlet (upgrade to outlet C109)	185	750	Lin.m	60	$ 1,500.00	$ 1,125,000.00	
Talbot Street Outlet (upgrade to outlet C108)	30	375	Lin.m	30	$ 700.00	$ 262,500.00	
Outlet improvements		5	No		$ 20,000.00	$ 100,000.00	
P&G				10%		$ 274,375.00	
Contigency				25%		$ 685,937.50	
Total						**$ 4,716,562.50**	

SH79 Upgrades (Geraldine North)							
Description	**Pipe Grade** *(1:x)*	**Pipe Diameter** *(mm)*	**Unit**	**Quantity**	**Rate** *($NZ)*	**Cost Estimate**	**Comments**
							Road Loweringto be considered at Preliminiary Design phase
Upgrade Soakpits			No	12	$ 15,000.00	$ 180,000.00	
P&G				10%		$ 18,000.00	
Contigency				25%		$ 45,000.00	
Total						**$ 243,000.00**	

Total		**$**	**9,857,868.75**
Design and Planning	12%	**$**	**1,182,944.25**
Total		**$**	**11,040,813.00**

PDP has no control over the cost of labour, materials, equipment or services furnished by others, or over contractors' methods of determining prices, or over competitive bidding or market conditions. Any opinion or estimate of costs by PDP is to be made on the basis of PDP's experience and qualifications and represents PDP's judgement as an experienced and qualified professional engineer, familiar with the construction industry.