THE IMPORTANCE OF MAINTAINING A HOLISTIC APPROACH IN STORMWATER DESIGN

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ABSTRACT

Catchment Management Plans (CMP's) provide a framework for the management of stormwater. They include policies and guidelines for the management of streams, floodplains and urban growth, and the operation, maintenance and improvement of stormwater assets. CMP's provide the framework for assessing comprehensive discharge consents and developing a prioritised programme of works to be incorporated within the Long Term Council Community Plan (LTCCP).

It is standard practice for identified remedial concepts to be split into separate projects and awarded on an individual basis for detailed design. However, as the entire process between the project identification and its actual inception can take several years, there is a considerable risk that the original concept is no longer the best practicable solution for solving the identified issues. This is because the circumstances under which the original concept designs were conceived have often changed. Such changes may include modification in hydrological standards, improvement in modeling methodologies, changes in land use zonings, advancements in construction technologies and the identification of additional stormwater issues within adjacent catchment areas.

By maintaining a holistic approach throughout the design process, considerable benefits can often be obtained. Recent work undertaken by Beca / SKM within the Ellerslie-Waiatarua catchment provides an insight into some of these benefits.

KEYWORDS

Stormwater, Catchment Management Planning, Best Practicable, Cross-Catchment

1 INTRODUCTION

Catchment Management Plans are produced to manage stormwater within a defined contributing area to a discharge point. Initial studies carried out in 2003 by Auckland City Council (ACC) have identified 36 key catchment areas. CMPs for each catchment area provide the framework for assessing comprehensive discharge consents and developing a prioritised programme of works to be incorporated within the Long Term Council Community Plan (LTCCP).

As time progresses, Council's improvement works and initiatives, including increased data knowledge, allows for a better understanding of their assets and a more in-depth understanding of stormwater issues both within a particular catchment and their surrounding catchment areas. The original LTCCP works were identified within the

bounds of their defined catchment area. A better understanding of catchment inter-relationships may allow these LTCCP works to be modified to better address cross-catchment solutions. This approach could mean bringing in flows from adjoining catchment areas to achieve a more holistic solution, even if it means seeking a variation to the existing network discharge consent to meet this change. This approach could allow Council to achieve greater benefits by providing one solution across several adjoining catchment areas, rather than addressing these issues separately on a catchment by catchment basis.

This holistic and cross-catchment solution approach was one of the key steps taken by ACC in determining the best practicable option for managing stormwater for the western Ellerslie-Waiatarua, Greenlane Soakage and Ellerslie Soakage catchment areas.

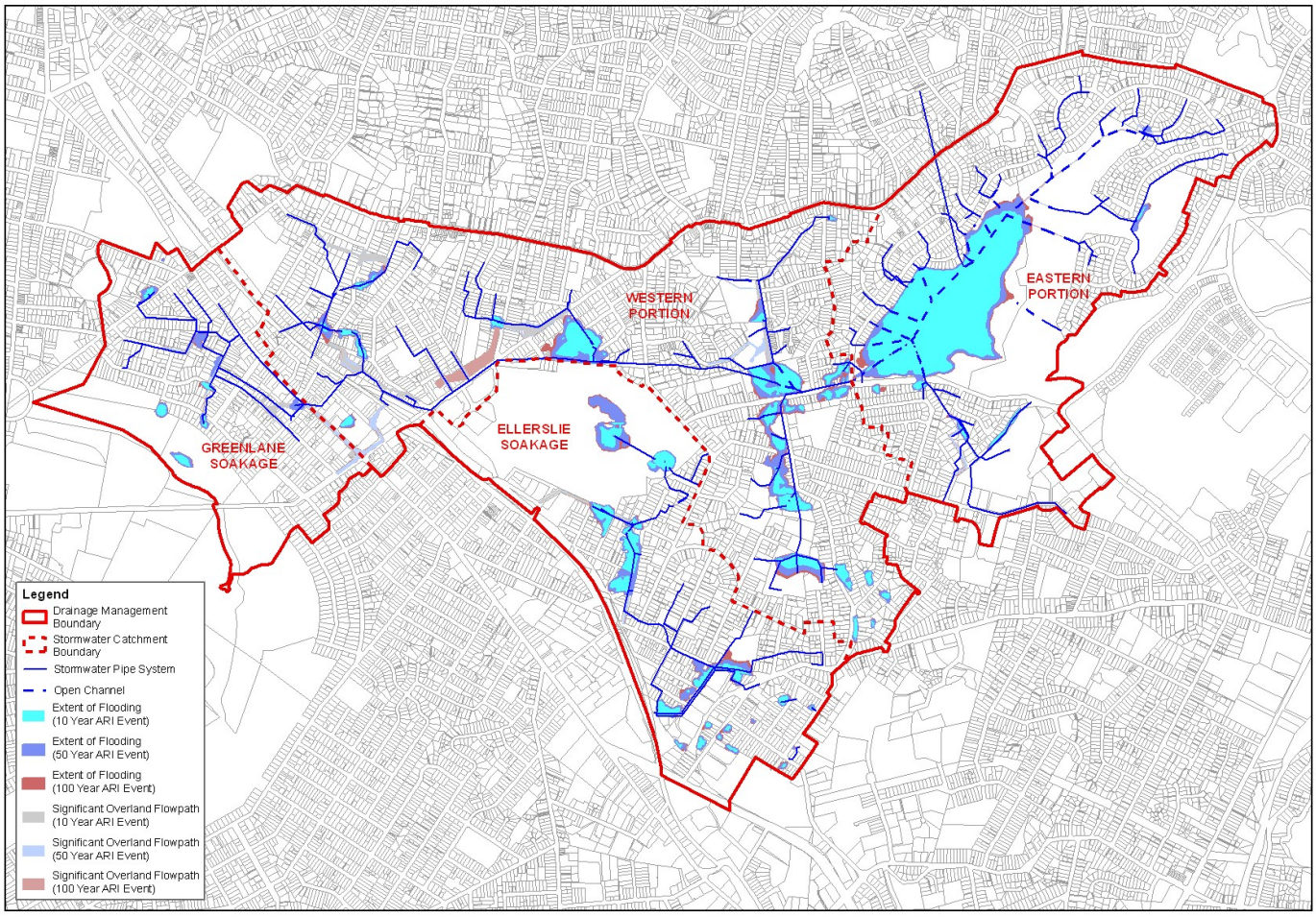
2 BACKGROUND

2.1 CATCHMENT DESCRIPTION

2.1.1 LOCATION

The western portion of the Ellerslie-Waiatarua Drainage Management Area incorporates the Auckland City suburbs of Ellerslie and Remuera and has a total contributory area of around 321 hectares (Figure 1). The catchment area is effectively comprised of two land locked basins, a western basin centered on the low lying area of Peach Parade and an eastern basin discharging to the catchment outfall within the southwest corner of the Waiatarua Reserve wetland. Whilst the catchment area is predominantly residential, it also incorporates the Remuera and Greenlane commercial areas and several large reserve areas.

Figure 1: Ellerslie-Waiatarua Drainage Management Area



2.1.2 SOIL TYPES

The following four separate soil types are present within the catchment area:

- Basalt and basanite lava / ash soil formation material of variable soakage abilities located west of the Southern Motorway
- East Coast Bays formation material overlying basalt and basanite lava / ash soil formation material located west of Greenlane East
- East Coast Bays formation material located east of Greenlane East
- Undifferentiated alluvium and organic rich alluvium formation material located in the low lying flood prone areas off Peach Parade and Abbotts Way.

Each of these soil types have distinct infiltration characteristics, ranging from high (greater than 8 mm/hr) to low (of less than 4 mm/hr) rates of water transmission.

2.1.3 DEVELOPMENT POTENTIAL

The catchment area is almost fully developed, with the possibility of limited infill development. Greenfield development sites are limited to a few blocks of residential / commercial zoned land off Abbotts Way and Marua Road.

2.2 PREVIOUS INVESTIGATIONS

A flood hazard mapping (FHM) study of the western portion of the Ellerslie-Waiatarua catchment was completed in 2004. This study involved the construction of a hydraulic model, the mapping of 10, 50 and 100 year ARI flood hazards and the identification of conceptual stormwater remedial measures to meet ACC flood protection standards. A total of 157 non-habitable floors were identified to be susceptible to flooding during the 10 year ARI storm event, with 135 habitable floors and one commercial floor identified to be susceptible to flooding during the 50 year ARI storm event.

The recommended stormwater remedial measures identified for the western portion were subsequently grouped into sixteen separate work packages to be incorporated within the LTCCP. These work packages had a combined construction cost estimate of $56 million and incorporated an enlarged detention pond within the Ellerslie Racecourse with an outfall pipeline constructed down Abbott's Way to the Waiatarua Reserve wetland.

ACC awarded Sinclair Knight Merz Limited (SKM) the two work packages related to the Abbott's Way pipeline in February 2006. The connecting work package related to the Ellerslie Racecourse detention pond was awarded to a separate consultant at around the same time. As per their management agreement, Beca Carter Hollings and Ferner Ltd (Beca) acted as ACC's representative for each of these three work packages.

3 REVIEW OF LTCCP WORK PACKAGES

The sixteen separate work packages incorporated within LTCCP were originally identified in 2004. Since that time, significant events had occurred which have a direct impact on the appropriateness of the original concept solution identified. These events included the following aspects:

1) modification in hydrological standards and improvement in modelling methodologies,
2) advancements in construction technologies,
3) the identification of additional stormwater issues within adjacent catchment areas and
4) changes in land use zonings.

The affect of each of these aspects on the LTCCP work packages are detailed below.

3.1 IMPACT OF HYDROLOGY / MODELING METHODOLOGY CHANGES

3.1.1 REVIEW PROCESS

The Ellerslie-Waiatarua catchment model was developed using Danish Hydraulics Institute (DHI) MOUSE software (Version 2000b). This model was reviewed to confirm the appropriateness of the design flows for the Abbotts Way work packages. This review was limited to model application checks only, with no detailed checking of input asset / catchment data undertaken.

The model review process identified the following issues of significance:

- the ‘Model B’ hydrological module was used in the model in conjunction with the Auckland City 10, 20, 30, 60, 120 and 180 minute design rainstorms (the model standard at the time of the original study)
- only two soil types were applied across the entire catchment, one with poor infiltration characteristics representing East Coast formation soils and one with good infiltration characteristics representing basalt and basanite lava / ash formation soils
- all culvert inlets were modelled using either energy loss or round edged manhole losses, which may result in the Q / H relationship at culvert inlets being modelled inaccurately for certain storm events
- storage volumes of depression areas were generally determined from two metre contour information derived from aerial photography
- the soakage capacity for the soakhole network was assumed to have a uniform soakage rate of 20 l/s for each public soakhole and 0 l/s for each private soakhole
- the overflow weirs of all soakholes were connected to the nearest overland flowpath node rather than the adjacent manhole node (serviced with a road catchpit network).

The model review process determined that:

- the model did not comply with the latest ACC modelling standards as defined by the Integrated Catchment Study (ICS) and approved by the Auckland Regional Council (ARC) to be applied across urban catchments within the Auckland Isthmus
- the modelling approach adopted is generally conservative with the identification of flood hazards likely to be overstated
- the over-stating of flood hazards is likely to have lead to the over-sizing of the stormwater remedial work packages incorporated within the LTCCP.

3.1.2 MODEL MODIFICATIONS

The following model changes were made in order to bring the model up to ICS standards:

- the MOUSE model Type B hydrological module data was converted to the Type B + RDI hydrological module data, with the application of the TP108 24 hour design storm rainfall profile (inserted with rainfall depths derived from the design rainfall maps contained in Appendix A of the TP108 documentation)
- four soil types were applied across the entire catchment to represent each of the four soil types defined in Section 2.1.2
- all culvert inlets were modelled using the passive flow regulation function, with inflow into the culvert inlet (under culvert inlet-control conditions) being controlled by a Q / H relationship derived from inlet-control nomographs
- the storage volume of all non-surveyed depression areas was updated using LiDAR contour information
- actual soakhole testing data was used to model the public soakhole network

- the private soakhole network was assumed to have sufficient soakage capacity to absorb the peak 10 year ARI runoff from the existing roof area in the ED scenario and the maximum permitted roof area in the MPD scenario (only 50% of this value was assumed to be absorbed in areas serviced by a stormwater reticulation network with a known poor soakage performance history)
- the overflow weirs of all soakholes were reconnected to the adjacent manhole node (where serviced with a road catchpit network)
- insertion of the recent channel / piping works undertaken within the catchment area
- insertion of the existing sedimentation culvert arrangement within the Waiatarua Reserve.

3.1.3 IMPACTS ON FLOOD HAZARDS

These model modifications had the following impact on the existing flood hazards:

- a reduction in the 10, 50 and 100 year ARI overland flows of up to 95% (average around 40%)
- a reduction in the 10, 50 and 100 year ARI flood levels within depression areas of up to 0.5 metres (average 0.1 metres)
- a 47% reduction in the number of non-habitable floors flooded during the 10 year ARI storm event (from 157 to 83 floor levels)
- a 22% reduction in the number of habitable floors flooded during the 50 year ARI storm event (from 172 to 135 floor levels).

3.1.4 IMPACT ON LTCCP WORK PACKAGES

These reduced modelled peak flows resulted in the elimination of two of the sixteen stormwater remedial work packages incorporated within the LTCCP, a saving of $3 million on the original scheme.

The scope of the proposed Ellerslie Racecourse detention pond / Abbotts Way pipeline work packages were also dramatically affected by the reduced modelled peak flows. The original concept design envisaged the construction of a 60,000 m^3 stormwater detention basin within the existing irrigation area in the Ellerslie Racecourse grounds. This detention structure would discharge flows to the Waiatarua Reserve wetland via a 1200 mm diameter tunnel under the Ladies Mile road crest and a 2250 mm diameter outfall pipeline running down Abbotts Way. The purpose of this detention structure was to attenuate peak flood flows from the upper catchment to ensure flood levels within the Waiatarua Reserve wetland did not exceed those permitted within the stormwater discharge consent. Such a large detention structure would require a considerable footprint, requiring the expensive purchase of privately owned land. The combined construction cost for both the detention basin and downstream pipe works was estimated to be $18 million (including land purchase costs).

The reduced modelled flow volume entering the Waiatarua Reserve wetland resulted in the proposed detention basin no longer being required to meet the stormwater discharge consent requirements. However, in order to convey the resultant un-attenuated flows, the downstream pipe works would need to be increased to a 1950 mm diameter tunnel under the Ladies Mile road crest and a dual 1950 / 900 mm diameter pipeline running down Abbotts Way. The construction cost for these new downstream pipe works was estimated to be $10 million, a saving of an additional $8 million on the original scheme.

Reduced modelled peak flows also resulted in the following changes being made to the remaining eleven stormwater remedial work packages incorporated within the LTCCP:

- The elimination of 872 metres of proposed pipeline upgrade works
- A reduction in sizing for 1,996 metres of the proposed pipeline upgrade works
- A change in sizing and realignment for 850 metres of the proposed pipeline diversion works.

The construction cost for these reduced pipe works was estimated to be $30 million, a saving of an additional $5 million on the original scheme.

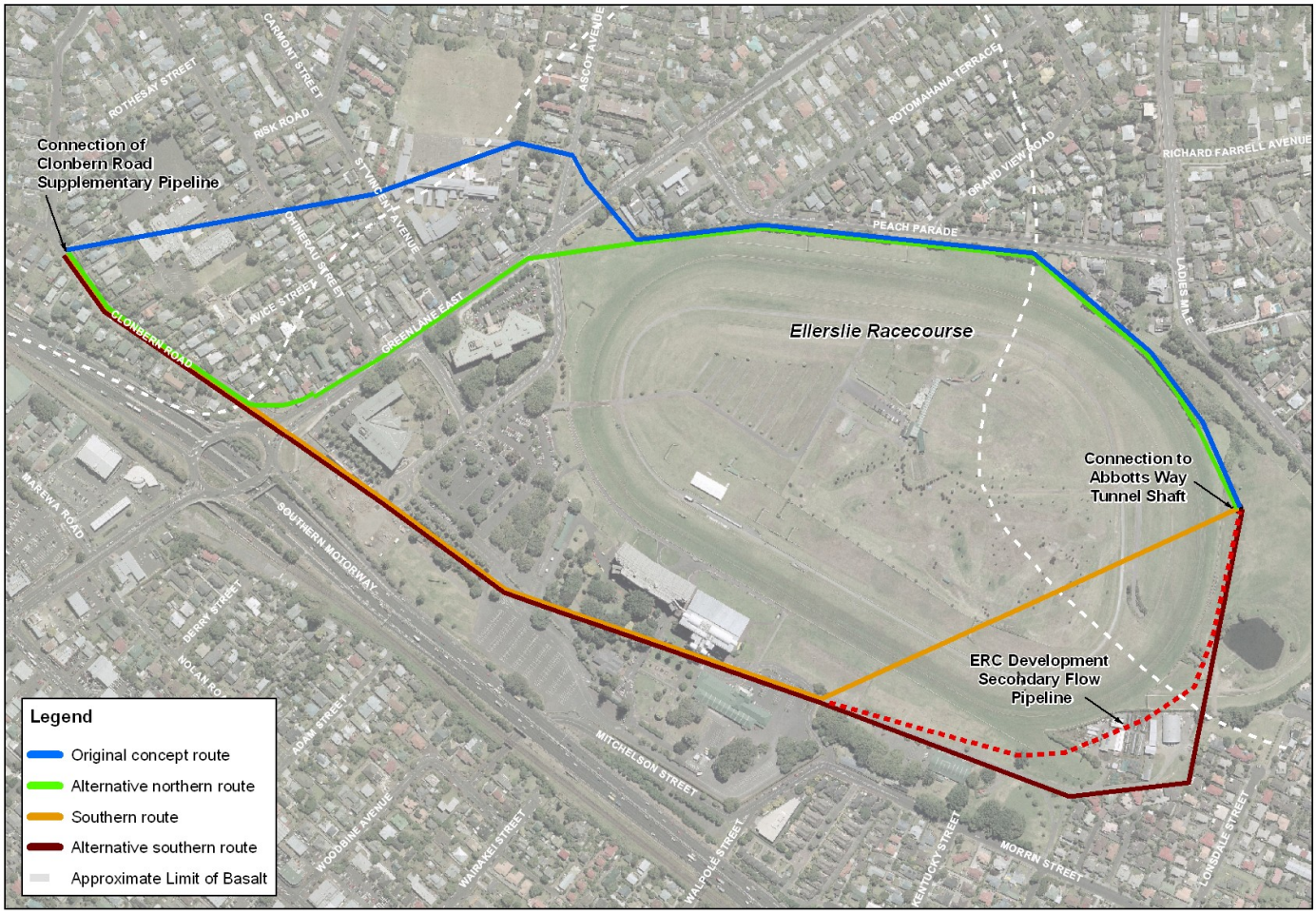
3.2 IMPACT OF ADVANCEMENTS IN CONSTRUCTION TECHNOLOGIES

The original remedial work package envisaged the construction of 2400 mm diameter supplementary pipeline running from the low point in the vicinity of the Clonbern Road / Lillington Road intersection to the proposed Ellerslie Racecourse (ERC) detention basin. This pipeline was originally proposed to run through numerous private properties to the north of the ERC grounds in order to minimise the length of pipeline requiring construction through solid basalt material. This pipeline was sized to accommodate the remedial work packages designed to address the 59 habitable floors west of Ladies Mile were identified to be at risk of flooding during the 50 year ARI storm event. Of these floors levels, 47 are located immediately north of the ERC grounds between Ascot Avenue and Grand View Road.

Reduced modelled peak flows resulted in the required supplementary pipeline being reduced to a 1950 mm diameter pipeline. Advancements (and subsequent cost reductions) in tunnel boring techniques allowed the following three alternative shorter pipeline routes to be considered (Figure 2):

- A southern pipeline route passing mainly through fractured basalt along the southern edge of the ERC and along Clonbern Road
- An alternative southern pipeline route passing mainly through fractured basalt through the south east corner of the ERC and along Clonbern Road
- An alternative northern pipeline route passing mainly through solid basalt along the northern edge of the ERC and along Greenlane East.

Figure 2: Trunk Pipeline Route Options through ERC



A risk assessment of the four pipeline route options determined all four pipeline routes to have similar risk attributes, with each pipeline route requiring extensive excavation through basalt areas. Whilst the original northern route options would affect up to twelve private properties, each of the three alternative pipeline routes had the advantage of minimising any potential intrusions to only one private property owner (the ERC), with the resultant reduction in associated consenting risks.

Initially it was thought that a southern pipeline route could also be utilised for the proposed ERC development (refer to Section 3.4), with the potential to achieve considerable cost savings (in the form of development contributions) to Council. However, model runs identified that significant surcharging of this pipeline route would occur during both the 50 and 100 year ARI storm event, thus preventing the direct connection of the ERC development. Unlike the two northern route options, both of the southern route options also had the disadvantage of not addressing any habitable floor flooding issues until the entire length of pipeline was constructed to Clonbern Road / Lillington Road intersection.

Based on this assessment, the alternative northern route option was identified to be the preferred route, as this option would allow for most of the habitable floor flooding issues to be addressed in the early stages of the project, whilst still minimising the disruption to surrounding property owners.

3.3 IMPACT OF ADJACENT STORMWATER ISSUES

Flood hazard mapping of the following three landlocked subcatchment areas within the wider Ellerslie-Waiatarua Drainage Management Area (Figure 1) have been completed since the identification of the LTCCP work packages:

- the Greenlane Soakage Catchment located west of the Southern Motorway
- the Ellerslie Soakage Catchment located south of the ERC
- an eastern Ellerslie-Waiatarua Catchment located east of Grand Drive and centred on the Waiatarua Reserve.

A total of 52 non-habitable floors were identified to be susceptible to flooding within these subcatchment areas during the 10 year ARI storm event, with 35 habitable floors and one commercial floor identified to be susceptible to flooding during the 50 year ARI storm event.

Differences in peak flow timings in conjunction with reduced stormwater discharge volumes into the Waiatarua Reserve wetland allowed the reassessment of the following works:

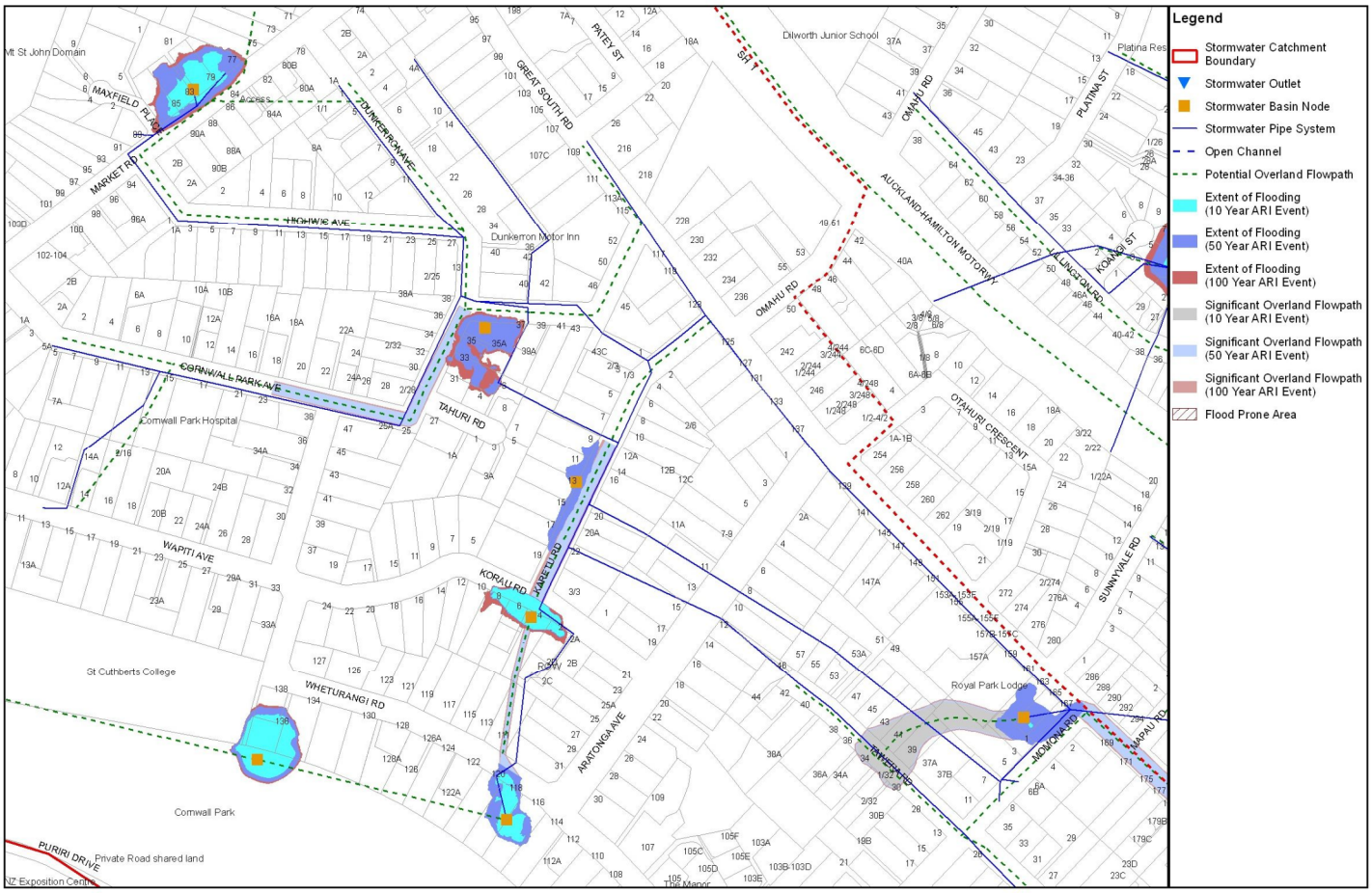
- the possibility of diverting excess flows from the Greenlane Soakage Catchment area into the proposed Clonbern Road remedial pipeline.
- the possibility of diverting excess flows from the Ellerslie Racecourse grounds into the proposed Abbotts Way pipeline to help reduce flooding issues within the downstream Ellerslie Soakage Catchment.

3.3.1 GREENLANE REMEDIAL ASSESSMENT

The Greenlane Soakage Catchment is located west of the Southern Motorway and has a catchment area of around 115 hectares (Figure 1). The catchment area is primarily serviced by a private / public soakhole network that utilises the generally good soakage abilities of its basalt and basanite lava / ash geological characteristics. However, as the geology in the centre of the catchment has a history of poor soakage abilities, this local soakage network is supplemented with a stormwater reticulation network draining to a soakage tunnel located along Tawera Road.

Flood hazarding mapping identified several significant flood hazards within the central portion of the Greenlane Soakage Catchment (Figure 3), with a total of 10 habitable floors and one commercial floor identified to be susceptible to flooding during the 50 year ARI storm event.

Figure 3: Central Greenlane Flood Hazards



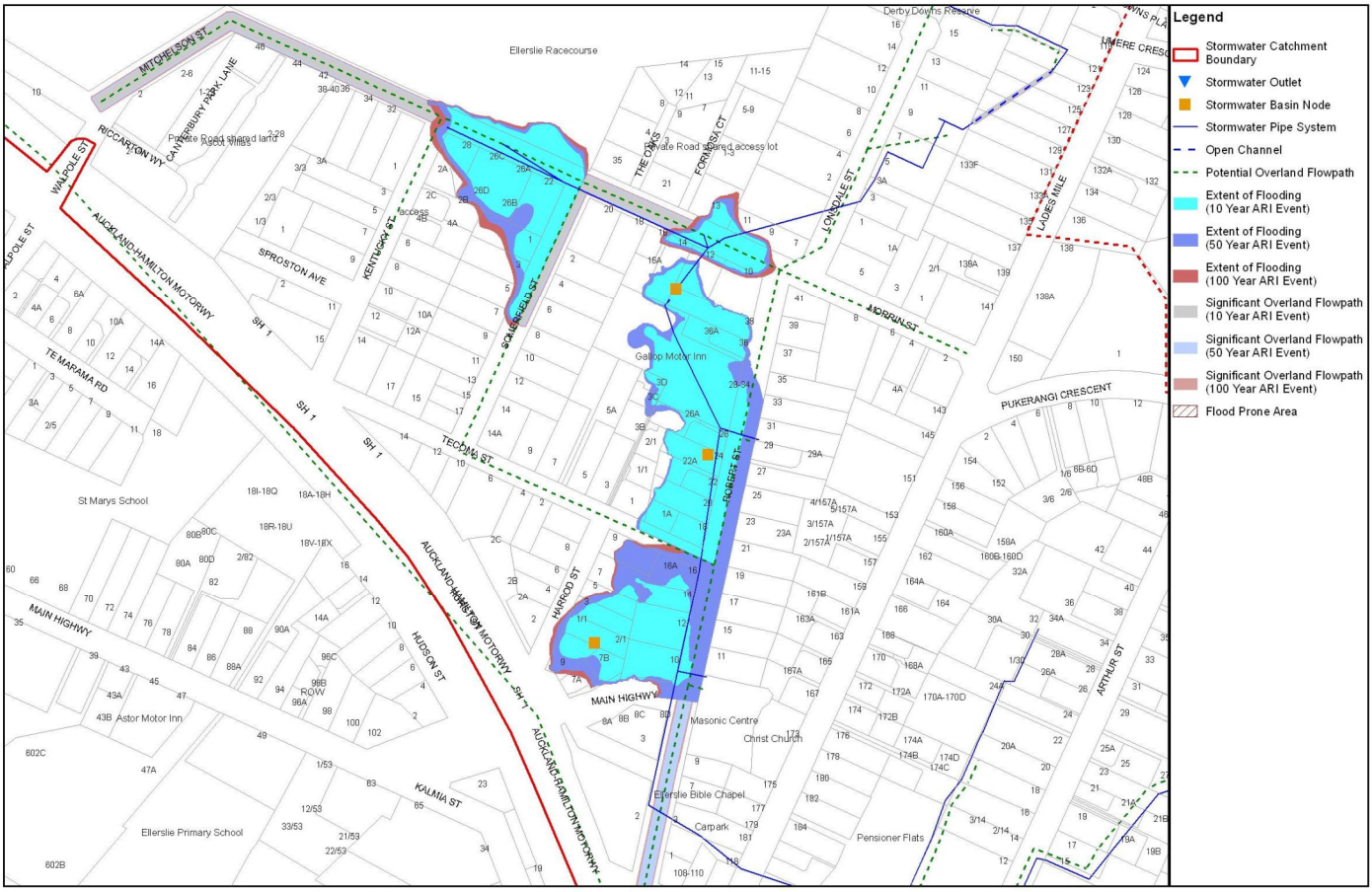
One of the remedial measures assessed to address these flood hazards involved the construction of a supplementary overflow pipeline connecting the Tawera Road soakage tunnel with the ERC main trunk pipeline running from Clonbern Road to Abbotts Way. Model runs indicated that due to differences in the timing of peak flows, this additional flow could largely be accommodated within the proposed trunk pipeline running around the ERC grounds without any need to increase pipeline diameters. However, a high cost / floor protection ratio (in excess of $2 million per floor) for the required supplementary overflow pipeline resulted in such an option not being considered further, with a decision made by ACC to solve the existing flood hazards by local soakage / attenuation measures.

3.3.2 ELLERSLIE RACECOURSE SUPPLEMENTARY PIPELINE

The Ellerslie Soakage Catchment is located west of the Southern Motorway and has a catchment area of around 163 hectares (Figure 1). The catchment area is primarily serviced by a private / public soakhole network that utilises the generally good soakage abilities of its basalt and basanite lava / ash geological characteristics. However, as the catchment area immediately south of the ERC grounds experiences high water table levels during the winter months, this local soakage network is supplemented with a stormwater reticulation network draining to the One Tree Hill catchment area.

Flood hazarding mapping identified several significant flood hazards within the northern portion of the Ellerslie Soakage Catchment (Figure 4), with a total of 9 habitable floors identified to be susceptible to flooding during the 50 year ARI storm event. This flooding is largely due to existing stormwater runoff from the southern Ellerslie Racecourse grounds during extreme storm events.

Figure 4: Northern Ellerslie Flood Hazards



The existing impervious surfaces located within the southern Ellerslie Racecourse grounds are currently serviced by a private soakhole network. Model runs identified that the total diversion of Ellerslie Racecourse flows to the Abbotts Way tunnel would reduce flood hazards within the Harrod Street and Robert Street depression areas by around 0.5 metres for the 10, 50 and 100 year ARI storm events. Such a large reduction in flood depths would remove the flood risk to the nine flood prone habitable floors located in these depression areas. However, the amount of flow diverted to the Abbotts Way tunnel will have a direct impact on the pipe sizing required for the supplementary pipeline running along the lower portion of Abbotts Way.

Model runs identified that the connection of diverted inflows from the Ellerslie Racecourse grounds would require the proposed 900 mm diameter supplementary pipeline along lower Abbotts Way to be increased to a 1350 mm diameter pipeline to avoid increasing the adjacent flood hazards.

3.4 IMPACTS OF LAND USE ZONING CHANGES

A plan change is currently lodged with the ACC to allow the redevelopment of around 9.7 hectares of predominantly pervious surfaces around the southern fringe of the Ellerslie Racecourse grounds. No detailed assessment of drainage options for the proposed development has currently been undertaken. However, concerns regarding the increase of discharges to the underground aquifer have been expressed by the ACC, as areas of the downstream Ellerslie Soakage Catchment already experience high groundwater levels with poor soakage abilities. Therefore, any significant extension of the existing soakage network associated with the proposed development will need to be carefully considered to ensure no adverse effects on groundwater levels within the downstream subcatchment area.

Though a more detailed assessment of the proposed Ellerslie Racecourse development is yet to be undertaken, the connection of this development area to the existing Abbotts way pipeline will likely be a cost effective option to ensure no adverse effects on flood hazards within the downstream Ellerslie Soakage Catchment.

4 OVERALL BENEFITS FOR AUCKLAND CITY COUNCIL

The review process resulted in the following benefits for the ACC:

1) A reduction in the combined construction cost estimate from $56 million to $40 million for the recommended remedial measures incorporated within the LTCCP, a saving of $16 million to ACC.
2) A reduction in the number private property consents required for the LTCCP works from 43 to 21, with a subsequent considerable reduction in consenting risks and associated consultation costs.
3) The added possibility of diverting stormwater flows from the Ellerslie Racecourse grounds into the Waiatarua Reserve wetland, reducing flood hazards within the downstream Ellerslie Soakage Catchment and removing the existing flood risk to an additional nine habitable floor levels.
4) A more holistic approach to stormwater design with the consideration of possible cross-catchment solutions which could potentially provide ACC with a greater cost / benefit solution.

5 CONCLUSION

Successful stormwater design involves the following principals:

1) Obtaining an understanding of the assumptions / limitations applied in the original study and assess their impact on the selection of the recommended remedial measures.
2) Undertaking a review of the provided network model to assess whether it is fit for use in the sizing / design of the recommended remedial works.
3) Assessing the impacts of your remedial design on adjacent remedial work packages, particularly if they are interconnected.
4) Undertaking a holistic overview of surrounding catchment areas and determine if any additional issues could be addressed by diverting flows into your remedial design.

ACKNOWLEDGEMENTS

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