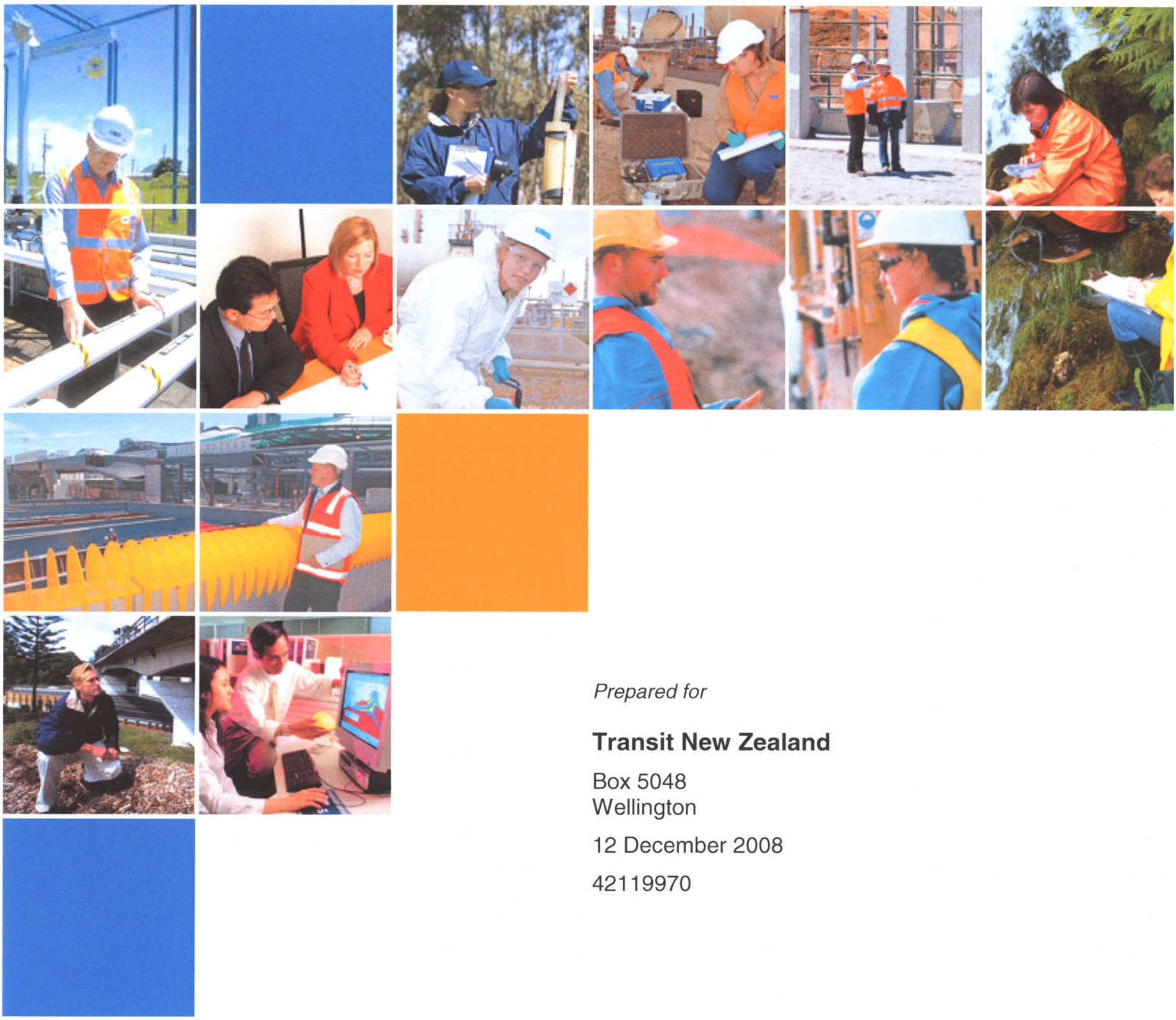
REPORT

SH20 Mount Roskill Storm Water Management System

Project Review & Summary



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Appendix

Section 1 Introduction

This report is in response to an initiative by the New Zealand Transport Authority to assess current State Highway projects against the draft Stormwater Treatment Standard for Road Infrastructure (STRI) document. The document is also referred to as the Storm Water Management Standard (SWMS).

This report is based on the SH20 Mt Roskill project, a 5km motorway through an urban/commercial/industrial environment in Mt Roskill, Auckland. The construction of the project is due for completion in April 2009.

This report covers two phases, namely:

- Phase 1, detailed in sections 2-5 of this report describes the project in terms of catchment characteristics, design philosophy, treatment devices, and the cost and time to construct the project.
- Phase 2, detailed in Section 6 of this report then compares the project with the proposed STRI document and details key points of difference between the project as designed/constructed and the STRI.

Section 2 Catchment Characteristics

2.1 Introduction

The SH20 Mount Roskill Extension traverses two catchments as detailed below, the highway works themselves measure some 46 hectares in total. The portion of the project to the east of the Hillsborough ridge is contained within the Royal Oak catchment, and drains eastward to the Manukau Harbour. The portion of the project to the west of the Hillsborough ridge is contained within the Oakley catchment, and drains westward to tributaries of the Oakley Creek.

The terrain and other factors of relevance to stormwater management differ in each of these catchments, and hence each is dealt with separately within this report.

2.2 Description of Catchments

2.2.1 Royal Oak Catchment

Terrain

The catchment falls generally from west to east, with the high point located at the Hillsborough ridge east of Hillsborough Road, the land falls to Queenstown Road and thence into the Manukau Harbour.

Area

The Royal Oak catchment area is approximately 50 hectares.

Topography

The catchment is typically of moderate contour (5% - 10%) and contains mixed use land comprising of residential, open and vegetated green space.

Drainage features

Two tributaries occur within the catchment, a smaller one to the south is ephemeral and crosses under the existing motorway where it is culverted, the larger north of this is a perennial stream (the Bel Air Stream), which drains a bush reserve. The larger tributary consists of approximately 750m of open channel, comprised of rocky chutes, small pools, grassy lined channel and geotextile-reinforced channel. This watercourse is piped from adjacent to the Queenstown Road bridge through to Onehunga Bay, a distance of some 900 metres.

Geotechnical Conditions and Soils

Miocene age Waitemata Group rocks are well consolidated marine mudstones and sandstones. These are considered as the basement rocks, which underlie the Auckland isthmus area and generally extend to hundreds of metres in depth. The Waitemata Group rocks are overlain in localised areas by relatively thin layers of Pleistocene age Tauranga Group materials.

The geological and hydrogeological soils within this catchment are chiefly comprised of Tauranga Group alluvium and weathered Waitemata Group. The Tauranga Group deposits are Holocene and Pleistocene peats, alluvium and swamp deposits, ranging from silty clays to silty sands, that occur mainly in the Carr Road area to the North of the catchment. The Waitemata Group materials are Miocene interbedded very weak to weak sandstone and mudstone. These materials can be deeply weathered.

Geotechnical Opportunities and Limitations

Weathered Waitemata group materials when used in compacted clay liners have given permeabilities in the order of $1x10^{-8}$ m/s with the selection of higher plasticity materials. Permeabilities of this order are

normally considered suitable for liner use in a stormwater quality facility. Given the in-situ permeability of the clay soils liners were not required for this project.

Where ground conditions are found to be inadequate for founding of the drainage structures a geogrid reinforcement layer and/or undercutting was incorporated into the design.

Erosion potential

The soils within the Royal Oak catchment, being in weathered Waitemata Series soil are highly susceptible to erosion.

Flooding

Flooding does not generally occur within the catchment although there are flooding issues within the adjacent Oakley Creek catchment discussed later.

Design storm event

The storm event for the proposed drainage strategy was a 100 year return period (1% AEP).

Vehicle kilometres travelled at time of opening

As at May 2008, measured traffic volumes on this section of SH20 are approximately 35,000 to 41,000 vehicles per day (week day) and 24,000 to 31,000 vehicles per day (weekend). Once the Mount Roskill extension opens, modelled volumes are expected to increase to 69,000 vehicles per day (2011 forecast). The project length within the Royal Oak catchment is 0.9km – corresponding to a forecast traffic flow of approximately 62,000 vehicle kilometres per day in 2011.

Discharge points

The catchment drains via existing reticulation and overland flow to the watercourses discussed above which then discharge to the Manakau Harbour within the vicinity of Orpheus Drive and the Onehunga Bay reserve. Runoff from the motorway is treated in the Beachcroft Avenue water quality pond prior to discharge. The ultimate discharge area consists of intertidal mud flats typical of the inner Manukau Harbour. The area in the vicinity of the discharge is not identified on any ARC plans as having high ecological value.

Catchment classification

Urban (from NSHS 2007).

Sensitivity of Receiving Environment

Attribute scores:	Attributes
Sensitivity	20
Ecological value	10
Human use value	5
Overall sensitivity rating (sum)	35

Section 2 Catchment Characteristics

2.2.2 Oakley Creek Catchment

Terrain

The catchment is generally flat to rolling except at the location of the Mount Roskill cone. It drains generally from south-east to north-west, ultimately discharging into the Waitemata Harbour at Waterview.

Area

The Oakley Creek catchment area is approximately 1400 hectares.

Topography

The catchment is typically of gentle contour (<5%) and contains mixed use land comprising of residential, commercial, light industrial, open and vegetated green space.

Drainage features.

Oakley Creek is a significant watercourse approximately 12km long. SH20 crosses the main channel at Keith Hay Park by way of a bridge. Immediately upstream of the motorway, the channel has been concrete lined, downstream it is culverted under the Mount Roskill Grammar playing fields.

Several other perennial tributaries to the Oakley Creek are present within the catchment described as follows:

The first tributary originates near Hillsborough Road and extends down the designation to join the main channel of the Oakley Creek at Keith Hay Park. This watercourse drains the uppermost reaches of a small sub-catchment predominantly serving industrial and urban developments. Previous channelling and piping has extensively modified the natural channel although it does still have grassy banks. As part of the SH20 Mount Roskill project scope, a 650m length of this watercourse will be piped with a 3050mm diameter concrete pipe.

The second tributary is a small watercourse draining Keith Hay Park and Akarana Golf Course. The channel is similar to the other watercourses in the area, being highly modified, straight and uniform with grassy banks.

The third tributary is located in the vicinity of Roma Road and NZ Foodstuffs, and drains an existing area of modified ephemeral wetland surrounded by willows. The watercourse downstream of the wetland meanders through grassed pasture. In its upstream area due to various industrial and residential developments the stream has been replaced by a network of culverts. As part of the SH20 Mount Roskill project scope, a 250m length of this watercourse will be piped with a 3050mm diameter concrete pipe.

A number of other smaller ephemeral stream environments are located within the catchment.

Geotechnical Conditions and Soils

The nature of the Waitemata Group Rocks was discussed previously. The Mount Roskill volcanic centre initially consisted of a tuff cone upon which a small scoria cone was built. The distribution of the basalt flows from Mount Roskill volcanic centre was controlled by the pre-existing topography of the underlying Waitemata Group rocks. Basalts flowed over the surface of the Waitemata Group rocks and generally filled in a valley in the rock north-west toward Mount Albert.

Waitemata Group materials are as described previously. Around the Mount Roskill area this is overlain with deposits of volcanic tuff ash, basalt lava and scoria. The tuff and ash range from clayey silt to thinly bedded hard clayey silt, dense sand and dense gravel. The basalt and scoria ranges from loose unwelded scoria to dense, fractured basalt rock.

Section 2 Catchment Characteristics

Geotechnical Opportunities and Limitations

The geotechnical opportunities and limitations for the Waitemata group soils within this catchment are as described for the Royal Oak catchment.

In the location of the Mt Roskill cone, due to the permeable nature of the volcanic soils in that area, the stormwater treatment facilities were designed to take full advantage of this. The Roseman Avenue and Roma Road ponds were designed as sandfilters, which enabled the treated stormwater to discharge to ground

Erosion potential

The weathered Waitemata Series soil within the Oakley catchment are susceptible to high erosion.

Flooding

Flooding is known to occur within the Oakley catchment during storm events. In particular, Keith Hay Park is located within a flood plain, and has a flood detention function during significant storm events. The function of this has not been adversely affected by the SH20 project.

Design storm event

The storm event for the proposed drainage strategy was a 100 year return period (1% AEP)

Vehicle kilometres travelled at time of opening

Once the Mount Roskill extension opens, modelled volumes are expected to be to 60,000 vehicles per day (2011 forecast) between the Hillsborough and Dominion Road interchanges, reducing to 46,000 vehicles per day (2011 forecast) between the Dominion Road interchange and the western termination. The project length within each of these two sections of the Oakley catchment is 1.9km – corresponding to a forecast traffic flow of approximately 200,000 vehicle kilometres per day.

Discharge points

The catchment discharges via existing reticulation and overland flow to the watercourses as described above then into the Waitemata Harbour at Waterview.

Discharges from the SH20 Mount Roskill project within the catchment occur to the main channel at Keith Hay Park and to a tributary channel at the western termination.

Catchment classification

Urban (from NSHS – 2007).

Sensitivity of Receiving Environment

Attribute scores:	Attributes
Sensitivity	20
Ecological value	10
Human use value	5
Overall sensitivity rating (sum)	35

Section 3 Design Philosophy

3.1 Design Philosophy

3.1.1 Objectives

The objectives for stormwater management within the SH20 Mount Roskill project were essentially to:

- proactively collect and manage runoff from the project works;
- attenuate this runoff in such a manner as to not result in increased peak discharges to the receiving environment as a consequence of the project being constructed; and
- provide treatment to this runoff prior to discharge to achieve compliance with Auckland Regional Council TP10 Guideline criteria and conditions of designation and resource consent relating to the project works.

Options Analysis

In order to minimise the amount of 3rd party land required for the construction of the project, the width of the corridor for the motorway extension was kept as narrow as possible, and cut and fill requirements were minimised through careful vertical alignment design.

The relatively constrained nature of the site necessitated that the reticulation, ponds, culverts and realigned watercourse were also designed to make best use of the available land.

Swales, reticulation, culverts, kerb/channel and vee channels were the adopted to convey the water to and from the various storage ponds and receiving environments.

Initially the design of the project was for a 4-lane design however allowance was to be made in the design and land take for possible expansion to 6-lanes. With this in mind elements of the stormwater system were designed to minimise the amount of alterations that would be required should the widening proceed. For example, manholes were positioned outside of the ultimate 6-lane carriageway to minimise future relocation works, and swales were located in the location of the future lanes in order for them to be ultimately be replaced by the lane and dished channel.

Options were explored to provide treatment via swales and thereby reduce the size of the stormwater ponds, but due to the requirement for the ponds to also provide a stormwater retention function this resulted in only a minor reduction in pond size, but a larger ultimate motorway footprint to accommodate the swales.

Flush mounted concrete nibs were used to define and allow for the surfacing adjacent to hard shoulder/bus lane while still allowing sheet flow from the roadway. At low points, where sheet flow was anticipated to be in high concentration flumes were incorporated into the design to prevent erosion.

The approach to the design of the ponds was to integrate the best practicable water quality devices within the scope of the works. The areas from which runoff was treated were identified as:-

- Motorway pavement surfaces.
- Additional pavement surfaces associated with 6-laning in the future.
- Ancillary pavement areas on local roads affected by the works.
- Cut and batter slopes.

Pond locations were identified by careful study of the topography and with due regard to the grading of the motorway.

Five permanent dual purpose ponds for water quality and flood attenuation purposes, namely:

- the Beachcroft Avenue pond (wet pond) (Royal Oak catchment)
- the Melrose Road pond (planted wetland) (Oakley catchment)
- the Keith Hay Park pond (planted wetland) (Oakley catchment)
- the Roseman Avenue pond (vegetated sand filter) (Oakley catchment)
- the Roma Road pond (vegetated sand filter) (Oakley catchment)

The proposal to attenuate peak runoff by incorporating detention ponds at strategic locations throughout the corridor is considered the best practicable option insofar as ponds provided for detention purposes will also be available to serve as treatment devices. These ponds enable the peak rate of runoff during storm events under maximum probable catchment development conditions to be no greater with the motorway constructed than would be the case without it.

In two locations where the underlying strata is suitable the treated, stormwater is also discharged to ground. This occurs at the Roseman Avenue and Roma Road ponds to the extent that the underlying volcanic soils will accommodate this.

Three methods for the treatment of the stormwater have been adopted as follows:

Wet Pond - This provides the benefits of: adsorption of organic material; bacterial decomposition; temperature benefits; volatilisation; settling/burial of contaminants in sediments; limited infiltration to groundwater. A wet pond will also provide a habitat for the fish and bird species present in the Onehunga catchment.

Planted Wetland - Provides the benefits of: uptake of contaminants in plant biomass; filtration through vegetation; adsorption of organic material; bacterial decomposition; temperature benefits; volatilisation; settling/burial of contaminants in sediments; limited infiltration to groundwater.

Vegetated Sand Filter - Combined with wetland type planting provides the benefits of: infiltration to groundwater; filtration of contaminants and sediments; adsorption of organic material; bacterial decomposition; settling/burial of contaminants in sediments; volatilisation; filtration through vegetation; and uptake of contaminants in plant biomass.

3.1.2 Criteria

Water Quality

The SH20 Mount Roskill project manages runoff from approximately 180,000m^2 of paved surfaces and 72,000m^2 of cut batter surfaces. It provides treatment to Auckland Regional Council TP10 Guideline criteria, which target 75% sediment removal, prior to discharge to the receiving environment. The ponds were designed to contain the 25mm storm event and release that over a minimum period of 24 hours.

It is worth noting that prior to construction of the Mount Roskill extension, runoff from the existing SH20 was discharged without any treatment at all.

Water Quantity

The SH20 Mount Roskill project incorporates flood attenuation provisions that target no increase in peak rate of runoff discharge to the receiving environment as a consequence of project construction.

There are existing flooding issues within the Oakley catchment that have been addressed within the comprehensive discharge consent that Auckland City Council holds for this catchment, and the SH20 Mount Roskill project respects the flood mitigation measures provided for under that consent. In particular, it preserves the capacity of Keith Hay Park to provide flood detention under severe rainfall events.

Section 3 Design Philosophy

Water volume was assessed for the various catchments and sub-catchments using HEC-HMS and HEC-RAS for 1% AEP flows, it was established that the design was sufficiently robust and that the proposed development with the designed controls in place would have negligible effect on the receiving infrastructure and environments even under maximum probable catchment development.

Design Standards

Design criteria adopted for stormwater management relate essentially to:

- provision for runoff from the 100 year return period (1% AEP) design storm event within channels, culverts, pipe reticulation and overland flow paths; and
- maintenance of appropriate freeboard above floodplain levels to pavement surfaces; and
- use of appropriate materials.

These criteria are entirely consistent with consenting criteria relating to water quality and flood attenuation.

References

The following documentation has been used in this design:

- ARC Guidelines for Stormwater Treatment Devices 1992, Technical Publication No. 10 (ARC TP10)
- ARC Guidelines for Stormwater Runoff Modelling in the Auckland Region 1999, Technical Publication No. 108 (ARC TP108)
- Highway Surface Drainage Design Guide 1977
- The comprehensive discharge consent held by Auckland City Council for the Oakley catchment, together with supporting reports and modelling data.

Section 4 Stormwater Management Devices

4.1 Stormwater Management Devices

4.1.1 Erosion and Sediment Control

Erosion and sediment control measures employed during the construction phase of the project comply with Auckland Regional Council TP90 Guidelines and the relevant conditions of resource consent granted.

4.1.2 Operational Stormwater Management

The stormwater management proposals incorporate:-

- Modifications to the existing reticulation network as necessary to accommodate the motorway extension;
- Piped diversions of two sections of a tributary to the Oakley Creek, namely:
  - a 650m length of watercourse from Melrose Road to Keith Hay Park; and
  - a 250m length of watercourse adjacent to the western termination.
- Various culverts beneath the motorway
- New reticulation serving the motorway extension; and
- Five permanent dual purpose ponds as described in Section 3.1.1 above.

Discharge of treated stormwater occurs in three locations. These are:-

- To Onehunga Bay from the Royal Oak catchment;
- To the main channel of the Oakley Creek at Keith Hay Park; and
- To a tributary of the Oakley Creek at the western termination.

Section 5 Cost and Time

5.1 Cost

The following cost indications are approximate only, and have been derived from tender price information. A degree of pro-rata adjustment has been necessary in some instances to "break down" costs into the categories listed.

Resource consents

Stormwater related resource consents were the subject of a notified hearing by the Auckland Regional Council, and subsequent appeal to the Environment Court, The estimated cost of input by a stormwater specialist to preparation of the assessment of effects on the environment (AEE) that supported the consent applications, and of presenting evidence on the subject at both hearings is approximately $40,000.

Building and other consents

Stormwater management works within this project did not require building consent, but were subject to an engineering approval process by Auckland City Council. This process incurred an estimated cost of approximately $30,000.

Final Design

Design fees for stormwater related works for this project amounted to approximately $390,000 (rounded).

Construction

Construction costs are as follows:

1.	collection	$625,000 (rounded)
2.	conveyance	$11,940,000 (rounded)
3.	attenuation	$425,000 (rounded)
4.	treatment	$425,000 (rounded)

Construction costs indicated are derived from the tender of the successful contractor – actual costs will doubtless have evolved from this position throughout the construction period. URS does not have access to this information.

The project works incorporate five ponds that provide both the attenuation and treatment function. For the purposes of this report, the costs of those ponds have been apportioned equally to those two functions.

Monitoring Costs

Construction monitoring has been undertaken by Opus International Consultants Limited, and URS does not have information on these costs.

Operation and Maintenance Estimated Annual Costs

Operation and maintenance costs are unknown at this time.

5.2 Time

Resource consents

The AEE that supported the Notice of Requirement for designation and resource consent applications was completed in November 2000.

The Auckland Regional Council hearing for resource consents was held in March 2002.

The Environment Court hearing of appeals occurred in June 2002, and the final determination was released in January 2003.

Accordingly, the resource consent process extended over a period of some 26 months.

Building and other Consents

Building consents and engineering approvals were applied for and gained over a 6 month period within the project design phase.

Final Design Time

The timeframe for design of this project at award of the professional services contract for the D&PD phase was 12 months.

Subsequent revisions to design criteria by Transit through value engineering, coupled with resolution of Auckland Volcanic Cones Society concerns associated with the impacts of the project works on the Mount Roskill volcanic cone added approximately 6 months to this timeframe.

Construction

Construction of the Mount Roskill Extension commenced mid 2005 and is expected to be complete by the end of 2008, or early 2009 – a construction period of approximately 42 months.

Collection - Stormwater collection works were constructed progressively throughout the overall construction timeframe of 42 months.

Conveyance - Stormwater conveyance works were constructed progressively throughout the overall construction timeframe of 42 months.

Attenuation - The Beachcroft Avenue pond in the Royal Oak catchment was constructed over a 7 month period as enabling works ahead of the main contract works commencing. Other stormwater attenuation works were constructed progressively throughout the overall construction timeframe of 42 months.

Operation and maintenance

Life expectancy prior to major works - The life expectancy of the major works is likely to be of the order of 50 years with minor maintenance works.

Life expectancy for renewal - The life expectancy for renewal is likely to be of the order of 50 years.

Section 6 Comparison With Proposed Stormwater Treatment Standards

6.1 Background

Following the preparation of sections 2-5 of this report on the stormwater management system, URS were further tasked by The New Zealand Transport Agency to carry out a comparison of the design of the SH20 Mount Roskill Extension project with the STRI draft document. This was to determine whether a project based on earlier standards would meet the latest design criteria, and the effects that the standards may have on the design features.

The STRI incorporates current best practice from existing standards, with an increased emphasis on water quality and environmental responsibility.

With the advent of the STRI document there are potentially a number of areas where a design based on an earlier and less elaborate set of standards may fail to meet certain criteria or requirements.

6.2 Overview of the Design

The SH20 Mount Roskill Extension project was designed over the period 2002-2004. The principal design references used were as follows:

- ARC Guidelines for Stormwater Treatment Devices 1992, Technical Publication No. 10 (ARC TP10). The Regional consents were granted based on this document.
- ARC Guidelines for Stormwater Treatment Devices 2003, Technical Publication No. 10 (ARC TP10). Elements of this document was incorporated where possible to do so.
- Erosion and Sediment Control Guidelines for Land Disturbing Activities in the Auckland Region Technical Publication No. 90 (ARC TP90).
- ARC Guidelines for Stormwater Runoff Modelling in the Auckland Region 1999, Technical Publication No. 108 (ARC TP108)
- Highway Surface Drainage Design Guide 1977
- The comprehensive discharge consent held by Auckland City Council for the Oakley catchment, together with supporting reports and modelling data.

The stormwater related resource consents were the subject of a notified hearing by the Auckland Regional Council, and subsequent appeal to the Environment Court. Stormwater management works within this project did not require building consent, but were subject to an engineering approval process by Auckland City Council.

6.3 Comparison of the Design with the STRI

The following comments concentrate on significant differences that can be identified between the standards which were used during the design and the STRI draft. There are areas of detail that have not been discussed, as in these areas the design would be broadly similar if the draft standards were applied.

In applying the standards and in order to comply with the various consenting issues, the design of the stormwater management systems associated with the project met and in many cases exceeded the requirements stipulated in the standards current at the time.

The main areas where the adoption of the STRI would change the design are as follows:

6.3.1 Water Quality

Based on recent studies that are referred to within the STRI discussing sustainable treatment methods, the ponds as designed whilst fully meeting the statutory requirements at the time could possibly be improved upon in the following areas.

Wetlands

The use of wetlands to remove pollutants and improve water quality has been proven to be beneficial, although the ponds within the Oakley catchment are all planted wetlands and sand filters, thereby providing excellent water quality treatment as is, it may be possible to retrofit the Beachcroft Avenue pond located in the Royal Oak catchment with a floating wetland.

Flocculation

The STRI suggests that the inclusion of flocculation treatment could be used to improve and assist with sediment control. These devices were previously only associated with the treatment of sediment in TP90 type temporary sediment control ponds. As such they could feasibly have been installed within the various detention installations within this design to increase treatment efficiency, or to maintain the 75% efficiency with a minor (ponds also provide attenuation) reduction in pond size.

6.3.2 Water Volume

Climate Change

The guidelines identify that global warming and the subsequent climate changes that this could create would have a significant effect on the design of stormwater systems. It is generally accepted that storm events are likely to be more extreme in the future and subsequently discharge rates higher and therefore more problematic. As noted above, the SH20 Mt Roskill project is designed to cater for 100 year return period (1% AEP) and can therefore be considered conservative, even when taking the effects of global warming into account.

Due to the level of the project in relation to sea level, the effects of sea level rise will not have a direct effect on the SH20 Mt Roskill project.

Reduction of Existing Flows

The STRI suggests that future designs should be prepared to limit discharge from a development to 80% of the existing flow, thereby giving a 20% allowance or protection to receiving systems.

As noted in section 2.2.2 above, there were pre existing flooding issues in the Oakley Creek catchment. The standards of the time set the requirement for post-development flows not to exceed the existing flows, and did not place any requirement for a project to address pre-existing flood issues. As such the stormwater ponds were designed to match the existing peak run off rates.

Compliance with the STRI would result in a considerable increase in pond size, and due to the corridor constraints would have resulted in additional land purchase to accommodate the larger ponds. Both of these items would add considerable cost to the project, and in the case of land purchase, potential delays.

6.4 Maintenance

Future maintenance of engineering works is now gaining a higher profile. The STRI draft document raises this in some detail. Designers are asked to consider the logistics of how and by whom, maintenance could be performed on the project, together with due consideration of health and safety.

Maintenance and safety were taken into consideration when the original designs were developed. For example:

- The cycleway that is constructed along side the ponds in the Oakley catchment has been strengthened to cater for maintenance vehicles,
- Areas of the cycleway not required for maintenance are built to a lighter standard, with bollards provided to prevent maintenance vehicles accessing these sections,

- The width of the ponds has been limited to allow clean-out with a long-reach excavator,
- A 1v:4h metalled access track has been provided into the forebay of each pond to facilitate clean-out,
- The ponds are fenced and/or densely planted to prevent public access.

6.5 Comments and Conclusion

The STRI appears to be a closely aligned to the current ARC standards with additional guidance included to cover climate change, peak run-off, and the consideration of maintenance in design.

The Mount Roskill SH20 Extension project was designed to fully comply with TP10 and as such the various stormwater facilities would generally meet the standards set down in the STRI draft with the exception of reducing the runoff to 80% of its pre-developed volume.

Appendix A

Stormwater Management System - Location Plan