## Official Height Standard Change

From 1 July 2024, Auckland Council adopts the official height standard for New Zealand called New Zealand Vertical Datum 2016 (NZVD2016).

This model was carried out prior to the height standard change.

**All levels included in this modelling report are in Auckland Vertical Datum 1946 (AUK1946/AVD1946).**

Levels in this report can be transformed from Auckland Vertical Datum 1946 into New Zealand Vertical Datum 2016 by applying an offset value of 0.282 m.

For example:

$$H_{NZVD2016} = H_{AVD1946} - \text{Offset Value}$$

A single offset value for the catchment has been taken from the Land Information New Zealand (LINZ) Auckland 1946 to NZVD2016 Conversion Raster therefore this offset should be taken as an approximation only for the catchment.

A more accurate height transformation value can be derived by downloading the conversion raster available on the LINZ website below:
https://data.linz.govt.nz/layer/103953-auckland-1946-to-nzvd2016-conversion-raster/

**IMPORTANT!!**

**This document consists of 4 PDFs:**

1. **Main Report**
2. **Appendix A: Drawings**
3. **Appendix B: Hydrological Modelling Data**

# 1. Main Report

# CENTRAL PAPAKURA AREA

## INTEGRATED CATCHMENT MANAGEMENT PLAN

***Flood Hazard Modelling Report***

***November 2016***

***Final***

PAPAKURA
DISTRICT COUNCIL

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# ADOPTION BY AUCKLAND COUNCIL

This report has been adopted by Auckland Council as a supporting documentation for the current floodplain polygons published from the modelling results.

This report was edited in 2016 to remove ICMP/Options specific contents and materials. This report was originally written in 2007 for Papakura District Council. Any ICMP/Options references remaining in this report do not hold.

This report is intended only as support materials for the floodplain published on the Auckland Council GIS viewer.

# QUALITY RECORD SHEET

**Document:** **Central Papakura Area ICMP Flood Hazard Modelling Report**

**Reference**: PDC ICMP003
**Initial Release Date**: 31 July 2008
**Update Date:** 30 November 2016
**Revision**: Final

## Description

This report is a short version of the full draft Central Papakura ICMP document, and is intended as a supporting document for the flood plain mapping published on Auckland Council GIS Viewer.

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| Nick Brown | Flood Planning Team Manager | Auckland Council | |
| | | | |

# DOCUMENT CONTROL

## Distribution List

The following organisations shall receive a copy of this document on release:

| Organisation |
|---|

## Revision History

The following table outlines the revision history of this document:

| Version | Publication Date | Prepared By | Release Note |
|---|---|---|---|
| Draft | 31 July 2008 | **Larry Shui** | Draft ICMP release for NDC application. |
| Final (FHM Report) | 30 November 2016 | **Larry Shui** | Flood Hazard Modelling Specific contents only. CMP/Options related materials removed. |

## Sign-off

The following persons have reviewed the document for its release:

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| Nick Brown | Flood Planning Team Manager<br>Auckland Council | |

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# ABBREVIATIONS

| | |
|---|---|
| AEP | Annual Exceedance Probability |
| ARC | Auckland Regional Council |
| ARI | Annual Reoccurrence Interval |
| ARWB | Auckland Regional Water Board |
| AMDA | Auckland Metropolitan Drainage Act 1960 |
| ARPS | Auckland Regional Policy Statement |
| ARP-ALW | Proposed Auckland Regional Plan – Air, Land and Water |
| ARP – Coastal | Auckland Regional Plan – Coastal |
| ARP-Sediment | Auckland Regional Plan – Sediment Control |
| ASF | Auckland Sustainability Framework |
| ATWS | Auckland Three Waters Strategic Plan (Draft) |
| BMP | Best Management Practices |
| BPO | Best Practicable Options |
| ERC | Environmental Response Criteria |
| HGL | Hydraulic grade lines |
| ICMP | Integrated Catchment Management Plan |
| LDA | Land Drainage Act 1908 |
| LGA2002 | Local Government Act 2002 |
| LTCCP | Long term council community plan |
| MCA | Multi-criteria analysis |
| MHWS | Mean high water spring tide |
| MHWN | Mean high water neap tide |
| MLWN | Mean low water neap tide |
| MLWS | Mean low water spring tide |
| MSL | Mean seal level |
| MUL | Metropolitan Urban Limit – a statutory urban limit for the Auckland Region managed by ARC |
| NIMT | North Island Main Trunk Railway Line |
| NZBC | New Zealand Building Code |
| NZCCO | New Zealand Climate Change Office |
| NZGD 2000 | New Zealand Geodetic Datum 2000 |
| NZTM | New Zealand Transverse Mercator – a kind of projection for definition of X and Y coordinates |
| OWRCMP | Old Wairoa Road Catchment Management Plan |
| PDC | Papakura District Council |
| PDP | Papakura District Plan |
| RDP | Regional Discharge Project |
| RMA | Resource Management Act 1991 |
| RPS | Regional Policy Statement |
| SAP | Stormwater Action Team |
| SCARCA | Soil Conservation and Rivers Control Act 1941 |
| TA | Territorial Authority |

| | |
|---|---|
| TSP | Takanini Structure Plan |
| TSS | Total Suspended Solids |
| VPD | Vehicles Per Day |

# DEFINITIONS

| | |
|---|---|
| Astronomical Tide | Highest tide on record due to tidal movement with the coinciding of the Earth, Moon and Sun on line and occurs every 18.6 years |
| Drainage System Model | The mathematical representation of physical process involved in runoff and stream flow. |
| Floodplain | The portions of the low lying land or valley adjacent to a river or stream, which becomes inundated during floods. Although the actual flow velocity in the floodplain could be very low, but the storage volume serves the function of attenuating the peak discharge. |
| Flood Risk Area - Modelled | All areas identified as subject to flood risks including the floodplain, low lying ponding area and overland flow paths, etc, via detailed studies. Flood levels and flow quantities are often determined. |
| Flood Risk Area – Unmodelled | Areas predicted to be subject to flood risks, although no detailed study has been undertaken. Flood levels and flow quantities are often unknown. |
| Flood Prone Area | Areas predicted to be prone to flooding due to blockage of culverts or bridges. |
| Floodway | The main channel of a river and the stream and the immediate fringe areas critical for conveyance of flood water. No encroachment should be allowed. |
| Flood Storages | Those parts of the floodplain that are important for the temporary storage of flood water during the passage of a flood. |
| Flood Attenuation | Reduction in peak discharge due to storage and lagging effects. |
| Habitable Floor | A building floor for human occupations such as a lounge room, rumpus room, kitchen and bedroom etc. |
| Hydraulic | A term given to the study of water flow, in particular, the prediction of flow depth, velocity, water surface profile, energy grade line and energy losses. |
| Hydrology | A term given to the study of rainfall and runoff process in a catchment taking into account parameters such as imperviousness, ground infiltration, depressional storage and evapotranspiration. |
| Model Calibration | The practice of adjusting a few hydrologic and hydraulic parameters (within reasonable bounds) to replicate the |

| | |
|---|---|
| | observed flows and stages in one or a few historic rainfall events. |
| Model Validation | The practice of running model simulations on one or a few historic events (not used in model calibration) for comparisons with observed flows and stages on a stream. This term sometime is used interchangeably with the term model verification. |
| Stormwater Detention | Ponds or tanks which can delay and reduce the peak discharge from the catchment areas. |
| Stormwater Retention | The practice of stormwater harvesting and reusing on development sites. |
| Water Surface Profile | A longitudinal plot showing the flood levels at any given location along a stream or river. |

***Toitu Te Marae o Tane***
***Toitu Te Marae o Tangaroa***
***Toitu Te Iwi***

***If the domain of the God of forest and tree is sustained***
***And the domain of the God of sea is sustained***
***So too will the people be sustained***

# EXECUTIVE SUMMARY

## ES.1 Scope Limitation

This report is an excerpt from the full draft Central Papakura Area Integrated Catchment Management Plan.

This report has been adopted by Auckland Council as supporting documentation for the current flood plain polygons published from the modelling results.

This report was edited in 2016 to remove ICMP/Options specific contents and materials. This report was originally written in 2007 for Papakura District Council. Any ICMP/Options references remaining in this report do not hold.

This report is intended only as a supporting document for the floodplain published on the Auckland Council GIS Viewer.

## ES.2 Introduction

The Proposed Auckland Regional Plan established an expectation for all territorial local authorities in the Auckland Region to prepare Integrated Catchment Management Plans in support of their Network Discharge Consent applications to the Auckland Regional Council (ARC).

The Integrated Catchment Management Plans (ICMP) are prepared by adopting a multi-disciplinary approach involving engineers, modelers, district planners, asset managers, ecologists, stream specialists, iwi, local residents and other interested parties. The ICMP will provide a Blueprint for managing land uses, growth development, flood hazard, water quality, stream quality, receiving environment quality and stormwater and wastewater networks on a stormwater catchment basis.

Five ICMP Areas have been identified for the Papakura District, including Papakura Stream, Pahurehure Inlet, Slippery Creek, Drury Creek and Upper Taitaia.

The Central Papakura Catchment covers existing and future urban areas in the lower half of the Pahurehure Inlet as shown in Figure 2, including the stormwater catchment areas traditionally known as Old Wairoa Road, Elliot, Price Edward and Pahurehure. The Central Business Area of Papakura is a part of the Central Papakura Area. The Takanini Structure Plan Areas 2A and 2B are subject to significant growth in the near future.

## ES.3 ICMP Objectives and PDC Stormwater Management Strategy

ICMP forms an important part of the new Stormwater Action Plan (SAP) initiated by ARC applicable across the region. The following objectives were identified for the PDC ICMP Project:

- To provide a comprehensive water resources planning tool, such as drainage system numerical models and mitigation toolboxes to assist planning, operation and management of the drainage system.
- To improve the understanding and knowledge of the drainage systems and their receiving environments in the District.
- To protect / improve health and safety of Papakura residents by identifying and mitigating flood risks.
- To develop a shared vision of our environments with the Stakeholders

- To protect / improve the water quality in the receiving environments to support recreational uses of environments by residents in Papakura, and to retain and enhance the diversity of ecosystem, etc
- To obtain a Network Discharge Consent from ARC in compliance with requirements of the Auckland Regional Plan – Air, Land & Water and Coastal.
- To identify constraints or controls on future land uses in the District from catchment management perspective.
- To identify, prioritise and develop an Implementation Plan or future works programme for the District.

The above objectives can be achieved through the following stormwater management strategies at Papakura District:

- Undertaking catchment management study in an integrated and systematic manner to assess the effects of future development in the catchment area and identity a range of remedial options.
- Incorporating low-impact development measures in new development to reduce stormwater runoff and enhance the amenity in the urban areas if practicable.
- Protection of the stream riparian margin and minimise infilling of 1% AEP flood plain.
- Protection or provision of significant secondary overland flowpaths in existing and new urban development.
- Implementing remedial works to augment the capacity of the stormwater drainage system by removing bottlenecks.
- Provide levels of service for stormwater drainage appropriate to the potential risks to the community in the specific area by taking into account the consequences of flood damages and frequency of flood occurrences.
- Impose strict controls on development in flood risk areas, especially on habitable/non-habitable floor levels, site grading and preservation of overland flow paths to avoid adverse effects on the existing properties.
- Require source controls at contaminant hot spots, such as sections of road with more than 5000 vpd, closed landfills and high risk industrial and commercial sites, to avoid diffusion of contaminants in the receiving environments.
- If practicable, provide centralised community stormwater management devices to avoid ineffective, often expensive, piecemeal stormwater treatment solutions.
- Involve local iwi groups in the stormwater management process and incorporate iwi philosophy in stormwater system design if practicable.

## ES.4 ICMP Study Scope

*PDC ICMP Master Programme*

1) Review of all historic data
2) Data gap analysis
3) Data capture including asset, catchment and meteorological data
4) Coastal marine receiving environment assessment
5) Waterways assessment
6) Interviews / Questionnaires / Workshops

7) Hydrological Modelling (rainfall, temperature, etc)
8) Hydraulic Modelling (pipe flow, storage, overland flow, floodplain)
9) Water quality modelling
10) Options development and comparisons
11) Stakeholders consultation
12) Obtaining Discharge and Network Consents

*Expected Outcomes*

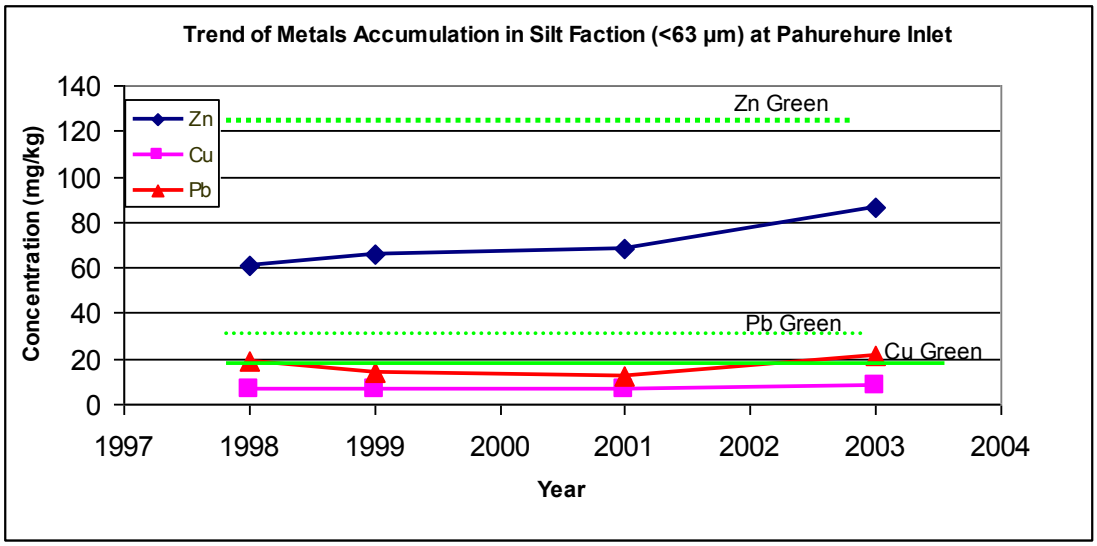
1) A good systematic understanding of the performances of stormwater drainage systems under various growth scenarios in the District
2) Improved understanding of flooding hazards in the District,
3) Improved understanding of the current status and water quality issues concerning our freshwater and marine water environments,
4) A planning and assessment toolset for managing the stormwater drainage system in the District – drainage system models, options assessment matrix
5) Best practical option - An implementation programme for structural (physical works) and non-structural management options (regulatory, education, etc)
6) Adequate info for application of a Network Discharge Consent from ARC

## ES.5 Status of the Receiving Environment

The Pahurehure Inlet is a shallow sheltered inlet, with the Southern Motorway traversing through the middle and dividing the inlet into two distinctive portions. To the east of the Motorway, the inlet is further sheltered by the motorway embankment, where mangroves are fast spreading with a shallow tidal flow channel formed upstream of the culvert pipe. To the west of the Motorway, the inlet is more exposed for tidal flushing. The increased shelter of the inlet area to east of the Motorway have led to increased rates of sediment deposition. A previous study (William & Wilcock, 1994) reported that the sedimentation rate of 6.6mm per annum at a site in Pahurehure Inlet east of the junction with the Oira Creek Channel, which is much higher than the typically reported rate of sedimentation for open harbour at less than 1mm per annum.

As a part of the Regional Discharge Project, the Auckland Regional Council (ARC) has established sediment quality guidelines, monitoring methods and Environment Response Criteria (ERC) which is presented in an analogous fashion to traffic lights with Green representing low; Amber, elevated; and Red, high contaminant concentrations. Marine sediment samples were taken at three monitoring sites in the Pahurehure Inlet between 1990 and 2003. Although, total metal concentrations in terms of Zinc (Zn), Copper (Cu) and Lead (Pb) are all below the threshold values for Green status, there is an identifiable uprising trend in the silt fraction of the sediment (<63µm).

**Figure ES1: Trend of Metal Concentration in Silt Faction**




## ES.6 Assumptions and Limitations

The flood hazards in the Central Papakura Area were mapped based on the maximum flood levels simulated in the model run with the following assumptions:

1. The modelled network is based on the existing network plus the committed upgrade works including the new 2.55m (Dia) tunnel/pipeline between the McLennan Reserve Upper Pond and the Pahurehure Inlet, and drainage upgrade works planned in the Central Business Area. Any future upgrade of the drainage network will potentially alter the predicted flood levels at some locations.
2. Hydrological model used in the simulation are for the Maximum Probable Development (MPD) scenario based on the current District Plan controls, the Takanini Structure Plan controls and the private plan changes currently pursued by the land owners.
3. The flood hazard extent was mapped based on the Auckland Regional LiDAR dataset (2006) with a vertical accuracy of ±0.25m; no specific site survey has been undertaken.
4. The predicted flood levels are based on the existing overland flow paths configurations and geometries of depressions. Should the overland flow paths and existing natural or engineered depression storages be modified in any way, the predicted flood levels may change accordingly.
5. Inlets are not explicitly modelled for flood hazards. Local flooding caused by inadequate inlet capacities may not be included in the maps.
6. Localised flooding caused by the lack of capacities in reticulations beyond the extent the modelled network is not covered by the maps.
7. Localised flooding due to faulty or inadequate private drainages at properties is not covered by the maps.
8. It is assumed in the model that the full hydraulic capacities of the networks are available during the design extreme events. Any increases of flooding caused by partial or full blockages of the drainage pipes have not been taken into considerations in the model.
9. Flood levels from model simulations may not be accurate for nodes beyond the most upstream loading nodes.

The contaminant load modelling was undertaken with the following assumptions and limitations:

1. The contaminant load modelling was carried out based on the ARC CLM tool (Timperley, 2006). The contaminant generations from various land uses have not been specifically verified (via stormwater sampling, etc) at the Papakura District.
2. Traffic volumes on roads in Papakura for the current and future scenarios were based on the knowledge of the District Traffic Planning Engineer combined with actual traffic counts data rather than simulations from traffic models.
3. Roof material types for all commercial and industrial properties were based on 2001 aerial photos and some site verifications. Roof materials for residential properties in pockets representing the construction eras were determined based on the 2001 aerial photos and verified through site visits. Proportions of various roof types for representative construction eras were then generalised over all residential properties based on the typical years of sanitary sewer constructions.

The reported status of the receiving environments also has the following limitations:

1. The contaminant concentrations in marine sediment and trend of changes were based on results of marine sediment monitory by ARC between 1998 and 2003.
2. Findings and outcomes from the Manukau Harbour East Study Project (sponsored by ARC and currently being undertaken by NIWA) have not been incorporated.

## ES.7 Outcomes

The following outcomes have been generated for the Central Papakura Area through the ICMP process:

1. Stormwater drainage system model to assist future catchment planning and engineering design of upgrading works
2. Water quality models for managing catchment contaminant load at the current level and under the future development scenarios
3. Management toolsets for dealing with flooding, erosion, water quality and stream quality issues in the catchment
4. Options evaluation tools and process
5. Project prioritisation tools and process
6. Identifications of significant issues such as flooding, erosion, water quality and stream quality in the Central Papakura Area
7. Identifications of available options to deal with issues
8. Life cycle cost analyses of available options and evaluation of options using a multi-criteria analysis
9. Establishment of a management plan consisting of structural and non-structural measures and their respective priorities for implementations in the catchment

# 1 INTRODUCTION

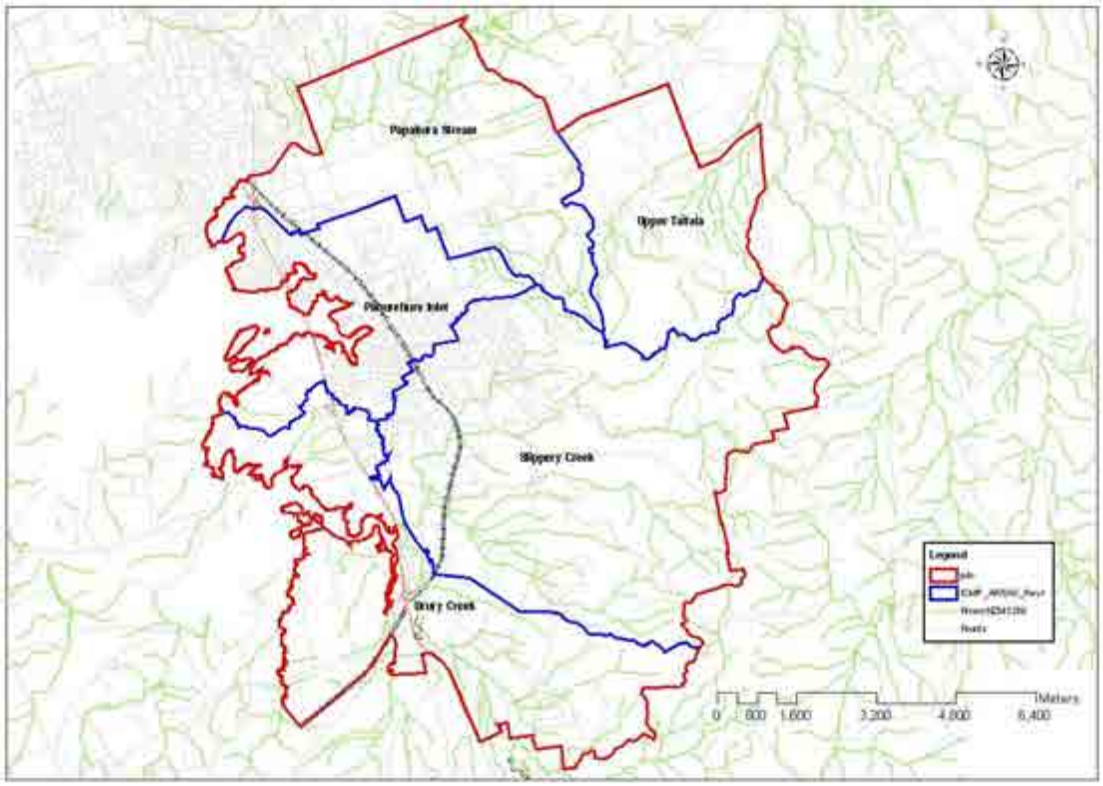
## 1.1 Central Papakura Stormwater Catchment Area

As part of the Integrated Stormwater Catchment Management Plan (ICMP) study undertaken by Papakura District Council (PDC), the Papakura District has been divided into five major management areas, mainly based on their respective receiving environments. The five major catchment areas are:

- Papakura Stream
- Pahurehure Inlet
- Slippery Creek
- Drury Creek
- Upper Taitaia

The five ICMP areas are shown in Figure 1.1 below.

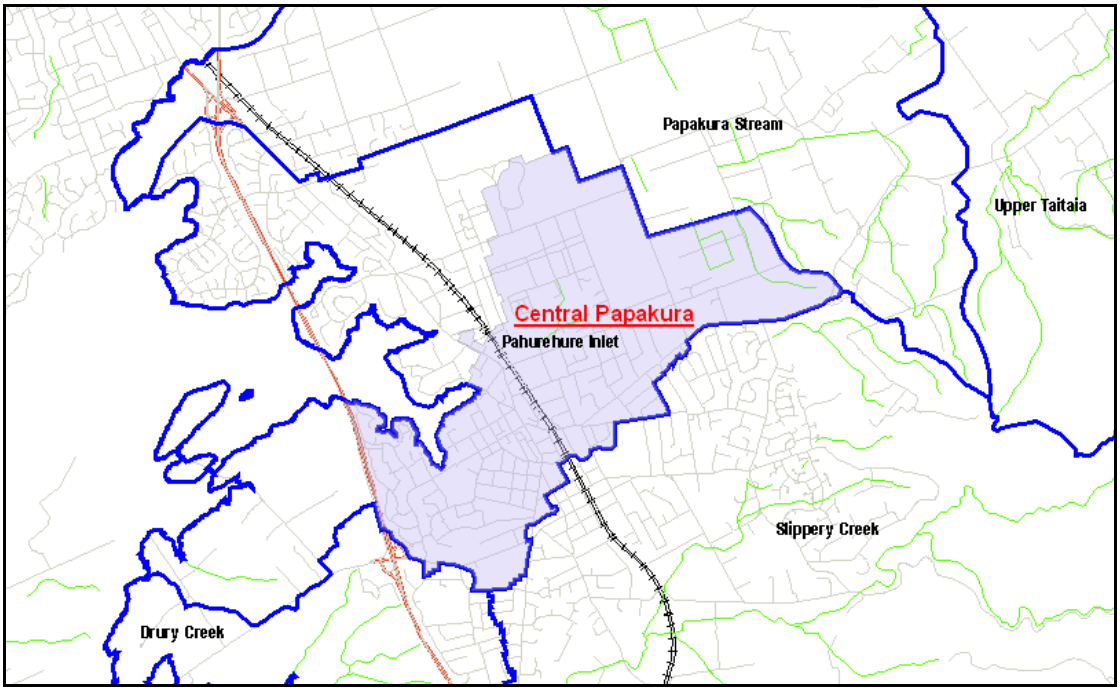
**Figure 1: Integrated Catchment Management Areas**




The Central Papakura Stormwater Management Area (CPSMA) includes stormwater sub-catchment areas traditionally known as the Old Wairoa Road Catchment, the Elliott Catchment, the Prince Edward Catchment and Pahurehure Catchment, and is situated in the lower half of the Pahurehure Inlet Catchment Area in the ICMP study. The stormwater catchments in the Central Papakura area discharges into the southern arm of Pahurehure Inlet, therefore it is rational and manageable to cluster these catchments into one ICMP study.

The areas covered by CPSMA are shown in Figure 2 below:

**Figure 2: Central Papakura Stormwater Management Area**




## 1.2 PDC Stormwater Management Objectives

The objectives of stormwater management in Papakura District Council can be generally described as the following:

- To provide adequate stormwater drainage levels of service via the primary drainage system and the secondary overland flow paths system in order to minimise both the magnitude and frequency of flooding of properties and public roads and other drainage nuisances to general public, to support the social and economic well-beings of our District, and to enable urban and rural development in the District.
- To protect the streambank and properties from excessive erosion which could cause instability to land.
- To maintain and improve the water quality in the fresh and marine water receiving environment. To continually improve the amenity value and habitat in the urban and rural streams and associated riparian reserves. To protect both the freshwater and marine ecological system in the receiving environments. To protect the cultural value of clean water in the marine and freshwater environments by working together with the local iwi groups.

Specific stormwater management objectives at Central Papakura Catchment also include:

- To maintain the current groundwater regime especially the low summer watertable to prevent consolidation of peat soils underlying the catchment area.

## 1.3 PDC Stormwater Management Strategy

The above objectives can be achieved through the following stormwater management strategies:

1. Undertaking catchment management study in an integrated systematic manner to assess the effects of future developments in the catchment area and identity a range of remedial options.
2. Incorporating low-impact development measures in new development to reduce stormwater runoff and enhance the amenity in the urban areas if practicable.
3. Protection of the stream riparian margin and minimise infilling of 1% AEP flood plain.
4. Protection or provision of significant secondary overland flowpaths in existing and new urban development. A significant overland flowpath is defined as an overland flow path where the flow in the primary drainage system exceeds 200l/s in a 10%AEP storm event.
5. Implementing remedial works to augment the capacity of the stormwater drainage system by removing bottlenecks.
6. Provide levels of service for stormwater drainage appropriate to the potential risks to the community in the specific area by taking into account the consequences of flood damages and frequency of flood occurrences.
7. Impose strict controls on development in flood risk areas, especially on habitable/non-habitable floor levels, site grading and preservation of overland flow path to avoid adverse effects on the existing properties.
8. Require source controls at contaminant hot spots, such as sections of roads with more than 5000 vpd, closed landfills and high risk industrial and commercial sites, to avoid diffusion of contaminants in the receiving environments.
9. If practicable, provide centralised community stormwater management devices to avoid ineffective, often expensive, piecemeal stormwater treatment solutions.
10. Involve local iwi groups in the stormwater management process and incorporate iwi philosophy in stormwater system design if practicable.

## 1.4 Central Papakura Catchment Management Goals and Objectives

The catchment management goals and objectives specific to the Hingaia South Catchment are set out below in Table 3. Linkages with the PDC community outcomes, the regulatory environment and progress indicators have also been established. The weightings on various objectives are tentative at this stage; these will need to be approved by the significant stakeholders.

**Table 1: Stormwater Management Goals, Operational Objectives and Performance Indicators**

**Community Outcomes**: **A** – Accessible and cared for natural environment; **B** – Safe and stable community; **C** – A well planned community

**D** – Healthy lifestyles; **E** – Pride in our community and heritages.

| *Community Outcomes* | *Goals* | *Operational Objectives* | *Performance Indicators* | *Mandate/Drivers* | *Weightings*** |
|---|---|---|---|---|---|
| **C** | Provide stormwater drainage infrastructure to support community wellbeing and to enable growth | Extend, upgrade and optimise the stormwater drainage network to meet the Levels of Service requirements. | Levels of Services. | ARP-ALW<br>AMDA<br>LGA2002<br>ARPS<br>TWS<br>LTCCP | **10** |
| **B, C** | Protect community from natural hazards, such as flooding and erosion. | Reduce the number of habitable floor flooding by 80% within the next 20 yrs.<br><br>Reduce property and road nuisance flooding* by 5% each year.<br><br>Control development in the coastal inundation/regression zone. | No of habitable floors flooded, reported property and road flood nuisance. | ARPS<br>SCARCA<br>ARP-ALW<br>RMA<br>PDP | **10** |
| **A, E** | Sustainable development to protect and enhance the quality of our natural environment. | Conserve and enhance riparian margins through new development.<br>Conserve natural wetlands and valuable coastal margins. | Total area of riparian margins protected and enhanced. Total area of wetlands protected and enhanced. Total area of coastal margins conserved. | ARPS<br>ASF<br>RMA<br>ARP-ALW | **8** |

| *Community Outcomes* | *Goals* | *Operational Objectives* | *Performance Indicators* | *Mandate/Drivers* | *Weightings*** |
|---|---|---|---|---|---|
| **A** | Maintain and enhance the ecological wellbeing in the receiving environments | Reduce the input of sediments, heavy metal and other pollutants to the marine receiving environment, maintain and enhance the stream ecological value. | Estuarine sediment accumulation rate, Zinc, Copper and Lead concentration levels in marine sediments, Total suspended solids removal rate from urban runoff. | ARP-ALW<br>ARP-Coastal<br>ASF | **8** |
| **A, D** | Protect and improve community uses of the natural environment | Nurture a gradual increase of community uses of the natural environment by enhancing access to the natural areas. | Survey of community use of the receiving environment. | ARPS<br>LTCCP | **8** |
| **A, E** | Social and cultural wellbeing | Incorporate iwi philosophies when designing stormwater infrastructure and when managing stormwater discharge | No of consultations with iwi group | ARPS | **8** |
| **C** | Enhance the amenity value of the stormwater system | Involving landscaping design in new stormwater infrastructure, such as ponds, wetlands and open channels. | List of new or retrofitted stormwater assets with good amenity value | ASF<br>LTCCP | **6** |

*Nuisance flooding refers to flooding occurred in rainfall events below the design rainfall for the stormwater system.

** The Weightings given in this table represent only the author's personal view. A consensus needs to be attained by working with a wide group of stakeholders.

## 1.5 Regulatory Framework and Planning Considerations

### *1.5.1 ARC Regional Plan: Air, Land & Water*

The Proposed Auckland Regional Plan: Air, Land and Water (PARP:ALW) establishes an expectation[a] that territorial authorities (TAs) will prepare Integrated Catchment Management Plans (ICMPs).

The Chapter 5 of the proposed Regional Plan for "Discharges to Land and Water, and Land Management" was approved by Environment Court of New Zealand. The Regional Plan defines ICMP in Clause 5.4.10 as

"*A plan for management of the stormwater and wastewater discharges, diversions and associated activities within the catchment or District which is prepared."*

ICMP shall identify:

> *(a) the **stormwater** or **wastewater** issues facing the catchment and the range of effects from those discharges, diversions and associated activities;*
> *(b) strategic objectives for the management of **stormwater** and **wastewater** discharges, diversions and associated activities within the catchment or district;*
> *(c) a range of management options and the preferred management approach for avoiding, remedying or mitigating environmental effects and risks;*
> *(d) roles and responsibilities for implementation of the preferred management approach;*
> *(e) tools to support implementation of the preferred management approach; and*
> *(f) a process for review.*

The Regional Plan Rule 5.4.11 allows separate ICMP documents and consent applications for the stormwater and wastewater discharges based on the organisation structures of the Territorial Authorities. In the case of Papakura District, United Water has a long term Franchise Agreement, and accordingly United Water is responsible for preparing a Network Management Plan for the wastewater system and obtaining consent from ARC. This ICMP will, however, provide requirements on the environmental performance of the wastewater system in the catchment.

The minimum requirements for ICMPs are set out in Schedule 9 of the Proposed Regional Plan.

### *1.5.2 Auckland Regional Policy Statement*

The Auckland Regional Policy Statement sets out the issues, policies and methods for managing natural hazards and water quality in the Region.

[a] Policy 5.4.6 reads "Consistent with the intent of Methods 8.4.4(2), 11.4.2(4) and 11.4.2(7) of the Auckland Regional Policy Statement, Territorial Authorities should prepare, and update as is necessary, Integrated Catchment Management Plans for the catchments within their districts in order to promote the integrated and sustainable management of stormwater diversions, discharges and associated river and lake bed activities".

**Table 2: Auckland Regional Plan Schedule 9 Compliance Checking**

Note: Not all sections referred to below may be present due to the 2016 abbreviation of this report to narrow its scope to support the published floodplain by Auckland Council

| Item | Description | Required for an ICMP | Where in this ICMP |
|---|---|---|---|
| **A** | **The issues arising from stormwater and wastewater discharges, diversions and associated activities facing the catchment or district, including:** | | |
| a (i) | A description of the drainage ***networks*** and their current and predicted future performance [LOS]. | Yes | 5.1, 5.2, 5.3, 5.5, 6.5, 9, 11.1 |
| a (ii) | A general description of non-network drainage within the catchment or network and its likely contribution to adverse environmental effects; | Yes | 6.12 |
| a (iii) | An assessment of the ***receiving environment*** and the actual and potential effects (including cumulative effects) of ***stormwater*** or ***wastewater*** diversions and discharges, and associated river and ***lake*** bed activities on: | | |
| | ▪ Public health; | Yes | 4.2.3? |
| | ▪ Flooding hazards, including legally authorised floor levels of ***habitable buildings*** and the State highway with respect to flood events up to and including 100 year ***ARI*** flood events; | Yes | 4, 6, 8, 9, 12, 13 |
| | ▪ ***Watercourse*** hydrology, long-term ***aquifer*** levels and authorised surface and groundwater uses; | Yes | 3.2, 3.1 |
| | ▪ ***Receiving environment*** sediment quality and water quality, including Environmental Indicator monitoring results; | Yes | 3.2, 3.3, 6, 8.4 |
| | ▪ Aquatic habitat, ecology and ecosystem health; | Yes | 3.2, 3.3, 6, Appendix C |
| | ▪ The natural and ***amenity*** values of ***lakes***, rivers, wetlands and ***aquifers***; | Yes | 3.1, 3.2, 6, Appendix C |
| | ▪ Riparian vegetation; | Yes | 3.2, 4, 6.11, 11, 12, 13, Appendix C |
| | ▪ The extent and quality of open stream channels; | Yes | 3.2, Appendix C |
| | ▪ ***Fish passage*** for native fish; | Yes | 3.2, 4.2.2, 6.10, 11.2.3, 12.1.2, 12.4, Appendix C |

| Item | Description | Required for an ICMP | Where in this ICMP |
|---|---|---|---|
| | ▪ The erosion and sedimentation of ***lakes***, wetlands, and perennial rivers; | Yes | 4.2.4 |
| | ▪ The discharge and accumulation of litter; | Yes | Include an overview summary with devices |
| | ▪ For discharges to the coastal marine area; erosion, accretion; natural character and public access | Yes | 4.1.7, 4.1.8, 6.7 |
| | The above assessment should identify the contaminants of concern within the catchment or network, which may include finer sediments (<100um), zinc, and petroleum ***hydrocarbons.*** The AEE should assess land-uses with high contaminant generation potential and the effects of ***stormwater*** contaminants discharged to estuaries and harbours. | | |
| a (iv) | The identification of potential urban growth, ***land use intensification,*** redevelopment and ***regionally significant infrastructure*** development within the catchment, taking into account the growth projections developed under the Regional Growth Strategy and related Sector Agreements produced by the Auckland Regional Growth Forum, and District Plans; | Yes | 3.3 |
| a (v) | A classification of the ***urban rivers and streams*** within the catchment in accordance with Section 3.5 of this Plan; | Yes | 4.2.2, Appendix C |
| a (vi) | Governance structures and management responsibilities for ***stormwater*** and ***wastewater*** networks; | Yes | 1.5,5.2 |
| a (vii) | Significant non-network diversion and discharge activities that may have a material effect on environmental outcomes. | Yes | 6.12 |

| Item | Decriptions | Required for an ICMP | Where in this ICMP |
|---|---|---|---|
| **B** | **A description of the strategic objectives sought for the stormwater and wastewater discharges, diversions and associated activities and receiving environments, including:** | | |
| b (i) | The social, ecological, economic, amenity and cultural ["MBL"] objectives; | Yes | 1, 11, 12, Appendix G |
| b (ii) | The community and iwi consultation undertaken in determining the strategic objectives; | Yes | 7 |
| b (iii) | Identified milestones required to achieve those objectives. | Yes | 1.2 |
| **C** | **A description and consideration of the range of management options available to achieve, or progress towards, the objectives identified in (b), including:** | | |
| c (i) | Methods by which network discharges, structures and activities from ***urban areas*** (development, redevelopment and greenfields development) will be managed; | Yes | 11, 12, 13 |
| c (ii) | Methods for the management of non-network activities, such as discharges from private properties; | Yes | 11, 12, 13 |
| c (iii) | District and other Plans, or other regulatory and non-regulatory means, including an assessment of the effectiveness of current Plan provisions and consideration of Plan changes or variations; | Yes | 11, 12, 13 |
| c (iv) | Education initiatives to support the management regime; | Yes | 11, 12 |
| c (v) | Methods to avoid adverse effects occurring, such as; source control, low impact design and any innovative methods; | Yes | 11, 12, 13 |
| c (vi) | Methods for managing high contaminant load sources; | Yes | 11, 12, 13 |
| c (vii) | Design standards and levels of service for the ***network*** | Yes | 9, 11, 12, 13 |

| Item | Descriptions | Required for an ICMP | Where in this ICMP |
|---|---|---|---|
| **D** | **The proposed catchment or network management method(s), including:** | | |
| d(i) | The identification of the Best Practicable Option (BPO) to prevent or minimise the adverse effects of ***stormwater*** or ***wastewater*** diversions, discharges and associated activities, including any methods to mitigate significant unavoidable adverse effects; | Yes | 11, 12, 13 |
| d(ii) | The methods by which ***network*** interconnections, non-***network*** discharges, ***urban rivers and streams*** **[E513/04/01]** and associated river and lake bed activities are proposed to be managed and integrated management will be achieved; | Yes | 11, 12, 13 |
| d(iii) | Any regulatory methods; | Yes | 11, 12, 13 |
| d(iv) | Any non- regulatory methods. | Yes | 11, 12, 13 |
| **E** | **A description of the processes and tools to support the implementation of the *ICMP* or compliance with the conditions of a network consent including:** | | |
| e(i) | Methods of monitoring and reporting progress; | Yes | 15 |
| e(ii) | A prioritised programme(s) for implementing the BPO; | Yes | 3 |
| e(iii) | Operation and ***maintenance*** programmes to ensure the effective functioning of the management method(s); | Yes | 2, 13 |
| e(iv) | Identification of the organisations with statutory responsibility or ability for implementing the proposed catchment management methods, and in particular those organisations with sole or primary responsibility for implementation; with partial or secondary responsibility or no responsibility. | Yes | 3 |
| e(v) | A process for reviewing the catchment or network management approach based on an increased understanding of environmental responses, public health issues, community needs and network priorities. | Yes | 15.7 |
| e(vi) | A description of the process for reviewing the ***ICMP,*** to reflect changes in knowledge, community aspirations, technology and other factors. | Yes | 15.7 |

The Auckland RPS contains a suite of Methods in section 11.4.2 of the Natural Hazards chapter. The stated role of the ARC is one of regional co-ordination, the regulation of stormwater diversions and discharges, and the promotion of catchment wide approaches to flood management [methods 1, 2 and 4].

The territorial authorities are assigned the function of establishing land use controls in district plans "*for the avoidance or mitigation of natural hazards*" [method 6]. Territorial authorities are also assigned the role of preparing "*flood management plans*" in areas either rezoned for intensification or where development could have adverse effects [method 7] and for undertaking and maintaining any "*hazard mitigation works*" [method 8]. Within 1% AEP flood hazard areas territorial authorities are also required to "*control infilling and storage of materials likely to be moved by flood events, and ensure that development within the zone is located in such a manner as to limit the restriction of flood flows*" [method 9]. Interestingly, the RPS also states that the ARC "*will, where appropriate, transfer day to day flood management functions, powers and duties to TAs*" [method 5].

Consequently, in the Auckland region the RPS makes it clear that the territorial authorities are responsible for flood plain management, including the identification of flood prone areas that are being developed.

The Auckland RPS recognises water quality as a significant issue in the Auckland Region. Auckland is a maritime Region with an extensive, often rugged, coastline, large harbours and estuaries and attractive islands of the Hauraki Gulf. The Region also have numerous lakes, rivers, streams, wetlands and aquifers. The quality of water can either enhance the values of these resources or degrade them with a direct effect on the quality of life of Aucklanders, visitors and all those who are resource users. Water is a resource which is sensitive to the impacts of activities on land or water. Hence, maintaining or enhancing its quality requires a comprehensive and integrated approach to its management.

The overall vision for water quality in the Auckland Region is as follows:

- Water quality at beaches, rivers and lakes will be suitable for swimming;
- People will continue to enjoy the abundant resources of our beaches, rivers, streams and lakes for fishing and shellfish gathering, cultural, commercial and other purposes;
- Natural ecosystems, valued for their own sake, will function without adverse effect.

RPS recognises that ARC has a primary responsibility as a regulatory authority under RMA via the various Regional Plans to work towards this vision with an aim to achieve:

- A steady reduction of sediment, sewage overflows and other contaminants into our waterways;
- The prevention of discharges of toxic and persistent contaminants which may have an adverse effect on aquatic ecosystems.

### *1.5.3 Takanini Structure Plan (TSP)*

Takanini has been identified as one of the greenfield areas on the Auckland Region Growth Strategy Map 2050. The Takanini greenfield area is identified in the Growth Strategy as future urban with a land area of 1,100 ha. The area is generally bounded by the railway line to the west, the district boundary with Manukau City in the North,

following a line South-west to Mill Road, along Mill/Cosgrave Roads in the east and Walters/Grove/Old Wairoa Roads in the South. Areas 2A, 2B, 3 and a portion of Area 4 are located in the Central Papakura ICMP Area.

For Takanini, the Growth Strategy set the following requirements:

- An additional 20,000 people will have to be accommodated
- At least an additional 3,000 job opportunities will have to be provided.

As a result of community consultation through a charette process, some broad design concepts were developed which include the following for stormwater management:

- An open space network that incorporates stormwater management and water quality systems should be provided.

The management of stormwater in the area underlain by peat is subject to the following key limitations:

- Groundwater recharge must be maintained in order to ensure that the peat layer does not dry out and settle;
- The groundwater level is reported to rise to the surface in winter in parts of the area (to be confirmed by monitoring) causing localised ponding;
- The area is very flat, and the available gradient for drainage is low;
- The existing drainage systems into the Pahurehure Inlet have limited capacity to accommodate the additional stormwater flow from the Structure Plan Areas. (New stormwater infrastructure including those for conveyance and treatment will need to be provided to minimise any effects on existing urban areas.) (Takanini Structure Plan, Urban Initiatives Ltd, 2000)

A key objective for stormwater management in this area is to prevent lowering of the groundwater level.

The Takanini Structure Plan Areas 2A, 2B, 3 and parts of Area 4 fall within the boundary of the Central Papakura Catchment. The densities of development in these areas have been increased from 500m$^2$ ~ 1000m$^2$ per lot in the TSP to 400m$^2$ ~ 500m$^2$ in the proposed plan change application now lodged with PDC.

### *1.5.4 Central Papakura Structure Plan*

The Papakura Central Area Structure Plan was prepared by Urban Initiatives for PDC in February 2000.

The Auckland Region Growth Forum has identified a growth node around the existing Papakura Railway Station. The Structure Plan foresees significant population growth (5000+) in the Central Papakura Area, envisaging this area becoming the focus point for users of the future much improved rapid transit system.

The Structure Plan promotes further high density residential development in the Central Business District area, by incorporating commercial development at the bottom floors of apartment buildings.

New cycle ways and pedestrian accesses have been planned to radiate from the Railway Station into the surrounding residential areas. Thoroughfares and large

commercial vehicles will be diverted away from busy commercial areas. Certain intersections will require upgrading.

The Structure Plan also recognises the need to upgrade the existing stormwater system due the higher density promoted in the Central Area. Although, as the existing imperviousness is already high in the CBD area, only marginal increase in imperviousness is foreseen during the redevelopment proposed in the Structure Plan.

It is also envisaged that flood nuisances due to the low level of service limited by the capacity of the existing drainage system tolerated by existing industrial and commercial users may not be acceptable once the area is redeveloped into premises with higher economic values and increased resident population. Perception of general public towards flooding risks and nuisances will also shift as the areas are transformed. Expectations towards higher levels of service by the general public will be inevitable.

As the population and traffic volume increase in the CBD area, it is foreseen that more contaminant may enter stormwater system, therefore potentially worsen the water quality in the receiving environments, if no proper stormwater quality management practices has been put in place.

### *1.5.5 Existing Catchment Management Plans*

The following existing Catchment Management Plans cover portions of the Central Business District:

**Old Wairoa Road Stormwater Catchment Management Plan (OWRCMP) – Prepared by Harrison Grierson Consultants Limited, August 2001**

This CMP mainly addresses stormwater drainage and treatment issues related with the area around the old Army Camp site in the Takanini Structure Plan. Under this CMP, a new stormwater treatment and attenuation pond has been constructed at Artillery Drive, and a new stormwater tunnel will be constructed in the future to direct discharge from the pond to the Pahurehure Inlet. These projects will relieve the existing overloaded drainage system through the downstream catchment areas including a portion of the CBD. While the main drainage systems in the catchment have been investigated, no detailed modelling of the downstream drainage system has been undertaken.

A Stormwater Discharge Consent (Permit No 25205) was granted by ARC in September 2004. A copy of the Stormwater Discharge Consent is included in Appendix F.

Since the issue of the above consent, the densities of proposed development in the TSP Areas 2A, 2B and 3 have been reviewed. The latest proposed plan change application promotes significantly increased densities varying from 400m$^2$ to 500m$^2$ per lot comparing with 500m$^2$~1000m$^2$ per lot allowed in the original structure plan and OWRCMP.

**Old Wairoa Road Catchment Flood Management Plan – Prepared by Connell Wagner Rankine & Hill, September 1992**

Hydrological and hydraulic modelling was carried out in this study to investigate flooding problems in the whole catchment. Ground survey and floor level information were obtained in the flood prone areas. Flood levels were given at critical localities.

This CMP also identified possible flood mitigation options in the catchment. The Artillery Drive Detention Pond and the need to deliberately divert flows from some upper catchment areas were suggested in this CMP.

### *1.5.6 Pahurehure Inlet Management Plan*

The Pahurehure Inlet Management Plan was completed in Nov 2006 by a joint effort between Auckland Regional Council and Papakura District Council.

The management plan recognises the improvement potential for the Papakura's water front and was embedded with the vision for the Pahurehure Inlet to become a high quality recreational, cultural and ecological precinct – a jewel in the crown of Papakura.

The strategic goals for the Pahurehure Inlet include the following:

1. The promotion and enhancement of recreational use and enjoyment of the inlet and its surrounds,
2. The maintenance, restoration and protection of environmental quality and important ecosystems within the Inlet,
3. The protection of cultural and heritage areas of importance and the improvement of understanding of these areas, and
4. The enhancement of the amenity of the Pahurehure Inlet to create a strong sense of place for the community.

The Pahurehure Inlet Protection Society (PIPS) has been at the forefront of articulating community aspirations around recreation, access and cultural issues. In the past, with the promotions of PIPS, the then Papakura District Council has proposed a tidal gate to create an open body of water for weekend and holiday recreational activities. A resource consent was given by then ARC to install tidal gates in the culverts under the motorway causeway to impound water in the Inlet during periods of high recreational use (i.e. weekends and public holidays).

However, the Environment Court declined this application in 2004 and one of the reasons the Court gave was the need for an all embracing plan for the future of the Inlet that considered the benefits of mangrove clearance and tidal gates together with effects on the environment and Maori values. The tidal gates project has therefore been put on hold by PDC until the development of the Pahurehure Inlet Management Plan.

The key issues identified in order to achieve the strategic goals include the following:

- mangrove and Pacific Oyster expansion,
- pathways and access points to the water must be enhanced,
- the provision of a quality water body for recreation,
- areas of ecological significance must be protected,
- historic and cultural heritage must be recognised,
- increased sedimentation, and
- loss of sandy beach

Inlet wide initiatives have been planned to tackle the issues above:

- Pathway and access enhancement at various locations,
- Mangrove removal (not to damage ecologically significant areas, retain mangroves where they provide erosion protection.
- Manage Pacific Oyster – prepare a management plan, control proliferation and effects on recreational use of the Inlet.
- Improve water quality
    - prepare ICMPs to address water quality issues,
    - continue to co-ordinate efforts from MCC and FDC to improve the water quality in the broader Pahurehure Inlet and Manukau Harbour including undertaking the South Eastern Manukau Harbour Contaminant Accumulation Study,
    - monitor high risk industry compliance, monitor the water and sediment quality in the Pahurehure Inlet,
    - undertake community education programme to increase knowledge and awareness.
- Cultural and heritage protection –
    - identify and protect the values important to Tangata Whenua and community, protect areas of culture and heritage importance and improve understanding of these areas,
    - establish an appropriate vehicle for Tangata Whenua to exercise their Katiaki role in relation to the Pahurehure Inlet.

# 2 Catchment Description - Physical

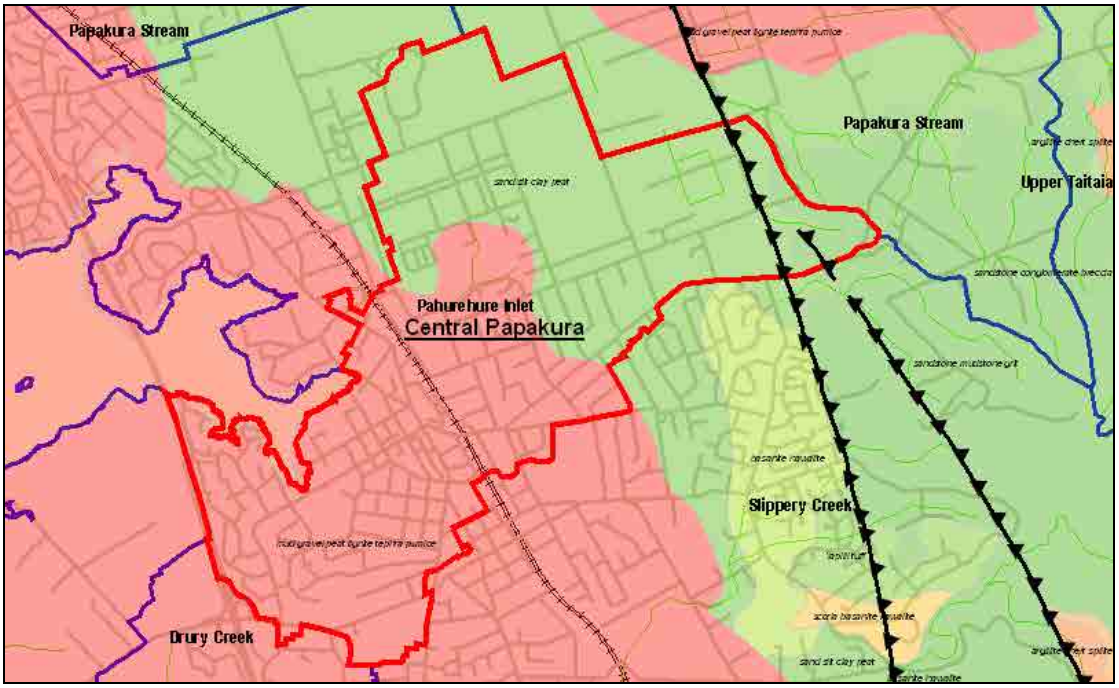
## 2.1 Soils and Geology

The IGNS Geological Map shows that most parts of the Central Papakura area are underlain by Tauranga Group Puketoka Formation soils, described as a matrix of pumiceous mud, sand and gravel, and muddy peat. The upper Old Wairoa Road Catchment area upstream the Artillery Drive Pond, is dominated by swamp peat deposits typical in the Takanini area and Clevedon Valley.

Where the land rises into the foothills of the Hunua Ranges, the base soils originate from the East Coast Bays Formation, typified by alternating weathered sandstones and mudstones with variable volcanic content.

The Drury Fault lines dissect the district in the North-South direction. There are pockets of basalt lava emitted from the fault lines.

**Figure 3: Central Papakura Geology**




Source: IGNS Geological Data for Auckland Region
(The Pink shade area is underlain by Puketoka Formation (a mixture of ash, silt and sand) and the Green shade area indicates Takanini Peat Soil (black organic clay).)

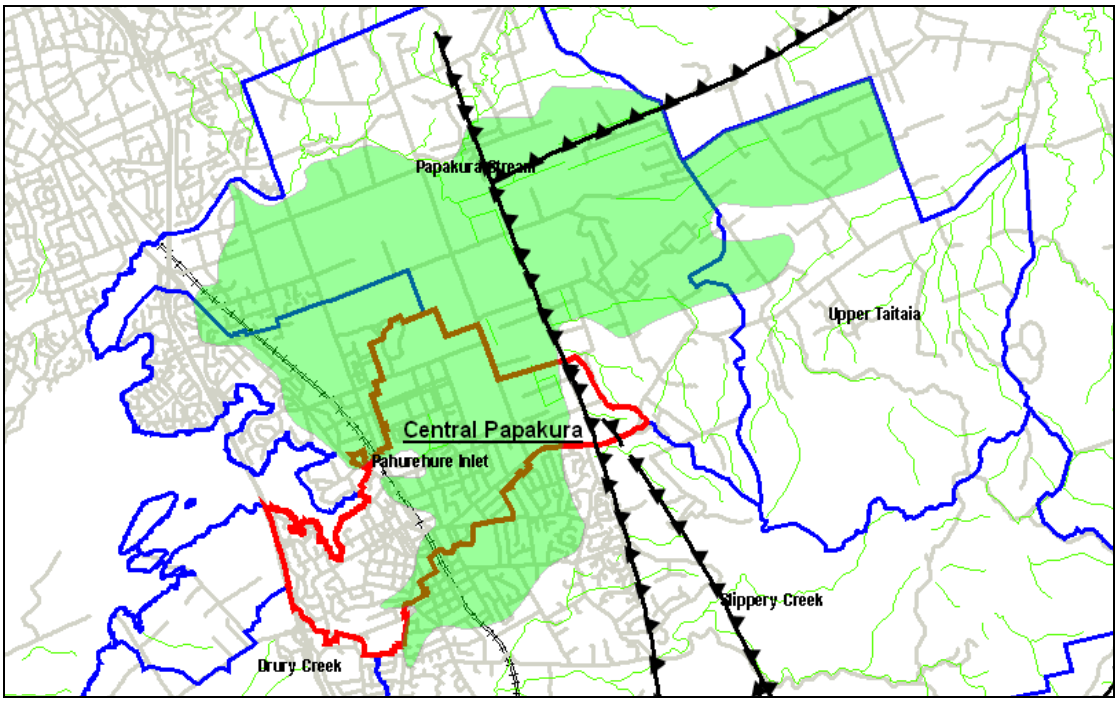
In the Takanini peat area, there is a silt veneer to a depth of 1~2 metres. The total thickness of the underlying black soft peat can reach more than 10 metres. Based on test data by Manukau City Council in 1983, the black peat material has a permeability equivalent to homogenous clay. It is also likely that Kauri stumps will be encountered in the ground. The bearing capacity of the peat soil is considered to be low.

One of the major issues to be considered for development in a swamp peat area is the possibility of settlement as the result of lowering the groundwater table due to implementation of surface water drainage systems and reduction of recharge due to increased imperviousness in the catchment.

"The sensitivity to potential settlement due to ground water lowering has been tested by the available Military Camp data and simulating a 0.5 m, 1.0 m and 1.5 m lowering of the water table. Lowering the water table has the resultant effect of increasing the total effective stress in the underlying soils due to the loss of buoyancy (reduction of pore pressure). It can be seen that for a permanent lowering of ground water level of as little as 500 mm, there would be a corresponding primary consolidation settlement of 100 to 230 mm.". (Takanini Stormwater, 1983)

A recent study undertaken by Pattle Delamore Partners Ltd (PDP) on soakage applicability in peat soils in the District utilising locally collected geotechnical data from development proposals and works undertaken by Council on public roads, shows a much more extensive peat soil areas when compared with the published IGNS geological data. It is suggested that until further accurate geotechnical investigation has been undertaken, the locally collected data be given a greater weight for considerations of the influence of peat soils.

**Figure 4: PDC Peat Soil Extent – PDP Study**



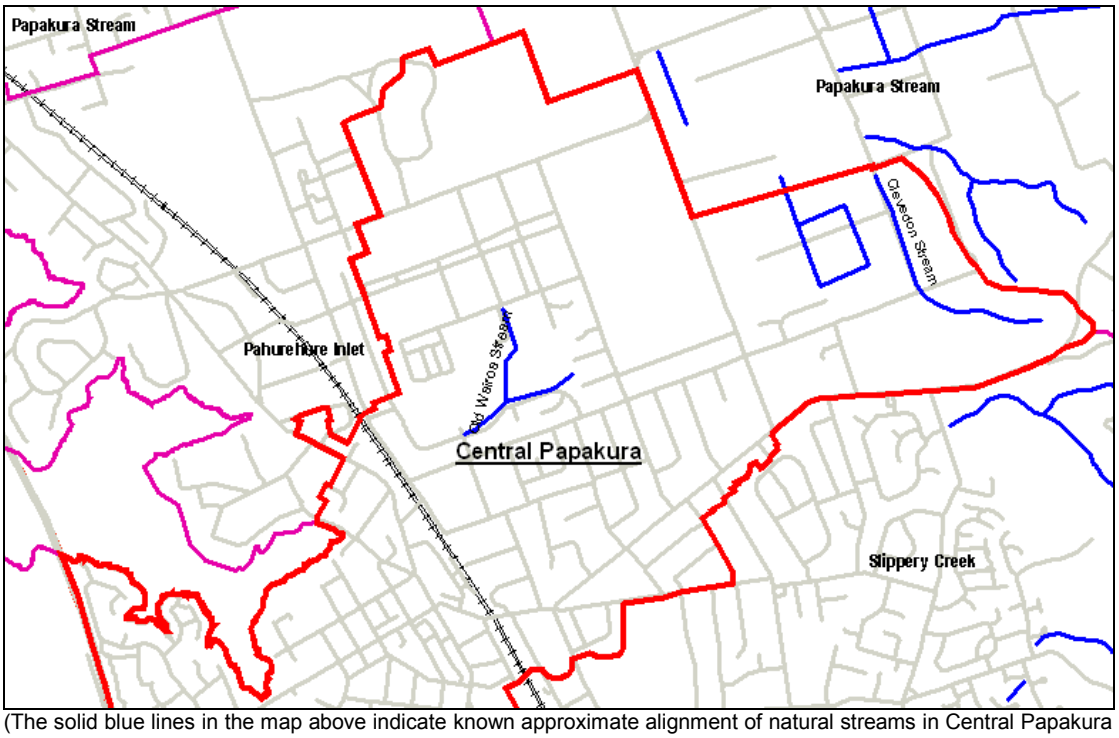

Source: Papakura District Peat Area Stormwater Discharge Review (PDP, 2006)
(The Green shade area indicates the extent of Peat Soils, the black lines with solid n triangles are known fault lines in the District.)

The Drury Fault runs northwards and cuts through the top end of the Central Papakura Catchment. Previous studies indicate the Drury Fault is still active. A recent study on the Drury Fault undertaken by A. L. Williams, et al for the Auckland Civil Defence Emergency Management Group, indicates that the potential for low level ground shaking, gradual vertical displacement or fault rupture will need to be considered in design of structures crossing or in proximity to the fault. The study also suggest consideration be given to establishing a fault avoidance zone while the land is still in rural use. The likely return period of activity on the Drury Fault is possibly in the order of several thousands of years and would not influence the present approach to seismic design of structures in the region.

## 2.2 Natural Streams

Two natural stream systems have been identified in the Central Papakura Area, namely the Old Wairoa Stream and the Clevedon Stream. The locations of these streams are shown in Figure 2.3 below:

**Figure 5: Central Papakura Streams**




(The solid blue lines in the map above indicate known approximate alignment of natural streams in Central Papakura area.)

The downstream reaches of the Old Wairoa Stream are suspected to have been piped all the way to the Pahurehure Inlet. Both the western and eastern reaches are well shaded with good riparian vegetation with incised main channel.

The Clevedon Stream is one of the many tributaries of the Papakura Stream. The stream channels downstream have been heavily modified by historic farming and grazing activities. Free accesses of stock to the stream channel have caused significant loss of riparian vegetation and other in-stream habitat.

The Old Wairoa Stream was investigated by the National Institute of Water & Atmospheric Research Ltd (NIWA) in July 2006. A full study report is included in Appendix C.

Both the Old Wairoa Stream and the Clevedon Stream were investigated as part of the preparation for the previous Old Wairoa Road Stormwater Catchment Management Plan. The H&G Aquatic Ecosystem Assessment report is included in Appendix D.

The status of the existing streams in terms of sediment quality, fresh water quality, habitat and ecosystem health will be discussed in detail in Section 4.2.

## 2.3 Surface Water Resources

There is no known surface water takes from either the natural streams or stormwater pipes in this catchment area.

The natural streams in the catchment are very short and have minimal or nil base flows in summer months. Therefore, there is little potential for any beneficial use of surface water from the streams.

The stormwater stored in the Artillery Drive Pond may be available for use such as irrigating the surrounding park and the adjacent soccer grounds, if such a need arises in the future.

## 2.4 Groundwater

The peat soils in the District are known to have high and fluctuating groundwater levels. Previous and recent geotechnical investigations for the peat soil area indicated that there is a great risk of irreversible ground settlement due to consolidation of the soft deep peat layers, should the groundwater especially the lowest summer water table be further lowered. It is critical to maintain the predevelopment level of groundwater recharge to the peat aquifer after development of this area.

One method of recharge is to incorporate a specifically designed recharge pit on each individual lot to capture the first 15mm of roof runoff and allow this to gradually seep into the underlying aquifer. A recent study by PDP "Papakura District Peat Area Stormwater Discharge Review" (2006) indicates that this is predicted to be adequate in maintaining the groundwater levels over a long term; based on the time series modelling undertaken.

The Manukau City Council report "Takanini Stormwater" (1983) includes measurements of groundwater levels in the area, as part of borehole investigations. However, no systematic monitoring of groundwater levels from this date onwards has been found.

As part of the Takanini South CMP study, groundwater variations were measured using a dip meter and 18 stand-pipe piezometers established in the catchment area. Groundwater levels were measured on an approximately weekly basis and particularly after periods of heavy or sustained rainfall for a total duration of approximately 1 year. Generally, the groundwater in the peat soils varied between approximately 0.5m below the ground surface in winter to 1.5m below the surface in summer. It is suspected road side ditches and farm drains in the area may have some influence on the groundwater levels recorded in some boreholes placed in close proximities of these drainage features. The groundwater water levels monitoring results are summarized in a report "Takanini South Groundwater Monitoring" by Harrison Grierson Consultants Ltd (H&G). These monitoring boreholes are, however, no longer available for continuing the monitoring.

As recommended in the Old Wairoa Road CMP, long term monitoring of the groundwater levels is to be carried out to confirm whether the recharge system is achieving the desired results. It will be necessary to undertake these long-term groundwater investigations using a combination of piezometers, seepage pits and trenches to obtain a greater understanding of the groundwater conditions in peat soils where potential ground settlement is a risk.

The ground water samples taken from the shallow peat soil aquifer were found to have low pH values at around 5, which indicate an acidic groundwater condition. Corrosion of the exterior of buried concrete pipes shall be taken into account during engineering design of stormwater drainage systems.

A copy of the ground water recharge study by Pattle Delamore Partners in 2006 is attached in Appendix E.

## 2.5 Groundwater Aquifer and Groundwater Resources

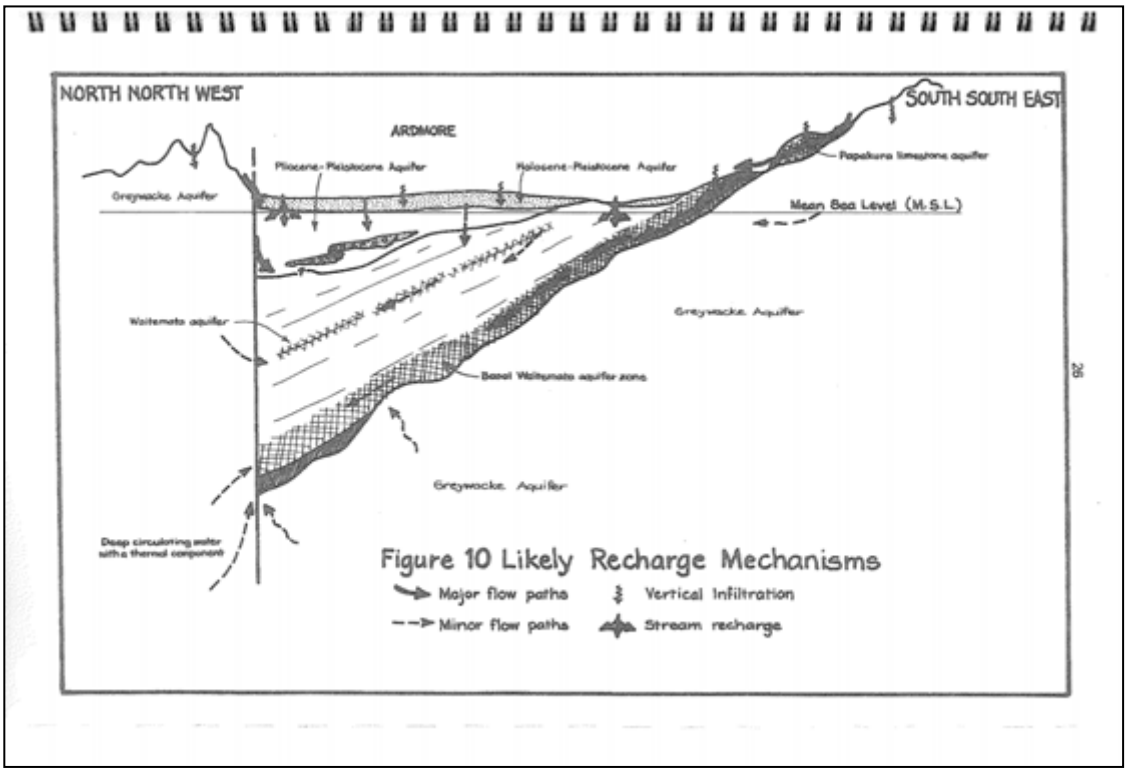
The Central Papakura Catchment is underlain by the Clevedon Valley Groundwater Aquifers, where six aquifer systems have been identified. Each aquifer is related directly to the lithological unit in which it lies – i.e. the Holocene to Pleistocene alluvials (the uppermost peat aquifer), the Pleistocene to Pliocene sediments, the Waitemata Series, the Papakura Limestone, the basal Waitemata rocks and the Greywackes. (Clevedon Valley Groundwater Investigation and Interim Management Strategy, Auckland Regional Water Board, August 1986)

Based on the Clevedon Valley Groundwater Investigation, the upper Holocene-Pleistocene (Clayey Peat) aquifer does not appear to be a significant water-producing aquifer, borehole yields are usually less than 50 $m^3$/day. In contrast, the lower Plio-Pleistocene aquifer has moderately high water producing capabilities, provided bores are constructed properly. Some of the larger 150mm diameter bores are capable of yields greater than 1,000 $m^3$/day.

Recharge of these upper aquifers is predominately by vertical infiltration with lateral infiltration along aquifer boundaries which intersect rising topography. Figure 6 from the Clevedon Valley Groundwater Investigation shows the likely recharge mechanisms.

Piezometric contours and general flow directions is shown in Figure 7 below. Seepage of groundwater at ground surface have been observed at properties in low lying area in the past, e.g. No 19 Keeney Court.

**Figure 6: Clevedon Valley Aquifer Recharge Mechanisms**



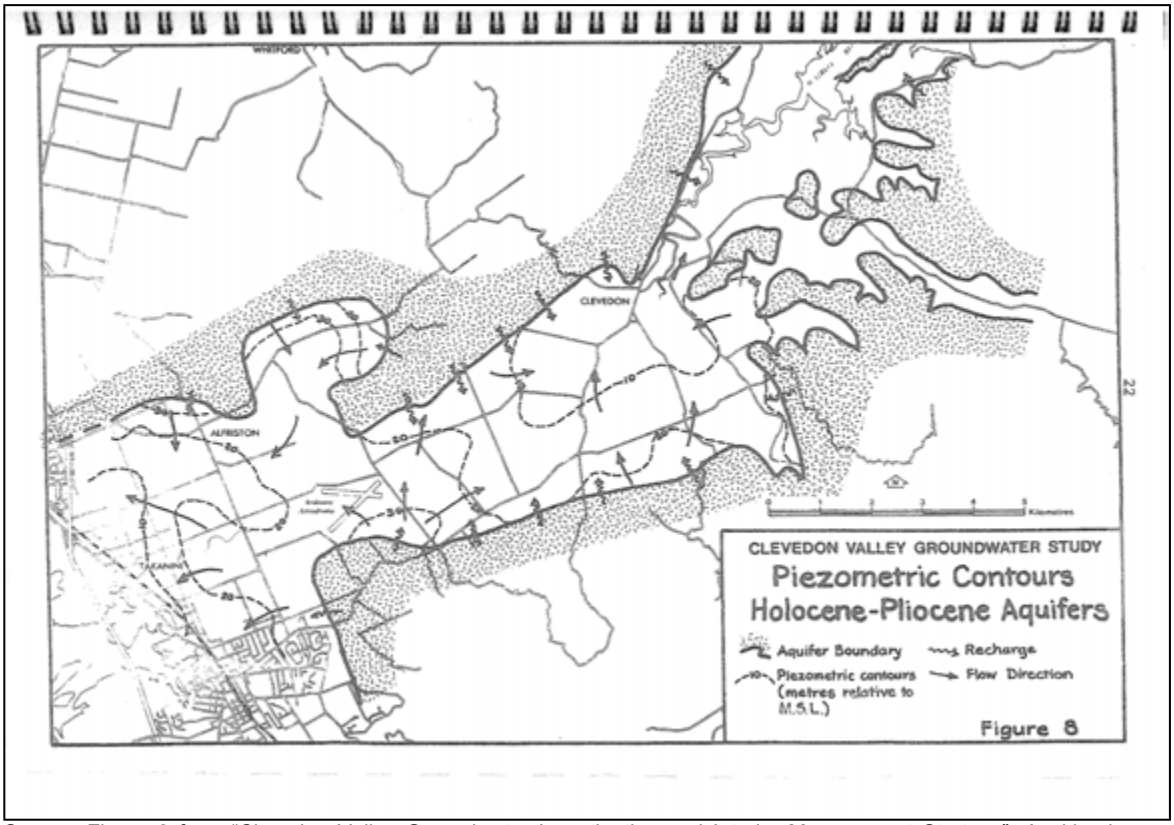

Source: Figure 10 from Clevedon Valley Groundwater Investigation and Interim Management Strategy, Auckland Regional Water Board, August 1986

Abstractions from these upper aquifers, especially to the west of the Ardmore Aerodrome will have potential impact on the groundwater table which can have detrimental geotechnical implications to the existing and planned urban development in the Takanini Area. Future development in the Takanini area will also affect the existing recharge mechanism to these aquifers. Further uses of groundwater resources from these aquifers should be limited until further studies and monitoring of groundwater levels in these aquifers can demonstrate the adverse effects of further abstractions can be minimised.

The Waitemata Series rocks are not high producers of water. Yields are highly dependent on rock fracturing. The recharge of this aquifer is inferred as primarily from infiltration along surface outcrops of the Waitemata Rocks and from fault zones. Vertical infiltration from above or below is likely to be minor.

The Papakura Limestone aquifer is the highest water-producing zone in the Clevedon Valley, while the Basal Waitematas bores yields vary considerably over short distances and the Greywacke is well known to have very low yields, as elsewhere in the Auckland Region. These aquifers are all recharged predominately through direct infiltration at surface outcrops, thus have little known interactions with the shallow peat aquifer.

**Figure 7: Clevedon Valley Aquifer Flow Direction**




Source: Figure 8 from "Clevedon Valley Groundwater Investigation and Interim Management Strategy", Auckland Regional Water Board, August 1986

## 2.6 Topography

The catchment is generally flat to very flat to the east of Porchester Road. The gradient of the land between the eastern extreme of the catchment and Porchester Road averages at 0.2% in the east-west direction, with mild undulations. The land to the west of Porchester Road falls towards the NIMT railway with an average gradient

of approximately 0.6%. In the north-south direction, the catchment area generally has minimal gradient if not nil in some places. A Topography Map for Central Papakura is included in Appendix A.

### *2.6.1 Old Wairoa Road Catchment*

The Drury Fault line cuts through the very top of the catchment. Between the fault line and the eastern extreme of the catchment, there exist rolling foot hills with pronounced gullies, the land falls from a high point of RL 67m to approximately RL 26m at the west side of the fault line.

The Catchment between the fault line and Grove Road is very flat, with less than 4m fall over 1400m. Areas between Cosgrave Road and the east extremity of the catchment natural drains north eventually into the Papakura Stream. Although, the previous Old Wairoa Road Catchment Management Plan (2003) and a 2004 Discharge Consent authorised the diversion of stormwater discharge from this area into the Old Wairoa Road Catchment. The reasons for this diversion include the following as understood from personnel involved in the decision process:

- To enable the development of this area prior to any drainage infrastructure can be installed in the areas to the north in the Papakura Stream catchment.
- To eliminate effects (mainly increased flooding) in the downstream Papakura Stream Catchment in both the Papakura District and Manukau City area.

The flat topography has created difficulties in providing an efficient drainage system, especially the provision of overland flow paths. On the other hand, the flat nature of the land tends to reduce the time of concentration in a storm event, and has a more pronounced dispersal effect by having a wide shallow flow across a large catchment area rather than highly concentrated channel flows or ponding often seen in a fast responding steep catchment.

The catchment area to the west of Grove Road, generally has reasonable fall with a few low lying gully systems draining the overland flows to the sea. However, the NIMT railway embankment traverses the catchment and cuts across two major gullies and causes flood risks at the upstream side of the crossings.

### *2.6.2 Elliot Catchment*

The Catchment generally falls towards Ray Small Park which was reclaimed from an estuary channel. The area between Rosehill Drive and Manse Road is flat with known surface ponding problems and lack of provision of overland flow paths.

### *2.6.3 Prince Edward and Pahurehure*

These coastal catchments generally have good gradient and all fall into Pahurehure Inlet. Some roads are known to have cut across overland flow paths with inadequate conveyance capacities in the pipes below the roads. Depressions were formed on some roads and on private properties during past development and thereby increased potential for flooding.

## 2.7 Vegetation

Kirks Bush is the largest preserved native bush area in Central Papakura. Other large reserve areas include McLennan Park, Bruce Pullman Park, Ray Small Park and Prince Edward Park, which are all covered by grass and isolated trees. Some

regenerated riparian planting is present at the Old Wairoa Stream. The Artillery Drive Pond is planted with native wetland species. The coastline to the east of the Southern Motorway is covered by aggressively growing mangroves.

## 2.8 Rainfall

The modelling of stormwater runoff requires a selection of extreme rainfall events appropriate to the climatology of the local catchment areas. This information should preferably be based on analysis of records of rainfall measured within the catchment area. However, rainfall records in the PDC area are generally sparse, discrete and comparatively short in length of monitoring.

The ARC TP108 rainfall contour maps (Appendix A, TP108) cover the PDC Area. In this case, it is considered appropriate to use the ARC TP108 24hr design storms for the modelling and design of the proposed stormwater system.

### *2.8.1 Design Storms Vs Time Series*

There has been continuous debate on which is better - Fictitious Design Storms or Real Time Rainfall Time Series?

ARC TP 108 has adopted the 24-hr Design Storms with a fictitious temporal pattern which nestles the extreme storms of shorter durations in the middle of the design storm. The design storm approach is supported due to the uncertainty associated with recorded extreme events and the need to cover the worst possible scenarios in engineered systems. After all, it is hard to find two identical extreme storms recorded and no one can predict what the next extreme storm event will be like.

The Real Time Rainfall Time Series is favoured for its comprehensiveness in analysing the performance of drainage system over history, the need to avoid dubious assumptions of the initial conditions (such as soil moisture content at the beginning of the rainfall) and boundary conditions (such as coincidences of high tides with peak storms) in the catchment. It is, however, very rare to find real time rainfall time series containing extreme storm events of value for designing engineered systems.

For the PDC ICMP Project, the TP108 24-hr storm events of various annual exceedance probabilities will be used to identify drainage system performance and flood risks. Recorded extreme rainfall events together with recorded flood heights and flooding extents will also be used for calibrations of the hydrological and hydraulic models.

### *2.8.2 Historic Rainfall Records*

The Papakura Filter Station site was situated on the Hays Stream near the mouth of the Hunua Gorge at the Hunua Ranges. It is approximately 40 metres above mean sea level and at the eastern extent of the gently sloping plain falling to sea level 4 to 6 km to the west. This rainfall station was discontinued after the ownership of the water supply reservoir was taken over by Watercare Services Limited (WSL) in 1992. A new automatic rain gauge was established by WSL in a nearby site.

The Papakura Filter Station rainfall data were analysed by Snelder in 1991 and summarised in the following Tables:

**Table 3: Depth (mm) – Duration – Frequency Data for Papakura Filter Station Site (Snelder, 1991)**

| Duration / Return Period | 10 mins | 20 mins | 30 mins | 1 hrs | 2 hrs | 6 hrs | 12 hrs | 24 hrs |
|---|---|---|---|---|---|---|---|---|
| 2 Yr | 9 | 14 | 18 | 26 | 35 | 54 | 73 | 85 |
| 5 Yr | 12 | 20 | 27 | 39 | 54 | 87 | 110 | 122 |
| 10 Yr | 14 | 24 | 33 | 48 | 67 | 109 | 134 | 146 |
| 20 Yr | 16 | 27 | 38 | 56 | 79 | 130 | 157 | 169 |
| 50 Yr | 18 | 32 | 45 | 67 | 95 | 158 | 187 | 199 |
| 100 Yr | 20 | 35 | 51 | 75 | 106 | 178 | 209 | 222 |
| Standard Error* | 3.7 | 5.9 | 7.7 | 11.0 | 15.0 | 26.6 | 30.6 | 34.6 |
| | | | | | | | | |

* Standard Error of Estimate for 100 year Return Period

**Table 4: Comparison of 100 Year Rainfall Depths at Papakura Filter Station with Data from Other Rainfall Stations in Auckland Region (from Snelder, 1991)**

| Time | Papakura Filter Station 1971-1988 | Whenuapai 647601 | Albert Park 648701 1962-1985 | Pukekohe 742802 1970-1985 | Wairoa Dam 752101 1949-1971 | Manganese Mine 750103 1963-1974 | Ngakoroa 742912 |
|---|---|---|---|---|---|---|---|
| 10 mins | 20 | 26 | 23 | 24 | -- | -- | 15 |
| 20 | 35 | 44 | 38 | -- | -- | -- | 25 |
| 30 | 57 | 48 | 47 | 38 | -- | -- | 31 |
| 1 hour | 75 | 62 | 68 | 52 | 59 | 68 | 48 |
| 2 | 106 | 82 | 90 | 69 | -- | -- | 68 |
| 6 | 178 | 118 | 134 | 158 | 140 | 170 | 121 |
| 12 | 206 | 162 | 169 | 185 | -- | -- | 160 |
| 24 | 220 | 194 | 214 | 200 | 260 | 315 | 199 |

## 2.9 Tide Levels

There is no tide level record at Pahurehure Inlet. The table below is a summary of tides leveling data at Onehunga – Manukau Harbour based on the Auckland Harbour Board Datum published in 1973.

**Table 5: Tides Levels at Onehunga – Manukau Harbour**

| Tides | Levels (RL above L&S Datum 1946) |
|---|---|
| Highest Recorded Tide 21-6-47 | 2.74 m |
| Mean High Water Springs | 1.7 m |
| Mean High Water | 1.49 m |
| Mean High Water Neaps | 1.1 m |
| Mean Sea Level | 0.10 m |
| L&S Auckland Datum 1946 | 0.00 |
| Mean Low Water Neaps | -0.9 m |
| Mean Low Water | -1.5 m |
| Mean Low Water Springs | - 1.6 m |
| Lowest Recorded Tide | -2.68 m |

## 2.10 Climate Change

The Ministry for the Environment (MfE) and the New Zealand Climate Change Office have the following publications which could provide guidance for local government preparing for climate change:

1. Preparing for Climate Change – A guide for local government in New Zealand (June 2004)
2. Coastal Hazards and Climate Change – A guidance manual for local government in New Zealand

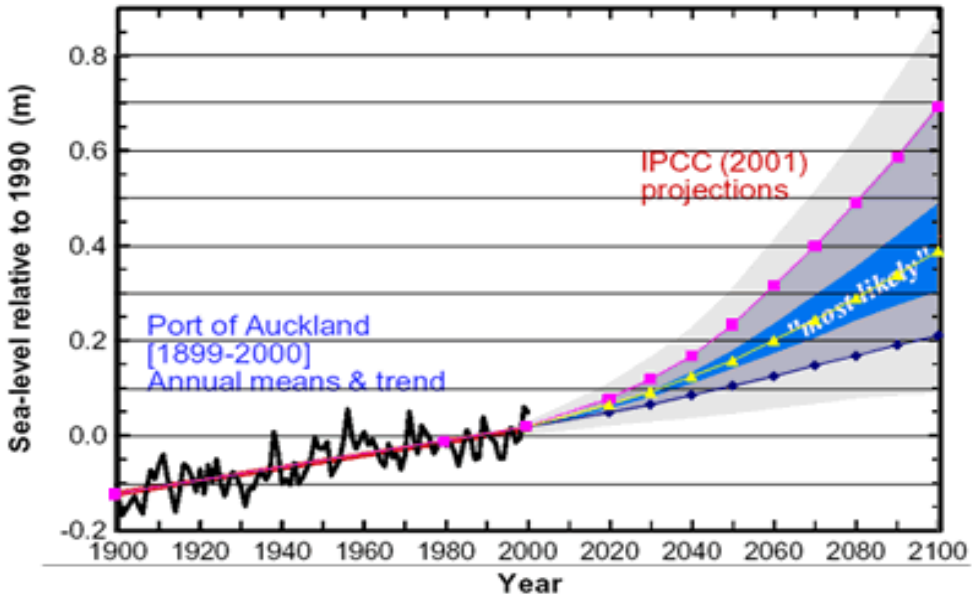
The potential impact of climate change on the stormwater catchment management is summarised below:

### *2.10.1 Sea Level Rise*

The Document 2 above recommended a future sea level rise of 0.2m by 2050 and 0.5m by 2100 (relative to 1990 levels). In general terms, accelerating sea-level rise round New Zealand may result in:

- Increased coastal erosion in some areas. Parts of the coastline that have historically been eroding may experience increased erosion trends; other areas that may have been relatively stable may begin to erode;
- Permanent high-tide inundation of very low-lying margins that may at present experience only episodic inundation;
- Episodic sea flooding of higher coastal and estuarine margins;
- Drainage problems in adjacent low-lying areas, where the gravity falls have been reduced;
- Salinisation of adjacent rivers and streams and landward intrusion of saline groundwater; and
- Increased rates and frequency of episodic wave run-up and overtopping of both natural and man-made coastal defences.

**Figure 8: Predicted Sea Level Rise at Port of Auckland**




Source: MfE/NIWA – Prepare for Climate Change

A general hierarchy of response options may include:

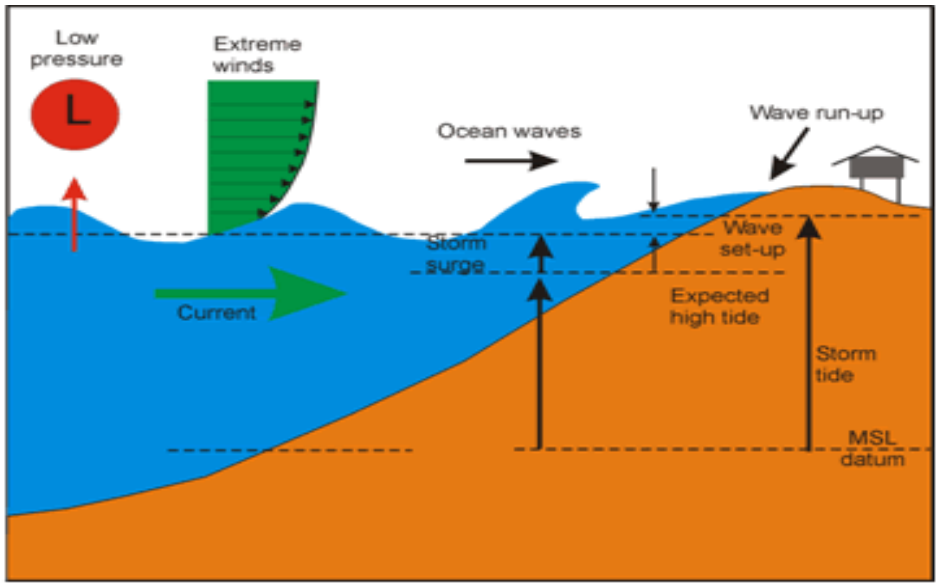
1. Restrict activities and land-use practices to protect natural defences such as sand dunes, gravel ridges, cliffs, salt marshes, and vegetation;
2. Management of land use to avoid areas of coastal hazard (e.g. location of development away from coastal hazards, retreat or relocate infrastructure);
3. Undertake 'soft defence works' such as re-vegetation, beach access-ways, beach nourishment, or drainage; and
4. Undertaken 'hard structural works' such as seawalls, rock armouring or groynes.
5. Long term monitoring of coastal hazards areas can be useful in identifying the trend of changes over time and ensure that the response options are effective and sustainable. Monitoring techniques need not be expensive; in most cases a regular photographic record should be adequate.

### *2.10.2 Increase of Storm Surge*

Storm surge can be defined as temporarily elevated sea levels due to adverse winds and low barometric pressures produced by storms. Wave set-up is the increase in sea level inside the surf zone (landward of the first wave breaks) relative to offshore storm-induced ocean level. Wave run-up is the extra height reached, over and above the storm-tide level, as the broken waves run up the beach and coastal barrier (if present) until their energy is finally expended by gravity and friction.

Storm surge heights above the predicted tide can reach around 0.5m on a yearly return period, and potentially can reach an upper limit of just over 1m around New Zealand. The likelihood of coastal inundation relates to the joint probability of a storm response coinciding with reasonably high tides. Though tides are well described, storm surge measurements around New Zealand are limited, which makes it difficult to carry out a rigorous return period analysis of the likelihood of coastal inundation from storm tides around the New Zealand coast. In the interim, the combination of an equivalent MHWS high tide level and a default value of a 0.9m storm surge, along with estimates of wave set-up and wave run-up will provide a realistic severe storm tide 'event'.

**Figure 9: Storm Tide Diagram**




Source: MfE/NIWA – Prepare for Climate Change

There are some indications that the storm surge magnitude may increase through increased storm intensity. The increased storm surge will in turn cause rises of storm tides and worsen sea floods.

Storm tide level is a useful measure for inundation from the sea, and comprises Mean High Water Spring (MHWS) + storm surge + wave set-up. The final inundation height is the sum of storm tide and the estimated local wave run-up.

The New Zealand Climate Change Office suggested that for a typical sandy coast wave set-up in the surf zone can vary from 0.6m to 1.0m resulting from offshore wave heights ranging from 4 to 7m. The wave run-up in storms can add a further 2 to 6m vertical height onto the storm tide level.

The coastlines at Papakura District are relatively sheltered, especially for the portion of the Pahurehure Inlet to the east of the Southern Motorway. Without a specific study, for the purpose of screening the risks, the wave set-up can be assumed at 0.4m and 0.6m, respectively for the sheltered coastline to the east of the Southern Motorway and for the coastline open to Manukau Harbour. The additional wave run-up heights can be assumed at 0.3m and 0.6m respectively.

### *2.10.3 Increased Rainfall*

The effects of climate change are predicted to result in both changes in long term average rainfall and changes in terms of frequency and intensity of extreme rainfall events. Changes in long term average rainfall will have implications on stream channel erosion risks, total sediment load to the receiving environments, groundwater management, water resources management and the stream habitat. Changes in extreme rainfall events are of particular importance for stormwater catchment management in terms of its implications on flood risks and performances of the drainage system.

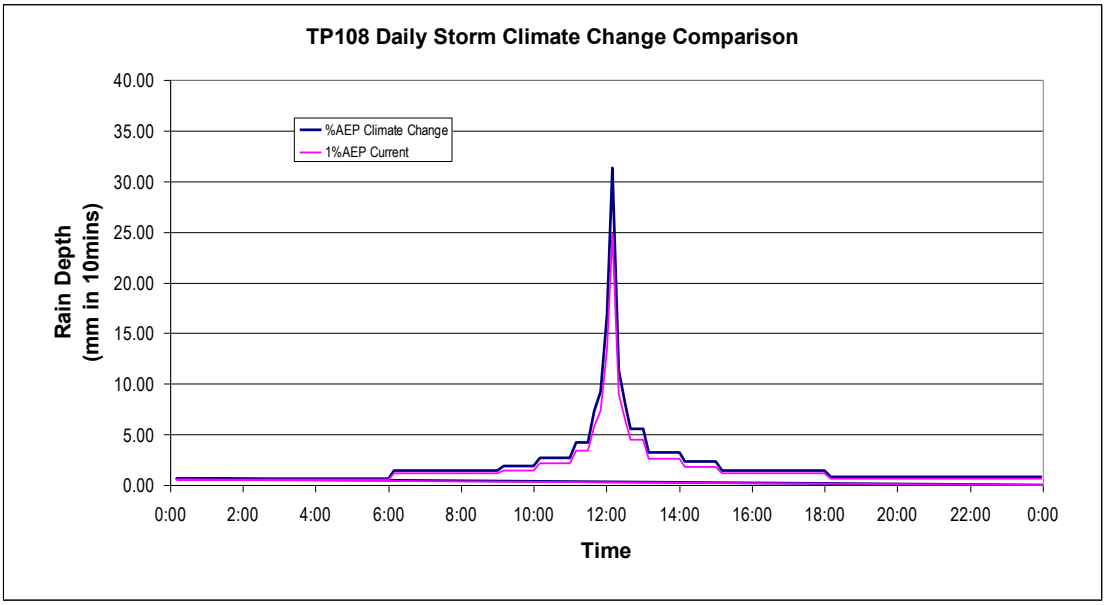
The New Zealand Climate Change Office (NZCCO) and Ministry for the Environment (MfE) have predicted the Annual Average Temperature may increase by 0.2 $^{o}$C(lower bound) to 1.3 $^{o}$C between years 1990 and 2030, and 0.6 $^{o}$C to 3.8 $^{o}$C between years 1990 and 2080.

The projected percentage adjustments to extreme rainfall intensities per degree Celsius of warming, vary from 8% for a short 10 min duration storm event to 6.7% for a 24hr duration storm event.

The predicted changes above indicate a potential increase of total rainfall depth of 25.5% (upper bound) by 2080 for a 24hr duration storm event, and a 30.4% increase for a 10 min duration storm event. In summary, we are expecting more rain with more intensified peaks.

The TP108 24hr Storm depths and temporal pattern have been adjusted according to the changes predicted by the NZCCO. Figure 10 below shows a comparison between the current TP108 1%AEP 24hr storm and the same storm adjusted for climate change.

**Figure 10: TP108 1%AEP Storm Climate Change**



# 3 CATCHMENT DESCRIPTION – LAND USES

## 3.1 Existing Land Uses

The Central Papakura Area includes the following traditional stormwater catchment areas known as Old Wairoa Road Catchment, Elliott Catchment, Prince Edward Catchment and Pahurehure Catchment. A map showing the District Plan land uses in these subcatchment areas is included as Existing Land Uses Map in Appendix A.

Land uses in the Central Papakura Area are dominated by residential activities. The commercial land uses are mainly centered around the Central Business District which straddles the Old Wairoa Road Catchment on the east side and the Elliott Catchment on the west side.

In the Old Wairoa Road Catchment, there are a few industrial and commercial developments on a strip next to the NIMT railway corridor on the east side. Existing residential development dominates the area between the Old Wairoa Road and the Clevedon Road. Takanini Structure Plan Area 2b and Area 4 are situated at the eastern extreme of the Old Wairoa Road Catchment, these areas are currently used for grazing and horse trekking.

TSP Area 2a is bounded by Walters Road to the north, Cosgrave Road to the east, Grove Road to the west and Fernaig Street to the south. This area is also currently used for horse trekking and grazing.

The Papakura Military Camp occupied a large area to the west of Grove Road, Housing New Zealand is developing a medium density housing development on the land to the west of the current Military Camp. This area is identified as TSP Area 3. The McLennan Park is situated to the south of Area 3, and it is mostly occupied by the Artillery Drive Pond and the Papakura Soccer Club.

In the Elliott Catchment, commercial land uses are mainly concentrated at the eastern extremity in an area bounded by Railway Street to the east, Wood Street to the west and south, and Elliott Street to north. Kirks Bush and the Southern Park lie in the southern side of the catchment, while the Ray Small Park and RSA buildings are situated in lower northern end of the catchment. The remaining land uses in Elliott Catchment are predominately residential.

Commercial land uses at the Prince Edward Catchment are primarily situated between Queen Street and Elliott Street. The Prince Edward Park is the main feature of this catchment lying between Wharf Street and Green Street. Residential developments make up the remaining catchment. The Pahurehure Catchment is bounded by the Southern Motorway on the western side, Elliott Street on the southern side and the Pahurehure Inlet surrounds the northern and eastern sides. The land uses in the Pahurehure Catchment are mainly recent residential development from the 1980s and 1990s.

## 3.2 History and Historic Sites

The Central Papakura Area, like many other parts of Papakura, has a history of human occupation and modification that extends back through tradition to the earliest period of settlement in the Region. The Tangata Whenua tribal groups in occupation of this area could trace their ancestry back to the earliest occupants of the land, and in particular to the Tainui Canoe, which entered the Manukau Harbour in the

fourteenth century. Because of its strategic location, this area was occupied by a number of iwi groups including Te Akitai, Ngai Tai, Ngati Tamaoho and Nagti Pou, etc, all being unified as part of the wider tribal confederation known as 'Te Waiohua'.

The first missionaries arrived in Papakura in 1834, and afterwards an increasing number of Europeans began to pass through the Papakura and Drury area as they travelled south to the Waikato via the overland route from Auckland and Manukau Harbour. The Crown purchased the 'Papakura Block' from the people of Te Akitai and Ngai Tai in January 1842 because its' strategic importance. This ill defined land block extended from Papatoetoe to just south of the present-day Papakura.

Recorded heritage sites in Central Papakura include the Selwyn Chapel building at 105 Great South Road, and Kirikiri Redoubt site at 935 Clevedon Road. Middens and other evidence of early Maori settlement were also found during the construction of the Artillery Drive Pond.

## 3.3 Population and Planned Growth Centres

The current population in Papakura District is approximately 45,450 according to the latest census data (2007). The future population and growth centres in the District are planned in the Auckland Regional Growth Strategy 2050, the Southern Sector Agreement, the Takanini Structure Plan and the Central Area Structure Plan.

### *3.3.1 Auckland Regional Growth Strategy: 2050*

The Regional Growth Forum (RGF) has prepared a Regional Growth Strategy looking ahead to the year 2050, to ensure the growth is accommodated in a way that meets the best interests of the inhabitants of the Auckland Region. The strategy provides vision for the Auckland Region with a population of two million in 2050.

The Regional Growth Forum consists of 10 elected representatives (mayors and councillors) from the Auckland Regional Council, Rodney District Council, North Shore City Council, Waitakere City Council, Auckland City Council, Manukau City Council, Franklin District Council and Papakura District Council. The Regional Growth Forum is a standing committee of the Auckland Regional Council and was established under an amendment of the Local Government Act 1974 in 1999.

Key features for future growth in the Southern Sector which includes Manukau City, Papakura District and Franklin District, have been identified in the growth concept by the RGF:

In the south, growth would be focused on two broad corridors, the southern rapid transit corridor or motorway, and further east in band along the current urban edge. Forty-four percent of growth could be by intensification, i.e. in centres and corridors within the existing urban area. There would also be some more intensive development at centres in the greenfield development areas. Papakura and Manukau City will become the two sub-regional centres. Greenfield development areas including Takanini, Redhill and Hingaia and other areas in Manukau City and Franklin will eventually accommodate around 85,000 people (30% of growth in the Southern Sector). The South could be home to around 600,000 people by 2050, which will nearly double the 1996 population of 325,000.

### *3.3.2 Southern Sector Agreement*

As part of the implementation process for the Growth Strategy, each Local Authority in the region, as well as the Auckland Regional Council (ARC), has signed a Memorandum of Understanding (MoU) to define and agree upon the responsibilities of the main stakeholders responsible for implementation of the strategy.

Providing for future growth within the Papakura District means that the current population of approximately 42,000 will grow to approximately 94,000 by 2050. The growth strategy proposes that this growth be accommodated in the following manner: 12,000 (23%) in existing rural and urban residential areas, 5,000 (10%) in the Papakura Central Area, and 35,000 (67%) in the growth areas.

It is predicted that a population growth of 24,000 will be accommodated by 2020, allowing for a vacancy factor of 20%. The agreement proposes to distribute this as follows: 5,520 (23%) in the existing rural and urban residential zoned areas; 2,400 (10%) in the Papakura Central Areas and 16,080 (67%) in Takanini and Hingaia areas.

### *3.3.3 Takanini Structure Plan*

Takanini has been identified as one of the greenfield areas on the Growth Strategy Map 2050. The Takanini Greenfield area is identified in the Growth Strategy as future urban with a land area of 1,100 ha. The area is generally bounded by the railway line to the west, the district boundary with Manukau City in the North, following a line South-west to Mill Road, along Mill/Cosgrave Roads in the east and Walters/Grove/Old Wairoa Roads in the South.

For Takanini, the Growth Strategy set the following requirements:

- An additional 20,000 people will have to be accommodated
- At least an additional 3,000 job opportunities will have to be provided.

As a result of community consultation through a charette process, some broad design concepts were developed which include the following for stormwater management:

*An open space network that incorporates stormwater management and water quality systems should be provided.*

*The management of stormwater in the area underlain by peat is subject to the following key limitations:*

- *Groundwater recharge must be maintained in order to ensure that the peat layer does not dry out and settle;*
- *The groundwater level is reported to rise to the surface in winter in parts of the area (to be confirmed by monitoring) causing localised ponding;*
- *The area is very flat, and the available gradient for drainage is low;*
- *The existing drainage systems into the Pahurehure Inlet have limited capacity to accommodate the additional stormwater flow from the Structure Plan Areas. (New stormwater infrastructure including those for conveyance and treatment will need to be provided to minimise any effects on existing urban areas.) (Takanini Structure Plan, Urban Initiatives Ltd, 2000)*

A key objective for stormwater management in this area is to prevent lowering of the groundwater level.

In the existing areas of Papakura that have been developed over peat, stormwater is discharged to soakage pits with overflows to a reticulated drainage system. If inadequate recharge has been provided at the existing development, then the requirements of stormwater recharge in the new development will need to be reviewed to ensure that the lack of recharge in the existing development area can be compensated to a certain degree.

### *3.3.4 Papakura Central Area Structure Plan*

The Papakura Central Area Structure Plan (Structure Plan) was prepared by Urban Initiatives for PDC in February 2000.

The Auckland Region Growth Forum has identified a growth node around the existing Papakura Railway Station. The Structure Plan foresees significant population growth (5000+) in the Central Papakura Area, envisaging this area becoming the focal point to users of the future much improved rapid transit system.

The Structure Plan promotes further high density residential development in the Central Business District area, by incorporating commercial development at the bottom floors of apartment buildings.

New cycle ways and pedestrian accesses have been planned to radiate from the Railway Station into the surrounding residential areas. Through taffic and large commercial vehicles will be diverted away from busy commercial areas. Certain intersections will require upgrading.

The Structure Plan also recognises the need to upgrade the existing stormwater system due the higher density promoted in the Central Area. However, as the existing imperviousness is already high in the CBD area, only marginal increase in imperviousness is foreseen during the redevelopment proposed in the Structure Plan.

It is envisaged that flood nuisances due to the low level of service limited by the capacity of the existing drainage system tolerated by existing industrial and commercial users may not be acceptable once the area is redeveloped into premises with higher economic values and increased resident population. Perception of general public towards flooding risks and nuisances will also shift as the areas are transformed. Expectations towards higher levels of service by the general public will be likely.

As the population and traffic volume increase in the CBD area, it is foreseen that more contaminants may enter the stormwater system, and potentially worsen the water quality in the receiving environments. Proper stormwater quality management practices will need to be put in place to avoid the impact on water quality.

## 3.4 Land Use Scenarios

The following future land use scenarios may be considered for the purpose stormwater catchment management:

- Existing land uses – the Base Scenario
- The current District Plan and Structure Plans Permitted Development Scenario
- The Maximum Probable Development Scenario under the current District Plan and possible plan changes

### *3.4.1 Existing Land Uses*

Existing land uses in the Central Papakura area are basically in line with the current District Plan. In the Old Wairoa Road catchment, some further subdivision opportunities exist in the area to the east of the NIMT railway, while the remaining catchment area is very much filled. Although, development opportunities can still be found by adjusting boundaries of existing lot to combine some of the vacant lands.

Existing impervious surfaces including roofs and paved surfaces at all commercial and industrial properties were mapped based on the 2001 aerial photos in the PDC GIS system. Impervious surfaces for pockets of residential development sampled to represent specific eras of construction were also mapped in GIS based on the 2001 aerial photos. The imperviousness for the remaining residential areas were analysed from the building footprint data covering the whole district combined with estimated percentage of paved surfaces for typical residential development for the era of construction.

A summary of percentages of impervious surfaces in all sub catchment areas is included in Appendix B – Hydrological Modelling Data.

### *3.4.2 Permitted Development Scenario*

The rules for permitted development activities for Central Papakura area are prescribed in the current District Plan. The most important aspect of rules is the limits set out for roofed areas and paved surface areas in terms of percentages of the total site areas. The Papakura District Plan also specifies slightly higher limits of imperviousness for Discretionary Activities in various zones.

**Table 6: Papakura District Plan and Takanini Structure Plan Imperviousness Control**

| Papakura District Plan Zones and Imperviousness Control | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Permitted | | | Discretionary | | |
| | Zone Name | Roof | Paved | Total | Roof | Paved | Total |
| Current District Plan | Residential 1 | 35% | 25% | 60% | 40% | 25% | 65% |
| | Residential 2 | 40% | 25% | 65% | 40% | 25% | 65% |
| | Residential 7 | 35% | 25% | 60% | 40% | 25% | 65% |
| | Reserve | 5% | 10% | 15% | 5% | 10% | 15% |
| | Business | 50% | 40% | 90% | 50% | 40% | 90% |
| | Industrial | 50% | 40% | 90% | 50% | 40% | 90% |
| | Rural Papakura | 1% | 1% | 2% | 1% | 4% | 5% |
| | Rural Residential Zone | 5% | 5% | 10% | 5% | 5% | 10% |
| | Rural Takanini / Drury | 2% | 3% | 5% | 2% | 3% | 5% |
| | Community Service Zone | 40% | 30% | 70% | 40% | 30% | 70% |
| | Special Prupose 1 Zone | 25% | 25% | 50% | 25% | 25% | 50% |
| | Special Prupose 2 Zone | 25% | 25% | 50% | 25% | 25% | 50% |
| | Special Prupose & Recreation Zone | 5% | 5% | 10% | 5% | 5% | 10% |
| Takanini Structure Plan | 1B | 40% | 30% | 70% | 40% | 30% | 70% |
| | 1A | 50% | 40% | 90% | 50% | 40% | 90% |

### *3.4.3 Maximum Probable Development Scenario*

The Maximum Probable Development (MPD) scenario takes into account possible plan changes for land use activities in the catchment area initiated by both Council and private developers.

In the Central Papakura Area, minimum lot sizes for TSP Area 2A & 2B were specified in the Takanini Structure Plan and these were adopted for the previous CMP by H&G. Currently H&G on behalf of Cosgrave Residents and Landowners Association Incorporated and Kirikiri Residents and Landowners Association Incorporated, is proposing a private plan change for the 2A & 2B area, which promote a higher density and smaller lot sizes (see **Table 7** below). These changes of land use will increase the imperviousness of the sub-catchment areas concerned, and have considerable hydrological effects on the downstream system. The land use scenario in the current private plan changes is considered the maximum probable development scenario for the area.

**Table 7: TSP Areas 2A&2B MPD Scenario**

| Zone | Description | Density | | MPD Imperviousness* | Remark |
|---|---|---|---|---|---|
| Area 2b | Low Density Residential | 500 | $m^2$/lot | 65% | An average density of 600m2/lot, 15 lots/ha, and a lot impervious area of 40%, allowed in the CMP |
| Area 2a | Low Density Residential | 400 | $m^2$/lot | 70% | An average density of 600m2/lot, 15 lots/ha, and a lot impervious area of 40%, allowed in the CMP |

# 4 RECEIVING ENVIRONMENTS

## 4.1 Marine Receiving Environment - Pahurehure Inlet

The Pahurehure Inlet is a shallow sheltered inlet, with the Southern Motorway traversing through the middle and dividing the inlet into two distinctive portions. To the east of the Motorway, the inlet is further sheltered by the motorway embankment, where mangroves are fast spreading. A shallow tidal flow channel have formed upstream of the motorway culvert pipe. To the west of the Motorway, the inlet is more exposed to tidal flushing. The increased shelter of the inlet area to east of the Motorway have led to increased rates of sediment deposition.

Larcombe reported that the increased sheltering, possibly together with raising of the seabed by sediment accumulation, has led to major spreading of mangroves within the inlets east of the motorway. Mangroves in turn increase the roughness of the sea bed, filter and adsorb fine sediment trough their leaves and stems like wetland plants, thus increase sediment retention in the area. The sediment that has accumulated within the inlets east of the motorway is unlikely to be entirely from the land catchments with discharge into the inlet. Large quantities of sediment can be transported into such sheltered inlets from seawards tidal current during rising tide periods and then deposited over the high tide period. (Larcombe, 2000)

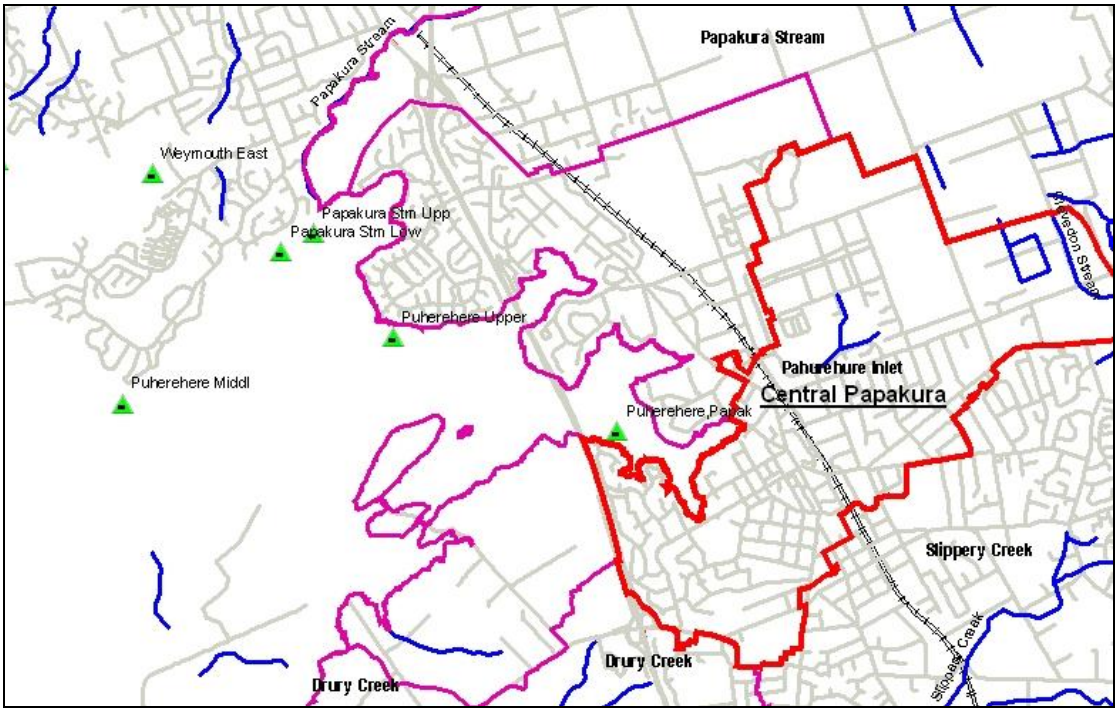
The Pahurehure Inlet is identified as General Management Area on the Map Series 1 – Sheet 14 on the Auckland Regional Plan: Coastal Maps. To the south of Pahurehure Inlet, Drury Creek is identified as Category 1 Coastal Protection Area (CPA).

As a part of the Auckland Regional Council Regional Discharge Project, three settling zone sites and two outer zone sites are being monitored in the proximity of the Pahurehure Inlet. The monitoring results presented in the 2003 report (ARC, TP203) indicate that all sites are currently in Green Status, in terms of sediment quality tested for concentration of Zinc, Copper, Lead and PAHs (Polycyclic Aromatic Hydrocarbons). Green status is determined based on the Environment Response Criteria (ERC) set out in the document “Blueprint for Monitoring Urban Receiving Environments” (ARC, TP168).

### *4.1.1 Regional Discharge Project Monitoring Sites*

The Auckland Regional Council established the Regional Discharge Project (RDP) to coordinate the renewal of stormwater discharge consents throughout the Auckland Region. Sediment quality guidelines, methods of assessing marine ecological health and receiving environment status determined based on the Environment Response Criteria (ERC) were developed as part of this project and published in “Blueprint for Monitoring Urban Receiving Environments” (ARC, TP168).

**Figure 11: Pahurehure Inlet RDP Monitoring Sites**




ERC for key marine sediment contaminants have been developed based on recommendations in the ANZECC Water Quality Guidelines (ANZECC, 2000) and other internationally recognised guidelines (Williamson & Mills, 2002). The primary stormwater contaminants of concern for the urbanised Auckland Region are Zinc, Copper, Lead and PAHs (Polyaromatic Hydrocarbons). As referred to earlier, ERC for these contaminants are presented in an analogous fashion to traffic lights: with Green representing low; Amber, elevated; and Red, high contaminant concentrations. Threshold values are shown in Table 6 below:

**Table 8: ERC for Marine Sediment (mg/kg)**

| Traffic Light Colour | Zinc | Lead | Copper | PAH |
|---|---|---|---|---|
| Green | <125 | <30 | <19 | <0.66 |
| Amber | 125-150 | 30-50 | 19-34 | 0.66-1.7 |
| Red | >150 | >50 | >34 | 1.7-3 |

*Source: ARC TP168

There are three sediment quality monitoring sites situated in the proximity of Pahurehure Inlet, as shown in **Figure 11** above. The Pahurehure Upper and Pahurehure Middle sites are both in the outer zone, and the Pahurehure Papakura site is in the deposition zone to the east of the motorway and this site is also an ARC Long Term Baseline (LTB) monitoring site.

### *4.1.2 Marine Sediment Quality and Trend*

As part of the ARC Regional Discharge Project, marine sediment samples were taken at the three Pahurehure Inlet monitoring sites separately in 1998, 1999, 2001 and 2003. The total metal concentrations in terms Zinc, Copper and Lead in

sediment less than 300 µm are all below the ERC threshold value for Green status (ARC, TP203, 2003). Although, there is a clear uprising trend of metal concentration in silt sediment (<63 µm). **Table 9** and **Table 10** below show marine sediment test results for heavy metals between 1998 and 2003.

**Table 9: Pahurehure Inlet Marine Sediment Total Metal Concentration (mg/kg)**

| Year | 1998 | 1999 | 2001 | 2003 | ERC Green |
|---|---|---|---|---|---|
| **Zn** | 64 | 71 | 72 | 66 | 125 |
| **Cu** | 13.8 | 10 | 7.3 | 8 | 19 |
| **Pb** | 6.5 | 15.2 | 7.1 | 14.6 | 30 |

**Table 10: Marine Sediment Metal Concentration In Silt Fraction (mg/kg) (<63 µm)**

| Year | 1998 | 1999 | 2001 | 2003 | ERC Green |
|---|---|---|---|---|---|
| **Zn** | 61 | 65.8 | 68.5 | 86.6 | 125 |
| **Cu** | 6.2 | 6.5 | 6.6 | 8.5 | 19 |
| **Pb** | 18.9 | 14.2 | 12 | 21.4 | 30 |

**Figure 12: Trend of Metal Concentration in Silt Faction**

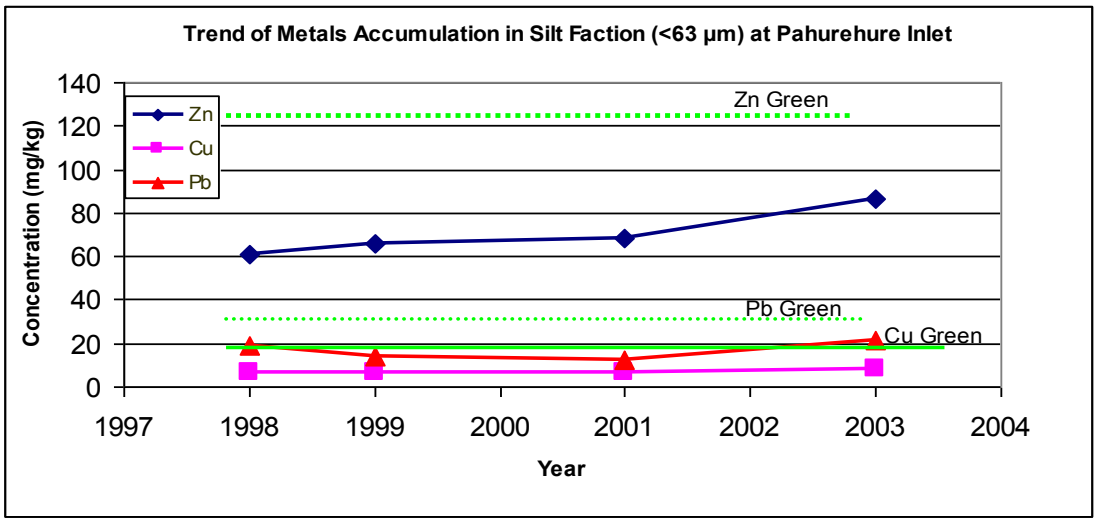
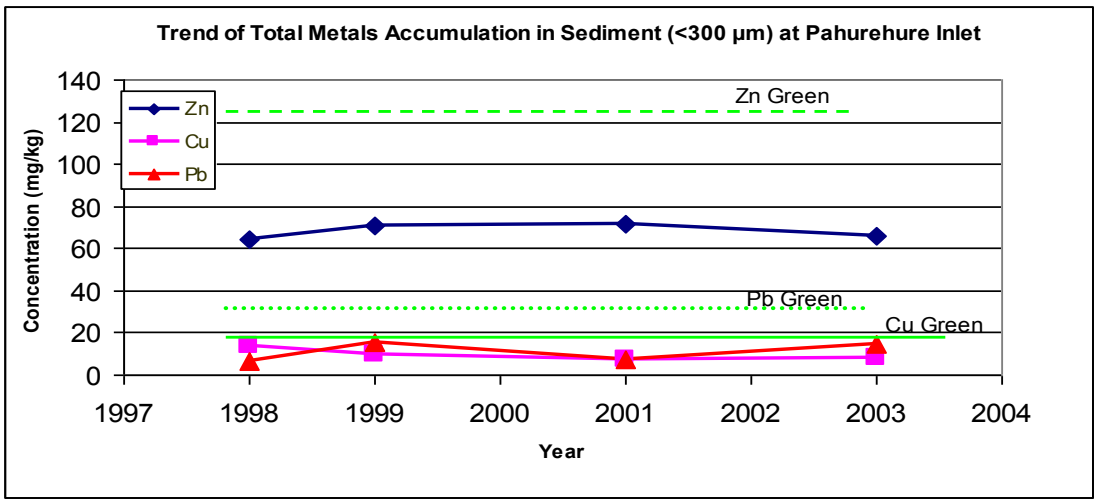



**Figure 13: Trend of Total Metal Concentration**



Zinc stands out as the metal most likely exceeding the ERC at Pahurehure Inlet, it has also been identified as being critical in most sites monitored in the region. Copper is the next metal likely exceeding the ERC, however, no clear rising trend has been shown in the monitoring so far. In 1987 New Zealand started moving to unleaded petrol, and became lead free in the petrol market in 1995. Adding lead to petrol has become illegal in New Zealand since Jan 1996. Therefore, we would believe the overall lead generations from urban area should have been reduced significantly. The current sediment sampling data shows no clear rising trend in lead concentration; some further monitoring will be required to confirm this.

Based on particle size distribution analyses on marine sediment samples at Pahurehure Inlet, the silt faction (<63 µm) is only 8.6% of the total sediment less than 300 µm, but the silt faction contributes 38.2% of total surface area of all sediments. The surface area is related with the contaminants (including heavy metals) adsorptive capacity of specific faction of the sediment.

Therefore, some emphasizes should be placed on removing sediment particles below 63 µm in the catchment directly contributing to Pahurehure Inlet.

### *4.1.3 Sedimentation Rate*

William and Wilcock (1994) reported sedimentation rates of 6.6mm/year at a site in Pahurehure Inlet east of the junction between the Oira Creek Channel and the main inlet channel, and 5-7mm/year adjacent to the Drury Creek off the Hingaia Peninsula. These rates are much higher than reported for open areas of the harbour where sedimentation rates are typically less than 1mm/year (Larcombe, 2000). Most estuary channels in Pahurehure Inlet are shallow and at risks of being filled.

### *4.1.4 Marine Water Quality*

Concentrations of dissolved copper and zinc can exceed Water Quality Guidelines in stormwater runoff from urban areas. Potentially, concentration of metals could exceed the Water Quality Guideline in marine receiving water, but there is little data to assess the frequency, magnitude, or extent of exceedance in Auckland. However, exceedances for dissolved metals are not expected to be widespread and/or persistent in the marine environment (ARC, TP168, 2004).

There is no historic record of marine water sampling at Pahurehure Inlet.

The complexity of hydrological processes such as persistence of salinity gradients, mixing, dispersion, storm flows, and tidal currents, makes it very difficult to sample on site.

The Global Manukau Harbour Model currently being developed by NIWA will hopefully identify areas of concerns in terms of marine water quality, where future marine water sampling can be undertaken in the future at Pahurehure Inlet. With significant growth areas, such as Hingaia Peninsula and Takanini, and increased traffic volume on major roads, the status of the receiving environments may need to be closely monitored.

Once the model is developed, it can also be used to examine a range of scenarios (land use changes, stormwater management practices, storm sizes, etc) to see how often, and under what conditions, marine water quality ERC (Table 5.2, TP168, ARC) are exceeded in estuaries and coastal areas.

Notwithstanding the limitations to the current status of understanding of inlet's behaviour, the Pahurehure Inlet is considered to have (overall) medium to low marine sensitivities (Auckland Regional Growth Forum: 1998). This means that the receiving environment will experience moderate to low adverse effects from the discharges of contaminants as results of stormwater runoff.

### *4.1.5 Ecological System*

There are a variety of birds that use the inlet for feeding and roosts including black shags, pied shags, pied stilts, godwits and oystercatchers. Migratory fish species include eel, common bully and whitebait in the southern branch with juveniles of flounder, snapper, mullet, kahawai and trevally (amongst others) likely to use the northern inlet as a nursery and refuge from predation. Typical mudflat communities are dominated by mud snail and mud crab and snapping shrimp. (Harrison Grierson, 2001)

ARC has developed benthic community health models for both the settling zone and outer zone. Ecological samples were taken by ARC from ten settling zone sites all ranked red or amber in terms of sediment quality. The benthic community health at all of these sampling sites was ranked amber (ARC, TP203). However, no sampling site in the above studies was situated in Pahurehure Inlet.

Mangrove marsh occupies extensive areas within the inlet area to the east of the motorway. Mangroves are in good condition and mangrove marshes are of moderate ecological value because of their high productivity of natural organic matter which is utilized by the marine food web, and their function in trapping sediments and nutrients, reducing wave run-up and reducing shore erosion by increasing the seabed roughness and dissipate the wave energy.

Mangroves appear to have spread rapidly within the sheltered areas of the eastern Pahurehure Inlet. Coffey (2000) predicted, that in the absence of proactive control measures, mangroves will rapidly colonise remaining mud flats in the upstream section of the Pahurehure Inlet to the edge of the existing low tide channel. Coffey also predicted a rate of mangrove spread at 1.34ha per annum and an estimated doubling time of approximately 17 years which is relatively conservative when comparing with a doubling time of 3~4 year at Whangamata Harbour observed by the Harbour Care group. Fast spreading of mangroves will reduce the open water area and encourage further sedimentation in the sheltered inlets.

### *4.1.6 Global Model*

The trend of changes in water/sediment quality in the Puhurehure Inlet has not been well understood yet. With significant growth areas, such as Hingaia Peninsula and Takanini, and increased traffic volume in major roads, the status of the receiving environments may need to be closely monitored.

ARC is currently planning a global model for the Manukau Harbour including Pahurehure Inlet, to understand the hydrodynamics and the fate of contaminant in the receiving environments. Once completed, the model will be able to simulate the long term effects of changes of land uses in the contributing catchment area covering parts of Manukau City, Papakura District and Franklin District.

The Pahurehure Inlet is considered to have (overall) medium to low marine sensitivities (Auckland Regional Growth Forum; 1998). This means that the receiving

environment will experience moderate to low adverse effects from the discharges of physical and chemical contaminants likely resulting in stormwater runoff.

### *4.1.7 Community Uses and Activities in Marine Receiving Environment*

Recreational use is limited with some duck shooting and recreational shellfish gathering. There is some boating and kayaking on the inlet, and the Papakura Sea Scouts Group operate from the Young's Beach Reserve but this is limited by the tidal nature of the inlet.

With an intention to improve the community's access to recreational use of the inlet, PDC initiated a study in 2002 to investigate the possibility of creating a weekend recreational lake in the inlet area inside the Southern Motorway by installing a tidal gate.

In November 2006 the Papakura District Council endorsed a Pahurehure Inlet Management Plan with a vision of promoting a high quality recreational, cultural and ecological precinct. This Management Plan is now formally endorsed by the Auckland Regional Council.

**Shellfish Gathering**
An inventory of edible shellfish present in the eastern Pahurehure Inlet was undertaken by Bioresearches (1992). Edible shellfish recorded were the mud snail Amphibola crenata, cockle Austrovenus stutchburyi, Pacific oyster Crassostrea gigas, though shell Mactra ovata, the whelks Cominella glandiformis and Cominella adspersa, and the top shell Diloma subrostata. (Bioresearches, 1992)

Mud snails attained an attractive edible size of 20mm or greater width in several areas. Small numbers could be taken for food, but the generally muddy habitat would make harvesting unappealing.

Cockles occur locally in beds with moderate densities. Most cockles were smaller than the attractive edible size of 25mm, but some beds well offshore in the centre of the inlet contained moderate numbers of attractive edible size. Large numbers of cockles are unlikely to be taken from the area because of the access to beds with cockles of attractive size, and the generally soft sediment conditions.

Pacific oysters are abundant and of large size. Some harvesting for food probably occurs, but access to the oyster beds is difficult because the soft muddy sediment in surrounding area.

**Contact Recreation**
There is no important public bathing beach within eastern Pahurehure Inlet, and the potential for contact recreation is limited by the shallow nature of the inlet and the generally muddy sediments. Small numbers of residents probably swim and undertake water contact recreation in areas where there are small beaches of sandy sediment about high tide level.

Due to the lack of recreational bathing beach areas in the District, PDC currently is not running any bathing beach water quality monitoring programme.

**Boating**
Boating uses of the inlet area east of the Drury Creek channel are limited because of the shallow nature of the area and the muddy sediments.

Kayakers use the motorway culvert at the southern inlet east of the motorway particularly when spring tides generate strong tidal currents through the culvert.

**Fishing**
Commercial fishing for flounders and grey mullets occurs within Pahurehure Inlet, particularly near the Drury Creek channel and the drainage channel from the eastern inlet.

Some recreational fishing is to be expected including set netting, drag netting and spearing for flounder, and set netting for grey mullet. Boat based line fishing occurs in the Drury Creek Channel, and in the western inlet.

**Passive Recreation**
Many foreshore reserves give access around the eastern Pahurehure Inlet, Walking and viewing are important recreational uses of the coastal area.

### *4.1.8 Potential Impact of Future Development on Marine Receiving Environments*

Urban developments are well known to increase peak discharge and total discharge volume during rainfall events, due to:

- decreased soil infiltration at impervious areas and at compacted pervious areas,
- reduced surface depressional storage,
- reduced time of concentration, and
- reduced evapotranspiration due to removal of vegetation and reduction of stored water both at the surface and in the root zone.

Urban developments are also known to increase contaminant generation in the stormwater runoff typically including both particulate and dissolved metals, Polycyclic Aromatic Hydrocarbons (PAHs), E coli and nutrients.

During the earthwork stage, excessive sediment can also be generated from construction sites if proper sediment retention measures are not implemented and maintained.

In May 2000, a report was prepared by Michael F. Larcombe for Papakura District Council titled “Effects of Stormwater Discharges from The Takanini Structure Plan Area on The Coastal Marine Environment”. This report forms part of the background research in support of the Takanini Structure Plan.

Larcombe concluded that “The increased peak flows and quantities of stormwater discharged to the Pahurehure Inlet during major rain storm events would not have any significant adverse effects on the marine area. The increased quantities of freshwater would have only local and short term salinity reduction effects because of the high degree of flushing and mixing of waters of the eastern inlet. The marine organisms of the inlet are tolerant of such salinity changes.”

Stormwater treatment devices and other low impact design techniques incorporated into the future urban development will also remove at least 75% of Total Suspended Solids (TSS) from the stormwater runoff.

Dissolved metals and metals attached to fine silt particles (especially Zinc) are also of concern. The existing monitoring data already show that there might be a rising trend of Zinc concentration in the fine silt faction of the marine sediment. Dissolved metals in stormwater runoff will also likely precipitate when the freshwater encounters saline water.

The stormwater quality management options are discussed in detail in Chapter 9.

## 4.2 Freshwater Receiving Environment

### *4.2.1 Natural Streams*

Two major natural streams are in the Central Papakura Area, namely the Old Wairoa Stream and the Clevedon Stream. Both streams are situated in the Old Wairoa Road catchment. They were surveyed and sampled by H&G in 2001 for assessment of habitat and ecosystem health in support of the Old Wairoa Road Catchment Management Plan. The H&G assessment report is included in Appendix D.

The Old Wairoa Stream was also surveyed and sampled by NIWA in 2006. Two sections of Old Wairoa Stream in the Central Papakura Catchment Area have been investigated in detail in terms of sediment quality, existing habitat, and ecological value and improvement options.

Samplings at Site 20 on the western branch of the Old Wairoa Stream show a poor fish community, elevated Zn concentration in sediment and a poor macro-invertebrates community, which was probably aggravated by the low or nil summer base flow condition.

The eastern branch of the Old Wairoa Stream originates from the Papakura Military Camp site and ends at the Artillery Drive Pond. Samplings at Site 21 indicated a good fish community and a fair macro-invertebrates community.

**Figure 14: Ecological Survey at Old Wairoa Stream**

The H&G 2001 fish survey found banded kokopu at the Clevedon Stream and the eastern branch of the Old Wairoa Road Stream. Some riparian vegetation has been planted at the eastern branch of the Old Wairoa Road Stream as part of the construction work at Artillery Drive Pond.

Historic drain clearing at some sections of both streams have damaged the riparian vegetation and in-stream habitat. The channel downstream from the Clevedon Stream in Area 4 has been heavily impacted by stock damage to the bank and the bed. The stream beds were dominated by fine mud and emergent aquatic vegetation. The Clevedon Stream had no shade from riparian vegetation along most its length.

NIWA recommended management options for these natural streams. The stream management options are discussed in Chapter 9 of this report.

### *4.2.2 Classification of Urban Streams*

Both the Old Wairoa Stream and the Clevedon Stream have been identified as permanent streams due to the presence of banded kokopu and broad-fin eels. As part of the PDC ICMP project, NIWA investigated all streams in the District and summarised their findings in the report "Papakura ICMP – Stream Management Component" (NIWA, 2006) which is included in Appendix C. Reaches of the streams have been classified by NIWA in accordance with the "Framework for Assessment and Management of Urban Streams in the Auckland Region" (ARC, TP232, 2004). The Classifications of the stream reaches are summarised in **Table 11** below.

**Table 11: Central Papakura Stream Classification**

| Site # | Stream Name | Site Location | Classification | % Imperv* | Data Collected |
|---|---|---|---|---|---|
| **20** | Old Wairoa | Upstream of Artillery Dr Pond | 3 | 24% | SEV, E Coli, Sed, WQ |
| **21** | Old Wairoa | Downstream of Military Camp | 3 | 20% | SEV, E Coli, Sed, WQ |
| **-** | Clevedon | Clevedon Rd | 3** | 1% | - |

* Imperviousness of existing development at 2005

**Classification inferred from previous H&G assessment (2001)

Type 3 stream reaches are generally found in catchments of moderate imperviousness (10~25%), and have been affected by their surroundings, but not highly modified. Natural values are somewhat degraded; however, these reaches offer the best opportunities for restorative action. Management objectives for these reaches are focused on fish passage and maintaining or enhancing amenity value and ecological function. Flood mitigation is also seen as an important function. (ARC, Regional Plan ALW)

### *4.2.3 Community Use and Activities in Freshwater Receiving Environment*

Passive recreational activity such as walking and viewing at the stream corridor are expected in the future once good riparian vegetation together with footpaths have been established at these stream reaches. Some children in the neighbourhood may

also play in the stream catching eels etc, but this should be discouraged due to both safety and ecological concerns.

### *4.2.4 Potential Impact of Future Development on the Freshwater Environments*

Future development in the catchment will potentially have the following impact:

- Increased channel defining peak discharge through the stream which may increase the potential for stream bank erosion,
- Low flow may be reduced due to reduced infiltration post development,
- Both water quality and sediment quality may be worsened due to contaminated runoff from the future urban area, if the stream reaches are upstream from the stormwater treatment devices, and
- Diversion of the Clevedon Stream from the Papakura Stream to Old Wairoa Stream may be necessary

However, opportunities for significant improvement to the existing stream reaches also come with future development:

- Restoration of riparian vegetations
- Eliminate stock access to stream channels
- Improved public access to the stream corridors, and
- Removal of fish passage barriers.

The stream management options are discussed in detail in Chapter 9.

## 4.3 Groundwater/Aquifers

As discussed in Section 2.5, there are six separable aquifer systems at the Clevedon Valley Aquifer.

Water samples from the bores in the various aquifer layers were analysed for their suitability for irrigation purposes, as part of the Clevedon Valley Groundwater Investigation. No surface water related contamination was identified.

Due to the relative small area of future urban development in the overall Clevedon Valley Aquifer area, and the low permeability (1x 10 e-8) of both the clayey peat soil and the underlying Waitemata and Greywacke soils, it is unlikely that existing and future urban development will cause contamination in the groundwater in the aquifers, even taking into account the implementation of shallow groundwater recharge system in the future urban areas.

Maintaining the level and mechanisms of recharge to these aquifers are critical for the success of development in these areas.

# 5 DRAINAGE SYSTEM OVERVIEW

## 5.1 Central Papakura Stormwater Drainage System

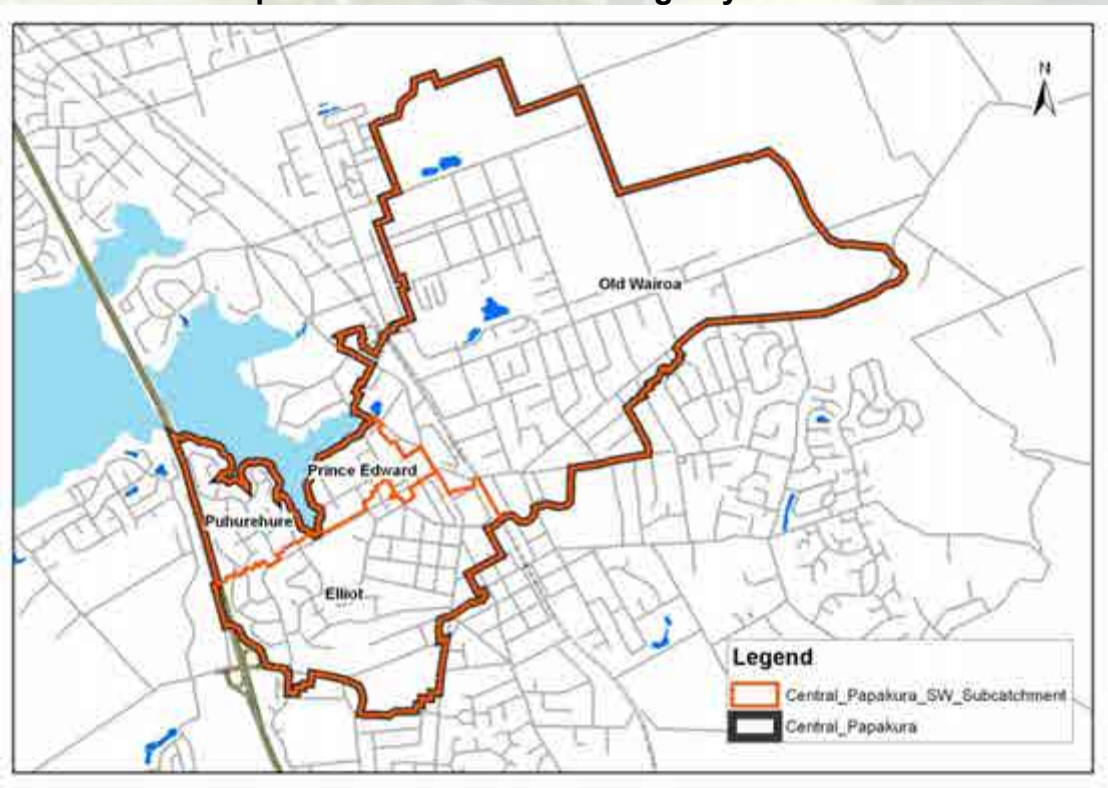



**Figure 15: Central Papakura Stormwater Sub-catchments**

The Central Papakura Area has four distinctive sub-catchments based on the existing stormwater drainage system, they are known as the Old Wairoa Road Catchment, the Elliott Catchment, the Prince Edward Catchment and the Pahurehure Catchment. Stormwater drainage systems in these catchments areas will be discussed below:

### *5.1.1 Old Wairoa Road Catchment*

The stormwater drainage system for the Old Wairoa Road Catchment is shown in Appendix A. The catchment extends from steep rural land at the eastern edge of the District, through the flat areas to the east of Grove Road, and central business area to the west of the NIMT railway embankment, to the Pahurehure Inlet.

The catchment has a wide range of land uses including rural – future urban, existing residential, commercial, industrial, military camp and Bruce Pullman Park. The drainage systems in the existing urban area are predominately stormwater drainage pipe networks which are known to have limited capacity to cater for amenity flows resulting from relatively frequent rainfall. In a large part of existing urban area including Alma Crescent, Hill Crescent, Grove Road, Edmund Hillary Avenue, Elizabeth Street and the western end of Clevedon Road, the drainage systems are primarily just for the road areas, and many older houses are drained via ground soakage systems which are typically ineffective in peat soil especially during winter months when the groundwater table is close to surface.

The existing drainage system in the rural (future urban) area is typically a network of road-side drains and farm drains. Some of these drains currently flow out of the catchment, northwards, into the Papakura Stream.

When the capacity of the primary pipe system is exceeded and the excess stormwater flow will take the route of the overland flow paths which generally follow the low lying gullies, but often obstructed by fences, buildings and other structures. In the flat area to the east of Grove Road, there are no obvious well defined overland flow paths; instead, the overland flows are in the form of wide spread sheet flow over a large area with shallow surface ponding in localised depressions.

To the west of Grove Road, the land generally falls towards the NIMT railway with more pronounced gullies. The railway embankment cuts off all overland flow paths, except at Subway Road where an underpass exists and which also allows overland flow to pass through and under the railway. The railway embankment is considered the most disruptive feature to the natural overland drainage system in this catchment.

Downstream of the railway embankment, the level of Great South Road adjacent to the Woolworths Carpark dictates the ponding level at the upstream properties and at the Subway Road. Once across the Great South Road, the overland flow will follow the route of major stormwater pipes along the a low lying gully behind Coles Crescent, before overtopping the roadway at Gills Avenue to reach Pahurehure Inlet.

Two stormwater ponds are in the Old Wairoa Catchment: the Gills Avenue Pond and the McLennan Park Wetland (previously known as Artillery Drive Pond).

The McLennan Park Wetland has an upper wetland pond and a lower wetland pond. The upper wetland pond is designed to attenuate peak flood flows up to 1%AEP from the upstream catchment areas including Takanini Structure Plan Area 2A & 2B, Bruce Pullman Park and existing development to the east of Grove Road. A new stormwater pipeline about 1km long has been designed to discharge the attenuated peak discharge in a 1%AEP event directly to the Pahurehure Inlet. The lower wetland pond provides further polishing to the treated runoff from the upper pond. With the proposed pipeline in place, the load on the existing drainage system along Old Wairoa Road will be reduced. This will provide some benefit in mitigating existing surface flooding problems in parts of the catchment.

The Gills Avenue Pond treats stormwater runoff from the remaining catchment areas which do not discharge into the McLennan Wetland. Due to limited volume available, the Gills Avenue Pond only proves partial treatment to the stormwater runoff from the contributing catchment area. The Gills Avenue Pond has negligible flood attenuation capability.

### *5.1.2 Elliott Catchment*

The Elliott Catchment drains an area bounded by the Broadway and the NIMT Railway to the east, the Southern Motorway to the west, Rosehill Drive and Beach Road to the south and Elliott Street to the north. A map showing the drainage system in Elliott Catchment is included in Appendix A.

The Catchment is very flat between Rosehill Drive and Manse Street in the south, and in the east between the NIMT railway and Great South Road. In the flat area, overland flow paths are generally poorly defined, with frequent ponding occurring at the low points of roads. The piped drainage network is also far from adequate, with many properties relying on ground soakage which is known to be inefficient.

The sub-catchment area between Great South Road and the RSA building next to Ray Small Park, includes a large portion of the central business area and other commercial development in the western fringe. This catchment has reasonable fall but most properties are fully developed with little consideration given to the overland flow paths. As a consequence, the significant overland flow paths are interfered with by buildings and fence lines at regular intervals. Some depressions also exist at the RSA car park which are prone to ponding in extreme rainfall events.

South Street is also known as one of the significant overland flow paths in the catchment, and potentially attracts overland flows from Beach Road in the south and Wellington Street in the north. At the low point of South Street, the overland flow flows between properties at No 32 and 34 South Street, then follows the low lying gully in private properties between Ashdown Place and Ray Small Drive, and eventually crosses Ray Small Drive and enters Ray Small Park.

Joyce Street is also a confluence point of at least two major overland flow paths in the area. One originates from the end of Bexley Place through the low lying properties between Elliott Street and Hanover Place, another follows the gully between Beach Road and Hanover Place. The overland flow path between Joyce Street and Ashdown Place is unprotected and interrupted at intervals by existing fences and other structures.

Elliott Street intercepts overland flows from a catchment area up to the Southern Motorway in the west. The overland flows accumulate at a low point along Elliott Street outside No 100, and then follow the route of the low lying gully on private properties below Elliott Street before entering Elliott Street through No 70.

Ray Small Park is situated in the lowest portion of the Elliott Catchment, where an extensive ponding may develop during extreme rainfall events. The flood flows eventually cross Elliott Street and discharge into an arm of Pahurehure Inlet.

Currently there is no stormwater treatment facility in the Elliott Catchment.

### *5.1.3 Prince Edward Catchment*

The Prince Edward Catchment lies between Elliott Street and Pahurehure Inlet and is bounded by Great South Road and Coles Crescent to the east.

The commercial block bounded by Great South Road to the east, Queen Street to the north, Elliott Street to the south and Wood Street to the west forms part of the central business area and is densely occupied by large commercial buildings. Overland flows in this area are significantly impeded by existing buildings. The embankment of Queen Street forms a dam above the existing stormwater pipes, and puts some commercial floors below the street level at flood risks.

The main pipe drainage system runs northwards from Elliott Street to the Pahurehure Inlet near Gills Avenue, following the alignment of an ancient gully. A short section of open drain remains between No 4 Wood Street and No 23 Coles Crescent. The overland flow path between Queen Street and Pahurehure Inlet approximately follows the primary pipe system, it is, however, cut off by fences and retaining walls, etc., along its way.

The areas along the coastline fall steeply to the Pahurehure Inlet, generally with piped systems draining the road area only. These areas are generally free from flood

risks. The basement of the Badminton Hall at No 41R Elliott Street may be prone to flood risk due to a depression formed at the building platform and capacity restrictions of the private drains. There are no recorded water quality management measures implemented in this catchment.

### *5.1.4 Pahurehure Catchment*

The Pahurehure Catchment lies between the Southern Motorway and the Pahurehure Inlet to the west and adjoins the Elliott Catchment to the South. This catchment generally falls in westerly direction from the Southern Motorway to the Pahurehure Inlet. The primary piped drainage systems are mostly provided on public roads and follow major overland flow paths. The major overland flow paths include Cricklewood Street, Rippleside Place, Westholm way and Rushgreen Avenue.

Ponding is expected at a few low lying cul-de-sac ends which also act as the termination points of overland flow paths. Under extreme rainfall events, spilling from the ponding areas may enter private properties before reaching the Pahurehure Inlet.

## 5.2 United Water Franchise Agreement with Papakura District Council

Papakura District Council owns the potable water distribution system and the wastewater reticulation, treatment and disposal system. Both of these are operated by United Water under a Franchise Agreement which came into effect in April 1997 and is for a period of 30 years. United Water is exclusively responsible for supplying water and wastewater services to residents within Papakura District.
The franchise agreement is a comprehensive document which sets performance standards including water and wastewater system performance, commercial fairness, insurances, forward planning and reporting.

Under the franchise agreement United Water must ensure that all infrastructure assets maintain at least a “B” grade for water distribution. Furthermore all infrastructure assets must be in a condition better than at the commencement of the 30 year period (condition assessments are required every 5 years). To date, United Water has satisfied both these criteria.

United Water has during the term of the agreement expanded the water and wastewater networks, incorporating both infill and green field development. The franchise agreement criteria described above regarding the improved condition of the network creates a strong commercial incentive for United Water to maintain the networks in satisfactory condition while catering for any requested increase in service demand in the future. (WSA, 2005)

## 5.3 Wastewater Drainage System

Wastewater reticulation servicing the Papakura District collects wastewater from households, commercial premises and industry, and transports this wastewater to via collection mains, trunk sewers and pumping stations.

Wastewater from Papakura, Red Hill and Takanini is gravity fed via the Papakura District Council owned collector reticulation mains to the WSL Papakura Branch Line, which feeds to the Mangere wastewater treatment plant operated by Watercare Services Limited.

Wastewater from the Drury area and from Wrightsons Bloodstock used to be treated at the Drury wastewater treatment plant owned by Papakura District Council and operated by United Water. Since the completion of the WSL Drury Pump Station and

new rising main to the WSL Papakura Branch Line, the Drury wastewater treatment plant has been decommissioned.

The Papakura District Council owned wastewater reticulation network operated by United Water comprises the following infrastructure (as at 30 June 2009):

- 261.1 km of wastewater reticulation main
- 4,717 wastewater manholes
- 15,312 wastewater connections
- 28 wastewater pumping stations

All wastewater pump stations which have a contributing catchment with equivalent population of 100 or more in the District are equipped with a standby pump and a comprehensive Supervisory Control and Data Acquisition (SCADA) system which is used for the monitoring and operation of the pump stations. This is consistent with the requirement of Rule 5.5.10 (b) vi (f) of the Auckland Regional Plan: Air, Land and Water.

## 5.4 Drainage System Planning – network expansion, upgrades, current and future major capital works

A fundamental planning tool for management of the stormwater system is the Stormwater Asset Management Plan (SWAMP). This takes account of the levels of service expected from the stormwater system, the condition and performance of the assets and the demand for asset capacity arising through urban development and statutory requirements. Integrated Catchment Management Plans assist in defining not only the demand for stormwater system capacity, but also capital projects that will satisfy that demand.

Papakura District Council updates the Stormwater Asset Management Plan (SWAMP) every year. As a requirement of the Local Government Act 2002, PDC also review their LTCCP (Long Term Community Consultation Plan) every two years. Major stormwater drainage capital works are identified in the SWAMP and LTCCP documents.

United Water also produces Asset Management Plans for the wastewater and water supply assets. United Water in conjunction with Watercare Services Ltd is understood to have been planning and undertaking many capital projects to expand the reticulation networks into the new development areas including the Hingaia and Takanini Structure Plan areas. These expansions and improvement works are in line with the terms of the franchise agreement and will provide commercial gains for United Water.

### *5.4.1 Major Stormwater Projects*

Recent, current and planned major stormwater projects in the Central Papakura Area including the following:

Artillery Drive Pond to Pahurehure Inlet Tunnel Outfall Project – this project was recommended in the current Old Wairoa Road Catchment Management Plan with some modifications identified in the discharge consent variation document. The tunnel will start from the Upper Pond at McLennan Reserve and end in Pahurehure

Inlet near the junction of Coles Crescent and Gill Avenue. This project will divert the stormwater discharge from the future Takanini Structure Plan Area 2A, 2BA and 2B away from the existing stormwater pipes through Old Wairoa Road and the Central Business Areas known to have very limited capacity. The engineering design of this project has been completed and currently (2009) on hold while issues related to funding and resource consents are resolved. The coastal permit application for the outfall structure at Pahurehure Inlet is underway.

CBD Drainage Upgrade – the stormwater drainage system in the Central Business District was studied in advance of other areas in Central Papakura, to fit within the overall programme of the Town Centre Improvement Project initiated by the Council. New stormwater pipes have been installed at Great South Road, East Street, Broadway, O'Shannessey Street and Wood Street to boost the capacity of the existing primary drainage system to cope with peak discharges resulted in a 10% AEP storm event. These works were completed between 2006 and 2008.

### *5.4.2 Major Wastewater Projects*

There is no public information on the capital works undertaken or planned by United Water. However, the following two major wastewater projects undertaken by Watercare Services Limited have some impact on the existing system in the Central Papakura Area.

Takanini Wastewater Trunk Sewer – this is a new trunk wastewater pipeline to service the future development in the Takanini Structure Plan Areas 1A, 1B, 2A, 2BA and 2B. This pipeline starts from the WSL Papakura Branch line situated in the coastal marine area downstream of the Waimana Reserve, runs under the Great South Road and the NIMT Railway Embankment, then follows the alignment of future roads in the TSP 1A and 1B area, and terminates at new Pump Station in the proximity of the intersection of Walters Road and Grove Road. This project is now completed.

Drury Pump Station and New Rising Main – this project diverts the wastewater which flowed to the Drury Treatment Plant to the WSL Papakura Branch line near Greenhaven Avenue. We understand that this project is complete and the Drury Wastewater Treatment Plant has now been decommissioned.

## 5.5 Stormwater System Level of Service

### *5.5.1 Level of Service*

One use of the term 'level of service' is to describe the capacity of the stormwater system in relation to the severity of rainfall event it will cope with without surface flooding. The pipe will convey the expected peak discharge during that event. Rainfall events are described by return period in years, or probability of annual exceedance as a percentage. Thus a 50 year return period storm is the same as a 2% annual exceedance probability (AEP) storm.

Current practice at Papakura is to design and construct a stormwater pipe system for 5 year (20% AEP) design return period. The Building Act 1991 requires (via the New Zealand Building Code) that buildings and site work should be serviced with stormwater drains having capacity to drain a storm with a 10 year return period. There is therefore an anomaly between the design capacity of drains required to be installed by property owners and drains provided by the council for industrial and residential land use.

Council will be looking at options to increase the design period to 10 year return period in new development areas and areas where urban intensifications are expected to happen. This proposed change in approach will provide improvement to maintenance costs to Council and more protection to residents from property flooding.

Overland flow paths are the routes taken by stormwater runoff that exceeds the capacity of the primary system. Overland flow paths are generally required to cope with peak discharges in a 1% AEP stormwater event in Papakura.

The following design standards for drainage system in public roads are preferred for all new subdivisions (this has been adopted in the updated PDC Code of Development):
All longitudinal drainage pipes including placement of inlets shall be designed to ensure that in a 10%AEP storm event, the maximum spreads of water flow at the kerb channel are limited to:

- 2.0m at all local roads
- 2.0m at all sag points
- 1.5m at all arterial roads

All transverse drainage crossing the roads, such as bridges and culverts shall be designed to pass the 1%AEP peak discharge with the maximum upstream ponding levels at least 500mm below the road crown level assuming no blockage to the entries.

For roads used as overland flow paths as part of new subdivisions, the maximum flow depth shall be limited to 300mm and at least one trafficable land width (in the middle of the road) shall be passable to emergency vehicles.

### *5.5.2 Current Overall Performance*

Overall performance can be related to flooding that occurs in a given rainfall event. If that event is smaller than the level of service event, then the system is not performing to the required standard. Causes of system failure are sometimes of temporary nature, such as blockages, rather than systematic under-capacity of stormwater drainage system.

The severity of under-performance relates to the type of flooding that occurs. Habitable floor flooding is the most serious property flooding, with flooding of properties seen as less serious.

Flooding of roadways is serious when emergency vehicle passage is blocked or the flooding has potential to cause a traffic hazard.

There are three complaints of habitable floor flooding in Year 2006. Although, the rainfall events associated with these complaints are not known. Property flooding problems with existing development are mostly due to lack of provision or protection of overland flow paths, inappropriate floor levels and often inadequate capacities of the primary drainage system. Remediation to these flooding problems will be progressed as Council funds are made available and an economically viable solution can be found.

The emphasises will be placed on control of new development in the flood risk area to ensure adequate freeboard to the floors, and implementing low impact designs to minimise any adverse effects on the existing areas. A few buildings at flood risks are approaching the end of their useful lives, therefore it is possible to mitigate the flood

risks during re-development of these properties, rather than rectifying the problems now which often require significant infrastructure upgrade and have adverse downstream effects.

After prolonged rainfall in winter months, the surficial soils in the District will often become saturated especially in the peat soil areas. This can lead to groundwater seepage and excessive ponding on some properties which is generally considered as a private drainage problem. The owners are generally guided with remedial options and only rarely will Council take the responsibility to improve the situation (unless the problem is proven to be caused by inefficiency in or a lack of a surface drainage system in the local area).

Although the New Zealand Building Code E1.3.2 states that surface water resulting from an event having a 2% probability of occurring annually, shall not enter the building, the Papakura District Plan and the Auckland Regional Plan ALW state that all habitable floors adjacent to flood plains shall be at least 300mm and 500mm above the predicted 1% AEP flood level. The more stringent requirements in the Regional Plan, i.e. 1% AEP flood protection, shall be applicable for building floor levels controls in the District.

Surface flooding incidents have often been noticed at major arterial and local roads in Papakura District. The existing drainage systems in public roads are generally not adequate to cope with the 20% AEP storm event peak discharges.

The wastewater systems at Papakura District are all separated and both wet weather and dry weather overflow frequencies and volumes are insignificant when compared with other network operators in the Auckland Region.

As a good practice, the wet weather overflow frequency shall be limited no more than twice per annum on long term averaged basis, the dry weather overflow frequency shall be limited to 30 No/annum per 100 Km of wastewater main.

All sewage overflow incidences are currently reported by United Water to Papakura District Council. The spatial distribution, frequency and causes of overflows are analysed through a GIS system, so that any clustering pointing to network capacity issues can be identified at early stage and remedial actions can be recommended to United Water.

# 6 ISSUES FOR CONSIDERATION

## 6.1 Flooding

There are flooding problems in the Central Papakura Area. The following is a compilation of known flooding problems based on previous studies, Council file records and recollections of long serving senior Council staff.

### *6.1.1 Elliott Catchment*

1. Ashdown Place – In the December 1988 storm event (50yr), flood water were reported by residents to have risen to within a few centimeters of the habitable flood levels at No 24 and No 26 Ashdown Place. Considerable overland flows were also observed coming through the low point at South Street then traversing through the low lying properties between Ashdown Place and Ray Small Drive, before crossing Ray Small Drive and entering Ray Small Park.

2. 34 South Street – This property with two slab-on-grade flats was reported to have been flooded in 1985 and 1988. This property is situated adjacent to the low point at South Street which is a major overland flow path for a fairly large catchment area. The flood water will take the route between this property and Ashdown Place. Most of the houses adjacent to South Street are elevated above the general ground level and are not likely to be at risk of flooding. However, these two flats with slab-on-grade construction are considered at risks in extreme events.

3. Joyce Street – Joyce Street intercepts overland flows from a contributing catchment up to Bexley Place. The overland flow will potentially accumulates at the depression at the cul de sac end, then take the overland flow paths through No 9 Joyce Street. Flooding to the basement of a residential house was reported in the past

4. RSA Carpark & Building at No 40 Elliott Street – this property is situated on a major overland flow path originated from Great South Road and East Street. Extensive ponding was reported in a few depressions in the carpark, formed in the construction.

5. East Street – extensive ponding has been observed at the low point of East Street in front of the Accent Point Building at No 28-34 East Street. Flooding of the ground floor carpark at the Accent Point Building was also observed. A few commercial buildings on the opposite side of East Street are also considered to have a high risk of flooding.

6. Nelson Street – The owner at No 1A Nelson Street observed stormwater entering the garage at this property during some relatively small rainfall events in the last few years. There are two garages between Great South Road and East Street on Nelson Street which all under similar floor risks. The flooding is considered to have been caused by a combination of factors including lack of inlets and a primary drainage system servicing Nelson Street, flat gradient, an inappropriately constructed vehicle crossing which draws water from road into the garage below the road, lack of reticulation to private properties and ineffective ground soakage systems for private drains.

The high frequency of minor flooding in this locality requires improvement of the primary drainage system.

7. Clark Street – Ponding will occur in a depression adjacent to the low point of Clark Street. The ponding will possibly cover No 9, 11 and 13 Clark Street. One of the basement garages on these properties was reported flooded in the past.

8. Corner of Duke and Nelson Street – There is an identified overland flow path coming down to the low point on Nelson Street near Duke Street. Ponding at the low point will spill onto No 21 Duke Street which is situated in a slight depression. Basement garage flooding was reported in the past.

9. Elizabeth Campbell Centre at No 294 Great South Road – Surfacing ponding was observed at this property adjacent to Great South Road. Ponding has occurred to at least one metre deep in the lowest point in the carpark and overtopping of the Great South Road has been reported in the past.

10. Corner of Wood Street and Great South Road – Due to the flat topography, occasional ponding has been observed at this locality. At No 299 Great South Road, the building floor level is below the street pavement. Runoff from the footpath areas are currently collected in a dished channel with very limited conveyance capacity. Stormwater from the road might have entered this building in the past.

### *6.1.2 Old Wairoa Road Catchment*

1. Corner of Prictor and Ingram Streets – habitable floor flooding was recorded in this locality in the past possibly on No 26 Prictor Street where the overland flow traverses through.

2. 91 ~ 97 Old Wairoa Road – the backs of these properties are situated in low lying gully on a major overland flow path. Flooding to a garage on No 91 was reported by Council staff.

3. 23 & 25 Edmund Hillary Avenue – Flooding of the low lying area between Clevedon Road, Edmund Hillary Avenue and Willis Road is exacerbated by the lack of stormwater reticulation in the area. Flooding of the garages at No 23 & 25 Edmund Hillary Avenue was reported in the past.

4. Great South Road to Coles Crescent – A major overland flow path follows the low lying gully between Coles Crescent and Great South Road. A 1992 study identified four residential dwellings and one commercial building below the estimated 10-year flood level and a further two residential dwellings under the 100-year flood level. With the construction of the McLennan Wetland Pond (or Artillery Drive Pond) and the planned new tunnel outfall to Pahurehure Inlet, it is expected that the flooding problem in this area will be partially remedied with at least a reduction of frequency of overland flow.

5. Porchester Road to Great South Road – A 1992 study has predicted that the current Woolworths building, its carpark and a portion of Subway Road will be under flood water in a 100-year event. Flood water will pond to a depth of 0.6 metres in the carpark before Great South Road is overtopped.

6. Shirley Avenue to Subway Road – Due to insufficient capacity in the primary pipe system, overland flows were observed in low lying properties between Shirley Avenue and View Road. In the 1992 study, 11 existing residential dwellings in this area have been identified with floor levels below the 100-year flood levels. Between View Road and Subway Road, frequent flooding of a depression on Old Wairoa Road outside No 3 was also observed. Approximately 14 commercial buildings and 3 residential dwellings were identified with floor levels below the estimated 100-year flood level. Flooding has been experienced to factories on the corner of Old Wairoa Road and Porchester Road. This is the result of the stormwater system capacity being exceeded and limitations on the overland flow path capacity through Subway Road.

7. Grove Road to Snell Avenue – Ponding of stormwater in the localised depression at the intersection of Snell Avenue and Keeney Court will occur in extreme events. In a 100-year event, about six residential dwellings were predicted to have flooding above the floor levels.

8. Snell Avenue to NIMT Railway – Four residential dwellings between Snell Avenue and Prictor Street were found below the predicted 100-year flood level in the 1992 study. Ponding at the two depressions at Ingram Street were also observed in relative minor rainfall events. Between Prictor Street and NIMT Railway, the overland flow ends in a low lying area bounded by Ingram Street, Vernon Street and NIMT embankment. In a 100-year event, the ponding developed behind NIMT embankment due to limited capacities of the pipes under the railway, will potentially flood about five residential floors and five commercial floors in the area. Discussions with factory managers in the area immediately upstream of the NIMT between Ingram and Margaret Streets indicated that flooding to the floors of some factories occurred in the 1988 flooding event. It is likely that the relatively small capacity of the stormwater system draining the area behind the NIMT has caused ponding and possibly flooding to properties at other times in the past.

9. Brightwell Street to Grove Road – Due to the very flat topography and the lack of the primary drainage system in the area, a wide spread shallow overland flow is predicted and it runs between Brightwell Street to the intersection of Old Wairoa Road and Grove Road. The flow depth was estimated to be less than 300mm in a 100-year event in the 1992 study. Three dwellings with slab on grade type of construction were identified previously as prone to risk with two thought to be below the 100-year flood level and another one marginally above the 100-year flood level.

### *6.1.3 Pahurehure Catchment*

No recorded complaint of flooding in this catchment. Potentially ponding will occur at the low points of roads which also act as overland flow paths.

### *6.1.4 Prince Edward Catchment*

1. Elliott Street – Ponding will develop in the low point outside No 29, 31 and 33. As the buildings were built across an overland flow path with no provision for overland flow. The building floors are also below the road level, some low bunds have been constructed across the vehicle access to stop water from getting inside the buildings.

2. Corner of Queen and East Streets - Ponding has been observed at the low point of East Street outside No 19a. This pond spills into the depression created by the Queen Street embankment. Flooding of a few commercial floors will occur if the capacity of the primary system is exceeded in an extreme event.

3. Queen Street to Pahurehure Inlet - A major overland flow path follows the low lying gully in the middle; it is interrupted at intervals by fences and retaining walls.

## 6.2 Overland Flow Paths

Overland flow paths are integral parts of the stormwater drainage system in urban areas. Protection of the overland flow paths is more critical when the capacity of the primary drainage system is limited.

A high number of overland flow paths exist in the Central Papakura area. Although, many of them are interrupted at intervals by fences, garages, garden sheds and retaining walls, etc. This has caused frequent localised flooding problems.

## 6.3 Stream Erosion

There are noticeable stream bank toe erosion problems at the two branches of the Old Wairoa Stream, due to the steepness of the bank and relatively high erodability of the soils at the stream bank. However, these problems are considered of a minor nature, and none of the problems currently poses a threat to any buildings or private properties. It is envisaged with the increased discharge into these streams once the upstream catchment has become urbanised, some toe erosion control measures will be necessary.

## 6.4 Peat Soil and Groundwater Management

Peat soils underlie a large portion of the upper Old Wairoa Road Catchment. Most of these areas are currently rural and zoned for future high density residential development. As discussed previously it is critical to maintain the existing groundwater regime in the peat soil to avoid drying out of peat soils and consequential ground settlement.

Unexpected ground settlement can result in damage to buildings, localised flooding and adverse affects on gravity drainage services.

## 6.5 Drainage Levels of Service

### *6.5.1 Stormwater Drainage System*

There are large areas in parts of the Old Wairoa Road Catchment and Elliott Catchment which do not have adequate stormwater drainage reticulation. Historically, stormwater drainage pipe systems were only installed on public roads and beneath some major overland flow paths.

Stormwater drainage for many residential properties relies on nominal ground soakage systems which are often ineffective given the nature of the soil geology in Papakura District.

Private stormwater discharges into the road kerb and channel are popular with some developments in 1980s. This set up generally provides a low level of stormwater drainage service which often results in a relatively high frequency of overland flow at public roads and private properties on overland flow paths. Notwithstanding the issues this discharge arrangement has brought to the District, it does generate a slow down effect in the catchment and reduce the times of concentration and thus the peak discharges.

Some careful consideration of the options to cope with future infill development in the catchment area will be required. To provide full stormwater drainage reticulation to all the properties will require extensive upgrade of many existing pipes and is anticipated to be prohibitively expensive.

The Central Papakura Area is generally well covered by wastewater drainage reticulations except for a few rural properties in TSP 2A & 2B areas. The key issues on levels of service for wastewater drainage are mainly frequencies of overland flows under both the dry weather and wet weather conditions.

The recorded sewage overflows from the wastewater system are enumerated later in this chapter.

## 6.6 Sea Inundations

No inundation of private or public properties by sea water has been reported in the past in the District. There has been no record of rare tsunami or extreme storm surge events at the Pahurehure Inlet. With the increased awareness of climate changes which may worsen storm surges and cause sea level rises, it is sensible to investigate the probable extreme sea levels, to identify areas susceptible to sea inundations and to establish a range of management options.

## 6.7 Coastal Erosion

Some coastal erosion problems have been recorded in the District. Sea walls have been built along the portion of the coastline at Conifer Grove fronting the Manukau Harbour. Some fresh bank erosion has been noticed on northern side of Karaka Harbour subdivision to the west of the southern motorway. The future climate changes will potentially worsen any coastal erosion problems due to the predicted sea level rises. On the other hand, since the construction of the Southern Motorway, there has been increased sheltering of the Pahurehure Inlet to the east of the motorway. Rapid expansion of mangroves forest in the inlet has also been noticed; this will possibly reduce the velocity of tidal flow, dissipate the wave energy and thus reduce t potential erosion of the sheltered coastline.

## 6.8 Sewage Overflows

During 2003/2004 there were 65 wastewater overflows within the Papakura District (recorded by United Water), with a total estimated volume of 325$m^3$. There were no overflows as a result of pump station failure during 2003/04. Approximately 20 wastewater overflow incidents were thought to have caused by stormwater inflow and infiltrations. This equated to just fewer than 30 sewer overflows per year expressed per 100 kilometres of wastewater main. For the same period, there were also 29 wastewater overflows caused by blockages or other faults on private wastewater pipes owned by individual property owners.

During 2004/2005 there were 39 wastewater overflow recorded by United Water, including one pump station overflow incident due to power failure. There were also 41 wastewater overflows caused by faults on private wastewater pipes. United Water reported no overflow incident caused by stormwater inflow and infiltration during 2004/2005. A map showing locations of reported wastewater overflows is included in Appendix A.

During 2008/2009 there were 64 recorded wastewater incidents and 45 incidents resulted in wastewater overflows. Approximately 3 incidents involved wastewater overflows into stormwater system and receiving water bodies and the remaining 42 overflows discharged to private or public lands.

The number of overflows in the Papakura District is considerably lower than that of other local network operators and the New Zealand average. This is likely due to the separate wastewater/stormwater systems, small catchment sizes and infrastructure that is reasonably new and in good condition.

## 6.9 Water Quality/Sediment Quality

As described in the previous chapter, ARC has been monitoring sediment quality at no fewer than three sites in the Pahurehure Inlet as part of the Regional Discharge Project. Past monitoring has shown 'green' status for sediments sampled at all three sites. A trend of escalation of Zinc concentration has been identified, which coincides with results from similar monitoring in other parts of Region.

Recent investigations at the Old Wairoa Stream by NIWA show escalated Zinc concentration in stream sediment in the eastern branch and a degraded macro-invertebrate community. The E. coli level at the eastern stream exceeded the National Microbiological Water Quality Guideline (MfE, 2003) for contact recreation.

No microbiological water quality sampling has been undertaken on the marine environments in this catchment. Nor have any contact recreational area been identified within the District.

The Draft Pahurehure Inlet management plan promotes more community use of the Pahurehure Inlet including contact recreational activities; this may necessitate microbiological sampling at the inlet in the future.

## 6.10 Fish Passage Barrier

Fish species including long fin eels and inanga were found by NIWA at the Old Wairoa Stream sites. It is important to maintain the fish passage between these streams and the Artillery Drive Wetland Pond during future development of these areas.

## 6.11 Riparian Margins Conservation

The existing riparian vegetations at the two tributaries of the Old Wairoa Stream are in reasonable condition and provide a good shade to the stream flow. It would be ideal to maintain the existing native vegetations if it cannot be enhanced during future development in this area.

**Figure 16: Old Wairoa Stream Eastern Branch**

## 6.12 Known Contaminant Sources

Known contaminant sources which may potentially affect water quality at the receiving environments in the Central Papakura area include:

- A closed historic landfill and an abandoned sewage treatment plant at Ray Small Park. Stormwater pipes through the landfill have been subject to chloride corrosion from sea water; leachate from the landfill may infiltrate into the stormwater pipes and discharge to Pahurehure Inlet.
- Unpainted and poorly painted zinc galvanised roofs,
- A portion of the Southern Motorway,
- High risk industrial and commercial land uses at the fringe of the Central Business Area, such as a timber yard,
- Wastewater overflows from overloaded pipes and pump stations under wet weather conditions, and
- Fuel service stations are potential sources of petroleum hydrocarbons (TPH) from spills.

At source management at these premises will prevent the contaminant generated being mixed with less contaminated runoff from the general catchment area. Allowing mixing of the contaminants could make their removal more difficult at downstream points in the catchment.

# 7 STAKE HOLDER CONSULTATIONS

It is an important and integral part of catchment management practice to understand the concerns and expectations of stakeholders including residents living in the catchment area. Clustering of issues at specific localities in the catchment area often point to major issues and weak points in the drainage system or management practices.

Strategies, values and visions for a catchment area shared between residents, community groups, stakeholders, politicians and Council managers can pave an easy path for significant improvements and active participation of the community in the implementation process.

Weightings of objectives by stakeholders can provide guidance on selecting options and setting priorities for managing the catchment.

## 7.1 Who Are Stakeholders

The term Stakeholder is loosely defined as any government departments either local, regional or central, community groups and parties, iwi, local residents, general public and any individual who takes an interest in the matter. So, in theory, this definition includes a large number of organisations and people; though, in reality, it merely refers to those who actually take an interest and are willing to be involved in the project.

Not all stakeholders are equal, however. In a literal sense, each has a different stake in the outcome of the project, and each comes to the table with varying degrees of understanding, awareness, concerns and expertise of the issues. Therefore, the wide diversity of the stakeholders shall be recognised during catchment management, and the options and opportunity for stakeholders shall be planned and structured in the catchment management planning process.

Conceptually, stakeholder involvement can be viewed as a pyramid, with the wide base representing the local residents and general public – many of whom are initially unaware of the issues in the catchment. The awareness and involvement of stakeholders becomes progressively greater towards the top of the pyramid, with the apex of the pyramid representing the key decision makers on the catchment management issues, e.g. the TLA stormwater asset managers and catchment planning engineers.

As a part of the PDC ICMP project, a steering committee comprising Directors from key areas of PDC affected by stormwater management, the Manager Stormwater Assets (formerly the Water Resources Manager) and the Stormwater Planning Engineers, was established to make critical decisions on stormwater catchment management issues in the District.

Other key stakeholders identified include:

- Elected members
- Council Senior Management Team
- The Kaitiaki Group which represents five iwi groups who have connections or interests in Papakura District – Ngati Te Ata, Ngati Tamaoho, Ngati Paoa, Te Akitai and Ngai Tai
- The Pahurehure Inlet Protection Society

- Local residents
- General Public

## 7.2 Questionnairing

Questionnaires were delivered to residents in the Elliott Catchment in 2004. Feedbacks from the residents have been analysed spatially to check for clustering of similar complaints. A summary map is included in Appendix A, showing all property owners supplied feedback and flooding issues reported.

Questionnaire surveys in other catchment areas have not been carried out.

## 7.3 Iwi Groups

The Kaitiaki group represents five iwi groups who either occupied or have ancestral connections with the District. Workshops have been held with Kaitiaki Group and a few Councilors to achieve an understanding of the project at an early stage.

At each of important milestones of the project, the Kaitiaki group has been updated with the progress and consulted on important issues in relation to the water resources management in the District.

Good iwi philosophies for water resources management will be adopted during management options development.

## 7.4 Other Stakeholders

An ICMP Steering Committee was established at PDC to periodically review and guide the progress of the project and coordinate the progress with related works undertaken by other parts of the Council. The Steering Committee meets monthly throughout the duration of the project.

A workshop was held with the Council Strategic Planning group to discuss the objectives of the ICMP project. The policy planners provided input on the permitted imperviousness in the future urban areas which will be used in the hydrological modelling process. Various land uses scenarios can also be provided for possible future urban areas, so that the hydrological implications of these land use scenarios can be fully understood. This will provide useful information for the preparations of structure plans and changes to the District Plans.

Formal meetings and informal conversations were often held between the stormwater catchment modelers and senior Council staff including the Stormwater Maintenance Engineer, the Development Engineer, the Roading Operations Engineer, the Manager Community Assets and other long-serving staff members who have a good knowledge of stormwater related issues in the District.

# 8 CATCHMENT MODELLING

## 8.1 Data Capture

### *8.1.1 Manholes and Pipes Data*

The PDC Geographical Information System (GIS) contains data including co-ordinates, pipe sizes, invert levels and material types for most manholes and pipes. The data were combined from various sources and the overall level of confidence is medium to low. A data collection consultant together with sub-consultants has undertaken surveys in manholes especially where data gaps have been identified. For each manhole inspected, a manhole inspection sheet was filled out to identify each inlet pipe and the outlet pipe.

Each manhole is represented as a clock face with the outlet pipe (or the dominant outlet pipe in case of two outlets are present) normally assigned the 12 O'clock direction, the inlet pipes are identified in a clockwise order based on their relevant positions to the outlet pipe.

So far, 95% of the manholes with data gaps have been inspected; some of the remaining manholes are either completely buried or not found for many reasons. The newly captured manhole and pipe data have been used in building the hydraulic models.

### *8.1.2 Stormwater Ponds Data*

Two stormwater ponds exist in the Central Papakura area: the McLennan Wetland Pond (Upper pond and lower pond) at Artillery Drive, and the Gills Avenue Pond.

Data on stormwater ponds, such as total volume, inlets and outlets, vegetation etc, are mostly kept in the report "Papakura District Council Papakura Stormwater Ponds Pond Assessment" (H&G, 2005).

Area – Elevation data for both ponds were obtained based on the recent 0.5m interval contours obtained via the Regional LiDAR dataset. Original design information and as-built plans were also referred for verification of the data.

### *8.1.3 Imperviousness Data*

The existing impervious surfaces including all roofs and paved surfaces in all commercial and industrial areas at Central Papakura have been mapped based on the 2001 aerial photos. Existing impervious surfaces in some typical residential sub catchment areas were also mapped. The sub catchment areas for impervious mapping were deliberately selected to represent specific eras of construction. Imperviousness in sub catchment areas which have not been mapped was inferred from building footprint data (which is available for the whole district) and estimated percentages of paved surfaces for each subcatchment area.

The maximum allowable imperviousness are derived from the current District Plan and structure plan rules with some adjustments to allow for changes to the rules already initiated by the Council.

### *8.1.4 Stream Data*

No stream cross-section field survey was undertaken in the Central Papakura Area. Some representative stream cross sections were derived from the 0.5m interval contours.

## 8.2 Hydrological Modelling

### *8.2.1 Catchment Delineation*

The Central Papakura Area consists of three historically known stormwater catchments – the Old Wairoa Road Catchment, the Elliott Catchment, the Prince Edward Catchment and the Pahurehure Catchment. The boundaries between these catchments were slightly adjusted during the ICMP process.

These Catchments were then further subdivided into sub-areas which are the fundamental hydrological units used in the hydrological model. Following the ARC ICMP Funding Eligibility Guideline, the sizes of the sub-areas are generally between 2 to 5 ha.

The boundaries between the sub-areas were determined based on the following criteria in the order of significance:

- Stormwater drainage pipe reticulation and connectivity – in the urban area, on occasions the direction of stormwater flow in the pipe system differs from the overland flow following the contours. A greater weight was given to the direction of the pipe network when determining the contributing catchment area for a specific point of interest in the overall catchment.
- Property Boundaries – The sub-areas boundaries will generally follow the property boundaries, based on the understanding that stormwater runoff from a typical small residential site is mostly discharged via one connection to the public reticulation network.
- Topographical Features – The topographical features, such as the 0.5m-inteval contours have been used in combination with the above to determine the sub-areas boundaries.

A map showing all stormwater sub-areas in the Central Papakura Area is included in Appendix A.

The impervious and pervious portions of the sub-areas have been separated and modelled separately due to differences in values of hydrological parameters, such as runoff curve numbers, times of concentration and initial abstraction depths. This is also required in the ARC TP108 guidelines.

Due to the presence of many pockets of un-reticulated existing urban areas in Central Papakura, it is critically important to understand fully the hydrological effects on the downstream system of providing full reticulation systems to these pockets. The existing un-reticulated areas are typically drained through old ground soakage systems that have often been ignored for years and are ineffective. This arrangement is not ideal, although it does prolong the time of concentration, and allows more localised storage to attenuate the peak discharges from these areas. Thus the directly connected impervious areas and unconnected impervious areas have been separated in the hydrological model definitions to allow these effects to be modelled.

### *8.2.2 Stormwater Runoff Model*

The ICMP Funding Eligibility Guideline notes that the ARC Technical Publication No. 108 “Guidelines for Stormwater Runoff Modelling in the Auckland Region” (TP108) is the most preferred stormwater runoff model. The TP108 implementation in the DHI MOUSE software is the Unit Hydrograph Method, which has been tested on past occasions on various other projects in the region and proved to be fully compliant with the original TP108 Methodology.

The TP108 guidelines present a recommended method for the application of the U.S. Soil Conservation Service's rainfall-runoff model to catchments in the Auckland Region. They are based largely on Technical Release No. 55 (TR55) prepared by the U.S. Soil Conservation Service (SCS, 1986).

The TP108 runoff model is suitable for:

- Assessing the effects of land use change,
- Modelling both frequent and extreme events,
- Application to distributed (a network of sub-catchments) or lumped catchments, and
- Simulating natural systems as well as engineered systems (such as pipe network). (ARC/BECA, 1999)

### *8.2.3 Key Model Parameters*

**Design Rainfall**

Design 24 hour rainfall depths maps are provided in TP108 to cover the whole Auckland Region. A standard centre-peaked 24 hour rainfall pattern with shorter duration rainfall bursts from 10 minutes to 24 hours nested within the 24 hour temporal pattern was derived statistically from rain gauge data representative of the Auckland Region. The Design 24 hour rain fall depths for various annual exceedance probabilities applicable to the Central Papakura Area are summarised in the **Table 12** below:

**Table 12: Central Papakura Daily Rainfall Depth**

| Rain Event ID | | Daily Rainfall Depth | | $I_{24}$ (daily average intensity) | |
|---|---|---|---|---|---|
| WQ Event | $P_{24}$ | 25.0 | mm | 1.04 | mm/hr |
| Extended Detention Event | $P_{24}$ | 34.5 | mm | 1.44 | mm/hr |
| 50% AEP | $P_{24}$ | 75 | mm | 3.13 | mm/hr |
| 20% AEP | $P_{24}$ | 115 | mm | 4.79 | mm/hr |
| 10% AEP | $P_{24}$ | 145 | mm | 6.04 | mm/hr |
| 5% AEP | $P_{24}$ | 160 | mm | 6.67 | mm/hr |
| 2% AEP | $P_{24}$ | 200 | mm | 8.33 | mm/hr |
| 1% AEP | $P_{24}$ | 220 | mm | 9.17 | mm/hr |

**Runoff Curve Numbers**

Typical runoff curve numbers were provided in TP108 for a range of land cover types and typical soils in the Auckland Region. At Central Papakura, typical surficial soil types include the Puketoka Formation and the Takanini Black Swampy Peat. The Puketoka formation is of alluvium including volcanic ash, sands, gravel and East Coast Bays Formation soils. The Takanini Black Swampy Peat is known to have the characteristics of typical silty clay soil, with typical hydraulic conductivity K values ranging from $1 \times 10^{-8}$ to $1 \times 10^{-9}$ m/s from on site tests undertaken recently. A runoff curve number of **61** was selected for the Puketoka Formation soils and **74** for the Peat soils. A runoff curve number of **98** was chosen for all impervious surfaces.

In the TP108 runoff model, the runoff hydrograph is calculated using the standard SCS synthetic unit hydrograph as in the original TR55.

**Time of Concentration**

In the TP108 runoff model, Time of concentration (Tc) is estimated using an empirical lag equation derived from a regressional analysis of data from the Auckland Region.

In Central Papakura, the flow path length and slope along the flow path for each sub area have been analysed using GIS tools. These data were then input into the Tc equation for calculations. For each sub area, Tc was calculated for the three distinctive hydrological components including the pervious portion, the connected impervious portion and the unconnected impervious portion with different channelisation factor values applied. A slightly slower time of entry for the pervious catchment was also taken into account in the calculations. A minimum Tc of 10 minutes was adopted for hydrological components in all sub areas.

A summary of hydrological input data for the Central Papakura area is included in Appendix B.

**Initial Abstraction**

The initial abstraction (Ia) depths for various components in each sub area have been selected in accordance with the TP108 guidelines. Ia depths of 0mm and 5mm were selected respectively for the pervious and impervious components of each sub area.

**Catchment Depressional Storage**

The TP108 model was validated for relatively steep catchments in the Auckland Region, of up to 12 km2 in size, with little hydraulic storage. For flat catchments with significant storages, separate hydraulic modelling of these areas will be necessary.

Both the natural and engineered depressional storage in the Central Papakura area have been explicitly modelled. The elevation – storage data for each of the significant storage areas were derived from contours and represented as basins in the model.

### *8.2.4 Model Calibration and Verification*

The TP108 runoff model is applicable to both urban and rural (or mixed) catchments. The model was validated against six gauged catchments in the Auckland Region and gave a standard error of 21% for all average recurrence intervals. For ARI of 2 to 100 years, the model predictions can be expected to be within ±25% at a confidence level of 90%. This level of accuracy was considered good for regionally calibrated model, for which average errors of 25% to 70% are typical (ARC/BECA, TP108, 1999).

Any short term flow gauging at Central Papakura are considered not adequate to justify any departures from the values of regionally calibrated hydrological parameters which are based on the few available very long term flow gauges, especially in the applications for flood risk modelling under very extreme storm events, where conservatism is seen as necessary.

Although, the simulated flows and flood extents in extreme events have been compared with historic complaints and local knowledge at Council and found good relevance.

## 8.3 Hydraulic Modelling

The stormwater drainage system at the Central Papakura Area includes the following hydraulic components:

- Stormwater drainage inlets
- Public and private stormwater drainage pipes, culverts and manholes
- Natural streams and engineered channels
- Overland flow paths
- Engineered storage ponds,
- Natural depressional storage areas, and
- Outfalls

The hydraulic modelling of the stormwater drainage system was undertaken using the DHI MOUSE software (version 2007).

The MOUSE Pipe Flow Model is a computational tool for simulations of unsteady flows in pipe network with alternating free surface and pressurized flow conditions. The computation is based on an implicit, finite difference numerical solution of basic 1-D, free surface flow equations (Saint Venant). The implemented algorithm provides efficient and accurate solutions in multiply connected branched and looped pipe networks.

The computational scheme is applicable to vertically homogeneous flow conditions which occur in pipes ranging from small-profile collectors for detailed urban drainage, to low lying, often pressurized sewer mains, affected by the varying water level at the outlet. Hydrodynamics of prismatic open channels can also be simulated.

Both subcritical and supercritical flows are treated by means of the same numerical scheme that adapts according to the local flow conditions. Naturally, flow features such as backwater effects and surcharges are precisely simulated. (DHI, MOUSE Pipe Flow Reference Manual)

### *8.3.1 Model Extent*

The model extent was determined based on the positions of the most upstream loading nodes. Branches further upstream of the most upstream loading nodes are generally very minor and relate to only very localised issues. It is neither feasible nor worthy to include all pipes in a model for a large catchment area.

Stormwater drainage inlets are not explicitly modelled at Central Papakura. The MOUSE software calculates the hydrographs for each of the sub area, and then adds the flows to the model nodes specified as the loading manhole for the sub area. The sizes of the loading manholes were increased to take into account the un-modelled storages, so that hydraulic shocks can be avoided.

### *8.3.2 Pipes, Manholes and Culverts*

The sizes, material types and invert levels at both the upstream and downstream ends, of all pipes and culverts were taken from the PDC Geographical Information System and additional data captured through on site survey. Interpolations of pipe invert levels were used as the last resort to fill up any remaining data gaps due to unfound and inaccessible manholes.

All pipes with unknown material types have been defaulted to Normal Concrete Pipe, which corresponds to a Manning's Number[a] of 85.

DHI MOUSE calculates the minor losses at the manholes due to expansions, contractions, drops, changes of direction and merges. There are nine ways of minor losses calculation available in MOUSE, the Mean Energy Approach was selected as the most suitable method for the typical manholes in New Zealand with half pipe height benches based on previous studies.

### *8.3.3 Natural Streams and Engineered Channel*

All sections of natural streams and engineered channels were represented in the model as links, with the typical cross section geometry defined.

### *8.3.4 Overland Flow Paths*

A library of typical overland flow path cross sections was established in MOUSE, including local roads, collector roads, arterial roads, commercial access ways, residential access ways and shallow gullies through the urban area. If no typical cross section in the library is found suitable, then a specific cross section will be created based on aerial photo and contours at the specific site. The typical Manning's roughness value for overland flow paths is 0.05, which reflects the frequent interruptions from fences, gardens and plants.

### *8.3.5 Natural and Engineered Depressional Storages*

There are three engineered stormwater ponds in the Central Papakura Area, namely McLennan Wetland Upper Pond (also known as the Artillery Drive Upper Pond), McLennan Wetland Lower Pond (also known as the Artillery Drive Lower Pond), and Gills Avenue Pond.

Only the McLennan Wetland Upper Pond is a designed flood detention pond which attenuates peak discharges from the future urban areas and some existing development areas. The two remaining ponds are mainly for water quality treatment purpose, their flood attenuation functions are minimal due to the limited live storage above the normal water level. The elevation-area data for these ponds were extracted from the half-metre contours derived from the LIDAR dataset. Pond outlet configurations were based on the PDC Pond Assessments Manual (H&G, 2005).

Significant natural depressions in the existing urban area were explicitly modelled. The elevation – area data were obtained from the PDC GIS contours with all existing building platforms excluded.

### *8.3.6 Outfalls*

Only outfalls discharging to sea were modelled as outlets in the hydraulic model. The tailwater levels at outfalls discharging to sea have been taken as the Mean High Water Spring, which is RL 1.7m in terms of LINZ Datum. The outfalls discharging into natural or engineered channels and ponds were modelled as general drainage nodes, where the hydraulic grade at the receiving channels and ponds are taken into account during the simulations.

### *8.3.7 Model Simulations*

The hydrological model was simulated for the current (2003) land use scenario and the maximum probable development scenario.

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[a] Manning's Number is the inverse of Manning's Roughness n value which is more often referred to.

The TP108 24hr design rainfall events were simulated in the model. The design rainfall events modelled include: 5yr, 10yr, 50yr and 100yr.

The design flows under various rainfall events were simulated by fictitiously increase the size of the pipes in the model so that restrictions of flow up to the 100yr event will occur in the model network. The simulated design flows were later used to check the performance of the existing pipe network.

The peak discharges via the overland flow links under extreme events such as a 100yr storm event, were extracted from the model simulation result files to identify the significant overland flow paths. The maximum water levels at all modelled nodes were also extracted from the Model simulation results, and used for flood hazards mapping for various extreme rainfall events.

## 8.4 Contaminant Load Modelling

The ARC ICMP Guideline requires that a robust contaminant management options analysis involves identifying areas of contaminant (including sediment, TPH and heavy metals) accumulation in the marine receiving environment, determining the sensitivities of the environments to these contaminants, predicting how contaminant accumulation in these environments will change over time as land uses change, and determining the extent to which different contaminant or management options would reduce this accumulation. This analysis is an essential part of the process leading to the selection of the optimum BPOs for contaminant management in the catchment(s) draining to each receiving environment.

### *8.4.1 ARC Contaminant Load Model*

Contaminant generation rates vary with the land use, building materials, traffic volumes and the areas of exposed soil, bush, pasture, etc. The ARC has developed a Microsoft Excel™ spreadsheet model to assist local authorities with evaluating different BPOs for managing stormwater contaminants. This model calculates annual contaminant loads for sediment, zinc, copper and total petroleum hydrocarbons (primarily oil and grease) based on the areas of different contaminant sources within a catchment.

The most important parameters for the contaminant part of the BPO analysis are the contaminant yields, i.e. the amount of a contaminant produced from a source of particular size over a specified time, and the contaminant load reduction that can be achieved by each management option.

The model calculates the annual load from each contaminant source according to the area of the source and its contaminant yield (i.e. g $m^{-2}$ $year^{-1}$). The sources included in the model are roof materials, roads, paved surfaces other than roads, unstabilised urban stream channels, urban pervious areas, construction sites, exotic production forest, mature bush, farmed pasture, retired pasture and horticultural land. Most of the sources have additional sub-categories, for example, the sub-category for roof materials includes the different materials, the sub-category for roads includes ranges for the numbers of vehicles/day and the sub-categories for most of the large sediment-producing sources include slope.

The model applies removal efficiencies for various water quality management options chosen including at source controls and treatment trains. The model calculates the

total (unmanaged) and managed loads of sediment, zinc, copper and TPH for each source i.e. the source loads.

### *8.4.2 PDC Stormwater Quality Management Units (SMUs)*

Based on the ARC Contaminant Load Model (CLM), a GIS based contaminant load modelling approach was developed as a part of the ICMP project. The Papakura District was divided into 108 SMUs.

The boundaries between SMUs were determined based on the followings:

- The PDC ICMP Areas boundary;
- The catchment boundaries for the existing stormwater quality management devices including ponds, wetlands, rain gardens and management trains;
- The catchment boundaries for any proposed or potential stormwater quality management devices; and
- The boundaries of existing and future development areas where a distinctive stormwater management practice, be it a management train or an individual device, can be implemented.

An ArcView shape file for the SMUs was developed. The land uses, slopes, vegetation, roof types, etc for each of the SMUs were analysed using other underlying dataset. The contaminant generation rates and water quality management options efficiencies in the ARC Contaminant Load Spreadsheet Model were adopted in the calculations for consistency.

The GIS SMU model allows the management options for each SMU to be varied, the managed contaminant load can then be calculated using built-in formulas. . The selected options can be changed over time to match a proposed works programme and the model will estimate the resulting loads.

### *8.4.3 Predicted Contaminant Loads For SMUs*

For each SMU in the District, the contaminant loads have been calculated for:

1. The existing land use (2003) including any existing stormwater treatment.
2. The proposed 2020 future land use scenario assuming no contaminant management options, i.e. source control or stormwater treatment.
3. The proposed 2050 future land use scenario assuming no contaminant management options, i.e. source control or stormwater treatment.
4. Each proposed future land use scenario assuming a range of different contaminant management options. (the contaminant management options will be selected based on outcomes of the receiving environment modelling)

The analysed contaminant loads were shown on GIS based maps, for visualisation and identifications of contaminant hot spots and the magnitude of reductions by various management options. The SMU contaminant loads maps are included in Appendix A.

## 8.5 Receiving Environment Modelling

The fate and trend of change of contaminant generated from the land use activities in the coastal receiving environment will need to be understood, before the impact of land uses on the marine ecological system can be predicted.

The Pahurehure Inlet and eastern Manukau Harbour receives stormwater runoff from the Papakura District including the Central Papakura Area, together with portions of Manukau City and Franklin District. Due to the complex nature and the high regional

interest in this receiving environment, ARC has initiated a Manukau Harbour East Receiving Environment Modelling Project currently being carried out by the National Institute of Water & Atmospheric Research Ltd (NIWA).

The receiving environment modelling is understood to involve establishing a hydrodynamic model to simulate the tidal current including the flow depths and velocities in the receiving environment. Contaminant loads will be added to the hydrodynamic model to simulate their fates. Tidal current velocities and depths are monitored at points of interests, to enable the calibration of the hydrodynamic model. Sediment cores have been taken so that the land uses history in the contributing catchment areas can be used to calibrate the sediment accumulation process in the past. The model will eventually enable the prediction of sediment accumulation under the future land use scenarios with or without the water quality management practices.

The outcomes of the receiving environment modelling project presented so far are very much in line with our understanding of the behaviours of Pahurehure Inlet. The final reports are not available at the time of writing.

# 9 DRAINAGE SYSTEM PERFORMANCE ASSESSMENT

## 9.1 Stormwater Drainage System Performance Overview

This chapter of the ICMP describes the predicted performance of the stormwater system as determined by the modelling runs.

The model simulations under various design events indicate the piped drainage systems in Central Papakura area generally have limited capacities with overland flows occurring at frequent rainfall events often less than 50% AEP (2yr return period).

Thematic maps showing the ratios of the pipe design capacity at bed gradient versus discharges under various design events, have been produced so that bottlenecks can be identified. The hydraulic grade lines resulted from design events simulations can also be shown on longitudinal profiles of critical pipes to assist design of future upgrades.

Frequent operation of overland flow paths is predicted in the old development areas in parts of the Elliott Catchment and the Old Wairoa Catchment. Although, it has been found that most of these overland flow paths are poorly defined and unprotected, often interrupted by fences, garden sheds and retaining walls.

Traditionally, in the Central Papakura area, stormwater drainage pipe systems are only installed to drain public roads. Stormwater pipes generally go through private properties only to follow the low lying gullies or relics of ancient stream channels which were the natural drainage routes to reach the sea. Reticulation to each private property was never required during the development prior to the late 1980s. Nominal soakage trenches were installed based on rule of thumb design criteria (once cubic metre of gravel filled trench for each house), on soils with low permeability, such as peat. The performance of this type of system was acceptable before the proliferation of infill development when the sections were larger and where space was available for temporary ponding and overland flows, and the low lying lands prone to flood risks were not occupied by infill houses. Since the introduction of new subdivision rules to allow infill houses in the early 1990s, many of the old nominal soakage systems were abandoned to give way to the new houses. Minor extensions of the existing pipe system have occurred and kerb discharges have become popular which overloaded the drainage system on the roads. This shift to a degree also decreased the time of concentrations in the catchment, thus worsened the catchment responses under short intense storms.

The capacities of stormwater inlets within the roads are generally limited; due to increased flows from kerb discharges and partial blockages due to lack of regular cleaning. The inlets are not explicitly modelled, but frequent and prolonged ponding at depressions on roads in Central Papakura Area have been observed in the past.

## 9.2 Un-reticulated Areas

The public stormwater drainage records have been spatially analysed with property boundaries to identify properties which are more than 20m away from any existing public stormwater drains. These properties are then mapped as un-reticulated areas. The percentages of un-reticulated areas in each sub area are then analysed to identify the needs of network expansion. Maps showing properties have no stormwater drains within 10 metres from their boundaries are included in Appendix A.

## 9.3 Design Flows and Pipe Capacities

The design flows under various design storm events for all modelled pipes have been summarised from the model simulations into a GIS shape files for ease of use by others. Maps showing design flows of pipes have been produced and included in Appendix A.

Capacities of pipes at their bed gradients have been analysed using both the Manning's Equation and Colebrook White & Darcy-Weisbach Equation. A minimum gradient of 0.5% was assumed for pipes without level information, pipes with negative falls and pipes with gradient flatter than 0.5%. The ratios between the design flows and the pipe capacities have been mapped and included in Appendix A.

## 9.4 Water Quality Management Overview

The total contaminant loads in terms of sediment, heavy metals including Zinc, Copper and Lead, and Total Petroleum Hydrocarbons (TPH), from each of the Stormwater Quality Management Units (SMUs) in the Central Papakura Area have been analysed under various scenarios: the current development with reductions and without reductions, from the existing stormwater management devices, and for the future 2020 and 2050 contaminant loads. The predicted contaminant loads for each SMU are shown in the maps in Appendix A.

The treatment efficiencies of the existing stormwater management devices can be summarised below:

**Table 13: Existing Stormwater Treatment Devices and Estimated Efficiencies**

| Device Name | Catchment Area (ha) | Known Efficiencies* |
|---|---|---|
| Gills Avenue Pond | 535 ha | 45% |
| McLennan Upper Wetland | 326 ha | 72% |
| McLennan Lower Wetland | 19 ha | 75% |

* Estimated for sediment removal based on ARC TP10 on long term average basis

There is no known public stormwater quality management devices installed at Elliott Catchment, Prince Edward Catchment and Pahurehure Catchment.

# 10 Hazards Identifications

## 10.1 Flood Hazard Mapping

The flood hazard maps for the Central Papakura Area are included in Appendix A. Two types of flood hazards have been shown on these maps:

- The Flood Plain Zone
- The Surface Flooding Zone

The flood plain zones are mostly in pronounced gullies and depressions where a clear flow path can be identified. The flood levels from model for this area are generally of high confidence. A minimum freeboard of 0.5m above the 1%AEP flood level shall be applied to all habitable floors.

The Surface Flooding Zone generally occurs in very flat upper catchment area where overland flows will follow a wide spread and shallow path across many properties. Due the nature of densely developed residential properties, the flow paths are interrupted by numerous fences, garden sheds, low walls etc, this gives great difficulties in accurately simulating the flood depth. Occasionally, but very rarely, deep and fast flood flow will be found in these areas. Under a 1%AEP extreme event, flood depths from 300mm (in flat areas) to 500mm (in localised depressions) can be expected. A minimum freeboard of 300mm shall be applicable for all habitable floors.

The flood hazards in the Central Papakura Area were mapped based on the maximum flood levels simulated in the model runs with the following assumptions:

1. The modelled network is based on the existing network plus the committed upgrade works including the new 2.3m tunnel/pipeline between the McLennan Reserve Upper Pond and the Pahurehure Inlet, and drainage upgrade works planned in the Central Business Area. Any future upgrade of the drainage network will potentially alter the predicted flood levels at some locations.
2. Hydrological models used in the simulation are for the Maximum Probable Development (MPD) scenario based on the current District Plan controls, the Takanini Structure Plan controls and the private plan changes currently pursued by some land owners.
3. The flood hazard extent was mapped based on the Auckland Regional LiDAR dataset (2006) with a vertical accuracy of ±0.25m; no specific site survey has been undertaken.
4. The predicted flood levels are based on the existing overland flow paths configurations and geometries of depressions. Should the overland flow paths and existing natural or engineered depression storages be modified in any way, the predicted flood levels may change accordingly.
5. Inlets to the piped system are not explicitly modelled for flood hazards. Local flooding caused by inadequate inlet capacities may not be included in the maps.
6. Localised flooding caused by the lack of capacities in reticulation beyond the extent of the modelled network is not covered by the maps.
7. Localised flooding due to faulty or inadequate private drainages at properties is not covered by the maps.
8. It is assumed in the model that the full hydraulic capacities of the networks are available during the simulated design extreme events. Any increases of flooding caused by partial or full blockages of the drainage pipes have not been taken into considerations in the model.
9. Flood levels from model simulations may not be accurate for nodes beyond the most upstream loading nodes.

## 10.2 Overland Flow Paths Mapping

A major overland flow path is defined the ICMP Funding Guideline as where the stormwater network capacity is exceeded in the 10%AEP and 1%AEP storms and the resulting overland exceeds 0.5$m^3$/s.

All major overland flow paths have been identified from the model simulations for the 1%AEP storm event, included in the Major Overland Flow Paths Maps in Appendix A.

All future development within 10m on either side of the overland flow paths shall be specifically designed by an engineer experienced in flood hazard assessments to ensure no obstruction of the overland flow path and all future habitable and non-habitable floor levels have be determined with full considerations given to the maximum flood levels and the required freeboard.

## 10.3 Erosion Hazard

Erosion is a natural process occurring on engineered and natural streams. Though, urban development can increase the discharges in the stream channels thus potentially increase the rate of erosion. Erosion, if uncontrolled, can cause instability at the stream bank and generate excessive sediment in the receiving water.

Erosion can be predicted either based on the method of permissible velocity or the method of tractive force. Since average flow velocities can be easily obtained from the model simulations, the method of permissible velocity has been used to verify the erosion potential of stream channels at Central Papakura Area. A permissible velocity of 1.1m/s was considered appropriate for the clayey silt material at these streams. If the peak flow velocity at the stream during a 50%AEP storm event (the typical bank full flow event or channel definition event in the Auckland Region), exceeds the permissible velocity, then the channel is predicted to be erodible. The modelling information was combined with observed existing stream bank erosion problems to identify areas of high risk for erosion hazards.

Another type of erosion is coastal erosion. The exposed coastal land is subject to continuing attack by waves and tidal currents. The coastal erosion may be worsened by removal of mangroves close to shore line and future climate changes.

All the identified areas of high risk for erosion hazards are included in the Map in Appendix A.

## 10.4 Sea Inundation

Development in the low lying coastal area may be subject to tidal inundation. Extreme tide level can combine with other factors such as storm surge, wave run-up, and future sea level rises, and pose a significant hazard to low lying coastal properties, if the building floors have not been elevated adequately.

Extreme sea levels may be caused by storm tides, wave run-ups and sea level rises. The major factors for, and the effects of sea level rises from climate changes, have been discussed in detail in Section 2.11. The 1%AEP sea inundation level at the coast can be assessed via the following equation for risk screening purposes:

$$SL_{1\%AEP} = MHWS + S_s + Ws + Wr + \eta + SLR \qquad \textit{Equation (1)}$$

Where:

$SL_{1\%AEP}$ = *1%AEP sea inundation level, RL (m) in terms of LINZ Datum*

***MHWS*** = *Mean High Water Spring, RL (m), at Manukau Harbour using Onehunga Port Data*
***$S_s$*** = *Storm Surge, assumed to be 0.9m as per MfE reports*
***Ws*** = *1%AEP Wave setup, assumed to be 0.4m and 0.6m for the sheltered and un-sheltered Pahurehure Inlets*
***Wr*** = *1%AEP Wave Runup, assumed to be 0.3m and 0.5m for the sheltered and un-sheltered Pahurehure Inlets*
***η*** = *0.25m, IPO/ENSO/annual variation in Meal Level of Sea*
***SLR*** = *Sea level rise, 0.2m to 2050 and 0.5m to 2100, as per MfE reports*

The extreme wave setup and wave run-up can be simulated if the near shore bathymetry and the extreme wind speed and direction data are available for the locations concerned. The above assumed levels are considered adequate for the purpose of screening risks, so that more detailed studies can be undertaken at locations with high risks.

Extreme 1% AEP Sea Inundation Levels for both the sheltered inlet to the east of the Southern Motorway and the unsheltered inlet to the west of the Southern Motorway, under the current and future climate change scenarios are summarised in the Tables below.

**Table 14: Current 1% AEP Sea Inundation Hazard**

| Location | MHWS (RL) | Storm Surge | Wave Setup | Wave Run-up | *η* | Sea Level Rise | Extreme Sea Level (RL) |
|---|---|---|---|---|---|---|---|
| East of Southern Motorway | 1.7m | 0.9m | 0.4m | 0.3m | 0.25m | - | 3.55m |
| West of Southern Motorway | 1.7m | 0.9m | 0.6m | 0.6m | 0.25m | - | 4.05m |

**Table 15: Yr 2050 1% AEP Sea Inundation Hazard**

| Location | MHWS (RL) | Storm Surge | Wave Setup | Wave Run-up | *η* | Sea Level Rise | Extreme Sea Level (RL) |
|---|---|---|---|---|---|---|---|
| East of Southern Motorway | 1.7m | 0.9m | 0.4m | 0.3m | 0.25m | 0.2m | 3.75m |
| West of Southern Motorway | 1.7m | 0.9m | 0.6m | 0.6m | 0.25m | 0.2m | 4.25m |

Extreme sea levels at individual sites can be specifically assessed by an experienced coastal engineer. In the absence of any specific studies, the above levels can be used for building floor level controls in the low lying coastal area. A freeboard of at least 0.5m shall be applicable.

All lands below RL 4.55m in terms of LINZ datum are considered as prone to sea inundation hazard.

**Table 16: Yr 2100 1%AEP Sea Inundation Hazard**

| Location | MHWS (RL) | Storm Surge | Wave Setup | Wave Run-up | $\eta$ | Sea Level Rise | Extreme Sea Level (RL) |
|---|---|---|---|---|---|---|---|
| East of Southern Motorway | 1.7m | 0.9m | 0.4m | 0.3m | 0.25m | 0.5m | 4.05m |
| West of Southern Motorway | 1.7m | 0.9m | 0.6m | 0.6m | 0.25m | 0.5m | 4.55m |

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