Erosion and Sediment Control Plan for the Mahurangi Catchment

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Erosion and Sediment Control Plan for the Mahurangi Catchment

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Executive summary

An erosion and sediment control plan (ESCP) has been prepared for the Mahurangi catchment. This ESCP identifies specific actions for rural land management activities to reduce erosion and the resulting discharges of sediment to the catchment's waterways and harbour.

The Mahurangi catchment covers approximately 11,500ha, with Warkworth being the dominant urban area. The western portion of the catchment extends from the Pukapuka Inlet sub catchment in the south west northwards beyond Warkworth to the ridge line in the north west corner that adjoins the Dome Valley, and is bounded to the west by the sub catchment of the Mahurangi River headwaters, and to the east by the Mahurangi Harbour. The eastern portion of the catchment includes the south west sub catchments of the peninsula that extend to the Te Kapa River inlet at the southern tip.

The main urban area within the catchment is Warkworth. The Snells Beach-Algies Bay urban area also encroaches into the catchment but most of the existing parts of that urban area lie to the east of the catchment boundary, draining directly to the open coast.

From a physical perspective, the focal point of the catchment is the Mahurangi Harbour, which has an area of 24.6km^2. Approximately 206.5km of freshwater rivers and streams discharge into the Harbour. Parts of the harbour have highly diverse marine habitats and communities, and water quality of the harbour is assessed as "good" by Auckland Council monitoring.

The harbour has degraded over time through an accumulation of sediment, and recent ecological monitoring indicates that four particular marine species considered sensitive to increased sediment concentrations are still exhibiting declines in abundance at the intertidal sites. However, monitoring also indicates that declines in wedge shell populations in the mid harbour and Te Kapa Inlet noted in previous years are no longer apparent due to the recruitment of new juveniles to these populations.

Land use within the catchment is varied, but is dominated by dry stock farming, with smaller areas of dairy farming, rural lifestyle blocks and production forestry. While not confirmed on the ground, riparian cover appears to be relatively extensive when compared to other rural catchments.

The Mahurangi Action Plan (MAP) was the original catchment management programme established for the Mahurangi catchment, and has been operating since 2004. This ESCP is an evolution of that prepared under the MAP as the guiding programme that has driven land management initiatives within the Mahurangi catchment.

This ESCP identifies that the priority sub catchments (in order of priority) are West Mahurangi, Te Kapa River and Pukapuka Inlet, and the Mahurangi River. Activities that are recommended to continue are to engage with industry organisations and liaison groups, develop land management plans, and maintain compliance monitoring of earthworks sites. Additional recommendations are to undertake stream walks to identify priority areas of stream bank erosion, ground truth and map riparian cover, enhance riparian cover where possible, survey water quality and undertake baseline monitoring, and verify erosion and sediment rates including from unsealed roads.

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1.0 Background

1.1 Purpose

The Sustainable Catchments Programme (SCP) is delivered by the Regional Environmental Priorities Team in the Environmental Services Unit (ESU) of the Auckland Council. It now incorporates Project Twin Streams (PTS) and is funded in the Long Term Plan through both the ESU and Stormwater Unit budgets.

The strategic objective of the SCP is to contribute to the achievement of the Auckland Council's stormwater, water quality and stream restoration outcomes through integrated, community based interventions in priority catchments. The types of interventions could include riparian and wetland restoration, sustainable land management, improved walkways, interpretation signs and research projects. Linking up and leveraging off existing council, iwi and community activities is critical to the programme's success. Auckland Council therefore provides an integration and/or facilitation role within a catchment.

Six catchment areas are currently part of the programme. These catchments are Waitemata (Project Twin Streams); Mahurangi; Kaipara (Hoteo); North East Coast (Whangateau Harbour); Waitemata (Oakley, Motions and Meola Creeks); Manukau (Papakura Stream); and Greater Tamaki.

As a component of the SCP, an erosion and sediment control plan (ESCP) is required for the Mahurangi catchment. The ESCP is to identify specific actions for rural land management activities to reduce erosion and the resulting discharges of sediment to the catchment's waterways and harbour. It will contribute to the objectives and outcomes of the SCP as detailed in Section 1.2.

All maps referred to this in this document are provided in Appendices A-I.

1.2 Objectives

As noted, the strategic objective of the SCP is to contribute to the achievement of the council's stormwater, water quality and stream restoration outcomes through integrated, community based interventions in priority catchments.

The objectives of the SCP that this Plan contributes to are:

Strategic objective:

> *To contribute to the achievement of council's stormwater, water quality (chemical and biophysical) and stream restoration outcomes through an integrated planning and implementation methodology delivering community based interventions into priority catchments.*

Environmental Objectives:

- Contribute to being the world's most liveable city.
- Contribute to enhancement of ecosystem services.
- Assist in the management of natural freshwater systems.
- Establish freshwater values and aspirations with communities.
- Enhance and increase Auckland's green infrastructure networks.
- Reduce yield of sediment to sensitive marine environments.
- Manage riparian margins for improved biodiversity, amenity and connectivity.
- Contribute to the enhancement of Hauraki Gulf ecosystems.
- Integrated management producing biodiversity gains.

Community Objectives:

- Recognise our diverse communities, varied goals and aspirations, capacity and levels of interest and tailor the programme accordingly.
- Foster sustainable, long-term community action, leadership and 'ownership'.
- Deliver interventions that will engage communities over the long-term.
- Promote creative and inclusive learning.
- Agencies, mana whenua, and community work in effective partnerships.

Programme Objectives:

- Deliver interventions that will help to achieve our environmental, community and programme objectives.
- Develop a consistent approach and methodology for the planning and implementation of the SCP across the region
- Establish and implement a consistent and robust monitoring and evaluation framework for the SCP.
- Adopt an adaptive management philosophy which provides for a structured, iterative process to decision making based on our monitoring and evaluation.
- Include principles of the Orders of Outcomes and Plan Logic in our planning and implementation processes.
- Achieve positive integration with other related Auckland Council programmes and plans.
- Implement a programme which promotes the efficient use of ratepayer funds and provides value for money outcomes.

In addition, the *Mahurangi Action Plan– A Strategic Plan for the Catchment 2010 – 2030* provides a strategic overview for the catchment and was developed by the Auckland Regional Council, Rodney District Council and the community of the Mahurangi. This is separate from the Mahurangi Action Plan (MAP) which was the original catchment management programme established for the Mahurangi catchment, and included an erosion and sediment control plan developed in 2004. Since the creation of Auckland Council the Mahurangi Action Plan has been adopted by the SCP. This ESCP is an evolution of one prepared under the MAP in 2004.

Some MAP initiatives that are relevant are:

- Implementing best practice soil conservation practices;
- Improve riparian management and plantings;
- Better stock management (including exclusion) in and around waterways;
- Improve practices in forestry operations;
- Improve rural roading practices; and
- Better management of urban and rural residential earthworks activities.

The objective that has therefore been developed for this ESCP is:

> To encourage soil conservation through sustainable land use practices and the integration of existing works and initiatives that in turn will contribute towards:
>
> - Avoiding or mitigating adverse effects of sedimentation on the Mahurangi Harbour; and
> - Protecting and enhancing the natural character of the rivers and streams and their margins; and
> - Protecting the habitat of macro invertebrates, native fish and shellfish of the Mahurangi Harbour.

To achieve the above, this ESCP:

- Reviews critical source areas for erosion as identified in previous research;
- Identifies works undertaken to date;
- Re-assesses priority areas and activities;
- Identifies and confirms appropriate management options for works and restoration;
- Identifies ways to implement these management options.

The key actions of the ESCP are to:

- Review and update the priority sub catchments within the Mahurangi catchment that are susceptible to sediment discharges based on the following criteria: closeness to water ways, soil type, slope, land use, and rainfall;
- Re-prioritise the areas within the sub catchment(s) where mitigation effort is best spent;
- Identify the appropriate land management practices;
- Prioritise any changes in land management practices.

Timeframes for implementation will be determined by the Auckland Council in consultation with the community of the catchment, and in the context of priority actions within other catchments.

1.3 Background

The Mahurangi Harbour is highly valued by the local and wider regional community. The sheltered bays, native bush and spectacular coastal views make the area a popular place for recreational boating, fishing, swimming and a range of outdoor activities.

The Auckland Council (AC) and the legacy councils (Auckland Regional Council (ARC) and Rodney District Council (RDC)) have been actively monitoring the state of the marine ecology in the Mahurangi Harbour for more than ten years. State of the Environment monitoring for the Mahurangi Harbour from 1993 onwards indicated that the health of the harbour was in decline and under stress, and this is believed to be due to sediment discharges from a combination of human activities and meteorological events, with sediment generated from land based sources identified as the primary cause.

The Auckland Council's Mahurangi Estuary Monitoring Programme report on data collected from July 1994 to January 2011 (Halliday et al 2012) indicated that although improvements to certain populations are becoming evident, increases (to previous levels) in abundances of taxa known to be sensitive to increased sediment loading have not yet been detected. Its previous recommendations concerning the need to investigate and implement improved sediment controls still apply.

The ARC resolved to proactively address the issues in the Mahurangi, and in 2004 the Mahurangi Action Plan (MAP) (AC, 2004) was developed as a five year pilot project with the RDC as a key partner. The Strategic Plan for the Mahurangi was produced in 2011 (AC, 2011a).

The primary objective of MAP was "*to halt, slow or reverse the adverse effects of sedimentation on the health of the Mahurangi Harbour."* A number of secondary and supporting objectives were developed to address Ecosystem Protection, Sustainable Farming and Forestry Practices, Cultural and Economic Values of the harbour, and *"to ensure the community takes ultimate ownership of protecting the estuary through a shared vision and that the community is happy with the state of the Mahurangi environment."*

The driving principle of MAP was to implement strategic, focused interventions to protect the health of the harbour. Priority sub catchments were identified where there was high community interest or involvement, or where the sub catchment contributed the highest relative proportions of sediment to the harbour. The priority sub catchments identified were:

- Dyers Creek (now referred to as West Mahurangi)
- Ducks Creek (now referred to Mahurangi East)
- Te Kapa River

The West Mahurangi sub catchment was identified as a priority sub catchment mostly due to the amount of community interest and involvement, and the potential for showcasing good land management practices. Mahurangi East and Te Kapa River sub catchments were chosen due to the actual and potential sediment contributions to the harbour.

An additional focus of MAP was to support and financially assist landowners and the local community in the implementation of works to reduce erosion and enhance waterways. These works included retiring erosion-prone land; fencing off streams, waterways and wetlands to exclude grazing stock, riparian planting, and modifying land management practices. Forty farm plans were written to help guide landowner actions.

While MAP was focussed on the effects of sedimentation within the Mahurangi Harbour and less focussed on wider (non-sediment related) community objectives, the SCP programme addresses a wider management framework to integrate multiple issues and objectives within the catchment and the broader cultural and socio-economic elements of the Mahurangi community. The MAP focus on sediment management now becomes a component of the SCP.

Ngati Whatua, Ngati Manuhiri and Ngati Paoa representatives have been involved with Auckland Council and its predecessors to help define their traditional and customary relationships with the catchment. These relationships are significant, and help to sustain the mauri of the harbour and in turn the mauri of the people (Auckland Council 2004).

1.4 Orders of outcomes and plan logic

The SCP (and Stormwater Unit) has adopted the 'Orders of Outcomes' framework as part of the planning, implementation, and monitoring and evaluation processes to overcome the difficulty of managing complex natural environments and monitoring the outcomes of numerous multi-party and multi-layered interventions and to ensure Plan Logic across all programme stages and deliverables.

The Orders of Outcomes model has four orders of outcomes:

1st Order: Enabling conditions that must be in place for higher level outcomes to be achieved;
2nd Order: Observable changes in uptake or practice;
3rd Order: Measurable positive changes in the social, cultural, environmental and economic state; and
4th Order: The vision.

The 1st, 2nd and 3rd Orders need to be developed sequentially in order to realise the overall programme objectives and the specific objectives of this ESCP. This ESCP will focus on the 1st Order to provide the enabling conditions that are required for subsequent higher level outcomes to be achieved.

2.0 Catchment Description

2.1 Location

The Mahurangi Harbour is situated approximately 50km north of Auckland on the east coast, as shown on the Appendix A map *Mahurangi Catchment Boundaries.* The Mahurangi catchment has an area of approximately 11,500ha, extending from the Dome Valley north of Warkworth to the mouth of the Mahurangi Harbour in the south.

The main urban area within the catchment is Warkworth. The Snells Beach-Algies Bay urban area also encroaches into the catchment but most of the existing parts of that urban area lie to the east of the catchment boundary, draining directly to the open coast. From a physical perspective, the focal point of the catchment is the Mahurangi Harbour, which has an area of 24.7km^2. Approximately 206.5km of freshwater rivers and streams discharge into the Harbour.

2.2 Climate

The Mahurangi catchment, similar to much of New Zealand, has a temperate maritime climate. The average annual rainfall over most of the catchment is approximately 1400mm. The catchment can expect a mean annual total of between 2,000-2,100 hours of sunshine, which includes about 48-50% of possible bright sunshine. The district has mild temperatures and does not experience wide seasonal extremes. Summer temperatures average 19˚C and winter temperatures average 10˚C. Occasional winter morning frosts do occur, most frequently in inland areas and in the east of the catchment. As soil temperatures rarely fall below 10˚C most of the catchment has year round grass growth.

Climate change predictions based on Warkworth indicate a decrease in average rainfall of 3 per cent by 2040 and 5 per cent by 2090. Seasonally, spring rainfall could decrease as much as 12%. The frequency of intense heavy rainfall events is expected to increase within the Auckland region. Temperatures within the Auckland region are likely to be around 0.9^o C warmer by 2040 and 2.1^o warmer by 2090, when compared with 1990 (Ministry for the Environment, 2012).

2.3 Harbour

2.3.1 General

The Mahurangi Estuary (high tide area 24.7km^2) is largely intertidal (65%), with a tidal volume of about 45 million m^3. The upper estuary is a 6.4km long tidal creek between Warkworth and Hamiltons Landing, bordered by dense stands of mangrove. Here sedimentation is strongly influenced by freshwater discharges, particularly during floods. The lower estuary, seaward of Hamiltons Landing, is wide and deep, with numerous embayments and tidal arms, and accounts for approximately 90% of the estuary's tidal

volume. At low tide, extensive intertidal flats flank the main tidal channel (Swales et al, 1997).

2.3.2 Water quality

Marine water quality is sampled by Auckland Council at two sites and began in 1993. The water quality of Mahurangi Harbour has been ranked as “good”, and is partly attributed to “good” water quality found at Dawson’s Creek and “excellent” water quality found at Mahurangi Heads (AC, 2013).

2.3.3 Ecology

Parts of the harbour have highly diverse marine habitats and communities. The harbour entrance has notable macro algal (seaweed) dominated by sub tidal rocky reefs and extensive horse mussel beds, which also extend into the central regions of the harbour (AC, 2011).

Huawai Bay and Pukapuka Inlet are notable for their intertidal sea grass meadows and variety of bivalve (shellfish) communities, dominated by cockles and *Macomona* (wedge shell). These occur throughout the other intertidal areas of the harbour entrance, the Te Kapa arm, and central region of the harbour (AC 2011).

The harbour is also an important area for juvenile fish, including snapper and flounder.

2.3.4 Sediment

Mahurangi Harbour has been the subject of long term monitoring by Auckland Council. The harbour has been found to be degraded over time through an accumulation of sediment (URS, 2006).

The populations of a selected range of invertebrate taxa have been monitored at intertidal and sub tidal sites in Mahurangi Estuary since 1994. Estuary-wide changes in the abundance of some macro faunal taxa and the horse mussel *Atrina zelandica*, and increases in the proportion of fine sand present in the sediments, were noted over the initial six years of monitoring (Cummings et al. 2007). The sediment composition changes occurred sometime between April 1996 and April 1997 and have persisted. Some of the patterns in the abundance of the monitored taxa are consistent with those that may be associated with elevated levels of sedimentation and/or organic enrichment (Halliday and Cummings, 2012).
The Auckland Council State of the Auckland Region Marine Report Card for the Mahurangi Harbour (AC, 2011) indicates that four species considered sensitive to increased sediment concentrations are still exhibiting declines in abundance at the intertidal sites, they are: the wedge shell (*Macomona liliana*), cockle (*Austrovenus stutchburyi*), a polychaete worm (*Scoloplos cylindrifer*) and the nut shell (*Nucula hartvigiana*).

The report also indicates that declines in wedge shell populations in the mid harbour and Te Kapa Inlet noted in previous years are no longer apparent due to the recruitment of new juveniles to these populations

2.3.5 Uses of the Harbour

The Mahurangi Harbour is a significant asset for commercial activities such as aquaculture, fishing and tourism. It is also widely used for recreational activities by locals and visitors.

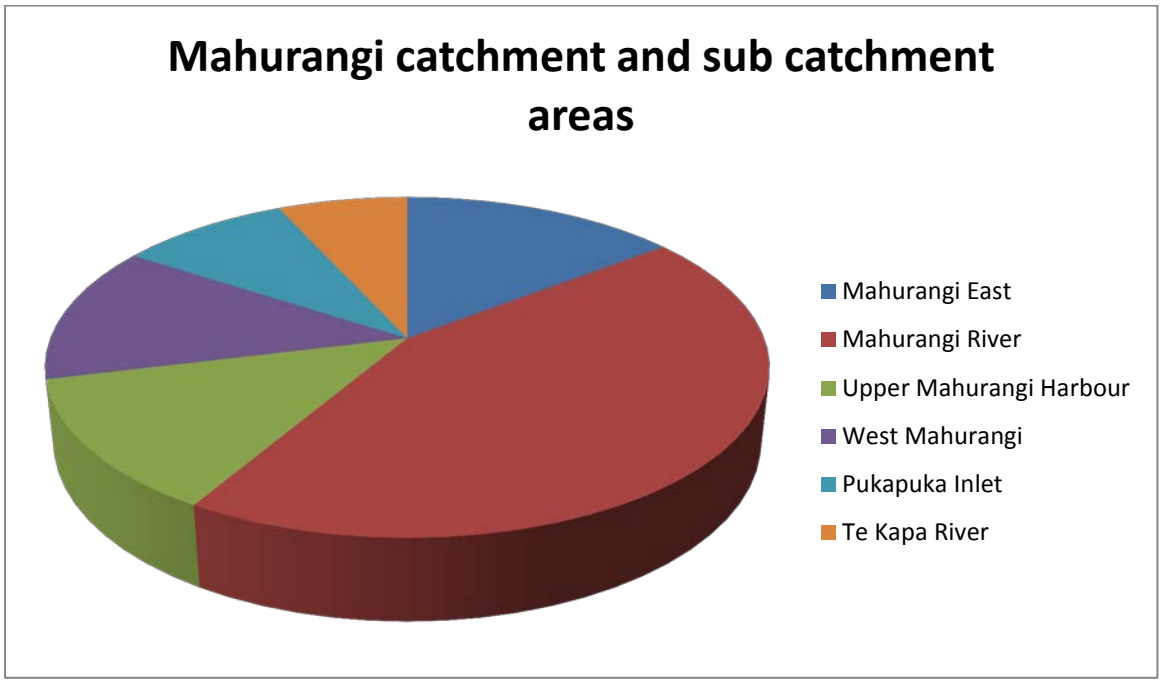
The Mahurangi catchment is a highly scenic area. All land in the catchment contributes to the visual quality of the area. A key feature of the character of the area is the strong visual connection between land and sea. The natural character of the coastline is also important. These elements are important to residents and to visitors and therefore also reflect the recreation and commercial attributes of the areas.

2.4 Land

2.4.1 Hydrology

The Mahurangi Catchment is divided up into sub catchments as shown on the Appendix A map *Mahurangi Sub catchment Boundaries* and in Figure 1 below. The sub catchments are defined by hydrological boundaries. Sub catchments within the Mahurangi catchment have been revised through the SCP programme to better reflect hydrological boundaries. The former Ducks Creek catchment is now part of the Mahurangi East catchment, and the former Dyers Creek catchment is denoted as the West Mahurangi catchment. The 'secondary' priority catchment boundaries (as determined through the MAP) of Te Kapa River, Upper Mahurangi Harbour, and Pukapuka Inlet remain unchanged.

Figure 1: Mahurangi catchment and sub catchment areas



Source – Auckland Council GIS

Figure 1 indicates that the Mahurangi River and its tributaries drain 44% of the catchment. The Upper Mahurangi, Mahurangi East and West Mahurangi sub catchments are each slightly greater than 13% of the total catchment area. The Pukapuka Inlet and Te Kapa River sub catchments are 9% and 7% of catchment area, respectively. In general terms, the catchment is dominated by tributaries which are short and steep, with many tributaries that are 3rd, 4th or greater order.

Information available on the ecological status of the individual freshwater streams is limited, with the majority of studies focussing on sources of sediment within the catchment (Hicks and Hawcridge 2004; Gibbs 2004; Gibbs 2006) and the effect of this sediment on the estuarine / harbour receiving environments (Cummings 2007).

2.4.2 Geology and soils

The dominant geology of the catchment is Waitemata Group marine sandstones and mudstones (taken from the Auckland Council GIS and the NZ Land Resource Inventory), as illustrated on Appendix B map - *Geology*.

Areas of Onerahi limestone are located to the north-east and north-west of Warkworth, along the true right fringes of the upper extent of the Mahurangi estuary, and extending from the upper reaches of the Pukapuka Inlet. A small ridge of limestone is also noted to the west of Snells Beach.

Pockets of andesitic tuff and tuffaceous sandstones are also present. More recent alluvial deposits are found in the middle and lower reaches of the main river valley, whilst older and higher level alluvial terrace deposits occur locally throughout the catchment (Feeney and Challis, 1984).

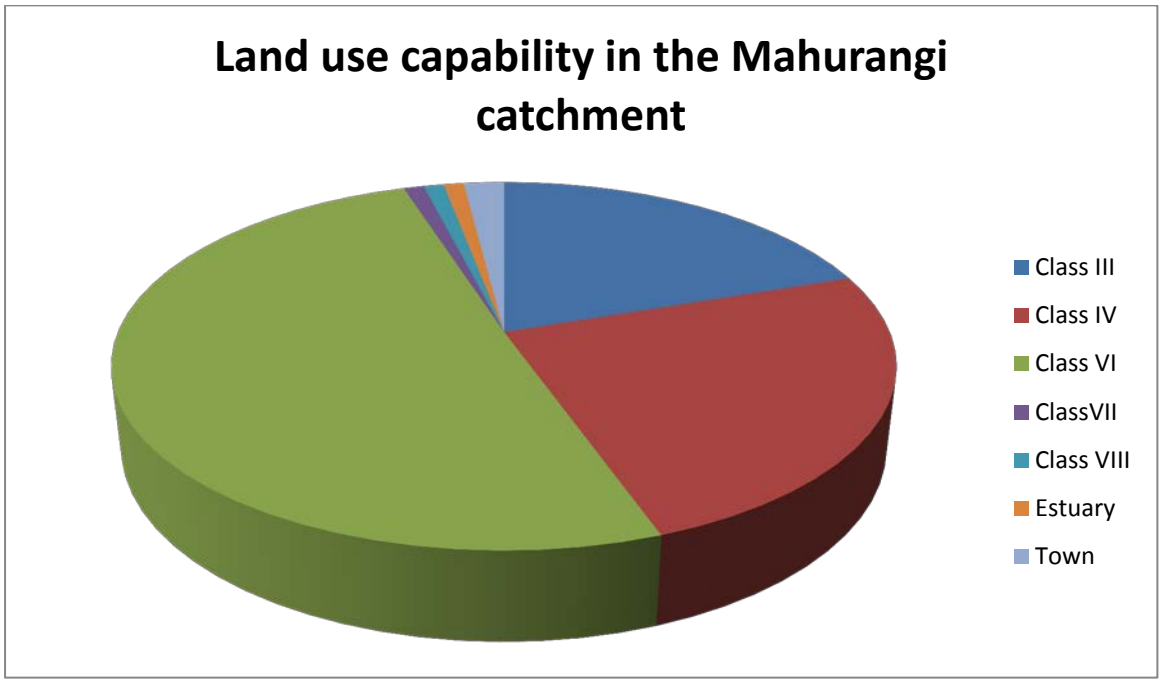
Appendix B also provides a series of maps identifying the spatial distribution of the key soil types within each sub catchment. Warkworth clay or sandy clay loams, and Whangaripo clay loam or clay are dominant (taken from the Auckland Council GIS and NZ Fundamental Soil Layers). Soils are leached and have low natural fertility under bush or scrub cover.

2.4.3 Land use capability

Land use capability (LUC) mapping gives an indication of the land's suitability for various uses, from the most versatile land (Class I) to the least versatile (Class VIII). It provides a standardised assessment of the suitability of a land unit for productive use, taking account of the physical limitations of the land, which include rock type, soil, slope angle, erosion type and severity, and vegetation.

Class I to IV land is considered suitable for horticulture or cropping, with classes V, VI and VII suitable for grazing or forestry, and Class VIII land unsuitable for any productive use. Appendix C provides a series of maps delineating the various land use capability classes within each sub catchment. Land use capability classes for the catchment (mapped at 1:50,000 scale) include Classes III through to VII. Notably, the majority of West Mahurangi and Te Kapa River sub catchments comprise Class VI land, whilst Mahurangi East is predominantly Class IV.

Figure 2: Land use capability (LUC) in the Mahurangi catchment



Source: NZ Land Research Inventory, LRIS Information Portal, Landcare Research

2.4.4 Freshwater quality

Water quality is assessed monthly by the Auckland Council at two freshwater stream locations in the Mahurangi, both on the Mahurangi River; 1) the Forestry Headquarters (FHQ) site, within exotic forest, and 2) the Water Supply site, within farm land. Water quality results of these and 32 other sites throughout Auckland are reported through State of the Environment Monitoring reports. The latest report, River Water Quality Annual Report 2012 (Lockie, S. et al 2013), uses the mean Water Quality Indices (WQI) from years 2009, 2010, and 2011 as a reference point to compare the 2012 results with. The report indicates that the FHQ site remains in the "Good" category based on a WQI of 82.8, with a slight deviation of -0.6 units from the reference point. The Water Supply site also remains in the same category of "Fair" with a WQI of 65.9. However, a deviation of -9.1 units has occurred when compared to the reference point. The report does not consider this change to be of particular concern indicating that high deviations were likely to be representative of the variable nature of water quality data. However, the report does indicate that when the mean indices across all sites

within each of the four land use classes are used, indigenous forest had the best water quality indices (excellent), followed by the exotic forest sites (good), with the urban sites having the worst water quality indices (fair), but the same quality class as rural sites (fair). The sites with rural and exotic forest catchments typically had water quality indices intermediate between native forest and urban sites.

2.4.5 Relief

The terrain within the catchment is diverse and varies from localised flood plains (generally within the mid to upper reaches of the catchment) to steep hill country which transitions to rolling terrain. Moirs Hill on the south-western boundary of the catchment rises to 358 m above sea level (asl) while The Dome rises to 336 m asl on the northern boundary. Between these peaks the land descends to gently rolling downland west of Warkworth. Of the land bordering the harbour, the western margins are somewhat higher (140-150 m asl) and steeper and more dissected than the eastern side (60-100 m asl) (Feeney and Challis, 1984). Terrain of the catchment is illustrated on the *Slope Classes* map in Appendix D.

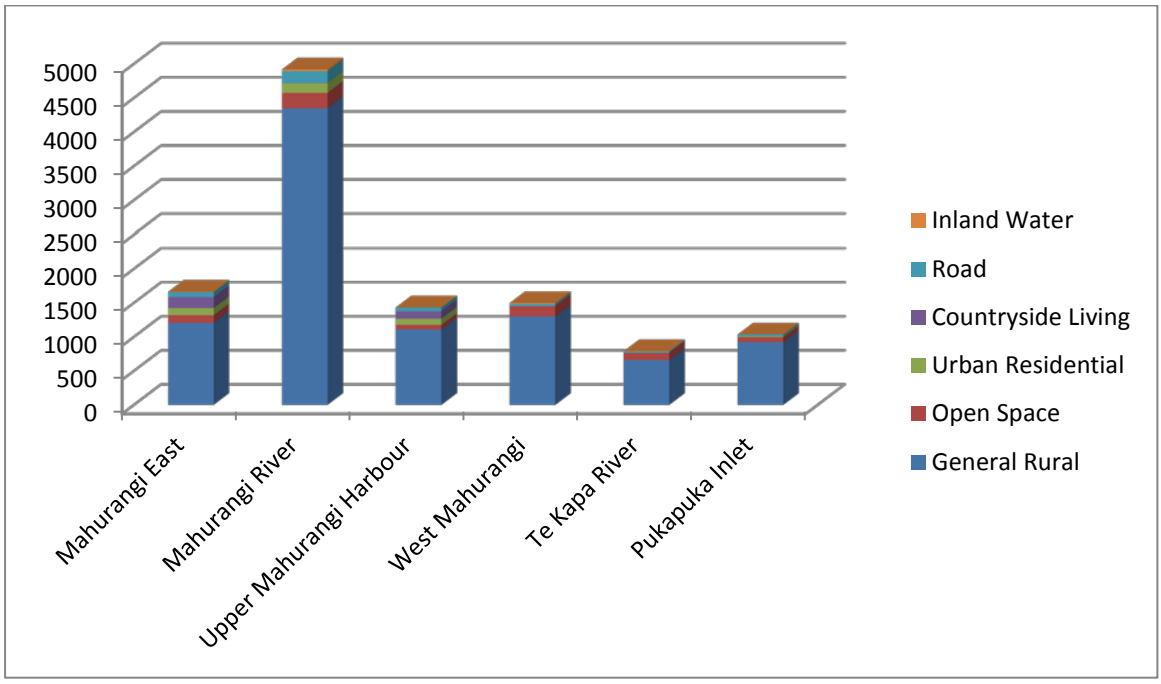
2.4.6 Land use

Data from the LCDBIII indicates that land use within the Mahurangi catchment is predominantly rural (9,545ha / 82%) comprising drystock farming (approximately 5,590ha), and exotic forestry (approximately 1,425ha). Other minor intensive land uses such as cropland, orchards, vineyards and market gardens occupy approximately 3% of the catchment. Dairy farming is a minor component of the catchment, comprising in the order of 250ha in total. Appendix E contains a map *Major Land Uses* in the Mahurangi catchment, which illustrates extent and distribution of major land uses in this catchment. Drystock farming dominates as the major land use, and in many areas extends down to the fringes of the harbour. Forestry is generally limited to the steeper upper extent of the Mahurangi River sub catchment, with other small pockets spread through the other sub catchments. Dairy farming is limited to small scattered holdings generally on the eastern side of the harbour.

Countryside living comprises 3% of the catchment, although lifestyle blocks occupy a large area. Urban areas occupy approximately 4%, with Warkworth the main urban area. A further 1% of the catchment is presently zoned as future urban.

Publicly owned land comprises 2.5% of the catchment (289ha), being 174ha owned by Auckland Council and 115ha owned by the Crown. Figure 3 below indicates the areas of various land use zones in the catchment and Appendix E maps for *Land Use* illustrate land use zones by sub catchment.

Figure 3: Land use zones within the Mahurangi catchment



Source: Auckland Council District Plan (Rodney Section)

2.4.7 Land cover, vegetation

Appendix F provides *Vegetation Cover* maps for each sub catchment, with corresponding data provided in Figures 4 and 5 below.

Vegetation cover within the Mahurangi catchment is largely made up of pasture, making up approximately 60% of the catchment. Native forests make up approximately 22% of the catchment and exotic forests including harvested forests make up approximately 12% of the catchment. The Mahurangi River has the highest percentage of exotic forestry of the Mahurangi sub catchments at 19%.

The Mahurangi catchment falls within the Rodney Ecological District, one of eight Ecological Districts in the Auckland Region. There were two key forest types that were originally associated with this District, and more specifically, with the Mahurangi catchment. Original forest cover in the Mahurangi would have been predominantly kauri-broadleaf (taraire, kohe kohe) forest with lesser areas of kahikatea-pukatea-taraire forest in lowland gullies and wetlands leading towards the harbour. Small areas of matai kahikatea-totara forest would also have been dotted throughout the catchment and rimu forest would have existed in some isolated areas north-west of Warkworth (LENZ, 2006).

Due to a history of human occupation and development/modification of the land, the current extent of kauri-taraire forest in the Mahurangi catchment has been assessed as being at 20-30% of its original cover, classifying the forest type as ‘at risk’. Kahikatea-Pukatea forest is assessed as being ‘acutely threatened’ at less than 10% of its original extent (LENZ, 2007).

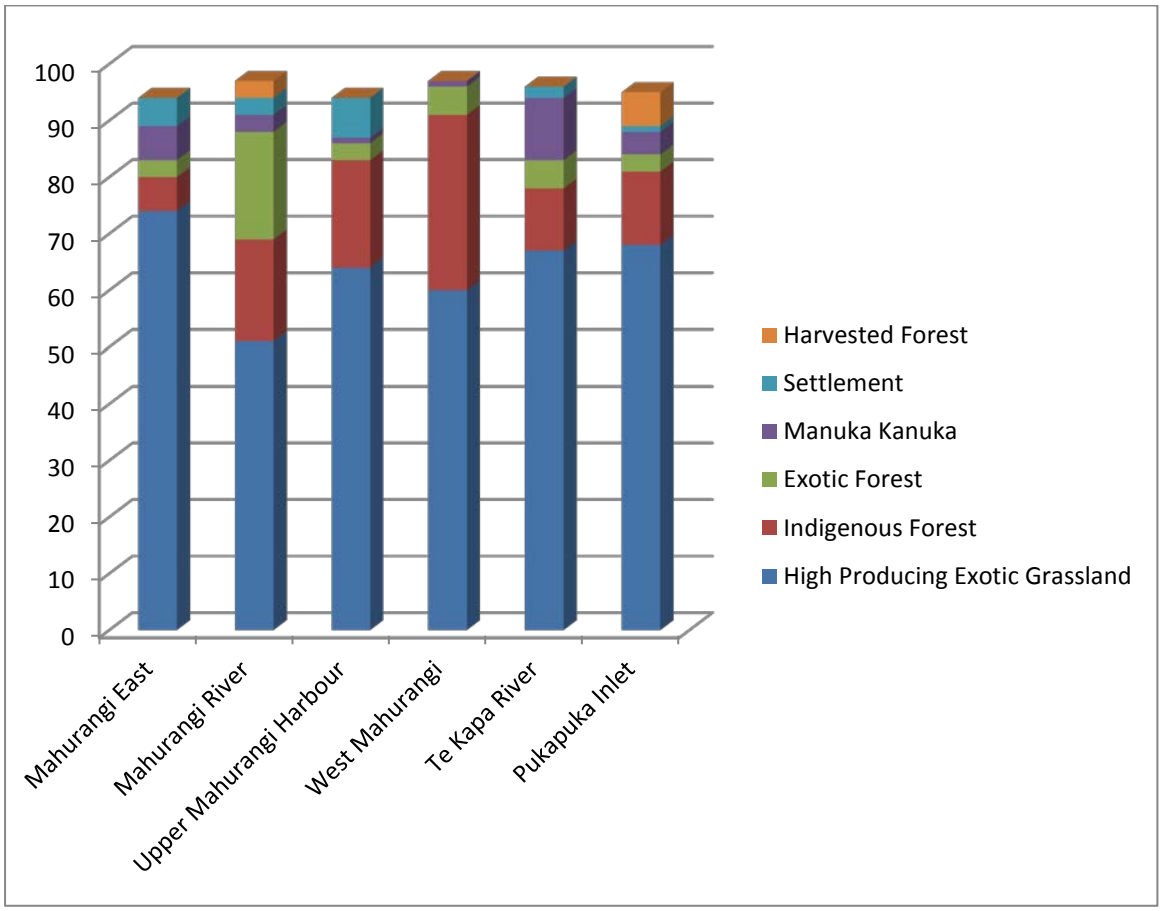
In addition to forest remnants, significant areas of coastal vegetation are also present within the catchment. These saline wetlands within estuaries and inlets evolved as a result of the drowning of embayments during the post-glacial marine transgression. The resulting landscape is characteristic of a drowned coastline. These coastal ecosystems include mangrove forests (*Avicennia resinifera*) and saltmarsh sedgelands composed of *Leptocarpus similis, Sarcocorniana quinqueflora, Selleria radicans* and *Juncus maritimus* (Tyson, 2005).

Vegetation clearance for farming has resulted in the remaining areas of indigenous vegetation in the Mahurangi catchment existing as fragmented yet widespread remnants. These remnants and their associated ecosystems still support both rare and common indigenous plant and animal communities (Tyson, 2005).

Native forest and bush is also found in the Mahurangi River foothills around Moirs Hill, Dome Valley and patches to the east of State Highway 1. These areas comprise mainly totara, kahikatea, nikau and kanuka (Tyson, 2005). Some of the native forests are protected in the form of reserves run by Auckland Council (Feeney et al, 1984). Areas of coastal forest and native bush are also dotted throughout the Auckland Council Regional Parks.

Intact freshwater wetlands are rare features, with only very isolated and scattered fragments of wetland remaining (Tyson, 2005). However, many of the foothill tributaries of the Mahurangi River are still surrounded by native riparian vegetation.

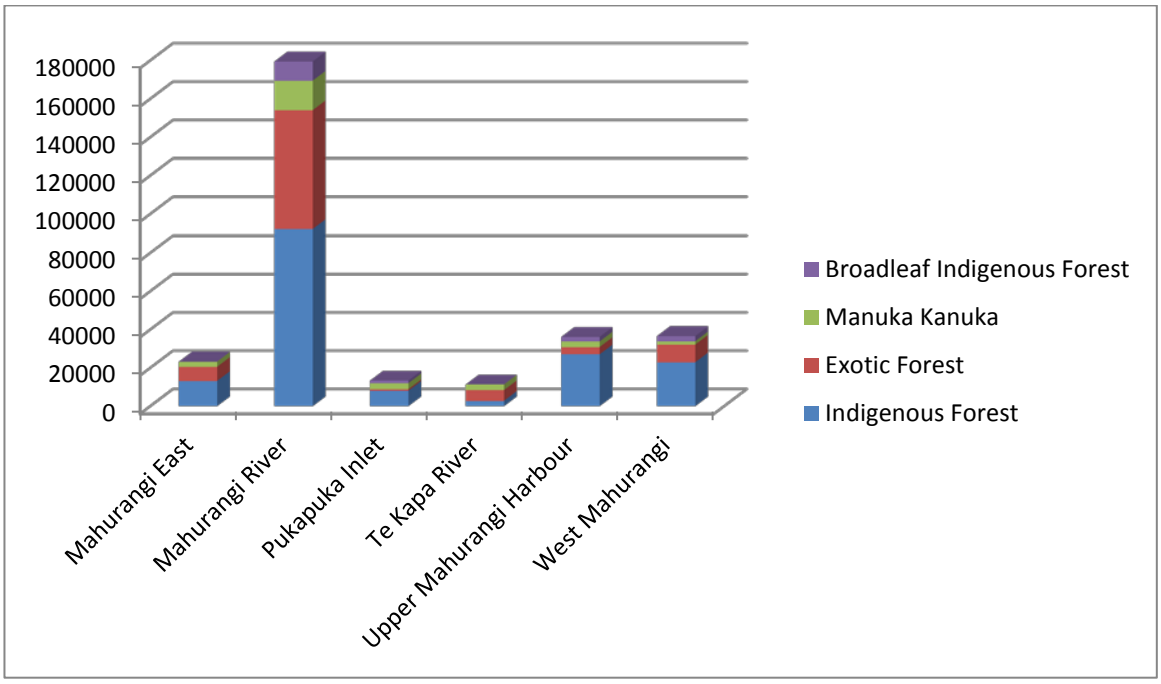
Figure 4: Main vegetation cover by sub catchment



Source: GIS Analysis of the LCDB III (Landcare Research)

A map showing *Streams with Riparian Vegetative Cover* is contained in Appendix F and was generated by intersecting NZS260 stream shape files with vegetation cover from the LCDBIII (Landcare Research). Figure 5 below provides an estimate of length of riparian vegetation cover by sub catchment. The map was generated without field survey or aerial photo comparison. Riparian vegetation cover along the stream channel ranges across the six sub catchments from 43% to 69%. The Mahurangi East sub catchment has the least riparian vegetation cover, while the Mahurangi River sub catchment has the greatest riparian cover.

Figure 5: Length of main riparian vegetation cover by sub catchment (m)

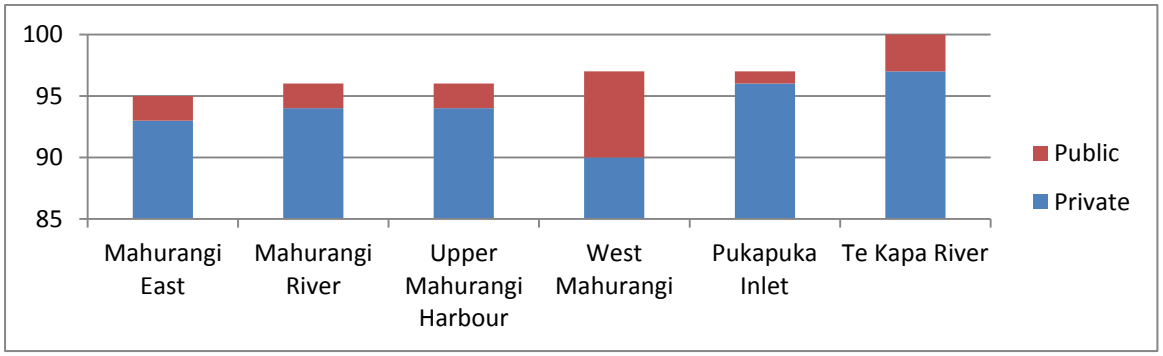


Source: The LCDB III (Landcare Research)
Note: Narrow strips of riparian vegetation not covered by the LCDBIII have been ignored.
Stream channel alignments and lengths based on NZS260 shape file (not verified via field survey or aerial photo comparison)

2.4.8 Land ownership

Figure 6 below indicates the area of private and public land in the catchment. The sub-catchments within the Mahurangi range from 90-97% private ownership of land, at an average of 94% across the catchment. Publicly owned ranges from 0-7%, at an average of 3% across the catchment. Public road reserves are not included in the summary and will account for any shortfall in total land ownership numbers.

Figure 6: Land ownership in the Mahurangi



Source: Auckland Council GIS

* Publicly owned land refers to land titles owned by the Crown and the Auckland Council. Public Road Reserves are excluded.

Local iwi are landowners within the catchment as well as performing a role as kaitiakitanga.

3.0 Catchment Issues

3.1 Erosion

The *Erosion Severity* map (generated from Landcare Research data in 2013 and based on soil characteristics) in Appendix G indicates that erosion rates within the catchment are generally low, with much of the catchment having negligible to slight erosion potential. Some small tracts of moderate erosion potential are identified within the steepest upper slopes of the West Mahurangi sub catchment, with a very small area identified in the Mahurangi River sub catchment. This is due to the combination of relief, soils and land cover.

Landcare Research has developed an erosion model for the use of North Island regional councils, which gives estimated annual average erosion rates in tonnes/km^2/year at 15m resolution. The New Zealand Empirical Erosion Model (NZeem) model (Dymond et.al, 2008), gives a quantitative spatial picture of where sediment in rivers is sourced. Classes of erodible land are generated, based on slope and proximity to watercourses, and whether woody vegetation is present. An erosion rate is estimated as a function of mean annual rainfall, a land cover factor, and an erosion coefficient that depends on the land type (i.e. erosion terrain). The model can be used to prioritise soil conservation works by running different land cover scenarios in particular catchments.

The *Estimated Annual Average Erosion Rates* (generated from the NZeem modelling below) map in Appendix G indicates likely moderate to high erosion rates in parts of the West Mahurangi and Mahurangi River sub catchments, with the balance of the catchment modelled as low to relatively low erosion rates. These predicted erosion rates have not been confirmed with field observation or site specific studies. These maps are likely to be more accurate as they are generated from a comprehensive modelling exercise.

3.1.1 Erosion potential modelling

New Zealand Empirical Erosion Model (NZeem)

Landcare Research has developed an erosion model which gives erosion rates in tones/km^2/year at 15m pixel resolution, called NZeem.

Table 1 below indicates the predicted annual erosion rates for each sub catchment based on NZeem.

Table 1: Predicted erosion rates

Sub Catchment	Area (ha)	Mean Annual Erosion Rates (tonnes/km^2/yr	Total Annual Erosion (tonnes/yr)
Mahurangi River	5063	81	4106
Mahurangi East	1676	62	1041
Upper Mahurangi Harbour	1458	66	967
West Mahurangi	1498	89	1326
Te Kapa River	788	69	547
Pukapuka Inlet	1035	65	675
Total Catchment	**11519**	**75**	**8661**

Source: NZeem

The NZeem model predicts a total erosion potential of 8,661 tonnes/yr. It is noted that the NZeem model indicates comparatively high erosion rates for the West Mahurangi sub catchment (formerly Dyers Creek sub catchment) which is consistent with the BNZ model (as detailed in Section 3.1.2.2. The slightly lower relative rate for the Mahurangi East sub catchment (formerly Ducks Creek sub catchment) may reflect the recent planting undertaken within the catchment.

Notably, the NZeem model indicates that the Mahurangi River sub catchment would exhibit a comparatively high erosion rate, similar to that of West Mahurangi.

3.2 Sedimentation

The accretion rate of the Mahurangi River has been examined by Trotter (1990), using seismic profiling and the examination of core samples. Seismic measurements made off Bradley Point in the lower harbour by Trotter (1990) suggested that the average rate of sedimentation on the tidal flats was about 1.2mm per year (i.e. 7-8 m in about 6500 years since the sea level rose to its present level). However, this estimate was calculated assuming the rate of accumulation was constant.

Harris (1993) concluded that while the average rate of accretion in the Mahurangi River over the last 6500 years has been about 1-2 mm per year, the average rate since the turn of the century has been an order of magnitude higher. The cause of this higher rate is suggested as being the clearing of forests, increased farming, and earthworks activities associated with roading and building.

A detailed study of sedimentation history and present day sedimentation processes was undertaken by Swales et al (1997), to determine how the Mahurangi estuary responded to historical changes in catchment sediment loads, associated with land use changes following human settlement. The investigations included probing and coring the sediment column, core analysis, assessing channel infilling from historical soundings, determining sediment accumulation rates from core stratigraphy and radiocarbon and pollen dating, examining records of historical land cover, and estimating estuary sedimentation loads from estuary infilling. The potential for estuarine sediments to be reworked by waves and tidal currents was also modelled (Swales et al, 1997).

The key findings from this research are summarised below:

- At least 7300 years ago the Mahurangi Estuary was a deep sub-tidal basin, slowly infilling (0.3-0.8mm/yr) with fine suspended sediment supplied by runoff from a native forest catchment. Up to 15m of mud has been deposited in the lower estuary over this time.
- Rapid catchment deforestation following European settlement (1850-1900 AD) resulted in severe soil erosion and rapid deposition of thick sequences of gravel, sand, mud and vegetation in the upper estuary. Some 3m of sediment has been deposited in the upper estuary since 1850 AD.
- The overall pattern of increased sedimentation in the estuary following catchment deforestation is similar to that documented in other Auckland estuaries. Background sediment rates of 0.3-0.8 mm/yr are similar to rates measured in Lucas Creek (1 mm/yr) and Hellyers Creek (0.35 mm/yr) in the Upper Waitemata harbour;
- Sediment loads were relatively low (120 tonnes/km^2/yr) prior to catchment deforestation (1850-1900 AD), which resulted in a 13-fold increase in sediment loads up to about 1,600 tonnes/km^2/yr. Since 1900 AD the average annual sediment load has declined by 25% to 1,170tonnes/km^2/yr but is still an order of magnitude higher than sedimentation loads from the earlier forested catchment. In the lower estuary, where most of the suspended sediment is deposited, sedimentation loads have averaged 702 tonnes/km^2/yr since 1900 AD.
- Sedimentation in the Mahurangi Estuary is dominated by floods and infrequent large floods can deliver a large proportion of the annual sediment load to the estuary. For example, the May 1985 flood alone delivered 75% of the annual average sediment load (for the 1975-1995 period) to the estuary (a 1% Annual Return Interval event).
- The largest sediment accumulation rates occurred in the upper Estuary (of the order of 15-20 mm/year) with rates of the order of 2-5 mm/year elsewhere in the harbour.
- The estuary is very susceptible to the impacts of catchment soil erosion as shown by rapid estuary infilling and a change to much coarser sediment deposition in the last 150 years. Despite the fact that future catchment sediment loads are unlikely to ever be as extreme as those which occurred during deforestation last century, sediment loads today are at least 5-6 times higher than prior to deforestation.

Swales et al. (1997) concluded that future development within the catchment which exposes soil to erosion will need to be carefully planned if periods of potentially increased sedimentation and the subsequent adverse environmental effects on the estuary are to be avoided or mitigated.

3.2.1 Sediment source mapping

Sediment loads within each main tributary of the catchment have not been measured. However, stream morphology, vegetation cover and land use are useful proxies to identify where sediment comes from. This approach was applied in *"A survey of sediment sources on streams in the Mahurangi catchment; Hicks, D.; Hawcridge, E. (2004)."* This research found that while 33% of sediment sources are entirely natural; 54% are induced or exacerbated by farm livestock; and 13% are created by human modifications to channel beds or banks, such as earthworks, track crossings and drain outlets.

Hicks et al (2004) indicate that specific activities that have a marked influence on sediment inputs into streams include:

- Earthworks adjacent to stream channels;
- Channel excavation by machinery;
- Trampling of swampy alluvium or colluvium by livestock next to in-filled channels; and
- Browsing and trampling of steep banks by livestock next to incised channels.

They also commented that excluding livestock from streams could potentially remove about half of current sediment sources; while avoidance of earthworks in or adjacent to channels (i.e. drain-cleaning, drainage, damming, track construction and culvert crossings), could potentially remove another eighth of sediment sources. However, they note that even if all possible measures are taken to control induced sediment sources on stream banks, natural processes will continue to generate sediment at about one third of the current sources catchment-wide.

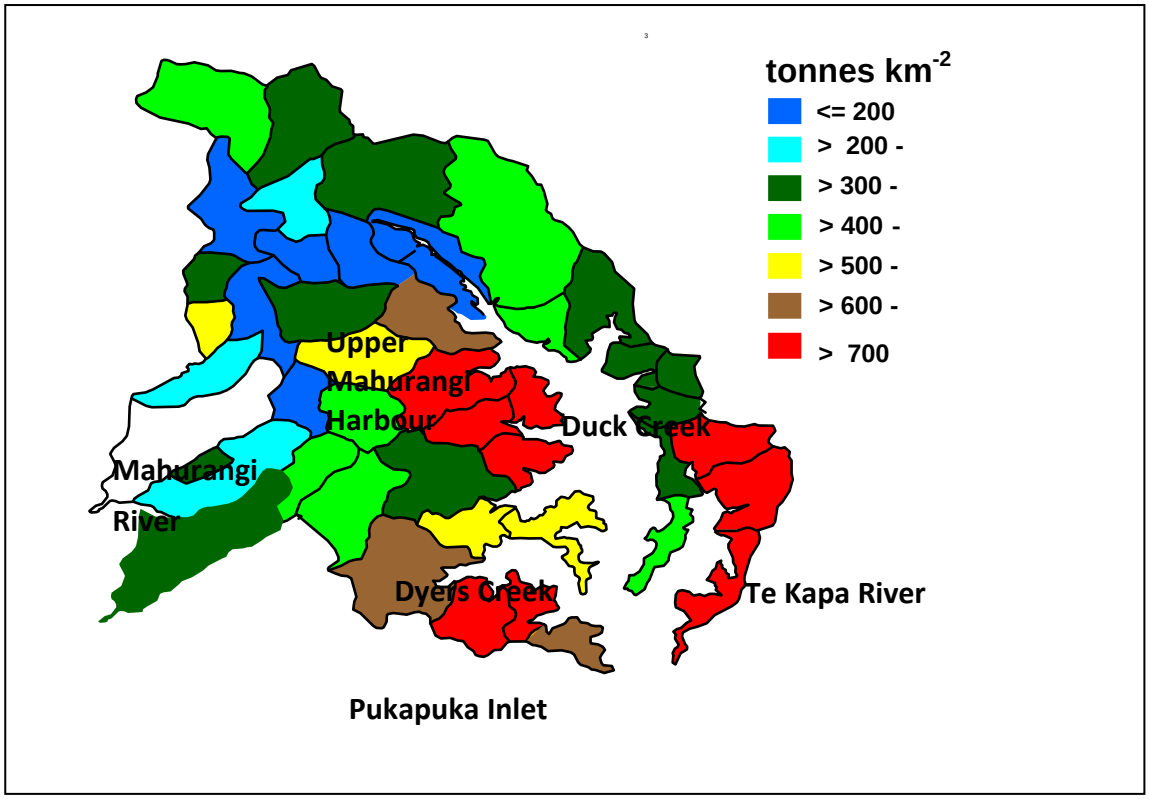
3.2.2 Sediment load modelling

Basin New Zealand Model

In order to gain an insight into the effect of rainfall patterns on sediment delivery to the estuary from the surrounding catchment, the ARC commissioned NIWA to use an established computer model to predict sediment yield over the long-term. Stroud and Cooper (1997) describe the set up and validation of the Basin New Zealand (BNZ) model for the Mahurangi catchment and model predictions of annual sediment load for the period 1976 – 1995. Auckland Council requested NIWA to update predictions to 2002. During this process, it was recognised that both annual and event-based sediment loads can affect estuarine biota. As a result, Stroud (2003) updates and substantiates these sediment predictions to the end of 2002 by providing information describing predictions of daily and annual sediment yields over this period.

The long term average sediment load delivered to the Mahurangi Estuary from the surrounding catchment was predicted by the model to be 52,270 tonnes/year (448 tonnes/km^2/year) and ranged from just over 13,000 tonnes/year to approximately 136,000 tonnes/year. Many of the areas displaying high sediment losses were located in sub catchments bordering the estuary, particularly Te Kapa Inlet, Pukapuka Inlet, and West Mahurangi as shown in Figure 7 below. These areas are dominated by pastoral land use, strongly rolling to steep slopes, and soil types that have low infiltration capacity (Stroud et al, 1997).

Figure 7: Predicted sediment loss by sub catchment (tonnes/km^2/year)



Source: BNZ Model

Sediment Numerical Modelling

A series of numerical models were developed by NIWA to determine water levels, waves and current flow within the Mahurangi estuary for a range of winds, tides and freshwater inflows, to provide information on sediment transport processes (Oldman et al, July 1997). These models were calibrated against a series of field data, and were shown to effectively simulate the movement of suspended sediments within the estuary and model deposition rates.

All the models were then used as predictive tools to determine potential sediment loads from within the catchment, under a range of proposed land-use development scenarios. The land use changes examined included an increase in the area of urbanisation, harvesting of the

existing Redwood forest, and conversion of the entire catchment to production forest. All scenarios predicted an increase in sediment loading over the current existing sediment load. The size of the increase in modelled sediment delivery to the estuary was subject to the degree of disturbance.

Oldman et al, 1998 noted that production forestry creates an increased risk of relatively high sediment loads being delivered to the estuary during harvesting.

3.2.3 Sediment source analysis

Isotope Mapping

The ARC engaged NIWA to undertake sediment source isotope mapping to identify and apportion the sources of catchment soil contributing to sediment deposition in the Harbour and to map the spatial distribution of the soil sources throughout the Harbour from pasture, native forest and exotic pine forest. The results of this study are contained in the Auckland Council Technical Publication 321: *Sediment Source Mapping in Mahurangi Harbour*, June 2006 (Gibbs, 2006).

This research informed the future direction of the MAP and associated actions and initiatives. Key points to emerge from the sediment source isotope mapping in relation to sediment generation from various land use activities within the catchment are set out as follows:

- Pastoral farming comprises 70% of the catchment area, contributes 15 - 55% of soil in the upper estuary and 10 – 30% across much of the rest of the Harbour.
- Urban development makes up approximately 4% of the catchment area and contributes little to sediment load.
- Native forests which make up approximately 20% of the catchment area also contribute sediment. This source contributes less than 30% in the upper estuary and generally less than 10% elsewhere.
- Forestry comprises 8% of the catchment area. It contributes a locally high proportion of sediment in the upper estuary (45 – 80%) and about 14% of the total sediment load across the whole Mahurangi Harbour.

	Catchment Area (%)	**Contribution to Soil in River Delta (%)**	**Contributes to Soil across Harbour (%)**
Pastoral Farming	70	15-55	10-30
Urban Development	4	<1	0
Native Forests	20	<30	<10
Forestry	8	45-80	14

Table 2 Land use type and sediment contribution (Gibbs 2006)

- On average, exotic pine forest land use contributes almost twice as much soil per unit compared to pasture and native forest land. However, most of the sediment load comes from pasture and native forest in the small sub catchments along the side of the harbour.
- If forestry harvesting on steep land exposes bare soil to a storm event, the proportions of sediment from pine forestry will increase dramatically.
- Most of the sediment load on Mahurangi Harbour is delivered in a small number of storm events each year.
- Under normal conditions (330 days per year – low flow conditions with no storm events) pine forest was estimated to produce 46.3 tonne (14%) and native plus pasture 283.8 tonne (86%) of sediment per year across the catchment.

3.2.4 Sediment effects on aquatic fauna

The Auckland Council State of the Environment annual monitoring programme underpins state of the environment reporting, and assists with the identification of large scale impacts of contaminants associated with varying land uses and disturbance regimes. Although current State of the Environment Monitoring results shows evidence of recovery of ecology in some areas, declines in abundance of intertidal species known to be sensitive to increased sediment loading (*Macomona*, *Austrovenus*, and *Atrina* species) are still evident. However, recent evidence of recruitment of juvenile shellfish is encouraging and highlights the potential for the recovery of areas of the harbour as the work in the Mahurangi Catchment continues. Additional catchment specific monitoring that aligns with previous research will assist and accelerate the ability to identify trends within the catchment (Halliday and Cummings, 2012).

Gibbs (2006) above shows that most of the sediment in the aquatic environment is delivered through regular, small storm events throughout the year. There have been various studies published on the effects of sustained turbidity in streams versus small events where turbidity is raised temporarily and then dissipated. The effects of sediment on aquatic fauna varies depending on the fish species as some are more tolerant to suspended solids than others (Boubee et al 1997). Large deposits of sediment into the head waters of streams can have multiple detrimental side effects such as smothering benthic organisms and leaving a sediment source within the environment that can be re-entrained during every storm event. This is the main tension between forestry as a land use and pasture farming as pasture farming tends to deliver regular sediment to streams in smaller doses whereas forestry harvesting can allow large slugs of sediment to enter the headwaters of streams.

3.3 Effects of land use

Native forest comprises a naturally complex, biologically diverse and stable ecosystem. Rainwater is intercepted by vegetation and evapotranspirated while the plant litter acts as a sponge on moisture.

Riparian vegetation is likely to be abundant under native forest conditions and has a number of valuable attributes: It provides a natural ecosystem corridor for wildlife and conservation; it is rich in biodiversity; it filters off stormwater suspended solid loads, nutrients and harmful microorganisms; it provides food sources for terrestrial and aquatic animals; it keeps streams cool and reduces wide temperature fluctuation; while shading reduces harmful aquatic weed growth.

Pasture, compared with forest vegetation, needs continuous artificial inputs, such as fertilizers and weed control, to maintain it. Grazing livestock maintain this type of vegetation cover. Soil density can be increased with livestock and permeability to rainwater can be reduced. Pasture is subject to higher erosion in times of high rainfall compared to a native forest cover. Less rainwater is held back following rains. Higher surface runoff through less ground cover increases soil erosion and sediment generation.

Rivers maintain a more even flow from forested areas as extreme fluctuations are dampened through prolonged release of water into streams. The onset of floods is delayed through the interception by vegetation mass and surface litter. On pastured areas surface runoff increases during storms, increasing the rapidity of flash floods. In areas where pasture is the dominant vegetation cover extreme events (flash floods and low flows) have the same incidence but tend to be more peaked.

Water quality is maintained in forested areas as soil erosion and sedimentation are reduced and riparian vegetation assists in maintaining natural water conditions. On the other hand, inputs required to maintain pastoral farming may end up in streams or pose threats to groundwater (e.g. fertilisers, herbicides). Dung and urine are sources of nutrients, organic matter and particulates; some may enter the soil for recycling and some may reach streams as pollutants. Dung is also a source of microorganisms and affects water quality.

Horticulture and cropping lead to high water needs and add to the demand on water resources. These can also result in sediment, nutrients and herbicides entering waterways. Subdivision initially involves new roads and earthworks which can contribute to erosion, siltation and enhanced overland stormwater flows.

3.3.1 Forestry and potential sedimentation

During the growth phase, commercial forestry blocks have comparable levels of surface erosion and mass movement to native forestry on the same land (Curran-Cournane et al 2013). However, potential increases in erosion and sedimentation during harvesting have been raised as issues requiring specific management throughout New Zealand. Auckland Council (2009) provides a review of forestry harvesting practices and spatial relationship within the Mahurangi catchment and highlights a number of issues for consideration. The following conclusions made by Auckland Council relevant to this plan are:

- Approximately 8% (977ha[1]) of the Mahurangi catchment is comprised of plantation forestry.
- The forestry blocks are clustered in two main areas: 1) within the central-western portion of the catchment which drains into the right branch of the Mahurangi River, and 2) a smaller cluster located at the foothills of the Dome Valley that drains into the left branch of the Mahurangi River.
- The majority of the forestry landholding is owned by one company (Prime Resources Ltd) comprising 78% (757ha) of the 977ha total. The remainder of the landholdings are all individually less than 50ha in area.
- Approximately 38% of the total planted area has been harvested and not replanted. Within the next 10 years there is likely to be approximately 513ha (53%) of forest maturing and harvest ready.

The report describes harvesting methods as being predominantly using cable haulers (swing yarders or 21m towers), with some ground based methods (skidders and tractors) on the gentler topography. Forest harvesting practices in New Zealand are based around ground-based and/or hauler harvesting operations. A ground-based operation involves tracking and the use of heavy machinery to haul logs back to a landing for processing. In winter particularly, this activity results in significant land disturbance which is difficult to control and many of the smaller harvesting operations fit into this category.

Most harvesting contractors in the Auckland region are proficient at installing controls and stabilising disturbances during or after works. However, given that many of the accepted best practice sediment controls are designed to be 50% effective in treating sediment discharges (AC, 1999), there is potentially still a significant volume of sediment that can find its way to the receiving environment. Hauler operations are seen by the forest industry as being more environmentally friendly, although the degree to which that is the case depends on the setting and ability of the hauler to lift the trees off the ground. Many harvest settings do not achieve this standard and severe gouging can occur in places. In some situations more significant disturbance is stabilised but usually only if the harvesting company is proactive about such practices. The Auckland Council is limited under the current rules to prevent such disturbance.

Although there is some awareness of the MAP amongst forest operators, riparian set backs are not prevalent within the forestry estate. This is generally because there is no regulation around providing riparian set backs, the sites are so steep that even a 5m set back and be extensive on a 40° slope, and trees can be 10m tall and fall across streams during harvesting.

[1] This only considers forest blocks greater than 5ha in size

Based on Auckland Council (2009) forest data and assumptions, it can be interpolated that the next period of significant harvest volume is due from 2019 through to 2034. It is therefore considered that the risk of increased sedimentation from forest harvesting operations is minimal in the next five years. However, from 2019 large tracts of forest will be harvest ready, including 450ha of Prime Resources owned forest. Although most of the forestry roading infrastructure is existing and will only require upgrade rather than capital works prior to harvesting recommencing, the nature of harvesting and roading operations will provide an inherent environmental risk that will need to be adequately managed.

Auckland Council is now undertaking an up to date re-assessment of forestry activities within the Hoteo catchment. The scope of the current assessment includes:

- Description and GIS representation of forestry within the catchment;
- Description and determination of factors influencing sustainable forestry within the catchment;
- Development of an integrated forestry strategy which will include an Action and Education plan for forestry within the three rural catchments (Mahurangi, Hoteo and Whangateau); and
- Review of previous studies (Whangateau and Mahurangi).

Notwithstanding the above, there has been a marked improvement in the standard of erosion and sediment controls implemented by forest harvesters over the last four to six years (pers. comm.. S. Bryant). This has resulted in an increase in the level of forward planning with respect to the interplay between harvesting and the need to install erosion/sediment control measures. Because forestry within the Mahurangi Catchment is currently dominated by a single contractor and its various partnerships, there is an opportunity to continue to develop the level of industry best practice applied to forestry operations.

3.3.2 Removal of riparian vegetation and stock control

Riparian vegetation and access to stream banks by stock are two key areas of focus within this catchment. An ARC survey in 2009 (Neale et al 2009) showed that in the Mahurangi pastureland (62%) was the most common riparian vegetative cover, followed by exotic woody vegetation (20%), native woody vegetation (13%) and wetland vegetation (6%). Correlations were established between stream bank erosion and environmental variables relating to land management practices, specifically land use type, extent and effectiveness of fencing, and extent of woody riparian vegetation.

This information demonstrates that there are extensive areas of stream bank that are potentially unshaded and have little riparian vegetation that is capable of bank stabilisation. Noting that there is approximately 20% of riparian vegetation is exotic we could assume that

over time these areas may be disturbed, with no guarantee that there will be any replacement, native woody revegetation undertaken.

Should the exotic woody vegetation consist mainly of plantation forestry and weedy species such as willows, it shows that there is a significant proportion of streamsides in the Mahurangi that are available for improvement and protection.

Neale (2009) also indicated that across the 180 rural land use sample sites (60 in each of rural lifestyle, dairy, and drystock land uses) in the Auckland region used in the survey, only 25% of surveyed stream length had an effective fence on both banks, with no significant difference amongst the land use types for this measure. The absence of an effective fence was the most common situation identified with 47% of stream length unfenced. Streams in drystock land use had considerably lower values for fencing measures (extent and type) than those in both dairy and rural residential land uses.

3.3.3 Quarries

The Rodney Lime Works is the only quarry of significance identified as being operative in the catchment. It is located on Sandspit Road just east of Warkworth and is operated by the Rodney Co-operative Lime Company.

Discharges of sediment laden stormwater and dust from the quarry are of general concern to local and downstream residents, although complaints to Auckland Council are rare. The quarry operates under a suite of resource consents and has authorisation to operate through to 2028 on its current regional land use consent for quarrying. Periodic compliance monitoring is undertaken by the Natural Resources Specialist Input Unit at Auckland Council.

Historic discharges of sediment from the quarry have occurred to the receiving environment, giving rise to the concern from local residents. During heavy rain events discharges of sediment are likely to continue.

3.3.4 Unsealed roads

To date there are no specific studies of sediment generation from the unsealed roads in the Mahurangi catchment. A study has been done in Auckland's Hoteo catchment (Jessen et al 1997) where sediment sources were identified. Unsealed roads in the study areas were estimated to account for up to 3% of the surface area of the sub catchments analysed. These roads included rural roads, forest roads, farm tracks and stock races. The soil types and terrain in the study areas varied, but were similar to the Mahurangi soils in some instances. As can be assumed for the Mahurangi catchment, higher sediment yields occurred on the more erodible soils and on the steeper terrain, particularly where roads were poorly constructed or maintained. In addition, high use forestry roads had the potential to generate significant sediment during forestry operations.

The conclusions to be drawn from the Hoteo study as they might relate to the Mahurangi are that the standard of road construction and maintenance can have a significant effect on the level of sediment generation from unsealed roads, particularly during forestry operations and on steep terrain and/or erodible soils.

3.4 Increased erosion from climate change

Information released by Ministry for the Environment (MfE) suggests that the frequency of heavy rainfall events is expected to increase within the Auckland region during this century due to climate change (MfE 2012). This brings with it the possibility of increased erosion on the more erosion prone (moderate erosion severity) land in the catchment, generally located in the south eastern headwaters of the right branch of the Mahurangi River, the Dyers Creek area within the West Mahurangi, and in the north west of the Pukapuka Inlet, sub catchments.

In the Mahurangi River sub catchment, these areas are predominantly vegetated with exotic forestry, with a small area of high producing exotic grassland. In the West Mahurangi sub catchment, areas of moderate erosion severity are generally vegetated with high producing exotic grassland, with small pockets of exotic forestry. And in the Pukapuka Inlet sub catchment, these areas are vegetated predominantly with exotic grassland, with small areas of both exotic forestry and indigenous forest.

The areas currently vegetated with either exotic forest or indigenous forest are less of a concern. It is considered that the current land use of these areas is optimised with regard to erosion protection from high intensity storms, and as long as these areas are vegetated in a similar state to the current situation, significant increases in erosion are unlikely. Any additional erosion potential during harvesting operations prior to revegetation of the exotic forest areas can be managed in accordance with appropriate harvesting plans and compliance monitoring by Auckland Council, and any further recommendations of this report.

With rising sea level, the harbour is likely to be an accreting zone as well as being subject to coastal erosion. However, community drivers for managing coastal erosion are more associated with property values and hazard management than the issues directly attributed to sedimentation from these processes.

3.5 Catchment issues summary

Erosion is a significant issue for the generation of sediment into the Mahurangi receiving waters. It is estimated that annual average sediment generation in the catchment may vary from 8,661 to 52,270 tonnes/year depending where in the catchment sediment is being generated and which model is used to estimate these amounts. Sediment generation rates have been modelled by different agencies to between 75 tonnes/km^2/year to 448

tonnes/km²/year. This plan does not attempt to analyse these differences but recommendations for further action are outlined in Section 5.0.

Sediment accumulation rates are estimated to be approximately 15-20mm per year in the upper estuary and 2-5mm per year in the rest of the harbour. Only 33% of sediment sourced within the catchment is naturally occurring with the remaining 66% of sediment coming from human settlement disturbance.

While pastoral farming makes up 70% of the land use within the catchment it only contributes between 15-55% of the sediment that accumulates in the upper estuary. Plantation forestry, on the other hand, makes up 8% of the catchment land use but contributes between 45-80% of the sediments accumulating in the upper estuary.

Forestry harvesting practices can exacerbate erosion and sediment loss in the steeper more erosion prone areas of the catchment, however continued compliance monitoring and a regular schedule of educational workshops will help maintain best practice among the industry.

Riparian margins are a source of sediment for the estuary and harbour with only 13% of riparian areas within the catchment having native woody vegetation. Approximately 47% of the stream edges within the catchment are unfenced, and only 25% of the stream is fenced on both sides. The majority of stream banks have pasture as the vegetation type so it is recommended that landowners are encouraged to fence off and plant up riparian areas to reduce stream bank erosion, help filter pasture sediment runoff, and aid with stream shading and bank stability. Further ground-truthing of riparian areas will help better inform future land management decisions.

As previously discussed in Section 3.1.2, a study of sediment sources in the Mahurangi catchment (Hicks, et al 2004) suggests that fencing to exclude livestock from riparian areas could remove about half of current sediment sources, regardless of the type of riparian vegetation present.

There is only one significant quarry in the catchment, and this is monitoring for consent compliance. It is recommended that this continue with no further land management required.

It is recommended that regular maintenance of unsealed roads in forestry areas and on steep hill country be undertaken to ensure that sediment generated from these areas during rainfall is reduced.

With increased erosion expected with sea level rises and climate change it is considered that this is another factor promoting the value of good riparian protection and best practice land

management. Auckland Council may wish to run regular land management workshops for a range of landowners to teach best practice techniques.

3.5.1 Priority catchments for restoration

The BNZ model identifies priority sub catchments as Te Kapa Inlet, Pukapuka Inlet, and West Mahurangi. The NZeem model identifies a priority sub catchment of West Mahurangi. The Isotope Mapping identifies priority sub catchments as those with forestry, being West Mahurangi and Mahurangi River.

The Mahurangi Action Plan identified priority sub catchments for implementation of tools based on scientific data as well as social analysis which were Mahurangi East and West Mahurangi. Key tools identified at the time were riparian margin protection through fencing and planting, as well as education and the raising of awareness. Based on the analysis contained within this document it is considered that the approach is still valid and should be continued.

Based on all of the information provided above, it is considered that the priority sub catchments for the Mahurangi (in order of priority) are West Mahurangi, Te Kapa River and Pukapuka Inlet, and the Mahurangi River.

4.0 Land Use Management Tools Implementation

4.1 The Mahurangi Action Plan

The Mahurangi Action Plan (MAP) has been in operation since 2004, and originally set up a landowner assistance fund to help landowners carry out capital works on their properties, including retirement and enhancement of watercourses and other erosion prone land, and construction/implementation of alternative stock water systems.

Initially MAP focused on providing a land management advisory service; interacting with individual landowners to plan, fund, and assist with restoration works on their properties. From Year 3, the Council considered that the role needed to focus more on the strategic leadership and implementation of the project with community engagement, facilitation, and networking. The land management advisory skills were recognised as a vital component of the project, but were contracted out. In Year 4 of the project, individual farm plans were initiated to help further focus priority activities on farms.

Some of the outputs from the first five years of MAP are summarized as follows (as supplied from the Sustainable Catchments Programme):

- Funded a number of research projects to guide strategic action;
- Identified priority sub catchments to focus work;
- Funded over 80km of stream and coastal edge fencing on private land (equating to 869ha);
- Planted over 120,000 native plants to reduce erosion, shade waterways and to improve the habitat for indigenous species;
- Investigated and funded alternative farm water supply projects to assist farmers to exclude stock from stream beds;
- Prepared 40 farm plans; and
- Organised nearly 10,000 hours of volunteer community involvement with the planting, involving mainly school and home-schooled children.

MAP has also supported broader community initiatives in which nearly 1,000 people have taken part, such as focus groups, business presentations, public awareness events, and community field trips.

The Sustainable Catchments Programme is continuing with the implementation of the MAP.

4.1.1 The Mahurangi Action Plan: A Strategic Plan for the Catchment 2010-2030

In 2009 a Strategy for the MAP was drafted by the Auckland Council titled *"MAP: A Strategic Plan for the Catchment 2010 - 2030"* (AC 2009) This document is an integrated catchment management strategy for the Mahurangi that engages council and community in the broader

issues related to a healthy Mahurangi Harbour and catchment. Based on the issues and priorities that were previously identified through the initial MAP process, this additional process has the potential to tackle some of the wider issues of concern to people in the Mahurangi that were beyond the brief of MAP in its 5-year pilot phase, including:

- Forestry, ahead of the next harvesting cycle;
- Rural and urban subdivision and development and their effects of erosion and sediment;
- Mangrove spread, reduced boating access and other issues strongly linked to sedimentation of the harbour, such as derelict oyster farms and coastal erosion;
- Access to the river, harbour and coast;
- Commercial fishing, including oyster farming and their effects on water quality;
- Effects of intensive rural croplands (orchards, vineyards);
- Industrial and commercial areas and their contaminant discharges;
- Biodiversity and connectivity opportunities; and
- Water supply, stormwater runoff and sewage treatment.

4.1.2 Land management plans

The Auckland Council has extended the farm plan approach to Land Management Plans that cover a wider variety of land use practices and issues. Additional aspects that are supported by council include the identification and management of waterways and wetlands, biosecurity and weed control, native forest protection, cultural values and other attributes specific to each property.

To date 40 land management plans have been completed within the catchment. Auckland Council is also starting to update these plans and add detailed soils mapping, which will assist farm management. The basis for selecting properties for soil mapping and land management plans is generally based on the identification of willing parties, and existing relationships with land owners. It is also related to changing land use e.g. dairy farm conversions. Often, participants are long-standing farmers who are at a position in their careers and debt structure to address a broader range of farm management issues and opportunities.

Developing these plans provides a significant opportunity for direct and positive engagement between Auckland Council and farmers and integration with the wider outcomes sought by the SCP. Monitoring of the implementation of the plans will be critical.

4.2 Land owner and industry relationships

Auckland Council is developing a range of relationships with specific land owners. However, a key link to establishing these relationships is through existing industry and community hubs. Within the Mahurangi Catchment, these groups include:

- Beef and Lamb New Zealand (Monitor Farm Programme)

- DairyNZ
- Fonterra
- Farm Discussion Groups
- Soils Discussion Group (including Northland farmers)
- Trees for Survival / and local schools
- Wai Care
- Conservation Volunteers New Zealand

The Auckland Council's input within the industry groups has focused on providing information, support (through soil mapping and farm planning) and access to potential funds, and linking this to other services and benefits provided by the industry e.g. stock health and productivity. Actions include participation in:

- Fields days
- On-farm workshops
- Education
- School and community planting days
- Participation in industry initiatives such as Soils Discussion Group, Beef & Lamb Land and Environmental Delivery programme, formation of land owner groups,

In addition to the above, relationships have been established with foresters through the NZ Farm Foresters Association and the Auckland Council Forestry Liaison Group. These are addressed through the additional report being prepared by Auckland Council.

4.3 Environmental enhancement funding

Auckland Council has an Environmental Initiatives Fund (EIF) which is used to support individuals and groups to improve and care for the region's natural, cultural and physical environments. Funding is available annually to support projects across the Auckland region and approximately 200 applications are received each year.

The Rodney Natural Heritage Fund (RNHF) is a contestable fund administered by Auckland Council and open to public to support individual and community initiatives that restore, protect, and enhance biodiversity and natural habitats within the former Rodney District. Funding is awarded on the basis of the initiatives providing clear and enduring environmental benefits. Projects could include, but are not limited to, pest and weed control, restoration planting, riparian protection, fencing.

The Rodney Environmental Education Fund (REEF), which is also administered by Auckland Council, has the purpose of assisting community groups and schools to actively participate in environmental projects and sustainability initiatives that have an educational focus. The

fund is open to applications from groups and individuals based on sustainability, education, and riparian planting.

The Waterways Protection Fund (WPF) is a grant offered to private land owners by the Sustainable Catchments Programme to encourage the protection of waterways through fencing and planting. Where farmers are fencing off access to drinking water for stock the fund can also extend to cover the cost of establishing alternative water supplies. The fund is opened to all priority sub catchments across the region as identified through research and monitoring.

4.4 Land use management tools implementation summary

The Mahurangi Action Plan and its recommendations still remain valid and the continuation of the implementation of the Plan through the Sustainable Catchments Programme is recommended. As part of that work, the continuation of the review and preparation of land management plans is a key tool for community engagement and education.

Continuing industry liaison is also a key tool for implementation of land use best practice and these relationships should be continued and strengthened. It is also considered important that the Auckland Council continue to offer environmental grants to land owners so barriers to the protection of waterways are reduced.

Auckland Council will need to continue to work with tangata whenua, the community and key players to develop a vision for a “healthy harbour”, shared objectives and priority actions to achieve that vision.

5.0 Recommendations

A summary of all recommendations to fall out of the previous discussion are summarised here for easy reference.

5.1 Setting sediment objectives

One key issue is to determine what the sediment management objectives for each sub-catchment are. While we have an idea of the erosion and sedimentation rates within the whole catchment there is no clear guidance on what is an acceptable erosion or sedimentation rate. This is an important piece of work that has wide implications for regional priority setting, scientific research and monitoring.

Linked to this will be the identification and implementation of measures that may be successful at achieving those targets. Some will be proxy measures, such as the length of streams retired and planted, areas of land re-vegetated or number of land management plans implemented. Others must be specifically focused on the ecological and sedimentation characteristics of the harbour. Specific monitoring of harbour characteristics will assist in the identification of improvements that are a result of changing land use practices, thus supporting the efforts of land owners.

5.2 Monitoring strategy

It is recommended that the SCP develop a Monitoring and Evaluation Plan for the Mahurangi catchment. Based on the range and scale of monitoring discussed above, a three tiered approach can be adopted for the monitoring of initiatives implemented to achieve catchment objectives. This does not include monitoring undertaken through regulatory mechanisms, which is ongoing at a frequency established by the Auckland Council Resource Consents Unit.

Objective 1 – Physical Characteristics and Practical Use

- Purpose – To define the degree of environmental change based upon visual measures taken on site within each property.
- Measurements include the vegetation community, vigor, density, channel morphology and stability; fencing and planting costs, problems, photos.
- Measurements taken annually for 5 years.

Objective 2 - Ecology and Level 1 Water Quality

- Purpose – To define the degree of physical, biological, and water quality improvements within limited resources.
- Measurements include water quality measures that are low maintenance and low cost, channel cross sections, Auckland Council habitat assessment measures (qualitative and quantitative), Macroinvertebrate Community Index.
- Measurements taken annually for 5 years.

Objective 3 - Level 2 Water Quality

- Purpose – To identify changes in catchment scale parameters.
- Install and rate weirs at critical locations.
- Measure baseline and storm event concentrations, flow and calculate loadings.
- Undertake harbour sediment studies.
- Frequency will vary between each type of measure but should also support state of the environment reporting.

Monitoring and evaluation of the outcomes and effectiveness of the actions identified in this Plan must be done with consistency across all other rural catchment programmes. Consequently, they are somewhat generic between catchments, particularly with respect to the three northern Rodney catchments (Whangateau, Hoteo and Mahurangi) but with specific outcomes to be measured for each estuarine / harbour receiving environment.

Targets and measures can be based on generally accepted environmental benefits (e.g. enhancing the extent and quality of riparian cover) versus specific measures (e.g. whether farm forestry management practices have reduced erosion form specific hill-country properties).

Options for assessing the effects of the practices on sediment entry into streams, and downstream water quality, could be any of the following:

- Self assessment by land owners after field training.
- Sub catchment monitoring by volunteers.
- Sediment discharge and water quality measurements by council staff, including SOE monitoring.
- SEV monitoring within various tributaries of each sub catchment.
- Ongoing sediment yield studies by Auckland Council or in partnership with organisations such as NIWA or universities.
- Using Wai Care as a mechanism for monitoring sediment reduction and other changes as a result of catchment planting.
- Ongoing environmental health monitoring of the Mahurangi Harbour.
- Ongoing monitoring of coastal erosion within the Mahurangi Harbour. Note, that this is not a measure of success of the sediment management programme, but will provide data to assess other measures against and support future management decisions.

It will be appropriate to monitor the success of the catchment initiatives at three levels:

(i) How many sites have engaged in environmental enhancement opportunities i.e. extent of riparian fencing undertaken, removal of fish barriers, number of farm plans adopted etc.
(ii) The level of performance achieved by the tools noted in (i) e.g. the health and resilience of riparian planting, the degree of implementation of farm plan actions and practices etc.
(iii) The downstream changes that can be attributed to (i) and (ii) e.g. reduced stream bank erosion, reduced in-stream sedimentation, stream health assessments (SEV), greater upstream migration of specific fish species, reduce nutrient runoff or sediment runoff, reduced sedimentation of estuaries / harbours, and improved water quality values.

Review and feedback will be required to ensure that achievement of (i) and (ii) is achieving (iii). In the event that it is not, further investigation and prioritisation will be required to document the ongoing drivers of sediment and water quality effects within the catchment.

MAP has supported a considerable amount of physical works since its inception. Ongoing monitoring is critical to the success of the project as it ensures that the key environmental benefits expected at the commencement of a project are achieved. This monitoring should include condition of physical structures (fences, water supply projects etc.) and survival of planting projects. Such monitoring may also identify where maintenance is required, or other subsequent works are required in order to achieve or enhance the original objectives.

This type of monitoring could be implemented or undertaken in the future to assess the benefits of riparian fencing, stock exclusion, and planting. The level of monitoring that could be implemented would depend on several factors, with three main objectives (discussed in the next section) that should define the degree of monitoring to be applied to a site.

It is also important to ensure that up-to-date modelling is available and undertaken. Continued research and study of the Mahurangi Harbour would be beneficial.

5.3 Build on relationships with forestry industry stakeholders

The impact forestry has had on sedimentation in the Mahurangi Harbour has been highlighted by several research projects, including ARC Technical Report document *Sediment Source Mapping in the Mahurangi (*Gibbs 2006). The ARC document *Mahurangi Action Plan – Forestry Context Project* (AC 2009) also found that although there is some awareness of the MAP amongst forest operators, riparian setbacks wider than 5m are generally not prevalent within the forestry estate. This is likely to be a reflection of the lack of regulation to enforce streamside management zones (the forest harvesting and replanting is undertaken as a permitted activity under the Auckland Regional Plan: Sediment Control

(ARP:SC) (AC 2012a)), as well as the reduction in return (less wood to harvest) by having a no-harvesting setback from the stream network.

Auckland Council has recently renewed its engagement with the forestry industry through the development of the Draft Auckland Unitary Plan. By 2014 much of the existing phase of harvesting will be completed. The next rotation will commence around 2020, by which time the Auckland Unitary Plan is likely to be operative. Under the current draft, many of the existing earthworks activities consented under the ARCP:SC would become permitted activities. This would further reduce the direct on-site presence that the council will have on forestry harvesting sites. Moreover, replanting of current harvest areas will have occurred under existing regulatory provisions, which do not prevent planting or harvesting within riparian margins. Thus, the potential 5m riparian exclusion promoted by the Draft Auckland Unitary Plan will not be implemented until after the next harvesting rotation.

Therefore, the relationship with the forestry sector must be actively fostered to ensure the highest possible level of voluntary compliance. This may include joint training initiatives for forest owners, managers and forestry workers. The dominance that Rayonier (and its various partners) has in the management of harvesting within the catchment does provide an enhanced opportunity for coordinated engagement. The report underway by Auckland Council will provide recommendations on further engagement with the industry.

5.4 Develop a 5-year detailed work programme

It is considered beneficial for the SCP to develop a detailed 5-year work programme, commencing with the Monitoring and Evaluation Plan, to set out the key activities to be undertaken to achieve catchment goals and outcomes. The detailed work programme should be broken down into sub catchments, with most effort and resources to be centered around the identified priority sub catchments.

Mahurangi East was identified in the MAP as a model sub catchment with a good deal of restoration work already carried out by land owners on a voluntary basis. Combined with the restoration work funded by MAP, a large portion of the catchment has now been fenced. Table 3 below, and the map *Mahurangi East Stream Channel Fencing* (contained in Appendix H), show that the extent of watercourse fencing in the Mahurangi East sub catchment (79%) is well in excess of the average extent catchment wide (50%).

Given that the percentage of riparian fencing in the Mahurangi East catchment is now significantly higher than the local and regional average, and that modelling suggests it is not a significant source, it is considered the catchment is no longer a priority in terms of riparian fencing.

Table 3: Current length of watercourse fencing in the Mahurangi east sub catchment

Category	Length (m)	%
Fenced with MAP Assistance	9,541	41%
Fenced without MAP Assistance	8,748	38%
Unfenced	4,802	21%
Total	**23,090**	**100%**

5.4.1 West Mahurangi sub catchment

West Mahurangi was viewed in the MAP as a sub catchment with a high priority for restoration due to the steep terrain and large areas of exposed soils due to slips, slumps and erosion. There is a significantly smaller amount of fencing that has been undertaken without MAP funding when compared to Mahurangi East, and this combined with the restoration work funded by MAP shows a significantly smaller extent of riparian fencing. Table 4, below, and the map West *Mahurangi and Upper Mahurangi Harbour Stream Channel Fencing* (contained in Appendix H), show that although the extent of riparian fencing in the West Mahurangi (and partially into the Upper Mahurangi Harbour) sub catchment (55%) is in excess of the average extent catchment wide (50%), there is still a significant amount of fencing left to be undertaken (almost 20km).

The West Mahurangi catchment (along with the Te Kapa River and Pukapuka Inlet sub catchments) was identified in the BNZ model and the Erosion Severity Maps as among the highest contributors of sediment to the harbour. In addition and as noted it is only just above the local and regional average for riparian fencing. As such, it is considered appropriate for West Mahurangi to remain a priority sub catchment for riparian fencing and targeting funding for any available grants.

Table 4: Current length of watercourse fencing in the west Mahurangi sub catchment.

Category	Length (m)	%
Fenced with MAP Funding	14,160	32%
To be Fenced with MAP Funding	1,372	3%
Fenced without MAP Funding	8,850	20%
Unfenced	19,228	45%
Total	**43,610**	**100%**

5.4.2 Other sub catchments – defining priorities

Based on a total watercourse length of 206.5km, the length of watercourse in the Mahurangi catchment outside of the Mahurangi East and West Mahurangi sub catchments is estimated to be approximately 140km. Taking into account the figures for the two sub catchments above, the total length of watercourse within the Mahurangi Catchment that is currently unfenced is estimated to be approximately 79km, or 55% of the length of watercourses within the catchment.

Given that Mahurangi East is no longer considered a priority sub catchment, other sub-catchments should be elevated to priority status to ensure continued options for funding of riparian restoration still exist. The BNZ model and Isotope Modelling identified parts of both the Pukapuka Inlet and Te Kapa River sub catchments as high sediment generating catchments. As such, it is considered that these catchments should be upgraded to high priority catchments for funding and riparian restoration work. In addition, those portions of Pukapuka Inlet and Te Kapa River sub-catchments which were determined as 'high risk' through the BNZ model should be investigated first.

Attention could be given to the Mahurangi River sub catchment. Not only is it the biggest sub-catchment, but it has a relatively high predicted erosion rate compared to some other sub-catchments. It also contains the majority of the production forest within the catchment which we know contributes the most sediment to the upper estuary of all land uses.

Restoration works in other sub catchments should be assessed on a case by case basis, and education and advocacy works should continue over the whole catchment.

5.5 Improved land management

5.5.1 Riparian protection

Riparian protection can provide multiple benefits to sediment control, and associated stock management benefits. These benefits can include:

- Reducing sediment inputs to waterways through reduced erosion and stream bank collapse;
- Establishing buffer strips which trap sediment, dung and nutrients in farm runoff;
- Excluding stock which deposit dung and trample stream banks;
- Reducing stock losses due to fatal incidents caused by steep gullies and bogs;
- Animal health benefits from clean water, with the opportunity to dispense remedies through reticulated supply and troughs;
- Shade and cover for stream life;
- Alternative water and shade for stock, sited away from the waterway, can also minimise damage to the watercourse where fencing may not be feasible; and
- Ecological corridors between more significant stands of forest.

The mechanism for the retirement of riparian margins must be focussed on the key land use improvement tool. If sediment continues to be the primary environmental management issue for the Mahurangi Catchment, then investment, as a minimum, in riparian setbacks for forestry, fencing to remove stock from stream banks and planting to provide for a wider range of benefits.

5.5.2 Alternative stock water systems

Commonly, where stock has direct access to permanent watercourses, there are no other stock water supplies within the paddock. In those situations, riparian protection necessitates the provision of alternative stock water supplies. Options include controlled water takes and distribution through troughs, or off-stream dams. Each option has cost implications, however, there are potential benefits to the farmer. Davies-Colley and Parkyn (2001) suggest that controlled stock watering through reticulated troughs is proven to benefit stock health through an unpolluted water supply and improve stock safety, through reduced loss of animals trapped in wetland areas or from grazing on poisonous riparian/semi-aquatic plants. They also indicate that stock management and mustering is made easier.

A Land Environment Plan Guideline (Stock Exclusion – Managing Stock Around Waterways) from Beef and Lamb New Zealand (2012) also suggests there are specific stock benefits from providing good quality reticulated water for stock watering. This guideline indicates that research has shown that cattle prefer to drink from a clean water trough rather than a stream. Reasons for this are suggested to be the improved water quality, better footing, improved visibility and a more desirable water temperature. In addition, increased weight gains and production are included as benefits, along with the ability to deliver animal remedies or supplements through reticulated systems.

5.5.3 Retaining wetland and other areas of indigenous vegetation

Retention of wetland and indigenous vegetation can be compromised as a by-product of rural intensification, as there can be pressure to drain or clear these areas for grazing. It is recommended that the fencing and enhancement planting of wetlands should be prioritised equally with stream restoration across the catchment.

5.5.4 Urban development

Approximately 1% of the catchment is zoned future urban. While much of this land development will be controlled through resource consents it is recommended that Water Sensitive Design principles should also be promoted through council interaction with the development community. Water sensitive urban design promotes:

- Retention of nature site features including streams, wetlands and natural vegetation;
- Avoidance or minimising development on steep slopes;

- Minimising earthworks;
- Best-practice erosion and sediment control methods during construction;
- Minimising impervious surfaces and subsequent retention requirements;
- Reuse or attenuation of stormwater on site.

Those principles will further reduce the risk of adverse effects through development, and retain and enhance existing site features including intermittent streams and riparian vegetation.

5.5.5 Identifying land that is better suited for tree cover

Some land may be better suited for tree cover than grazing – these areas need to be identified at a property level during preparation of land management plans. This could be achieved through maintaining grazing under spaced plantings, or closed canopy timber production with little to no grazing, interspersed with open grazed paddocks. Spaced plantings allow continued grazing while providing erosion control. Timber crops may be the most profitable land use for some areas in the long term, if they retain soil productivity and benefit water quality. They also provide potential benefits in terms of greenhouse gas emissions and qualifying for Emission Trading Scheme (ETS) units (albeit that this advantage is vigorously debated). While capital for investing in plantation forestry on farms is often a constraint, joint venture arrangements such as the various grant schemes available under the ETS may overcome these. However, production forestry also has drawbacks in terms of sediment generation during harvesting if not adequately managed. Allowing gullies, unproductive areas and key corridors or linkages to regenerate into native vegetation will have additional biodiversity benefits.

5.5.6 Forest harvest management

Plantation forest harvesting is highly regulated within the industry, apart from forestry blocks less than 1ha in size. The Unitary Plan also allows us to 1ha of native forest to be removed without resource consent in the General Rural zone of Rodney. While regulation is in place for larger forestry blocks and compliance monitoring is undertaken, it is considered beneficial to undertake internal training workshops with all staff involved in forestry activities to understand the harvesting processes, erosion and sediment controls and industry best practice. It is considered that the SCP can lead that training programme.

It is also recommended that each forestry block prepares a harvest plan and this is reviewed by compliance staff at Council to provide feedback and advice.

5.5.7 Land management plans

As previously discussed, land management plans are currently used extensively as a direct by-product of initiating the MAP. Land management plans provide an opportunity to integrate

all the elements identified above and for direct and positive engagement between Auckland Council and farmers. In turn, they benefit the farming operation and the wider outcomes sought by the SCP. They can provide a key non-regulatory initiative within rural catchments. They are most appropriately used for active commercial farms rather than smaller lifestyle blocks. Land management plans have the following general objectives:

- Reduce sediment and nutrient inputs into the Mahurangi Harbour as a result of storm water runoff.
- Identify and minimise or mitigate sediment sources on farms and lifestyle blocks within the catchment.
- Gather basic information on the riparian resources of a property, and make recommendations on retirement and restoration of these riparian areas.
- To demonstrate best practice sustainable land management techniques.
- To develop a staged programme of prioritized changes.
- To provide opportunities for community advocacy, demonstrating best practice as a tool for motivation and inspiration.

Specific land management plans could be developed by Council with an agroforestry focus, where there are opportunities on a property to provide production/protection value from unproductive land under traditional land management practices. These plans would provide solutions for areas that include unstable steep faces where pasture growth and stock numbers are repeatedly depleted by erosion. Auckland Council already advocates conversion of steep erodible land to forestry on faces where trees can be safely grown and harvested, and scrub retention or reversion to stabilise land too unstable for commercial forestry.

These plans would be used to model the effects of a sustained tree planting and harvesting scheme on a property, while working within the farm's physical and financial constraints. A land inventory assessment would be required, followed by some sort of options analysis using computer programs such as the Agroforestry Estate Model. Establishment and management costs, and production returns would be modelled for each scenario.

Land management issues that are covered in these plans could include:

- Farm woodlots
- Farm shelter
- Scrub or bush retirement
- Stockfeed and biofuel opportunities
- Fencing subdivision
- Track layout
- Improved stock management

- Impact on stock numbers and farm income
- Riparian and wetland management

In addition, measures to mitigate the negative effects of climate change may provide other opportunities for revegetation/afforestation.

It is recommended that the preparation of new and review of existing land management plans continues.

5.5.8 Alternative funding mechanisms

Four existing Auckland Council environmental funds have been discussed earlier in this report:

- Environmental Initiatives Fund;
- Rodney Natural Heritage Fund;
- Rodney Environmental Education Fund; and
- Waterways Protection Fund.

Other funding mechanisms may be available for use within the Mahurangi catchment.
Other specific potential funding mechanisms include the following.

- The Sustainable Farming Fund (SFF).
  Provided for by the Ministry for Primary Industries (MPI), the SFF invests in farmer, grower and forester led projects that deliver economic, environmental and social benefits to New Zealand's primary industries. Since 2011, the SFF has been open to aquaculture projects that support economic, environmental and social performance in the marine and land-based aquaculture sector.

  The SFF funds "Communities of Interest" to undertake applied research and extension projects that tackle a shared problem or develop a new opportunity. SFF projects are led by rural land owners and managers often with the support of industry organisations, agribusinesses, researchers or consultants. Most successful projects are able to leverage a high proportion of other funding or in-kind support to complement the SFF grant.

- The QEII Trust.
  The QEII Trust works in partnership with private land owners to secure long-term protection of significant natural and cultural features, in perpetuity, usually through the legal mechanism of an open space covenant. QEII acts as a perpetual trustee to ensure the covenant remains protected forever. QEII works closely with the Department of Conservation, regional and district councils, the Historic Places Trust, Landcare Research, the New Zealand Farm Environment Award Trust and many

other groups and individuals committed to protecting and enhancing New Zealand's diverse open space. The Trust provides expertise in legal protection and legal documentation, funding assistance (partial fencing costs) and survey arrangement and costs.

Incentives for water and soil protection can be directed to prioritise areas where work can be achieved at a sub catchment, rather than individual property level, and where dialogue has achieved a commitment for action and maintenance (e.g. via a Care Group, group farm planning, or catchment planning process). A transitional funding period could be considered (i.e. a cut-off date). The need to legally bind future landowners to maintain works (e.g. on a title) must be balanced against the extra cost and bureaucracy involved. Wetlands and seepages may require specific focus as they are often associated with the headwaters of streams and tributaries.

It is seen as a role of the SCP to facilitate the distribution of information about alternative funding sources and to assist landowners to apply for these funds. It is recommended that this is a key activity for the programme within the detailed 5 year work programme.

5.5.9 Other land owner support mechanisms

There are many mechanisms that do not require direct funding of land use practices that can be used to support the above adjustments to land management. These include:

- Ensuring particular landholders have readily available and practical information on any specialty values on their property, or significant potential positive/negative impacts on downstream values;
- Farm planning – especially group capacity building to produce farm plans;
- Study groups and decision support tools based on the strengths and weaknesses of the farm's land/soil types, combining economic, farm physical, and environmental aspects;
- Local field days with examples of good practice, even small things that can make a difference (such as any local winners of merit awards in the Farm Environmental Awards);
- Proactive promotion of Care Groups and more intensive support for them;
- Particular school-based initiatives around the key issues of that locality;
- Utilise, support and expand existing programmes like Wai Care and Trees for Survival;
- Stronger liaison with Maori land trusts/marae to address specific concerns or barriers;
- Participatory research projects with science agencies, farmers, iwi, hapu etc.; and
- Learning forums involving people with different perspectives. The focus could range from a single farm, to sub catchments and even to larger catchments.

The SCP now provides a regionally integrated and funded programme for prioritising and implementing catchment based land management and environmental outcomes and it is recommended that this continues.

5.5.10 Iwi support and relationships

Maintaining close relationships with local iwi is important for the longevity of the programme, and the ability to meet objectives. It is also considered that support for iwi initiatives will help to restore and maintain the health of the Mahurangi Harbour for the benefit of all people. It is recommended that continued communications occur with all tangata whenua, with the idea to work towards strong working relationships and clear communications on all levels.

5.6 Recommendations summary

The following recommendations have been made for the future priorities of the Sustainable Catchments Programme:

- Set sediment management objectives for sub catchments and the Harbour;
- Identify implementation measures to achieve the sediment management targets;
- Develop a Monitoring and Evaluation Plan for the catchment overall;
- Continue to build on the current landowner and industry relationships that have been established;
- Develop a 5 year detailed work programme, identifying key actions to take place within each priority sub catchment;
- Continue to focus on riparian protection on public and private land;
- Continue with the provision and revision of land management plans;
- Retain and protect wetlands and seepages as key components of stream headwaters;
- Promote Water Sensitive Urban Design for the catchment through submissions to Auckland Council policy and planning documents;
- Undertake internal training of all staff involved with the forestry industry to allow staff to better understand the issues and industry best practice;
- Continue with the provision of Auckland Council ecological enhancement funding;
- Work closely with and support tangata whenua initiatives for the improvement of the health of the Mahurangi Harbour and its sub-catchments;
- Acknowledge external ecological enhancement funding and assist landowners to lodge applications; and
- Continue and develop a wide range of educational tools for landowners around reducing erosion and sediment to the Harbour.

6.0 Conclusion

6.1 Catchment issues

There are a number of erosion and sediment sources throughout the catchment, the main being:

- Steep highly erodible hill country
- High intensity pasture farming
- Unprotected riparian margins
- Forestry harvesting areas.

Best practice land management can help in reducing erosion potential in these areas and therefore sediment runoff rates during storm events. The Auckland Council regulates a number of significant land use activities in the catchment as a way to control sediment runoff and protect significant natural habitats, however for those land uses that are permitted activities it is important for the Sustainable Catchments Programme to offer advice and assistance.

6.2 Land use management

It is recommended that the Sustainable Catchments Programme continue with the implementation of the Mahurangi Action Plan and also the Mahurangi Action Plan Strategy. It is also recommended to continue liaison with industry leaders and local iwi.

6.3 Sustainable catchments programme

The following recommendations have been made for the future priorities of the Sustainable Catchments Programme:

- Set sediment management objectives for sub-catchments and the Harbour;
- Identify implementation measures to achieve the sediment management targets;
- Develop a Monitoring and Evaluation Plan for the catchment overall which should consider but not be limited to:
    - Stream walks to map and quantify the extent and quality of stream riparian vegetation, and extent and quality of stock exclusion fencing.
    - Survey of fresh water quality in all streams in the catchment to provide monitoring baseline information to enable refinement of land use management.
    - Information on the impact and extent of sedimentation from unsealed roads would be beneficial to ensure these are being constructed and maintained to minimise environmental effects;
- Continue to build on the current landowner and industry relationships that have been established;

- Develop a 5 year detailed work programme, identifying key actions to take place within each priority sub-catchment;
- Continue to focus on riparian protection on public and private land;
- Continue with the provision and revision of land management plans;
- Retain and protect wetlands and seepages as key components of stream headwaters;
- Promote Water Sensitive Urban Design for the catchment through submissions to Auckland Council policy and planning documents;
- Undertake internal training of all staff involved with the forestry industry to allow staff to better understand the issues and industry best practice;
- Continue with the provision of Auckland Council ecological enhancement funding;
- Verify/refine predicted erosion rates in the catchment by undertaking specific research, for example, sediment source surveys or tracing.
- Information on the impact and extent of sedimentation from unsealed roads would be beneficial to ensure these are being constructed and maintained to minimise environmental effects.
- Work closely with and support tangata whenua initiatives for the improvement of the health of the Mahurangi Harbour and its sub-catchments;
- Acknowledge external ecological enhancement funding and assist landowners to lodge applications; and
- Continue and develop a wide range of educational tools for landowners around reducing erosion and sediment to the Harbour.

6.4 Timeframes

Timeframes for implementation will be determined by Auckland Council, based on community consultation and the implementation of initiatives within other priority catchments. It is recommended that any existing implementation tools continue to be delivered.

7.0 References

Auckland Council (1999). Erosion and Sediment Control Guidelines for Land Disturbing Activities in the Auckland Region. Technical Publication Number 90 (TP90).

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Appendix A Catchment maps

Map 1 Mahurangi catchment boundaries

Map 2 Mahurangi sub catchment boundaries

Appendix B Geology and soils

Map 3 Mahurangi Geology

Map 4 Mahurangi East soil types

Map 5 Mahurangi River soil types

Map 6 Upper Mahurangi soil types

Map 7 West Mahurangi soil types

Map 8 Pukapuka Inlet soil types

Map 9 Te Kapa River soil types

Appendix C Land use capability

Map 10 Mahurangi East LUC

Map 11 Mahurangi River LUC

Map 12 Upper Mahurangi LUC

Map 13 West Mahurangi LUC

Map 14 Pukapuka Inlet LUC

Map 15 Te Kapa River LUC

Appendix D Relief

Map 16 Slope classes

Appendix E Land use

Map 17 Major land uses

Map 18 Mahurangi East land use

Map 19 Mahurangi River land use

Map 20 Upper Mahurangi Harbour land use

Map 21 West Mahurangi land use

Map 22 Pukapuka Inlet land use

Map 23 Te Kapa River land use

Appendix F Vegetation cover

Map 24 Mahurangi East vegetation cover

Map 25 Mahurangi River vegetation cover

Map 26 Upper Mahurangi vegetation cover

Map 27 West Mahurangi vegetation cover

Map 28 Pukapuka Inlet vegetation cover

Map 29 Te Kapa River vegetation cover

Map 30 Mahurangi streams with riparian vegetation cover

Appendix G Erosion severity and erosion rates

Map 31 Mahurangi erosion severity

Map 32 Mahurangi estimated annual average erosion rates (NZeem)

Appendix H Stream channel fencing

Map 33 Mahurangi East stream channel fencing

Map 34 Mahurangi West and Upper Mahurangi stream channel fencing

Appendix I Priority sub catchments

Map 35 Mahurangi priority sub catchments for land management