Appendix 3.29.3

Livestock Exclusion Policy Options Report – Draft Only

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Executive Summary

It has been documented both in New Zealand (MfE, 1997), and overseas (Novotny, 1999), that streams draining catchments in areas of pastoral agriculture generally have poor water quality. There is evidence that a large proportion of the contamination of rural streams by sediment, nutrients and faecal matter is derived from livestock access to the riparian zone and the stream channel itself (ARC, 2001). Unrestricted livestock access to streams and riparian zones appears to be widespread throughout the rural areas of New Zealand (MfE, 1997) and the Auckland region

With respect to the marine area, the Auckland region's marine environment is highly diverse and consequently there is a large variation in both the physical conditions and the biological diversity (ARC, p.196). However it is of concern that water quality was declining at some sites rated "good" and "excellent" for coastal water quality (particularly for nutrients and suspended sediments). It is too early to tell if these changes are strongly linked to land management practices (ARC, p.196, 2010).

The quality of coastal water is poorest at inner harbour monitoring sites, but is relatively good in outer harbour or open coastal locations. Open coast sites had the best coastal water quality, primarily due to strong tidal flushing, their distance from freshwater inputs and isolation from contaminants resulting from urban land uses. Inner harbour sites tended to have the poorest water quality because of their proximity to freshwater inputs that carry contaminants from the land and lees flushing (ARC, p.196, 2010).

In summary, the major contributor to the loss of both marine and freshwater quality is due to the excessive loads of suspended sediment that originate on the land, then enter freshwater systems and finally deposited in the marine environment. In additional to this, extensive, and an over-propionate loss of many riparian ecosystems has occurred due to the predominance of pastoral farming practices in many rural parts of the region.

Various national and regional policy initiatives also require, and give direction to, specific planning responses. Specifically, certain NZCPS policies, such as Policy 21 – *Enhancement of water quality* - that requires stock exclusion where water quality has deteriorated where it is having a significant adverse effect, and various objectives of the NPS: FM and policy directives of the Draft Auckland Plan - demand a particular policy and planning response.

Five potential policy approaches were developed – based on the assembled evidence and approaches taken by other regional councils. Costs and benefits of each of these policy approaches were assessed. "Policy approach 4" would be the most efficient in achieving fresh water quality improvements and restoration of riparian biodiversity in prioritised catchments, as well has contributing to some water quality improvements in non-prioritised catchments. This particular policy approach utilises a mixture of both financial incentives and rules, specifically, the fencing of all livestock from both permanent and intermittent streams in priority catchments, via permitted activity conditions. Riparian planting would also be required in these catchments. In relation to "non-prioritised catchments" the fencing of livestock from "intensive" farming practices would also be required as a permitted activity condition.

1 Introduction

1.1 Introduction to this Report

It has been documented both in New Zealand (MfE, 1997), and overseas (Novotny, 1999), that streams draining catchments in areas of pastoral agriculture generally have poor water quality. There is evidence that a large proportion of the contamination of rural streams by sediment, nutrients and faecal matter is derived from livestock access to the riparian zone and the stream channel itself (ARC, 2001). Unrestricted livestock access to streams and riparian zones appears to be widespread throughout the rural areas of New Zealand (MfE, 1997) and the Auckland region.

1.1.1 The Effects of Livestock on Streams and Riparian Margins

In general, the literature suggests that livestock cause appreciable damage to streams and the riparian zone (Belsky et al, 1999). The negative effects that stem from livestock having access to water bodies are due to the removal and damaging of existing riparian vegetation, the breakdown of the riparian soils by trampling, (ARC, 2001), the loss of stream bank stability (which can induce stream channel erosion) (Magner, et al, 2008), the mobilisation of stream bed sediments, and the direct input of effluent. These effects can then culminate in the degradation of water quality and ecosystem function.

The impacts of unrestricted livestock access on rural streams can be appreciably reduced by effective riparian management (ARC, 2001) and it is recognised that the restoration of degraded rural streams represents the greatest opportunity to enhance the quality of the Auckland stream network (ARC, 2005).

Cattle actively seek riparian zones – in humid New Zealand, as well as in semiarid regions (AgResearch NIWA, 2000), for shelter and cooling as well as for drinking water and to forage. Their large weight and high hoof pressure makes them particularly damaging to riparian soils and stream banks (ARC, 2001). Stream channel widening can be limited to mainly cattle assess points, where cattle force a path to the channel and then progressively ‘develop’ that track over time.

Sheep seem appreciably less damaging to stream banks than cattle, probably because of their lighter weight and consequently lower hoof pressure. Also sheep have less affinity for water than cattle and seem less likely to force access to riparian zones (ARC, 2001). Thus stream bank slumping and destabilised channels seem to be more of a feature in cattle land than sheep-grazed land. There is less evidence in relation to deer and goats, however it is expected that their stream damage potential to be intermediate between that of cattle and sheep (ARC, 2001). Deer seem to seek out water and anecdotally their “wallowing” activity is very damaging to headwater wetlands.

However, the severity of these impacts may be highly variable between streams depending on:

- Climate;
- Stream and river hydrology;
- Landform;
- Soil type and geology;
- Stream size and geomorphology;
- Vegetation cover; and,
- Grazing animal type and density.

It should be considered that in a humid environment, such as the Auckland region which is known for high intensity rainfall and which the original riparian ecosystem was forest which was never subject to hoofed grazing, the potential damage may be more severe than where grazing hoofed animals had “always” been present (ARC, 2001).

1.1.2 The Benefits of Reduced Livestock Access to Streams and Riparian Margins

Reduced livestock access to riparian zones and stream channels is expected to have major benefits to stream water quality and stream ecosystem health (ARC, 2001). Some benefits that will potentially accrue to the grazier on-site once livestock have been excluded from water bodies and riparian vegetation has been re-established are:

- Healthier stock through having access to a controlled, reticulated unpolluted water supply system (i.e. via the provision of troughs);
- Improved amenity and increased ecosystem function within water bodies
- Reduced losses from animals being trapped in streams or rivers or from grazing poisonous riparian or semi-aquatic plants;
- Easier mustering and stock management;
- Provision of shelter and the development of more favourable micro-climate conditions; and,
- Land owners increased “feel-good” factor.

An immediate water quality improvement is expected once livestock are removed from water bodies because the source of animal waste deposition in the stream channel and contributing near-channel areas. Thereafter water quality may continue to improve more slowly (months to years) as riparian sol and vegetation recovers and faecal bacterial stores are flushed from the stream sediment riparian zones (ARC, 2001). Water quality may never be restored completely to that of a fully forested catchment if some or most of the catchment continues to be grazed by livestock, because nutrient trapping in riparian zones is not 100% efficient, and some sources may bypass buffers, e.g. runoff from farm roads and discharge from field drains.

2 Literature Review

2.1 International Literature on Livestock Exclusion

2.1.1 Introduction

In general, there is a consensus in the scientific literature that poor livestock management impacts on rivers and riparian zones in a number of ways. The degradation of stream water quality has been linked to livestock grazing in many parts of the world (McKergow, et al, 20003, p.253). Belsky et al (1999, p.1) state that livestock grazing has damaged approximately 80% of stream and riparian ecosystems in the western United States. Livestock seek out water, succulent forage, and shade in riparian areas, leading to trampling and overgrazing of streambanks, soil erosion, loss of streambank stability, declining water quality, and drier, hotter conditions. These changes have reduced habitat for riparian plant species, cold-water fish, and wildlife, thereby causing many native species to decline in number or go locally extinct. Such modifications can lead to large-scale changes in adjacent and downstream ecosystems (Belsky, 1999, p.1)

The main processes that contribute to livestock-induced water quality pollution of stream and rivers are direct faecal defecation into the stream (Miner, et al, 1992; Larsen, 1995), runoff of faecal material from the adjacent land (Larsen, et al, 1994), increased erosion of stream banks by cattle shearing, and re-suspension of river sediments by cattle trampling (Trimble & Mendel, 1995; Belskey et al, 1999).

2.1.2 The Quantified Water Quality Effects of Fencing

Livestock exclusion fencing has been shown, through a 13-year monitoring study, to reduce sediment yield from a beef cow pasture by up to 40% (Owens, et al, 1996). Alternatively, simply providing an off-stream water supply without fencing was shown to reduce sediment from streambank erosion by 77% and concentrations of total nitrogen and phosphorus by more than 50% in a cow-calf pasture; however this study was relatively short-term and included only limited monitoring of stream (Sheffield, et al, 1997). While relatively large reductions in sediment yield as a result of livestock exclusion fencing have been documented by a few studies, reductions in nitrogen and phosphorus yields are much less certain (Line, et al, 2000).

Line et al (2000) carried out a study to evaluate the effects of excluding dairy cows from, and planting trees in, a 335-metre long and 10 to 16-metre wide riparian corridor along a small North Carolina stream. Analysis of 81 week pre-exclusion and 137 week of post exclusion fencing data documented a 33% reduction of nitrate + nitrite, a 78% reduction in total Kjeldahl nitrogen, a 76% reduction to total phosphorus and a 82% reduction in sediment loads.

McKergow et al (2003) also found that riparian fencing and livestock exclusion are likely to be valuable for reducing stream sediment. In this study, a 1.7 km stream reach near Albany, Western Australia, was fenced and planted with eucalyptus species and managed independently from adjacent paddocks. After this fencing, water quality was monitored over a 4 year period. Suspended sediment (“SS”) concentrations fell dramatically following improved riparian management and livestock exclusion – SS concentrations and loads were at least 90% lower. However, changes in phosphorus (“P”) and nitrogen (“N”) in this study were less certain. Other authors have also reported more variable reductions in nutrients – e.g. Williamson et al (1996) – a New Zealand study - and Line, et al (2000)

Another “before and after” cattle fencing study by Miller et al (2010) – based on a 800 metre reach of Lower Little Bow River in Southern Alberta, Canada – did demonstrate an improvement of riparian health and some water quality variable. However not all water quality variables improved. Therefore Miller et al (2010) and others have commented that improvements in these in-stream variables may depend more on upstream watershed-scale conditions and impacts rather than localised reach-scale livestock-access issues.

2.1.3 Economic and Other Benefits of Livestock Exclusion and Riparian Buffer Strips

A relatively early case study to attempt to quantify the economic costs and benefits (including discounting and opportunity costs) of implementing vegetative buffer strips (“VBS”) was completed by Rein (1999). This study investigated the costs and benefits associated with the installation of VBS on a 36-acre strawberry farm. Rein (1999) concluded that the total benefit to the grower was $1,488 for the first year and $6,171 over five years. Rein (1999) also calculated the benefits to society, which were $4,545,720 per year. Other potential benefits to growers (non-quantified) include, the establishment of habitat for beneficial insects, reduction in groundwater pumping costs and to society (non-quantified) include improved water quality for fish nursery habitats and improved “existence values”.

In another study, De Young and Leep (2011) looked at production gain from better riparian management practices in a study from Canada. When grazing occurs and frequency - how often grazing occurs - are what grass managers try to control. Riparian areas are a resilient grazing resource but just like upland pasture they must be utilized at an appropriate level and given periods to recover. Riparian grazing management is ultimately about paying special attention to these sensitive areas in the day to day management of the entire cattle operation. On the Canadian Plains Riparian areas occupy a small number of acres in pastures but are an important forage resource. Economists from the University of Alberta found that if the riparian area constituted at least 7.5% of the pasture area, investment in infrastructure to improve riparian management could be profitable. A survey of 346 producers who had changed to controlling riparian area grazing and rotational grazing practices found that 80% reported higher weights gains, 91% reported higher forage production, 88% reported higher forage quality and 52% reported lower overwintering costs. Riparian management usually involves remote watering or protecting water quality by maintaining riparian health. Recent research has shown that improved water quality can improve feed intake, feed efficiency and weight gains.

2.2 National and Regional Literature Review

2.2.1 National Literature Review

At both a national and regional level, there is a shortage of published studies that explicitly quantifies the water quality benefits of livestock exclusion – most studies describe the benefits of changes in wider riparian or land use management (Neale, per comm., Aug, 2011).

Nationally it is recognised that cattle accessing stream channels and riparian margins can cause appreciable water quality contamination, particularly microbial contamination from faecal sources, and it is argued that excluding cattle from streams and riparian margins will have major water quality benefits. Davies-Colley et al (2004) studied the water quality impact of a herd of 246 dairy cows crossing a stream ford, which is a tributary of the Motueka River. On the first crossing, the tightly bunched cows produced a sharp spike of contamination – *E. Coli* peaking at 50 000 cfu/100 ml. Other crossing events increased SS by c. 54%, reduced visual water clarity by c. 11%, and increased TN by c. 10%. (Davis-Colley, et al, 2004, p. 574). Adrian Meredith (Environment Canterbury, pers. comm. – sighted in Davies-Colley et al (2004)) measured similarly high faecal contamination of a stream subject to crossing of a dairy herd (concentration up to 100 000 cfu/100ml), and estimated that the yield was equivalent to tripling of the average faecal contamination level of that stream.

A study that focused on the exclusion of deer of a farm near Mosgiel showed quite significant improvements in water quality (Mc Dowell, 2008). Water quality data from this study indicated that riparian planting and fencing-off a stream from deer access significantly decreased the mean concentrations of NO_{3-}N, NH_4, -N, SS, PP, and TP. This also translated into decreases in the loads of these constituents, varying from 78% to 98%. Mean concentrations of *E.coli* and DRP showed no significant difference with fencing off and planting.

Streams draining catchment in pastoral agriculture generally have poor water quality, which has been documented in New Zealand (MfE, 1997) and overseas (Novotny, 1999). Unrestricted livestock access to streams and riparian zones appears to be widespread throughout the rural areas of New Zealand (MfE, 1997) and there is evidence that a large proportion of the contamination of rural streams by sediment, nutrients and faecal matter is derived from livestock access to the riparian zone and the stream channel itself (ARC, 2001).

2.2.2 Regional Literature Review

2.2.2.1 **Specific Papers on the Auckland region**

The most regionally relevant study of the effects of livestock of streams and options for the management of these effects in the Auckland region comes from a review done by Davies-Colley & Parkyn (2001). This study reviewed more than 250 papers and scientific reviews, and cited 90 papers in this report, of which an emphasis was placed on authoritative reviews, “landmark” papers, and New Zealand literature. In general, the literature suggests that livestock cause appreciable damage to streams and the riparian zone (Belsky et al. 1999). Livestock, particularly cattle, damage riparian vegetation and soil structure, and cause stream bank erosion, and degraded water quality. Cumulative effects of deforestation and grazing have also led to reduced stream heath as indicated by invertebrate and fish communities, both in New Zealand and overseas. However the severity of these impacts may be highly variable between streams depending on climate, hydrology, landform, soil type, stream size and geomorphology, as well as vegetation cover and grazing type and intensity. In a humid environment, such as the Auckland region which is known for high intensity rainfall and in which the original riparian ecosystem was forest never subjected to ungulate grazing, the potential damage may be more severe than where grazing ungulates have ‘always’ been present (Davies-Colley & Parkyn, 2001).

Sighted in Davies-Colley & Parkyn, (2001), Clark (1998) states that the severity of degradation of water by livestock is “localised, site-specific and manageable, rather than being generalizable and unavoidable”. Davies-Colley & Parkyn (2001) consider that this is broadly correct for the Auckland Region. However, Davies-Colley & Parkyn (2001) would point out that water quality degradation is hardly “localised” if appreciable contamination of downstream water bodies, including lakes and coastal waters, occurs as a result of “local” livestock activity. Davies-Colley & Parkyn, (2001) further comment that the main implication of Clark’s assertion, however, is that something can be down about the damage of livestock to streams and their riparian zones. The philosophy of Davies-Colley & Parkyn (2001) report is that reducing livestock pressure on the riparian zone, by approaches ranging from permanent fencing through to ‘incentives’ for stock to seek shade and water off-stream, has the potential to appreciably reduce a range of impacts on streams. This is a testable hypothesis, one that *has* in fact been tested to some extent overseas (e.g., Sovell et al. 2000) and one that warrants testing by adaptive management, guided by monitoring and scientific experiment, in Auckland region.

In relation to water quality in Auckland’s rivers and streams, the most comprehensive data is contained in TP 336 – *River Water Quality: State and trends in the Auckland region* (Scarsbrook, 2007). This publication reports the results of ARC’s long-term (between the period of 1986 to 2005) water quality monitoring network from a network of 27 sites. It notes that Auckland streams tend to have high temperatures, high concentrations of nutrients, and high levels of faecal coliform bacteria and suspended sediments, however, there are strong correlations between most water quality parameters and land cover characteristics (Scaresbrook, p.1, 2007). This report further states that due to the strong correlations between most water quality parameters and land cover characteristics, it's suggested that these water quality issues are associated with intensive landuses (Scaresbrook, p.35, 2007) Overall, sites in urban catchments have poorer water quality than sites in forest or rural catchments.

2.2.2.2 State of the Auckland Region 2010 - Report

The former Auckland Regional Councils *State of the Auckland Region 2009* (ARC, 2010) also contains relevant data that demonstrates a relationship between land cover and water quality. Again, using the data from 27 long-term monitoring sites, average Water Quality Index ("WQI") is highest (97.2 - "excellent") for forested sites, "fair" (64.2) for rural sites, and "poor" (49.1) for urban sites (ARC, p.149, 2010). The parameters within the WQI are: dissolved oxygen; pH; turbidity; ammonia; temperature; total phosphorus; and total nitrogen. In relation to water quality trends, it is stated that for both forested and rural sites, the majority of sites showed no change between 1995 and 2005. When the trend analysis was summed for all sites, most parameters at most sites showed either no change or an improvement in the water quality for ecological health. The small number of declining trends showed no consistent pattern but one site (Wairoa), showed declining trends in three parameters (dissolved oxygen, ammoniacal nitrogen and turbidity) (ARC, p.149, 2010).

In relation to the suitability of water for stock drinking, the former ARC used the threshold of 1000 E. coli per 100ml water. The ARC 2010 (p.151) report found that the majority of the 13 rural sites failed to meet the ANZECC stocking drinking guideline at least once during 2007. However, the two Mahurangi sites met the stock watering guideline throughout 2007 and the Hoteo site failed to meet the guideline only once. To assess the effect of land cover on the ecological quality of the river, (derived from the Macroinvertebrate Community Index ('MCI") measure) each of the 52 sites in the invertebrate monitoring programme were assigned to one of the four catchment land cover types (native forest, exotic forest, rural and urban) on the basis of the predominant land cover in their catchments (ARC, p.156, 2010). The findings are that the native forest sites clearly produced the best average MCI score indicating "excellent" ecological quality, followed by the exotic forest sites which produced an average score, indicating "good" ecological quality. In contrast, the urban sites produced the lowest average MCI scores indicating "poor" ecological quality at these sites. The rural sites were intermediate between the urban and exotic forest sites.

Another measure is Quantile Index of Biotic Integrity ("QIBI") that enabled the former ARC to assign a score to a site based upon the fish species found there. The QIBI predicts which fish species should be present at a site – based on its elevation and distance from the coast – and compares this prediction with the fish species actually found there. QIBI scores range from 0 (no native fish found) to 60 (the full range of species predicted for that site were present. The average QIBI scores were: Native “good” (39.1); Exotic forest “fair” (33.7); Pasture “fair” (30.9); and Urban “fair” (28.6).

The results from the former ARC’s freshwater monitoring programmes consistently emphasise the importance of the land cover type in the surrounding catchment on both water quality and ecological quality of the river. The findings indicate that the life supporting capacity of urban and rural rivers is impaired (ARC, p.159, 2010). There is a statistically significant correlation between the ecological quality and the water quality at the 16 sites that were common to both monitoring programmes. This correlation shows that sites with poor water quality also have poor ecological quality, while good water quality is linked with good ecological quality (ARC, p.159, 2010).

Overall, in relation to fresh water quality for streams and rivers, an analysis of the trends for the Auckland region between 1995 and 2005 indicated that, for most water quality parameters at most sites, the water quality was either stable or improving. Another notable finding was the large variation in the water quality and ecological quality at different rural sites. This raises questions around the land management of rural catchments (ARC, p.160, 2010). For example, rural sites in the monitoring programmes ranged from unfenced rivers with degraded riparian vegetation to rivers with riparian fencing and riparian buffers of native woody vegetation. This is an important observation, since as over 60 percent of the rivers in the Auckland region flow through rural catchments

In relation to lakes, the water quality of the monitored lakes was generally degraded due principally to nutrient enrichment, but the microbiological lake water quality was good when compared with national guidelines for recreation.

With respect to the marine area, the Auckland region’s marine environment is highly diverse and consequently there is a large variation in both the physical conditions and the biological diversity (ARC, p.196). Overall, the coastal water quality around the region showed significant improving trends in water quality, with reduced levels of faecal indicator bacteria, suspended solids, total phosphorus, soluble reactive phosphorus and nitrate. However it is of concern that water quality was declining at some sites rated “good” and “excellent” for coastal water quality (particularly for nutrients and suspended sediments). It is too early to tell if these changes are strongly linked to land management practices (ARC, p.196, 2010).

The quality of coastal water is poorest at inner harbour monitoring sites, but is relatively good in outer harbour or open coastal locations. Open coast sites had the best coastal water quality, primarily due to strong tidal flushing, their distance from freshwater inputs and isolation from contaminants resulting from urban land uses. Inner harbour sites tended to have the poorest water quality because of their proximity to freshwater inputs that carry contaminants from the land and lees flushing (ARC, p.196, 2010).

In conclusion, this State of the Auckland region report states that there is a trend for sites close to more rural catchments to show declining water quality and declining ecological health, possibly reflecting the continued input of sediments and nutrients from associated land management practices in these areas (ARC, p.196, 2010). Therefore, in order to successfully manage the marine environment, it is essential to monitor and manage land-based activities n the contributing catchments. Sediment is a concern in the region and is an issue that may increase in importance in more rural areas in the future, as shown by the increasing levels of sediment or nutrient loads at some sites that presently have the best water quality. Some locations in the Mahurangi Harbour show a continuing decline in species that are sensitive to sediment (ARC, p.196, 2010).

2.2.2.3 Technical Publication 270 – A Survey of Sediment Sources on Streams in the Mahurangi Catchment

In specific relevance to the Mahurangi Catchment, is Technical Publication 270 – *A Survey of Sediment Sources on Streams in the Mahurangi Catchment* (ARC, 2004). The conclusions of this report are that a third of the sediment sources are entirely natural, an eighth are created by human modifications to channel beds or banks, and over half are induced or exacerbated by farm livestock. Actives that stand out are: earthworks adjacent to channels; channel excavation (includes drain-clearing); sedimentation behind dams; trampling of swampy alluvium or colluviums by livestock next to infilled channels; and, browsing and trampling of steep banks by livestock next to incised channels (ARC, p.viii, 2004). This report also states that “regardless of what vegetation is planted – or isn’t – fences to exclude livestock potentially could remove about half of current sediment sources.” (ARC, p.ix, 2004).

2.2.2.4 Survey of the Riparian Characteristics of the Auckland Region – TR 2009/002

An important regional report that relates directly to the subject of livestock exclusion is *A Survey of the Riparian Characteristics of the Auckland Region* – TR 2009/002 (ARC, 2009). This report concluded that it is estimated that there are 13511 km of rural stream banks (just related to “permanent” flowing streams) that are unfenced in the Auckland region. This study also found that 25% of the 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 by this survey, with 46.9% of stream length or 51% of bank length unfenced. Streams in drystock land use had significantly less fencing than those in both dairy and rural residential land use (ARC, p.1, 2009). This study also found that nearly half the Region’s rural stream banks are affected in some way by erosion, although only 5.4% of stream banks were subject to active erosion. Streams in rural residential land use had the least stream bank erosion for all measures. Drystock streams had the greatest extent of erosion recorded, with 54.6% of drystock stream banks affected by erosion. Of this, 9.6% was recorded as active erosion, significantly more than both rural residential and dairy streams. This survey has in effect determined a benchmark in relation to the current status of livestock access to permanently flowing pastoral streams in the Auckland region.

2.2.3 Literature Review on Livestock Exclusion by RIMU

Effects of sediment on the freshwater environment – A discussion paper for policy development in the Auckland Region. - Martin Neale, January 2008

Introduction

The effects of sediment on the freshwater environment can be divided into two main areas.

1. Suspended sediment in the water column.
2. Sedimentation on the stream bed.

Sediments suspended in the water column increase turbidity and reduce light penetration, whereas sedimentation modifies the stream bed by altering surface and sub-surface conditions. Whilst the two areas are obviously linked, it is a useful division to examine the effects of sediment in the freshwater environment.

It should be noted that the majority of the studies investigating the effects of sediment in freshwaters have focussed on running waters, with little attention on the effects on standing waters. Similarly, studies of the biological effects of sediment on fish are better documented than for other freshwater organisms.

Suspended sediment

The primary effect of suspended sediment in freshwaters is to increase turbidity and reduce light penetration through the water. The aesthetic effect of this primary effect is often of initial concern to humans, as turbid water is less acceptable for consumption, contact recreation and visual enjoyment.

The environmental and biological effects are typically not as apparent as the simple aesthetic effects. Whilst exposure to high levels of suspended sediment can be lethal to fish and invertebrates, the concentrations required are rare in Auckland. The indirect and sub-lethal effects of lower concentrations are more important. The reduction of light penetration through the water column has two main biological effects; decreasing the light available for primary production through photosynthesis and reducing the visual ability of sighted organisms.

The reduction in primary production (plant and algae growth) has potentially wide reaching consequences since plants and algae often form the basis of the food chain in freshwater environments. Therefore as well as declining diversity of aquatic plant and algae communities, decreases in plant or algae growth reduces the food available to invertebrate and fish herbivores. The reduction in primary production is principally in response to lack of light available for photosynthesis, although high levels of suspended sediments can cause direct damage to plants through abrasion.

The effect of suspended sediment on the clarity of water reduces the visual ability of sighted organisms and many studies have reported that poor visibility reduces the foraging success of fish predators. Given that short term exposure to high levels of suspended sediment in laboratory studies had little effect on the survival of invertebrates and fish, it could be reasoned that the absence of these organisms from turbid streams may be a result of reduced long-term feeding ability.

However, the effects of turbidity on fish migration are important in New Zealand as 70% of species undertake migrations to and from the sea in order to complete their life cycle. Native migratory fish, particularly Banded Kokopu, actively avoid turbid water during their upstream migrations. Therefore, high turbidity in the lower regions of rivers may discourage the entry of migrating fish into a watercourse despite the potential presence of high quality habitat in tributaries upstream.

Suspended sediments may also have direct physical impacts on freshwater organisms. Multiple studies have recorded increases in invertebrate drift with increasing suspended sediment concentrations. This is likely to be a combination of a behavioural response by invertebrates to avoid sediment and invertebrates being directly dislodged by sediment particles. In addition, high concentrations of suspended sediments carried in the water column can damage fragile structures, particularly feeding and respiration apparatus, in both fish and invertebrates.

Sedimentation

In the Auckland Region, the effects of sedimentation are potentially of lesser impact on freshwater systems than suspended sediment. The effect of sedimentation on gravel bed streams has been extensively studied, where sedimentation reduces the diversity of invertebrate communities mainly through the “clogging” of the gaps between the gravels, preventing the transfer of water, food and oxygen to the productive deeper substrates. Most streams in Auckland are in “soft” geological formations, where stream substrates are composed of inorganic substrata dominated by sand and silt sized particles, these habitats are less susceptible to degradation by additional sedimentation. Organic substrates, such as woody debris, plants and their roots, rather than the stream bed, are typically the most stable and productive habitats in these streams.

Furthermore, much of the work on the effects of sedimentation on fish communities has focussed on the Salmonid family. These fish lay their eggs in the gravels of stream beds where sedimentation can reduce the transfer of oxygen to the developing embryos. Salmonid fish are not native to New Zealand and are not common in the Auckland Region because of the high winter temperatures. The freshwater fish communities in Auckland are typically members of the Galaxiidae and Eleotridae families which do not lay their eggs in the stream bed, but typically on marginal vegetation or in-stream debris upon which sedimentation is less of an issue.

In summary, whilst suspended sediments and sedimentation are inextricably linked, the effects of elevated suspended sediment are potentially more severe to Auckland Region’s freshwater environments than those of sedimentation.

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Martin Neale – August 2011

In general there is a consensus in the scientific literature that poor livestock management impacts on rivers and riparian zones in a number of ways, including:

- damage to riparian vegetation
- damage to soil structure
- cause stream bank erosion
- lead to degraded water quality

However, there are a shortage of published studies that identify the benefits of "stock exclusion"; most studies describe the benefits of changes in wider riparian or land use management. This often includes stock exclusion, but includes wider best management practises, including riparian planting, improved effluent management and reduced fertiliser applications (e.g. Wilcock *et al*., 2009).

It is recognised that cattle accessing stream channels and riparian margins can cause appreciable water quality contamination, particularly microbial contamination from faecal sources, and it is argued that excluding cattle from streams and riparian margins will have major water quality benefits (Davies-Colley *et al*., 2004). Similarly, Collins *et al*. (2007) state that bridging of stock crossings and permanent fencing removes a direct source of contamination. Both of these studies lack data that describes the benefits arising after stock exclusion has been implemented, rather they provide evidence of the impacts of cattle prior to their exclusion. The reasoning is sound, particularly given their findings that cattle have a disproportionately high rate of defecation in streams compared with land, but the absence of post exclusion data is a limitation of both of these papers.

There are two main studies in the New Zealand context that have described the effects of changes in riparian management over time. First, Wilcock *et al*. (2009) evaluated the environmental outcomes associated with the implementation of a range of "best management practices", including riparian protection (stock exclusion and planting), dairy effluent management and fertiliser application in the Waiokura Stream catchment in Taranaki (a 2100 hectare catchment in predominantly dairy land use (44 farms)). Improving trends in water quality measures were observed (between 2001 and 2007) over a similar timeframe as livestock exclusion increased (from 40% to 52% between 2001 and 2004, with additional fencing between 2003 and 2008). Whilst the findings of the study are a result of a range of management practices, they conclude that there were significant improvements in water quality (especially TSS, TP and *E. coli*) associated with riparian fencing.

In a similar study, Jowett *et al*. (2009) investigated the impact of stock exclusion and riparian planting (average of 4m on each bank) on two small pastoral streams (~ 1m wide) in Waikato that had un-restricted access for livestock. However, this study focussed on the effects on the biological communities rather than water quality parameters. Ten years after restoration activities began, increases in the abundance and diversity of sensitive fish species had been observed, along with continual improvement in the macro-invertebrate community. The study concluded that riparian management (including stock access and re-vegetation) are effective interventions to restore the biological communities of river systems, but outcomes may take a long time (up to 20 years) to eventuate.

The effects of riparian restoration were also investigated by Parkyn *et al*. (2003), but rather than a before and after study, spatial replication was substituted for temporal replication. The study used paired sites of differing riparian management and condition in the same or nearby catchments, so that fenced and planted reaches was compared with unfenced, grazed reaches. This type of approach introduces confounding factors into the study, but given the relative paucity of NZ based studies the results of the study are important. Based on the investigations of nine river sites in the Waikato Region, it was observed that in general protected sites (i.e. those with riparian fencing and planting), had more channel shading, less periphyton, less macrophytes, less soluble reactive phosphorus, less total nitrogen, less erosion and greater water clarity when compared with similar sites with unrestricted stock access.

Several studies have documented an increase in bank stability (or a decrease in bank erosion) associated with stock exclusion. In Auckland, modelling based on a survey of 180 pastoral sites indicating an almost 1:1 relationship between fencing and bank erosion; the model predicting a 1% increase in effective fencing would result in a 0.9% reduction in bank erosion (Neale *et al*., 2009). Similar results have been published from studies in Canada (Scrimgeour & Kendall, 2003) and the United States (Ranganath *et al*., 2009). Whilst these studies did not focus on water quality or ecological measures, a relationship between bank erosion and water quality is likely to eventuate through suspended sediment levels.

3 Issues: Pressures on the Coastal and Marine Environment – Megan Carbine-2008

3.1 Introduction

At the intersection of land and ocean, estuarine and coastal ecosystems are of critical importance to the Region's cultural, social, economic and environmental wellbeing. These ecosystems have high and often conflicting resource use and their health is under increasing pressure from both direct use and activities which generate discharges to the marine environment.

Marine based activities or uses that potentially have an impact in the marine environment may include coastal reclamation and coastal structures, which can remove habitat and alter hydrodynamics, dredging and dredge disposal, mining (sand and other potential minerals), aquaculture which uses space and can generate effects on habitats and fishing including both the impact of harvest levels and the impacts of fishing methods such as trawling and dredging. Power generation using tides and waves is an emerging issue. The high use of Auckland's harbours for boating and shipping means that the risk of oil and chemical spills is always present.

Land based activities can generate discharges of sediment, chemical contaminants, nutrients and sewage to the marine environment. Increased sediment to the marine environment can influence marine ecology, both through increased suspended sediment concentrations and sedimentation rates. Increased suspended sediment concentrations can influence primary production and the organisms that feed by filtering the water. Increased sediment deposition can smother organisms and change the habitat (increasing muddiness) so that it is no longer suitable for some species. Toxic chemicals generated on land, such as heavy metals and organic pollutants can have negative effects on organisms living in the marine environment. Increased nutrients (particularly nitrates and phosphates) in the marine environment can lead to eutrophication which can result in algal blooms and ultimately in hypoxia (low oxygen). Algal blooms are also affected by light, temperature, season and water flow, so it is possible for algal blooms to occur without nutrients being a primary driver. Sewage overflows can add nutrients to the marine environment, but also pathogens which may pose a human health risk.

3.2 Sedimentation

Sedimentation and infilling of estuaries is a natural process, however the rate of these processes is being considerably increased by human activities on land, which currently represent the main cause of historically recent changes in sediment delivery to coastal zones (GESAMP 1990). Globally, sediment loads delivered to estuaries and coasts have increased by as much as an order of magnitude or more due to human activities such as catchment deforestation, conversion to pasture and rapid urbanisation in recent decades (Syvitski et al. 2005).

Increased inputs of fine terrestrial sediments due to human activities has adverse effects on coastal ecosystems due to decreased water clarity reducing productivity, increased sediment deposits smothering organisms and clogging feeding structures and a change from sand to mud habitat. By examining the sequence and composition of sediment deposits in sediment cores the effects of human activities on sedimentation rates through time can be determined.

Studies in Auckland estuaries (See Swales et al. 2002a; TP211) show that sediment accumulation rates (SAR) have increased during the last 150 years or so due to human activities. Before catchment deforestation (1840–1900), SAR measured in Auckland estuaries were typically less than 1 mm yr^{-1}. Catchment deforestation, conversion to pasture and horticulture and rapid urban development during the last 50 years saw the SAR increase by as much as an order of magnitude during this period, accelerating estuary infilling. Tidal creeks close to catchment outlets have infilled most rapidly, averaging 20 mm yr^{-1} over the last 50 years. Many of these tidal creeks are now entirely intertidal so that they are completely exposed during low tides. In the main body of estuaries, sedimentation has built extensive intertidal flats, with SAR averaging less than 5 mm yr^{1}. In the last 50 years, intertidal flats have become shallower by approximately 0.5 m, which is significant as the average high-tide water depth in many Auckland estuaries is less than one meter

Today, Auckland's east-coast estuaries are at various stages of infilling. Waitemata Harbour for example, retains substantial sediment accommodation space in its central mud basin, while its tidal creeks have largely infilled. In the Mahurangi estuary, the large tidal creek above Hamiltons Landing has largely infilled and sediment has now partially infilled the central mud basin, so that the subtidal volume of this system is shrinking. Other estuaries, such as the Wairoa (Clevedon) have completely infilled with sediment forming tidal flats that have been colonised by mangroves. In Wairoa this has occurred because the land catchment (311 km^2) is large in comparison to the estuary (high-tide area < 3 km2). Evidence from sediment cores suggests that the Wairoa is exporting land derived fine sediments to the adjacent coastal environment.

The overall pattern for Auckland is an increase in SAR 100–150 years ago (~1850–1900 AD), which coincides with European settlement and large-scale catchment deforestation. Sedimentation rates increased rapidly from approximately100 years ago. For some estuaries cores indicate that sedimentation rates continued to increase until 20–40 years ago (~1960–1980 AD) and since that time have not increased further or have slightly reduced. These apparent plateaus may relate to reductions in catchment sediment loads and/or estuary storage capacity. At other sites, SAR has continued to increase suggesting further increases in SAR for the foreseeable future. There is no compelling evidence that sedimentation is yet slowing down in Auckland estuaries as they infill and it is likely that sediment infilling of Auckland estuaries will continue at several mm yr^{-1}. The effects of catchment sediment loads will be greatest in tidal creeks, at the catchment outlet. Estuary sedimentation has been partially offset by relative sea level rise, which effectively slows down the pace of estuary "aging" due to infilling. This sea level rise offset of estuary sedimentation is most effective in the main bodies of estuaries where average SARs over the last 50 years or so have been similar to sea level rise. This balancing process has been much less effective in tidal creeks, which have rapidly infilled seaward from their catchment outlets.

More recent sediment core dating has been carried out for the Weiti/Okura/Karepiro Bay area (Swales et al. 2008, ARC TR2008/026) and Kaipara Harbour (report pending).

Indicator: Sediment Accumulation Rate

Annual average sediment accumulation rates in Auckland estuaries is given in Table 5.1 of Swales et al. (2002a; TP211). The sediment accumulation rate (SAR) could be a key State of the Environment (SOE) physical indicator of the effects of catchment use change in estuaries (see Hume et al 2002; TP166 and Swales et al. 2002; TP211). However sampling has not occurred in a consistent manner since the 2002 report and therefore up to date results can not be used as an indicator in the 2009 SOE report. It is recommended that prior to the next SOE report (20013/14), the findings of Swales et al. (2002) are revisited and a consistent sampling programme of sediment accumulation rates across Auckland receiving environments is implemented.

Indicator: Turbidity or Total Suspended Solids as measured in the saline water quality programme

The variables turbidity, visual clarity and total suspended solids have been measured as part of ARC's long term water quality monitoring programme. All three variables provide a similar picture of suspended sediment levels across the 27 sites monitored. Total suspended solids (TSS) showed significant decreasing trends at 13 sites; however there were sites where TSS increased. In addition, there is no event component to sampling so high sediment loads delivered during storm events are not captured.

3.2.1 Sediment Sources (TP321 Max Gibbs)

ARC and NIWA developed a novel technique to track the source of sediments deposited in the marine environment. The technique uses specific signatures or fingerprints in catchment sediments (compound specific isotopes) and compares these to the signature of sediments in the marine environment. A study using this technique was carried out in the Mahurangi Harbour where land derived sediment entering the harbour is affecting the ecology of the harbour due increased suspended sediment in the water and increased sediment depositing on the harbour floor.

Table X : Catchment contributions to harbour sediments – terrestrial soil contributions

Land use	% of catchment	% contribution harbour sediments*	% contribution to deposited sediment on river delta**
Forest	8%	14%	50-54%
Pasture	70%	10-30%	15-55%
Native	20%	<10%	<30%

*The rest of the harbour sediments are made up of marine and estuarine sediments.

** Note that land-use percent of catchment figures change when considering just the river delta

The study confirmed that the major sources of sediment in the upper harbour are from pasture, native forest and exotic pine forest. The majority of sediment entering the harbour was derived from pastoral land use (10-30%). However pine forest contributed higher than expected loads. Despite being only 8% of the catchment use, it contributed 14% of recent sediment to the overall harbour and contributed the majority of sediment deposited on the river delta. The bulk of the harbour's annual sediment load is delivered by a few storms. The risk of erosion is greatest during these more intense rainfall events.

3.3 Effects of sedimentation in the marine environment

Sedimentation has been identified as an increasing and widespread problem for a range of habitats worldwide (Airoldi 2003). Land derived sediment is increasingly being recognised as a disturbance agent in coastal marine communities.

The effect of sediment can vary between soft sediment and reef environments, between intertidal and subtidal environments, and between sheltered and exposed locations.

3.3.1 Effects on soft sediment habitats in estuaries and harbours

Estuaries are particularly vulnerable to the effects of catchment landuse changes because of their close proximity to the sediment source and physical and biological processes that promote sedimentation. Auckland's numerous and varied estuaries are highly valued features of the coastal environment and are variously impacted by land runoff (Swales et al.2008).

A considerable amount of research by NIWA, both FRST and ARC funded, has been undertaken on the effects of sedimentation on intertidal and subtidal soft sediment macrofauna communities. This research is synthesised in an ARC publication (Gibbs and Hewitt 2004; TP264).

3.3.1.1 Effects of increases in suspended sediment,

Land derived sediment usually enters the coastal waters as suspension via estuaries following erosion of a disturbed catchment during rain. Consequently, the first impact on the benthic communities is an increase in turbidity or suspended sediment concentrations.

Typically, increased turbidity reduces light penetration into the water column impacting primary production by plants (pelagic phytoplankton and benthic microphytes) which require light to photosynthesize.

Elevated suspended solids also impact directly on suspension feeders, interfering with their ability to feed or diluting the food quality with inorganic particles.

In a laboratory experiment adult cockles, pipi and scallops all exhibited the ability to continue feeding in high levels of suspended sediment over the short-term (< 1week) but their condition was adversely affected by high suspended sediment concentrations occurring for long time periods (Nicholls et al. 2003; TP211). The type of suspended sediment was also important with land derived sediment affecting cockles more than resuspended marine sediment. Growth rates of juvenile cockles and the reproductive status of adult cockles and pipis in the field were adversely affected by high suspended sediment concentrations.

The effects of elevated suspended sediment concentrations may be less direct. The herbivorous gastropod *Zeacumantus lutelentus* (horn shell), that can be found in high densities in the surface layers of intertidal sand and mud flats throughout the Auckland region, showed no direct effects to increasing suspended sediment. However if the reduction in light associated with increased suspended sediment reduced primary production by benthic microphytes, this could reduce the available food supply to *Zeacumantus*.

Burial times and death rates in the heart urchin, *Echinochardium australe*, a large burrowing deposit feeder common in the subtidal zone in both sandy and muddy subtidal habitats, increased with increasing exposure to suspended sediment. While it is unlikely that deaths occurred directly from the suspended sediments, stressed animals remaining on the sediment surface are more vulnerable to predators (Lohrer et al. 2003; TP217).

Further examples of the effects of elevated suspended sediment concentrations are give in Gibbs and Hewitt 2004 (TP264).

3.3.1.2 Effects of sediment deposits

Subtidal:
Land derived sediment can impact the subtidal benthic community by settling on the sea floor and forming a blanketing layer that alters the sediment structure and forms a layer through which the benthic macrofauna must burrow to survive. An experiment at a coastal and a harbour site at Mahurangi used a range of animals to determine the immediate and longer-term impacts of subtidal sediment deposition (Lohrer et al. 2003; TP217, summarised in Gibbs and Hewitt 2004; TP264). The ability of polychaete worms and shrimps to move up through the sediment decreased with increasing thickness of the sediment deposit, with a threshold level of about 3 mm. Substantial numbers of heart urchins were found dead on the sediment surface. The feeding rates of horse mussels (*Atrina zelandica*) and a solitary ascidian (*Styella plicata*) were significantly affected by sediment deposition over time and their condition deteriorated over three weeks (Lohrer et al. 2003; TP217).

Intertidal:
The thickness of the deposited layer and the period it remains on the intertidal sediments determines the impact on the benthic community. The results of a series of field and laboratory experiments in a number of locations are summarised in Gibbs and Hewitt 2004 (TP264).

Catastrophic deposition events are rare and cause sudden changes. NIWA studies show that long lasting thick layers of land derived sediment defaunate the intertidal zones and the recovery process is slow. Unlike the subtidal deposition where the deposited sediment remains partially fluid for some time after deposition, thick layers of land derived sediment on the intertidal one become dewatered during low tide. In hot weather the sediment becomes hard and impervious to small macrofauna.

Sublethal, non-catastrophic events are the most likely occurrence in the intertidal zones. The sediments are unlikely to be defaunated by these events, however, they can undergo subtle changes which may be cumulative and ultimately alter the structure of the benthic communities impacted. While benthic communities may recover quickly from a single deposition event, a succession of deposition events at shorter intervals than the recovery time can result in cumulative effects that cause the habitat and the benthic community to change. In an experiment at Whitianga, differences in the sediment properties lasted about 50 days and effects varied between sites. Deposition of approximately 2 cm of sediment had an immediate negative effect on macrofauna, recovery of which lagged behind the recovery of the sediment properties.

3.3.1.3 Effects of long term changes in habitat.

Elevated sedimentation regimes tend to reduce the overall ecological heterogeneity with increasing muddiness. In estuaries, multiple habitat types such as saltmarsh, seagrass and unvegetated intertidal flats promote diversity by enhancing recruitment and maintaining species with requirements for multiple resources. The modification or reduction of available habitats due to elevated sedimentation has been shown to lower diversity and abundance with functional differences including a reduction in the number of suspension feeders (Ellis et al. 2004), More generally, the loss of large macrofuana could have important implications for ecosystem function in estuarine and marine ecosystems.

3.3.1.4 Examples of sediment effects in harbours and estuaries from current monitoring

Mahurangi Harbour

The populations of a selected range of invertebrate taxa have been monitored at intertidal and subtidal sites in Mahurangi Estuary since 1994. Estuary-wide changes in the abundance of some macrofaunal 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. 2001). The sediment composition changes occurred sometime between April 1996 and April 1997 and have persisted (Figure 2 & 23; Appendices 2 & 5). 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.

In 2004, Dr Greg Skilleter (University of Queensland, Australia) peer reviewed the Mahurangi Estuary monitoring programme for the Auckland Regional Council (ARC 2004a). His brief was to determine if the monitoring programme was sufficiently robust to support the conclusions made in the 2003 Mahurangi Estuary monitoring report (Cummings et al. 2003) that an ecologically significant decline in the condition of certain biota was occurring. Dr Skilleter was also asked to assess whether the available information supported the conclusion that sediment was the most likely cause of the observed ecological changes and, if so, whether management changes designed to reduce sediment loads in to the estuary would be sufficent to significantly improve the health of the resident biota.

Dr Skilleter concluded that there were (i) very, broad scale (estuary wide) declines in the abundance of some sedimentation-intolerant taxa, and (ii) general increases in the abundance of other groups, and that (iii) these changes are consistent with a model of large scale increases in sedimentation and benthic resuspension across the estuary (ARC 2004a).

A major joint project between Auckland Regional Council and the Rodney District Council was initiated (i.e., the Mahurangi Action Plan, MAP), the aims of which were to protect and enhance the existing values of Mahurangi Estuary and, especially to 'halt, slow or reverse the adverse effects of sedimentation' on it's health (see http://www.arc.govt.nz/environment/coastal-and-marine/sustainable-catchment-programme/mahurangi-action-plan/mahurangi-action-plan_home.cfm for details). Over about six years, the MAP has contributed to fencing and planting in selected subcatchment areas, to limit access of stock and input of sediments to waterways. Target catchment areas in the vicinity of our monitoring sites were Dyers Creek and Te Kapa Inlet. In response, a new intertidal monitoring site was established at Dyers Creek in October 2005 so that any changes over time in its ecology may be able to be linked to changes in catchment management.

Populations and communities of the monitored macrofaunal taxa, and site sediment characteristics, have not changed markedly at the intertidal or subtidal sites over the past two years of monitoring (final report number pending). A total of 24 intertidal populations have shown ecologically significant trends in abundance; 10 increases and 14 decreases (Table 4). Of most concern is that five taxa considered sensitive to increased sediment loadings are exhibiting declines in abundance in Mahurangi Estuary (*Macomona liliana, Austrovenus stutchburyi, Notoacmea scapha, Nucula hartvigiana, Scoloplos cylindrifer*; Table 4). Four of these continue to decline in abundance at the muddiest site, Hamilton Landing, and no sign of increase in these populations has been observed. Decreasing trends for Austrovenus, Nucula and Notoacmea scapha at Te Kapa Inlet are correlated with the continued expansion of the muddy portion of this site noted over the monitored period. The apparent recovery of *Macomona* noted at some sites in our previous report was due to large recruitment events in 2006–2009; unfortunately these high abundances have not persisted.

East Coast Estuaries

In 2000 the ARC began monitoring in Okura Estuary with the intention of capturing potential changes in the ecology of the estuary associated with periods of pre-development, development and post-development phases. In August 2002, four other estuaries were added to the monitoring programme (Puhoi, Waiwera, Orewa and Mangemangeroa). In August 2004, Turanga and Waikopua estuaries were added to the regional monitoring programme. Ten sites in each estuary are monitored for ecology and sediment grain size. Overall, the macrofaunal communities in the estuaries appear to be maintaining their status. However, some changes consistent with those predicted to occur as a result of increased sediment mud content or sedimentation were observed. Trends over time in community composition consistent with increased sediment mud content were detected for two sites in Turanga, Puhoi and Orewa and one site in each of the other estuaries, with the exception of Mangemangeroa. Changes of concern in the abundance of taxa or diversity, consistent with ecological predictions of response to increased terrestrial sedimentation or mud content, were observed at 1 site in each of Orewa, Puhoi, Waikopua and Waiwera, and at 4 sites in Okura. While the changes observed do not indicate a large degree of change across these estuaries, they are sufficient to warrant continuation of the monitoring programme in its reduced state.(final report number pending)

3.3.1.5 Guidelines for sediment effects in harbours and estuaries

Four guidelines have been produced from the sedimentation work by NIWA for ARC (Gibbs and Hewitt 2004; TP264).

- In general, the thicker the layer of mud, the more animals will be killed and the longer recovery will take. This will affect both the number of species and the number of animals within each species. Some species are more sensitive than others.
- A mud layer greater than 20 mm thick, remaining for longer than five days, will result in all resident species in that area (with the exception of mobile crabs and shrimp) being killed by a lack of oxygen.
- A mud thickness of 5 mm, persisting for longer than 10 days, will reduce the number of animals and the number of species, thereby changing the structure of the animal community.
- Frequent deposition of mud, less than 5 mm, may still have long term impacts that can change the animal communities.

It is important to acknowledge the limitations of this work, in terms of information gaps, underlying assumptions and the effect of simplification. **Four key points must be remembered when considering the above guidelines.**

- Community responses at the scale of an estuary or coastal area have been extrapolated from manipulative experiments. The underlying assumption is that the processes defined in the small scale experiments in one part of the system can be applied to the whole system.
- There has been little work done on sublethal effects such as organism health, growth and reproductive output. Such sublethal effects may occur at sedimentation levels lower than those described above but may over time lead to changes in population and community structure. All of these are likely to be important when making long term forecasts of population and community changes.
- Interactions between the stress caused by increased sediment inputs and other facts, whether natural (e.g. predation) or anthropogenic (e.g. contaminants) are likely to multiplicative.

- Little knowledge has yet been generated on the effect of duration and frequency of events over long-time scales or on large spatial scales, to the distribution of estuarine and coastal habitats.

3.3.2 Effects on rocky reefs

Sediments found on rocky reefs are typically a result of changing land use and/or sediments that are already a part of the reef system in the form of either soft highly erodible rock (sand and mud stones) or sediments derived from soft mud bottoms that are in close proximity to shallow reefs (e.g. the shallow reefs of the East Coast Bays). It is generally accepted that where wave action is reduced as a result of shelter afforded by islands and peninsulas, reefs are subjected to higher levels of sedimentation and consequently effects of sediments are typically found in sheltered areas. At more wave exposed locations high sediment loads in coastal waters is less common (except at locations such as Gisborne and the Hawkes Bay).

3.3.2.1 Ecosystem level effects

The effects of sediments are varied and typically range from smothering and burial to disruption to the feeding capability of certain reef species. Sediment related mortality and sediment related inhibition of population dynamics not only impact at the species level but may also have flow on effects for the entire ecosystems. With the reduction and /or removal of habitat structuring species (e.g. large brown algae) as a result of increasing or continual sediment inundation, primary productivity can be severally reduced. Without the pivotal habitat forming algal species, reef ecosystem function will diminish resulting in reef ecosystems not being capable of sustaining characteristic reef species (e.g. crayfish and snapper). It is these types of ecosystem level changes that impact directly on the values and usage of the marine environment by humans.

3.3.2.2 Algae and Seaweed

Studies of gradients in sediment deposition on rocky reefs from both New Zealand and overseas clearly demonstrate the effects of sediments on community composition. Algal diversity and composition show clear changes as a response to increasing levels of sediments. Reefs with ‘high’ levels of sediments covering the rocky substrate typically have species that are more tolerant or have adapted to the increased stress of sediment inundation. Associated with the effects of sedimentation is turbidity or reduced water clarity. With increased turbidity, light penetrating to depth can be significantly reduced. These reductions can be so severe and persistent that the lower depth range at which algae normally survive is reduced (the depth at which they are normally found is shallower) and less shade tolerant species are replaced by more shade tolerant species (Gostigate ref).

3.3.2.3 Invertebrate and Filter Feeders

Sediment effects on filter feeders are varied and are partly dependent on the species and environment that they are found in. Some rocky reef inhabiting filter feeders (e.g.

barnacles, mussels and oysters) are often found in highly turbid locations. Recent research indicates that moderate suspended sediment concentrations are not lethal to bivalve species but bivalves do display signs of acute responses to sediments (Swartz et al ref). Observations of a slow reduction in condition over time are assumed to be a direct result of sediments interfering with the filtering ability of an organism's gills and associated feeding structures. These results are consistent with studies undertaken overseas on corals and other filter feeding species. (Section needs expanding)

Sediments have been demonstrated to inhibit the fertilisation and settlement of the larval life stage of a number or characteristic reef dwelling species (e.g. kina and paua) and continued exposure to sediments can increase mortality rates of such species. Furthermore, there is mounting evidence to suggest that natural concentrations of sediments found on wave sheltered rocky reefs have a strong and negative effect on the settlement and growth of kina (Walker 2007). Further research has demonstrated varying effects of sediments on larval development and survival. Such effects result from variations in the dose of sediments and the duration of exposure to sediments (Philips ref).

3.3.3 Summary of sediment effects

Land derived sediment can influence estuarine and coastal ecology, both through increased suspended sediment concentrations and sedimentation rates. Increased suspended sediment concentrations can influence primary production by reducing light and benthic organisms that feed by filtering the water by affecting feeding structures and reducing food quality.

Studies have shown that benthic communities on intertidal sand and mudflats are highly vulnerable to deposition of land derived sediment. These communities comprise a diverse range of benthic organisms, which have adapted to cope with the stress associated with tidal conditions. Possible impacts of sedimentation range from lethal catastrophic events that smoother the benthic communities, to sublethal deposition events and increases in suspended sediment concentrations that alter the functional stability of the benthic community through subtle changes to food supply and physical structure of the sediments that form the habitat and cause shifts in the structure of benthic communities. The change in sediment structure due to accumulation of small deposits of land derived sediment over time may favour one species over another leading to changes in the types of species present.

The effect of increased sediment loadings on individual organisms can flow through the communities and ecosystems along a variety of pathways (Figure 1)

While the magnitude of a sediment event may be an important factor in determining impact, the frequency of event may be more important in determining the risk to the benthic community. Catastrophic events may be rare but sublethal events may occur with every rainfall. In this case the impact could depend on the ability of the benthic community to recover between events and may involve a long-term change in the habitat with resultant changes to the benthic community.

The recovery of a benthic community depends on many factors, including depth of deposition, the previous history of the community and the sediment structure of the habitat before the event. For example, land derived sediment deposition on a diverse sandflat community is likely to have a far greater impact on that benthic community than the same deposition on a mudflat community where diversity is lower and the benthic community has already adapted to a silt/clay environment. Recovery from lethal catastrophic events may be driven by physical (e.g., wave action) and biological (e.g. bioturbation) parameters and considerable time can elapse before the original benthic community returns, if it ever does. Recovery of defaunated sediment may depend on the availability of appropriate macrofauna to recolonise the sediment.

Thrush et al. (2004) summarises all of the work presented in TP264 (Gibbs and Hewitt 2004) in a conceptual model (Figures 5 + 6). This model assumes that changes in the estuarine sediment loading regime will, by favouring some species and habitats over others, influence estuarine biodiversity. Event frequency, extent and magnitude will influence the recovery response of the benthic community by affecting habitat suitability and the possibility for undisturbed areas to provide colonists to disturbed areas. The result is that, with increasing frequency, extent and magnitude, recovery time increases and depletion of sensitive species occurs. Finally a depleted community or estuary occurs, with low diversity and low function.

TP #	Report
TP158	Norkko, A. Talman, S. Ellis, J., Nicholls, P., Thrush, S. (2001) Macrofaunal sensitivity to fine sediments in the Whitford embayment. Report prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 158.
TP159	Hewitt, J., Hatton, S., Safi, K., Craggs, R. (2001). Effects of suspended sediment levels on suspension-feeding shellfish in the Whitford embayment. Report prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 159.
TP160	Physiological responses of mangroves and salt marsh to sedimentation
TP161	Berkenbusch, K., Thrush, S., Hewitt, J., Ahrens, M., Gibbs, M., Cummings, V. (2001) Impact of thin deposits of terrigenous clay on benthic communities. Report prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 161.
TP162	Gibbs, M., Thrush, S., Sukias, J., Berkenbusch, K., Thompson, D., Bury, S. (2001). Evaluation of terrestrial sediment spatial patterns throughout the Whitford embayment and its benthic food web using stable isotope techniques. Prepared for Auckland Regional Council by NIWA. Auckland Regional Council Technical Publication Number 162.
TP166	Hume, T., Bryan, K., Berkenbusch, K., Swales, A. (2001). Evidence for the effects of catchment sediment runoff preserved in estuarine sediments – phase 1. Report prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 166.
TP204	Senior, A., Ramsay, D. Risks to estuarine biota under proposed development in the Whitford catchment: summary report. Report prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 204.
TP205	Senior, A., Oldman, J., Green, M., Norkko, A., Hewitt, J., Collins, R., Stroud, M., Cooper, A., Thrush, S. (2003). Risks to estuarine biota under proposed development in the Whitford catchment. (Full report). Report prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 205.
TP211	Nicholls, P., Hewitt, J., Halliday, J. (2003) Effects of suspended sediment

	concentrations on suspension and deposit feeding marine macrofauna. Report prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 211.
TP217	Lohrer, A., Hewitt, J., Thrush, S., Lundquist, C., Nicholls, P., Liefting, R. (2003). Impacts of terrigenous material deposition on subtidal benthic communities. Report prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 217.
TP221	Swales, A., Hume, T., McGlone, M., Pilvio, R., Ovenden, R., Zviguina, N., Hatton, S., Nicholls, P., Budd, R., Hewitt, J. Pickmere, S., and Costley, K. (2002). Evidence for the effects of catchment sediment runoff preserved in estuarine sediments – phase II (field study). Report prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 221.
TP222	Lundquist, C., Vopel, K., Thrush, S., Swales, A. (2003) Evidence for the effects of catchment sediment runoff preserved in estuarine sediments – phase III (macrofauncal communities). Report prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 222.
TP264	Gibbs, M., Hewitt, J. (2004). Effects of sedimentation on mcarofaunal communities: a synthesis of research studies for ARC. Report prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 264.
TP321	Gibbs, M. (2006). Sediment Source Mapping in Mahurangi Harbour. Prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 321.

3.3.4 Heading 3

4 Methods

4.1 Legislative and Planning Framework

4.1.1 Principles and Purpose of the RMA

The RMA's overall purpose and specific guiding principles or priorities which are relevant to all decisions made under the Act, including those relating to freshwater, are set out in sections 5 to 8. All decisions made under the RMA must be consistent with its purpose to promote the sustainable management of the country's natural and physical resources. Sustainable management is defined to incorporate not only the protection of natural and physical resources, but also the use and development of these resources. Therefore, central to the Act is a need to balance competing demands of protection on the one hand and various competing uses and development on the other.

Sections 6, 7 and 8 establish issues or values that are required to be given a degree of priority in decision-making and in the application of the RMA's purpose. Priorities of particular relevance to freshwater are:

- The preservation of the natural character of wetlands, rivers and lakes and their protection from inappropriate subdivision use and development (s6(a));
- The protection of significant habitats of indigenous fauna (s6(c));
- The maintenance and enhancement of public access to and along lakes and rivers (s6(d));
- The relation of Māori and their culture and traditions with their ancestral water (s6(e));
- The protection of recognised customary activities (s6(g));
- The protection of the habitat of trout and salmon (s7(h));
- The principles of the Treaty of Waitangi (s8).

The RMA establishes a permissive framework for new land-use activities, which in effect means land-use activities are permitted unless a national environmental standard, regional plan or district plan states otherwise (s9). In contrast, a restrictive regime applies to water related activities (ss13, 14 and 15).

A similar contrast exists in relation to existing activities. Existing, lawfully established land-use activities may continue even if the activity contravenes a rule in a district plan or proposed district plan (s10). The same 'exemption' does not apply to takes of, or discharges to water, nor to land-use activities covered by rules in a regional plan.
As a unitary authority Auckland Council is responsible (under s30) for the management of natural resources including air, water, the coastal marine area and (under section 31) for the management of the effects of land uses and subdivision.

For freshwater management we are required to establish objectives, policies and rules for the integrated management of all natural and physical resources in our region, which includes land and its relationship to water(s30(1)(a)); We have the ability to control the use of land to maintain the quantity of water in water bodies, to maintain and enhance the quality of water and ecosystems in water bodies and to avoid or mitigate natural hazards (s30(1)(c)). Historically Auckland has not exercised its ability to control land for the purpose of maintaining and enhancing water quality yet policies and methods developed under these functions may well deliver our freshwater objectives to a far greater degree than other powers.
The purpose of the ARPS is to provide an overview of the resource management issues for Auckland and to include policies and methods to achieve the integrated management of all natural and physical resources of the region (s59). The ARPS is due for review and needs to give effect to the NPS freshwater.

The ARPS is given effect to through regional district plans (s67 (3) and s75(3)).

Auckland has three regional plans; The ALWP, Dairy Discharge Plan and the sediment plan. Regional plans assist the council to carry out its regional functions and may include rules, in addition to objectives and policies. The RMA requires that such regional rules:

- Do not result in a reduction of the quality of water in any water bodies at the time of the public notification of the proposed rules, unless it is consistent with the purpose of the RMA to do so (s69 (1)); and,
- Shall only permit the discharge of contaminants or water into water where the council is satisfied that, after reasonable mixing, the following adverse effects will not result (s70(1)) in:
  - The production of conspicuous oil or grease films, scums or foams or floatable or suspended materials;
  - Any conspicuous change in the colour or visual clarity;
  - Any emission of objectionable odour;
  - The rendering of fresh water unsuitable for consumption by farm animals;
  - Any significant adverse effects on aquatic life.

Regional plans can also manage water bodies in accordance with classes described in Schedule 3 of the RMA. Schedule 3 establishes 11 water quality classes including for example ‘aquatic ecosystem purposes’ and ‘contact recreation purposes’ and sets standards that councils must apply in relation to each.

District Plans assist the council to carry out its functions under the RMA and may include rules controlling land-use activities (including earthworks, farming and urban development) and also subdivision. Of particular relevance to freshwater, district plans may include rules relating to the taking of esplanade reserves at time of subdivision.

Given the clear direction from the NPS freshwater and the Auckland Plan the hierarchy of policies from RPS to RP and DP should be developed top down.

Subject to the purpose and principles of the RMA, decision-makers on all resource consent applications must consider any actual and potential effects of the proposed activity, the relevant provisions of a range of RMA policy statements, plans, environmental standards and regulations, and any other relevant matter (s104). In addition to these general requirements, for discharges to freshwater bodies decision-makers must also have regard to (s105 (1)):

- The nature of the discharge and the sensitivity of the receiving environment;

- The applicant's reasons for the proposed choice; and,
- Possible alternative methods of discharge including discharge to another receiving environment.

Likewise Schedule 4 of the RMA states that an assessment of environmental effects completed for a resource consent application should include, among other things, a description of the nature of the discharge, the sensitivity of the receiving environment and possible alternative methods of discharge.

The requirement to consider possible alternative methods of discharge has been considered at the Environment Court . The Court's conclusion suggests that the scope of this requirement is related to the potential adverse effects of the proposed activity i.e. if it is found that a discharge is likely to have significant adverse effects then greater consideration of alternatives would be justified.

The ability of consent authorities to grant applications for discharge to freshwater is further restricted under s107 of the RMA which states that resource consent shall not be granted for a discharge that would, after reasonable mixing, result in a number of specified adverse effects.

The listed adverse effects are consistent with those that are applied through s70 (1) to permitted activity rules in regional plans, and create a clear and consistent minimum base-line for decisions permitting the discharge of contaminants to water.

4.1.2 The NZ Costal Policy Statement

Three policies in the NZCPS (2010) relate to the management of freshwater in the coastal environment.

Policy 21 'Enhancement of water quality' sets out methods by which priority is to be given to improving water quality where it has deteriorated such that it is having significant adverse effects on ecosystems, natural habitats, or water based recreational activities, or is restricting existing uses such as aquaculture, shellfish gathering and cultural activities.

Policy 22 'Sedimentation' directs controlling activities in order to reduce sedimentation within the coastal environment.

Policy 23 'Discharge of contaminants' sets out requirements in relation to the management of discharges within the coastal environment. These include general matters to which decision-makers must have particular regard, as well as specific directions in relation to discharges of human sewage and stormwater to the CMA.

4.1.3 The Draft Auckland Plan and the NPS: FM

As the Auckland Plan was being drafted, central government released the NPS for Freshwater Management 2011. Freshwater management must now be viewed in a broader, more integrated manner, and the effects of land use, development, water abstraction and discharges must collectively be managed to safeguard the life supporting capacity and ecosystems of our lakes, wetlands, streams, rivers, and aquifers. By delivering improved freshwater quality Auckland also stands to benefit from improved water quality in coastal marine environments. Auckland Council is responsible for implementing the NPS: FM in Auckland through its policies, plans and programmes.

The NPS: FM requires local authorities to involve iwi and hapu in the management of freshwater and identify and reflect tangata whenua values and interests in freshwater and fresh water ecosystems management.

The Auckland Plan recognises the value of the natural resource of the Region and the issues faced to overcome environmental degradation, including poor freshwater quality. The plan recognizes the need to manage development such that the quality of our environment is valued and sustained.

The Auckland Plan has four directives closely aligned with the management of freshwater quality.

Directive 5.4	*Protect ecological areas, ecosystems and areas of significant indigenous biodiversity from inappropriate use and development, and continue to restore and improve ecosystems and indigenous biodiversity.*
Directive 5.7	*Set appropriate limits on pollutants to achieve water quality improvements.*
Directive 5.9	*Protect nationally and regionally significant freshwater from land based development and enhance less significant and degraded areas.*
Directive 5.11	*Protect coastal areas, particularly those with high values, special natural character or significant marine habitats and recreational importance, from the impacts of land based development.*

4.2 Current Auckland Regional and District Approach

Auckland Regional Policy Statement ("ARPS")

The issues, objectives, policies and methods that relate to water quality are contained in Chapter 8 of the ARPS, which became operative in 1999. Within this chapter, water quality is acknowledged as a significant issue in the Auckland region. It is further stated that water quality has been degraded in urban estuaries and sheltered harbor areas, as well as in a number of freshwater lakes and many of the region's rural streams. The water quality of many urban streams has also been severely impacted.

There is only one objective within the ARPS that relates to water quality in Chapter 8, (Objective 8.3) which is to maintain water quality in water bodies and coastal waters that have good water quality, and to enhance water quality which is degraded. One of the accompanying policies (Policy 8.4.1 (2)) states that minimum standards for water quality in terms of section 69 of the RM Act shall be set where the use of minimum standards is shown to be the most appropriate means of achieving the purpose of the Act. A subsequent method (Method 8.4.2 (3)) also notes that the ARC will use the most efficient and effective method, including the setting of appropriate standards. Policy 8.4.4 (2) concerns land use intensification in rural areas, and "shall only occur where adequate provision is made for: "…(iv) protection of the intrinsic ecological values of aquatic systems" There are no policies or methods specifically related to the exclusion of livestock in this chapter.

In relation to natural heritage, the ARPS sets out the relevant provisions in Chapter 6. Issue 6.2.1 states that the heritage of the Auckland region has been depleted and continues to be under threat. Objective 6.3 (1) states "to preserve or protect a diverse and representative range of the Auckland Region's heritage resources.", and Objective 6.3 (3) goes further by explicitly referring to restoration – "to protect and restore ecosystems and other heritage resources, whose heritage value and/or viability is threatened." Policy 6.4.10 specifically relates to the restoration of natural heritage, and Methods 6.4.11 mention the consideration of use incentives to promote the protection or restoration of ecosystems and heritage resources.

Draft Auckland Regional Policy Statement – August 2010

In Chapter 13 – *Land and Water Management* - the Draft ARPS contains a policy (Policy 13.4.6 – *Managing water quality in rural areas*) that states (b.) "adopting best practice in terms of management of fertiliser application and soil disturbance; where practicable, preventing stock access to rivers and streams" and (c) "encouraging the planting of riparian margins that abut permanent rivers and streams and preventing stock access." Policy 13.4.7 (*Prioritising restoration and enhancement*) directs the prioritisation of water resources for restoration and enhancement of the quality of freshwater bodies and their associated indigenous biodiversity (page 151).

In relation to, Chapter 12 - *Indigenous Biodiversity* - contains some policies that relate directly to the protection (Policy 12.4.1) maintenance (Policy 12.4.2) and the prioritisation for the restoration and enhancement (Policy 12.5.2) of indigenous biodiversity. The exclusion of livestock from fresh water bodies is not explicitly noted, however, many associated policies could be used to support this initiative. The Coastal Environment in contained in Chapter 9 and includes Objectives 9.2.6 "To protect the integrity, functioning, and resilience of ecosystems within the coastal environment" and Objective 9.2.7 "To protect the values of the coastal environment by managing the adverse effects of contaminants on water quality."

The exclusion of livestock from freshwater bodies, or the CMA, is not expressed in Chapter 9 – *Coastal Environment*. However, Policy 9.5.4 *Protecting water quality in the coastal environment,* does give some supportive direction to this initiative. Policy 9.5.4(c) notes that "The discharge of contaminants into the coastal environment shall avoid adverse effects on: i) areas identified as having high natural character (Policy 10.3.2) or high recreational value (see the policies in section 9.7 recreation and amenity values); ii) the values of estuaries and harbours; iii) identified areas and values of significance to Tangata Whenua". Policy 9.5.4(d) notes that “Priority shall be given to enhancing water quality in the coastal environment in accordance with policy 13.4.7 prioritising restoration and enhancement.”

Proposed Regional Plan: Air, Land and Water (“PRP: ALW”)

This proposed regional plan, which incorporates Variation 1, was notified in June 2002. The “decisions version” was released by the Auckland Regional Council in 2004 and appeals were lodged with the Environment Court in 2005. Certain provisions of this plan still remain non-operative.

The Proposed Regional Plan: Air, Land and Water (“PRP: ALW”) does not include any rules in relation to the exclusion of livestock access to water bodies. However, it should be noted that there is a stated intention in the PRP: ALW (Policy 5.4.49) to notify a Plan Variation/Change to the stock access part of Chapter 5 within two years of the notification of the ARC Hearing Committee decisions. These Hearings were concluded in 2004. This intention is stated in the associated explanation to Policy 5.4.49, and goes further by saying that “... an appropriate combination of advocacy (including financial assistance for voluntary initiatives), education (including demonstration facilities) and regulation (including rules)...” is anticipated. Policy 5.4.50 acknowledges that adverse effects from stock crossing points and grazing adjacent to any lake or permanent river of stream should be avoided.

Stock access is acknowledged as an issue that “...can cause a range of significant adverse effects on water quality and instream and riparian habitat values.” (Issues 5.2.30 and 5.2.31). These issues have two associated objectives (Objectives 5.3.17 and 5.3.18). Objective 5.3.17 notes that – in relation to stock access – “To maintain the instream and riparian habitat values and water quality of lakes, and Permanent rivers and streams by a) protecting existing areas of high value, and b) enhancing degraded areas”. Objective 5.3.18 relates to avoiding, remedying or mitigating the adverse effects of stock access to stream beds and margins. Associated methods related to stock access (Methods 5.6.31, 5.6.32, 5.6.33 and 5.6.34) state the use of education, advocacy, financial incentives and the establishment and operation of demonstration sites to prove the effectiveness of a variety of practices/techniques to protect or enhance vulnerable areas. Reference is also made to the use of District Plan provisions to protect riparian zones etc via the subdivision approval process.

Auckland Regional Plan: Coastal (“ARP: C”)

In relation to the ARP: C, the grazing of cattle and stock in any Coastal Protection Area 1 is a Prohibited Activity, as identified in Chapter 16 – *Disturbance of Foreshore and Seabed III: Other than Dredging or Extraction*. This is supported by Policy 16.4.14 where “the grazing of cattle and stock on the foreshore and in sensitive parts of the coastal marine area, especially coastal protection areas, should generally be avoided.”

The recently enacted New Zealand Coastal Policy Statement 2010 (“NZCPS”) contains a policy (Policy 21 – *Enhancement of water quality*) that explicitly relates to livestock exclusion.

More specifically (Policy 21) , “*Where the quality of water in the coastal environment has deteriorated so that it is having a significant adverse effect on ecosystems, natural habitats, or* *water-based recreational activities, or is restricting existing uses, such as aquaculture, shellfish gathering, and cultural activities, give priority to improving that quality by:*

> *d) requiring that stock are excluded from the coastal marine area, adjoining intertidal areas and other water bodies and riparian margins in the coastal environment, within a prescribed time frame*;..."

4.3 Other Council's Approaches

4.3.1 Regional Councils

4.3.1.1 Horizons Regional Council – Proposed One Plan – As Amended by Decisions – August 2010

Issue 6.1 – *Water quality* – states that direct stock access to water bodies and their beds is one of the principle causes of water quality degradation. Other causes include nutrient enrichment and high turbidity and sediment loads caused by land erosion, run-off from agricultural and the discharges of stormwater. Issue 7.1 – *Indigenous biological diversity* – states that "*the diversity within remaining areas is declining owing to their isolation or as a consequence of a range of activities, most notably: ...b) stock access..."*

With respect to the rule regime, existing dairy farming activities are a controlled activity (Rule 13.1) where dairy cattle must be excluded from wetlands and lakes that are a rare habitat or threatened habitat and the beds of rivers that are permanently flowing or have an active bed width greater than 1m. Activities that do not comply with Rule 13.1 are a restricted discretionary activity (Rule 13.1A). New dairy farming land use activity are also a controlled activity (Rules 13.1B) where dairy cattle are excluded from wetland and lakes, and beds of rivers of permanently flowing rivers. Activities that do not comply with Rule 13.1B are a restricted discretionary activity (Rule 13.1C). Horizons also uses financial incentives (of up to 50%) to incentive fencing (and riparian planting) in certain catchments.

No mention of fence types (just "exclusion") or set back distances. Also just applies to dairy farming activities (i.e. land use).

4.3.1.2 Waikato Regional Council – Regional Plan – Operative in Part – September 2007

Livestock access to water bodies is addressed in Chapter 3 – *Non-Point Source Discharges* – and Chapter 4 – *River and Lake Bed Disturbances*. Chapter 3 contains an explicit policy related to livestock access (Policy 3- *Livestock access to water* *bodies*) that states "*Use a mixture of non-regulatory methods (education and incentives) and a permitted activity rule to manage the adverse effects of livestock access to water bodies*." The Methods include environmental education, integration with Territorial Authorities, economic incentives, streamside enhancement fund, risk-based incentives and the use of rules (pages 3-99 to 3-101).

The management of livestock access to the banks and beds of rivers and lakes for certain outcomes are stated in Objective 4.3.2 of Chapter 4. Policy 4 – *Livestock access to water bodies* and Policy 5 – *Enforcement of livestock access to water bodies rule* – states the use of rules to manage the adverse effects of livestock access. Method 4.3.5.3 – *Livestock access* – states that livestock will be excluded from the mapped portions of the water bodies identified as priority 1 water bodies in Table 4-1. However Rule 4.3.5.5 – *Discretionary Activity – Livestock on the beds and banks of priority one water bodies* – does allow livestock access, but subject to certain standards and terms. Rule 4.3.5.4 – *Permitted Activity Rule – Livestock on the beds and banks of rivers and lakes* – makes the access of livestock a permitted activity (subject to adverse quality effect type conditions, i.e. SSD standards, erosion visual clarity) to water bodies that are not priority 1 water bodies. Setbacks, and fence types not specified. Application to intermittent stream appears to be negotiable see Implementation Method 4.3.5.2, 4. Rules written as "Livestock on the Beds and Banks of Rivers and Lakes, are..." Discussion with EW staff indicates that subsides for fencing costs are applied at a minimum 3-metre set back on streams greater than 1-meter wide. Regional Coastal Plan makes the presence of livestock in sensitive areas a prohibited activity.

The Waikato Regional Council also subsidies the costs of fencing, riparian planting and water reticulation. This council also administers the "Biodiversity Project", "Project Watershed" and an "Environmental Education Programme" which provides an advisory service and education activities, such as field days and seminars.

4.3.1.3 Environment Waikato – Proposed Variation No. 6 – Water Allocation – End of Environment Court Hearing – Clean Version 8 August 2011

Two rules (3.3.4.14A and 3.3.4.16) refer to Method 3.3.4.22 Standard – "How riparian planting and stock exclusion fencing should apply", which forms part of a Riparian Vegetation Management Plan. This standard sets specifies that fencing should generally be permanent and effectively exclude livestock present, that livestock exclusion fencing is not required where there is no livestock, that fencing must be completed within 3 years of a water take consent being granted, fencing must be set back a minimum of 3 metres from the top of the bank, riparian planting must be undertaken within the full extent of the riparian setback, where no suitable planting already exists, a minimum of 80% of riparian plantings shall be made up of native plant species appropriate to the characteristics of the site and catchment, and plantings must be undertaken at a density of no less than 2500 stems per hectare. Intention is to apply this regime to permanently flowing rivers only (Rob Van Vorrthuysen, per comm. 20 December 2011).

Rule 3.3.4.14A – Controlled Activity Rule – Taking of Surface Water for Existing Milk Cooling and Dairy Shed Wash Down makes reference to Method 3.3.3.22 as a standard and term. Also Rule 3.3.4.16 – Discretionary Activity Rule – Surface takes – refers to Method 3.3.3.22 as a standard and term.

4.3.1.4 Environment Canterbury – Natural Resources Regional Plan

Policy WQL5.1 – Non-point source discharges to surface water – sets out polices (sub - policy (6)) around livestock access to wetlands, lakes or a permanently or intermittently flowing rivers where there should be no significant adverse effects from the discharge from livestock. Sub-policy (7) prohibits (from 12 months after this policy becomes operative) intensively farmed livestock from discharging contaminants or disturbing the beds of above mentioned water body types. Also prohibits intensively farmed livestock from discharging or disturbing beds from various other areas, i.e. upstream of community water supply, salmon spawning areas, etc.

So Rule WQL21 states that the discharge of contaminants or disturbance or a wetland, bed of a river or lake by livestock, is a Permitted Activity if certain adverse effects do not occur. If the discharge or disturbance is from intensively farmed livestock, then these activities are prohibited, after 12 months of this rule becoming operative.

4.3.1.5 Environment Southland – Regional Water Plan – Operative March 2010

Rules 16, 17 and 42 give effect to Policy 35, which encourages the exclusion of all stock from surface water bodies and artificial watercourses where practicable. This policy that when stock access to water bodies does occur, it is managed in a manner that avoids significant effects on water quality, bed and bank stability, and habitats. The three rules utilise section 15, 9 and 13 respectively. Rule 16 – *Discharges associated with stock access to surface water* – makes stock access a permitted activity where any set water quality standards are not reduced. Rule 17 – *Stock grazing and access to surface water* – makes the grazing or access of stock within 3 metres of a water body (just when intensive winter grazing is occurring), any Natural State surface water body, or Regionally Significant Wetland identified in Appendix B, a non-complying activity. Rule 42 – *Stock access to river and lake beds* – makes stock access to beds a permitted activity.

Environment Southland have also implanted a "*Regional Action Plan for the Southland Region*" (May 2007) which is consistent with the goals and targets as set out in the "Dairying and Clean Streams Accord". Environment Southland also offers financial assistance for: riparian fencing (up to 50%); planting of native or exotic trees (up to 50%); the provision of alternative stock water systems (50% up to $1000); improvements to stock crossings (50% up to $1000); rehabilitation of eroded streams banks (50% up to $1000); construction of wetlands (25% to 100%); and technical assistance from external experts (50% up to $500).

4.3.1.6 **Environment Bay of Plenty – Regional Water and Land Plan – Operative December 2008**

Issue 6.1 – *Activities in the Beds of Rivers, Streams and Lakes* – in Chapter 6 – *Beds of Rivers, Stream, Lakes and Wetlands* – does not explicitly mention the issue of livestock access to water bodies, but does note that plant removal can lead to erosion of the bed or bank of the water body, as well as bed disturbance practices. Livestock access is explicit in Issue 6.2.1, which states, “The presence of stock in the beds of permanently flowing streams and rivers, lakes and wetlands can lead to adverse effects on the environment”. The associated objectives (6.2.2) are to exclude stock in the beds of the Rotorua Lakes and Ohau Channel and all Natural State rivers and streams; to encourage the exclusion of stock from wetlands, streams and rivers where erosion problems are evident, where quality is degraded due to stock activity, where there are high contact recreation or food gathering, with a water supply classification, and in the catchment of the Rotorua Lakes, Tauranga or Ohiwa Harbours.

Policy 115 (Method 233, 234, 235, 236) is to raise landowner awareness about the adverse environmental impacts of stock presence. Policy 116 is to provide financial assistance to landowners to implement measures to prevent stock access where there is a benefit to the regional community. Policy 118 (Method 238) is to promote the use of farm quality programmes that avoid, remedy, or mitigate adverse effects of grazing and stock presence in beds.

Rules relating to stock access are in Chapter 9.3 – *Grazing and Stock in the Beds of Surface Water Bodies*. These rules do not apply to ephemeral flow-paths and artificial watercourses. Rule 6 – *Controlled stock crossings of the bed of a stream or river* and Rule 7 – *Stock in the bed of a river or stream*, are both permitted activities (conditions mainly adverse water quality conditions, or an Environmental Plan or Property Plan has been developed). The associated conditions limit the number of stock crossings and require fencing. Rule 8 – *Stock in the beds of Rotorua Lakes and Natural State Rivers* a prohibited activity. Everything else not permitted by Rules 6 or 7, and not prohibited by Rule 8 is a discretionary activity, as per Rule 9. Fence types or set back distances are not specified.

Incentive funding is also available for riparian protection in the Rotorua Lakes catchments (Environmental Bay of Plenty Operations Report 2003/08 October 2003). For high priority areas – primary protection (this includes protection fencing, re-vegetation, within protected areas, erosion control structures, pest and plant control, constructed wetlands, native fish passage) 75%, associated activities (this includes stock water supply, stream crossings within protected areas and woodlot establishment) 50%, and other components (this includes specialist reports and nutrient budget preparation). For all other areas, 50% for primary protection and 25% for associated activities.

Summary Table:

RC	Plan Name	Rule Type	Livestock & river type	Effects based
EW	Regional Plan 2007	Livestock on beds & banks PA where water body not mapped as priority for Livestock Exclusion Areas – no specified setback distance	All livestock types. Inference is that only applies to permanent	Conditions of PA are effects based (water quality, erosion)
		DA where Priority One water body - no specified setback distances	As above	As above
	PV6 – August 2011	Taking of surface water CA – related to S & T's of requiring a consent to acquire a water take	Just applies to irrigated farms, so intensive farming	No – specifies a 3m setback and riparian planting
Horiz ons	One Plan- Proposed 2010	Land use activities CA – no specified setback distance	Dairy & permanent only	No – dairy cattle must be excluded
ES	Reg. Water Plan 2010	Discharges PA – except for winter grazing	All livestock types, infers permanent	Conditions of PA are effects based (water quality)
		Non-Com Activity if intensive winter grazing within 3 m of stream	All livestock types, infers permanent	
ECan	NRRP	Discharge & disturbance PA if no adverse effects occur and if not intensively farmed livestock	All livestock types and both P & I	Yes
		D & D Prohibited if from intensively farmed livestock (operative late 2011)	As above	NA
EBOP	Reg. Land & Water Plan 2008	Activities in beds of L & R are PA if not Rotorua Lake or Natural State River – Prohibited Activity if is	Excludes ephemeral	Yes

4.3.1.7 Stock Access to the CMA – Brief Overview of Some Other Regional Councils

Northland Regional Council ("NRC")

In the Northland region, **stock access to and use of** the coastal marine area is prohibited in Marine 1 and 2 Management Areas except for droving of stock and riding of horses, which are permitted activities where conditions are met. Other councils prohibit the **presence of stock** in sensitive areas (e.g. Waikato Regional Council, Hawke's Bay Regional Council) or prohibit **grazing of stock** in parts or all of the coastal marine area (e.g. Bay of Plenty Regional Council, Auckland Council).

Northland Regional Council introduced provisions in its Regional Coastal Plan (2004) prohibiting access to and use of the coastal marine area by stock where it is not otherwise specified as a permitted activity. A 5 year period was allowed after the plan became operative before the prohibition took effect (i.e, until July 2009). The rules apply to the Marine 1 (Protection) Management Area and Marine 2 (Conservation) Management Area.

The Issues, Objectives, Policies and Methods of Implementation are set out in chapter 9 and the Rules contained within chapter 31 of the Regional Coastal Plan for Northland. NRC produced a brochure: http://www.nrc.govt.nz/stockexclusion that includes information on options for excluding stock, how to get site-specific technical advice, funding assistance, etc:

Funding
The NRC's Environment Fund has targeted funding to assist landowners in high priority ecologically sensitive locations or where coastal water quality is a high priority. The Environment Fund can contribute up to 50% of the total project cost.

Excerpts from the Regional Coastal Plan for Northland:

Issues 9.1.2
The importance of marine vegetation to sustaining the life-supporting capacity of the coastal marine area, maintaining coastal water quality, and stabilising foreshore areas, and the consequent need to limit its degradation and loss through such activities as reclamation, drainage, pollution, marine farming activity and cattle grazing.

Objectives 9.1.3

A - The protection of areas of significant indigenous vegetation within Northland's coastal marine area from the adverse effects of subdivision, use and development.
C - Greater integration between land management planning, catchment management planning and marine (or coastal) environment planning leading to a reduction in the sediment and nutrient runoff.

Policy 9.1.4.9 To avoid the adverse effects on the coastal and estuarine ecosystems and coastal water quality, which can result from stock access to and use of the coastal marine area.
Explanation: *The control of stock (including cattle, goats, sheep, horses and other farm animals) in the coastal marine area is necessary to protect areas of significant indigenous vegetation and significant habitats of indigenous fauna, such as saltmarsh, mangrove and eelgrass, from the threats posed by browsing, trampling and defecating.*

Methods of Implementation 9.1.5
Educate the public generally, and farmers in particular, of the significant adverse effects and threats of stock trampling and grazing of estuarine vegetation, and the benefits of fencing-off foreshore areas from adjoining farmland.
Publicise funding sources available to assist with coastal fencing projects
Include rules within this plan to prohibit stock access to, and use of, the coastal marine area except for the purpose of horse riding and droving (subject to specified conditions), and allow a 5-year period after the Plan is made operative before the prohibition takes effect, so that any necessary fencing can occur.

Rules:
"Access to and use of the coastal marine area by stock *which is not otherwise a permitted activity under rules 31.3.12 (f) and 31.3.12 (g)"*

31.3.12 (f): *"The* ***droving of stock*** *in the coastal marine area on the condition that:*
(i) the droving shall not occur in estuarine areas or areas of saltmarsh or mangroves and no grazing of intertidal vegetation shall be allowed to occur; and
(ii) the stock shall be moved along at all times and shall not be left unattended."

31.3.12 (g): *"The* ***riding of horses*** *in the coastal marine area on the condition that:*
(i) horse riding is not precluded by any bylaw for the time-being in force; and
(ii) horses must be kept under control at all times; and
(iii) no grazing of intertidal vegetation shall be allowed to occur; and
(iv) horses shall not be ridden or taken into marine protected areas or bird breeding areas."

Waikato Regional Council

The Waikato Regional Coastal Plan (adopted in 2004) prohibits the presence of livestock in sensitive areas of the coastal marine area. The relevant Issues, Objectives and Policies are general provisions, e.g. relating to natural character, habitat and coastal processes; protection of habitats of important species; exotic plant control. Specific methods relating to livestock in the coastal marine area are contained in sections 16 and 17.

Implementation Methods 16
16.2 Habitat and Coastal Processes

16.2.9 Livestock in Sensitive Areas (Prohibited Activity) - The presence of livestock in or on mangroves, saltmarsh or eel grass, or on muddy substrata, in the CMA is a prohibited activity for which no resource consent shall be granted.
Principal Reasons for Adopting: The presence of livestock in estuarine areas may damage or even destroy existing vegetation and stop regeneration, e.g. mangroves and saltmarsh. The destruction of fish spawning habitat can also be a result of livestock grazing and trampling. Archaeological sites and waahi tapu can also be damaged.

Other Methods 17
17.2 Natural Character, Habitat and Coastal Processes
17.2.15 Livestock Grazing - Environment Waikato will consult with territorial authorities, farmers and farming organisations to ensure the intent of the Rule prohibiting livestock grazing in ecologically and culturally sensitive areas of the CMA is understood, and to ensure the management of livestock does not adversely impact on coastal sediments, vegetation or water quality.

Principal Reasons for Adopting: Although livestock grazing in the CMA has been commonly undertaken, it must be recognised that it has significant adverse effects on the inter-tidal environment, in particular vegetation, water quality and foreshore stability. To protect sensitive areas of the CMA from adverse effects, livestock will also need to be managed above Mean High Water Springs. Co-operation with farmers will therefore be critical.

17.6 Foreshore and/or Seabed Disturbances
17.6.3 Damage to Margin Habitats from Livestock and Horses - Environment Waikato will consult with and encourage local authorities to prevent damage to dune areas and other fragile margin habitats from livestock and horses.
Principal Reasons for Adopting: Livestock and horse grazing and trampling can cause extensive damage to dune vegetation, mangroves and other important transition zones. Trampling and grazing can also lead to erosion and the degradation of the physical and biological functioning of beach systems.

Bay of Plenty Regional Council

The Regional Coastal Environment Plan (2003) identifies that stock grazing and trampling can damage and destroy estuarine vegetation or depress regeneration. Stock grazing can also result in direct faecal contamination of coastal water. Accordingly the rules prohibit grazing in the coastal marine area. Relevant Issues, Objectives and Policies are general provisions relating to disturbance activities.

Rules
Rule 58 (14.2.4(k)) - The grazing of stock in the coastal marine area is a prohibited activity [applies in all zones].

Methods of Implementation 14.2.6 - Advocacy
14.2.6(a) In consultation with landowners and in collaboration with the Department of Conservation and district councils, Environment Bay of Plenty will promote and encourage the cessation of stock grazing on private land within the coastal marine area by way of education, promotion and where practicable incentives, compensation and/or operational works. This

may include the use of environmental plans and farm plans. The information in the maps and the Third Schedule – Areas of Significant Conservation Value, the Sixth Schedule – Significant Marshbird Habitat Areas and the Seventh Schedule – Significant Indigenous Vegetation Areas, will be used as a guide to setting priorities.

4.3.2 District Councils

(Susan Andrews to insert summary of TA approaches)

5 Identified Policy Directions

5.1 Problem Definition

The problem or issue "definition phase" is an essential first step of the policy cycle. Firstly, existing and aspiration values associated with certain water bodies, catchments or environments are determined. These values are identified from national policy statements, various RMA related plans, Council strategies and plans, and as a result of consultation with tangata whenua and other stakeholders. Secondly, once the relevant values have been identified, state of the environment monitoring information (and the results of consultation) are used to establish where – and to what degree - these values are either absent, diminished or potentially threatened.

The marine environment is highly valued by Ecklander's for many reasons. As stated in the Draft Auckland Plan, "*Auckland's natural ecosystems and indigenous biodiversity are part of our unique character*" (Auckland Council, p.86, 2011). This is further reinforced by Priority 3 which is "*Treasure our coastline, harbours, island and marine areas*." The Draft Auckland Regional Policy Statement asserts that ""*the coast provides significant amenity value to the regional community, and public access and use of the coastal environment is important to the social, economic and cultural well-being of its residents. The regional and national importance of the Hauraki Gulf-Tikapa Moana and its islands and catchments has been recognised in the Haraki Gulf Marine Park Act 2000*."

However, some of the region's coastal values, especially in low energy estuarine environments, have been degraded, while other values are threatened. As stated in the State of the Auckland Region 2009 report, open coast sites have the best coastal water quality, primarily due to strong tidal flushing, their distance from freshwater inputs, and isolation from contaminants resulting from urban land uses. Inner harbour sites tended to have the poorest water quality because of their proximity to freshwater inputs that carry contaminants from the land and less flushing (ARC, p.196, 2010). What is also of concern is that coastal water quality has declined at some sites rated "good" and "excellent" for coastal water quality (particularly for nutrients and suspended sediments) (ARC, p.196, 2010).

In addition, many of Auckland's fresh water bodies are valued many reasons such as, their amenity, the provision of ecosystem functions and habitats for indigenous species, and for the sustenance of traditional relationships with tangata whenua (Draft RPS, 2010). The NPS: FW also articulates a number of national values for freshwater, both human use values and intrinsic values. However, the evidence from two long-term fresh water monitoring programmes – one which assesses the Macro-invertebrate

Community Index ('MCI"), and another, the Quantile Index of Biotic Integrity ("QIBI") - both demonstrate that rural land use is correlated with degraded water quality. This state of the environment monitoring evidence confirms that many values associated with freshwater have either been lost, have been diminished, or continue to be under threat.

In addition to these values, Auckland's unique indigenous biodiversity also contributes to the character and identity of the region. However, certain types of ecosystems, such as lowland riparian ecosystems, are currently under-represented in the region, and where they are present, are often in poor ecological health (Draft RPS, 2010).

Therefore, in summary, the major contributor to the loss of both marine and freshwater quality is due to the excessive loads of suspended sediment that originate on the land, then enter freshwater systems and finally deposit in the marine environment. In additional to this, extensive, and an over-propionate loss of lowland riparian ecosystems has occurred due to the predominance of pastoral farming practices in many rural parts of the region.

5.2 Policy Responses

In addition to identifying the relevant regional resource management issues, various national and regional policy initiatives also require, and give direction to, specific planning responses. Specifically, certain NZCPS policies, such as Policy 21 – *Enhancement of water quality* - that requires stock exclusion where water quality has deteriorated where it is having a significant adverse effect, and various objectives of the NPS: FM and policy directives of the Draft Auckland Plan, demand a particular policy and planning response. Therefore, the following "principles" were developed in an effort to guide the development of these policy approaches:

- Reduce the amount of sediment that enters streams from out-of-stream sources (i.e. from riparian zones and adjacent steep slopes);
- Reduce the amount of sediment that enters fresh water bodies from in-stream sources (i.e. from stream channel erosion and disturbance of the stream bed);
- Minimise significant cumulative adverse effects of sediment that is transported to estuaries and harbours via rivers and streams;
- Minimise nutrient and microbial inputs into streams;
- An objective of restoring a representative portion of riparian ecosystems within the region.

5.3 Consultation

Some internal and external consultation has been carried out in relation to the exclusion of livestock. Certain elements were taken from this consultation, and used to develop some of the policy approaches.

- On the 11th August 2011, a workshop was help with various Auckland Council staff (ranging from planning and policy through to operations staff) in an effort to set out the context of the issue of livestock exclusion, and to help identify possible planning options that could be investigated further. This workshop built on the presentations and lessons learnt from Horizons, Environment Waikato and Northland Regional Council on the 30th July 2011. The lessons learned from these regional councils have been used to develop the subsequent policy options (see discussion below).

- In relation to external consultation, four general policy options (ranging from the status quo through to a relatively restrictive rule regime) were presented at the Rural Advisory Panel ("RAP") meeting on 23rd September 2011. The feedback was generally positive, and a further, but more detailed workshop was requested. This further RAP workshop was planned for the 21st October 2011. However this additional workshop has been postponed until November.

- A further meeting was held with specific RAP members, including Richard Gardner, Bill Cashmore, Wendy Clark and Jim Dollimore on the 23rd September. In this meeting, these members articulated what they considered as reasonable in relation to livestock exclusion. Overall their objective is to improvement the water quality of all water bodies, both rural and urban. In relation to fencing, the installation of a 2-wire "hot-wire" fence at a minimum of a 2-meter horizontal setback from permanently flowing water courses on all "intensive farms" is considered reasonable. This approach should not be implemented by controlled activity rule. The fencing of the "shore front" should be prioritised and incentivised. In relation to "extensive farming" best management practices should be encouraged. The installation of livestock crossings should all be a permitted activity. This approach provides that basis to "Policy Approach 3".

- Presentation to Council staff on 13 December 2011 in an attempt to gain a "consensus" as to which option to promote. No consensus was achieved.

- Presentation to the RAP meeting on 16 December 2011. There was a request to conduct a workshop on the 17 February 2012 in an effort to gain feedback on various possible policy options.

- Farmers attended workshop 13 April 2012 – gained consensus from all eight farmers as to direction forward for livestock exclusion. Independent facilitation was used.

- Collaborative style workshop help 20 July 2012, which included members of RAP and various NGO's. Option 4 was agreed with.

- Gained political direction at PWP (political working party) workshop in 26 July 2012 for option 4 to go into draft unitary plan.

- Some further political direction was given at a Auckland Plan Committee Workshop on 5 July 2013. At this workshop, the existing recommended approach was agreed with for freshwater bodies (and wetlands), however, in relation to livestock exclusion in the CMA, a different direction was agreed to.

5.4 Discussion and the Development of Policy Approaches

As discussed previously, the exclusion of livestock can have beneficial effects on water quality. Specifically, Davies-Colley & Parkyn (2001) report indicates that reducing livestock pressure on the riparian zone, by approaches ranging from permanent fencing through to 'incentives' for stock to seek shade and water off-stream, has the potential to appreciably reduce a range of impacts on streams. ARC (p.23, 2000) Technical Publication 350, also reports that the "exclusion of stock will eliminate stream bank damage from trampling and nutrients and pathogens that result from the direct input of faeces". In response to this, five policy approaches have been generated. These policy approaches have as their objective, either, the exclusion of livestock from certain parts of catchment, and certain types of water bodies (i.e. permanent and intermittent), through to the total exclusion of livestock from all types of freshwater bodies within entire "prioritised" catchments.

It is also important to realise that the types of rivers and streams in the Auckland region are unusual, when compared to other regions in New Zealand The Auckland region has an estimated 16,500 km of permanently flowing rivers, which increases to 28,240 km when intermittent and ephemeral rivers are included (Storey & Wadhwa, 2009). As no mainland location in the region is greater than 20 km from the coast, the catchment areas of each river are relatively small. This means that most of the rivers reach the sea before they merge with others to form large rivers. Consequently, most rivers are first and second order, meaning they are relatively small, with most less than a few metres wide. In fact, about 78% of permanent rivers in the Auckland region are first and second order. Less than 1% of permanent rivers in the region are sixth and seventh order (ARC, p.141, 2010).

The relatively low elevation of the Auckland region and the underlying geology also have a profound influence on the nature of the rivers, usually resulting in slow flowing, low gradient rivers with soft substrate beds (Storey & Wadhwa, 2009). Fast flowing, high gradient rivers with hard stony substrates are mostly restricted to catchments that drain the Waitakere or Hunua Ranges.

5.4.1 Riparian Planting, Buffer Zone Width and Effectiveness of Riparian Management

Unfortunately there are few studies that have specifically addressed the issue of how wide a buffer zone needs to be to protect stream health (ARC, p.21, 2000). Most research has focused on the ability of buffer zones to trap sediment and nutrients, in particular nitrate (N) and phosphorus (P). The consensus in the literature is that grass buffer strips are effective at filtering sediment and sediment-associated pollutants (particulate P and N) from surface runoff (ARC, p.21, 2000).

Where a grass buffer strip has been designed sensibly to treat sheet flow rather than channelized flow, most researchers report sediment removal occurs within a few metres of the upslope boundary (Barling & Moore, 1994, Fennessy & Crock, 1997). John Quinn (NIWA, pers. comm. – cited in ARC, 2000) has established some grass filter widths that would effectively remove suspended solids in surface runoff in Waikato pastoral catchments for riparian areas classified by topography. Estimates were obtained from methods in the DoC/NIWA guidelines and data from Quinn (1999) and McLaren & Cameron (1990). Most buffer widths necessary were found to be < 10m. Australian guidelines recommend a width of 10 metres for a forest buffer on low gradient land and 5 metres for a dense grass buffer on steeper riparian land (Prosser, et al, 1999).

In relation to grass filter widths, Quinn (1999) has stated a number of estimations that were derived from Waitako pastoral catchments. For example a riparian class of “lower floodplain”, with a slope length of 20 metres (and a “low” slope), a grass filter width of 1 metre would be suitable, where as an “upper floodplain high relief” with a slope length of 30 to 100 metres (and a “low” slope), a grass filter width of 1 to 2 metres would be suitable. But a “V-shaped hill valley” with a “medium” slope of 50 – 150 m slope length would require a filter width of 5 – 15 metres. These filter widths need to be widened by 1 metre if cattle were to graze under fences. This data suggests that the determination of the filter width is quite dependent upon the slope of the adjacent terrain. Similarly for grass filter widths, the determination of the filter width is quite dependent upon the slope of the adjacent terrain. A variable approach to determining buffer widths (depending on adjacent topography) is taken by the Waikato Regional Council in their publication “*Clean Streams: A guide to managing waterways on Waikato farms*” (WRC, 2004).

Another approach for calculating filter widths comes from Quinn & McKergow, (2007, NIWA Client Report). This report sets out a table that recognises land slope, the drainage class, and clay content. The table then determines the percentage of hillslope length that should become well-designed grass filter strip widths. These guidelines in this table come from a DOC 1995 publication.

In relation to producing self-sustaining, low maintenance, indigenous vegetation, ARC (p. 17, 2000) states that from an assessment of buffer widths in the Auckland region, a 10 metre wide buffer should result in a relatively maintenance-free riparian buffer strip width, even though the marginal 1-2 metres are likely to suffer from long-term weed infestations. This publication recommends that a buffer width of 10 – 20 m on either side of the stream would be needed to support sustainable native forest vegetation, and that this width should protect most aquatic functions (ARC, p, 31, 2000).

As an alternative to the use of tables that apply various factors to the calculation of filter widths, is the use of a minimum set back distance figure that is would be applied in any situation. Waitako Regional Council has commented (Therese Balvert WRC, now Biodiversity Officer, pers. comm., 2011) that the use of site specific guidelines can be confusing to many landowners. In response, WRC now stipulate that a fencing subsidy would be available if the landowner fenced at least 3 metres back from permanent flowing streams. The 3 metre figure was determined through submissions, meetings and focus group sessions with landowners. The set back distance for fencing in Plan Variation 6, at the moment, has also been agreed – via mediation - to be a minimum of 3 metres.

In conclusion, there appears to be two approaches to the issue of determining fencing setback distances. On approach is by the use of a formula (or guidelines) to determine distances along various sections of a steam. Use of this method would most probably result in the best water quality improvements because it would recognise local site and soil conditions.

The second approach would be to stipule a generic minimum setback distance that could be applied to all water bodies, regardless of local soil and site conditions. Determination of a minimum setback distance could come from various sources. ARC (p. 19, 2000) states that 10 metres could be used as a general guideline for a minimum buffer width that is sustainable for native vegetation and that larger buffers (20+ metres) will be required on large waterways where edge effects are present on both edges of the buffer on each side of the stream. But this ARC (2000) report does finally recommend a buffer width of 10 – 20 m of native vegetation on either side of the stream. Small streams with low banks may not need trees for shading and stabilisation. Therefore tall grasses, sedges and flaxes may provide the functions of indigenous tress species and require less width for sustainability (ARC, p.31, 2000).

However, with this second approach of stipulating a generic minimum set back distance, the lesson from Waitako Regional Council would be that the final determined set back distance would be a compromise - only reached after stakeholder engagement, submissions and the resolution of appeals. Any compromise reached would most probably only have a minimal benefit on water quality improvement.

As a guide to how land would be fenced, if a 10 metre wide buffer distance is adopted for permanent flowing streams, and a 2-metre wide for intermittent flowing portions, then approximately 12% of the total land area of an average farm would be fenced off (Chris Hatton, per comm., 2011).

In relation to the effectiveness of riparian management, Parkyn et al (2003) studied a number of riparian restoration schemes in the Waikato region to determine whether riparian management was achieving improvements in stream health (Parkyn, p.16, 2004). The buffer zones had been fenced to exclude stock and tree species had been planted (or remnant vegetation was present). The age of planting ranged from “recent” (c. 2 years) to “mature” (>20 years) within each substrate/hydrological grouping. In general, streams in buffer zones showed rapid improvements in clarity, back stability, and nutrient contamination. Often channel widths decreased in buffered reaches where the plantings were young, presumably from a reduction in trampling by stock.

However, significant changes to macro-invertebrate communities towards “clean water” or “native” communities did not occur at most of the sites over the time-scale that were measured in this study. The lack of improvement in QMC scores and taxa richness may indicate number of things, such as times-scales of recovery, etc, however one stream with a wide buffer of >50m, 25 year old plantings, and the whole stream planted did show significant improvement in invertebrate communities compared to nearby pasture stream. What was particularly evident in lowland streams where catchment influences had a greater impact than local riparian influences (Parkyn, p.16, 2004).

In relation to the requirement for riparian planting, our advice from consultant (Rob Van Voorthuysen), is that we could require riparian planting, as per section 30(1)(c), specifically for the reasons of: maintaining and enhancing the quality of water in water bodies and coastal water, and maintaining and enhancing of ecosystems in water bodies. In addition, section 6 – *Matters of national importance* – also guides councils, with respect to the preservation of the natural character of the coastal environment including the coastal marine area), wetland, and lakes and rivers and their *margins*... (s. 6(a)). The fencing of water bodies also contributes to the maintenance of indigenous biodiversity, as per section 30(1)(ga), 31(1)(b)(iii) and section 6(c). Requiring riparian planting for the restoration of indigenous biodiversity would require a legal opinion.

5.4.2 The Use of Financial Incentives

A number of the proposed policy approaches suggested in this report involve the use of financial incentives (as subsidies), specifically in relation to the capital costs of fencing. However these subsidies could also be used to further incentivise riparian planting and the installation of alternative stock drinking water systems, etc. The rationale behind the use of public money to effectively subsidise private businesses (in this case, pastoral farming) is discussed by Murray (2011).

Murray reports that "...*effective riparian management (including livestock exclusion from waterways and planting of restorative vegetation) offers benefits which will be enjoyed by the wider public as well as privately, by the land owners. Public benefits include the benefit of clean streams which have 'use' values in the form health impacts, but also 'non-use' values such as the knowledge that the waterways will be kept for future generations*" (Murray, p. ii, 2011). This argument indicates that the use of public money to subsidise livestock exclusion, via fencing, can result in an achievement of a public benefit, over and above just a private benefit. This public benefit is primarily an improvement in freshwater quality, and therefore improved coastal water and ecosystem quality, downstream of a particular farm where the incentive may have been imposed. Therefore, Murray (p. ii, 2011) makes the case for a "shared responsibility model" (sometimes referred to as a "mixed funding model") which recognises that the costs of protecting the waterways are shared between private land owners and the wider public, reflecting the benefits realised by all.

Another reason that offering fencing subsidies is beneficial is reported by three contacted regional councils – Environment Southland, Horizons, and Waikato Regional Council. These councils reported that offering incentives, before applying a regulatory approach, had helped to change behaviour and lessen resistance to fencing. This is further reinforced by a Ministry for the Environment publication (MfE, 2001). This publication states that "*The most critical element of motivation towards things riparian is money, or in many cases, the lack of it. Irrespective of moral or philosophical support for sustainable farming practice, a shortage of cash, accompanied by the perception that riparian management is inevitably costly to the pocket and to farm productivity, is the overriding reason expressed for lack of action*." (MfE, p.79, 2001). This report continues by saying that "...*all of the most substantial and successful riparian projects have had ready access to money*." (MfE, p.79, 2001). Because of these reasons, offering a subsidy towards the costs of fencing is suggested in policy approaches, 2, 3, 4 and 5.

5.4.3 The Prioritisation of Catchments

All of the regional councils contacted for the research phase of this report - Environment Southland, Horizons, Environment Bay of Plenty, and Waikato Regional Council – had prioritised either specific catchments, or certain "high value" water bodies, that were then subject to financial incentives and, in some cases a more restrictive regulatory regime. The common reasons given by these councils for prioritising certain, catchments or water bodies, is that prioritisation is necessary because resources are limited, and that certain water bodies may be sensitive - and have a high public profile - so require action more in the short term. However, prioritising catchments can be difficult, since in many cases, conflicting criteria and objectives, can exist.

In addition, catchment approaches seem to have a greater effect than just localised riparian planting approaches. As noted above, Parkyn (p.16, 2004) commented what was particularly evident in the Waitako region study was that catchment influences had a greater impact on the improvement of invertebrate communities than local riparian influences. Ranganath, et al (p.33, 2009) concluded (from a case study in south-western Virginia) that while livestock exclusion from streams has positive impacts on streams, best management practice implementation along short stream stretches does not have the desired in-stream benefits. In particular, benthic macro-invertebrate response depends more on upstream watershed-scale conditions and impacts than localised, reach-scale livestock-access issues. Therefore, a more targeted approach addressing entire stream lengths and the associated watersheds may be required to restore the integrity of aquatic ecosystems (Ranganath, et al, p.33, 2009).

Therefore, as a result of this common practice by these councils (primarily due to limited resources), the prioritising of catchments is suggested in policy approaches 2, 4 and 5. In addition, the literature reviewed above supports the approach that it is more effective to fence the waterways within entire catchments, than just to fence off stock from streams in localised areas.

5.4.4 Fencing Applied to "Intensive" versus "Extensive" Farming Practices

Policy approach 3 involves the fencing of "intensive" farms (dairy farms and other farms that utilise "break-feeding" practices), while best management practices would be encouraged for "extensive" farms. The reasoning for this division is three-fold.

Firstly, much literature confirms that intensive farming practices can cause greater environmental effects, as compared to less intensive or "exclusive" farming practices. Smith, et al (1993) noted major effects of intensive farming on the condition of small streams and creeks in terms of turbidity, faecal contamination, and aquatic plant growth induced by elevated levels of N and P. Therefore, the targeting of intensive farming practices is based on a "pressure" argument, due to the generally higher stocking rates, and the addition of fertiliser that intensive farming entails. Secondly, Horizons livestock exclusion rules are just focused on dairy farms only, so a precedent has been set.

Thirdly, the high value of rural land in the Auckland region (as compared to other rural areas in New Zealand) has induced a certain response from land owners in the region. The ARC 2010 State of the Auckland Region Report states that, "*These high land values mean that rural producers in the Auckland region may need to produce their goods more efficiently, sell into high value niche markets and/or increase productivity per hectare by increasing inputs and/or by focusing on higher value products (such as intensive horticulture of factory farming) in order to earn a commercial rate of return equivalent to that achievable in other regions*. *The alternative method of meeting the high cost of rural land ownership is to cross-subsidise rural production costs with off-farm income*." (ARC, p.24, 2010) In relation to dairy farming specifically, "*Data from the Livestock Improvement Corporation suggests that, since 2002, the number of dairy farms decreased by 33 per cent and the number of effective hectares in dairying decreased by 24.5 per cent. Despite the decline in cows, farms and land area devoted to dairying, the intensity of production appears to be increasing on the remaining dairy* *farms. The size of the average dairy farm is increasing. This is reflected in data that show the average herd size increased 21 per cent between 2002 and 2008"* (ARC, p.44, 2010).

This response to high rural land values would suggest that rural land use in the Auckland region has generally fallen into two types - either relatively intensively farmed, or alternatively, where the land is not operated as a farming enterprise, it is lightly stocked, or not stocked at all.

Therefore, policy approach 3 recognises the differences between intensive and extensive farming practices.

5.4.5 Alternatives to Livestock Fencing

The majority of research literature shows that totally excluding livestock from streams is the most acceptable best practice to follow (Hoorman & McCutcheon, 2005). However, a number of options to stream fencing are available. Off-stream watering areas are an effective alternative to stream fencing (since this encourages livestock away from streams) and providing livestock with controlled stream crossings (by covering the stream bed with coarse gravel) reduces random trampling of stream banks (Hoorman & McCutcheon, p.2, 2005). Other means include, providing shade and placing feed supplements in upland areas away from streams, and employing controlled grazing strategies that in effect allow the managed grazing of stock on riparian areas for short periods of time, during dry weather conditions.

However, Hoorman & McCutcheon, (p.4, 2005) do sound a note of condition. They recommend that the grazing of riparian areas should not occur when stream-banks are eroding, or when conditions are too wet to graze. Further, grazing is not recommended when the native species is not predominately grass or legumes, or during peak fish and aquatic organism spawning periods.

It is concluded by this report, that applying these alternatives to stream fencing would not be applicable in the Auckland region. This is mainly because, many stream banks are eroding, conditions are often wet (due to Auckland's sub-tropical climate) and the native riparian species are not predominately grass or legumes. Also, applying controlled grazing strategies requires good management skills to be applied in a consistent manner, over the long-term, and would be difficult to monitor. Therefore, developing a policy approach that involved alternative methods to fencing was not attempted.

5.4.6 Economic Considerations

A number of economic benefits to farmers can be achieved when water bodies are fenced and planted. One interviewed farmer that farms within the area covered by the Whaingaroa Catchment Management Project, estimates that the cost savings from riparian planting were in the vicinity of $39,800. Even deducting the costs of the planting (which he estimated at about $15,000 a year for an eight-year period), he was (p.13)

Currently, there is 13,500 km of unfenced rural permanent banks and 6,000 km of unfenced rural intermittent banks in the Auckland region. To complete this over a 20 year period, there would be a need to fence 1000km per year for 20 years. If done over 50 years, then approximately 400km of stream banks would need to be fenced.

5.4.7 Discussion of Activity Status Types

If the use of regional rules to require the fencing of livestock from freshwater bodies and the CMA is adopted, then a decision on what activity status type this rule would be is required. The livestock exclusion rules applied by three regional councils – Environment Southland, Horizons, and Waikato Regional Council, generally start at a permitted activity (or a controlled activity in one case), and if one or more of the conditions are not complied with, the activity defaults up to either discretionary or non-complying for Environment Southland and Waikato Regional Council, and to restricted discretionary for Horizons.

The wording of the standards and terms associated with a permitted activity (or controlled activity) to require fencing also varies between councils. Some standards and terms (for example Horizons) explicitly state that livestock must be excluded, while others (for example Waikato Regional Council) are “effects based”. This means that livestock are still allowed to access a water body, but only up until a certain water quality parameter has been reached, or until there is obvious treading or erosion effects on the river banks. It is recommended – after discussion with these three regional councils – that any permitted activity standards and terms drafted by the Auckland Council, should be explicit with respect on the requirement to fence. This is because specifying a fencing requirement is easier to monitor (and enforce) than utilising a “no adverse effect” type standard and term.

It is recommended that if a regional permitted activity status rule regime is implemented and if one or more of the associated conditions are not complied with, then the activity should default up to restricted discretionary. This is recommended because since a rule regime for livestock exclusion would be a new initiative, (and can be applied to existing land uses) stating what discretion would be limited to will help to guide potential consent holders through the consent application and monitoring process. It is also recommended that section 9 land use provisions be utilised, (i.e. for the activity of grazing) as opposed to using section 13 (restrictions on the uses of beds of lakes and rivers) and section 15 (the discharge of contaminants) mechanisms. This is recommended primarily because any subsequent fencing would be outside the vicinity of any river or stream bed (so therefore could not be applied) and reducing livestock access to water bodies would not completely arrest the discharge of contaminants to water.

However it appears that any one of these mechanisms could be used. A recent review of regional council's and unitary authorities by Hawes (2011) reveals that four councils regulate the disturbance of river beds only under section 13, two councils regulate the discharge of contaminants to only under section 15, while four councils regulate both activities. Five councils regulate the use of land under section 9, with three of the councils using section 9 rules exclusively. Only one of these councils is a unitary authority. In other words, four regional councils regulate the use of land for water quality outcomes.

If the permitted activity fencing conditions are not complied with (or there are adverse environmental effects cause by stock access to water bodies or the CMA), then the Auckland Council would apply for abatement notices, enforcement orders, or use other enforcement mechanisms in Part XII of the RMA.

6 Conclusions

To be completed when other requested inputs are received, and options have been refined.

7 References

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Acknowledgements

8 Appendix 1