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NORTH SHORE CITY COUNCIL

Proposed Plan Change 23: Riparian Margins

Submitted to:
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Private Bag 93500
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North Shore City

REPORT

Report Number: NORCC-NSC-027

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Golder Associates

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1.0 INTRODUCTION

1.1 Background

Streams are an important environmental asset in North Shore City (NSC). They also form an integral part of the stormwater drainage system within the city. As increased development takes place, it results in changes to the hydrological flow regime resulting in higher peak flows and reduced low flows in streams. Increased development also results in the removal of riparian vegetation, construction of structures in stream beds and flood plains, and in some cases piping or channelisation of streams.

As part of a suite of initiatives being carried out by North Shore City Council (NSCC) associated with stormwater and the aquatic environment in NSC, including the preparation of Integrated Catchment Management Plans (ICMPs), NSC have given some consideration to the issue of additional protection and enhancement of streams within the City including what protection should be given to the riparian margins of the streams.

Accordingly, a North Shore City Council Proposed Plan Change (PCC) 23 on riparian margins has been developed, as part of an integrated suite of Plan changes focused on stormwater and the aquatic environment in NSC. The proposed plan changes have received a number of submissions, and the present report provides comment on the submissions and the matters raised.

1.2 Terms of Reference

Golder Associates (NZ) Ltd (Golder) has been contracted to provide expert assistance and advice regarding the submissions on the North Shore City Council Proposed Plan Change (PCC) 23 on riparian margins. The objectives of this report are to:

- Review the proposals in the submissions and policy or rules of the PCC.
- Comment on the feasibility and merits of each proposal alongside the PCC.
- Provide recommendations on existing and revised policies and rules in the PCC.

1.3 Approach and Layout of this Report

Our approach has been to provide a sequence of scientific evidence of the benefits of riparian vegetation to aquatic ecosystems, knowledge of the values of streams and waterways in the Auckland region and North Shore City in particular, and to critique the proposed plan change and the associated submissions in order to provide recommendations for the proposed plan that meet the stated objectives of the plan.

In laying out the report first we define and provide an overview of riparian vegetation including the benefits to water quality and stream ecology. This includes a specific section on riparian margins in urban streams, reflecting the largely urban nature of the waterways of North Shore City and definitions of key terms and attributes that are used throughout the plan and its content. We then review the values of North Shore City streams and their existing riparian margins as a context for the plan review. A brief summary of the proposed plan change and submissions received then follows before a more critical appraisal of the key plan changes and submission is provided. Finally we provide recommendations for the plan change.

2.0 RIPARIAN MARGINS

2.1 Overview

Riparian margins are transitional semi-terrestrial areas influenced by freshwater extending from the edges of waterbodies to the edges of upland communities. Because of their spatial position, riparian zones integrate interactions between aquatic and terrestrial environments and communities. They are dynamic environments characterised by strong energy regimes, habitat heterogeneity, diverse ecological processes and multidimensional gradients (Naiman et al. 2005). Riparian zones typically possess the wet and sometimes inundated soils that are commonly found on floodplains and near the bottom of hill slopes adjoining streams. Riparian margins influence water quality and quality through a range of processes and interactions with aquatic and terrestrial systems (ARC 2001, Figure 1). These transitional zones provide habitats that are important for the survival of a number of native plants and animals.

Appropriate management of riparian zones can be a very effective means of reducing the impacts of catchment development on watercourses while still maintaining economic production or residential living (Table 1). Sustainable land use can be achieved by harnessing the natural abilities of riparian zones to absorb excess nutrients and to process waste materials before they enter watercourses.

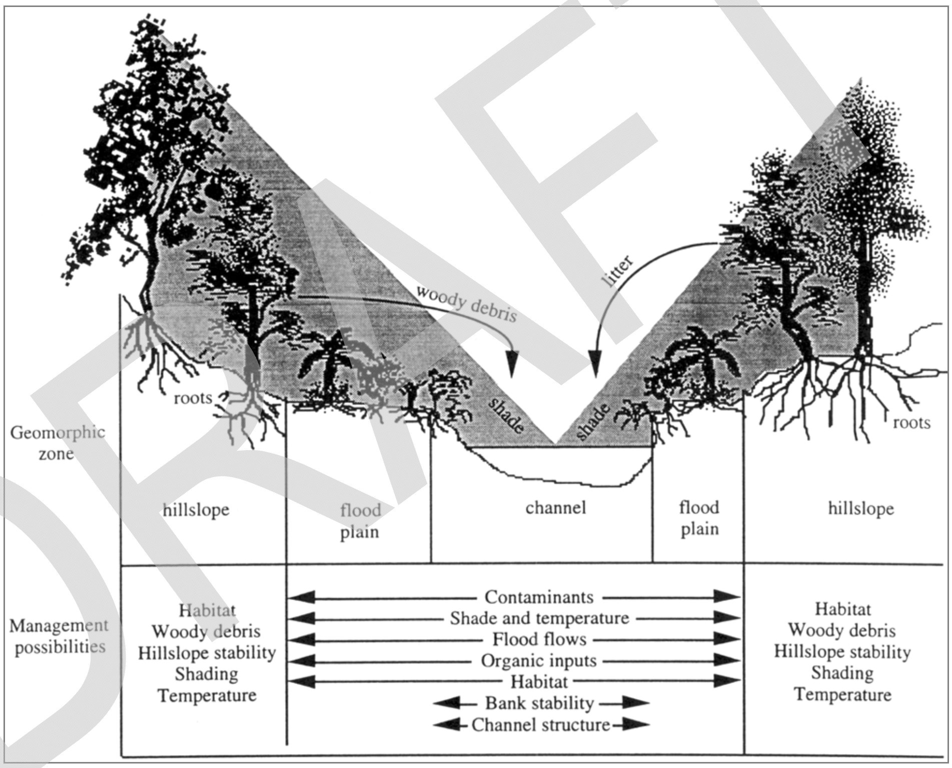

Figure 1: Conceptual diagram of a stream and its riparian area showing geomorphic zones and management possibilities (ARC 2001).

2.2 Riparian Margins and Stream Ecosystems

Riparian vegetation is a significant factor in the productivity and functioning of stream ecosystems (Cummins et al. 1989, Tait et al. 1994). The vegetation canopy shades incident light and reduces water temperatures thus influencing primary productivity (Towns 1981, Binkley & Brown 1993, Davies & Nelson 1993, Rutherford et al. 1997). For example, Quinn et al. (1992) concluded that shading by riparian vegetation reduced periphyton growth in pasture streams and influences the composition of the macroinvertebrate community.

Table 1: Summary of riparian zone functions that potentially buffer streams from various land use effects (Collier et al. 1995).

Riparian zone function	Potential in-stream effects
Buffers banks from erosion.	Reduces fine sediment levels.
Buffers channels from localised changes in morphology.	Maintains water clarity.
Buffers input of nutrients, soil, microbes and pesticides in overland flow.	Reduces contaminant loads.
Denitrifies groundwater.	Prevents nuisance plant growths.
Buffers energy inputs.	Encourages growth of bryophytes and thin periphyton films.
Provides in-stream food supplies and habitat.	Maintains lower summer maximum temperatures.
Buffers floodflows.	Increases in-stream habitat features and terrestrial carbon inputs.
Maintains microclimate.	Maintains food webs.
Provides habitat for terrestrial species.	Reduces floodflow effects.
Maintains dispersal corridors.	Increases biodiversity.

Woody debris contributed by riparian vegetation is often an important determinant of structure and complexity of stream morphology and ecology (Harmon et al. 1986, Sedell et al. 1988, Collier and Halliday 2000). The vegetation canopy also can contribute terrestrial prey for carnivorous fish (Bilby and Bisson 1992, Edwards and Huryn 1996). The influence of riparian vegetation can be expected to change with increasing stream size and flow variability (Quinn et al. 1993). Riparian vegetation can also heavily influence stream channel morphology, with small streams having generally wider channels in forested catchments than pasture catchments (Zimmerman et al. 1967, Sweeney 1993, Davies-Colley 1997).

Riparian margins may then be managed for the benefit of the waterways while still allowing productive use of the land. In addition, riparian zones strongly influence life in streams and rivers by providing shade and food and are often unique habitats in their own right (Collier et al. 1995).

2.3 Water Quality and Riparian Margins

Increased nutrients in waterways have the potential to cause eutrophication, increased plant and algal growths, toxic algal blooms, and in extreme cases, proliferations of sewage fungus. Increased sediments in waterways influence the visual clarity of the water, which affects the aesthetic values, fish feeding, light penetration. Fine sediments settling on the bottom of streams and rivers can reduce the habitat for the bottom-dwelling biota and can result in lower species diversity and productivity.

It has now been demonstrated that riparian zones can significantly reduce the concentrations of sediment and nutrients in surface water and groundwater entering streams. Nitrates and phosphorus inputs to streams can be reduced by as much as 90%. Research has shown that most nitrate removal in riparian zones occurs less from plant uptake and more from microbial denitrification. However, without adequate soil-water contact time, riparian zones are limited in their ability to remove nutrients. Recent research suggests that high nitrate removal (> 90%) can occur if adequate contact time of 7 days/m is allowed, while low nitrate removal occurs with low residence time (2 - 4 mins/m) (Burns & Ngyuen 2002).

The width of the riparian zone will, in part, influence the contact time, or residence time of nutrients and sediments in the streamside management area. In addition, during high rainfall events, **in rural areas at least,** large amounts of nitrate simply move across the surface of riparian areas, without adequate soil contact time, and hence enter waterways. The width and type of riparian planting may influence the residence time of nutrients and sediments during high rainfall events. What-is-more, the success of riparian treatment of diffuse sources of nutrients will depend on the soils and geology. If soils are impermeable and poorly drained then more surface runoff will occur, and there is a need to align wider riparian buffer areas and ground vegetation cover with location and size of runoff areas.

2.4 Riparian Margins in Urban Areas

The aquatic and terrestrial environments of North Shore City (NSC) have been significantly modified by human development. Anthropogenic influences on these environments include forest clearance and burning by Maori, kauri logging and clearance by early Europeans, and more recent urban growth and development (ARC & NSCC 2005). One of the key resource management issues arising from current growth in NSC are greenfield developments, where semi-rural catchments are converted to more intensive urban land uses. Land development associated with urban intensification directly affects riparian zones, water quality, stream morphology and landscape values, because streams and their riparian vegetation are often totally lost (ARC 2001).

The retention and restoration of healthy riparian margins in urban environments has a range of ecological benefits that may differ from benefits derived in non-urban environments (e.g., pastoral, forestry). Mature trees in riparian margins shade waterways, regulating instream temperatures and allowing development of diverse and abundant aquatic communities. Riparian vegetation also provides terrestrial carbon inputs into stream food webs, slows the flow of floodwaters through urban environments and reduces stream bank erosion. The restoration of terrestrial vegetation along stream networks also provides ecological corridors through developed environments, providing habitat and dispersal opportunities for indigenous birds, herpetofauna and invertebrates.

Parkyn et al. (2000) listed the main uses of riparian zones in the Auckland urban areas as:

- Provision of vegetation roughness to slow bank overflow during floods.
- Provision of instream habitat for invertebrates and fish.
- Provision of shade for light and temperature control (reduction).
- Improvement to aesthetics for enhancement and human recreation.
- Stabilisation of stream banks.

The benefits of riparian management for water quality and stream biota are less clear in urban areas than has been demonstrated in rural areas. Several studies have shown the benefits of riparian vegetation along urban streams; for example, Urban et al. (2006) suggest that maintaining and restoring watershed vegetation corridors in urban landscapes will aid efforts to conserve freshwater biodiversity. In contrast, Walsh et al. (2007) concluded that riparian forest cover may influence richness of some macroinvertebrate taxa, but catchment urbanisation probably has a stronger effect on sensitive taxa. In catchments with even a small amount of conventionally drained urban land, ecologically successful restoration and enhancements of streams in urban catchments will most likely require attention to both riparian zones and to catchment urban drainage (i.e., restoration of riparian vegetation alone is unlikely to affect the biotic integrity of streams). In the USA, Roy et al. (2005) concluded that management practices that rely exclusively on forested riparian areas for stream protection are unlikely to be effective at maintaining ecosystem integrity.

In a similar study of the Twin Streams catchment in Waitakere City, Auckland, Kingett Mitchell (2005) found that habitat quality is related to ecological state in areas with less intensive urban development, but for sites where catchment imperviousness exceeds around 20%, the negative effects of catchment-scale urban disturbance will outweigh the potential benefits of localised enhancements for good quality habitat. In other words, improving habitat (cf. riparian vegetation) is outweighed by other large-scale catchment drainage factors.

This is an important finding and it is worth noting that the NSCC have presented an integrated suite of plan variations for the purpose of stormwater and catchment drainage management which means that the benefits of riparian planting are more likely to achieve the objectives established in the Plan.

2.5 Riparian Zone Width

Riparian margin width has significant impacts on a variety of functional outcomes (ARC 2004):

- Creation of self-sustaining vegetation communities with minimal weed invasion.
- Development of links between terrestrial and aquatic habitats.

- Provision of desired in-stream effects as outlined in Table 1.

An evaluation of the width required to achieve necessary to create riparian margins that support sustainable vegetation and meet aquatic functions was performed by Parkyn et al. (2000):

- 5 - 6 m wide buffers: these are recommended for small waterways or where there are no other options for wider planting. These buffers are so narrow that edge effects mean natural regeneration of indigenous species is limited and they need on-going maintenance to keep them weed free.
- 10 m wide buffers: these allow for indigenous vegetation succession and should result in a relatively low-maintenance riparian zone. Edge effects mean that the outer 1 - 2 m of the buffer is likely to suffer weed infestations, and these weeds would spread to the interior of the riparian zone wherever canopy gaps occurred.
- 15 - 20 m or wider: buffers of this width are thought to be self-sustaining for indigenous vegetation, and should be required on large waterways.

Given these results, a 10 m minimum riparian buffer width was recommended as a general guideline for achieving a high level of functionality in riparian margins in the Auckland region (ARC 2004).

A range of other literature confirms that riparian buffers must be at least 10 m in width to achieve significant improvements in instream habitats. Parkyn et al. (2003) found that buffer width was related to changes in stream health as measured by change in invertebrate communities (using the Qualitative Macroinvertebrate Community Index, QMCI), and that buffers of 10 - 20 m were necessary to significantly elevate the QMCI (Figure 2). Reeves et al. (2006) found that dense riparian plantings with widths of 15 m or more provide the most sustainable riparian plantings in urban and rural landscapes. This is an important finding as it highlights the importance of the integrity (size, density) of the riparian margin itself and the ability of the vegetation to remain complete, intact and functional and resilient to disturbances such as wind damage and introduced pests and weeds. Riparian zones (and associated waterways) retain their own micro-climate that is typically cooler and more humid than in and the sustainability

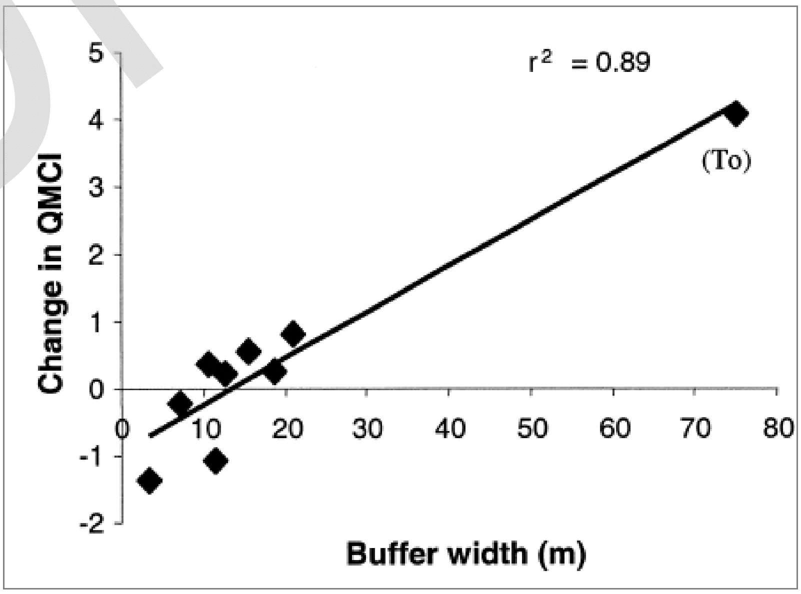

Figure 2: Change in quantitative macroinvertebrate community index (QMCI) scores between buffer and control reaches versus changes in buffer width (Parkyn et al. 2004).

3.0 NORTH SHORE CITY STREAM VALUES

3.1 Overview

Streams are a major environmental asset in NSC, providing habitat for a diverse range of freshwater fish, macroinvertebrate and aquatic plant species (Kingett Mitchell 2002, Boothroyd et al. 2003, Young et al. 2003). They also form an integral part of the stormwater drainage system within the city. Stream networks throughout NSC remain extensive despite the high degree of residential and industrial development throughout the city. There are over 80 streams in the city with approximately 285 km of stream length. Detailed information was collected about the values and characteristics of 26 (150 km) of these under the North Shore City Stream Assessment (NSCC 2004). In their study of the streams of North Shore City, Kingett Mitchell (2002) found that sites with the highest water and habitat quality were associated with the highest native vegetation cover, while the most heavily modified sites had greater periphyton and macrophyte growths (i.e., higher light levels and less shade).

Native fish species present in North Shore streams include the banded kokopu (*Galaxias fasciatus*), which is common and widely distributed. Threatened species present in NSC streams include the giant kokopu (*Galaxias argenteus*) and long fin eel (*Anguilla dieffenbachii*), both of which are listed as in gradual decline (Hitchmough et al. 2007). Other native fish species present in North Shore streams include (ARC & NSCC 2005):

- Torrentfish (*Cheimarrichthys fosteri*).
- Koaro (*Galaxias brevipinnis*).
- Estuarine triple fin (*Grahamina* sp.).
- Common smelt (*Retropinna retropinna*).
- Giant bully (*Gobiomorphus gobioides*).
- Yelloweye mullet (*Aldrichetta forsteri*).
- Redfin bully (*Gobiomorphus huttoni*).
- Koura (*Paranephrops planifrons*).
- Inanga (*Galaxias maculatus*).
- Short finned eel (*Anguilla australis*).
- Common bully (*Gobiomorphus cotidianus*).

North Shore City's stream network forms an important part of its stormwater disposal network. However, increases in development and impervious areas within catchments channels more water through these waterways, disturbing the natural balance of these environments. Consequences of elevated stormwater flows through streams include loss of aquatic habitat, increased erosion, increased deposition of sediments and a loss of ecological and amenity values (NSCC 2005).

Increased development within urban areas also leads to the construction of structures such as tunnels, culverts and channels within stream networks. These structures may create barriers to fish passage, obstruct flow causing flooding, concentrate or redirect flow thereby increasing erosion, and elevate water temperature (Kingett Mitchell 2002; Young et al. 2003; NSCC 2005).

3.2 Extent of riparian margins within North Shore City

Hill Young Cooper (2007) performed a review of riparian quality and development along North Shore City streams. This included a detailed assessment of riparian margins within three waterways, namely Awaruku, Kahika and Eskdale Streams (Table 2). Despite the small sample size, Table 2 illustrates that the extent of anthropogenic development within NSC riparian margins varies across the city. The Awaruku Stream catchment contains the Long Bay Regional Park and a mixture of residential and rural land uses, however it has been heavily modified as a result of urbanisation. The Awaruku Stream has the lowest proportion of vegetation within the 10 m riparian margin of the streams studied and further significant development is anticipated within its catchment. In contrast, the Kahika Stream catchment is largely developed to capacity, primarily with residential land uses, and has the lowest proportion of development within the 10 m riparian margin of the three streams assessed. The Eskdale Stream catchment has significant areas of bush and open space, and developed areas predominantly comprises residential properties with relatively low proportions of encroachment into the 10 m riparian margin.

Table 2: Riparian margin characteristics in Awaruku, Kahika and Eskdale Streams (Hill Young Cooper 2007).

	Awaruku	Kahika	Eskdale
Number of properties abutting stream	151	182	463
Existing buildings within 0-10 m margin:			
- number of lots	78	31	74
- average % building coverage in margins	7%	1.8%	2.5%
- sites with less than 10% coverage in margins	50	23	54
Number of lots with buildings within 5 m margin	20	11	22
Average % existing vegetation within 0-10 m margins	63	88	88
Existing carparking within 0-10 m margin			
- number of lots	44	12	30
- average % carparking coverage in margins	7.5%	1.4%	1.8%
Existing yards within 0-10 m margin			
- number of lots	100	50	114
- average % yard coverage in margins	22.5%	9%	8%
Proportion of 10 m riparian margin covered by vegetation (%)	63%	89%	88%

4.0 PROPOSED PLAN CHANGE 23

4.1 Context

Proposed Plan Change 23 is an outcome of the NSCC Integrated Stormwater Planning Project initiative that stems from new strategic directions for the management of stormwater and aquatic environments identified by NSCC and ARC. These initiatives recognise the significant value that residents of NSC place on protection of aquatic environments, and their dissatisfaction with current approaches to catchment management. The new strategic direction also incorporates changes to statutory documents relating to stormwater management and the contents of seven Integrated Management Plans (ICMP) already prepared by NSCC (NSCC 2007).

These initiatives represent NSCCs response to changing paradigms in the field of stormwater management. Previously this discipline focussed primarily on flood control and abatement; however modern approaches to water management recognise the importance of simultaneously maintaining and enhancing stream health. Stream health refers to the overall ecological, amenity and recreational values of NSC streams. Key strategic drivers for improving stormwater management under the NSCC Integrated Stormwater Management Project include (HYC 2006):

- Integrating management of stormwater, wastewater and water supply;
- Improvement of beach and stream water quality;
- Reduction of flooding;
- Reduction of erosion.

Hill Young Cooper (2006) performed a gap analysis of NSCCs current mechanisms for stormwater management and identified nine key issues. The protection and enhancement of riparian margins was one of these issues, and it was mooted that these goals were not adequately promoted by District Plan provisions at the time of development, when this is most appropriate. Recent development trends in NSC have lead to maximisation of the coverage of lots in impervious surfaces, through large dwellings, buildings on smaller sites and extensive hard landscaping (NSCC 2007). Hill Young Cooper (2006) flagged that provision for improving the protection of the ecological and amenity values of riparian margins should be included in the District Plan, including controls or guidelines in relation to structures of the development of impermeable areas within riparian margins. Further assessment of riparian quality and development in North Shore riparian margins was performed by Hill Young Cooper (2007).

North Shore City Council furthered the Integrated Stormwater Planning Project through the preparation of Proposed Plan Changes 22-25 and associated Variations 2-8, and these were notified to the public on 12 April 2007. The proposed plan changes aim to improve stormwater and stream management in NSC, and comprise measures that:

- Address the effects of stormwater runoff on stream health (PCC 22 and Variations 2, 3, and 4);
- Address the effects of development on stream health and riparian margins (PPC 23 and Variations 5 and 6);
- Address the effects in areas subject to natural flooding hazards (PCC 24 and Variations 7 and 8); and
- Address the effects of sediment and erosion from site works (PCC 25).

4.2 Content

Proposed Plan Change 23 and Variations 5 and 6 seek to address the effects of development on stream health and riparian margins throughout NSC. Changes in the PCC affect Sections 8.2, 8.4.2 and 14.6; Objectives 8.3.5 and 9.3.1; and Rules 9.4.4 and 9.4.3 of the District Plan. These changes include:

- Provision of a description of riparian function, intermittent stream and riparian margin;
- Provision of a description of the issue of urban development on streams with reference to intermittent streams;
- Protection of streams and riparian margins through restricting development within the first 5 m of the riparian margin and enabling development up to 10% of the riparian margin provided enhancement and restoration is provided;
- Amending rules in Section 8.4.2 Protection of Habitats to also refer to streams;
- Amending policies under Objective 8.3.5 to enable restoration and enhancement as a Permitted activity in accordance with Catchment Management Plans, while all other development in a riparian margin (including diversion and modification of streams) is a Discretionary activity. A riparian margin of 20 m is retained in the Rural and Urban Expansion zones, and is increased from 5 m to 10 m in all other zones.
- Amending assessment criteria for Discretionary activities to provide increased detail about effects on riparian margins and streams, including intermittent streams.
- Adding information requirements for Discretionary activities, being a Planting and Weed Eradication Plan for development in the riparian margin, and details relating to diversion and modification of intermittent streams.
- Amending policies and explanations under Objective 9.3.1 Protection of the Environment to include protection of riparian margins and stream health.
- Deleting Rule 9.4.4 Building Platforms and relocating it under Rule 9.4.3 General Standards for All Site Works and Subdivision Activities. Amending the rule to ensure that building platforms are clear of riparian margins.

- Amending assessment criteria in Section 14.6 to provide for consideration of the effects of public works and network utilities on riparian margins and streams.
- Consequential amendments throughout the plan to identify the issue of stream health and protection of riparian margins, including cross references back to amended provisions in Section 8.4.2.

4.3 Objectives for Riparian Management

The Plan contains objectives to meet the purpose of the RMA. The existing objectives are detailed in Chapters 8 and 9 of the Plan:

8.3.5 Stream protection – To protect and enhance the natural character and ecological amenity and recreational value of rivers, streams and other natural bodies of water.

9.3.1 Protection of the Environment – To avoid, remedy or mitigate the adverse effects of subdivision and development on the environment, including the physical environment, biota, amenity values and landscape.

The enhancement of riparian margins of waterways is now a well-recognised means of protecting stream environments (for reasons outlined in Section 2 above). Such protection (and enhancement) initiatives are recognised at a variety of scales, from local communities (e.g., Council Wai-Care[1] and other community initiatives) to wider regional and national initiatives (e.g., Clean Stream Accord[2]).

Retaining and protecting existing riparian areas by restricting development in the riparian margins, increasing protection (e.g., fencing), providing sufficient riparian buffers (wide riparian margins), enhancement planting and pest control all contribute to achieving the benefits of stream protection via managing riparian vegetation. As outlined in Section 2.3 riparian margins alone may not provide for all of the measures of stream protection, but aligned with other measures (e.g., stormwater controls, bank stability), protection of stream environments can be achieved.

The purpose and objectives for retaining and protecting riparian margins need to be very clear (i.e., shading for temperature/light reduction, nutrient removal, Collier et al. 1995) although in practice there are usually multiple objectives (cf. Section 8.2 of the PCC, Section 2 above) that are categorised as 'stream protection'. Such categorisation is reasonable as the attributes that define carefully planned riparian margins (cf. Sections 2 and 5.2.1) will contribute to these multiple objectives (e.g., management of riparian margins provision of shade may also provide for managing bank stability).

5.0 SUBMISSIONS REGARDING PROPOSED PLAN CHANGE 23

5.1 Overview

A total of 33 submissions were received regarding PPC 23, including nine submissions in full or part support of the PCC, and all submissions have been evaluated in NSCC (2008). Submissions were amalgamated into five groups: overall approach, jurisdiction, efficient use of land, ecology and other matters. The group of submissions concerning the overall approach of the PPC raised issues such as:

- The PCC deals with issues outside the jurisdiction of NSCC;
- The PCC is not consistent with the Auckland Regional Plan: Air, Land and Water;

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[1] Council

[2] Agreement between Fonterra Co-operative Group, the Minister for the Environment, the Minister of Agriculture, and regional councils. The parties to the Accord agreed to work together to achieve clean healthy water, including streams, rivers, lakes, groundwater and wetlands in dairying areas. The Accord is both a statement of intent and a framework for actions to promote sustainable dairy farming in New Zealand.

- The level of prescription and detail is inappropriate for a District Plan;
- The PCC is not consistent with the District Plan's objectives;
- Deletion of the entire PCC or all references to riparian margins.

These planning orientated issues have thoroughly investigated and addressed in NSCC (2008) and are not discussed in detail in this report, which focuses on evaluation of ecological and technical matters raised in the submissions, including:

- Undertake further analysis of streams to determine the appropriate extent for riparian margins;
- Add additional width to proposed riparian margin rules;
- Extent of encroachment within riparian margins;
- The definition of stream;
- The value of exotic vegetation;
- The focus on native vegetation;
- Retention of the current riparian margin width (5 m);
- Provision of a clear definition of riparian margin;
- Replacement of the term 'waterway' with 'stream'.

These concerns are analysed and addressed in the following sections.

5.2 Riparian Margins

5.2.1 Definition

Various definitions of riparian vegetation exist in the literature. A particularly useful definition is as follows:

***Riparian zone, area or strip**: a strip of land which separates an inland, upland or hillslope area from streams, lakes and wetlands, and where activity is modified to prevent adverse effects on the water quality, biota and habitat within the watercourse.*

This definition is preferable because it makes a separation between the waterway and the productive or other landuse (which could include residential, commercial or industrial landuse), and it specifies different activity (i.e., plantings, weed management, non-productive activity) from the upslope productive components. The definition also provides for the purpose being to prevent adverse effects.

5.2.2 What is a stream?

Several submissions have questioned the use of the term 'stream' in the Plan Change. As with riparian margins, there are various definitions of 'stream', and many variant terms to describe the same or similar geomorphological structures in the landscape. The RMA defines a stream (to be found under definition of river) as 'river means a continually or intermittently flowing water body of fresh water; and includes a stream and modified watercourse; but does not include any artificial watercourse.' Although some ambiguity might surround the term watercourse, we suggest that the definition of stream is quite sound. For North Shore City streams, any ambiguity is likely to form around concrete channels and whether they form a 'stream' or an 'artificial watercourse', and around headwater streams. For the purposes of the plan change it is worth clarifying that a concrete channel is a stream where it follows an original, or is a diverted original stream channel. Further details on the ecological values of concrete channels is outlined in section x below.

5.2.3 Measurement of the riparian margin

The District Plan currently stipulates that riparian margins are to be measured from the centre line of streams, where streams are greater than three metres in width. Proposed Plan Change 23 alters this approach and states that riparian margins should be measured from the edge of streams. Numerous submissions were received in support of retention of the status quo regarding the frame of measurement for riparian margins, presumably with many submitters driven by the desire to reduce the impact of PPC 23 on the area of land permitted for development within their properties.

The current method of measuring riparian margin width (i.e., from the stream centre line) fails to account for the width of the stream, and results in a maximum riparian margin width of 3.5 m (i.e., 5 m minus a minimum of 1.5 m equals 3.5 m). This method also introduces inaccuracies into riparian width measurement due to potential errors in the mapping of stream centre lines. It is recommended that the delineation technique present in PPC 23, i.e., measurement from stream edges, be retained as it promotes the protection of the true extent of riparian margins present.

The question of what constitutes the stream edge is somewhat vexed. In assessments of instream habitat, ecologists often refer to 'wetted' width (width of the wetted stream channel area, which will vary with flow) and 'bankfull' width (measurement from the height of bank where the channel would be 'full' of water and about to spill out into the floodplain; width from one bankfull to the opposite bankfull). Such attributes are included in the habitat assessments of USEPA (Kaufman & Robison 1999), Australia (Parsons et al. 2004) and Europe (Petersen 1992), Christchurch (Suren & McMurtrie 2006) and Brierley (1996). The bankfull attribute for defining the edge of a stream takes into account all flow frequencies in defining the 'stream', and defines the margin at which benefits of riparian vegetation for the stream ecosystem starts to accrue. Davies-Colley 1997, Jowett & Richardson 1996, 2003) have shown links between the channel and stream (wetted) width to the biotic communities.

For the North Shore City, with the exception of some headwater ephemeral streams, almost all streams have a well-defined channel and are generally entrenched within the valley floor, typically with well-defined banks. This means that defining the stream edge as the wetted edge (i.e., the water's edge of the stream) should be a reasonably straight forward practice in most circumstances; and with the exception of during flood events, the wet edge of the stream it will not vary greatly day to day. Where and when variation does occur, it is unlikely to cause a great discrepancy in the width of the riparian zone measurement.

Recommendation

It is recommended that the riparian margin be measured from the point of the edge of the stream water in the stream on the day of assessment (excluding isolated marginal pools and backwaters). Furthermore, it is recommended that the 5 and 10 m are measured horizontal from the stream wetted edge and not via the bank contours (i.e., it is a straight line measurement).

5.2.4 Extent of riparian width

The proposed increase in riparian margin width contained within PPC 23 was the subject of many submissions. Numerous submissions were in favour of retaining the current five metre width, and many of these also supported the continuation of measurement of riparian width from stream centre lines as discussed above. Other submissions did not directly oppose increasing riparian margin width, but advocated for consideration of stream characteristics and values when determining riparian margin width.

Available scientific evidence indicates that a riparian margin of five metres is unlikely to provide significant protection to instream values and that margins of 15 - 20 m are more suitable for enhancing aquatic habitats (Parklyn et al. 2000, 2003; Reeves et al. 2006). Although riparian widths as little as 5 m can slow down and reduce contaminants from surface runoff in pasture environments, the sustainability of the riparian margins can be diminished at lower widths (see Section 2.5).

5.2.5 Matching riparian vegetation with stream values

Little of the available literature equates matching instream values with the extent and magnitude of riparian planting; ARC have based their strategy for defining riparian width on stream widths. Notably however, Parkyn et al. (2003) found that riparian width was related to changes in stream health and that riparian margins of 10 - 20 m were necessary to significantly change aquatic invertebrate communities (see Section 2.5 above). Most riparian planting protocols and guidelines advance riparian planting for the benefit of maintaining and enhancing instream ecosystems (see Section 2 above) and therefore recognise current and potential aquatic values for the site. The evidence suggests that, rather than alone, but in combination with other regulatory, landscape and reducing impact mechanisms, riparian planting can lead to improvements in stream health.

In addition, the question of scale of riparian benefit and value emerges. Future value of a stream or part of a stream maybe in its potential for improving connectivity or improving fish passage rather than an improved biotic state at the exact location of riparian enhancement.

Despite the apparent low values often attributed to urban streams, clearly there are many values that can in fact be given to the urban streams of the NSCC (cf. Section 3 above). The question arises of where stream values are low, is it warranted to retain a lesser (or no) riparian margin, when there may be potential for the riparian vegetation to improve the biological health is apparent? For example, Parkyn et al. (2006) concluded that riparian protection of small pasture streams offered sufficient habitat to improve the streams natural values and move measures of stream health closer towards those of native forest streams. It is likely that, given the implementation of other stormwater management measures, that retaining vegetation riparian margins will contribute to increasing natural values of streams in the North Shore City. Specific knowledge of stream reaches will be necessary to understand the current and potential values of the waterway, and it is important that consideration is given to attributes such as connectivity and fragmentation in assessing potential value.

Despite studies showing the aquatic values of the streams of North Shore City, clearly not all streams and/or stream reaches carry the same values; and their potential may be limited at some locations. As a consequence in order to meet the objectives of the plan, it may be appropriate to allow for independent assessment of some (or all) stream reaches in order to understand the specific aquatic values at a location, and to allow for more site-specific provision for riparian margins to occur.

5.2.6 Extent of encroachment within riparian margins

PPC 23 provides for the protection of streams and riparian margins through preventing development within the first 5 m of the riparian margin and enabling development up to 10% of the riparian margin within the 5 - 10 m zone provided enhancement and restoration is provided. The restricted development envelope within the 5 - 10 m zone of the riparian margin limits the loss of additional riparian area and vegetation for the purpose of maintaining the sustainability and functionality of the riparian zone (cf. Section 2).

It is not clear how a 10% development envelope was decided upon; there is little evidence in the literature of any specific thresholds for the loss of sustainability of riparian margins. Nevertheless, as Reeves et al. 2006 have highlighted, the integrity (i.e., wholeness, density etc) of the riparian vegetation has purpose for functionality and resilience,

Clearly not all areas of existing or potential riparian vegetation will be the same and the existing integrity, density, quality, functionality and value of the riparian vegetation will vary. With such variance the 10% development threshold may not meet the objectives of the Plan in all cases. In other words there will be circumstances where the quality of the riparian zone is such that even encroaching within 10% of the vegetation will be detrimental; in other circumstances where quality and integrity of the riparian vegetation is lower there may be opportunity to increase the threshold and still meet the objectives of the plan. In almost all circumstances there would need to be a substantial maintenance programme (through a management plan) for each site.

Of course the same arguments of variance of the quality etc of riparian zones will be apparent for the 0 - 5 m width of the riparian vegetation. However, such riparian buffers are narrow (i.e., 5 m) and edge effects mean natural regeneration of indigenous species is often limited and they need continuous maintenance to keep them weed free and maintained sufficiently to meet the objectives of the plan. Furthermore, this bankside 5 m width of riparian is the closest in proximity to the stream and can have immediate benefits for instream habitat (e.g., habitat for terrestrial organisms that fall into the stream, bank stability through plant roots and shading and cover at the margins of the stream).

As a consequence, in order to meet the objectives of the plan, it may be appropriate to allow for independent assessment of some (or all) stream reaches and associated riparian margins in order to understand the specific aquatic and riparian values at a location, and to allow for more site-specific provision for riparian margins to occur.

Recommendation

We recommend retaining the protection of the 0 - 5 m riparian vegetation as a discretionary activity with assessment criteria for any applications for deviation from this rule.

We recommend that the limited 10% encroachment into the 5 - 10 m riparian zone be retained as a discretionary activity but provide assessment criteria for any deviation from this rule.

5.2.7 Intermittent and headwater streams

Significance of intermittent and headwater streams

Land use changes such as urbanisation, deforestation and re-engineering can have significant impacts on intermittent streams. Two types of intermittent stream can be distinguished from an ecological perspective, i.e., those that occur in headwaters and those that occur in mid-reaches of stream networks. Headwater intermittent streams result from the longitudinal expansion and contraction of stream networks in response to seasonally rising and lowering water tables near the tops of catchments (see section below). Intermittent streams of the mid-reaches occur where streams that originate in wet upland regions flow across flat plains with water tables that are permanently or seasonally below the river bed (Storey & Quinn 2008). Permanent streams are given greater protection than intermittent streams under the Proposed Auckland Regional Plan: Air, Land and Water.

However, PPC 23 (section 8.3.5) recognises the importance of intermittent and headwater streams, providing a description of their values and maintaining that they must be protected to the greatest extent possible. A number of submissions opposing this component of PPC 23 were received, many of which were concerned that these provisions will unduly restrict development potential in areas containing intermittent streams.

An extensive review of the values associated with headwater streams in the Auckland Region was performed by Parkyn et al. (2006), and this study concluded that small headwater streams should be given the same status as small perennial streams regarding management for the protection of natural values. Significant biodiversity values were associated with headwater streams, and additional taxa occurred in these habitats that were not found in the perennial streams sampled throughout a range of land uses. Furthermore, the overall community composition and structure, and invertebrate metrics of ecosystem health were not significantly different between perennial stream habitats and the smaller headwater habitats. Storey & Quinn (2008) also found that total macroinvertebrate abundance in headwater intermittent streams was comparable to nearby perennial streams in an analysis of intermittent streams in Hawkes Bay; even disconnected pools had high biotic diversity.

Headwater and intermittent streams also perform important functions that influence entire stream networks, maintaining hydrologic connectivity and ecosystem integrity at regional scales. Maintenance of headwaters promotes transport of matter, energy and organisms to the lower reaches of stream networks, connecting the upland and riparian landscape to the remainder of stream ecosystems. Alteration of headwater streams modifies fluxes between elevated and lowland stream reaches and eliminates distinctive habitats. The ecological effects of modification within headwaters and intermittent streams are magnified by the elevated runoff and nutrient inputs to waterways that are associated with development activities (Freeman et al. 2007). Burns & Ngyuen (2002) suggested that approaches that minimised decline in subsurface hydraulic conductivity of pastoral wetlands as a result of soil compaction would minimise the run-off of nitrates into streams.

The ecological values inherent in headwaters and intermittent streams justify more extensive protection for these habitats than that provided by the Proposed Auckland Regional Plan: Air, Land and Water. Recent research suggests that the distinction between permanent and intermittent streams is arbitrary in some respects, and the approach to conservation of intermittent streams present in PPC 23 is justified. However, management of intermittent streams and headwaters is complex and consideration must also be given to social and economic factors. Some provision for incorporation of these perspectives is present in PPC 23, as Policy 8.3.5.6 maintains that intermittent streams should be retained "to the greatest extent possible".

Defining intermittent and perennial streams

There is much inconsistency in the terminology applied to streams that flow for only part of the year; temporary, transient, intermittent and ephemeral have all been used to describe streams with irregular flow (McKergow et al. 2005), Nevertheless, flow duration is typically used to differentiate between stream types: intermittent streams cease to flow for parts of the year; ephemeral streams may flow during storm events but typically not for extended periods following a storm – and can be divided into ephemeral streams with defined and undefined channels (maybe termed swales) (Wigington et al. 2005).

Defining headwater streams

Definitions of headwater streams vary but clearly every waterway is fed by many first and second-order streams that connect upland and riparian systems with permanent river systems downslope. A first-order stream is usually an intermittent or perennial stream with no temporary or perennial tributaries, while a second-order stream is formed by the confluence of two first-order streams (Freeman et al. 2007). Many first-order streams do not have well-formed or defined channels or flood zones, and may be a large area of predominantly wet boggy vegetation. In these circumstances it is difficult to define where a stream starts and can be subject to dispute; especially when visited and observed in different seasons. These areas may also be termed wetlands, especially where the channel is poorly defined or spread out. Emergent wetland vegetation can be expected to develop where water velocities during floods are not high enough to scour the channel.

Johnson & Gerbeaux (2004) described seepages as a type of wetland most likely to also be termed headwater streams: an area of slope with surface and groundwater flow that is "less than that which would be considered as a stream or spring" and which receives periodic flushes of water from rainfall. In their Proposed Auckland Regional Plan: Air, Land and Water, the ARC make no definition of headwater stream; rather streams categorised as intermittent streams simply do not meet the criteria assigned for permanent water.

As part of the NSCC Long Bay District Plan variation, springs (seepages) were defined as surface expressions of the underground water flow (i.e., as overland water flow). This underground flow or groundwater passes through permeable or porous sediments above relatively impermeable soil or rock layers. Saturated soil in lowland areas can force the groundwater flow to the surface forming seepages or springs. Springs and seepages form important components of hydrological systems, providing an important connection between groundwater and surface waters. Although seemingly small, the flow from springs and seeps can provide important sources of water for streams especially during dry summer months.

Despite these definitions, there is a need for a practical definition that can be used 'on the ground' on the North Shore. For the purposes of the PPC 23 we suggest the following as a definition for overland flow paths and headwater streams:

A headwater stream is formed from a variable area of seepage(s) and overland flow path(s) with or without a permanently-formed water channel and that converges on a point(s) downslope in the catchment where a visible incised channel is formed. Seepages and overland flow paths are recognised by often wet and boggy depressions in the landform with distinctive vegetation that differs from the surrounding landuse. From the point where a visible incised channel is formed downslope, the channel forms a permanent or intermittent stream and accordingly is subject to the respective definitions of these stream types.

Recommendation
We recommend that the PPC 23 is applied to headwater streams (including overland flow paths). Given the often spatial extent and irregular area of headwater areas and overland flow paths, for the purpose of the PPC 23 we suggest that the 10 m riparian zone is formed longitudinally or circularly (whichever encompasses the greatest extent of headwater stream) from a 10 m radius from the point of the first recognisable stream channel that occurs downslope. Note that as headwater streams are characteristically variable in spatial extent, under this definition, in some circumstances only a small portion of the headwater stream will be protected.

5.2.8 Concrete channels

Concrete channels are often a feature of highly urbanised environments. The North Shore is no exception and concrete channels make up a proportion of the waterways of the City. Typically, the streambed and banks of concrete channels are comprised of smooth hard surfaces, with little or no instream macrophytes or riparian vegetation. This means that very little organic matter is available to these channels; nor is any organic matter able to be retained in these streams. However, algal communities can form along the bottom of the concrete channels and form an important food source for the organisms present.

The lack of shade accompanying concrete channels, and the typically very shallow baseflow (often a shallow film of water running over the surface of the channel base) means that temperatures can be high. Kingett Mitchell (2002) found that concrete channels had the highest water temperatures for sites sampled in the North Shore region (mean = 20.8°C) while dissolved oxygen concentrations were typically above saturation probably as a result of the shallow stream depths and the high abundance of periphyton growth on the concrete channels. In addition, the concrete stream reaches were characterised by the highest water clarity for sites sampled in the North Shore. Kingett Mitchell (2002) also reported a mean riparian width of 0.5 m, with streamside vegetation extending to a maximum of 1.4 m for Group 4 streams (including concrete channels).

Concrete channels also supply important ecosystem services, being valued principally for drainage, and the fast and efficient removal of stormwater and floodwaters from residential, commercial and industrial areas. Other services include recreational, biodiversity, aesthetics and cultural uses.

Concrete channelled-streams are often regarded as having little in the way of ecological values and contain only a small number of invertebrates; in concrete-channels there is no shelter or refuge from fast flows and only very small organisms can live in them (Suren and Elliott (2004). The concrete-channel waterways of North Shore City contain few species of organisms but nevertheless such communities do form functional ecosystems. Observations undertaken by Kingett Mitchell during their survey of North Shore City streams suggest that the concrete channels sampled had functional ecosystem values as follows:

- During baseflows a thin film of algae and bacteria provides the base of a food chain for higher organisms. The algae also form a potential for uptake of contaminants in the waterway.
- A large abundance of a small number of species (typically worms, chironomid midges and snails) providing secondary production for higher organisms.
- The presence of a fish species (especially eels and inanga) living in or in the vicinity of the channels, and the migration of other native fish (e.g., banded kokopu) through the channels to other habitat upstream.

The question emerges as to whether concrete channels should be subject to the same proposed plan change as other non-concrete streams of North Shore City. The main benefit of riparian vegetation to concrete channels will be shade (to reduce high temperatures) and the potential input of organic matter (leaves, twigs etc). On the other hand, the input of large amounts of organic matter and/or large components of organic matter (i.e., tree branches) has the potential to compromise the ecosystem services provided. Consequently, a different community of riparian planting may be appropriate for concrete channels (e.g., low stature non-woody plants).

Recommendation

We suggest that the proposed PCC 23 is also applicable to concrete channels, accepting that the riparian plant communities may be different from those suggested for non-concrete channel streams of the North Shore.

5.2.9 Exotic versus native trees

In most circumstances in New Zealand, native plants are recommended for riparian planting. In Auckland, the ARC advocate for eco-sourced native vegetation for all replacement and restoration planting in the Auckland region for their overall, but unspecified, wide range of beneficial environmental effects (ARC 2001). The Riparian Strategy and Guideline (ARC 2001) recommends that native vegetation in the Auckland Region should be protected, enhanced or restored. The strategy allows for the protection of some exotic plants depending on purpose and status; the protection of existing exotics is supported if they are non-invasive and have positive environmental values, such as landscape and amenity value. The strategy goes on to say that while, in many cases these existing trees also provide food and habitat for a wide range of birds and terrestrial species, the preferred long-term management strategy for beneficial exotic species in riparian zones would be to under-plant and replace with natives in a natural succession.

Research on the pros and cons of native versus exotic plants for achieving the benefits to stream ecosystems in New Zealand is limited. Quinn & Scarsbrook (2001) considered the restoration of restoring the food supply (energy base) to streams and concluded that it is best to plant trees with fast-decaying leaves in flood-prone streams with poor leaf-trapping (retention) ability; and a mix of trees with fast and slow-decaying leaves in streams that better retain leaves within the stream (e.g., typically headwater streams). These results support those of Parkyn & Winterbourn (1997) who also concluded that no strong associations occurred between invertebrates and native tree leaves in streams. Quinn & Scarsbrook (2001) went on to suggest that native species do not have to be planted to provide food and habitat for stream invertebrates; although native plants do provide a land-based benefit for terrestrial-based biodiversity and conservation value.

The research results outlined above suggest that a focus on exclusive native riparian planting for the purpose of enhancing instream ecology will not offer distinct advantages over planting exotic plants, especially in the short length, flood-prone streams of the North Shore City. Nevertheless, there are advantages in advocating native riparian planting for the greater ecosystem benefits of connectivity along catchments (connecting existing native plantations, reserves and headwaters), and for the purpose of enhancing local environments for native birds, reptiles and invertebrates. We suggest that the overall benefits of native riparian zones outweigh the use of exotic plants and recommend that eco-sourced native plants are advocated for the protection and enhancement riparian zones on the North Shore, but accept that significant existing exotic plantings may equally achieve the aquatic ecological objectives.

Recommendation

That PPC 23 advocates for eco-sourced native vegetation for all replacement and restoration riparian planting in the North Shore region.

5.2.10 Other mechanisms

As mentioned in Section 4.3, the protection and enhancement of riparian vegetation is now a well-recognised means of protecting stream environments; so much so that it is essentially an automatic 'default' activity for resource use (including land subdivision) mitigation and compliance, as well as corporate and voluntary acts of stream protection. The benefits of riparian margins are clear and well-researched (see Section 2), although anticipated outcomes may not always be achieved (cf. Section 2.4).

Despite the focus on riparian management, it is pertinent to ask a question of what other mechanisms can achieve the same goals and objectives (i.e., stream protection through the benefits that can be derived from riparian vegetation). There are a number of alternative mechanisms that can achieve at least some of the same outcomes as riparian planting. These include improving bank stability (through engineering design or strengthening; or worse - channel straightening), shading and temperature control (through artificial stream cover), adding instream habitat, and reducing stormwater run-off. Many of these result in further disturbance to a waterway (e.g., engineering solutions) or require continuing maintenance to retain the protective capacity of the enhancements.

6.0 POLICY RECOMMENDATIONS

The Sections above provide an overview of the issues facing riparian management and its implementation in streams of North Shore City. However, given the variation in aquatic and riparian quality and condition throughout the North Shore City streams, the following is recommended:

Definitions

- **Riparian zone, area or margin**: a strip of land which separates an inland, upland or hillslope area from streams, lakes and wetlands, and where activity is modified to prevent adverse effects on the water quality, biota and habitat within the watercourse.
- **A headwater stream** is formed from a variable area of seepage(s) and overland flow path(s) with or without a permanently-formed water channel and that converges on a point(s) downslope in the catchment where a visible incised channel is formed. Seepages and overland flow paths are recognised by often wet and boggy depressions in the landform with distinctive vegetation that differs from the surrounding landuse. From the point where a visible incised channel is formed downslope, the channel forms a permanent or intermittent stream and accordingly is subject to the respective definitions of these stream types.

Measurement of riparian margins

- It is recommended that the riparian margin be measured from the point of the edge of the stream water in the stream on the day of assessment (excluding isolated marginal pools and backwaters). Furthermore, it is recommended that the 5 and 10 m are measured horizontal from the stream wetted edge and not via the bank contours (i.e., it is a straight line measurement).

Extent of encroachment within riparian margins

- Retaining the protection of the 0 - 5 m riparian vegetation as a discretionary activity with assessment criteria for any applications for deviation from this rule.
- Retaining the limited 10% encroachment into the 5 - 10 m riparian zone be retained as a discretionary activity but provide assessment criteria for any deviation from this rule.

Intermittent and headwater streams

- The PPC 23 is applied to headwater streams (including overland flow paths). Given the often spatial extent and irregular area of headwater areas and overland flow paths, for the purpose of the PPC 23 we suggest that the 10 m riparian zone is formed longitudinally or circularly (whichever encompasses the greatest extent of headwater stream) from a 10 m radius from the point of the first recognisable stream channel that occurs downslope. Note that as headwater streams are characteristically variable in spatial extent, under this definition, in some circumstances only a small portion of the headwater stream will be protected.

Concrete channels

- The proposed PCC 23 is also applicable to concrete channels, accepting that the riparian plant communities may be different from those suggested for non-concrete channel streams of the North Shore.

Exotic versus native riparian vegetation

- The PPC 23 advocates for eco-sourced native vegetation for all replacement and restoration riparian planting in the North Shore region.

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APPENDIX A

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Report Limitations

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