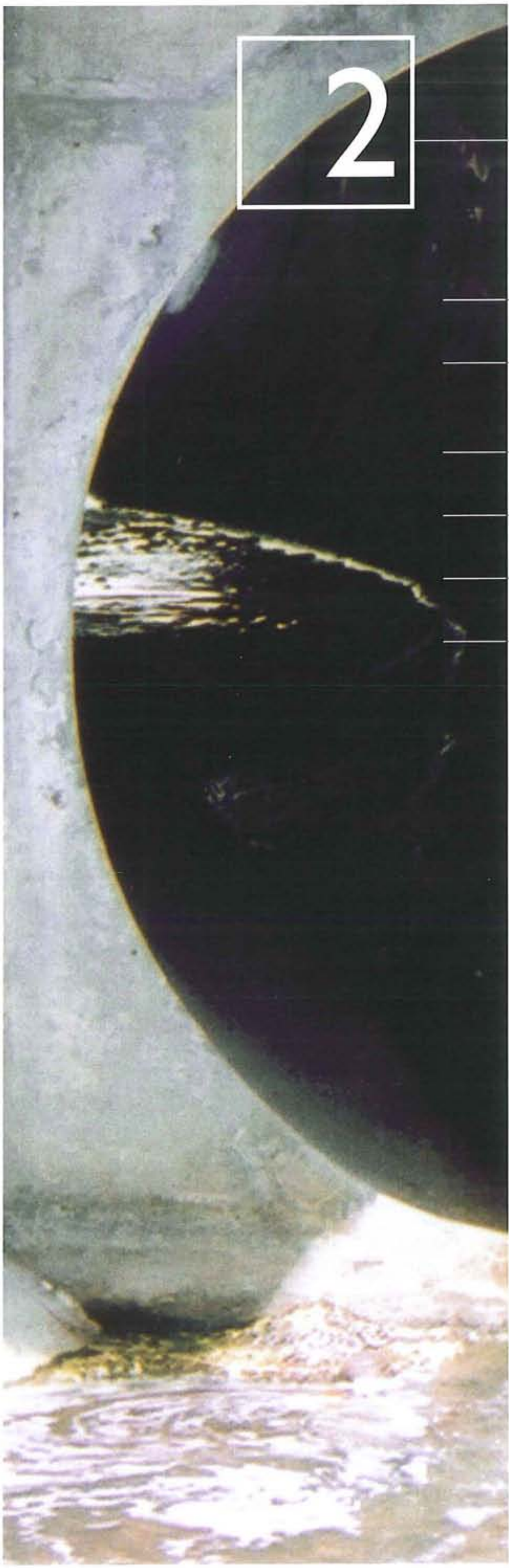

2 Impacts of Development

Page

Urban development has resulted in the piping of many waterways in Christchurch

2.1 Introduction

This chapter provides a brief summary of the impacts of development (urban and rural) on waterways and wetlands. Subsequent chapters suggest actions to lesson the impacts, as well as to provide for the six values identified by Council: ecology, landscape, recreation, heritage, culture, and drainage.

Traditionally, urbanisation has caused major changes to the catchment of an urban waterway, and to the waterway itself, including:

- removal of catchment vegetation and an increase in catchment impervious ground cover
- provision of stormwater drains that concentrate and transport rainfall and runoff (with associated contaminants) directly to streams, thus altering stream hydrology and water quality
- replacement of natural meandering streams with straightened, artificial channels designed to pass large discharges of water during storms
- removal of riparian (bankside) vegetation that prevents bank erosion and provides shade and habitat for instream and streamside communities
- regular removal of streamside vegetation and significant proportions of instream vegetation
- gradual reduction in base flow conditions
- in-filling or drying up of natural springs and loss of associated wetland areas.

The alterations to waterways ultimately suppresses the diversity of instream communities. Whereas unmodified streams can support diverse communities, the conditions in urban waterways often preclude all but the hardiest of species that are capable of withstanding the prevailing conditions (Figure 2-1).

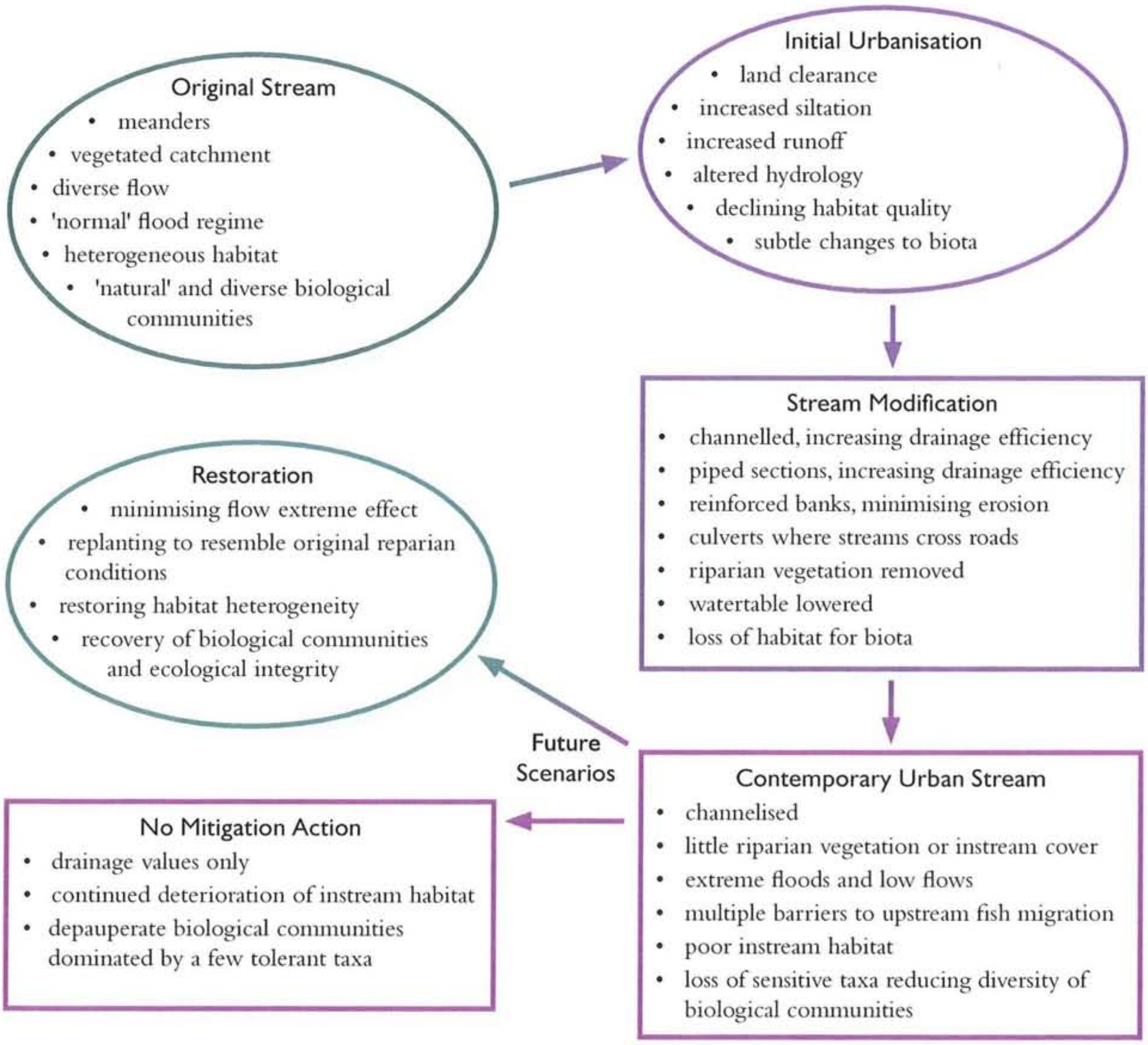

Figure 2-1. Conceptual model summarising the impacts of urbanisation on a natural stream ecosystem. The original stream is altered from a healthy system supporting a diverse community to one of low ecological value. Future issues facing managers include the decision to restore the stream or to take no action. Model adapted from Suren (2000).

2.2 Impacts of Urban Development on Waterways

The relationship between a functioning waterway and the surrounding catchment is a complex and closely interrelated one (Figure 2-2). Single catchment modifications could cause a flow-through of effects through the waterway system. Similarly, seemingly non-related modifications to the catchment could create compounding effects on the waterway and its environment.

Due to the nature of waterways, any catchment alterations occurring upstream can cause impacts that are downstream of the actual initial catchment disturbance. Consequently, catchment disturbance may effect a waterway far past where that disturbance is visually evident.

As a general rule, smaller streams are likely to be more responsive to catchment and riparian changes because of the greater degree of shading by riparian vegetation, shallower depths and lower flows (Davies-Colley & Quinn 1998).

This section only briefly introduces the main impacts (both direct and indirect) of urban development on waterways. Refer to Williamson (1993) and Suren (2000) for more detailed information on the impacts of urbanisation on waterways.

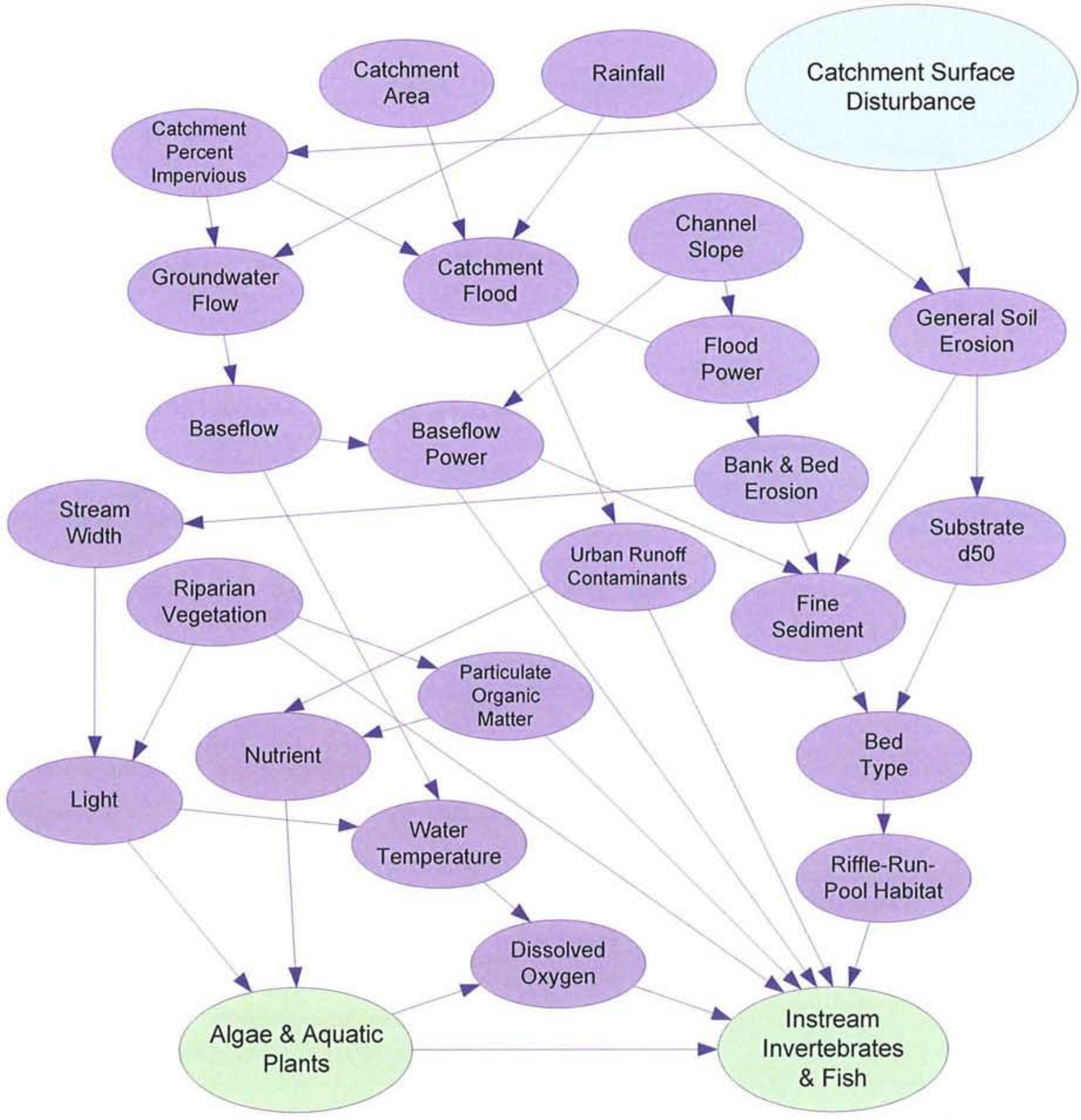

Figure 2-2: Diagram illustrating the complex interrelationship of factors (both natural and those caused by catchment development) that contribute to stream ecosystem health.

2.2.1 Increased Flood Flows

Urban development has a considerable influence on hydrology. Most natural lowland catchments are vegetated, which intercepts rainfall and allows the infiltration of water into the soil. Urbanisation replaces vegetation and permeable soil with hard surfaces that reduce infiltration and soil percolation. The surface roughness that retards water flows is also decreased. Many areas with pervious cover are also so compacted that the runoff response is similar to impervious surfaces. Consequently, water that was once intercepted by vegetation or filtered through the ground is retained on the impermeable surfaces and carried to stormwater systems. Impervious surfaces and underground drainage systems increase the stormwater runoff and the speed and efficiency at which it is transported to waterways and wetland areas.

Such changes in the landscape cause an increase in the number of floods, runoff volume and flood height, the rate of rise of floods, and a decrease in flood duration. Consequently, during rainfall there is a greater peak flow and shorter lag time for stream flows in urban areas (Figure 2-3). For example, a lag time of 2 hours in a rural area can decrease to 20 minutes in an area with 20% impervious areas (National Water and Soil Conservation Organisation, NWSCO, 1981).

Flood flows in streams with no natural refuge areas, (e.g. channelised streams), can wash away and damage organisms due to the movement of fine substrates.

During significant storms a considerable amount of litter accumulated in the drainage system becomes mobile. This can cause blockages at debris traps and at any other obstructions in the waterway channel.

2.2.2 Reduction in Base Flows

An increase in impervious areas within a catchment will reduce soil percolation, which may reduce groundwater recharge and consequently stream base flows, often to the point that sections dry out during summer months (Figure 2-4). Draining of wetland areas also compounds the problem, as wetlands buffer downstream flows by filling during rainfall then slowly discharging over an extended period. Most heavily modified waterways have a relatively wide channel to contain storm flows. Unfortunately, such channelised streams are too wide to support natural stream ecosystems during base flow conditions.

Reduced base flows decrease the habitat and cover available for stream inhabitants, thereby increasing competition and vulnerability to predators. With reduced flows there is also the likelihood of increased water temperatures and lower dissolved oxygen levels, both of which cause additional stress to instream inhabitants. Temperature is one of the primary factors that influence the growth and survival of stream invertebrates (Quinn & Hickey 1990). For example, many mayflies will not survive if exposed to temperatures above 20°C for extended periods.

Base flows in many Christchurch streams are also affected by subsurface flows from the Waimakariri River, often outside of the waterway's surface catchment area. Thus activities that intercept this groundwater flow, such as quarrying and irrigation could have some impact on these systems.

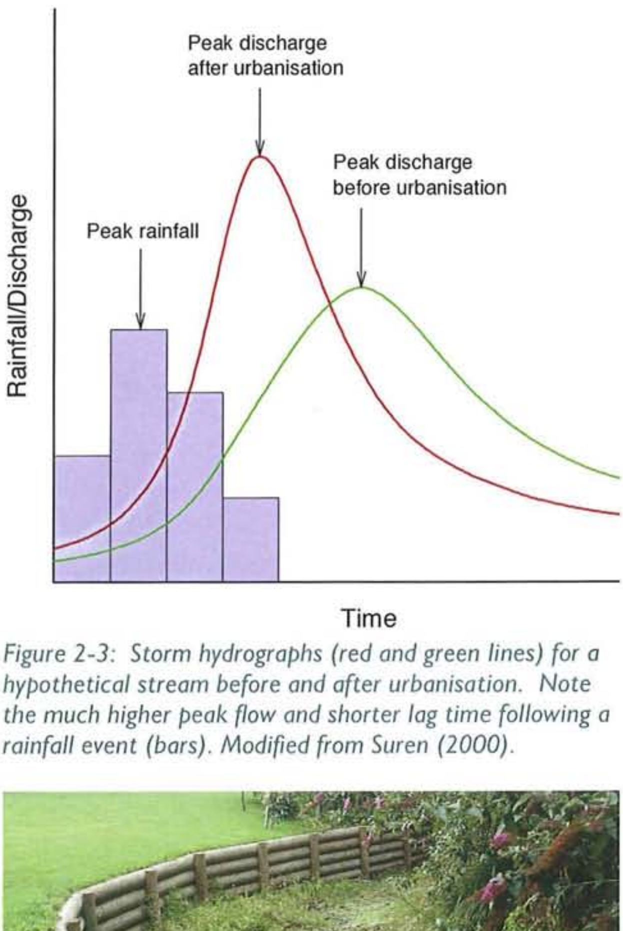

Figure 2-3: Storm hydrographs (red and green lines) for a hypothetical stream before and after urbanisation. Note the much higher peak flow and shorter lag time following a rainfall event (bars). Modified from Suren (2000).

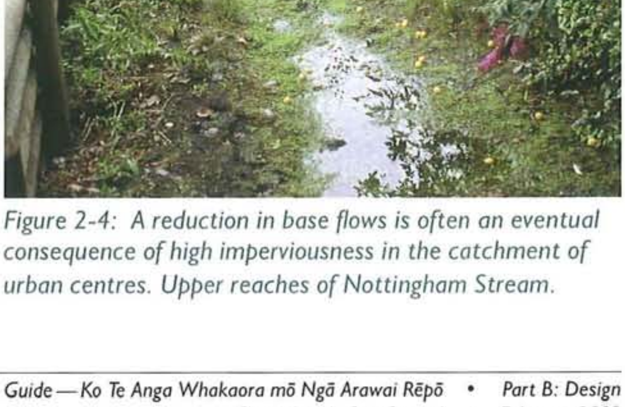

Figure 2-4: A reduction in base flows is often an eventual consequence of high imperviousness in the catchment of urban centres. Upper reaches of Nottingham Stream.

2.2.3 Channelisation

Channelisation incorporates the straightening and realigning of a natural channel in order to increase hydraulic efficiency to drain away excessive water and quickly transport stormwater to the sea (Brookes 1988). Channelisation is often accompanied by bank reinforcing in order to minimise erosion, bank destabilisation, and the natural movement of the waterway channel (Figure 2-5).

Reinforced straight channels offer little structural complexity; there is little habitat heterogeneity, which reduces the number of organisms that can survive in the stream. As illustrated in *Chapter 3.2: Instream Communities and Their Habitat,* the habitat preferences of aquatic organisms vary greatly. Thus a broad range of substrates, depths, and velocities, coupled with bank side vegetation, are needed to support a diverse community. In addition, channelised streams offer little cover for instream organisms during normal or flood flows. In particular, aquatic organisms are exposed to extreme conditions during flood flows, with essentially nowhere to hide.

Figure 2-5A: Concrete lined drains were once installed for good drainage, and to prevent erosion caused by increased flows following channelisation. Victory Drain at Centaurus Road.

Figure 2-5B: Timber lined drains were similarly used in the past, with only drainage and erosion control in mind. Papanui Stream above Grants Road, 1996.

2.2.4 Increased Channel Erosion

Stream channels in an unmodified catchment are in a dynamic equilibrium with the amount of water they carry. However, as urbanisation increases the volume and velocity of water during flood periods, it can also lead to changes in the dimensions of the stream channel, unless preventative measures are taken (Brookes 1994).

With urbanisation a stream will, over time, adjust its hydraulics and morphology to the new conditions that have been created. This can lead to bank erosion where banks are not fully stabilised (either through bank works or planting of vegetation). Repeated bank erosion during flood periods may increase cross-sectional area such that during low flows there is insufficient water to cover the enlarged channel. The continual bank erosion and reduced low flows may also contribute to increasing the sediment loading of the stream.

Bank erosion appears to be an important sediment source in the largely urbanised Avon River/Ōtākaroro catchment, a situation relic from the early 1900's when much of the drain network in Christchurch had unprotected banks and sediment yields were much higher (Hicks 1993).

Bank works to prevent channel erosion in order to protect buildings or for human safety can further decrease available habitat for animals. For example, channel works often remove the undercut banks that fish use for cover.

2.2.5 Reduction in Water Quality

The main contributor to water quality reduction in urban waterbodies is stormwater. Stormwater is rainwater that runs off roofs, roads and other hard surfaces. The rate of runoff from these hard areas increases in proportion to the extent of impervious areas. The stormwater is generally channelled to underground piped drainage systems that efficiently transport and discharge stormwater directly into waterways, and hence downstream to wetlands and estuaries.

The impacts of stormwater contaminants are exacerbated during dry periods when streams exhibit low flow conditions. Stormwater entering streams during the first flush of rain following a dry period typically contain high concentrations of contaminants, which have built up on impervious surfaces and in stormwater sumps. This can be further compounded if the waterbody is experiencing low flow conditions, as the contaminants become more concentrated.

Stormwater from urban catchments contain a wide range of contaminants, ranging from suspended sediments, nutrients, micro-organisms, to chemical contaminants; inorganics such as metals (e.g. lead, copper, and zinc) and organic compounds (synthetic hydrocarbons like petroleum and biocides). These will be discussed in the following sections.

Table 2-1 provides a guide to concentrations of stormwater contaminants in the water and sediment of receiving environments, which have been drawn from areas throughout New Zealand. These levels have been compared with the following Australian and New Zealand Environment Conservation Council (ANZECC 2000) guideline values:

- Trigger levels: Trigger values (recorded here at the 95% protection level) are chemical-specific estimates that can be used as part of a risk based decision scheme for managing and protecting aquatic systems. Values exceeding these levels may warrant further investigation.
- ISQG-Low and ISQG-High levels: The ISQG (Interim Sediment Quality Guideline) values give high and low values, designed to provide guidance about the potential ecological effects of sediment contaminants (e.g. ISQG-high indicates a high ecological impact). Due to the lack of extensive research in New Zealand, these levels have been based on the best available overseas data. Sediment quality guidelines are being actively considered by regulatory agencies world wide. Refer to ANZECC (2000) for further guidance.

Table 2-1 shows that most of the sampled urban streams contained higher contaminant loads than those found in the stream running through native forest, or recommended by the ANZECC (2000) guidelines. In particular, the sampled Christchurch waterways show high levels of zinc, lead and total PAHs (polynuclear aromatic hydrocarbons) compared to most of the other waterways and compared to the ANZECC (2000) guidelines.

Table 2-1: Contaminant levels in stream base flows and sediment from different areas throughout New Zealand, compared to ANZECC (2000) guideline values. Data were collected over 20 weeks from November 1998 under base flow conditions.

Area	Area Type	Dissolved (mg/m^3)		Total (mg/m^3)		Sediment (mg/kg dry weight)			
		Copper	Zinc	Suspended Sediment	PAH	Copper	Zinc	Lead	Total PAH
Christchurch	residential [1]	0.9	11	4.2	0.46	49	785	270	99.3
	residential/commercial	0.5	8	0.5	0.17	77	860	420	29.6
	commercial/industrial [1]	1.4	17	2.2	0.18	87	955	320	14.6
Hamilton	rural/residential [1]	0.9	20	28.5	0.22	45	780	109	1.0
	rural/residential /industrial	1.0	16	26.0	0.79	42	520	94	0.9
	residential	1.0	28	7.8	0.09	18	770	56	0.1
	residential/industrial	1.4	61	12.0	2.69	160	1500	290	4.5
Auckland	rural	1.3	11	27.0	0.09	5	22	4	0.1
	residential [2]	2.0	20	6.6	0.13	42	438	62	0.5
	residential/commercial [3]	2.1	32	7.1	0.14	30	294	67	1.0
	native forest	0.9	5	2.3	0.06	60	110	9	0
ANZECC 2000 Guidelines	**Trigger level [4]**	**1.4**	**8**						
	ISQG-Low					**65**	**200**	**50**	**4**
	ISQG-High					**270**	**410**	**220**	**45**

[1] average from 2 sites; [2] average from 5 sites; [3] average from 3 sites; [4] for a 95% protection level.

Dissolved copper, dissolved zinc and total suspended solids are medians of 20 weekly samples. Total PAH (polynuclear aromatic hydrocarbon) is a single analysis on an unfiltered composite of the 20 weekly samples.

Source: Unpublished data, Mike Timperley, NIWA Auckland.

2.2.5.1 Sediment Loading

While every stream will naturally carry varying amounts of sediment, sediment levels often markedly increase during catchment development. Sediments are typically transported to streams via efficient stormwater systems that carry water from widespread sources, sediment loaded runoff from bare riparian margins, and from stream bank erosion. Stormwater can carry a significant amount of suspended sediment, particularly in developing or newly developed areas.

Catchment size and geography, amount and intensity of rainfall, and catchment proportion undergoing development will influence the amount of sediment entering streams (Williamson 1993). Sediment discharges increase markedly following vegetation clearance of a catchment for development, then decrease until physical development begins. Well established urban catchments typically have small amounts of sediment discharging into streams. The predominantly low gradient of most Christchurch lowland streams means that much of the heavier sediment discharged to streams remains in the system (i.e. doesn't get flushed out to sea).

Sediment inputs can increase both suspended solids (held in suspension above the streambed, measured as turbidity) and sediment bed load (which covers the streambed). Increasing sediment bed load will smother the streambed and alter the habitat of streams with naturally low fine sediment loads and coarse substrates (Figure 2-6; Quinn et al. 1991):

- stable substrates are covered, reducing habitat availability and causing abrasive injuries to instream organisms (due to the constant movement of the fine particles)
- interstitial spaces are clogged, promoting oxygen depletion
- food sources are contaminated (e.g. algal layers laden with silt are less palatable for browsing or grazing invertebrates).

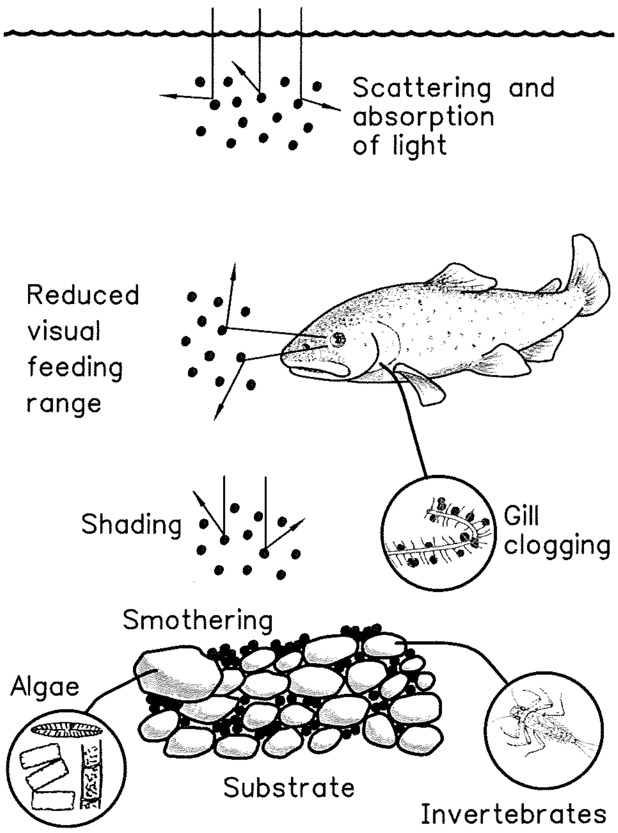

Figure 2-6: Some of the effects of fine sediment on stream ecosystems. Adapted by J. Walter from Quinn et al. (1991). Mayfly from Winterbourn et al. (2000), trout by S. McMurtrie.

Fish and invertebrate communities in streams with high bed sediment loads (natural or otherwise) are generally less diverse than in streams with coarser substrates.

Suspended sediments can clog fish and invertebrates gills, decrease light availability for aquatic plants (Figure 2-6; Quinn et al. 1991), and reduce visibility for fish. Fine sediments from urban streams are also generally very contaminated with chemicals. These chemicals could have potentially severe impacts on instream life, as discussed in the following section.

Chapter 4: Soils and Geomorphology of Christchurch, outlines the main sources of sedimentation for Christchurch waterways.

2.2.5.2 Chemical Contaminants

Chemical contaminants such as metals and organic chemical compounds become a more important concern for waterways as urban development matures and the intensity of urban contaminant sources increase.

Chemical contaminants may enter receiving waters in dissolved form (i.e. metal ions) or bound to organic matter or inorganic particulate matter (especially clay and smaller particles). The greatest concentration of pollutants is generally associated with finer particulate matter (i.e. < 250 nm). Within the aquatic environment, the dissolved ions are generally biologically available, whereas those bound to particles are mostly biologically unavailable (but see below).

Chemical contaminants in streams can adversely affect aquatic life through two pathways:

- Direct interaction between the dissolved form (i.e. metal ions) and an animal's gills. This interaction can occur in the water column and in interstitial waters in the sediment. However, the majority of these dissolved ions are usually bound by particulate matter, so are not biologically available.

- Incidental ingestion of very small particulate matter that is highly contaminated. Contaminated particulate matter trapped on algae and bacterial biofilms can be accidentally ingested by grazing invertebrates and fish. If these contaminants are converted to free ions or more toxic forms in the animals' digestive system, it could be potentially lethal and could also impact on animals further up the food chain (e.g. fish that feed on the contaminated invertebrates). The bioavailability of particulate contaminants has not yet been properly determined.

Invertebrates may be more susceptible to chemical contaminants than fish due to several reasons:

- fish are more migratory than invertebrates and are not usually associated with stream sediments
- fish may be feeding on terrestrial invertebrates, which will not have not been exposed to sediment contamination.

Actual tolerance levels of New Zealand invertebrates to chemical contaminants are not well known, and it is not particularly valid to extrapolate toxicity tolerances from overseas studies. The National Institute of Water and Atmospheric Research (NIWA) is currently investigating the lethality of ingesting contaminated particles for aquatic invertebrates.

As much of the fine particulate matter does not settle out in streams, it will eventually reach the rivers, lakes and estuaries that urban streams discharge to. There the particulate matter settles and contributes to the contamination of the bed sediments. In many situations the contaminants in these bed sediments are steadily increasing because of urban stormwater.

Some Christchurch urban streams that have well developed catchments typically have reasonable water quality, but high contaminant loads in the sediment (M. Timperley, NIWA Auckland, personal communication,). It is possible that the bed sediment contaminant concentrations are limiting aquatic biota in urban streams that have been historically subject to continual additions of chemical contaminants.

Metals

Zinc, copper, and lead are the most common metal pollutants found in urban aquatic environments. Road transport is the major contributor of these metals; lead from car emissions, copper and zinc from vehicle component wear (Snelder & Trueman 1995). Zinc is also relatively common as it is widely used as an anti-corrosion agent. The cessation of lead use in petrol and roof stormwater collection systems has since reduced lead discharges from urban catchments. However there are still moderate to high concentrations of lead in the bed sediments of some Christchurch streams, probably due to historical contamination (Table 2-1).

Metals typically form strong bonds with organic matter or inorganic particulate matter, thus a large proportion of total metal concentrations in urban streams would be biologically unavailable. During rainfall events however, stormwater can contain high concentrations of dissolved copper and zinc.

The bioavailability of such metals is generally higher in stormwater, which has a low capacity to complex metals (bind them to dissolved organic matter). Thus the combination of high concentrations and high bioavailability in stormwater might be hazardous to instream animals, despite a short exposure time.

Hydrocarbons

Most hydrocarbon components found in stormwater are believed to be relatively innocuous in the aquatic environment (Williamson 1993). Soluble aromatic hydrocarbons, which are most toxic to aquatic life, normally evaporate once leaked onto the road. Additionally, microbes present in some aquatic systems are known to degrade organic chemicals although this activity may be limited in the presence of heavy metals.

PAHs (polynuclear aromatic hydrocarbons) could adversely effect aquatic sediment-feeding animals. PAHs are a major class of toxic organic pollutants present in urban stormwater. Their main source is from the partial combustion of fossil fuels (i.e. vehicle emissions) and wood (fires). These compounds can settle out of the atmosphere and end up in streams via stormwater drains.

An additional source of PAHs is the spillage of oil or disposal of car engine oil into stormwater drains. While the latter is only a small fraction of total oil discharge, it may have an effect far in excess of the volume of its contribution (Williamson 1993).

Like metals, PAHs typically become bound to fine particulate matter, and so may be potentially toxic to animals that accidentally ingest them. It is not yet known how toxic these contaminants are to aquatic organisms. A recent study by NIWA has indicated that bed sediment PAH concentrations are extremely high in some Christchurch streams (Table 2-1).

Further information about the adverse effects of stormwater contaminants and guidelines for accepted contaminant levels can be obtained from ANZECC (2000) and Williamson (1993).

2.2.6 Vegetation Maintenance Practices

Maintenance of Bank Vegetation

The traditional management practices for riparian vegetation along urban streams has typically involved extensive cutting of bank vegetation (Figure 2-7). Besides a greatly reduced aesthetic appeal, such hard-handed vegetation maintenance adversely impacts on instream organisms by resulting in the:

Figure 2-7: The long grass growing on the banks of this stream (top) provides both valuable cover for fish and invertebrates, and exit and entry points for invertebrates. The non-descriminant removal of all bank vegetation from the same reach (above) has removed valuable habitat cover, and illustrates the lack of regard for stream ecosystems by the old riparian maintenance practices. Old Lake Outlet Stream, 1997.

- removal of immediate cover for invertebrates and fish, which is especially important where there is little stable substrate in the stream
- removal of exit points for emerging insects
- removal of entry points for egg laying female adult insects
- reduction of a terrestrial food source for fish, which may feed on invertebrates that fall off the overhanging vegetation
- increased light levels and potentially increased in-stream temperatures
- increased microbial activity during the decay of large amounts of cut vegetation left in the stream can also reduce dissolved oxygen levels to a point where it can affect instream organisms in areas with little flow.

Removal of bank vegetation can also impact on native plant species through:

- the direct loss of native plants
- reduced species diversity
- the loss of seed sources
- the establishment of an environment that is more favourable to exotic species (e.g. through increased light levels and the release of nutrients).

Nevertheless, some targeted maintenance of bank vegetation may be required to keep particular weed species under control.

Maintenance of Aquatic Vegetation

Aquatic plants (macrophytes) are often periodically removed from urban waterways due to the drainage problems they create. They are removed by hand in smaller tributary waterways, mechanically dug out in water races, or mechanically cut in larger rivers.

The maintenance practices and removal of these plants in small tributary waterways can heavily impact on the aquatic animal community if significant amounts of vegetation are removed. The disturbance caused by excessive macrophyte removal has the following impacts:

- aquatic invertebrates and fish are removed along with the plants
- in streams with soft sediments, a large number of organisms remaining in the stream no longer have a stable habitat, food source, or cover
- soft bed sediments become resuspended with the loss of vegetation that once bound it together
- in streams with high nutrient inputs the nutrient levels increase due to the loss of the nutrient-binding plants.

The constant removal of aquatic plants has additional repercussions:

- Broken pieces can float downstream thereby facilitating the establishment of nuisance species further downstream.
- Most nuisance species are adept at becoming quickly established in any newly disturbed environment, and will often out-compete the slower growing native species during these early colonisation stages. Thus continual maintenance ensures the ongoing dominance of weedy species.

2.2.7 Loss of Riparian Vegetation

The riparian zone has multiple beneficial functions that benefit the instream environment (*Chapter 9.7: Bank Vegetation*). Thus removal of riparian vegetation invariably leads to a range of deleterious impacts on the stream environment:

- loss of shading leading to increased temperatures and temperature fluctuations, as well as possible proliferation of aquatic plants and algae
- increased overland runoff and soil erosion due to loss of the vegetative protective buffer that intercepts rainwater
- increased bank erosion due to the loss of stabilising plant roots and an increase in overland runoff
- loss of cover for fish and invertebrates that is usually provided by overhanging vegetation and large debris in the stream
- loss of food, habitat, and oviposition (egg laying) sites for aquatic invertebrates that is usually provided by overhanging vegetation, accumulated woody debris, and plant matter in the stream
- loss of riparian habitat and 'green corridors' for terrestrial invertebrates and birds.

2.2.8 Barriers to Fish Access

Eighteen of New Zealand's 35 indigenous freshwater fish are diadromous (need to migrate to the sea for part of their life cycle), thus urban drainage systems often create barriers to native fish and trout, including:

- tide gates
- free over-falls from culverts and weirs
- culvert water flow is too fast for fish to negotiate
- piping of a waterway for extended sections.

Such barriers mean that suitable upstream habitats may not be able to be colonised by many fish species, thus lowering the diversity and ecological potential of these habitats.

2.2.9 Aquatic Plant Proliferation

Both algae and aquatic plants (macrophytes) are an integral part of a stream community and so are beneficial to the overall functioning of a stream system. However in modified environments such as urban areas, increased inputs of nutrients from fertilisers, animal waste, and garden waste, combined with decreased shade can cause excessive growth.

In particular, the extensive proliferation of nuisance aquatic plants (which are generally introduced species) degrade the recreational value of waterways and cause management and drainage problems such as fouling boats, nets, and water intakes, and impeding flow (Figure 2-8). They may also smother native plant communities, facilitate additional deposition of fine sediments, and cause large fluctuations in dissolved oxygen levels, the latter of which could negatively effect some stream organisms.

There are some native macrophytes that provide useful habitats and cover for aquatic organisms, which are not invasive and so should not negatively impact on drainage values of a waterway.

2.2.10 Habitat Fragmentation

Although waterways represent a continual linkage, from headwaters to sea, urbanisation has nevertheless caused a fragmentation of these systems. Sections of more natural waterways may occur within the urban landscape but can be effectively isolated from each other by extensive piped or channelised waterway networks. Such isolation, loss of linkages, and corridors invariably reduces the viability of the remaining natural areas.

Figure 2-8: Egeria densa can completely choke a waterway, and has recently been found in some of Christchurch's larger waterways. Above: pond near the Waimakariri River, Kaiapoi.

2.3 Impacts of Rural Land Use on Waterways

Many spring-fed waterways on the periphery of Christchurch city flow through areas where agriculture is the prominent form of land use. For example, the Styx River/Pūrakaunui, Halswell River/Huritini, and the Ōtūkaikino (South Branch of the Waimakariri River).

Wayne McCallum

Figure 2-9: Stock with access to a stream will remove riparian vegetation and cause considerable damage to the banks, resulting in sedimentation of the streambed and a reduction in water quality (top). Where stock have weakened banks they can collapse and release significantly large amounts of sediment into the stream (above), smothering the gravel substrate.

Rural land use does not always produce the extreme hydrological changes, or high chemical contaminant loads characteristic of urban land use. This is mainly due to the lower traffic and population densities, and lack of a significant increase in impervious layers.

Nevertheless, rural development can have significant impacts on instream values. Cattle, sheep and land cultivation may appear to have a benign effect on waterways, especially now that most point source discharges (such as those from diary sheds) are prohibited. The reality however, is that non point source pollutants from both stock and cultivation, a reduction in riparian vegetation, bank damage from stock, loss of wetlands and springs, and alterations to flow regimes will all significantly impact on instream values.

The following factors associated with rural land use will reduce water quality and degrade the stream environment:

- Increased inputs of pollutants due to loss of the protective riparian zone increasing overland runoff and lack of fencing allowing stock access to the stream, as well as direct discharge of effluent or other discharges to the stream.
- Increased sediment loads from soil disturbance in the catchment (for example, tilling the soil), bank erosion caused by stock access to the waterway (Figure 2-9), or from ongoing drain excavation and maintenance.
- Reduced habitat diversity from the continual draglining or excavating of waterways undertaken to maintain hydraulic efficiency, but which creates uniform depth, velocity, and habitat, and incises the channel.
- Increased bank erosion as a result of deeply incised waterways causing subsequent bank collapse, or bank damage due to stock.
- Increased nutrient concentrations, particularly from overland runoff of fertilisers and faecal contamination.
- Bacterial contamination from overland runoff and stock access.
- Biotoxin runoff, especially from horticultural sprays.
- Abstraction of water for irrigation and stock watering. If this lowers water levels enough it could reduce the instream habitat, increase vulnerability to competitors and predators, increase water temperatures, and increase the concentration of pollutants.
- Loss of wetlands and springs due to the over-

deepening of waterways that is done to lower groundwater levels. This can result in the loss of wetlands and springs due to the subsequent drying out of land.

The amelioration of such impacts are relatively simple if landholders are willing to adjust their practices to accommodate certain strategies. The easiest response is to desist from activities that cause damage to waterways by, for example, not tilling land to the water's edge. A more active method is the creation of fenced riparian zones between areas of land use and waterways. These zones, or strips, serve as an ecological buffer that stops sediment and nutrients from entering waterways, through a combination of physical obstruction (e.g. sediment) and plant assimilation (e.g. nutrients). It is necessary to note that the effectiveness of a riparian strip will vary according to soil type, slope and adjacent land use. Because of this it is not possible to recommend a generic strip width, but Environment Canterbury staff have the expertise to assist in decisions on appropriate strip sizes for different catchment situations.

Where there is a lack of point source discharges, simply fencing the stream off from stock and establishing a good riparian zone will, over time, contribute to improving both water quality and habitat (Figure 2-10). This was illustrated by the 24-year history of rehabilitation of a North Island rural stream (Howard-Williams & Pickmere 1993).

The efficacy of a fenced riparian zone however, is dependant on more than its width. A strip requires active management to ensure, for example, that undesirable weed and pest species are controlled and fences themselves are maintained. In turn, the creation of a riparian strip that includes the planting of indigenous trees and shrubs can not only manage for the adverse effects of land use but will also make a positive contribution to local biodiversity.

Often in the development of a riparian strategy on a rural property the contribution of small drains and wetted zones are overlooked. Although the fencing of these areas increases the cost for a landholder, the failure to do so can mean that the benefits of fencing larger water courses are lost as contaminants from various drains inundate them.

The cost of fencing all of the waterways on a property can therefore be high; added to this may be the expense of supplying alternative sources of stockwater to animals that have traditionally drunk from nearby streams. These costs can be reduced by the use of less permanent fencing options such as hotwires, which can be moved between waterways as stock are shifted. In other cases, one or two hotwires may be satisfactory for permanent fences, if their role is to keep adult cattle and horses out of a stream.

Grant funding for fencing is also available through Environment Canterbury's Environment Enhancement Fund, which can provide some financial support for projects including those associated with waterway improvement that enhance or protect biodiversity. Environment Canterbury's resource care section can be contacted for information about this scheme.

A set of guidelines for reducing the impacts of agricultural runoff on water quality (Ministry for the Environment 2000) can be obtained from the Ministry for the Environment (MfE) web site: http://www.mfe.govt.nz/about/publications/water_quality/managing_waterways_farms.htm

Figure 2-10: Stock can have significant adverse effects on waterway ecosystems through the consumption and trampling of riparian vegetation, trampling of banks, addition of sediment, and the addition of nutrients and pathogens via their excreta. As illustrated above, simply fencing off a stream to prevent stock access can greatly improve a waterway and its riparian zone. Travis wetland in the background, fenced off from stock.

2.4 Impacts of Development on Wetlands

Rural and urban development has resulted in the loss of, and dramatic changes to, remaining wetland habitat in Christchurch. The pressures of both rural and urban development have reduced the number of wetlands in Christchurch to just over 50 identified remaining wetland remnants. In addition, the general impacts of development and river control works and other activities often prevent new wetlands from forming naturally.

2.4.1 Impacts of Urbanisation on Wetlands

In the past, wetlands have tended to be treated as "waste land" and in many areas have been filled or drained. Filling of wetlands is still a threat to wetland ecosystems and those that do remain have an uncertain future.

In an urban setting, the volume of water reaching a wetland is often reduced through changes in the surrounding waterway system and in the water table. The water that does enter an urban wetland is likely to have increased levels of sediment, nutrients, and various pollutants, which can become concentrated within a wetland.

Figure 2-11: Grey willows have overtaken some of Travis wetland, altering the natural light, temperature, and drainage regime of the once open wetland, and complicating restoration attempts.

The flow patterns of water entering and leaving a wetland may also be altered. For example, increases in impervious surfaces around the wetland, channelling of waterways upstream, and the use of stormwater systems, all contribute to creating higher peaks of flow into a wetland.

Within the wetland itself, new pond areas may be formed (e.g. as the result of stop bank formation) and this can create problems such as higher water temperatures, increased weed and algal growth, and low dissolved oxygen levels. Sediment can build up, along with an increased concentration of nutrients, pollutants, and salt through evaporation. Suitable habitat for mosquitoes may be inadvertently formed.

Many people still perceive wetlands as "waste land" and so dumping of rubbish is common. This includes the dumping of garden waste, which often creates weed problems.

Even in the absence of the dumping of garden waste in wetlands, weeds are a major problem in urban wetlands throughout New Zealand. Weeds compete directly with existing remnant native vegetation for resources, and some are also capable of changing the entire habitat structure. Grey willow is an example of a species that can invade a wetland that was formerly open and dominated by short vegetation, to one that is dominated by a tree canopy (Figure 2-11), with consequent effects on light levels, temperature, drainage, etc.

Bird life in urban wetlands is often reduced, even when the habitat is otherwise suitable, because of the impact of nearby predators. Movement and noise, both within and adjacent to an urban wetland, can also disturb wildlife.

Fire is likely to be more frequent in an urban wetland area; species that die back in winter, such as raupo, seem to create an attractive target for deliberate fires.

Trampling of vegetation, by stock or vehicles, can be a significant problem, especially in low-growing salt meadows. Vehicles can cause extensive damage in a short time by damaging vegetation and through compaction of the substrate.

Wetlands are dynamic systems, that over time will progress through various types of vegetation and eventually become dry land. The capacity for new wetlands to be created is greatly diminished in an urban environment and so active maintenance may be required to maintain some existing wetlands.

2.4.2 Impacts of Rural Land Use on Wetlands

Wetlands in rural areas face similar problems to those in urban situations, although usually to a lesser degree. However they also face additional pressures.

Stock Damage

Stock, especially cattle, can cause significant physical damage to a wetland, through the trampling and consumption of native wetland vegetation. Stock can also significantly increase nutrient loads. This can occur even when stock do no have direct access to the wetland itself, primarily as a result of overland runoff to wetlands or to streams draining into wetlands.

While stock can cause considerable damage to wetlands, light grazing by some stock is sometimes used as an appropriate means of weed control for particular wetlands.

Drainage

Drainage is still a common threat to wetlands in rural ares, where the primary focus is on providing feed for stock.

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