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Committee Environment
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Urban stream sediment quality investigation

1. Purpose

To report on the results of an investigation into the sediment quality of 22 urban streams across the Wellington Region.

2. Background

Discharges of stormwater are a permitted activity in both the Regional Coastal Plan and the Regional Freshwater Plan. Over the last few years, the Resource Investigations Department has been investigating the effects of stormwater discharges on various receiving environments. These investigations identified that stormwater entering various urban streams and the coastal environment contains a wide range of contaminants, including heavy metals, poly-aromatic hydrocarbons (PAHs) and organo-chlorine pesticides (OCPs). Monitoring of marine sediment quality in Porirua Harbour in May 2004 also identified elevated concentrations of heavy metals in some harbour sediments, particularly those located in close proximity to stream confluences and stormwater outfalls.

The primary objective of this investigation was to determine whether the discharge of stormwater is causing significant contamination of the sediments within urban streams, in particular, whether the degree of contamination poses a risk to aquatic ecosystems.

3. Strategic context

Clean and healthy rivers, streams, and coasts are one of the *Take 10 Quality for Life* targets of Greater Wellington Regional Council's Long Term Council Community Plan. Monitoring to date indicates that urban stormwater discharges may represent a major hurdle to achieving this target. This is the primary reason the Council is developing a Regional Action Plan for Stormwater Management in the Wellington Region.

4. Methods

Twenty two streams were selected for sampling (Figure 1). These streams receive stormwater from either industrial or residential sources, or a combination of both. A total of 29 sediment samples were collected and analysed for the following:

- heavy metals – antimony, arsenic, cadmium, chromium, copper, mercury, nickel, lead, silver and zinc;
- 16 US EPA priority poly-aromatic hydrocarbons;
- organochlorine pesticides (e.g., DDT, lindane and dieldrin);
- total organic carbon (TOC); and
- particle size distribution.

5. Results

The results of the analyses were compared against the Interim Sediment Quality Guidelines (ISQG) contained within the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000). These guidelines are based on two sets of trigger values (concentrations); ISQG low and ISQG high. The low and high trigger values represent a statistical probability of adverse effects on aquatic ecosystems of 10% and 50% respectively.

In sediments, organic carbon binds with organic contaminants to reduce their bioavailability. Therefore, to enable a comparison of potential toxicity between sediments with different amounts of total organic carbon (TOC), the sediment guidelines for organic contaminants require results to be normalised to a TOC content of 1%.

Table 1 lists the streams that were sampled and the elements or compounds, which exceeded ISQG trigger values. The nature of the streambed is also summarised with respect to the dominant substrate present (e.g., gravel, sand, silt, etc.), as determined from particle size analysis. Particle size analysis assists with interpretation of the contaminant loadings; contaminants such as heavy metals are generally associated with the finer sediments (clay, silt) rather than courser sediments.

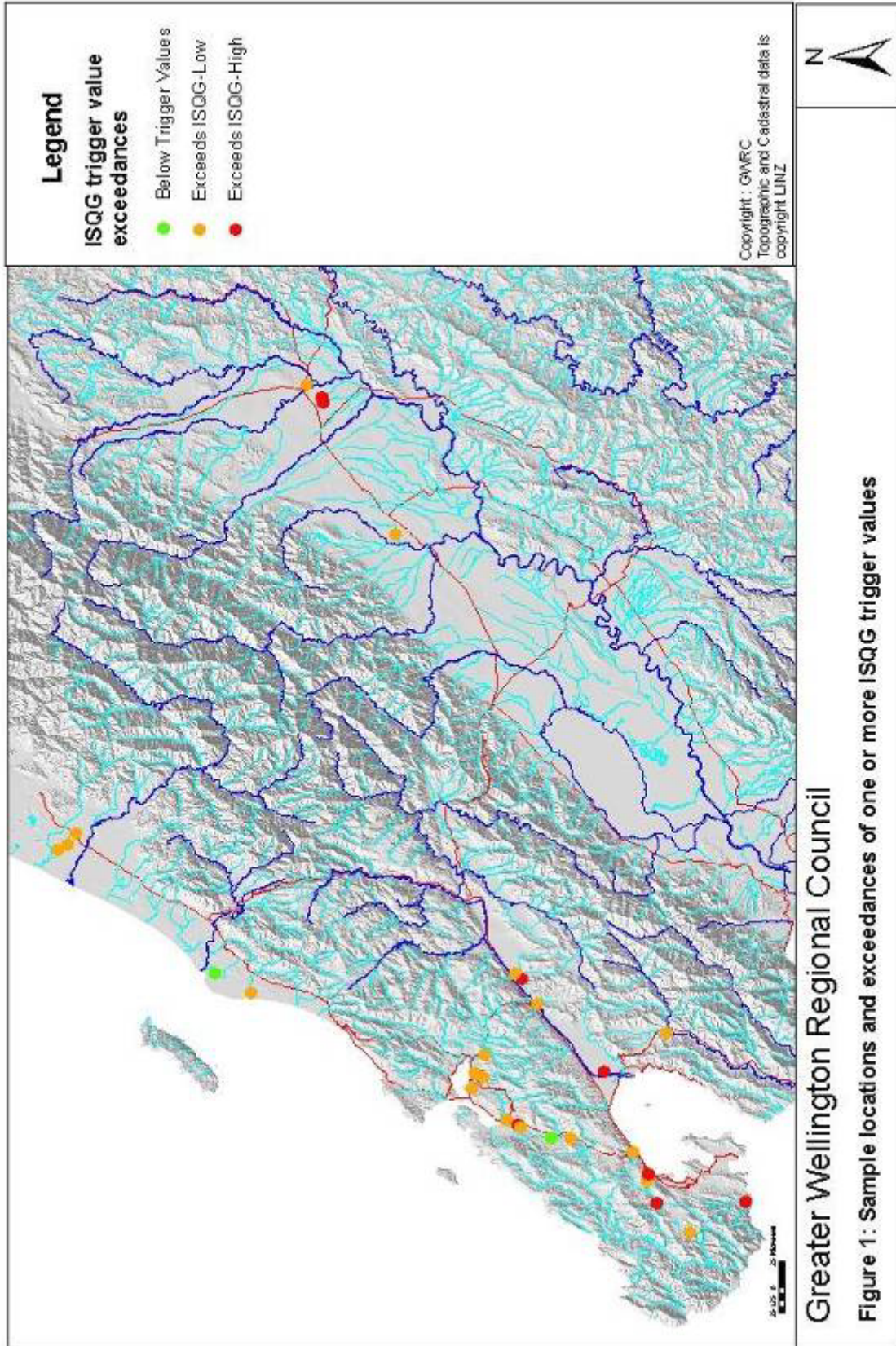


Table 1: Streams sampled for sediment contamination and elements or compounds, which exceeded ISQG trigger values

Stream Name	ISQG Low Exceedances	ISQG High Exceedances	Nature of Streambed*
Kapiti Coast District			
Mangapouri Stream	DDT, Dieldrin, Lindane, Hg		Sand
Tikotu Stream			Sand
Wharemauku Stream	DDT		Silty sand
Mangapouri Stream	DDT, Dieldrin, Lindane, Hg		Sand
Porirua City			
Pauatahanui Stream	DDT		Gravelly sand
Browns Stream	DDT, Zn		Sandy gravel
Duck Creek	DDT		Sandy gravel
Porirua Stream	DDT	Lindane	Sandy gravel
Mitchell Stream	DDT		Sandy gravel
Kenepuru Stream	DDT, LMW PAHs, HMW PAHs		Sand
Wellington City			
Karori Stream	DDT, Zn		Sandy gravel
Owhiro Stream	DDT, Pb, Zn	Dieldrin, Lindane	Gravel
Kaiwharawhara Stream	DDT, Dieldrin, LMW PAHs, Ni, Pb, Zn, PCBs	HMW PAHs	Gravelly sand
Ngauranga Stream	Zn		Sandy gravel
Upper/Lower Hutt City			
Black Stream	DDT		Silty sand
Opahu Stream	DDT, Dieldrin, Ag, Hg, Pb, Zn	LMW PAHs, HMW PAHs, Lindane	Sandy gravel
Stokes Valley Stream	DDT		Sandy gravel
Hulls Creek Stream	DDT, Dieldrin, Zn	Lindane	Gravel
Mawaihakona Stream	DDT		Silty sand
Masterton District			
Makoura Stream	DDT, Dieldrin, Pb, Sb, Zn	LMW PAHs, HMW PAHs,	Sandy gravel
Opaki Stream	DDT, Dieldrin, Zn	LMW PAHs, HMW PAHs,	Silty sand
Kuripuni Stream	DDT, Dieldrin, Lindane, LMW PAHs, HMW PAHs, Pb, Zn		Sandy silt
Carterton District			
Waikakariki Stream	DDT, Dieldrin, LMW PAHs, HMW PAHs, Pb		Silty sand

Note: LMW = Low Molecular Weight, HMW = High Molecular Weight

* Gravel = greater than 2 mm, sand = 63 µm-2 mm, silt/clay = less than 63 µm.

5.1 Heavy metals

None of the 29 samples exceeded the ISQG high trigger values for any of the metals tested and 10 streams did not have any samples with metal concentrations exceeding ISQG low trigger values. Of those streams that did exceed one or more of the ISQG low trigger values, the most common contaminants were lead and zinc; samples from six and eleven streams exceeded the ISQG low trigger values for these metals respectively. There

were no exceedances of ISQG trigger values for arsenic, cadmium, chromium or copper. Antimony, nickel and silver ISQG low trigger values were exceeded once, each in a different stream. Mercury concentrations exceeded ISQG low trigger values in three stream sediment samples, two from the Mangapouri Stream.

The highest concentration of zinc was 352 mg/kg in the sediment sample from the Opahu Stream in Hutt City. This result exceeds the ISQG low trigger value of 200 mg/kg and is approaching the ISQG high trigger value of 400 mg/kg. The Opahu Stream sediment sample also contained the highest concentration of mercury (0.75 mg/kg) nearing the ISQG high trigger value (1.0 mg/kg).

5.2 Poly-aromatic hydrocarbons

For assessment against the ISQG trigger values, the PAH results were split into two groups; low molecular weight PAHs (LMW PAHs) and high molecular weight PAHs (HMW PAHs). With the exception of Duck Creek in Whitby and Tikotu Stream in Paraparaumu, PAHs were detected in sediment samples from all of the streams studied. In terms of guideline values, sediment samples from eight streams exceeded one or more of the ISQG low trigger values, with samples from four streams also exceeding one or more of the ISQG high trigger values.

The highest total LMW & HMW PAH concentrations were present in the Opaki and Makoura Streams in Masterton and exceeded the ISQG high trigger values by a factor of three and four respectively.

5.3 Organo-chlorine pesticides

The following OCPs were detected in the sediments of almost all of the streams studied; cis-chlordane, endosulfan sulphate, DDT, lindane and dieldrin. Of these, only DDT, lindane and dieldrin were present at concentrations that exceeded ISQG trigger values. For example, DDT and its breakdown products exceeded one or more of the ISQG low trigger values in 25 of the 29 sediment samples analysed. However, DDT and its breakdown products did not exceed any ISQG high trigger values.

Five sediment samples exceeded the ISQG high trigger value for lindane with one sample also exceeding ISQG high trigger value for dieldrin. The highest concentration of lindane (0.0068 mg/kg) was found in sediments from the Kaiwharawhara Stream at Otari Bush and was almost seven times the ISQG high trigger value (0.0010 mg/kg).

Polychlorinated biphenyls (PCBs) were detected in sediment samples from the Kaiwharawhara Stream at School Street and the Opaki Stream at Colombo Road. Only the concentration in the former exceeded the ISQG low trigger value; the total PCB concentration was 1.000 mg/kg compared with the ISQG low trigger value of 0.023 mg/kg. While the ANZECC (2000) guidelines do not provide an ISQG high trigger value for total PCBs, the Canadian guidelines

on which they are derived,¹ set an upper trigger value of 0.18 mg/kg. The Kaiwharawhara Stream sediment sample exceeds this value by a factor of five.

6. Discussion

Nearly one third of the streams sampled exceeded one or more of the ISQG high trigger values and 95% of the streams exceeded one or more of the ISQG low trigger values (Figure 2).

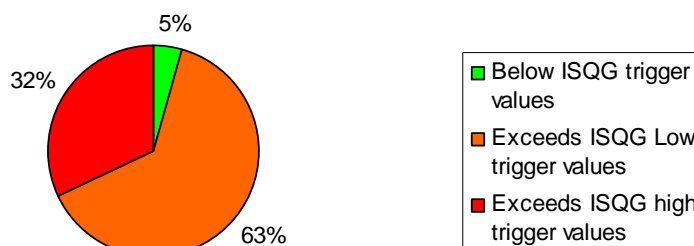


Figure 2: Percentage of streams with sediments exceeding one or more ISQG trigger values

The results of previous investigations have shown that there are high concentrations of heavy metals (notably copper and zinc) and organic contaminants in the fine sediment material (particulates) associated with stormwater. These particulates regularly exceed ISQG high trigger values yet, in the case of metals, high concentrations were not found in many stream sediment samples. This is likely to be a function of the substrates sampled; as noted in Section 5, high concentrations of metal and organics are associated with finer silt particles and there was a notable absence of silt in the samples collected from most streams (refer Table 1).

The lack of fine sediments may be due to the steep topography in some urban areas, together with rapid discharge rates from hardstanding areas during rainfall events, preventing the fine particles associated with stormwater from settling out. Therefore, it is highly likely that these sediments – and the contaminants attached to them – are rapidly flushed through stream systems and into the coastal marine area. This highlights the importance of marine monitoring programmes such as the Porirua Harbour marine sediment monitoring programme.

Exceedances of ISQG trigger values in streams where there are little or no fine sediments and low organic carbon levels is a cause for concern. The lack of organic carbon may increase the bioavailability of contaminants, potentially posing a greater risk to aquatic life.

The likely sources of contaminants in the stream sediments sampled include stormwater runoff from industrial yards, roads, carparks and roofs. In some cases, current or historic landuse practices may also play a role. For example, three operative landfills and one closed landfill are located in the Owihro Stream catchment. The widespread detection of DDT certainly reflects historic landuse practices.

¹ "Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments" (Long et al, 1995).

7. Conclusions

The results of this investigation have identified significant contamination in the sediments of a number of urban streams in the Wellington Region. Some streams, including the Kaiwharawhara Stream in Wellington City and the Opaki Stream in Masterton, contain contaminants that exceed ISQG high trigger values, indicating the possibility of adverse effects on aquatic ecosystems. Such results highlight the need for a review of Greater Wellington Regional Council's permitted activity standards for stormwater discharges.

8. Further work

This project complements a number of other stormwater and sediment monitoring projects being undertaken by the Resource Investigations Department and provides an important link between the contaminants found in stormwater and contaminants found in the marine environment.

Further stormwater investigations programmed for this year will focus on stormwater contaminants entering stream systems early on during rainfall events ('first flush'), when concentrations are likely to be greatest. Where possible, the stormwater will be sampled from streams at locations close to the sites sampled during this sediment sampling investigation, including existing state of the environment water quality monitoring sites.

9. Communications

Copies of the results of this investigation will be made available to the relevant territorial authorities.

10. Recommendations

It is recommended that the Committee:

- 1. receive the report; and*
- 2. note the contents;*

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