STORMWATER QUALITY – AN ANALYSIS OF RUNOFF FROM MODERN SUBDIVISIONS AND THE IMPLICATIONS FOR STORMWATER TREATMENT

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ABSTRACT (200 WORDS MAXIMUM)

In New Zealand many consultants, as well as Regional Councils, rely on water quality data from mature older residential areas, to describe the stormwater quality for modern residential subdivisions, when assessing the treatment needs and environmental effects of stormwater discharges. This paper will present an analysis of stormwater monitoring in Christchurch City and Selwyn District that demonstrates that the stormwater from these modern areas generally has lower concentrations for many contaminants than have been previously reported in literature. Possible reasons why these concentrations are lower, which include the use of factory painted zincalume roofing iron and less leaks from vehicles, will be discussed along with the implications these may have on the requirements for stormwater treatment for modern residential subdivisions.

KEYWORDS

Stormwater, Runoff, Runoff Contaminant Concentrations

PRESENTER PROFILE

As a senior engineer at Pattle Delamore Partners Ltd, Andrew has been working in the field of stormwater management for 20 years. He has extensive experience in consenting, designing, testing, and constructing stormwater treatment systems in Canterbury.

1 INTRODUCTION

The concentrations of contaminants of interest in stormwater and the receiving environment form the basis of determining suitable treatment methods for stormwater from residential and industrial areas. The use of reliable information is important so that the treatment system achieves a suitable level of treatment while being cost effective to build and maintain. In New Zealand stormwater treatment is usually assessed based on water quality data from mature older residential areas. As demonstrated in this paper, using the historic and generic data does not necessarily reflect the quality of stormwater runoff from modern residential subdivisions, which due to factors such as changes to roofing materials and removal of lead from petrol, may have different stormwater quality than previously. This paper will present an analysis of stormwater monitoring in the Christchurch City and Selwyn District that demonstrates that the stormwater from these areas generally has lower concentrations for many contaminants than have been previously reported in literature.

2 STORMWATER QUALITY

2.1 CURRENT STORMWATER QUALITY DATA

The design of stormwater management systems relies on suitable information on stormwater quality. The usual source of such information includes studies such as Williamson (1993) or publications such as Auckland Regional Council's TP10 (2003) or Christchurch City Council's Waterways Wetlands and Drainage Guide (2003). Figure 1 below shows typical concentrations for key parameters that are currently adopted in Christchurch when describing typical stormwater quality (CCC, 2003). Most of this data has been taken prior to 2000 from a range of urban environments throughout New Zealand. This paper compares these pre 2000 subdivision results to post 2000 sampling for mature and new subdivisions and will aid in determining if there is a variation in stormwater concentrations from residential areas over time.

Table 6-2: Discharge concentrations of some stormwater contaminants for different land use categories in New Zealand and recommended ANZECC (2000) trigger levels.

Site	Suspended Sediments g/m^3	Cadmium mg/m^3	Copper mg/m^3	Lead mg/m^3	Zinc mg/m^3	Nitrogen TN mg/m^3	Phosphorous TP mg/m^3
Urban (10%ile)[1]	50	-	15	-	90	1300	200
Urban (50%ile)[1]	170	-	40	-	260	2500	420
Mairangi Bay (residential)[2]	-	0.090	8	2.5	80	-	-
Pakuranga (residential)[3]	-	0.056	15	-	444	-	-
Hayman Park (commercial)[4]	30	-	38	-	249	-	140
Riccarton Main Drain (residential)[5]	62	-	-	-	400	1000	250
Milnes Drain (flat rural/residential)[5]	128	-	-	-	200	1800	400
Wigram Detention Basin (mixed)[6]	101	1.300	14	33.0	412	-	-
ANZECC trigger level (no observable effect)[7]	25	0.013	0.33	1.2	2.4	1600	37
ANZECC trigger level (90%50% protection*)[7]		0.300	-	6.0	15	-	-

[1] Williamson (1993); [2] Opus (2000, cited in Kingett Mitchell *et al.* 2001); [3] Auckland Regional Council (1992); [4] Leersnyder (1993); [5] Main (1994); [6] Brown *et al.* (1996); [7] ANZECC (2000); * 90%50% means that for contaminant levels of this order it should be expected that 90% of the species will be safe 50% of the time.

Figure 1: Stormwater Runoff Contaminant Concentration (extract from CCC, 2003)

2.2 RECENT SAMPLING DATA

In order to determine how stormwater quality has changed since 2000, subdivision monitoring data was collated from a range of locations within various residential subdivisions in the Christchurch and Selwyn District area. Data was collated from three new subdivisions (developed post 2000) and one old subdivision (developed pre 2000). All of the data collated was from samples collected post 2000. Samples were collected from flow in curbs, flow into sumps, or if the rainfall had just finished water within a sump, within the subdivisions. This ensured that only direct runoff from the roads and lots is analysed and gives a representative sample of stormwater runoff before any treatment is provided. At some sites, multiple samples were collected throughout a single rainfall event. At other sites a single sample was collected during the rainfall event. Most samples were taken within the first flush (first 25mm of a rainfall event). All samples were grab samples.

The subdivisions can be characterized as having single dwellings on sections varying in size from around 400 m^2 to around 800 m^2. Total impervious area (roof, hardstand, and roads) varies from around 50% to 65% of the total area.

Table 1.0 below shows the sample location and details of the monitoring data collated for new and old subdivisions throughout the Christchurch and Selwyn District Area.

Residential Subdivision	Sample locations	Total N° of samples	Subdivision Age	Sample dates	Source	FF or non-FF?
Kirkwood	1	7	Post 2000	2005	PDP	FF
Vasari Grange	1	1[1]	Post 2000	2011	Selwyn District Council	FF
Aidanfield	2	26	Post 2000	2006	CCC	Range
Halswell	3	39	Pre 2000	2006	CCC	Range
1. 4 samples were taken at various times throughout a single FF rainfall event – EMC results reported.						

Table 1.0: Sample Location and Frequency of Sampling for Monitoring Data Reported

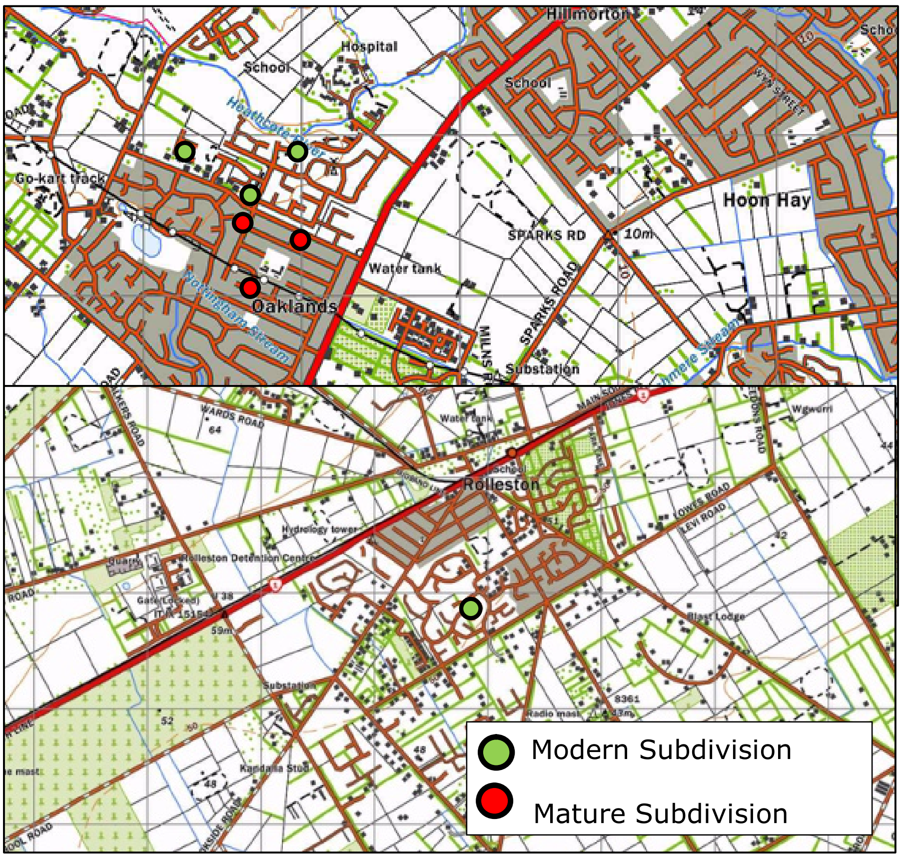

Figure 2.0: Sample Point Locations

Sampling parameters for the various data sources varied, common parameters included heavy metals, Total Suspended Solids (TSS), nitrates, phosphorus, E.Coli and Total Petroleum Hydrocarbons (TPH). In order to compare results to historic contaminant concentrations, key parameters were analysed which include total lead, total zinc, total copper and TSS. Generally these parameters are of most importance in treatment and are also indicator parameters for other types of contaminants. Analysis on other parameters such as nitrates and phosphorus are also discussed in the paper but not analysed in detail due to the lack of monitoring data available.

2.3 CONCENTRATION VS. RAINFALL AND ANTECEDENT PERIOD

In the aim of finding a set of recommended parameter concentrations for new subdivisions that can be adopted for design purposes, factors that influence contaminant concentrations in stormwater runoff must first be explored.

It is commonly accepted in stormwater quality literature that there is a relationship between rainfall and contaminant concentration. In Christchurch the first flush is generally accepted as the runoff from the first 25mm of a rainfall event. In order to assess how the samples fit within this a comparison between rainfall and concentration has been made. Figure 2 shows the concentrations for heavy metal samples obtained from the Adianfield and Halswell subdivisions. Figure 3 shows that there is a weak correlation between rainfall and metals concentration. All samples are point samples with the rainfall reported as being the preceding rainfall up to the point where the sample was taken.

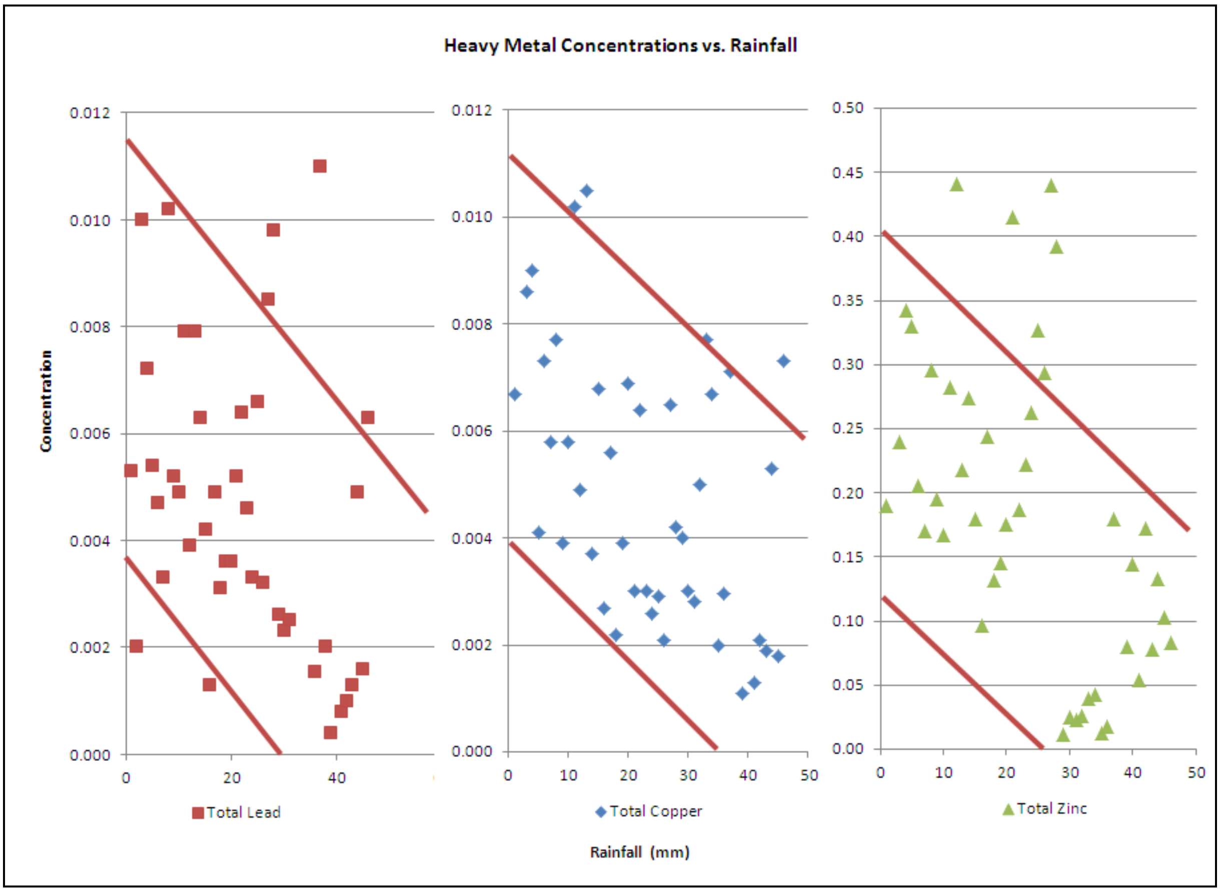

Figure 3: Metal Concentrations vs Rainfall

Based on these results it is important to identify which results are first flush and which samples are taken outside of the first flush event.

Figure 4 shows the concentration for heavy metals versus the antecedent dry period for results obtained from CCC for Adianfield and Halswell subdivisions. Figure 3 shows that there is no apparent correlation between the length of the antecedent period and heavy metals concentrations.

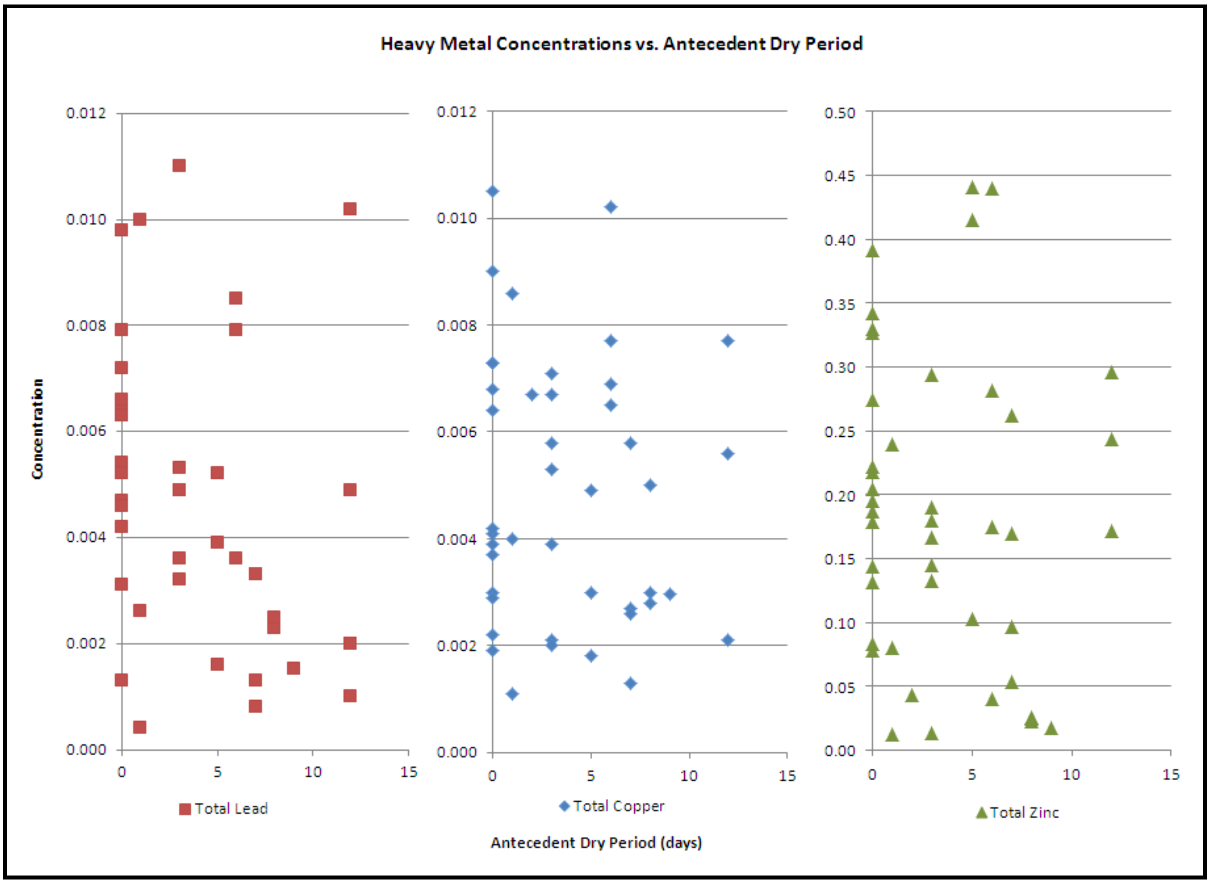

Figure 4: Metal Concentrations vs Preceding Dry Period

2.4 DISSOLVED VS. PARTICULATE FORM

Table 2.0 shows metal concentrations for Kirkwood and Vasari Grange (post 2000 subdivisions) showing the portion of dissolved vs. particulate forms of the metals. These show that on average, the relative percentage of the particulate and dissolved forms of the metals are:

Metal	Particulate[1]	Dissolved[1]	General Dissolved Percentages (ARC – TP237)[2]
Copper	51%	49%	~34%
Lead	96%	4%	~7%
Zinc	73%	27%	~48%

1. Results based on Kirkwood and Vasari Grange Sampling
2. ARC TP237 Table 10

Table 2.0: dissolved vs. particulate forms of heavy metals

The comparison with ARC TP237, Table 2.0 indicates higher concentration of copper in and a lower concentration of zinc in dissolved form in Canterbury. Lead concentrations are similar to reported ARC values.

2.5 CONCENTRATION RESULTS FROM POST 2000 SAMPLING

Figure 5 shows a box and whisker chart of four key parameters for sampling taken from post 2000 subdivisions (Kirkwood, Vasari, Aidanfield) and pre 2000 subdivisions (Halswell). All data is from the first flush portion of the rain events. Figure 5 also shows the average contaminant concentrations in stormwater currently adopted from stormwater design as given in Figure 1 (CCC 2003). ANZECC (2000) 90% protection values have also been shown on the figure to show how stormwater compares to stream water quality.

Figure 5 shows that heavy metals concentrations in post 2000 subdivisions are lower than the concentration in pre 2000 mature subdivisions. The biggest reduction in concentrations between post 2000 and mature subdivisions is zinc. The median concentration for zinc has decreased from 0.253 mg/L to 0.041mg/L. It can also be seen that the distribution of zinc concentrations has reduced in post 2000 subdivisions. This reduction in zinc could be attributed to the removal of galvanised zinc roofing materials and their replacement with COLORSTEEL® (factory coated Zincalume®roofing materials in new subdivisions. The concentration of zinc in mature subdivisions from the 2008 sampling is still similar to the concentrations reported in CCC (2003) (Figure 1). This indicates that mature subdivisions in Canterbury are discharging zinc at similar concentrations as reported in literature.

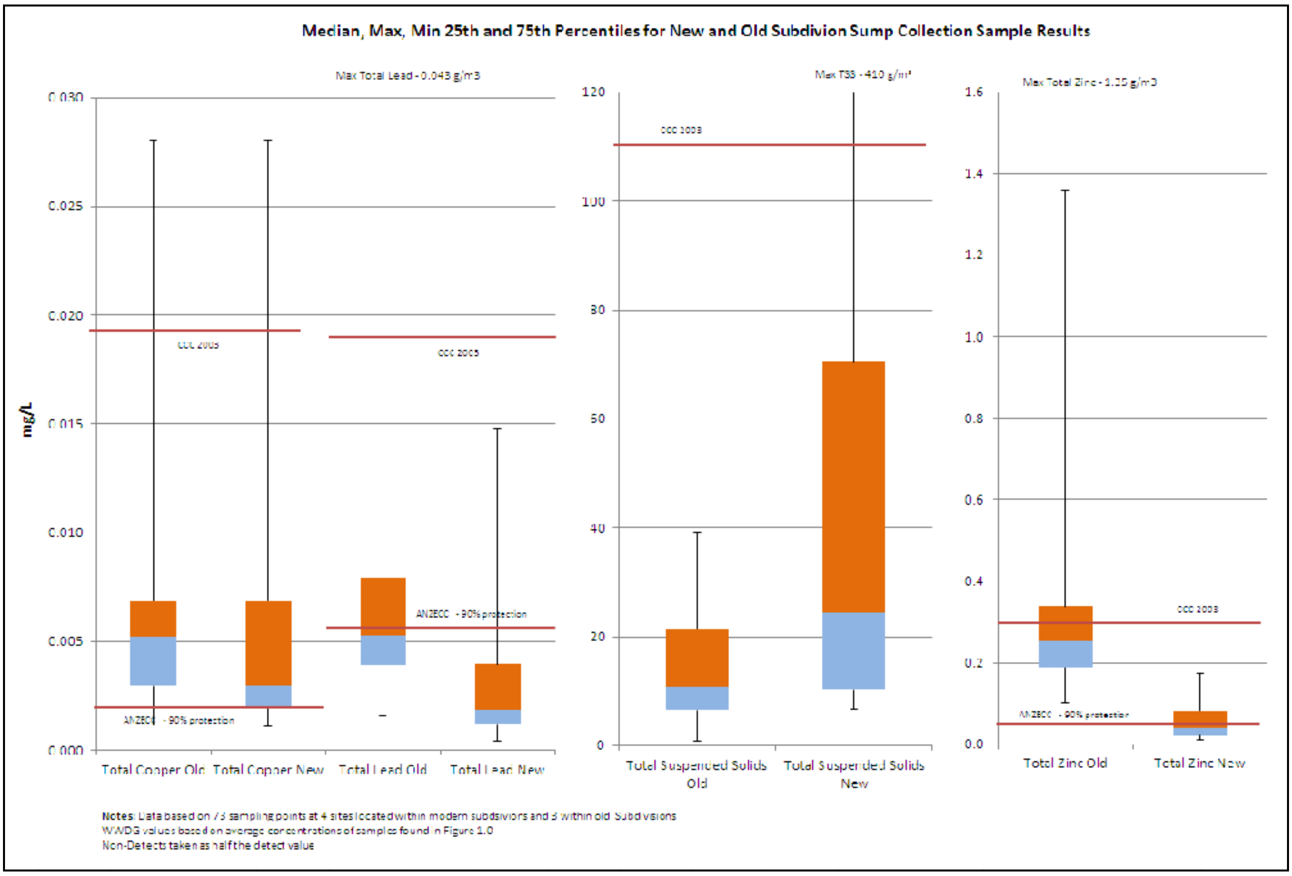

Figure 5: Sample Results for 2008 CCC Samples for Mature and Modern Subdivision

The concentration of lead has decreased significantly from concentrations previously reported in literature for both new and mature subdivisions. This suggests that the source of the lead contamination has been removed from the stormwater catchments in 2008 compared with pre 2000 sampling. This is attributed to the removal of lead from petrol. It is of interest that there is a significant difference in the lead concentration between the mature and post 2000 subdivisions, with a reduction in median concentrations from 0.0053 mg/L to 0.0019 mg/L. It is possible that the difference between the older subdivisions and the modern subdivisions are also due to sources such as lead paints which are still present in older subdivisions but not present in modern subdivisions.

Copper concentrations for the post 2000 and mature subdivisions are generally well below the concentrations previously reported in CCC 2003 (Figure 1.0). There is much less difference between the concentrations for copper between post 2000 and mature subdivisions than for other metals. Sources of copper in the stormwater environment are generally associated with roofing material, guttering and downspouts and car brake wear. While some modern subdivisions do not permit the use of copper for roofs, downspout and guttering, others do, hence some variability in copper concentrations is likely.

TSS results show that the TSS concentrations for post 2000 subdivisions are higher compared to old subdivisions. Although average concentrations are similar the spread of TSS in post 2000 subdivisions is also very high compared to old subdivisions. Very high maximums are observed in the post 2000 results. A possible reason for this is that some new subdivisions contain high sediment loads left over from construction or still have some undeveloped lots with exposed soils. Results for TSS also show that the concentrations of the post 2000 sampling are much lower compared with the concentrations reported in CCC 2003 (Figure 1.0).

While the results tend to show a reduction in metal concentrations from mature subdivisions to modern post 2000 subdivisions, the concentrations (apart from lead from modern subdivisions) for metals are at or above the ANZECC 90% level of protection concentrations. Therefore, the discharge of stormwater to urban waterways should still be subject to treatment. Data for sampling rounds taken after the first flush showed a slight decrease in concentrations, although due to the weak relationship shown between rainfall and concentration (as shown in Figure 3) there was no significant change between results and hence results are not reported in this paper.

2.6 OTHER STORMWATER CONTAMINANTS

Other contaminants commonly analysed in stormwater treatment include total nitrogen, TPH, E.Coli and phosphorus. Data for these contaminants is limited, however results are available for two post 2000 subdivisions; Kirkwood, Vasari Grange and Dissolved Reactive Phosphorus DRP from one CCC site. Table 3.0 shows the range of concentrations obtained from these two subdivisions along with the average concentrations reported in CCC 2003 and Williamson 1993 (Figure 1.0).

Total Nitrogen results show little difference between mature and post 2000 subdivisions. E.Coli results indicate that E.Coli samples can be highly variable and depend highly on the location of the sample and the land use type e.g. its locality to parks etc. TPH results were all below detect levels indicating that TPH is very low in typical residential stormwater and that concentrations may only be expected in the event of an accidental spill.

Contaminant	Post 2000 sample	CCC 2003
Total Nitrogen (g/m^3)	0.5 – 2.6	1 – 2.5
E.Coli (MPN/100ml)	2 – 145	97[2]
TPH (g/m^3)	< 0.7[1]	1 - 5[2]
DRP (g/m^3)	0.005 – 1.0	0.25 – 0.42[3]
1. All samples below detect limit 2. Williamson 1993 3. Total phosphorus reported		

Table 3.0: Concentrations of Other Stormwater Contaminants

2.7 PRE 2000 VS. POST 2000 SAMPLING IN MATURE SUBDIVISIONS

To compare the effect of how contaminant concentrations have changed with time irrespective of land use, a comparison between samples taken in 2008 for mature subdivisions only has been investigated. Table 2 shows the 2008 sampling results from mature subdivisions compared to CCC 2003 (Figure 1.0) samples taken pre 2000.

Contaminant	Pre 2000 samples (g/m^3)[1]	2008 samples (g/m^3)[2]
Total Suspended Solids	115	11
Total Copper	0.019	0.0053
Total Lead	0.018	0.0053
Total Zinc	0.30	0.25
1. Samples taken from Williamson, Mairangi Bay, Pakuranga, Riccarton Main Drain, Milnes Drain and Wigram Detention Basin: Results are an average of these reported concentrations – source: CCC 2003 2. Samples taken from Halswell CCC data at three monitoring sites – FF concentrations reported. 3. All results are based on all sample data for all rainfall depths and are median values		

Table 4: Change in Contaminant Concentrations Over Time

Table 4 shows that concentrations of TSS, copper and lead in the 2008 sampling round has reduced compared to samples taken pre 2000. The reduction of these contaminants could be due to the removal of lead in petrol, removal of lead in paints, removal of older cars which may place more heavy metals on the road and general improvement in water quality from public awareness of chemicals. Zinc however remains reasonably consistent indicating that the influence of galvanised zinc roofing contributing to stormwater runoff is still apparent in mature subdivisions.

These results should be considered when retro fitting or designing a system within a mature development. Consideration must be given to the fact that even though metals concentrations have reduced through the use of modern cars and materials, high concentrations of some contaminants such as zinc could still be expected.

2.8 COMPARISON OF CONCENTRAIONS TO CURRENT WATER QUALITY DESIGN LEVELS

Figure 6 shows a summary of heavy metal concentrations for pre and post 2000 subdivisions. The data has been arranged in order of sample date (older samples to the left and recent samples to the right). Arranging results in this order allows a comparison between older samples taken and mature subdivisions and recent samples taken from modern subdivisions to be made. Note that the y axis is a log scale to enable all three metals to be shown on a single graph.

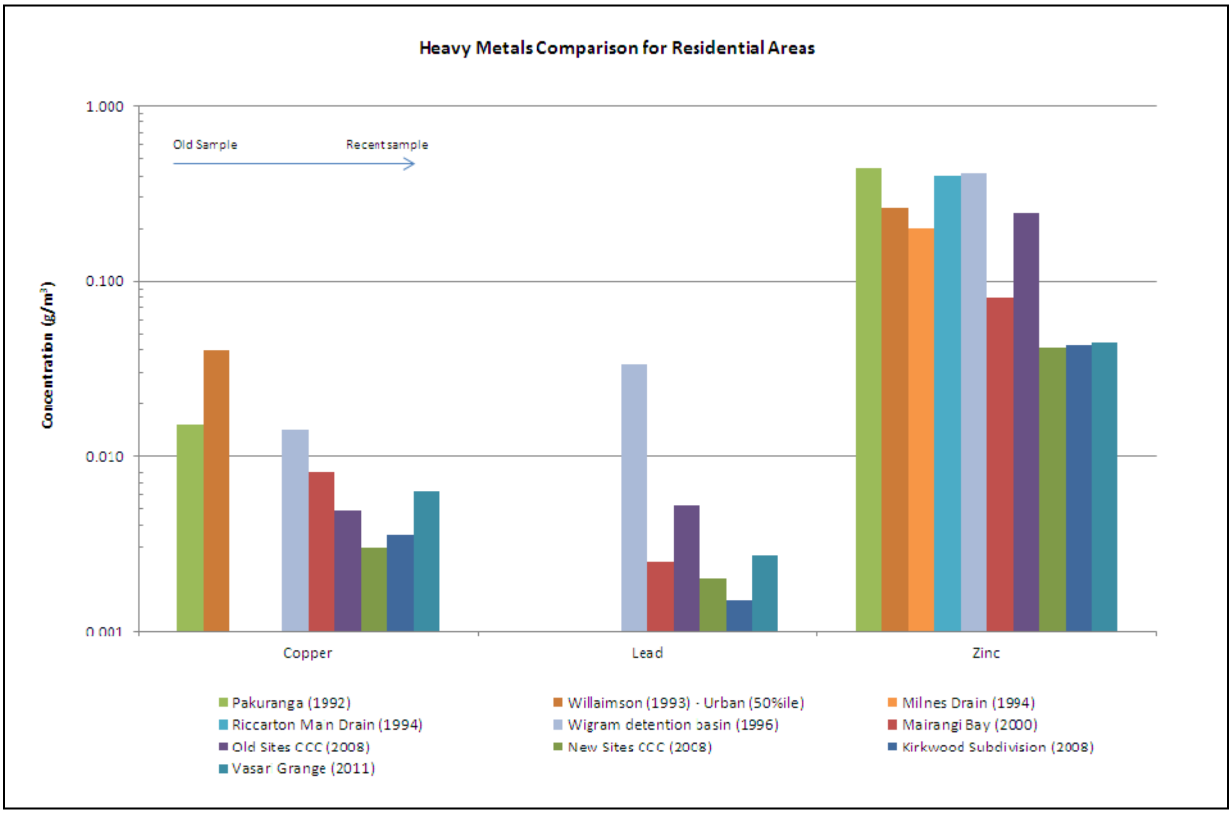

Figure 6: Heavy Metal Concentrations for Residential Areas
(Note: Vasari Grange, Kirkwood and CCC results report first flush concentrations)

Figure 6 shows that the samples taken from the older subdivisions (including recent samples taken from mature subdivisions) show higher metals concentrations compared to more recent samples. A notable downwards trend is apparent from 1992 through to 2011 samples.

A very distinct drop in zinc levels can be seen between the 1996 and 2000 samples. In 1994, Zincalume® steel was introduced to the New Zealand market. Zincalume® steel has almost completely replaced the use of galvanised steel for new roofing in New Zealand (Shedden, B., et al, 2007). ARC (2005) reported on a mass balance calculation of zinc from various sources in stormwater. It concluded that roof zinc accounted for about 50% of the zinc from residential catchments. The concentrations of zinc in the stormwater from the modern subdivision are well under 50% of the previous concentrations. This indicates that either zinc from roofing was greater than 50% of the total source of zinc in residential catchments or that there is virtually no zinc coming from modern roofs. This second point seems unlikely. A single sample of rainwater from a COLORSTEEL® roof in Canterbury (PDP, 2009) had concentrations of heavy metals as shown in Table 5. These results indicate that low concentrations of zinc are still likely to occur from modern roofing and that in the Canterbury environment zinc from roofs contributes a significant portion of zinc in urban stormwater. The zinc and lead concentrations for Old CCC (2008) is somewhat out of place as even though the sampling round is post 2000 high concentrations are still evident compared to other samples taken post 2000. A reason for this could be that stormwater runoff from mature subdivisions still contain lead and zinc due to the presence of older building materials such as zinc roofing.

Metal	Total Concentrations (g/m^3)
Arsenic	<0.0010
Cadmium	<0.00005
Chromium	<0.0005
Copper	0.0014
Lead	0.0001
Nickel	<0.0005
Zinc	0.037
Single point sample taken from a COLORSTEEL® roof (PDP 2009)	

Table 5: Contaminant Concentrations off COLORSTEEL® Roofing

Figure 7 shows the concentration of suspended sediment for the same environments as Figure 6. The concentration of TSS has reduced from pre 2000 samples taken from mature subdivisions compared to the post 2000 sampling.

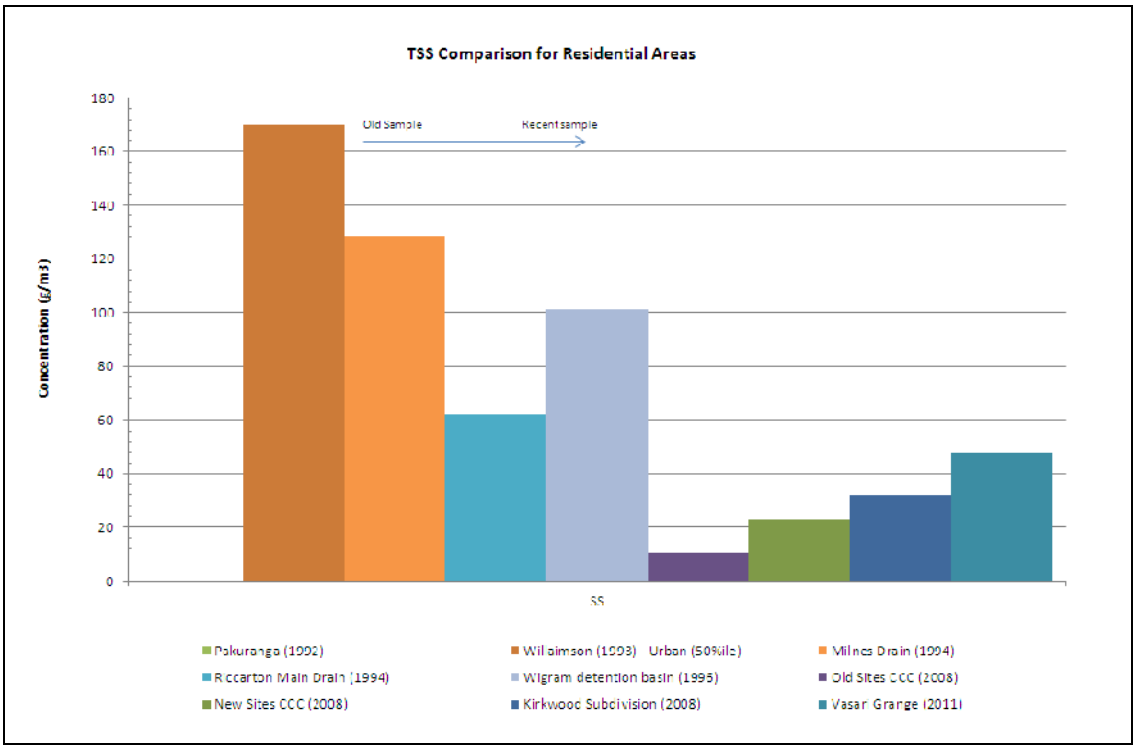

Figure 7: TSS Concentrations for Residential areas
(Note: Vasari Grange and Kirkwood results report first flush concentrations)

It is not clear why the concentrations for TSS have reduced for the post 2000 sampling compared to pre 2000 sampling. Two of the older sets of results (Riccarton Main Drain and Wigram Detention Basin) represent the Christchurch area so rainfall intensity is unlikely to be the reason for the differences. Certainly modern Zincalume® roofing with factory applied paint does not peel as much as old painted galvanised roofing.

Figure 7 also shows the drop in TSS load for 2008 sampling in mature subdivisions compared to the 2008 sampling in modern subdivisions (also shown in Figure 5). As shown in Figure 5, the TSS concentrations for post 2000 subdivisions were highly variable whereas the mature subdivision TSS results were relatively consistent. Again this indicates that new subdivisions have highly variable TSS loads possibly due to construction and undeveloped lots.

2.9 CONTAMINANT CONCENTRATION DURING A STORM EVENT

Stormwater monitoring was carried out by Selwyn District Council (SDC) on the 18th January 2011 in Rolleston at Vasari Grange during an 18mm rainfall event. Vasari Grange is an 18 lot residential subdivision in the Rolleston township. Four first flush stormwater samples were collected throughout the single rainfall event. The stormwater samples are from hardstand areas only and do not include runoff from roofs. The samples were analysed for suspended solids, total and dissolved heavy metals, nitrogen, phosphorus, E. coli and TPHs. The samples were collected at two hourly intervals after approximately, 0.6 mm, 3.5 mm, 8.0 mm and 16.0 mm of rainfall.

Concentrations were normalised to allow comparison between the four samples taken. Figure 8 shows that the first sample collected at Vasari Grange (after 0.6 mm of rainfall) contained the highest concentrations for all determinands. The second highest concentrations were generally recorded in the third sample whilst the third highest concentrations are generally recorded in the second sample. This is slightly unusual, generally the concentration of a determinand would be expected to decrease as cumulative rainfall increases, i.e. the highest concentrations are found at the start of the event and the lowest at the end of the event with concentrations taken during the event decreasing over time. One factor that may account for the trend shown in this sampling is the intensity of the preceding rainfall. Intuitively, higher rainfall intensity may result in greater contaminant concentrations because of the greater dislodgement of the contaminants.

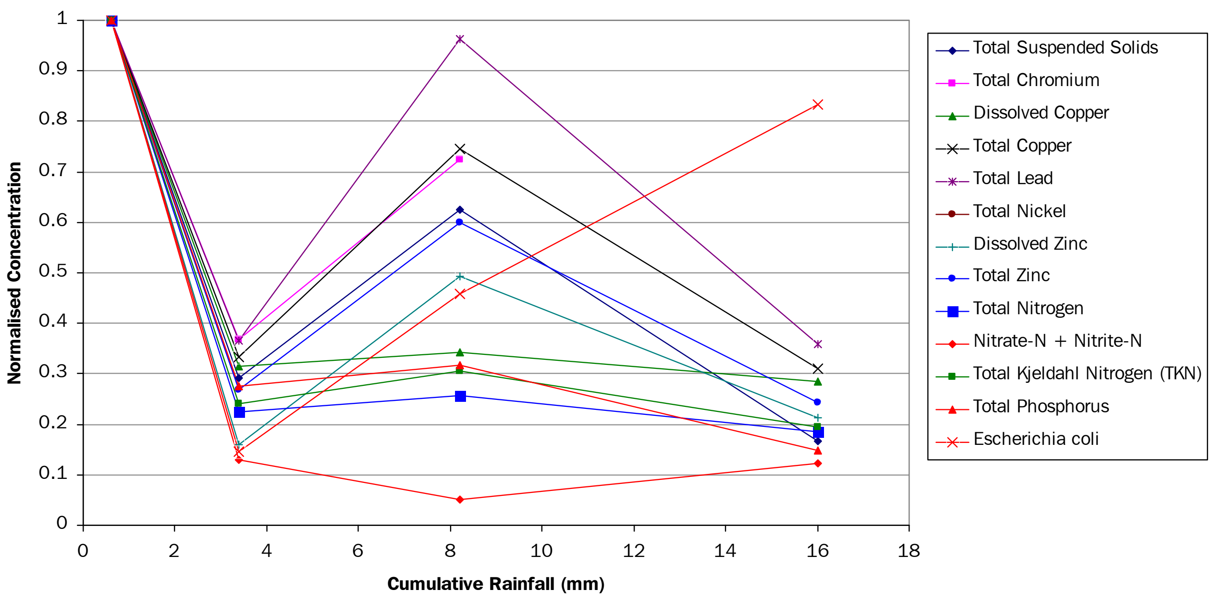

Figure 8: Plot of Normalised Determinand Concentrations for Vasari Grange

For the two hours between the collection of the first and second sample there is approximately 3 mm of rainfall which equates to an average rainfall intensity of

1.5 mm/hr, whilst between the second and third sample, there was closer to 5 mm of rainfall which equates to an average rainfall intensity of 2.5 mm/hr. The slightly higher intensity may have resulted in a greater dislodgement of determinands. The intensity of rainfall between the third and fourth samples was 3.3 mm/hr. These results indicate that intensity plays a part in stormwater concentrations but after most of the contaminants are washed off (the first flush effect), an increase in intensity does not further increase the concentrations of contaminants in the stormwater.

3 RECOMMENDED MODERN CONTAMINANT CONCENTRATION VALUES

Table 6 shows the current contaminant concentrations that have been generally adopted for stormwater treatment design along with the recommended concentrations for stormwater treatment in new subdivisions based on analysis in this paper. Recommended concentrations are based on post 2000 sampling taken in new subdivisions within the Christchurch and Selwyn District from Kirkwood, Vasari Grange and Aidanfield. Only first flush samples have been analysed and the 75th percentile values reported. The 75th percentile values have been recommended as these ensure an adequate factor of safety in the analysis.

Contaminant	**Current**[1]	**Recommended**[2]
Total Suspended Solids (g/m^3)	115	70
Total Copper (g/m^3)	0.019	0.007
Total Lead (g/m^3)	0.018	0.004
Total Zinc (g/m^3)	0.30	0.08
Total Nitrogen (g/m^3)[3]	1.8	1.0

1. Samples taken from Williamson, Mairangi Bay, Pakuranga, Riccarton Main Drain, Milnes Drain and Wigram Detention Basin – Average concentrations reported.
2. Recommended 75th percentile concentrations are FF from Vasari Grange, Kirkwood and New CCC Sites (total of 30 sample events)
3. *Total Nitrogen concentrations based on sampling from Kirkwood and Vasari Grange*

Table 6: Recommended Contaminant Concentrations

It should be noted that the recommended TSS concentration given in Table 3 assumes that the subdivision is fully developed. As shown during construction of a subdivision and for a period afterwards high peaks of TSS could be expected. This has implications on stormwater design particularly in the early stages of a development.

4 IMPLICATIONS OF CONTAMINANT CONCENTRATIONS FOR STORMWATER TREATMENT

The contaminant concentration present in stormwater along with quality of the receiving environment impacts on the level of treatment required for stormwater.

Typically, surface waters represent the most sensitive receiving environment for stormwater discharges. In the Canterbury region the Canterbury Regional Council has set acceptable concentrations of contaminants in receiving waters. These are generally based on the ANZECC (2000) guideline values plus additional factors for colour and clarity. Typically the water quality in lowland rivers is required to meet the 90% level of protection after reasonable mixing.

Table 7 shows the comparison between previous stormwater concentrations and modern stormwater concentrations and the ANZECC guidelines. As an example, it shows the concentrations in a river where a stormwater flow of 100 L/s is introduced into a flow of 500 L/s. It is assumed for this example that the background concentrations of contaminants in the river are below the level of detection.

Contaminant	Current Design Value	Current in River after Dilution	Recommended Design Value	Recommended in River after Dilution	Guideline Values ANZECC (2000)/CRC
TSS (g/m^3)	115	19	70	12	No greater than 20% change in clarity
Total Copper (g/m^3)	0.019	0.003	0.007	0.0012	0.0018
Total Lead (g/m^3)	0.018	0.003	0.004	0.0007	0.0056
Total Zinc (g/m^3)	0.30	0.05	0.08	0.013	0.015
Total Nitrogen (g/m^3)	-		1.0	0.17	3.4

Table 7: Stormwater and River Contaminant Concentrations Compared with Guidelines Values for Lowland Canterbury Rivers

For the particular example, the concentrations in the river after mixing show that using current stormwater contaminant concentrations would result in concentrations that exceed typical guideline values and treatment is required. However, using the recommended concentrations no treatment would be required for heavy metals. However, depending on the existing clarity of the river, some treatment to remove suspended solids may be required. Also the increase in flow resulting from the residential discharge may also require some detention to restrict the rate of runoff.

Of course this scenario changes at every location depending on the size of the stormwater discharge, the size of the river, the existing concentrations of contaminants in the receiving water and the quality that needs to be met.

In some situations, the current stormwater concentrations may require a treatment train approach to get the required level of treatment, but using the recommended concentrations a simple first flush dry pond may be all that's required. This could have significant impacts on costs when providing stormwater treatment for a new subdivision.

5 CONCLUSIONS

Monitoring of stormwater in Canterbury from modern residential subdivisions over the past 6 years has shown lower concentrations of contaminants than have been reported in previous literature. In addition, monitoring from mature subdivisions has also demonstrated lower concentrations, apart from zinc, compared with the concentrations in previous literature.

These lower concentrations are attributed to;

- Replacement of galvanized zinc roofing materials with Zincalume®
- Removal of lead from petrol
- Less wear + leakage of hydrocarbons from modern vehicles
- Possibly lower rainfall intensities in Canterbury resulting in lower rates of contaminants being washed off impervious surfaces

This paper provides recommended stormwater concentrations from modern subdivisions. Where possible they represent the 75th percentile value of the data to provide a conservative assessment of stormwater runoff. As these recommended concentrations are much lower than previously reported they could potentially result in a simpler treatment than would normally be recommended based on previous concentrations, while still providing suitable protection to the receiving environment. Reduced treatment requirements, while maintaining acceptable environmental outcomes, would have significant benefits to developer as well as long term maintenance costs for councils.

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