Figure 1 – Performance of Humeceptor™ to Retain Total Suspended Solids During Field Monitoring Across Various Sites

To place these results in context, the event mean concentration commonly exported from a site is around 75 – 100 mg/l. Sizing a **Humeceptor™** to provide around 75 – 80% removal of total suspended solids will provide an event mean concentration downstream of about 15 - 20 mg/l, although many of the individual events documented in **Figure 1** have provided lower concentrations again. Total suspended solids concentrations around the 15 – 20 mg/l is consistent with many of the regulations in force across Australia, although, often they are not particularly well enforced where proprietary products are concerned.

Further to our discussions above regarding particle size distributions and the capture efficiency of **Humeceptor™**, **Figure 2** shows the particle size distribution of accumulated material removed from a **Humeceptor™** unit recently monitored on a Perth industrial site. This data was generated by the CSIRO. As shown, the material successfully retained is extremely fine, with practically 90 – 95% being finer than 100 µm and 40 – 50% finer than 10 µm. **Retaining 50% of the material finer than 10 µm is demonstration of a product that retains fine material**. It is interesting to note that this accumulated material possessed a very high level of hydrocarbons as well, with a measured sediment concentration of 13,000 mg/kg of total Poly Aromatic Hydrocarbons bound into the accumulated solids material. There was also a very high concentration of heavy metals. For example, there was between 260 to 2,700 mg/kg of Chromium, 18 to 66 mg/kg of Arsenic, 29 to 250 mg/kg of Copper, 7,600 to 23,000 mg/kg of Iron, 11 mg/kg or Nickel and 50 to 770 mg/kg of Zinc bound into the accumulated sediment material. These are all well above the recommended sediment concentrations for heavy metals present within aquatic ecosystems, and is testament to the performance that can be achieved by capturing the fine suspended solids material.

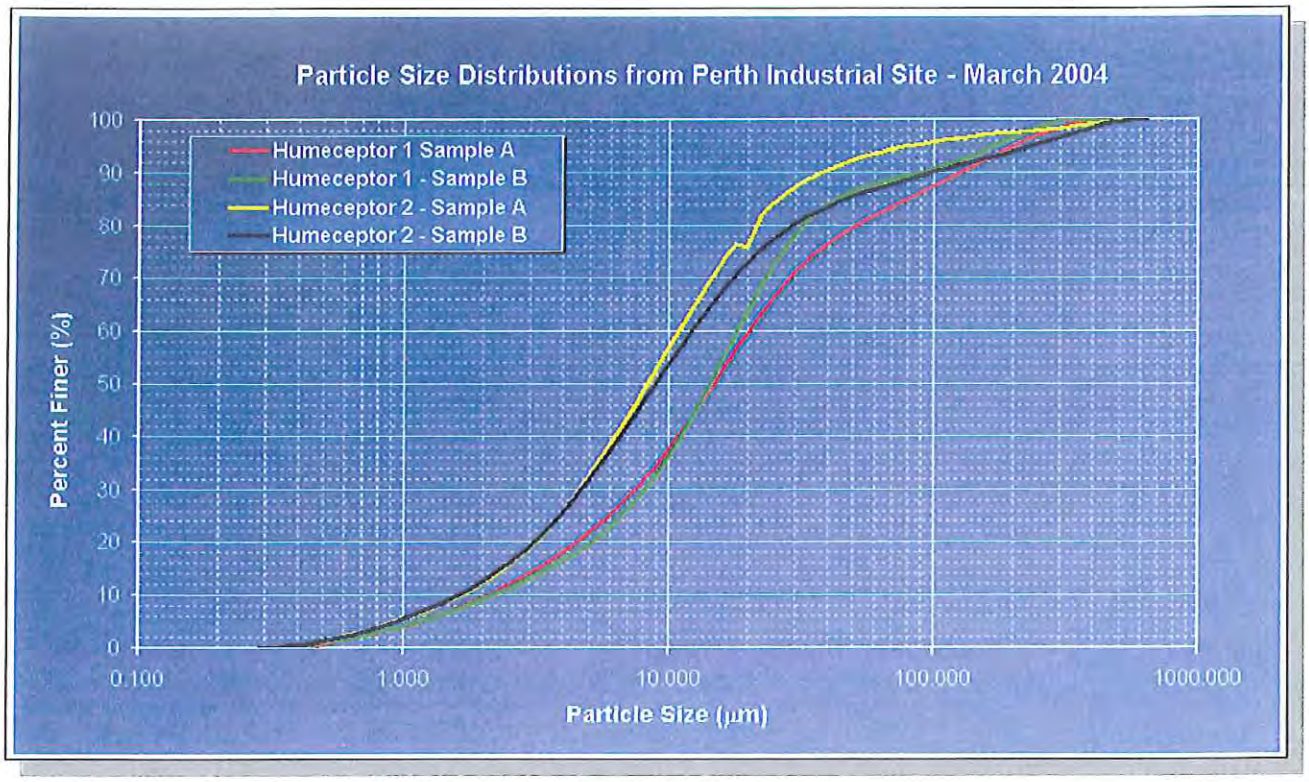

Figure 2 - Particle Size Distributions from Recent Monitoring of Hume*ceptor*™ Units on a Perth Industrial Site

Petroleum Hydrocarbons: In general, **Hume*ceptor*™** will achieve the following performance for the capture of petroleum hydrocarbons:

- < 1 ppm for influent concentrations up to 5 ppm
- < 2 ppm for influent concentrations up to 10 ppm
- < 5 ppm for influent concentrations up to 100 ppm
- < 10 ppm for influent concentrations up to 1000 ppm
- For concentrations greater than 1000 ppm, a removal efficiency of 98%

As you can see, the percent removal efficiency achievable is related to the incoming concentrations. For example, higher concentrations tend to achieve a higher percentage removal, whereas it becomes increasingly challenging to continue the same percent efficiency as the incoming concentration becomes relatively small. For example, for incoming concentrations less than 1 ppm, only very small improvements are generally possible. In general, where incoming concentrations are below 1 ppm, the **Hume*ceptor*™** will further decrease this to below 0.5 ppm, but from a percent removal measure, this equates to something like 20 – 50% depending on the exact concentrations. I have provided three graphs below, which summarise the main data available from field monitoring studies. Following the above discussion, I have split this data into events where the upstream concentration was already less than 10 ppm as opposed to events where the concentration was greater than 10 ppm, to demonstrate to you the effect of the upstream concentration.

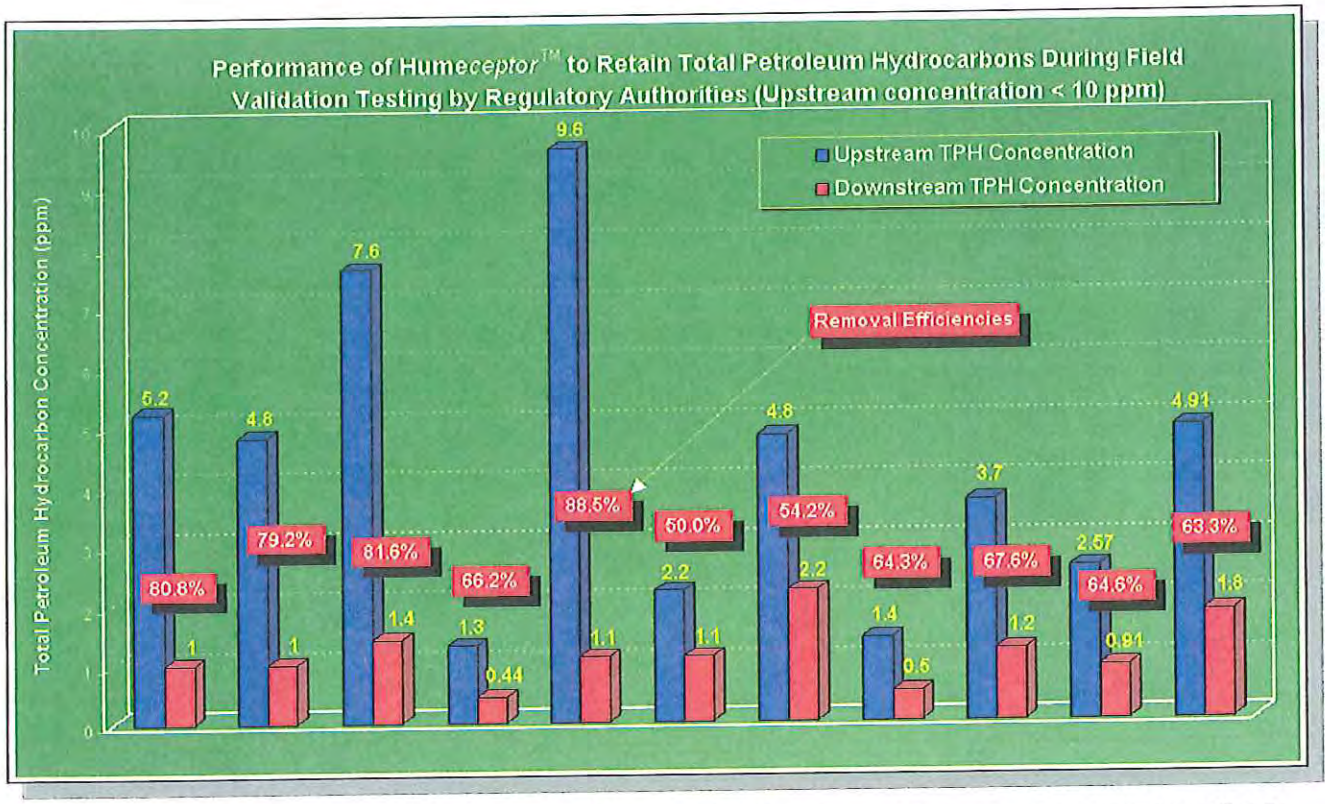

Figure 3 – Performance of Humeceptor™ to Retain Petroleum Hydrocarbons During Field Monitoring (for Inlet Concentrations < 10 ppm)

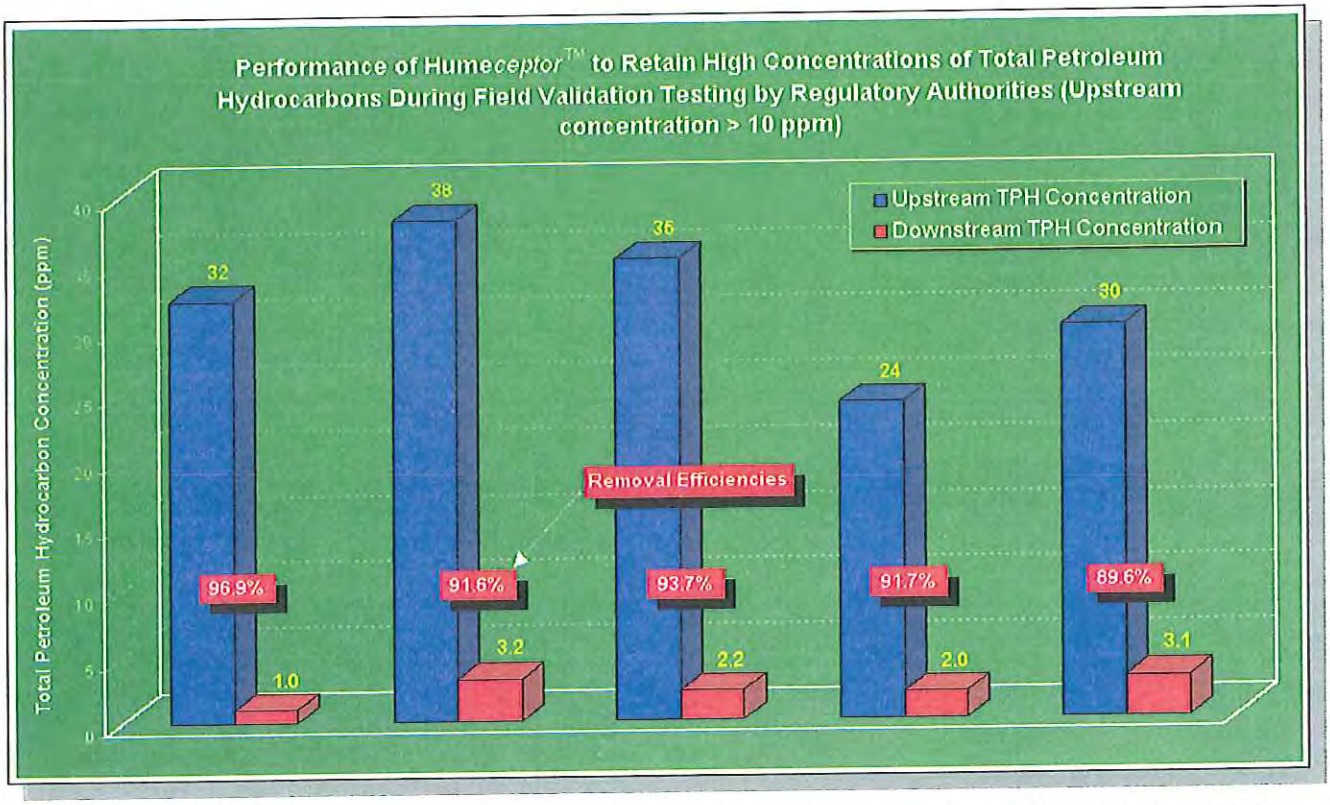

Figure 4 – Performance of Humeceptor™ to Retain Petroleum Hydrocarbons During Field Monitoring (for Inlet Concentrations > 10 ppm)

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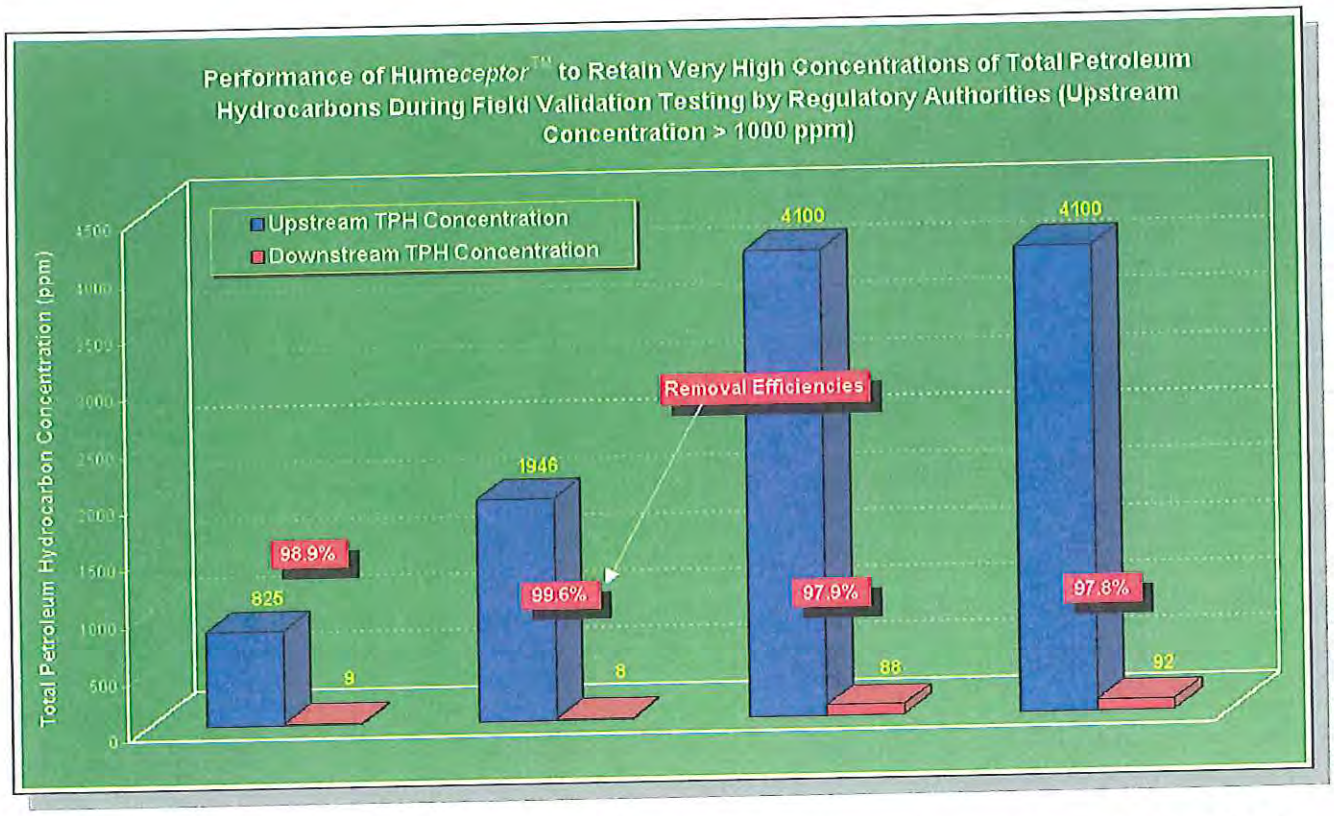

Figure 5 – Performance of Humeceptor™ to Retain Petroleum Hydrocarbons During Field Monitoring (for Inlet Concentrations > 1000 ppm)

The final graph above (**Figure 5**) is some data for very high concentrations, in excess of 1000 ppm which is fairly rare in practice. The test with 4,100 ppm entering the unit was an extreme test case, undertaken in a laboratory on a full scale **Humeceptor**™ unit at Coventry University in England. This was at a constant inflow concentration of 4,100 ppm over a 30 minute period with a constant flow discharge equal to the full treatment flow rate of the tested unit, so this represents a very extreme test.

To place the above data on hydrocarbons into context, Duncan (1999), in his review of worldwide stormwater quality data, collated data by land use. The arithmetic mean concentration as reported by the CRC for Catchment Hydrology (Duncan, 1999) for roads was 55 ppm and for highly urbanised catchments was 13 ppm, with overall concentrations varying from less than 1 ppm to about 200 ppm. Under these conditions **Humeceptor**™ will generally result in a downstream concentrations less than 10 ppm.

Heavy Metals: As discussed above, the removal of a large proportion of the total suspended solids load has a beneficial flow on effects for a range of heavy metals that become adsorbed onto the surface of the fine suspended material. This was clearly demonstrated on the Perth industrial site that I mentioned above, where the results of heavy metal analysis undertaken of the accumulated material clearly demonstrated the high affinity of various heavy metals to be bound into the accumulated material. However, I should note that heavy metals are partitioned between dissolved and particulate forms. **Humeceptor**™ does not purport to have any effects on dissolved constituents, therefore the removal efficiencies for heavy metals does tend to be much more variable than that provided above for hydrocarbons and total suspended solids.

Given the wide range of heavy metal data available, I have provided a table below, that provides a snapshot of the available data. As I mentioned above, in general, the data demonstrates removal efficiencies between 30 – 60% of the total loads, which reflects the capture of most of the particulate forms. In this regard, I draw your attention firstly to **Table 1**, which I have sourced from a Stormwater Management Textbook by Minton (2002), an authority in the United States. This data is one of few datasets available which analysed the partitioning of metals between dissolved and particulate forms, in this case from a freeway. This table shows the range of the total metal loads that are likely to exist in the particulate form.

Table 1 – Particulate Metals as a Percentage of Total Metal Load

Heavy Metal	Range	Mean Percentage of Particulate Metals
Cadmium	4 - 55	34
Copper	29 - 69	48
Zinc	4 - 46	23
Lead	55 - 82	73

It is obvious why the removal efficiency for heavy metals based purely on capturing the particulate fraction varies widely. Provided **Hume*ceptor***™ is sized to deliver the removal of a majority of the total suspended solids load, it will also capture the approximate particulate percentages of heavy metals noted in **Table 1**. **Table 2**, below, summarises the heavy metals data from monitoring of **Hume*ceptor***™ devices under field conditions. It is interesting to note that there is general agreement between the field data from **Hume*ceptor***™ studies and the particulate fractions noted under **Table 1**. In general, the best performance is achieved for Lead, since it exists largely in a particulate form, broadly followed by Copper. The least effective capture efficiency is for Zinc, which is not surprising given that the data reported under **Table 1**, suggests that it exists largely in a dissolved form.

Table 2 – Summary of Field Performance Data for Selected Heavy Metals

Location	Barium (Ba)	Lead (Pb)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Zinc (Zn)
Boston, Massachusetts	55 %	83 %	29 %[1]	67 %	-	-
Seattle, Washington	Wide range of metals with efficiencies varying from – 12 % - 46 %				46 %	0 %
St. Paul, Minnesota	-	76 %	-	18 %	46 %	38 %
Edmonton, Alberta	-	51 %	-	41 %	21 %	38 %
Madison, Wisconsin	-	24 %	27 %	-	25 %	17 %

I have extracted the data for Copper and Chromium in **Figure 6** and **Figure 7** below. Whilst we have undertaken testing for Arsenic, unfortunately, on all of the sites tested, the Arsenic concentrations have been below the detectable limit of the analytical procedures.

Figure 6 – Performance of Humeceptor™ to Retain Total Copper During Field Monitoring Studies

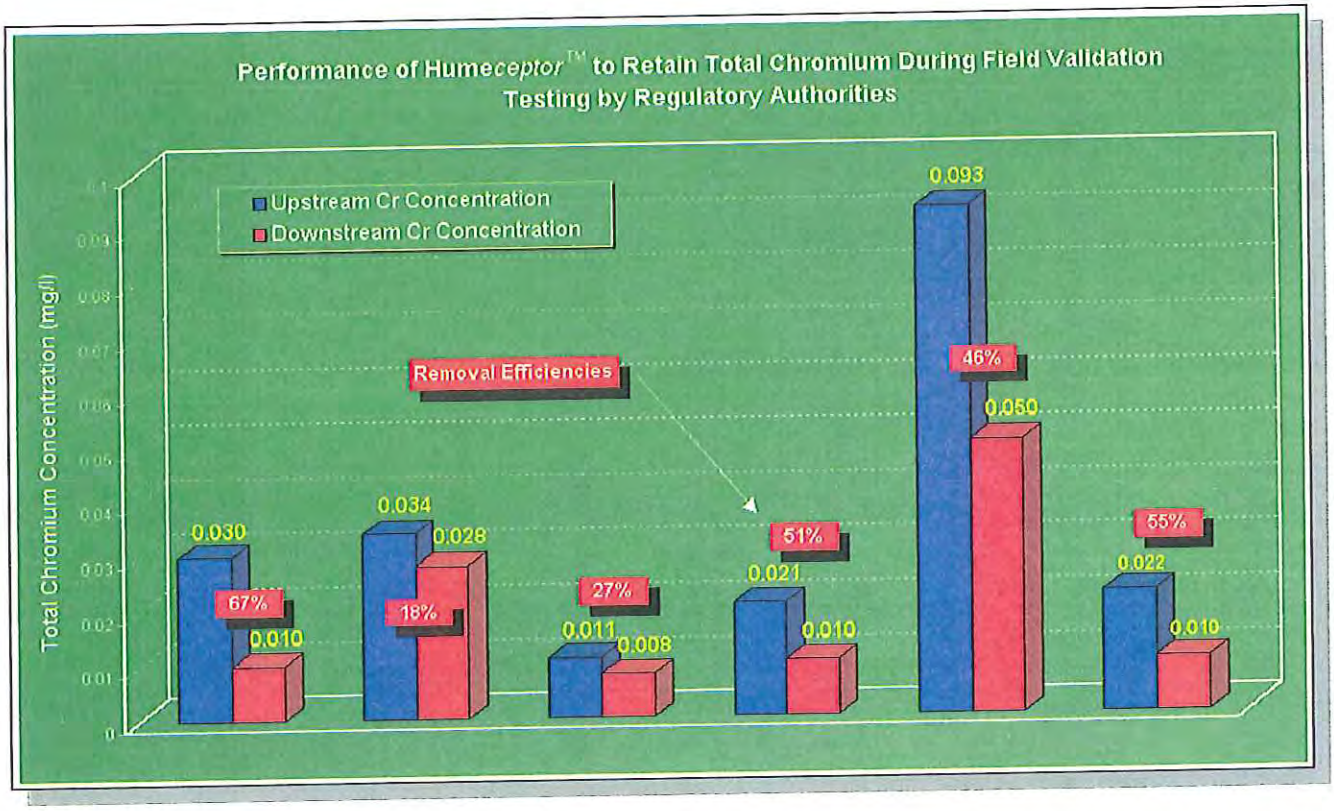

Figure 7 – Performance of Humeceptor™ to Retain Total Chromium During Field Monitoring Studies

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One of the most comprehensive field monitoring studies for **Humeceptor**™ collated data across a wide range of heavy metals exported from a petrol station forecourt area. Data was collected during first flush conditions and across overall individual events. I have provided this data below for your interest in **Table 3** and **Table 4**.

Table 3 – Average Metal Concentrations During First Flush Conditions

Metal / Constituent	Average Concentration (mg/l)		Nominal Removal Efficiency
	Upstream	*Downstream*	
Aluminium	0.810	0.215	73 %
Boron	0.40	0.13	68 %
Barium	0.027	0.008	70 %
Calcium	12.5	3.9	69 %
Copper	0.021	0.004	80 %
Iron	2.560	0.345	86 %
Potassium	3.05	1.50	51 %
Magnesium	1.6	0.5	69 %
Manganese	0.123	0.060	51 %
Sodium	5.8	2.1	64 %
Sulphur	2.65	0.90	66 %
Silicon	2.25	0.45	80 %
Strontium	0.125	0.041	68 %
Zinc	0.40	0.077	81 %

Table 4 – Overall Event Mean Concentrations for Various Heavy Metal Components Across Four Monitoring Events

Metal / Constituent	Average Concentration (mg/l)		Nominal Removal Efficiency
	Upstream	*Downstream*	
Aluminium	0.21	0.16	22 %
Boron	0.015	0.010	33 %
Barium	0.014	0.010	31 %
Calcium	6.77	5.73	15 %
Copper	0.018	0.010	46 %
Iron	0.27	0.30	- 12 %
Potassium	1.95	1.51	22 %
Magnesium	0.69	0.62	9 %
Manganese	0.055	0.050	8 %
Sodium	2.71	2.51	7 %
Sulphur	1.81	1.50	18 %
Silicon	0.83	0.57	32 %
Strontium	0.071	0.058	19 %
Zinc	0.13	0.13	0 %

Nutrients: As noted above, nutrients (nitrogen and phosphorous) are partitioned between dissolved and particulate forms. As discussed above, **Humeceptor**™ will have little effect on the dissolved fraction, but will successfully remove a large proportion of the particulate fraction. The removal efficiencies are therefore quite variable since it does depend on the partitioning between the different

species. I note, however, that our data for nutrients is fairly limited, but it does generally support the removal of approximately 50% of nitrogen and 40% of the phosphorus load. I have provided in **Figure 8** and **Figure 9** some further detailed monitoring data relating to nitrogen and phosphorus for your consideration. This data represents individual rainfall events on primarily two sites, one which was a truck loading / unloading facility and the other was a newly constructed commercial car park associated with an office complex. I have provided a summary of the data in **Table 5**. It should be noted that the concentrations of nutrients on both of these sites is fairly low, so the removal efficiencies achieved represent fairly sound results. It is usual to expect that higher influent concentrations will lead to higher percent removal efficiencies.

Table 5 – Summary of Field Performance Data for Nutrients (Nitrogen and Phosphorus)

Land Use	Total Nitrogen (TKN)			Total Phosphorus		
	Upstream EMC (mg/l)	*Downstream EMC (mg/l)*	*Removal Efficiency (%)*	*Upstream EMC (mg/l)*	*Downstream EMC (mg/l)*	*Removal Efficiency (%)*
Truck Loading Facility	1.68	0.91	45 %	0.24	0.16	30 %
Commercial Car Park	1.83	0.64	65 %	0.36	0.24	32 %

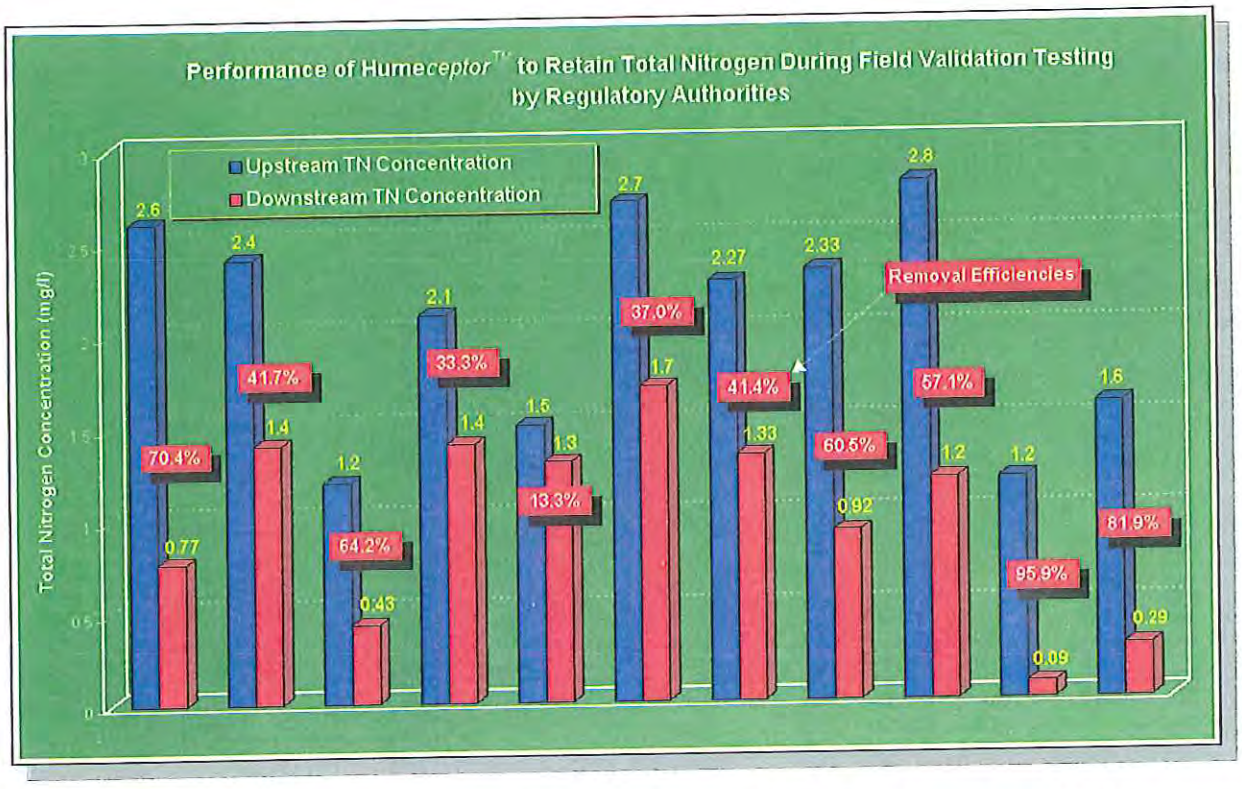


Figure 8 – Performance of Humeceptor™ to Retain Total Nitrogen During Field Monitoring Studies

As shown in **Figure 8** the removal efficiency has varied for individual events from around 10% through to 90% for total nitrogen. **Figure 9** shows a similar range for total phosphorus between 15 to 60%. This variation will have been primarily related to the fraction of dissolved nutrients versus the particulate proportion. It is further interesting to note that there is a strong correlation between the removal efficiency of nutrients (and heavy metals, which also exist in both a dissolved and particulate

form) and the actual removal efficiency achieved during these events for total suspended solids. This will be due to the sorption of these contaminants onto the suspended solids material. As shown by the data in both figures, whilst on average a removal efficiency for total nitrogen around the 50% has been suggested and around 40% for phosphorus, there are plenty of results that show better results have been achieved.
For example, there are several individual rainfall events shown in **Figure 9** that indicate actual removal efficiencies for total phosphorus around 45%.

The focus on removing total suspended solids in terms of its "flow-on" effects to other contaminants is well supported by literature and regulatory requirements elsewhere. One of the most proactive regulators regarding water quality and stormwater management in this part of the world is Auckland Regional Council in New Zealand, who has produced a very sound stormwater management manual.

The following quote is provided from this document for your interest:

"*The primary water quality objective of the treatment devices in this manual is to remove 75% of the total suspended sediment on a long term average basis. Removal of sediment will remove many of the contaminants of concern, including* ***particulate trace metals, particulate nutrients****, oil and grease on sediments and bacteria on sediment*"

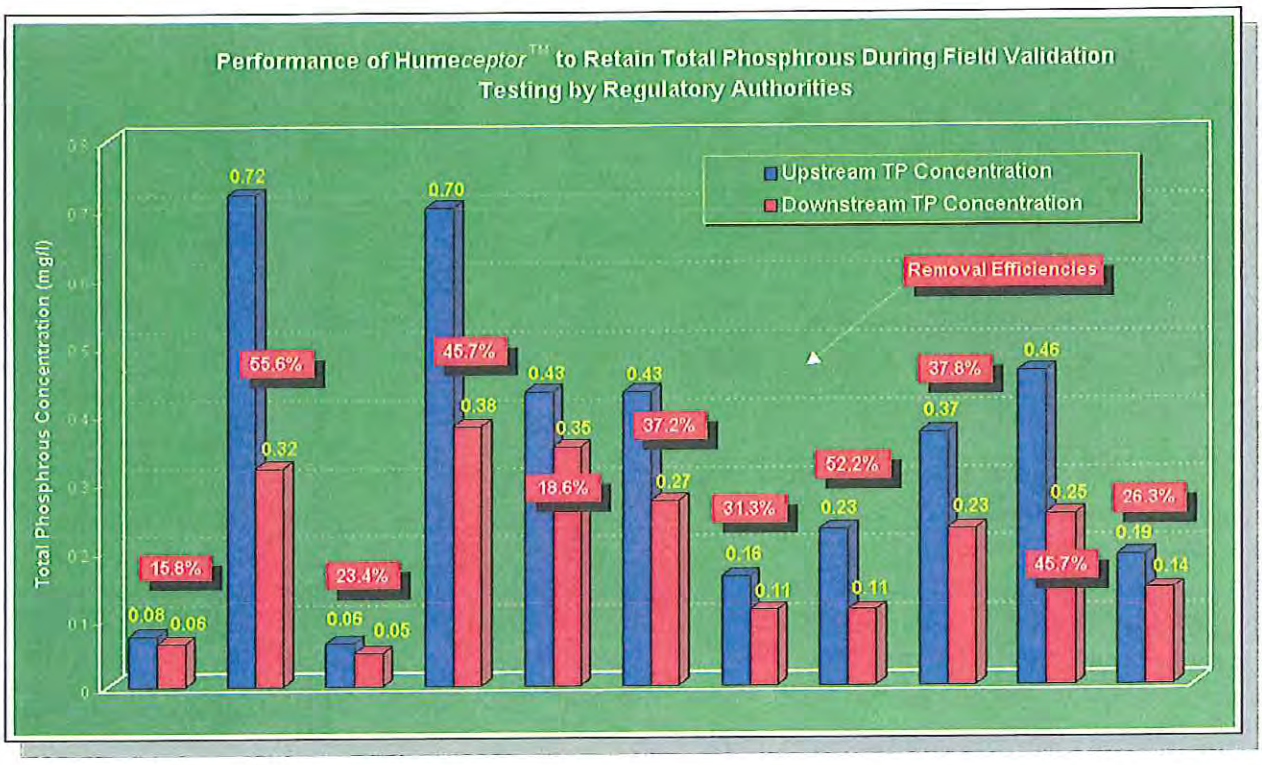


Figure 9 – Performance of Humeceptor™ to Retain Total Phosphorus During Field Monitoring Studies

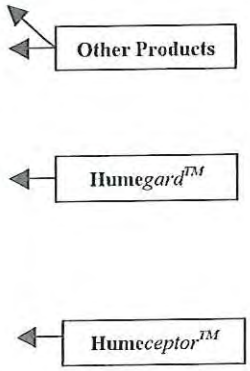
Litter: As mentioned above **Humeceptor**™ does not capture litter, it is not designed to. Therefore it is a suitable device for the following applications: Carparks, Roads, Industrial Sites, Commercial Sites, Emergency Oil Spill Capture, Unsealed Sites, Rubbish Dumps, Shopping Centres, Residential Sites where a GPT is also used in a treatment train, Airports etc. These types of sites, with exception of Residential and Shopping applications, do not generate the quantities of litter to justify the use of a GPT.

The priority in terms of pollutants are Total Suspended Solids with majority being fine (< 63micron), Petroleum Hydrocarbons and Heavy Metals. The **Humeceptor**™ device is focused on these pollutants. **Humeceptor**™ does have the ability to capture and retain small items such as cigarette butts. It is more than likely that the majority of litter generated will consist of cigarette butts anyway. Mot industrial and commercial sites utilise grated inlet pits and therefore if litter was present it could not find a path into the drainage system.

If there is one major difference between GPT's and **Humeceptor**™ it would be the operational velocity generated within the sump. It is simply too high in a GPT to allow seperation of the smaller particles and oils / hydrocarbons. **Table 5** below details the scouring velocity of particle sizes and demonstrates the requirement for low operational velocity if fine particles are to be rmoved from stormwater.

Table 5 – Published [1] Scouring Velocities for Various Sediment Particle Sizes

Description of Sediment	Particle Diameter (μm)	Scouring Velocity (m/s)
Pebbles	2000	0.72
Coarse Sand	1000	0.51
Medium Sand	500	0.36
	250	0.25
Fine sand	125	0.18
Coarse silt	62	0.13
	31	0.09
Medium silt	16	0.06
-	-	-
Fine silt	< 10	0.007



Metcalf & Eddy, 1991, "Wastewater Engineering: Treatment, Disposal and Reuse", 3rd Edition, McGraw-Hill, New York

The **Humeceptor**™ unit is a finely engineered product when compared to the majority of its competitors. Independent third party regulatory authorities under field conditions have extensively verified the performance of the **Humeceptor**™ product to deliver a water quality outcome.
We trust the above technical discussion provides a level of confidence regarding the use of the **Humeceptor**™ Hydrodynamic Source Control Unit.

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If you have any questions or queries in regards to **Hume*ceptor*™**, please don't hesitate to call.

Regards

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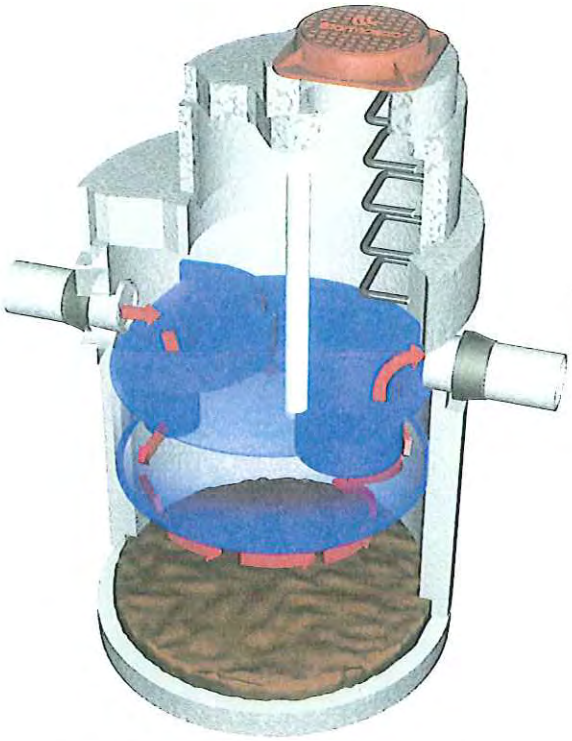

Schematic of the Hume*ceptor*™