Evaluation of Gully Pit Inlet Litter Control Systems

Final Report

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Prepared for	Brisbane City Council GPO BOX 1432 BRISBANE QLD 4001 Att.: Mr. M Steer
Prepared by	Mr. Michael White Mr. David Pezzaniti Urban Water Resources Centre University of South Australia MAWSON LAKES SA 5095
Telephone Facsimile	+618 8302.3652 +618 8302.3386
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TABLE OF CONTENTS

SUMMARY **3**

1. INTRODUCTION AND PREAMBLE **4**

2. TEST SPECIFICATION AND PROCEDURE **5**

3. TEST RESULTS AND OBSERVATIONS **7**

3.1 36MM HORIZONTAL BAR 7

3.2 "MESHED" PIT INSERT 10

3.3 TRAY BASKET 12

3.4 ENVIROPOD LITTATRAP ESTING 14

3.5 CHAMBER WATER LEVEL PRE-TESTING 19

4. CONCLUSION **20**

APPENDIX A **A1**

APPENDIX B **B1**

SUMMARY

Stormwater pollution control is usually managed near source or at the end of a drainage system. The Brisbane City Council and Gold Coast City Council are currently investigating several options of managing stormwater litter at the source utilising their Lip-in-Line Gully Pit (small lintel).

A range of devices are currently available to collect litter using the gully pit, however there is limited information regarding;

- The effect on the inlet hydraulic capture performance, and
- the effectiveness of litter capture.

Four litter control systems were evaluated for both on-grade and sag conditions with varying approach flows up to 320 L/sec. Test results and observations included:

- The horizontal bar placed across the inlet had little effect on hydraulic capture for on-grade slopes. However for sag conditions and at flows above 200 L/sec, the hydraulic capture capacity was reduced. Depths at invert were up to 50mm greater for the case without litter and up to 120mm greater with litter.
- Both the mesh and tray basket inserts were ineffective in collecting and retaining litter. Both systems had no significant effect on the hydraulic capture capacity of the gully pit.
- The Enviropod LittaTrap basket is capable of collecting and retaining considerable amounts of pollution at flow rates up to 320 L/sec. Resuspension of pollution occurred at flows above 100 L/sec, however the unit still retained up to 70% of pollution at 1% longitudinal slope at an approach flow of 320 L/sec. The Enviropod LittaTrap basket affected the hydraulic capture capacity of the gully pit at 12% grade due to blockage caused by litter trapped in the overflow outlet.

1. INTRODUCTION AND PREAMBLE

Brisbane City Council engaged the Urban Water Resources Centre to undertake a hydraulic evaluation of various litter control systems for a typical Lip-in-Line Gully Pit.

Hydraulic testing was undertaken using a short (2400mm) lintel inlet with the roll top kerb and channel and flows ranging from 0L/sec to 340L/sec at longitudinal grades of 1%, 4% and 12%. Testing was undertaken with the following gully pit litter control systems:

- A 36mm diameter horizontal bar placed across the mid point of inlet opening (as shown in Appendix A),
- meshed pit insert,
- a tray basket (900x500x150), and
- standard Enviropod LittaTrap trash basket.

Testing was carried out using the full-size road test rig at the University of South Australia. A standard litter sample was developed and used for the evaluation. Litter comprised of 80% organics (leaves) and 20% paper, plastic and sediment. A modified litter sample (Appendix B) was used for the evaluation of the horizontal bar system. It contained a greater proportion of larger litter, including plastic food and drink containers, plastic bags and aluminium cans.

Briefly, the aim of the evaluation was to:

- Determine the litter capture performance characteristics of each system, and
- determine the effect that each litter control system has on the inlet hydraulic capture performance.

2. TEST SPECIFICATION AND PROCEDURE

Test specification:

- Approach flows ranging from 0 – 320 L/sec.

- Channel longitudinal slopes:
  - 1%, 4% and 12% (3 off)
  - "Sag" 0% slope for all configurations.

- Road pavement modelled to simulate asphaltic construction (hot-mix) seal (Manning's "n" = 0.014).

- Crossfall slope of 3.3%.

- Kerb type: Roll-top type kerb-and-channel currently set-up on Road Rig.

- Lintel: Small (S) as per Gold Coast City Council (Drawing 59301).

- BCC perpendicular support bar grate

Procedure:

The test procedure involved:

(i) Add the pollution (10L) to an approach flow of 25 L/sec.

(ii) Observe and record the amount of pollution retained.

(iii) Increase approach flow and record capture flow.

(iv) Observe and record amount of pollution retained.

These procedures were repeated several times during each test to assess the effect of increasing flows on litter and hydraulic capture performance. Testing and evaluation for each of the litter control systems were slightly different.

36mm diameter horizontal bar.

Testing of the horizontal bar was conducted with the modified litter sample only. It was accepted that the inlet would collect most organic litter and have no effect on the capture performance of the bar inlet configuration.

Meshed Pit insert.

Testing was conducted to determine capture efficiency of the meshed insert under fully blocked conditions. The insert was fabricated from sheet metal hence simulating blocked conditions. Testing was conducted using the standard litter sample.

Litter Crate Basket (900x500x150).

Assessment of collection performance, type of litter collected and comments on re-suspension and effect on hydraulics (with basket fully laden) for the standard litter basket was carried out.

Enviropod LittaTrap Basket.

The Enviropod LittaTrap insert required modifications to withstand the force of the high approach flow. The plastic sides on the top of the basket were replaced with sheet metal and strengthened.

NB: A new plastic was being tested during this trial. Subsequently a plastic with increased strength and durability designed to withstand flows greater than 320l/s is now used on all Enviropod LittaTrap units.

3. TEST RESULTS AND OBSERVATIONS

3.1 36mm horizontal bar.

Testing was undertaken to determine the effect on hydraulics and capture performance of the lip in line gully inlet with a bar placed horizontally across the inlet. The modified litter sample was used for this test and was added to the gutter at an approach flow of 25L/s. The flow rate was increased up to 320L/s and amounts of litter retained on the inlet were observed at each increment. "Sag" results, calculated as depth at inlet, are shown in Figure 3.

Test results and observations:

Litter Capture Performance.

The table below shows percentages of litter added that is retained on the grate or by the bar for varying approach flow.

SLOPE	APPROACH FLOW L/s	% LITTER RETAINED
1%	25	100
	85	88
	243	82
	320	76
4%	25	88
	60	82
	120	76
	180	18
	320	18
12%	25	94
	60	30
	240	30
	320	6

Discussion:

For the 1% longitudinal slope, 76% of the litter was retained at an approach flow of 320L/sec (see Figure 1). The remaining 24% passed through the inlet beneath the bar or bypassed the inlet. The high capture efficiency is due to the lower approach flow velocities at flatter grades. The majority of litter retained in front of the bar was plastic bottles and milk cartons.

At the steep (12%) slope the inlet retained 30% of litter at an approach flow of 60L/sec. The high velocity forced the majority of litter past the inlet. At an approach flow of 320L/s only a plastic bag remained stuck on the grate.

Figure 1: Pollution remaining after 320L/sec at 1% slope.

The horizontal bar caused a build up of litter at the downstream end of the inlet. Water was observed 'jetting' over the downstream transition, due to the litter caught, at higher approach flows and more significantly at steeper slopes (see Figure 2).

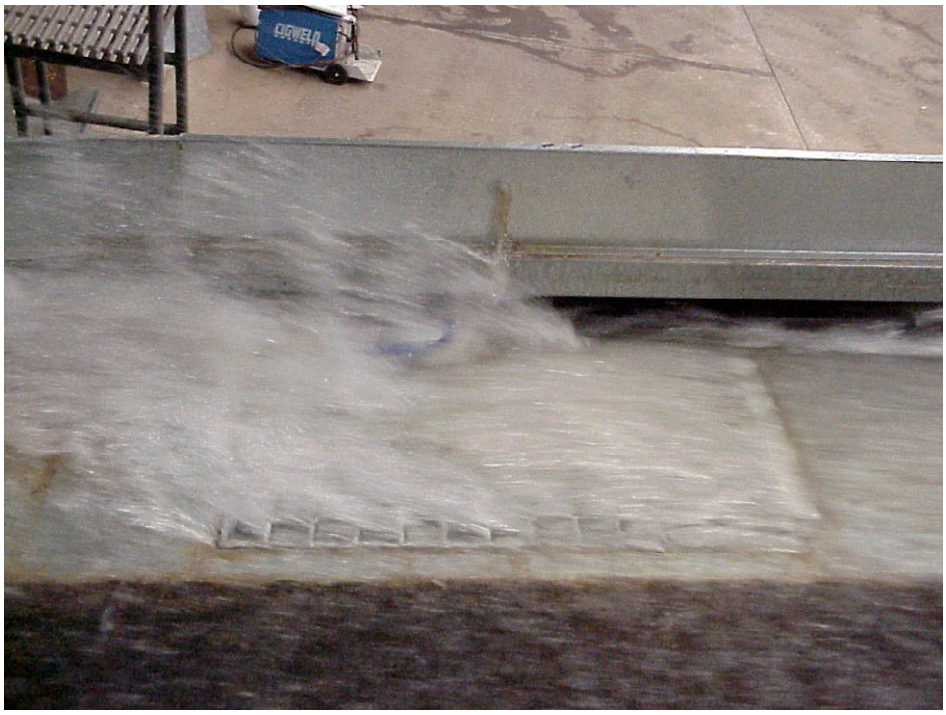

Figure 2: Water 'jetting' due to build up of pollution.

Hydraulic performance.

On-grade tests:

The reinforcing bar did not effect the hydraulic capture performance of the inlet for on-grade tests.

Sag tests:

Under sag conditions, the bar alone significantly reduced capture capacity (see Figure 3). The flow pond depth at invert was up to 50mm greater for the case with the horizontal bar. Testing was also conducted to assess the effect on pond depths at invert with litter retained by the horizontal bar. As expected, the litter reduced the capacity of the inlet to capture flow, with pond depth increase up to 120mm greater for the same approach flow. Litter retained by the horizontal bar further reduced the hydraulic capacity of the gully pit.

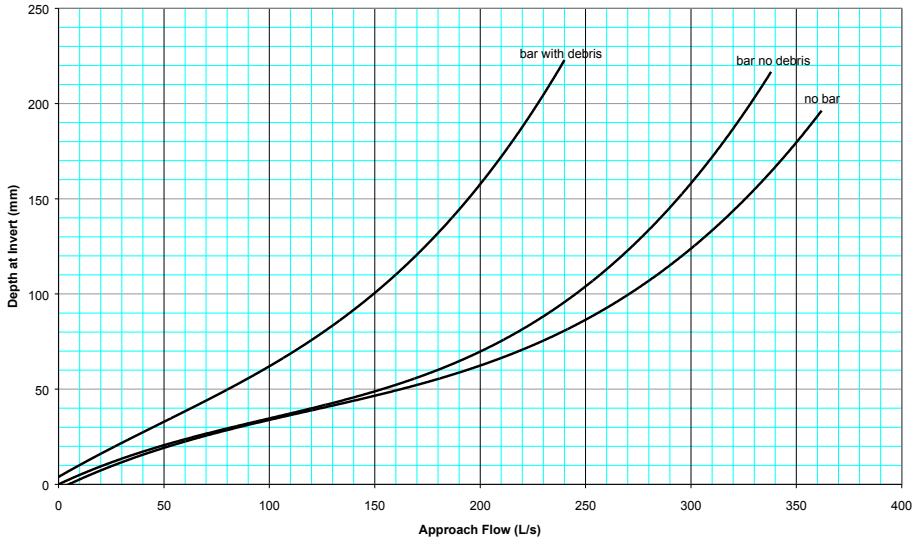

Figure 3: "Sag" Reinforcing Bar "0" Grate.

3.2 "Meshed" pit insert.

The meshed pit inlet configuration (see Appendix A) was modified to simulate fully blocked conditions. For this reason, a steel plate was used instead of mesh.

Test results and observations:

Observations from the testing were:

Litter capture performance.

- At 1% and 4% slope, all litter was captured by the inlet (at 25L/sec), however only 5% of the 10L of litter was retained by the insert for both longitudinal slopes. This litter was resuspended and passed through the inlet when flow was increased to 60L/sec.
- At 12% slope and approach flow of 25L/sec, 10% of the 10L of litter was retained in the inlet box. This material was mostly semi-buoyant litter (wet leaves) which either sank to the bottom or remained in suspension. The grate captured a small proportion of litter. However when the test was repeated at 25L/sec remobilisation of the captured material in the inlet occurred and only 5% was retained. At 60L/sec

all litter had passed through the chamber except for an aluminium can.

Hydraulic performance.

On-grade:

The mesh insert did not significantly effect the hydraulic capture performance of the gully pit for all longitudinal slopes.

Sag:

At 0% (sag) longitudinal slope, the mesh insert caused the inlet to reach 'orifice' condition sooner (ie. at a smaller approach flow).

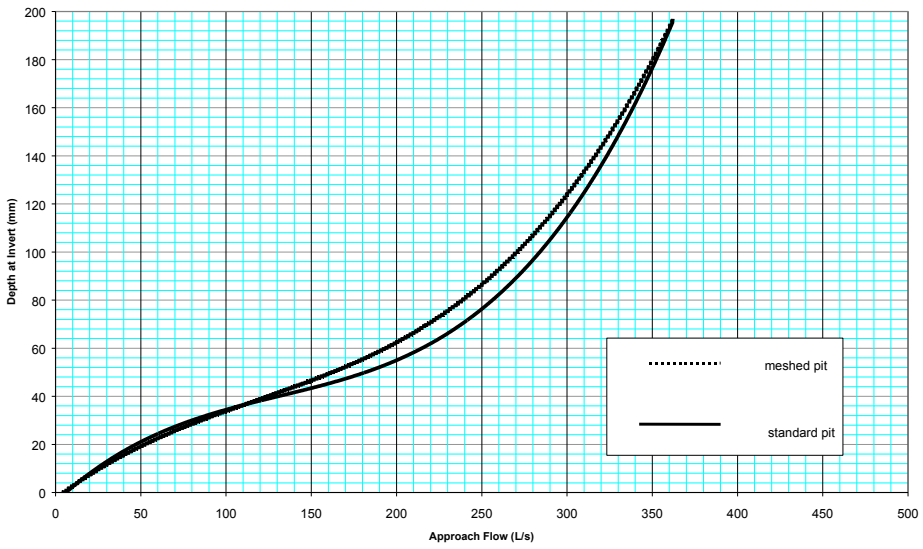

Figure 4: Sag "0" Grate results – meshed pit insert

Discussion:

From the observations above, the 'blocked' meshed insert had no significant effect on the hydraulic capture performance (on-grade) of the inlet. All floatable litter passed through the chamber at 25L/sec and semi-buoyant litter was remobilised at flows greater than 25L/sec.

For the sag condition, the insert affected the hydraulic capture between 150-340L/sec. Above 340L/sec it would appear that the capture (orifice) was controlled by the inlet opening.

3.3 Tray Basket

The tray basket insert (Appendix A) was tested for capture and hydraulic performance under similar conditions.

Test results and observations:

Litter capture performance.

On-grade

- 40% of the litter added to the approach flow (25L/sec) was retained in the basket for all on-grade longitudinal slopes.
- Once the basket became blocked nearly all (90%) of pollution added thereafter bypassed the basket.
- At the steeper (12%) grade the basket was more effective in capturing the litter.
- As the approach flow increased, the litter capture performance of the basket was marginally better at the 12% grade than for 1% and 4%. However, when subjected to an approach flow of 330L/sec, only 2% of the pollution was retained in the basket for all grades.

Sag

- The pit was bisected for the sag test to simulate flow from opposing directions (see Figure 5). The basket retained 80% of the litter with the approach flow set at 50L/sec. However it did not retain any of the larger plastic litter.

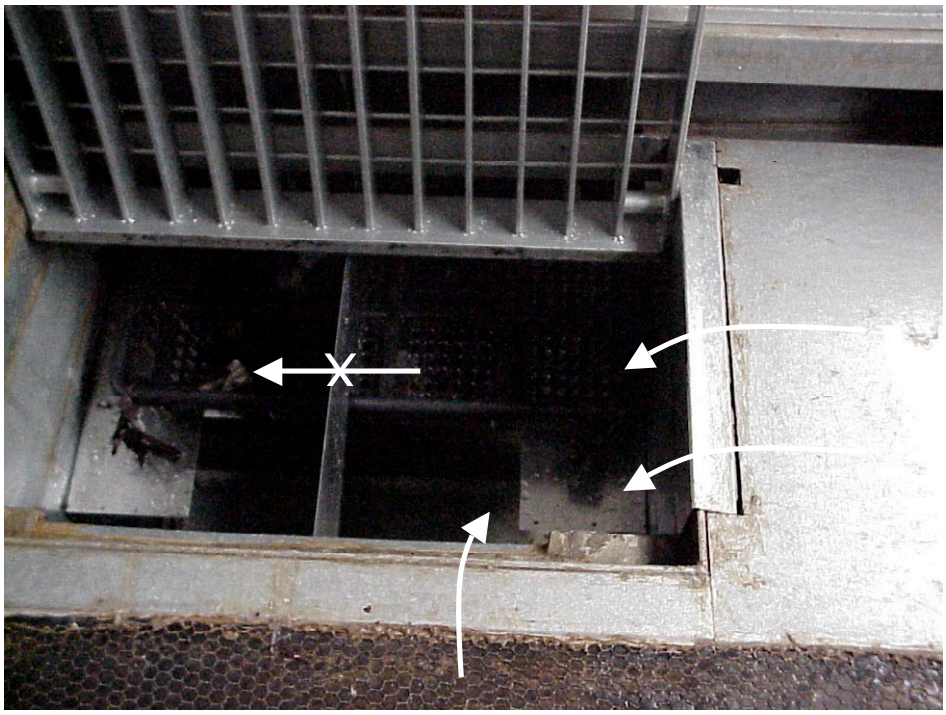

Figure 5: Modified tray basket setup for Sag test.

Hydraulic capture performance.

On-grade:

The effect of the basket on the hydraulic performance of the pit was insignificant.

Sag:

The basket caused the pond depth to increase, resulting in "orifice" flow conditions at lower flows (see Figure 6).

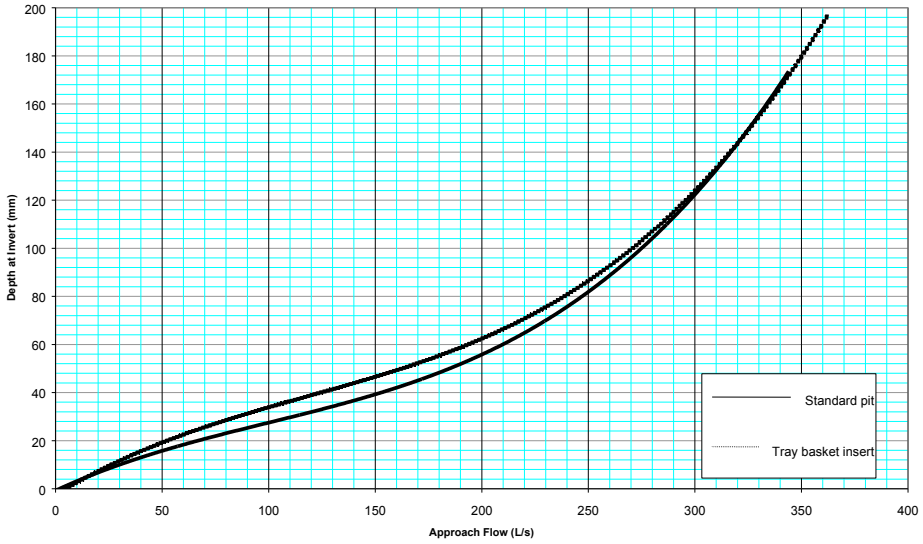

Figure 6: Sag results - tray basket.

3.4 Enviropod LittaTrapTesting

Hydraulic testing, including high chamber water level (CWL) pre-testing, and pollution capture performance testing was carried out for the Enviropod LittaTrap basket. Two basket (collection bag) types were assessed; a coarse and a fine fabric.

Test results and observations:

During initial tests, plastic sheeting on both the front and back sides of the basket failed when subjected to high flows (>100L/sec). The sides were subsequently replaced with sheet metal.

Litter Capture Performance

On-grade

During the initial tests, all of the litter (10L) was captured with approach flow set at 25L/sec. It was decided to increase the amount of litter until bypass occurred. 30L of litter was collected (at 25L/sec) before bypass.

1% grade:

- All litter was collected and retained up to an approach flow of 100L/sec for both collection baskets.
- Approximately 15% of the litter had bypassed the unit at 200L/sec due to resuspension.
- The finer mesh basket retained 70% of litter after an approach flow of 320 L/sec and the coarse basket retained 65%.
- The mesh in both baskets became blocked after a flow of 320 L/sec and held water for a short period after flow was stopped.
- As the flow dropped from 320L/sec to below 50L/sec some of the pollutants attached to the fabric dislodged from the sides. The low flow effectively washed the litter off the basket sides (see Figure 7).

Figure 7: Self cleansing action of basket at low flows.

4% longitudinal slope:

- At an approach flow of 200L/sec, the water level in the basket was higher (100mm below invert) for the finer meshed basket than the coarse mesh (200mm below invert). The higher water level in the pit can be attributed to the reduced size in mesh of the basket.
- Both baskets retained 55% of debris after an approach flow of 320 L/sec.

12% longitudinal slope:

- The water level in the pit rose above the overflow level at 100L/sec therefore resulting in small losses.
- After 320L/sec the coarse mesh basket retained 65% of debris while the fine meshed basket retained 60%.

Sag

For the sag test, the basket was bisected in half to simulate flow approaching from opposite directions. 20L of litter was used for the sag litter tests because of the high capture capacity of the basket before bypass. The following observations were made:

- With the coarse mesh the basket retained 50% of the 20L of litter after being subjected to an approach flow of 340L/sec. The bag became considerably coated with larger sized litter (mostly organics).
- With the fine mesh, only 10% of the 20L was retained after an approach flow of 360L/sec (equivalent). The finer mesh experienced less coating on the sides of the basket. It was observed that the flow into the basket had the effect of 'washing off' some of the litter attached to the sides and therefore allowing litter to bypass the basket at higher flows.

Hydraulic Capture Performance

On-grade

When compared to the standard lip in line gully pit, the capture capacity of the Enviropod LittaTrap basket was:

- The same for 1% and 4% longitudinal tests
- At 12% grade:
  - 12L/sec less between 200 and 320 L/sec approach flow for the fine mesh basket, and
  - the same at 200L/sec for the coarse mesh basket, and 6L/sec less at an approach flow of 320L/sec.

It was observed at the 12% grade that a plastic drinking bottle and plastic bag were trapped in the overflow outlet, reducing the capture capacity of the pit insert (see Figure 8).

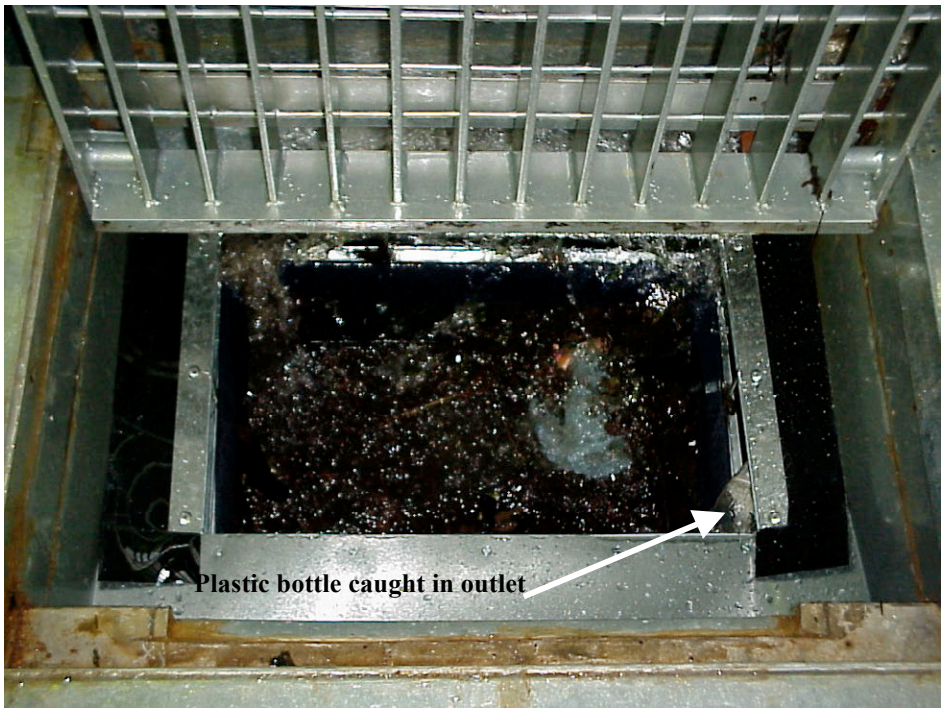

Figure 8: Litter trapped in overflow outlet.

- At 1% and 4% grades, the fine mesh basket (with litter) captured up to 5L/sec more than the coarse mesh basket at an approach flow of 320L/sec.

- At 12% longitudinal slope, the coarse mesh basket captured up to 11L/sec more than the fine mesh basket at an approach flow of 200L/sec and 8L/sec more with an approach flow of 320L/sec.

Sag

Four sag tests to determine hydraulic performance of the inlet were conducted; two with fine mesh (with and without litter) and two with the coarse mesh (with and without litter). This enabled a comparison of performance between the two baskets under empty and blocked conditions. The results were also compared to sag capture results with no basket. Pond depth at invert versus approach flow characteristics are provided in Figure 9.

Fine mesh sag test

At low to medium approach flows (up to 200L/sec) the addition of litter reduced the capture capacity of the inlet, increasing the pond depth at invert by up to 15mm. However at flows above 200L/sec there was no difference in flow pond depth at invert for the case of with and without litter.

Coarse mesh sag test

The effect of the coarse mesh was to increase the flow pond depth at invert by up to 15mm at flows below 200L/sec, as for the fine mesh. However the coarse mesh (with litter) showed similar flow pond depths to the fine mesh (without litter) up to 200L/sec.
The results from the sag test are presented in figure 9 below.

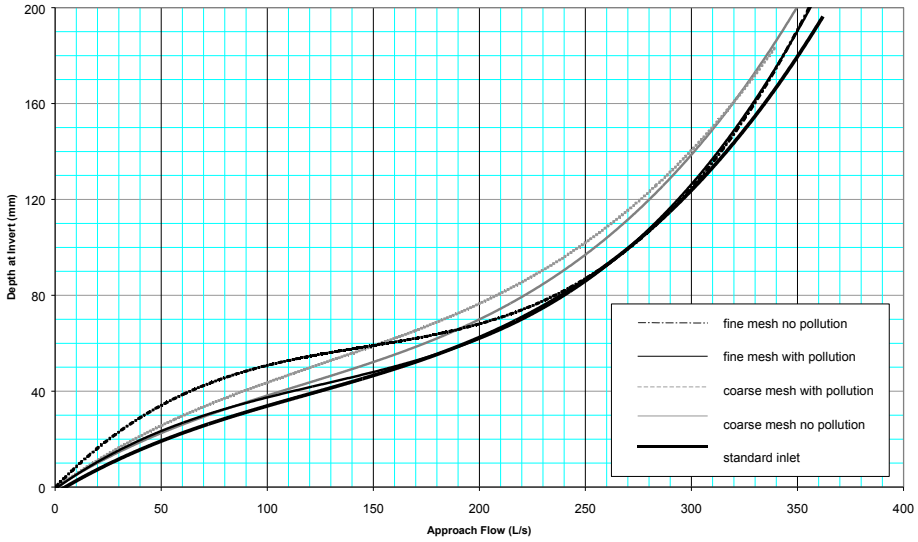

Figure 9: Sag test results (depth at invert)

Discussion of results

Both baskets were effective in capturing and retaining a large proportion of litter at flows up to 100L/sec. At 1% longitudinal slope the fine mesh basket was slightly better in capture performance, whilst at the 12% slope the coarse mesh basket was slightly better.

The fine mesh basket resulted in lower depths at invert at the same approach flow than for the coarse mesh basket. This is due to the resuspension of litter in the basket at high approach flows. Only 10% of the 20L of litter added to the fine mesh basket was retained, where as 50% was retained by the coarse mesh basket.

3.5 Chamber Water Level Pre-testing

Testing was carried out to determine the effects on inlet capture as a result of high chamber water level. Tests were conducted for the 1, 4 and 12% longitudinal grades. It was observed that with the short lintel (2.4m) a high CWL of 150mm below the gutter invert did not affect the capture performance.

4. CONCLUSION

The main findings from the testing programme are:

- The reinforcing bar placed across the inlet had little effect on hydraulic capture for on-grade tests. However for sag conditions and at flows above 200 L/sec, the hydraulic capture capacity was reduced. Depths at invert were up to 50mm greater for the case with no pollution and up to 120mm greater with pollution. A build up of pollution on the grate, restricted by the bar, caused 'jetting' of water above the kerb.
- The crate basket was ineffective in retaining pollution above a flow rate of 25 L/sec for on-grade testing. Nearly all (90%) of pollution added to the gutter after the basket had become blocked bypassed the basket. After an approach flow of 320 L/sec only 2% of pollution was retained for all longitudinal slopes. The basket was more effective in retaining pollution under sag conditions.
- The mesh pit insert was inefficient in retaining pollution above a flow rate of 25 L/sec. Only 5% of the pollution was retained at an approach flow of 25 L/sec for the 1% and 4% longitudinal slope. 10% was retained for the 12% grade however all pollution had bypassed the pit at an approach flow greater than 60 L/sec for all slopes.
- The Enviropod LittaTrap basket was capable collecting and retaining large amounts of pollution and had no significant effect on the hydraulic performance of the gully pit. The basket retained up to 70% of pollution added after an approach flow of 320 L/sec. At 12% grade, litter was trapped in the overflow outlet, reducing the capture capacity of the gully pit. This could also occur for flatter grades and high approach flows. Initial testing of the basket led to some modifications to increase support under high approach flows used in the testing programme.