LARGE SCALE SEWER OBSTRUCTION – REAL STORY AND IMPLICATIONS EXPLORED

Timothy Preston, GHD Ltd
Christopher Mance, Christchurch City Council

ABSTRACT

Behaviour of the Riccarton Interceptor trunk sewer in Christchurch has confounded modelling and led to uncertainty in regard to future upgrade planning.

A Parshall Flume was recently re-discovered at the downstream end of this trunk sewer with a substantial obstruction blocking its throat. This obstruction and the collected debris, was removed resulting in a significant improvement in the hydraulic performance of the trunk sewer. A permanent flow monitor installed a short distance upstream provides continuous flow and level data before and after removal of the obstruction.

This paper explores and compares observed, measured and model predicted behaviour of the trunk sewer with the blocked flume and under normal clean conditions. This modelling is used to illustrate how far upstream the obstruction may have affected sewer performance. It also explores whether there could be significant benefit from demolishing the flume.

Implications for future growth planning around the Riccarton Trunk sewer will be discussed and recommendation made for a more robust future assessment of future upgrade options.

KEYWORDS

Trunk Sewer, Blockage, Obstruction, Surcharging, Parshall Flume, Modelling

1 INTRODUCTION

In recent years the Riccarton Trunk sewer has provided challenges not only to Christchurch City Council's Operation and Maintenance Unit, but also to modelling investigations and future planning. The sewer has been observed to be almost always near full (gorging) and yet has never been known to overflow in wet weather. Modelling to understand these observations had had limited success. Consequently field investigation was recommended but was not considered a high priority.

Recently an abandoned 225mm (9") Parshall Flume was re-discovered in the sewer together with a significant obstruction in its throat. The obstruction and collected debris was subsequently removed resulting in a significant improvement in the hydraulic performance of the trunk sewer. A permanent flow monitor is installed a short distance upstream of the flume providing continuous flow and level data, before and after removal of the obstruction.

As the trunk sewer has minimal gradient, it is possible that the effect of this obstruction could have extended for kilometres upstream, and sediment may have been deposited for several hundred metres upstream.

This paper will present, investigate and describe:

- The physical configuration of the sewer, flume, nature of the blockage, how it was removed and the associated flow gauge data.
- Use of modelling to better understand the effects of this obstruction, in terms of increased flow depths, over a range of flow conditions and explore for what distance upstream this effect may have been significant.

- Use of modelling to better understanding whether any benefits would be realised from removing (demolishing) the Parshall Flume itself.

- Implications for future growth planning around the Riccarton Trunk sewer will be discussed and recommendations for future planning evaluation described.

2 BACKGROUND

2.1 GEOGRAPHY

The Riccarton Interceptor is a 450 and 525mm dia trunk sewer which takes flows from the Christchurch suburbs of Avonhead, Ilam and Riccarton and discharges into the Southern Relief sewer. The interceptor was installed in 1954, three decades after initial development of the local sewer in the older Riccarton suburbs. Here the interceptor runs deeper than the local sewer network and consistent with its history it cuts off and interconnects with the local sewer network in several places.

The interceptor long-section is presented in Figures 6 & 7 (refer later section 4.3.1) with the location of key features described annotated.

At the downstream end of the interceptor (manhole 2820355) near the intersection of Blenheim Road and Division Street, a Parshall Flume was installed during construction of the interceptor. Immediately downstream of the flume there is a 400mm step down in invert level and the pipe size increases to 900mm dia. This 900mm pipe can become surcharged itself in severe events due to downstream constraints, but in most circumstances this provides for a reliable free flowing discharge from the Parshall Flume.

Two manholes upstream of the flume (180m distance) is a permanent HVQ type flow gauging site that has been in use since 2004.

Further upstream on Riccarton Road (1280m from the flume), there is a significant point of intersection with the local network, with a 225mm dia local network pipe connected into and out of the interceptor at manhole 2819650. In periods of high flow and surcharged conditions, flow from the interceptor can bifurcate with some flowing out into the higher local 225mm dia sewer pipe. This is still contained in the sewer network, so it is not an overflow in the manner of overflows requiring discharge consent, however for the sake of brevity it is referred to herein as the “Riccarton Road overflow”.

The first 2,000m upstream of the flume has a 525mm pipe diameter and near constant 0.1% gradient (1:1,000). The next 600m upstream drops in size to 450mm dia but with an increased gradient of 0.4%. The next 1,000m upstream passes through the University of Canterbury grounds and is still 450mm dia but with a reduced gradient of 0.12%.

The University of Canterbury is the most significant entity in the Riccarton Interceptor catchment. The majority of the University campus buildings drain into the interceptor. During holiday periods when the University is quiet there is a notable reduction in flows in the interceptor.

2.2 WHAT TRIGGERED THE INVESTIGATION

Regular surcharging (gorging) of the Riccarton Interceptor at even relatively low flows was pretty much the accepted ‘norm’. Plans were in place for it’s upgrade, and in the meantime, it was more about managing the situation than looking for particular answers to the problem or even ‘quick-wins’.

The Riccarton Interceptor surcharging investigation was essentially kicked-off with the asking of a simple question:

> *What if something else, something unseen, was playing a role in the surcharging?*

It wasn’t long before a long-ago decommissioned and forgotten Parshall Flume has been found in the Riccarton Interceptor trunk sewer, and the hunt was on.

2.3 TIMELINE

The timeline of key events relevant to this paper are presented in Figure 1 below, which illustrates:

- Milestone activities of sewer cleaning and gauge equipment maintenance.
- Periods of flow variation due to University holiday period and rain.
- Periods where the flow gauge data is unreliable or unavailable.
- Four periods of interest for comparison before and after the above changes.

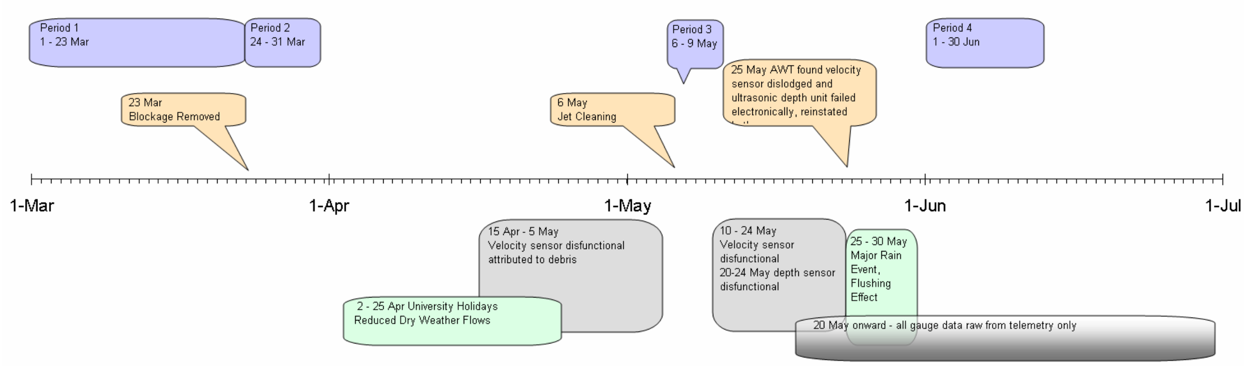

Figure 1: Timeline

The main focus of this paper is to understand and compare differences in hydraulic conditions in the sewer from periods 1, 2 and 3. Period 4 is expected to be similar to period 3, but is presented in some cases due to the short time window available for period 3.

2.4 FINDING THE OBSTRUCTION AND ITS REMOVAL

Historical observations of dry weather flow gorging in the Riccarton Interceptor had become accepted among council staff as the 'norm'. It was assumed the sewer was undersized, and an Excel spreadsheet used to estimate maximum DWF and WWFs suggested the same. The question whether there was some other issue at play wasn't investigated further at the time, but a recent drive by council staff to improve the operational efficiency of the trunk sewer system kicked-off some further investigation work into the Riccarton Interceptor surcharging issue.

Prior to site visits being carried out, 'as built' drawing (stored on microfiche) were reviewed. It wasn't long before the first line of enquiry was developed. A long forgotten Parshall Flume structure at the tail end of the Riccarton Interceptor was observed on the 'as builts' and a preliminary site visit carried out (during the morning when flows weren't particularly low). The flume was observed from the surface, but no obvious obstruction could be seen, apart from the fact that is was running full, and slightly overtopping.

A man-entry visit was planned, and video taken of the inside of the flume chamber. Once again, other than the flume and sewer running 'full' no obvious obstruction was observed (Note: What didn't happen during this man-entry of the chamber was some prodding around in the throat of the flume, which may have picked up the obstruction).

This is where a bit of luck played a role. AWT (CCC's long-term flow monitoring contractor) was due to install a flow gauge in the Riccarton Interceptor, and the rectangular conduit upstream of the flume (a 2' by 4' approach channel) was identified as being the ideal location for the flow monitor. AWT went to install their monitor in the early hours one morning. Due to the lower water levels and improved water clarity at night, the obstruction in the throat of the 9" flume (Photo 1) had become clearly visible. They were unable to remove the obstruction, but informed CCC of their findings (good communication between client and contractor pays dividends). AWT subsequently changed their plans and installed their flow gauging equipment in manhole 2320370 upstream (the same manhole as had been used for previous flow gauging).

City Care, CCC's maintenance contractor was instructed to remove the blockage, and on the morning of the 23rd March 2010, a length of DN225 PVC pipe was removed from the throat of the flume (Photo 2). Immediately, the water level upstream of the flume dropped by approximately 150mm, and the process of getting the Riccarton Interceptor back to operating as originally designed started.

Photographs 1&2: Blocked Flume (AWT 3:35am), Obstruction Removed

The hydraulics of the trunk sewer literally changed overnight, with velocities improving, and surcharging of the lower reaches dramatically reducing, to the point that previously wet benching in some manholes became noticeably dryer. Jetting of the downstream manholes followed, improving the hydraulics of the line, before a significant wet weather event at the end of May 2010, may have cleared the trunk sewer still further. Photos of the flume after clearance have not been obtained due to the confined space entry requirements for access.

Overall, this investigation into an issue that had been considered the 'norm' led to a significant improvement in the hydraulic behaviour of the Riccarton Interceptor, which in turn, may be aiding a reduction in the severity of overflows in the adjacent catchment, to which the Riccarton Road overflow discharges.

2.5 AS BUILT INFORMATION

CCC have stored on microfiche a large collection of 'old' as-built drawings of their water, wastewater and stormwater systems. These drawings are easily accessible, and regularly referred to, as key as-built information is generally not captured in CCC's Geographic Information System (GIS).

The as-built drawings for the Riccarton Interceptor (Figure 2) were no exception, and important details of the Parshall Flume and other assets could be easily verified with out expensive and time consuming field surveys.

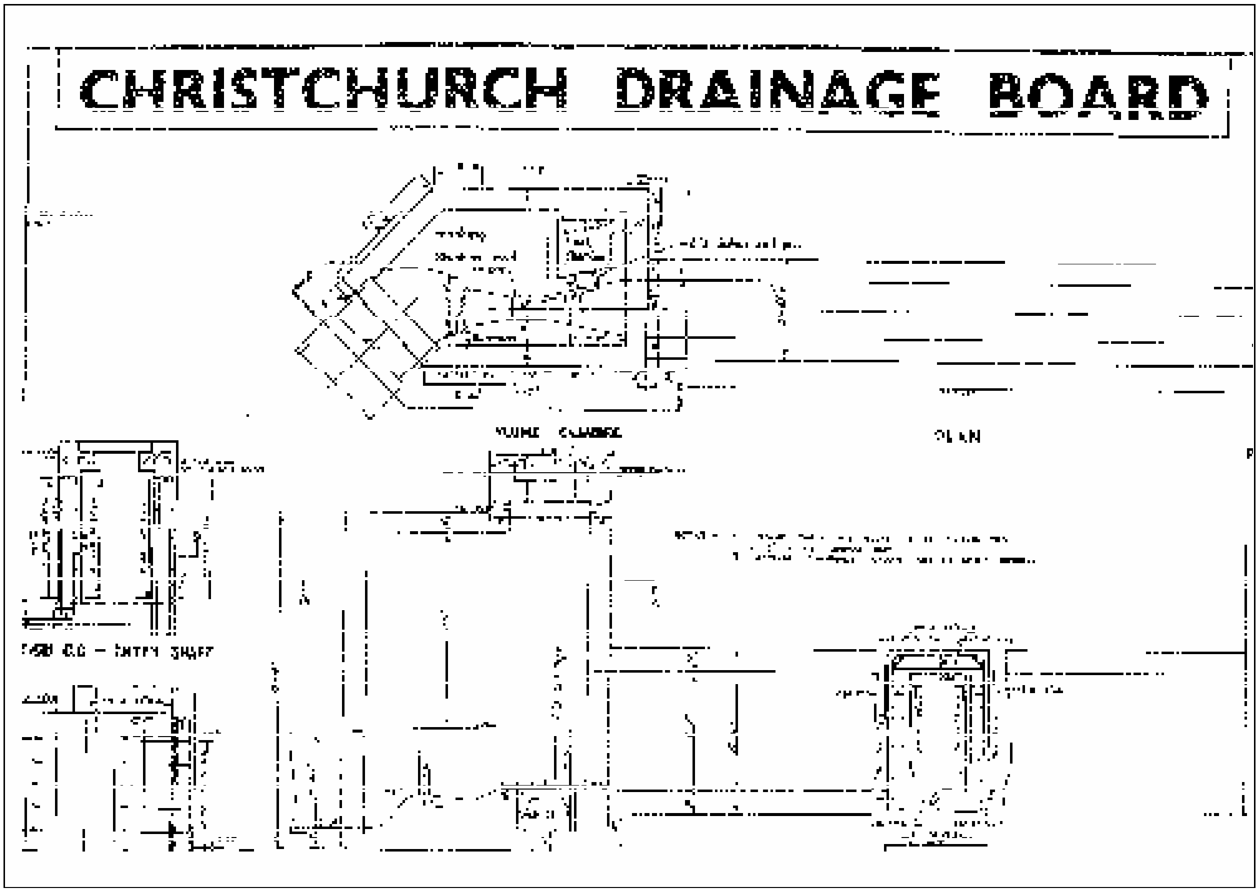

Figure 2: Parshall Flume As-Built Drawing

Key As-Built dimensions of the Parshall Flume were compared with ISO 9826 (1992). All key dimensions were consistent with the 225mm (9-inch) flume except that the 75mm (3-inch) initial upslope was not provided. This exception is not considered material and is neglected in the following analyses.

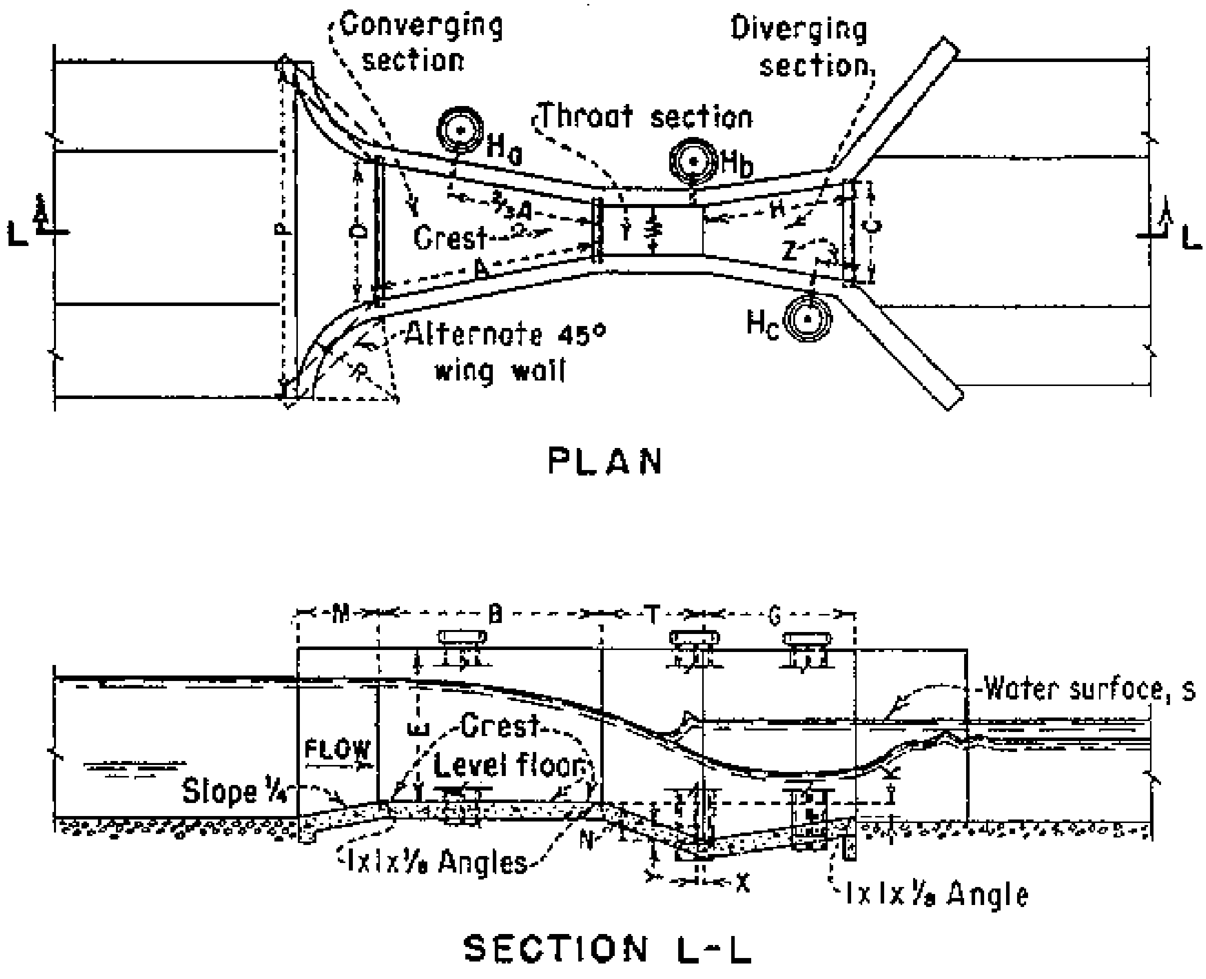

Figure 3: Parshall Flume Standard Drawing (USBR 2010)

2.6 CCC SEWER MODELLING

Christchurch City Council undertook an initial phase of trunk sewer modelling with Mouse software through the 1990's. After a period of inactivity, in 2005, GHD began to perform trunk sewer modelling on behalf of the council, building on and improving the initially established model, converting it to Mike Urban software, and recalibrating it based on 2004-2005 flow data.

During the 2005 calibration work, depth calibration at the Division Street flow gauge site only achieved a "B" standard of accuracy. Data from that period has been presented with the grey points on Figure 14 (refer later section 4.3.3). This indicates that the flume was much more blocked in 2010 than it was during 2005.

The current model has undergone various refinements since 2005 but underlying flow and hydraulic calibration is still predominantly unchanged from this calibration work.

2.7 DRY WEATHER FLOW CHARACTERISTICS

Table 1 presents typical dry weather flow data for the Riccarton Interceptor, both from the current model and from recent flow gauging data.

Model results suggest that during periods of peak dry weather, some flow will be diverted into the Riccarton Road overflow. During periods of higher wet weather flows, more flow would be diverted into the overflow, with minimal change in the Riccarton Interceptor flow or levels downstream. Wet weather flows were therefore not considered to be of interest and it was decided to limit the focus of this study to the various dry weather flow conditions.

Flow (l/s)	Night flow	Average flow	Peak flow
Current model (winter weekday)	42	99	156
March 2010 gauge	22	74	155
June 2010 gauge *	30	74	140

Table 1: Dry Weather Flow Characteristics (flow – l/s)

* Gauge data for June 2010 is preliminary and has not yet been finalised by AWT Ltd.

3 MEASURED SEWER PERFORMANCE

3.1 FLOW GAUGING ISSUES

Gauge installation and initial (min, avg & max) calibration was carried out from 24 Feb to 11 Mar 2010. The HVQ gauge consists of an ultrasonic depth measurement device and a Doppler type velocity sensor installed in the pipe invert.

Hydraulic conditions at the site were reasonable for gauging, however low velocity was noted, and sediment observed in the pipe invert of the manhole immediately downstream. Where such sediment is present there are risks associated with sediment movement and variation in depth over time, affecting hydraulic conditions or interfering physically with the sensor.

Investigation by AWT subsequently resulted in discovery of the Parshall Flume 180m downstream and the obstruction backing up flow upstream of the flume. It was then realised that these high depth, low velocity conditions upstream of flume caused the sediment which was observed at the gauging site.

Raw data adjustments from 24 Feb to 25 May have been made based on the initial Feb-Mar calibration work. As is illustrated later in this paper, the hydraulic conditions changed significantly on 23 Mar and the validity of the raw velocity data adjustment is slightly questionable for data after 23 March. A single point (min) calibration check carried out on 20 May suggests some change in the velocity adjustment may be required for more recent data but this can't be confirmed until the next full calibration check is completed.

Raw data through the end of April and parts of early May indicated gauging equipment recording issues. Distorted velocity readings during late April are attributed to debris (or ragging) interfering with the velocity sensor, due to the modest nature of the distortion and the fact that velocity patterns returned to normal on June 6th, when city council operations staff jet cleaned the length of sewer between the Parshall Flume and just downstream of the gauging equipment.

Subsequent failure of the velocity sensor on May 9th was more absolute as was the failure of the depth sensor on May 20th. AWT visited the site on 25 May and found that the velocity sensor had become dislodged from its fixed position and the ultrasonic depth sensor had suffered an electrical failure. Both measurements were reinstated and reasonable data is evident thereafter.

On special request for this paper AWT have provided adjusted data for the 25 May to end of June data period, however this data is not finalised by AWT and will not be until the next full calibration check is completed.

3.2 FLOW GAUGE DATA

Depth and flow data from four periods of the Division St flow gauge are presented in Figure 4 below.

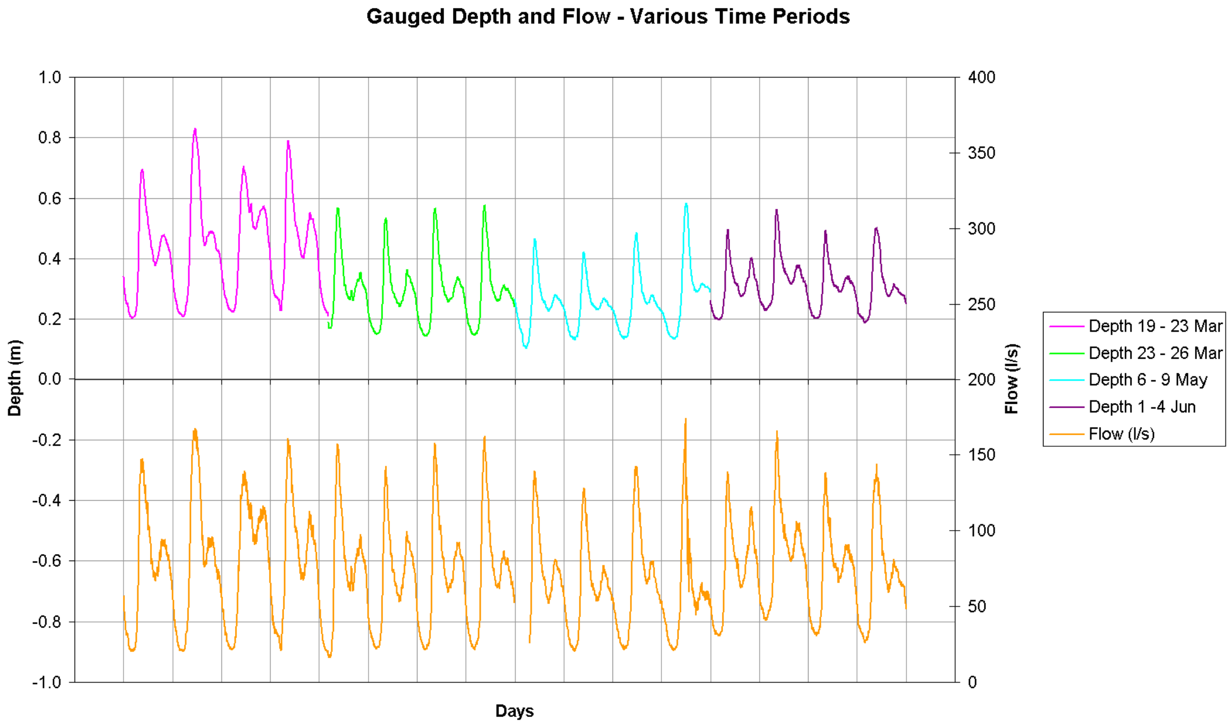

Figure 4: Gauged Depth and Flow Time-series

This illustrates the dramatic reduction in flow depth that was achieved due to removal of the blockage on March 23rd and the more subtle improvement that was achieved during subsequent jet cleaning on June 6th, against a background of reasonably consistent daily flow patterns.

Depth and velocity relationships from the four periods of the Division St flow gauge are presented in Figure 5 below.

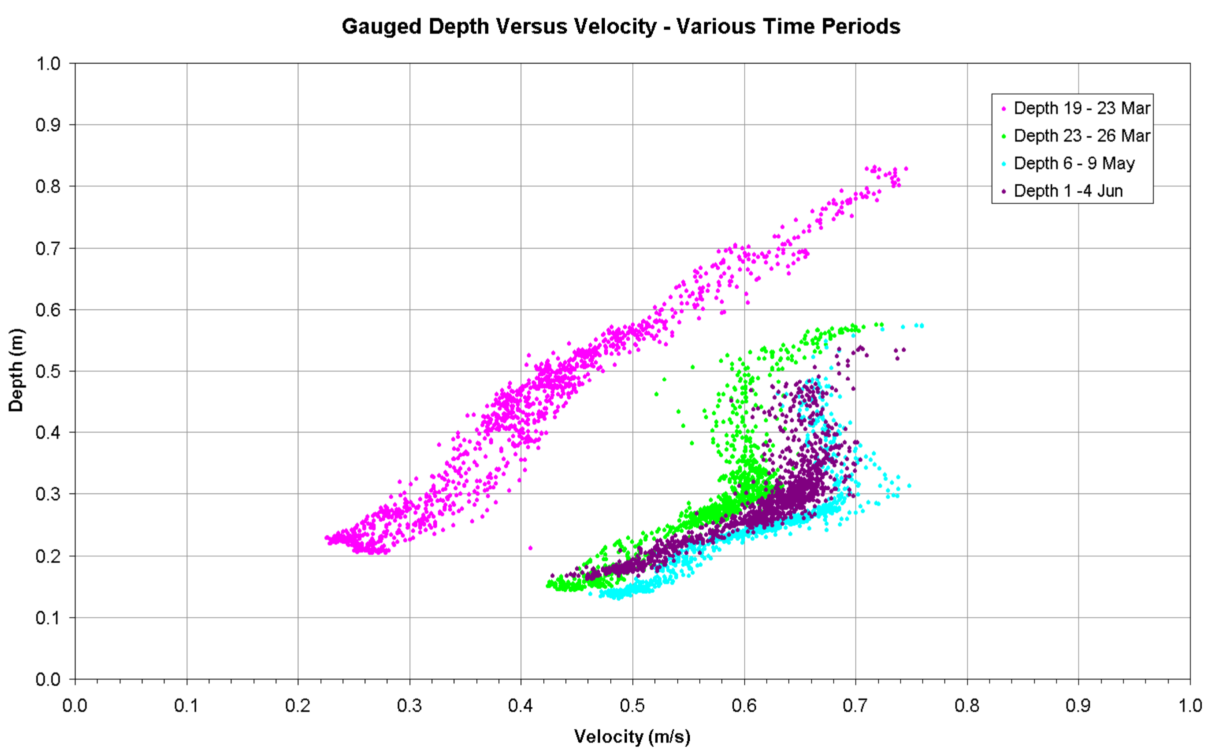

Figure 5: Gauged Depth / Velocity Relationships

This illustrates the improvements in velocity and reduction in flow depth achieved from each phase of sewer cleaning. The change that occurred with Mar 23 removal of the blockage was major and a conclusive improvement. The change that occurred on June 6th with the jet cleaning operation was more subtle but still noteworthy. Differences between 9th May and 1 June (around rainfall flushing) are minor and may be insignificant. Data from June is preliminary and cannot yet be finalised by AWT.

4 MODELLED SEWER PERFORMANCE

4.1 MODEL BUILD

Modelling was undertaken with the intention to imitate the flume in both its blocked and cleaned conditions. Key aspects of modelling for this analysis were:

- Modelling was truncated downstream of the flume, representing a free flowing condition and precluding surcharging conditions downstream.

- Based on observation of the obstruction and nature of flows observed the blocked flume was modelled with a standard flat crested weir set at 600 mm above the pipe invert, with a 600 mm crest width.

- The clean flume was represented by a Q-H relationship based on the ISO 9826 flow calculation method Q (m3/s) = 535 H (m) ^ 1.53

- The removed flume was modelled by including two additional lengths of pipe downstream from the flume before a free flowing outlet condition.

- The 225mm dia Riccarton Road overflow pipe at manhole 2819650 was represented in the model at its correct invert level (225mm above the soffit of the interceptor); with a gradient of 1:500 and an outlet-weir 100mm above the pipe invert 75m downstream from the manhole. The actual slope of this local sewer is thought to be 1:300; however the above modelling adjustments were made in recognition that the model would not provide any local flow and would otherwise under-represent likely downstream hydraulic conditions in this pipe.

Dry and wet weather flow data for the model used winter weekday flow patterns from the model calibration to 2005 flow data.

4.2 MODEL VERIFICATION

Dry weather flow model performance upstream of the flow gauging site was verified informally by CCC staff observations of water level and high water marks in several manholes upstream of the flow gauging site.

After removal of the obstruction, previously unseen benching and pipe soffits became visible. The extent of the historical surcharging became evident from signs such as debris on the benching, ragging of the step irons and water marks higher up the manhole walls, but there was now no evidence of recent high level surcharging that had in the past been associated with the Riccarton Interceptor.

Photographs 3 and 4 below show ‘before and after’ conditions in manhole 2819795, located 450m upstream of the flume. Photo 3 was taken at 10:50am many days before blockage removal. Photo 4 was taken at 11:58am on the morning when the blockage was removed. Model predictions for this manhole are presented in Figure 10 (refer later section 4.3.2).


Photographs 3 & 4: Before (10:50am) and after (11:58am) at manhole 2819795, 450m upstream

Photos 5 & 6 below are both taken after removal of the blockage from the flume. High water marks on the walls in Photo 5 illustrate the continued daily surcharging levels in that manhole which is approximately 150m downstream of the Riccarton Road overflow. Ragging and debris on ladder rungs in Photo 6 show how high the surcharging has been in the past. What is interesting is that in this photo is that the benching is now observed to be virtually dry, even though the photograph was taken shortly after a sustained wet period.


Photograph 5: After cleaning at a manhole 150m downstream of the Riccarton Road overflow manhole

Photograph 6: After cleaning at manhole 2819090 200m upstream of the Riccarton Road overflow manhole

4.3 MODEL RESULTS

Model results for blocked and cleaned flume conditions and for the flume removed are presented using long-sections, time-series and scatter-plots in the following sections.

4.3.1 LONG-SECTIONS

Model predicted sewer performance upstream of the Parshall Flume for the blocked and cleaned conditions at model time 9:15am is illustrated in the following two figures. This flow condition was selected as it demonstrated the most dramatic difference between blocked and clean sewer performance.

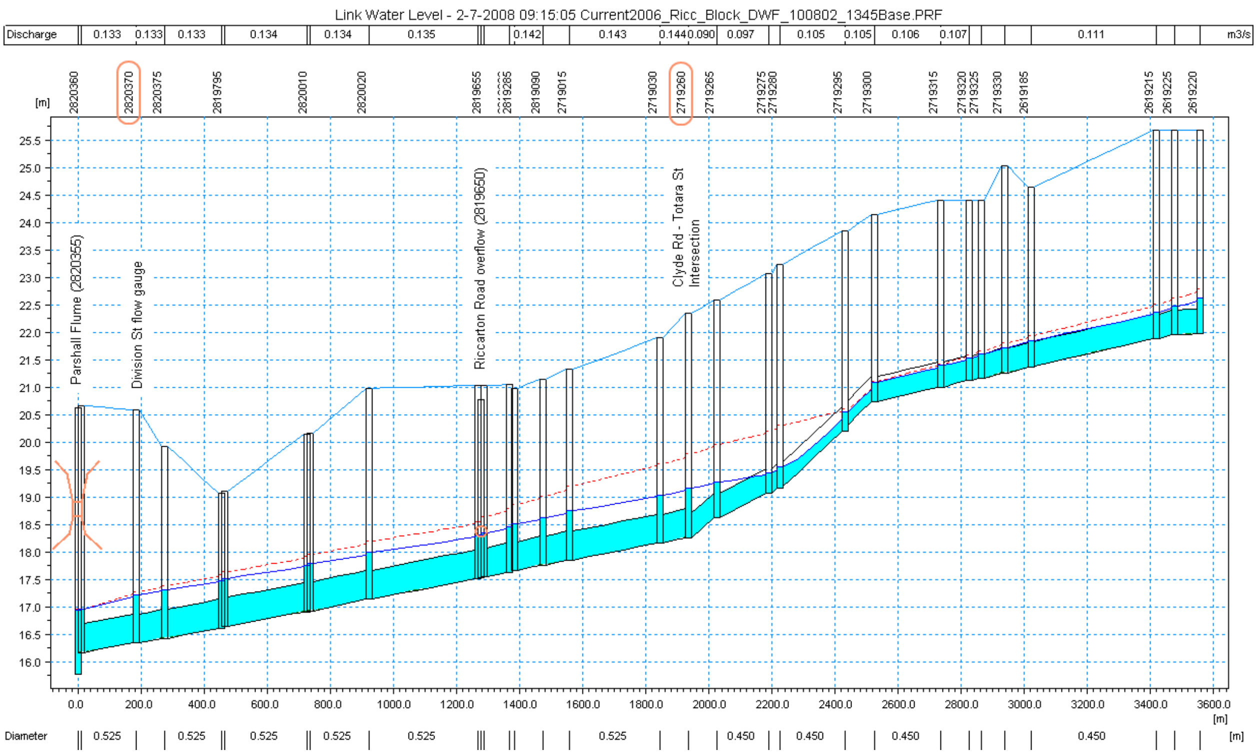

Figure 6: Blocked Flume Model Long-section

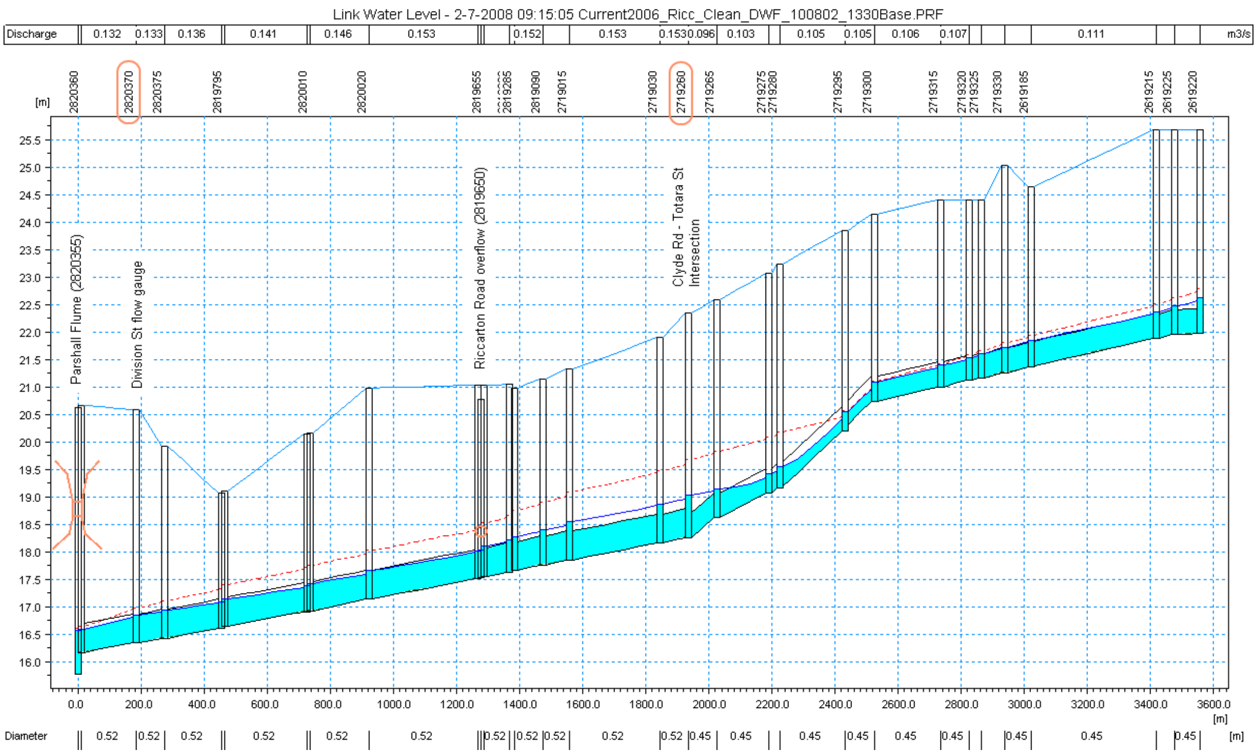

Figure 7: Clean Flume Model Long-section

These two figures illustrate the significance of the blocked flume in the 2,000m of sewer upstream of the flume, under conditions somewhat less than peak dry weather flows (blue lines). Pipe full and some minor surcharging are evident in this lower section of the sewer when the flume is in it's normal clean condition, but significant surcharging is already evident for the same flows when the flume is in it's blocked condition.

The significance of the Riccarton Road overflow 1280m upstream from the flume is evident in the peak dry weather flow depths (red dotted lines). In both figures the hydraulic grade line is depressed at this location, with the depth in both cases constrained by the effect of this overflow. The upper reaches of the Riccarton Interceptor are not affected by surcharging, although in wet weather events with larger flows this continuous surcharging upstream from the Riccarton Road overflow would be anticipated.

4.3.2 DEPTH TIME-SERIES

Time-series of model predicted flow depths for each of the three model conditions (blocked, cleaned, flume removed) are presented for various manholes upstream of the Parshall Flume in Figures 8-13.

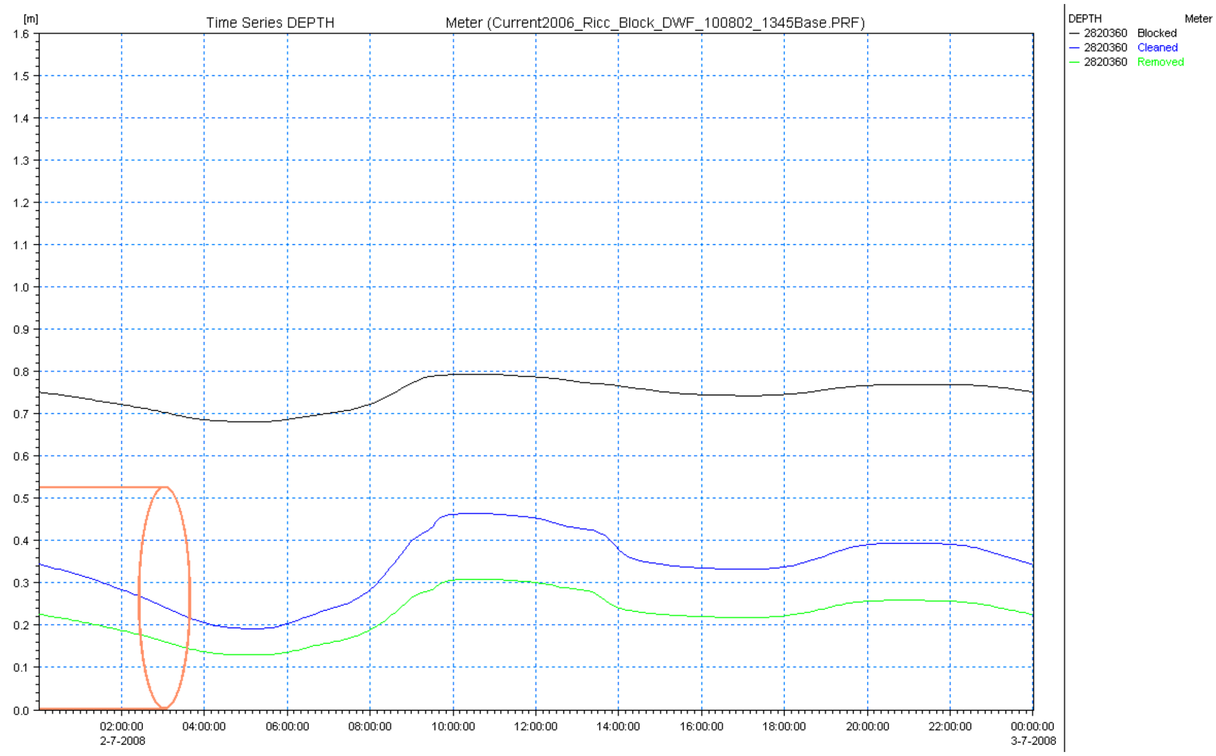

Figure 8: Modelled Depth Time-series - 10m upstream of the flume (manhole 2820360)

Throughout this series of similar figures, the first data (black) with the highest depths is from modelling of the blocked flume, the next data (blue) is from modelling the cleaned flume and the last data with the lowest depths (green) is from modelling with the flume removed.

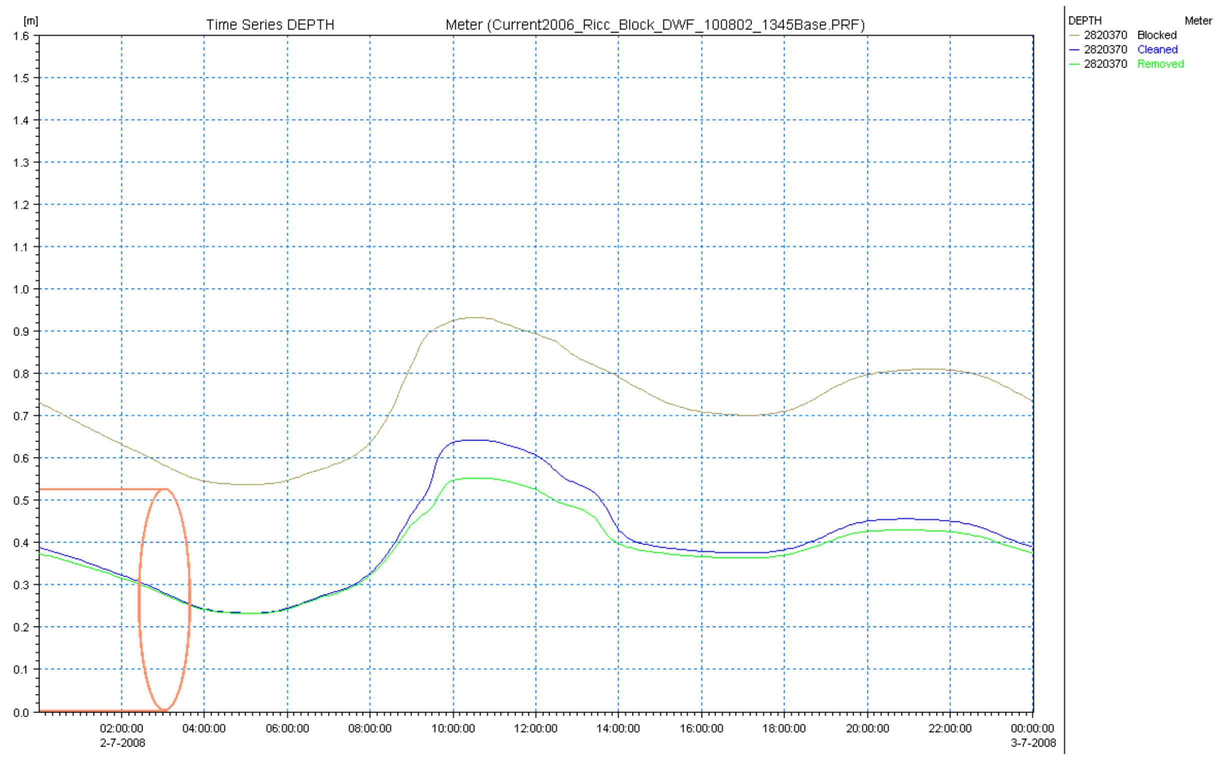

Figure 9: Modelled Depth Time-series - 180m upstream at Division St Gauging Site (manhole 2820370)

Figures 8 & 9 illustrate the locally large significance of the blockage in the flume and lesser but still noteworthy significance of the flume itself.

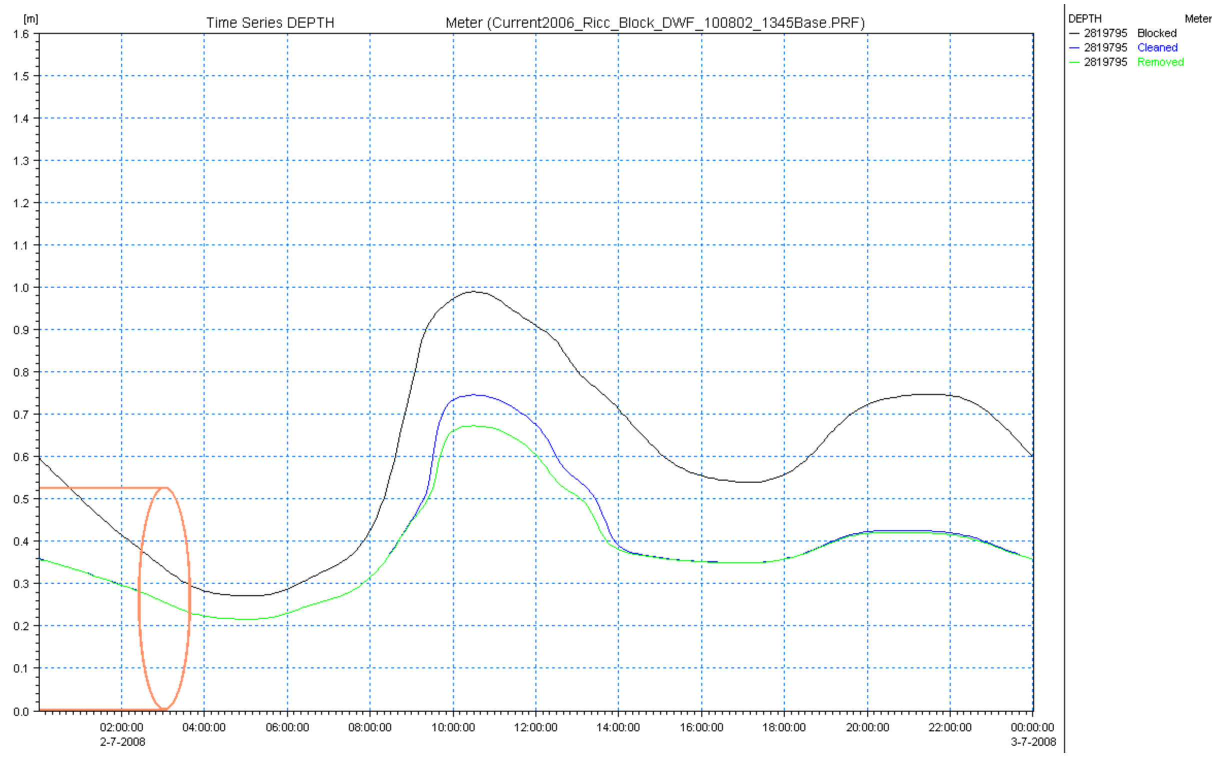

Figure 10: Modelled Depth Time-series - 450m upstream (manhole 2819795)

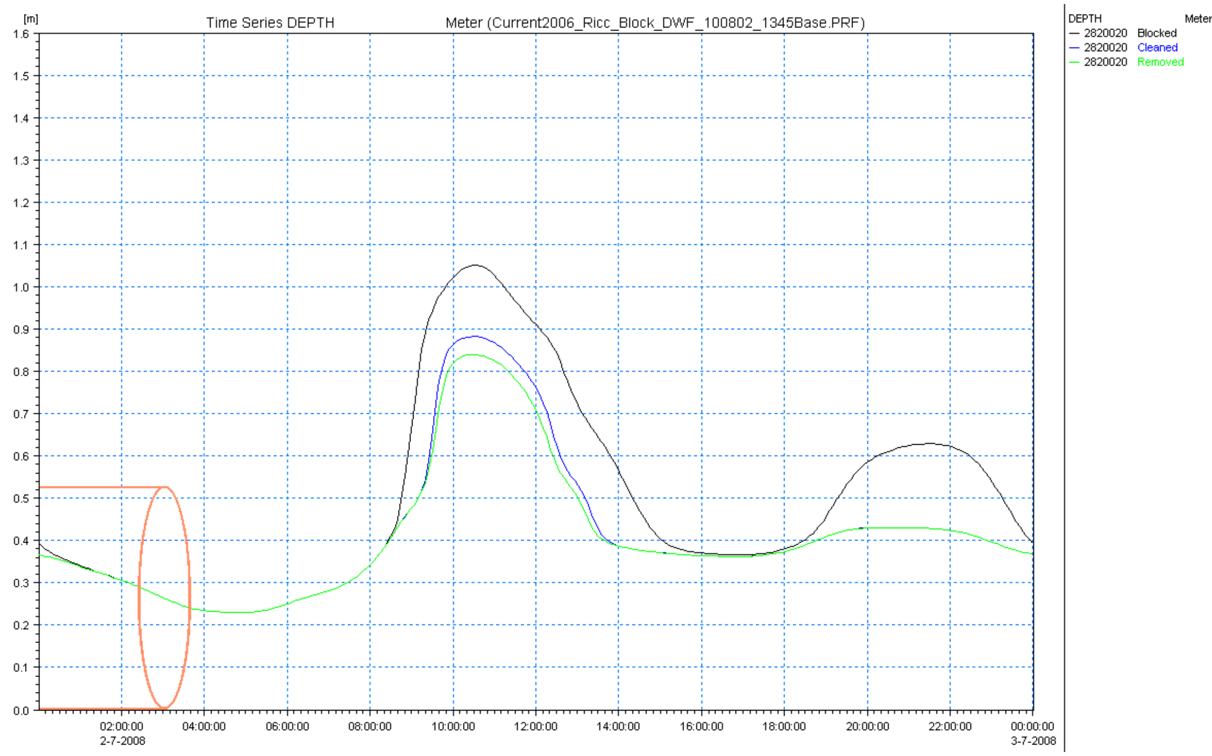

Figure 11: Modelled Depth Time-series - 920m upstream (manhole 2820020)

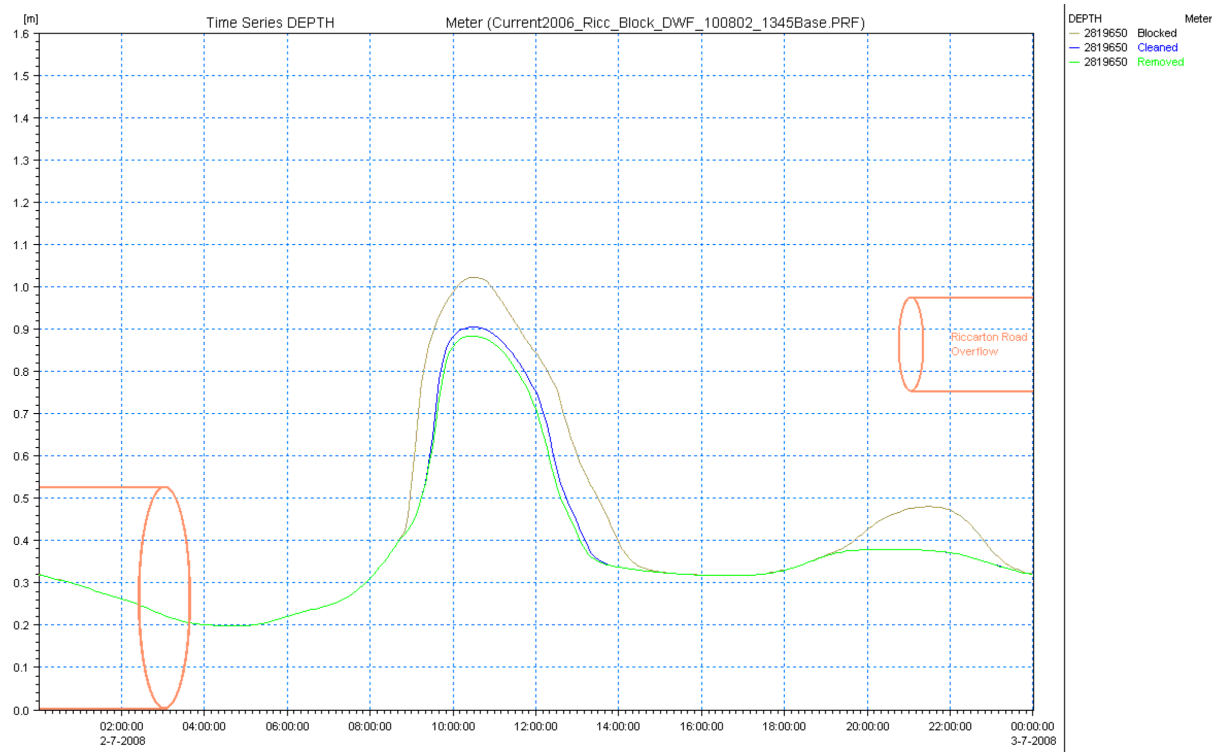

Figure 12: Modelled Depth Time-series - 1280m upstream at Riccarton Road overflow (manhole 2819650)

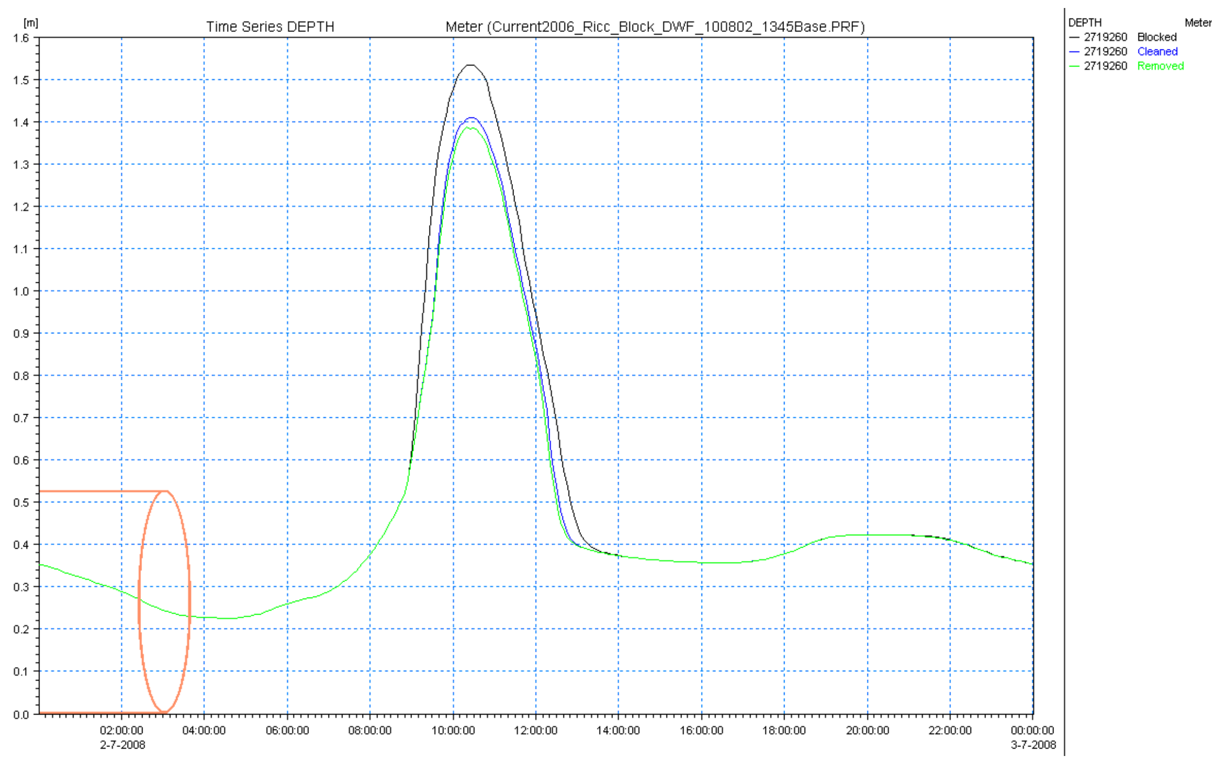

Figure 13: Modelled Depth Time-series - 1950m upstream (manhole 2719260)

The last four figures illustrate effectively how differences in depth between the blocked flume (black) and clean flume (blue) diminish rapidly with distance upstream from the flume. They also illustrate how differences between the clean flume (blue) and removed flume (green) become insignificant upstream of the Division St flow gauging site.

4.3.3 FLOW VS DEPTH RELATIONSHIPS

The relationships between flow in the upstream link and depth in the manhole at the Division St flow gauging site and the Riccarton Road internal overflow manhole are presented in Figures 14 & 15.

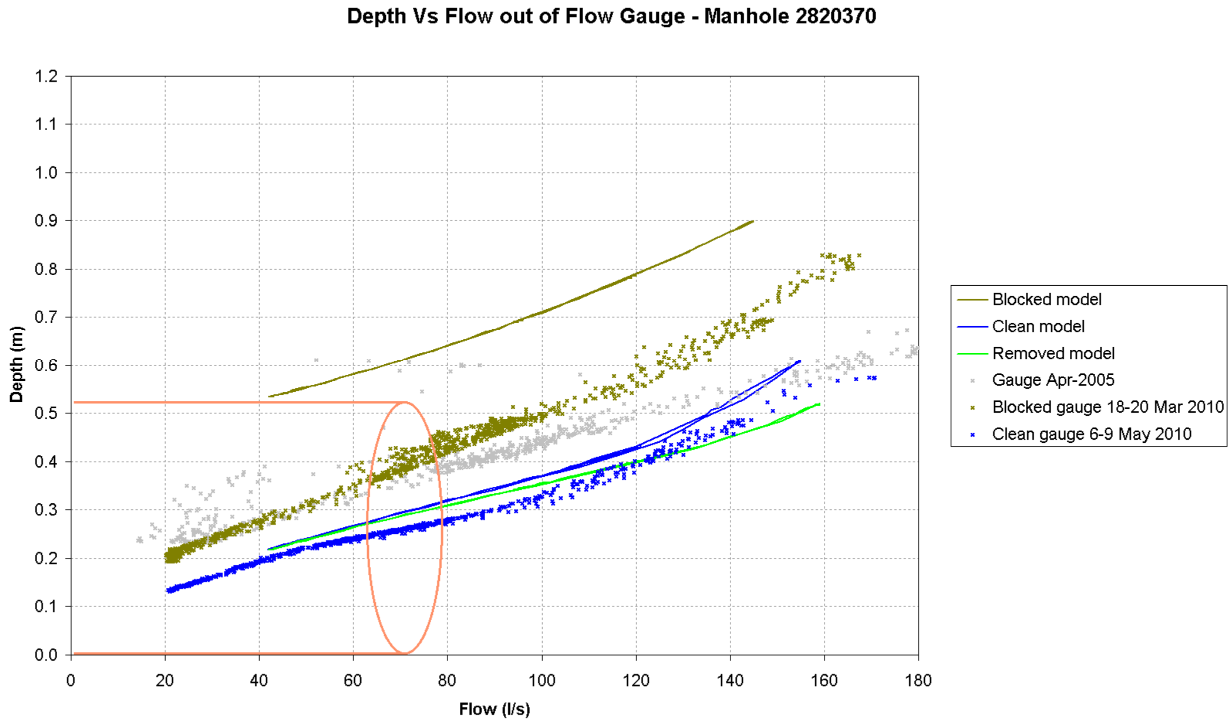

Figure 14: Flow Vs Depth at Division Street Gauging Site 180m upstream (modelled and measured)

Figure 14 illustrates the model predicted distinction between performance of the blocked, cleaned and removed flume, with strong improvement predicted with cleaning of the blocked flume and more subtle improvement predicted if the clean flume was to be removed.

These relationships are also compared with the blocked and clean flume relationships determined from the flow gauging data. As is evident for the clean flume, the measured data (blue line) and model prediction (blue points), match reasonably well. The 25mm discrepancy is considered of minor significance and could reflect either gauge calibration accuracy (noting the field calibration has not been carried out since the March 23 change in hydraulic condition) or could suggest that a minor adjustment in model head-loss parameters could be appropriate.

Comparison for the blocked flume measured data (brown line) and model prediction (brown points), does not match. This difference is most likely caused by overestimating the magnitude of the blockage when determining how it would be represented for modelling. This result suggests that there was probably significant flow passing under and around the blockage which was not evident from visual inspection, thus the actual blockage is measured as having only about half the effect that was anticipated through the modelling work.

For further comparison, data from the April 2005 calibration data is shown to illustrate the possible condition of the flume during this period. Comparison of this data suggests with the 2010 data suggests that the flume was neither clean nor fully blocked during the 2005 calibration data period.

Figure 15 below presents a similar relationship further upstream at the Riccarton Road overflow. In this case, flow data is taken from the pipe upstream of the manhole, so as to capture both flows kept in the interceptor and flows overflowing into Riccarton Road.

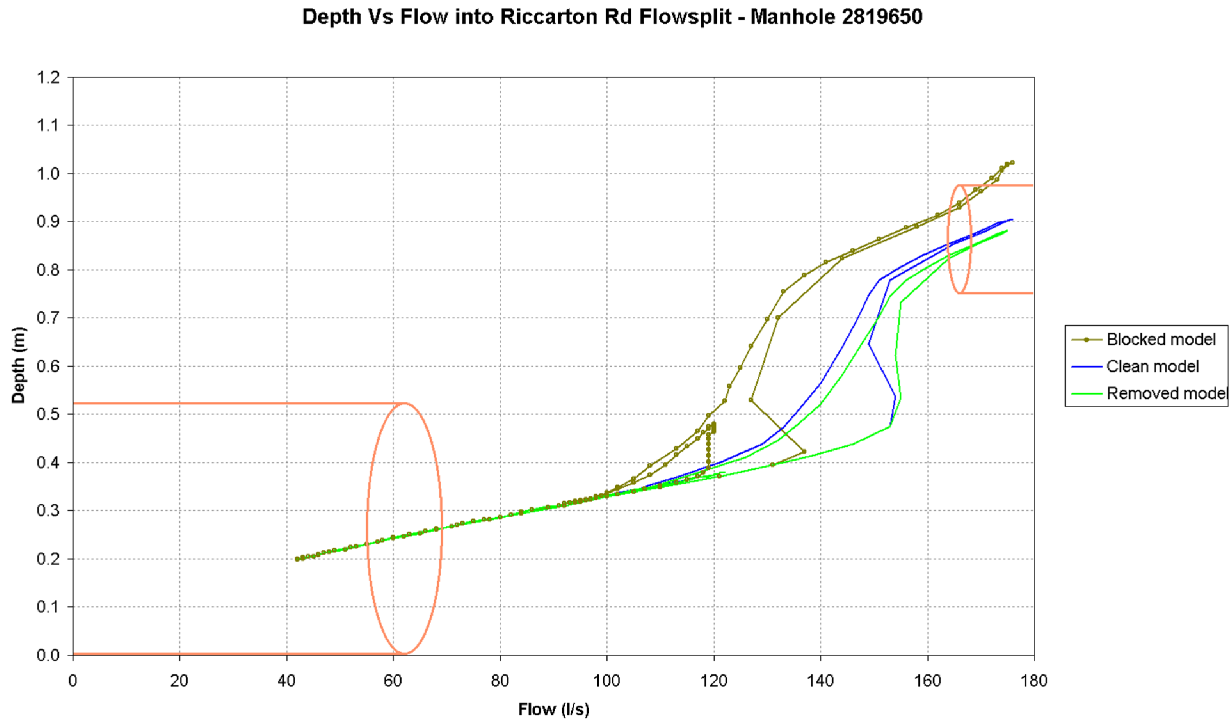

Figure 15: Flow Vs Depth at Overflow Site 1280 upstream (modelled only)

Figure 15 illustrates rather different model predicted characteristics of the sewer further upstream from the flume. Results for all downstream conditions illustrate a jump up in flow depths in the jump transition from 90% pipe full flow to approx 140% pipe full surcharged flow conditions. This jump transition is a common and real feature of long uniformly flat graded sewer pipe and has been recognised as a phenomenon to varying degrees in several parts of the Christchurch trunk sewer network.

All results also demonstrate a hysteresis loop, which is typical of the more gradually dropping water levels following surcharging in such systems. The blocked model results also demonstrate a secondary hysteresis loop during the evening peak when flow depths also approach pipe full.

The major contrast between the three modelled conditions is in the peak flow which is attained prior to the surcharging transition. For the blocked condition this is 137 l/s, whereas in the clean and flume removed conditions this increases to 154 and 155 l/s respectively.

Another feature of Figure 15 is that the flow – depth relationships above a depth of 0.75m again converge as they are all limited by the overflow which has its invert at this level.

The overall conclusion from Figure 15, 1280m upstream from the flume, is that:

- During low flow conditions the blocked, clean or removed flume has no effect.
- During intermediate flow conditions the blocked flume will induce surcharging at significantly lower flows than the cleaned flume, but removing the flume will have negligible benefit.
- During higher flow conditions (surcharged and activating the Riccarton Road overflow), results from blocked model predict a higher degree of surcharging than the clean model, but removing the flume will have negligible benefit. Model results also showed that peak overflow rate from the blocked and clean models were 30 and 20 l/s respectively.

5 DISCUSSION

5.1 PERFORMANCE IMPROVEMENT IF THE PARSHALL FLUME WAS REMOVED

The depth Vs flow relationships presented in the previous section illustrate the model predicted contrast in performance, which may be expected were the Parshall Flume to be demolished and removed from the system.

At both locations presented, for flows less than 100 l/s (between measured average and peak dry weather flow) there would be negligible improvement in sewer performance from removal of the Parshall Flume. At low flow conditions, depth and minimum velocity conditions would not be materially improved by removal of the flume.

For flows in excess of 120 l/s, with predicted flow depths of around 400mm (76% of pipe full), a modest benefit from removal of the flume starts to become evident.

At the Riccarton Road overflow, (manhole 2820270), 1280m upstream from the flume, as flows approach 151 l/s with the Parshall Flume in place, overflow into the 225 dia pipe is predicted to begin. If the Parshall Flume was removed this phenomenon would be predicted to occur at 155 l/s. This difference is minor illustrating the only modest affect of the flume at this point. For flow rates in excess of 160 l/s, the predicted effect of the Parshall Flume is to raise water levels by only 20mm.

At the Division St flow gauging site (manhole 2820370), 180m upstream from the flume, as flows increase form 120 – 150 l/s the reduction in depth that could be achieved through removal of the Parshall Flume increases from 25mm to 100mm. At ‘pipe full depth’ flow the sewer is predicted to be 140 l/s with the flume in place and 160 l/s with the flume removed. This difference in flow rate for a given depth may appear significant, however it evidently has little effect at the Riccarton Road overflow manhole upstream.

In summary, there is minimal effect on depths of flow, velocities or pipe capacity either near the flume or upstream across low-med flow conditions (<75% pipe full), nor in surcharged conditions (>100% pipe full). With near peak dry weather flow conditions there is a material difference in flow depths, with the flume being demonstrated to trigger the transition into surcharging conditions at lower flows than if the flume were removed. Consequently the duration of the surcharged conditions during each dry weather peak will be reduced if the flume is removed.

The predicted extent of this reduction is illustrated on the depth time-series graphs presented in a previous section. The greatest reduction in surcharge duration is predicted to occur closer to the flume at the Division St flow gauging where surcharge duration would be reduced from 4 hours to 2.3 hours. The sewer is not known to present customer or operational problems during the presently frequent surcharging conditions hence it would have to be concluded that reduction in surcharging duration is of minor benefit.

A final potential benefit to consider is dry weather flushing velocities. Model results predict peak dry velocity, in the worst reach of pipe between the Division St flow gauge and the Riccarton Road overflow, would increase with removal of the Parshall Flume from 0.715 to 0.735 m/s. Both of these flushing velocities are acceptable and the difference immaterial.

In conclusion, no material hydraulic benefit can be anticipated from removal of the Parshall Flume. If left in place the flume should be monitored regularly for accumulation of debris and blockages. It is possible that the frequency of blockages and costs of cleaning may in future justify the cost of demolishing the flume but it is also likely that leaving the flume in place may be the most efficient use of public funds.

5.2 IMPLICATIONS FOR FUTURE PLANNING FOR THE RICCARTON TRUNK SEWER

The two major findings from this study relevant to previous modelling are the significance of the blocked Parshall Flume and the affect of the Riccarton Road overflow.

Modelling indicates that the impacts of the blocked Parshall Flume, while locally significant are minor within the broad context of the Riccarton Interceptor. The blockage is likely to have reduced capacity marginally, increased the rate and frequency of flow into the Riccarton Road overflow and increase surcharged water levels marginally, but none of this has implications for previous planning studies.

Retrospective analysis of the 2005 flow gauge data used in calibration (refer Figure 14 in the previous section) suggests that the flume and/or pipe near the flow gauging site was also partially blocked during 2005. Recognition of the flume's existence and cleaning of the flume and pipe will have the likely effect of increasing the accuracy to which depth calibration can be achieved at the Division St flow gauge, but will have minimal other affects as calibration flow data will not be affected.

Previous planning for a future upgrade of the Riccarton Interceptor were based on modelling carried out before the Riccarton Road overflow was recognised to exist. This overflow is at a low level being close to the interceptor pipe soffit and has been shown from the modelling in this study to be significant in preventing surcharged conditions during peak dry weather flows and would be even more significant during medium sized wet weather flows.

Flow monitoring has not been carried out on this overflow to determine how much flow is being lost from the Riccarton Interceptor at this point and consequently understanding of infiltration characteristics of upstream catchments has been significantly compromised. The capacity of the local 225 dia sewer network to pass flows from the Riccarton Interceptor has not been investigated. The resulting uncertainty about flows to be expected from the upstream catchments creates a high level of uncertainty on findings of the previous planning studies. Further flow monitoring and development of a higher level of modelling detail down to 225mm dia pipe in this area is recommended to provide suitable confidence from which to plan.

The Riccarton Road overflow is a likely explanation for the observed tendency for the Riccarton Interceptor to be full or surcharged much of the time despite never overflowing during wet weather events.

6 CONCLUSIONS

A long-ago decommissioned and forgotten Parshall Flume has been found in the Riccarton Interceptor trunk sewer. The flume was found to be badly blocked, causing increased depth and reduced velocity upstream. When this obstruction was removed and associated debris cleaned out, flow depths and velocities, as recorded on a flow gauging station upstream, both improved substantially.

Modelling has been carried out to determine the significance of this blockage with the modelling setup based on visual observation of the nature of the blockage. Modelling has shown that while the blockage is significant in the vicinity of the flume, especially at low flow conditions, this effect dissipates rapidly with distance upstream. Subsequent analysis has also indicated that the flume blockage was in reality less severe than what was estimated from visual evaluation of the blocked flume.

The result that the flume blockage did not have significant effect upstream is largely due to the moderating effect of the Riccarton Road overflow, which prevents the lower section of the Riccarton Interceptor from becoming significantly surcharged during peak dry weather and during modest rain events. During modelled peak dry weather flow, the predicted flow rates into the Riccarton Road overflow were increased from 20 l/s to 30 l/s as a result of the blocked flume.

If it were not for the Riccarton Road overflow, the effect of the blockage would have been far more significant, both in depth and in lateral extent of surcharging. Without this overflow the blockage would have increased the frequency and severity of surcharging and would have increased the risk manhole spilling in a sufficiently large rain event.

Modelling has also been carried out to determine the significance of the Parshall Flume on flow conditions upstream. This concludes that there would be no more than minor hydraulic benefits from removal of the flume. Its removal is not recommended unless the costs of keeping the flume clean and clear, justify the cost of a project to remove it.

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AWT identified the blockage in the flume. AWT provide sewer flow gauging services for Christchurch City Council and provided specific comment and analysis regarding the flow gauging period for this study.

DHI supply the Mike Urban software used for Christchurch City Council sewer modelling and confirmed some of the modelling methodologies used in this study.

POST SCRIPT

During recent years, several investigations have been carried out trigger by flow conditions which modelling has identified as abnormal. Two years ago, high measured flow depths at the Grassmere overflow led to investigations and finding of a rope and significant volumes of sediment in the 900 dia sewer downstream. The rope was cut but attempts to remove the sediment have not yet been successful.

Field staff reports of downstream surcharging and manhole spilling preventing the operation of two pumps in PS39 was also contrary to modelling predicted norms. Field investigation in this case identified that one of two inverted siphon river crossings had never been commissioned and was still plastered closed. This has recently been placed in service and pump station testing is planned.

In a third example, a piece of rope, believed to be the same piece dislodged previously from Grassmere upstream, was removed from the River Road siphon and overflow location on the Northern Relief trunk sewer. This resulted in stark improvements in the operation of the sewer. An associated reduction in overflow frequency eagerly anticipated.

A coordinated programme using modelling to identify abnormal sewer performance and field investigation to find and address root causes, has paid dividends with council improving performance of their sewer system performance at minimal cost.

REFERENCES

USBR, United States Department of Interior Bureau of Reclamation – Hydraulic Investigations Group, "Water Measurement Manual", Chapter 8 - Section 10, www.usbr.gov.pmts.hydraulic_lab/pubs/wmm