Inlet Screen Performance Studies

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Inlet Screens – why are they needed?

- The Urban Wastewater Treatment Directive of 1991 set out a number of requirements which had the fundamental objective of reducing the detrimental impact of effluent discharges on marine and aquatic environments.

- In the UK this led to a large number of wet weather discharges being identified as ‘unsatisfactory’ and in need of attention.

- One of the standards applied at the time called for “separation from the effluent of a significant quantity of persistent material and faecal/organic solids greater than 6 mm in any two dimensions”.

- This standard resulted in increasing numbers of “finescreens” being developed by numerous suppliers and left purchasers with a wide choice of options when considering new screening plant.

The National Screen Evaluation Facility

- The National Screen Evaluation Facility (NSEF) based in Northumbrian Water's Chester le Street STW was commissioned in 1998 and has been used to evaluate the effectiveness of many different screens from various manufactures.

- The Facility enables screens to be 'Type Tested' using raw sewage and an average Screen Capture Ratio (SCR) to be determined. The average SCR for any particular screen is generally accepted as the comparator for process performance when considering new screens.

- The SCR value is derived by sampling screen discharges and downstream gross solids loading.

* ***Reference from "Inlet Screens for STWs/WwTWs", Thomson RPM Technical Note, Ref TRPM TN001, January 2012***

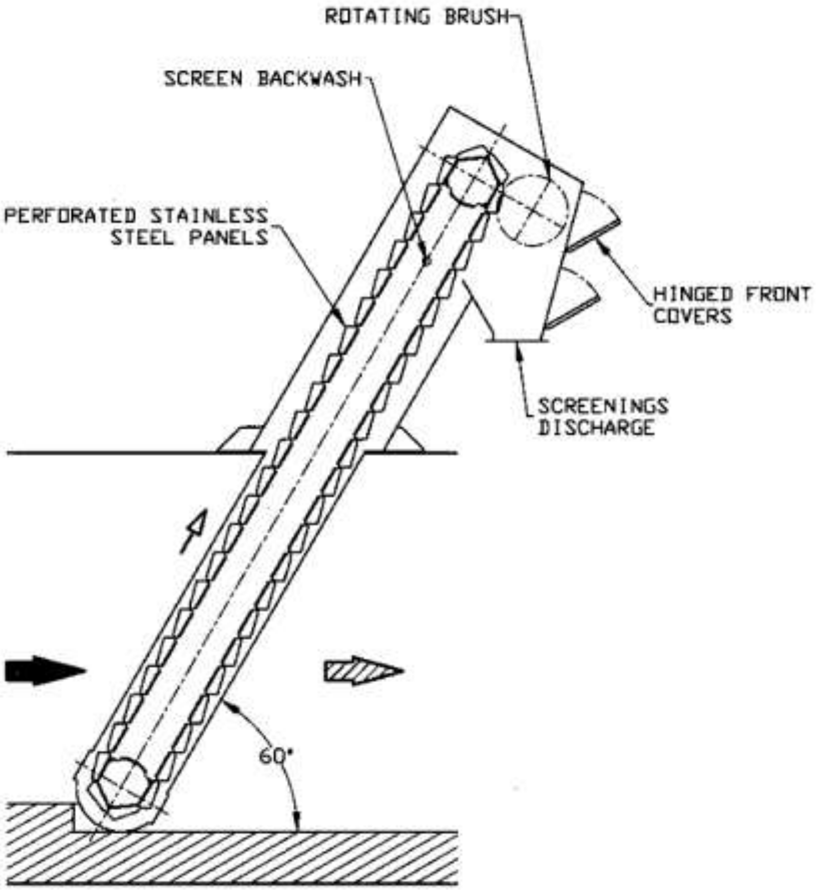
Inlet Screens – Common Types

Finescreens

- Finescreens consist of a series of stepped perforated plates placed across the line of flow and inclined at 45 - 60 degrees.

- The screen may be continuously operated or moved up incrementally, initiated by time intervals or differential headloss.

- United Utilities specifications stipulate an SCR value of at least 72% for this type of screen.



Inlet Screens – Common Types

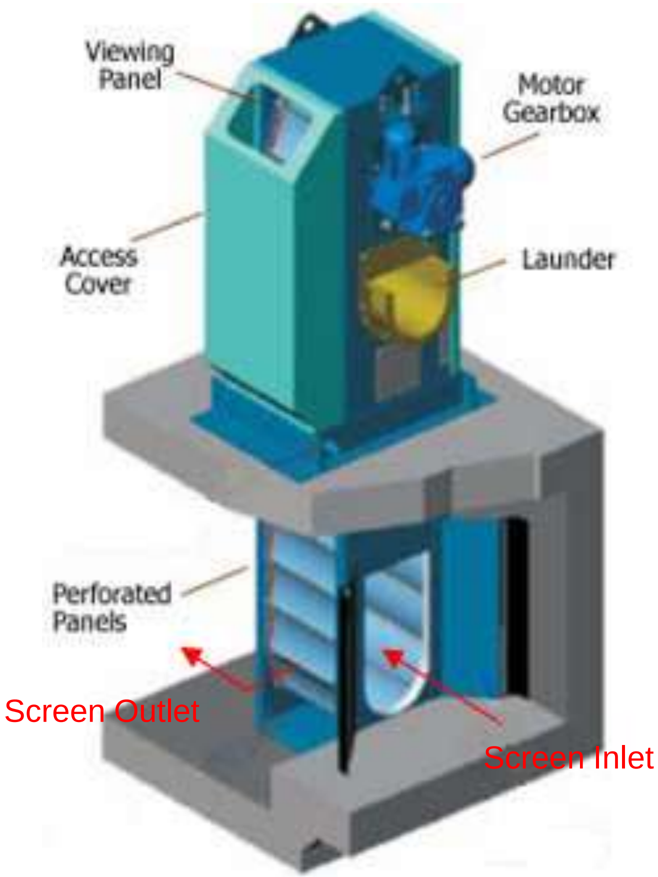
Bandscreens

- Screening is achieved by passing the sewage through a vertical band shaped screen curtain, comprising an assembly of perforated panels which are in line with the direction of the incoming flow.

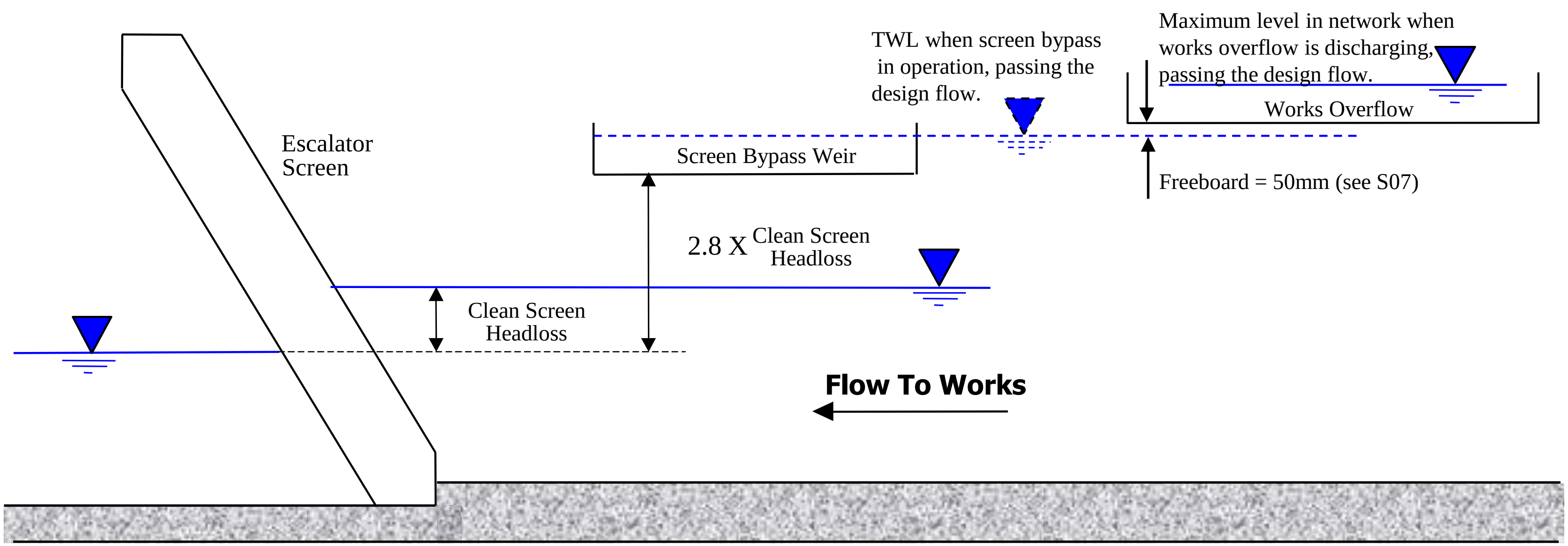
- The screenings enter the inside of the screen curtain where solids are retained and transported out of the flow by driving the band, moving the dirty panels from the screening zone to the panel cleaning area.

- Screened flows pass through the curtain into narrow outlet channels which run along both sides of the screen.

- United Utilities specifications stipulate an SCR value of at least 78% for this type of screen.



Inlet Screens – Hydraulic Design Methodology



•At least one standby screen shall be provided equal in hydraulic capacity to the other screen(s) in that group.

•United Utilities have produced spreadsheets based on the orifice equation to calculate headloss across various types of fine screens (i.e. escalator and band).

•The spreadsheet assumes the open area of the screen plate has been reduced by 10% due to solids loading in order to calculate what is deemed to be a Clean Screen Headloss (CSH).

•There is no reliable and consistent for what constitutes a 'fully loaded' screen as the extent of solids loading is variable and may not be coincident with the maximum hydraulic loading for the screen. Consequently, an arbitrary factor of 2.8 times the 'clean' screen headloss is used to represent the maximum design headloss across the screen

Inlet Screens – Screen Production Rates

•"The accurate prediction of gross solids loading is extremely difficult, with catchment characteristics, network operation, weather conditions and seasonal variations all being significant variables which determine the actual rate of receipt of gross solids at STW". *Reference from "Sewage and Catchment Characterisation" Thomson RPM Technical Note, Ref TRPM TN004, January 2012*

•In order to derive an instantaneous screenings volume that must be capable of being processed by the screens and screenings handling plant, UU adopt an approach similar to most UK water companies, which is to use suitable multiplying peaking factors, which will be applied to a basic average load figure of 0.03 m3/d/1000PE.

•The peaking factor applied by UU range 50 to 80 depending on certain catchment characteristics such as whether there are screened CSO's and/or detention tanks in the catchment, whether it is prone to deposition (typically long, flat sewers) and whether there is a pumped flow contributing more than 20% of the average flow which may deliver surges of rags.

Inlet Screens – Reasons for Poor Performance

•A recent UU study into inlet screen performance found evidence that there is room for significant improvement in the way most inlet screens, particularly at the larger sites, are operated and maintained.

•Overloading of screens and screens handling equipment, sometimes on a relative frequent basis particularly downstream of inlet pumping stations.

This suggests theoretical design parameters are not always sufficient and in practice may be exceed at certain catchments.

Finescreen plates shortly after the start-up of a storm screw

Inlet Screens – Consequences of Poor Performance

- Increased levels upstream of the screens resulting in localised flooding at the head of works and/or in the upstream network.

- Breach of consent due to premature spills at the works overflow.

- Compliance failures due to excessive screenings effecting downstream processes.

- Considerable operational expense associated with cleaning blockages.

Normal Operating Condition

Flood Event

Rags blocking Detritor Inlet Vanes

Inlet Screens – UU Strategic Proposals

•It is accepted that assessing the adequacy of design standards is difficult if the general condition and maintenance of our screens is below standard. Therefore a prerequisite to any of the proposals below is that there is a clear, applied and auditable maintenance regime is in place.

•Implement a strategy to monitor the performance of inlet screens and investigate ways of using the data gathered to find ways of predicting screen failure.

•It is proposed that there is a change in the way that inlet screens are sized and designed and that a more intelligent approach is adopted; this approach should allow for collection of data on screenings loading and trials of proposed screen arrangements, including two stage screening. This recommendation is a recognition that all screens sit at the bottom of different catchments and more data is required to increase confidence in future designs.

Finescreen Headloss Investigation

Objective

•Some screen suppliers believe the method adopted by UU could provide a 100% over-prediction of CSH. If this is correct then applying a 2.8 factor to CSH will only exacerbate the over-prediction.

•The gathering of field data is therefore required in order to develop the hydraulic understanding of finescreen performance and also allow UU to respond more confidently to suppliers claims that our methods are overly conservative.

Survey Details

•A short survey was at carried out at a site containing four Finescreens. The survey involved logging Flow To Works (FTW) and screen differentials for six weeks during a winter period (10^{th} December 2007 to 18^{th} January 2008 inclusive).

Finescreen Headloss Investigation
- Site Layout and Operational Procedure

•Flow To Works (FTW) at the site was 276 Ml/d (3200 l/s) and Flow To Full Treatment was 155 Ml/d (1794l/s).

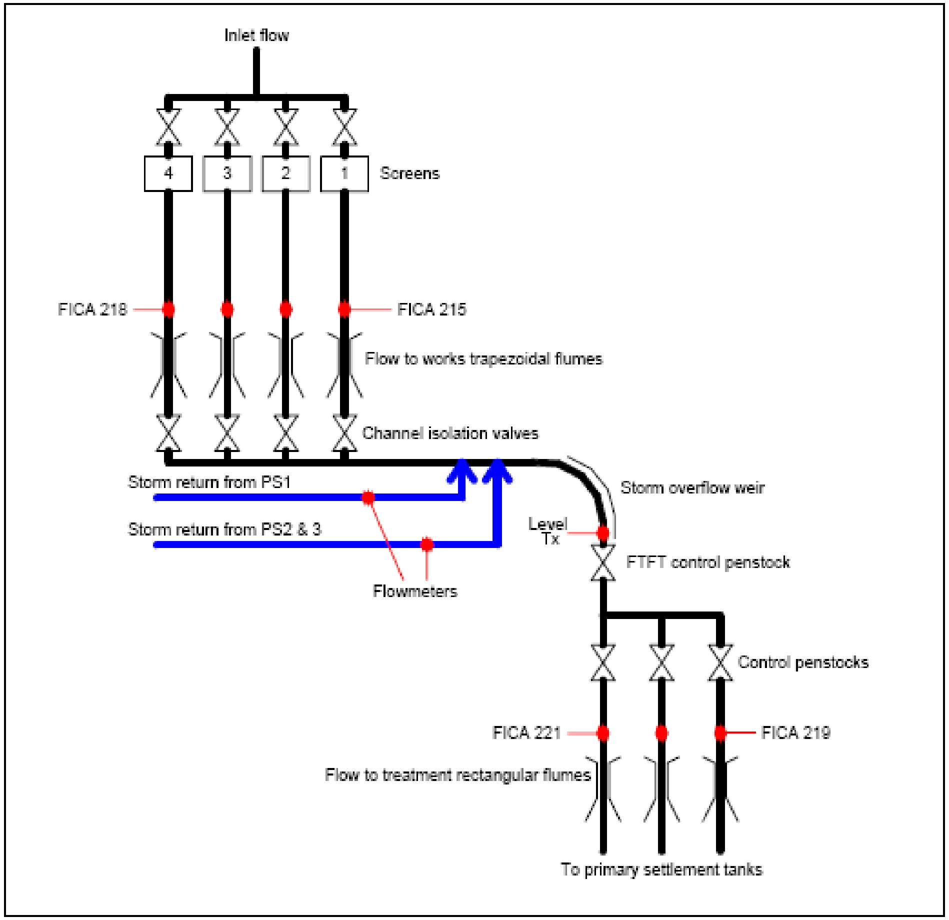
•The number of screens/lanes in use is dependant on FTW readings taken at the trapezoidal flumes.

•There is always a minimum of two screens/lanes in use.

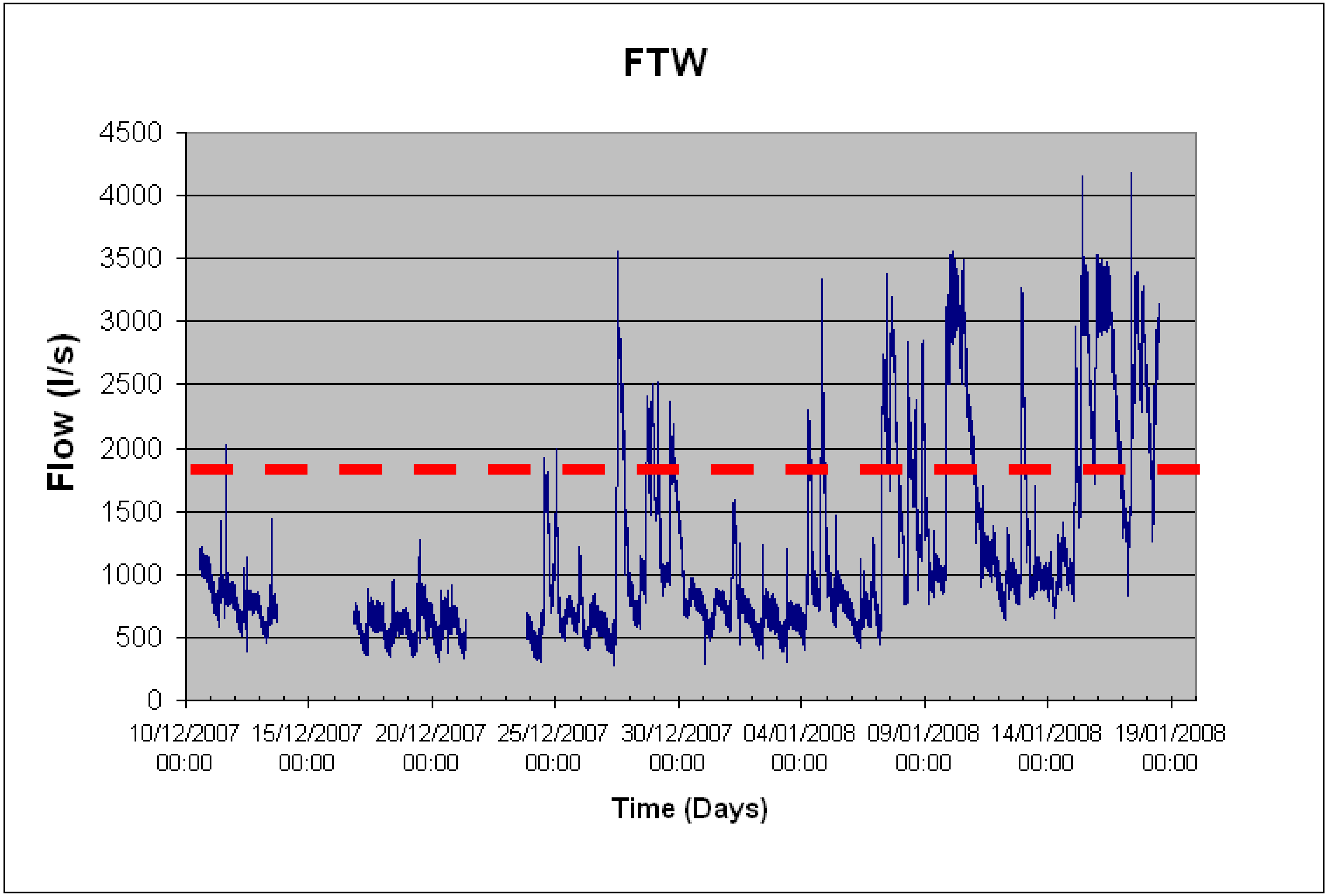
• The 1st assist screen/lane is brought online, by opening its inlet and outlet penstocks, when flows exceed 1400 l/s. The 2nd assist screen/lane is apparently only brought online when flows exceed 1800 l/s.

•When the differential is above 250mm the screen starts running (stepped run) till the differential across the screen falls below 250mm again and then the screen stops.

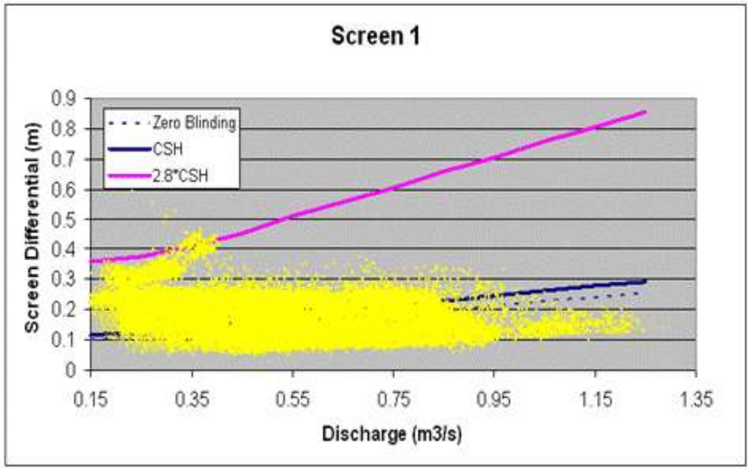
•If the differential still increases and exceeds 300mm the screen starts running continuously on the high speed until the differential falls below 300mm.

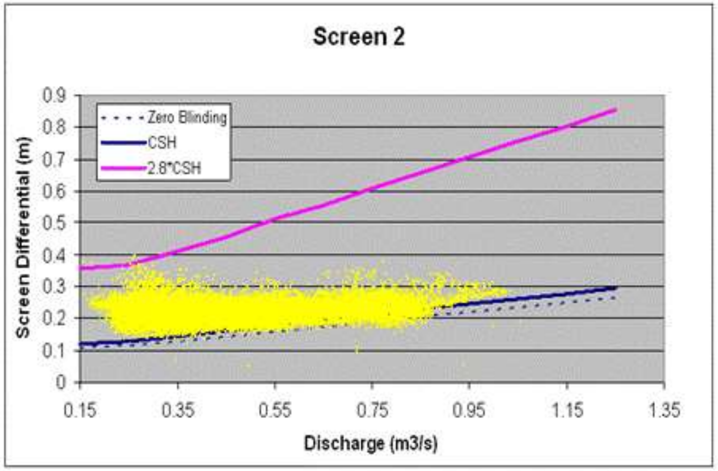


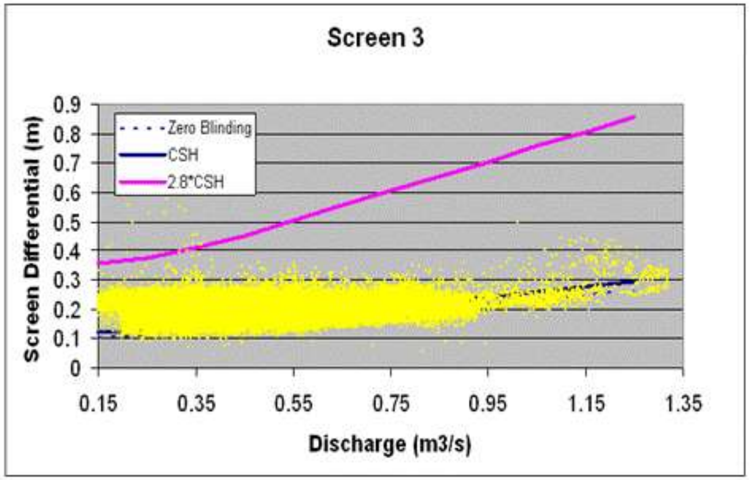
Finescreen Headloss Investigation
- Flow To Works Readings

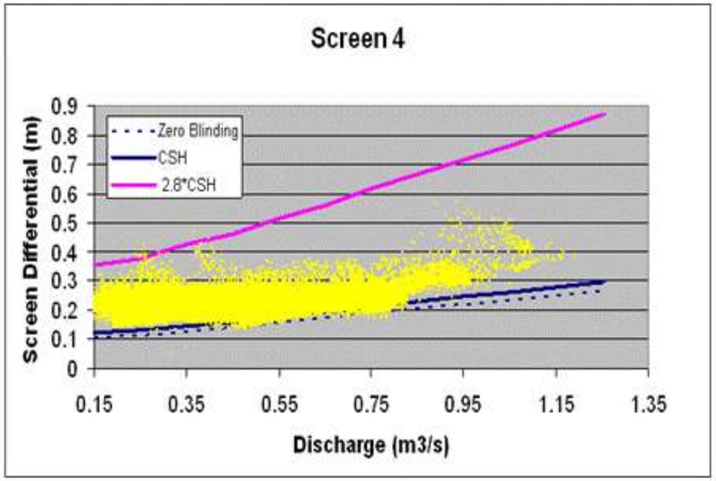


Finescreen Headloss Investigation
- Screen Differential Results

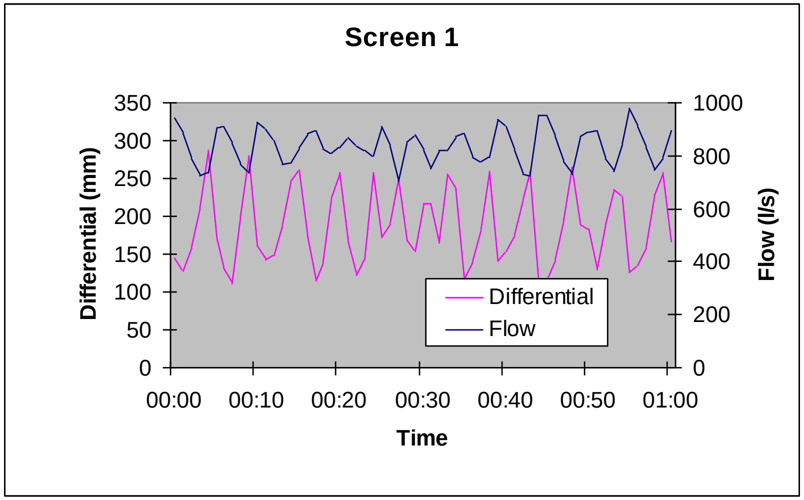


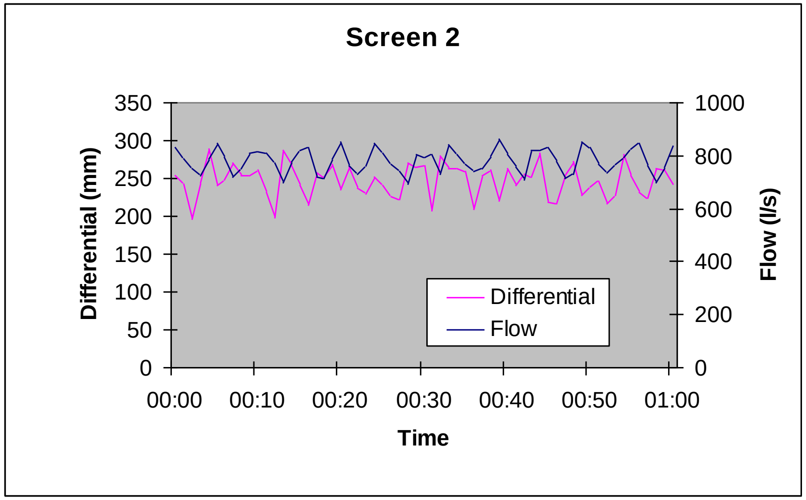


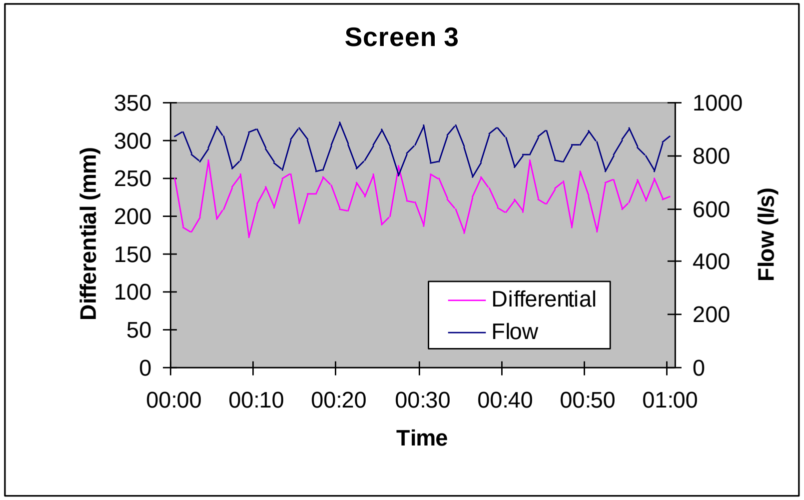


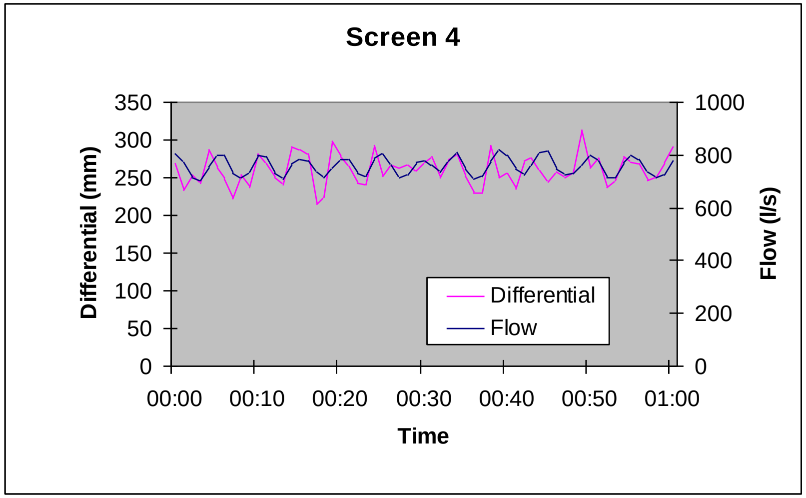


Finescreen Headloss Investigation
- Screen Differential Results









Finescreen Headloss Investigation
- Conclusions

- The results obtained from this study generally suggest that the current UU method of calculating CSH across escalator screens is good.

- The cases in which lower differentials were observed are thought to be due to deterioration of screen performance rather than an over-prediction of CSH.

- Maximum differentials generally appeared to be a function of the setting at which the screens run continuously.

- There was some evidence to suggest that larger differentials can occur but in this study they fell well below the UU design case of 2.8 x CSH.

- **However, this is only a pilot study and much more data is required at different catchments and for longer periods during both summer and winter periods before anything more conclusive can be presented on CSH and how maximum differentials across escalator screens compare to the UU design case of 2.8 x CSH.**

Bandscreen Headloss Investigation

Objective

•Monitor the performance of the new inlet works during the post completion phase of this project.

•Measure actual headlosses across Bandscreens in order to be able to respond more confidently to suppliers claims that the method adopted by UU for calculating screen headloss is overly conservative.

Survey Details

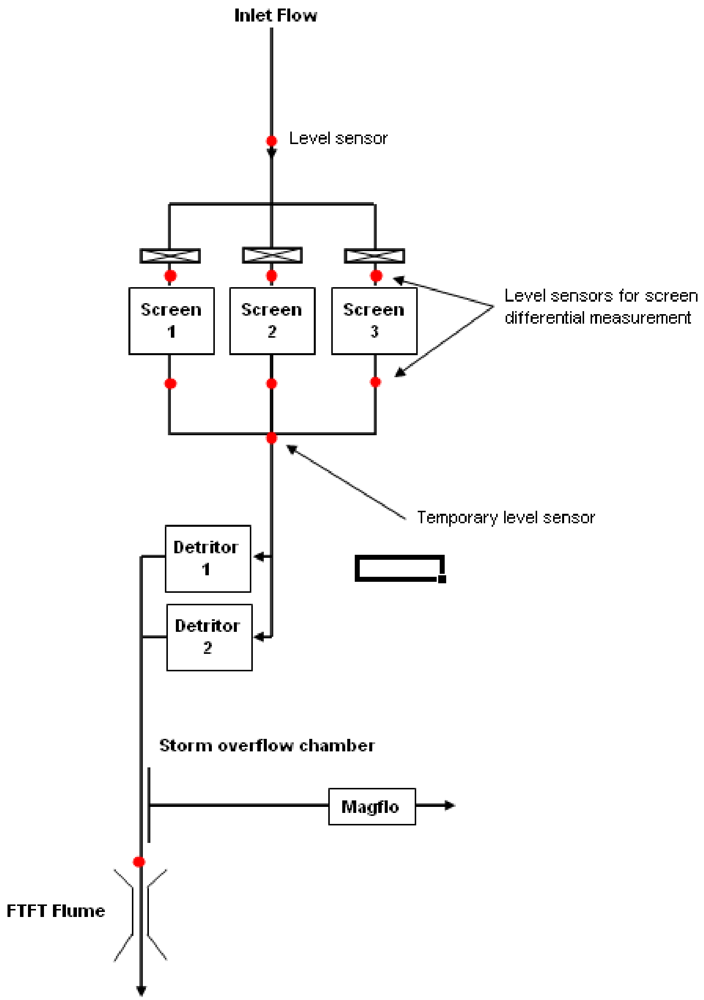
•Performance monitoring at a new inlet works containing three Bandscreens was carried out from 29th August 2009 to 21st January 2010. The data logged during the monitoring period was Flow To Full Treatment (FTFT) and Flow To Storm Tanks which summated provided Flow To Works (FTW), water levels upstream and downstream of the screening plant along with screen differentials across each screens.

Bandscreen Headloss Investigation
- Site Layout and Operational Procedure

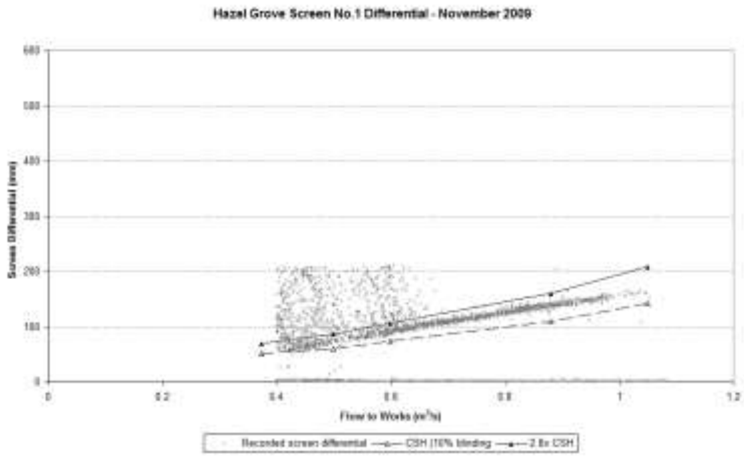
•The works was designed to pass a maximum Flow To Works (FTW) value of 90.7 Ml/d (1050 l/s) and the current FTFT consent is 32.3 Ml/d (374 l/s).

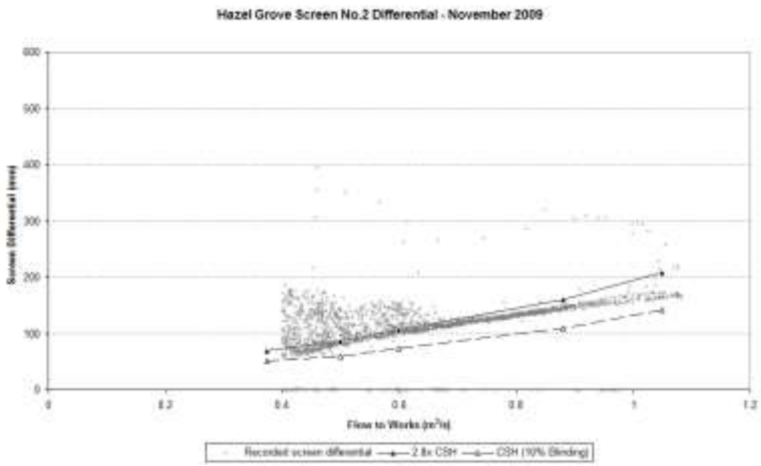
•The inlet works was designed to operate on a duty/assist/standby basis. The number of screens in use is dependent on the water level in the common inlet channel upstream.

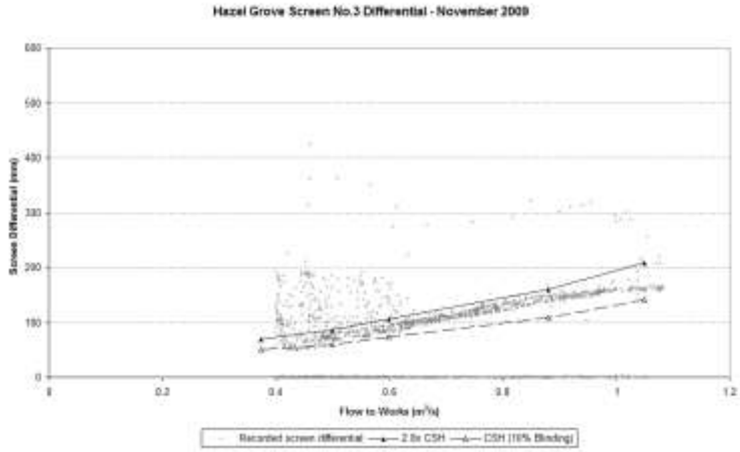
•Screen running times are controlled by the difference between the water level immediately downstream and upstream of each screen. When this differential rises above 200mm the screen will start to run until the differential falls below 100mm.



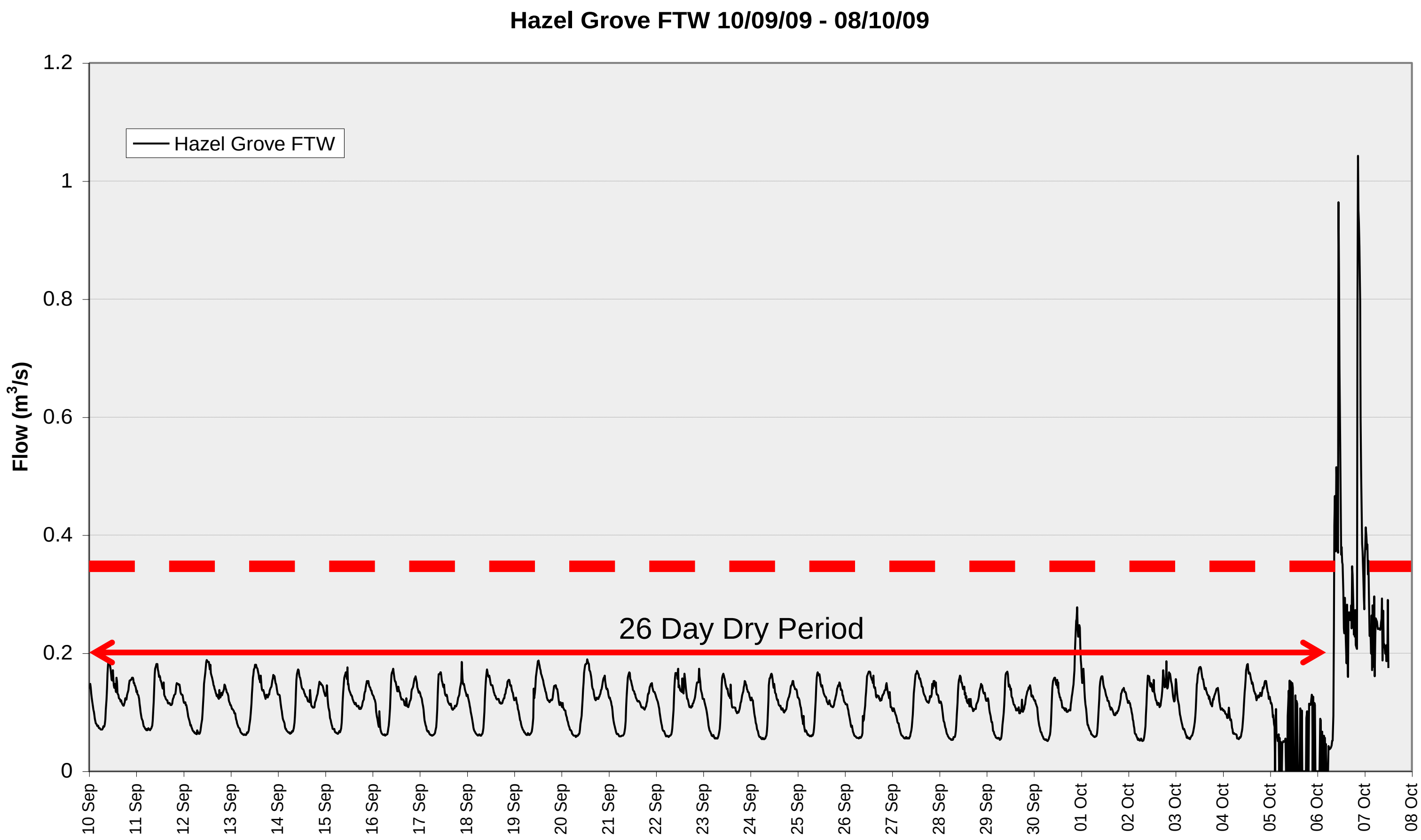
Bandscreen Headloss Investigation
- Screen Differential Results



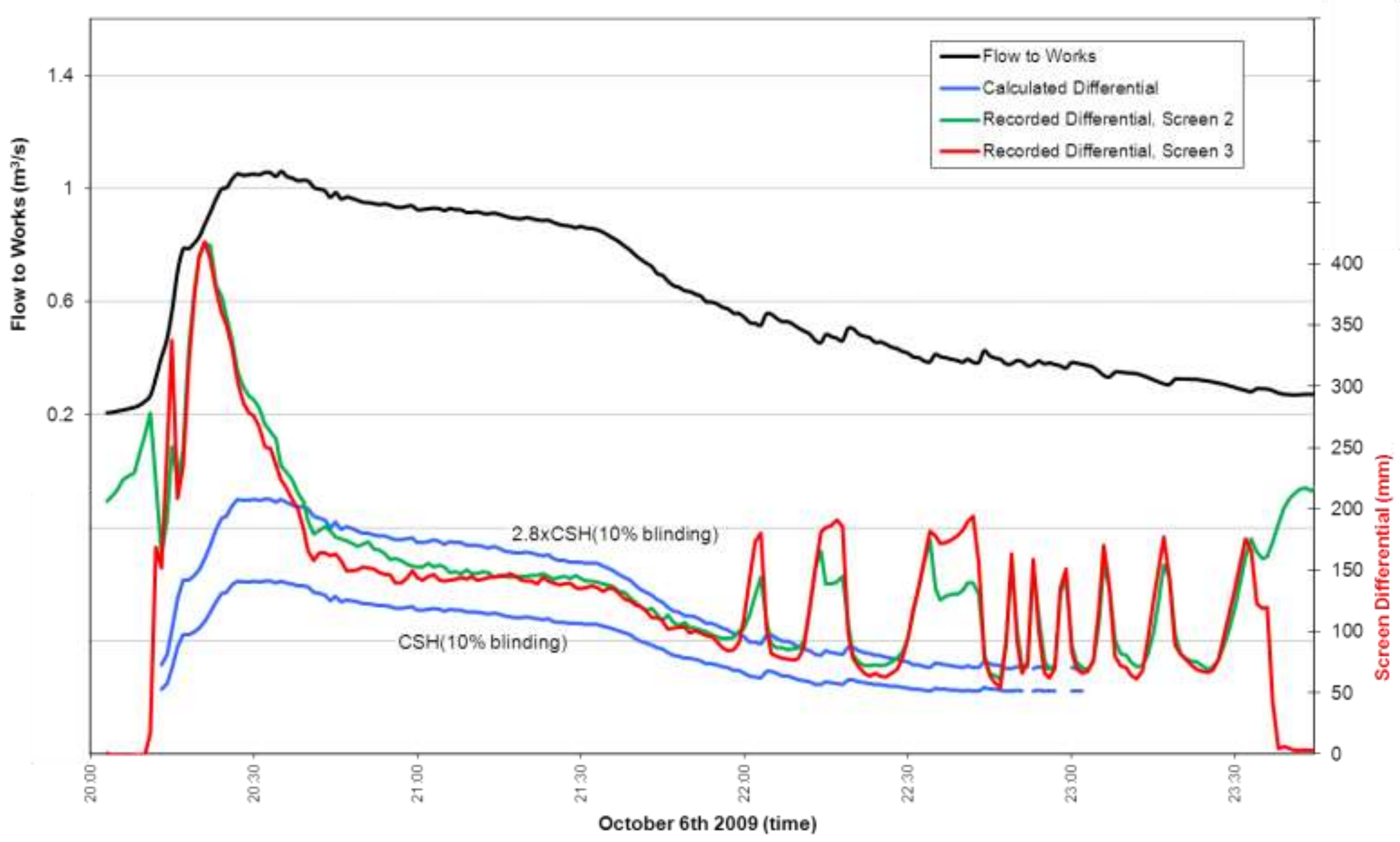




Bandscreen Headloss Investigation
- Flow To Works Readings showing First Flush



Bandscreen Headloss Investigation
- Screen Differentials during First Flush



Bandscreen Headloss Investigation - Conclusions

•The data shows that recorded screen differentials across band screens are higher than the calculated CSH. This suggests that the UU calculation method for determining band screen headlosses under-predicts CSH.

•A comparison of the theoretical 2.8*CSH and the recorded screen headlosses during the first flush event shows that recorded headlosses can be significantly higher that predicted.

•Calculations have determined that recorded headlosses during a first flush event were approximately equal to 11*CSH.

•**However, this is only a pilot study and much more data is required at different catchments and for longer periods during both summer and winter periods before anything more conclusive can be presented on CSH and how maximum differentials across band screens compare to the UU design case of 2.8 x CSH.**

Screens Loading & Headloss Investigation

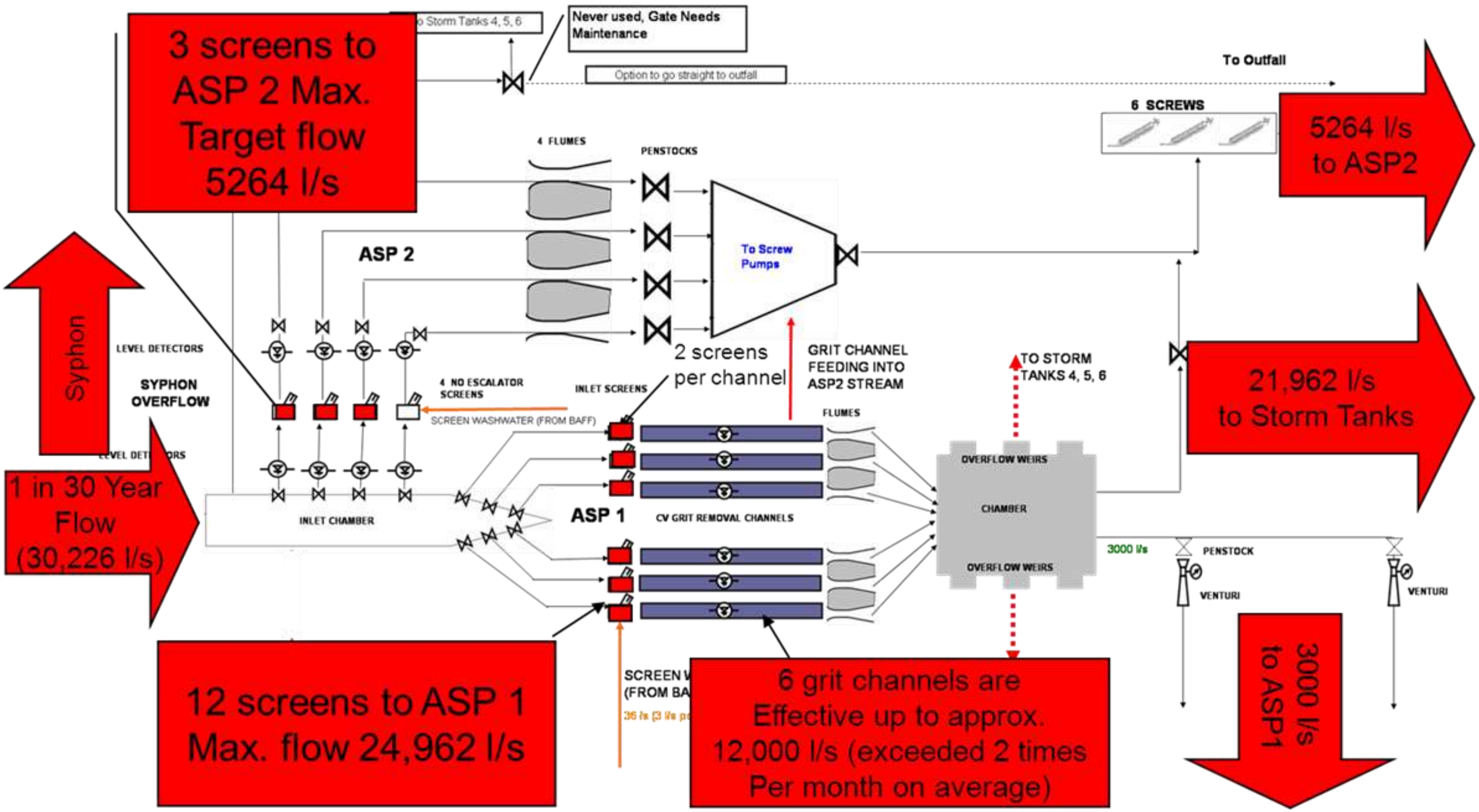
Objective

•Monitor impact on gross solids loading at this large treatment works as a consequence of making improvements to a substantial number UIDs across the catchment.
•Establish preliminary design parameters (i.e. average load and peaking factor) for a planned capital investment scheme at the site involving the construction of a new inlet works.
•Monitor screen headloss during high flow and/or load events in order to access performance against current design standard.

Survey Details

•Thompson RPM appointed to carry out the monitoring study which took place for a duration of 633 days. Flow To Works (FTW) was monitored using existing site flow measurement devices and load cells were placed under the screening skips in order to monitor gross solid loading. Loss of flow data was deemed negligible but approximately 200 days were affected by either no or only partial load data due to various site specific issues. At the end of the study UU continued to monitor gross solids load along with screen headloss.

Screens Loading & Headloss Investigation - Site Layout and Operational Procedure



Screens Loading & Headloss Investigation - Site Layout and Operational Procedure

- Flow Split between two streams based on target flow ratio of 70% of the flow to ASP2 is to go to ASP1 (e.g. if 1000 l/s goes to ASP2, the flow to ASP1 is 700 l/s thus totalling 1700 l/s).
- Target flows are based on actual flow to ASP2 (measured at flumes downstream of the screens) plus an offset (increase in flow) based on recorded depths in main inlet channel.
- Flow is controlled by the penstocks to ASP2.

ASP 1

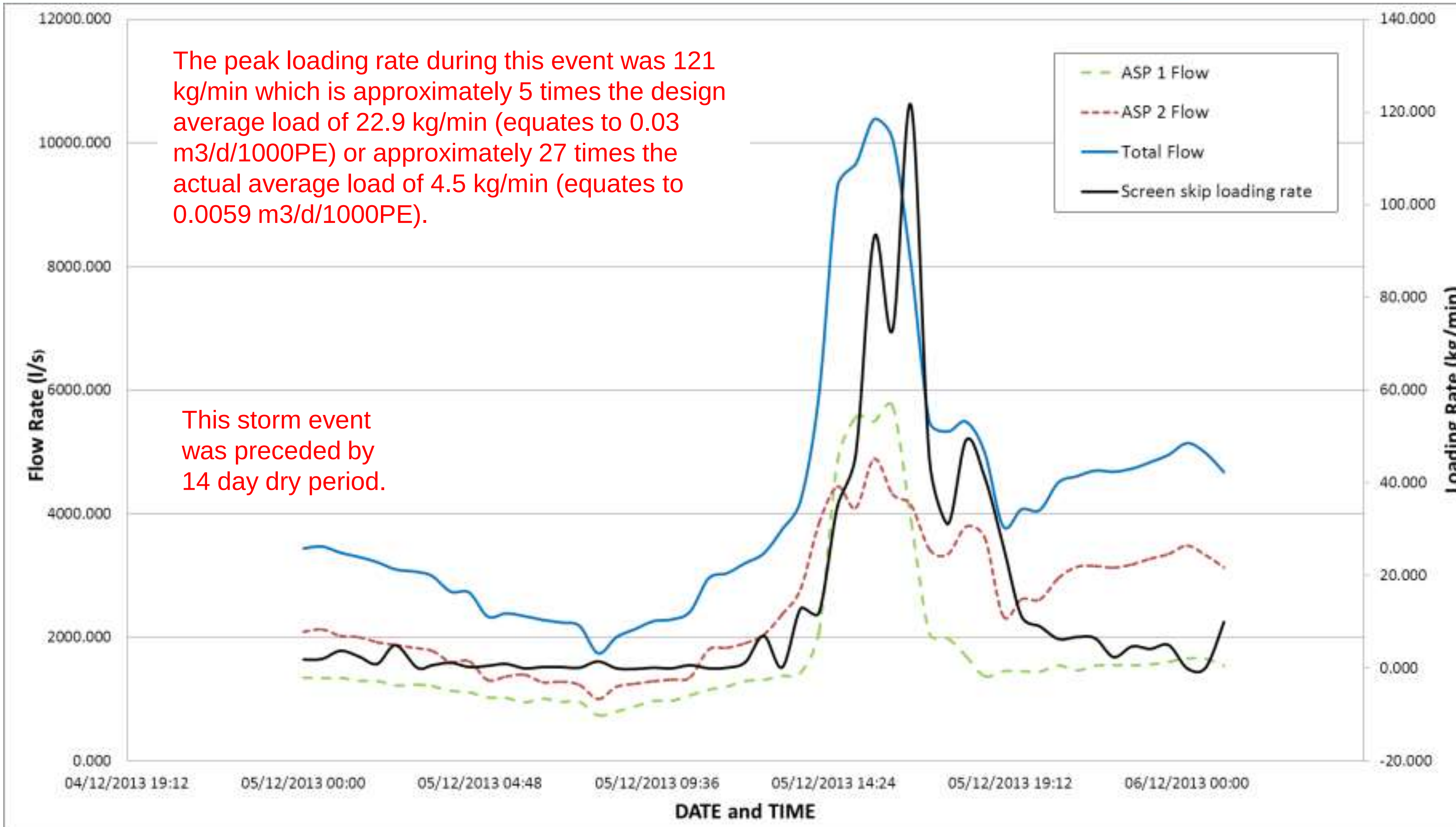
- Flows up to 3000 l/s (FtFT) 4 screens are in operation.
- If flow increases, additional screens brought into service manually.
- Maximum flow through ASP1 screens approx. 23,500 l/s.

ASP 2

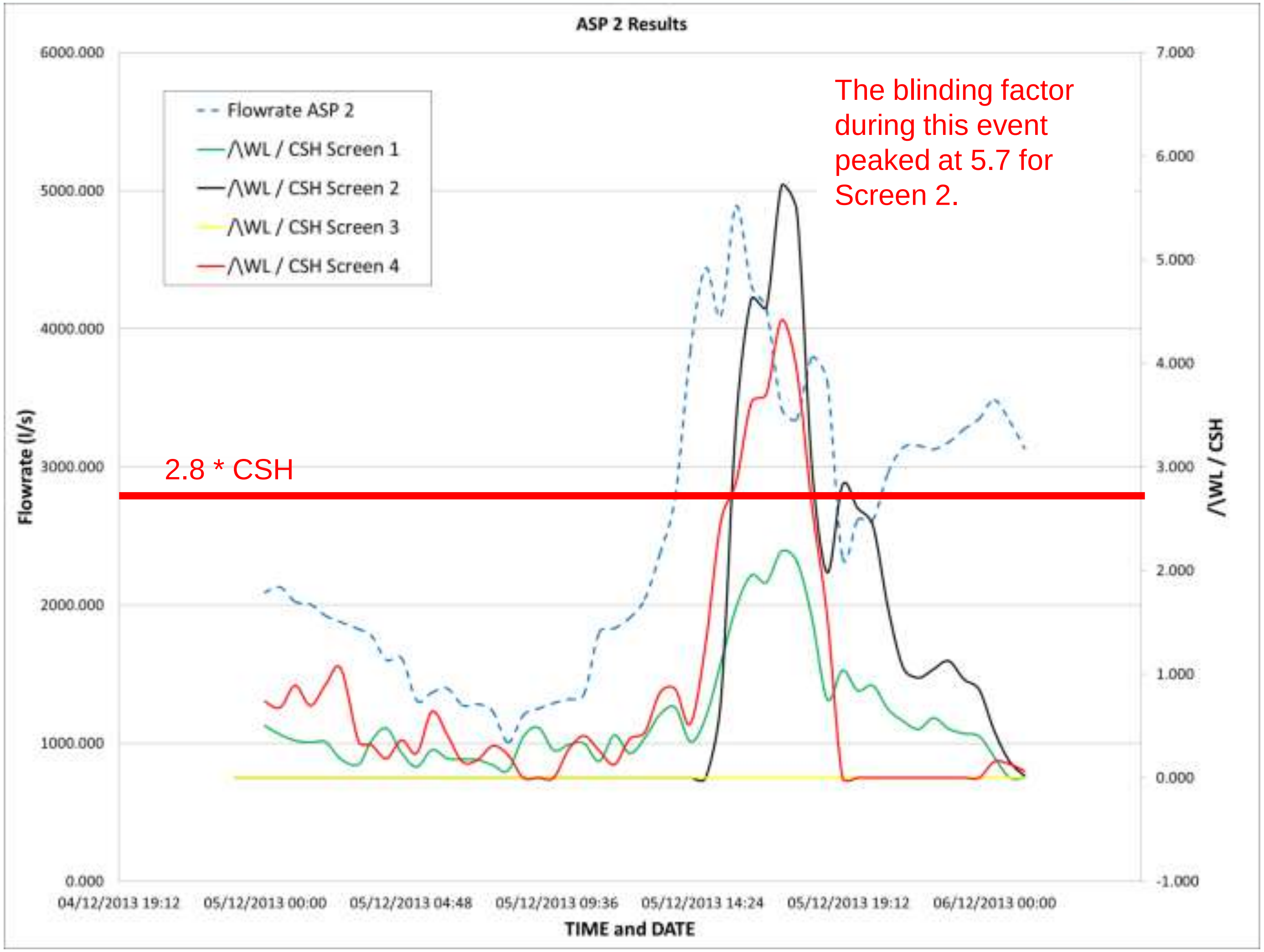
- Flow <= 1750 l/s : 1 screen in operation.
- Flow > 1750 l/s and < 3000 l/s : 2 screens in operation.
- Flow >= 3000 l/s and up to FtFT (5264 l/s) : 3 screens in operation.

- Screen running times are controlled by the difference between the water level immediately downstream and upstream of each screen. When this differential rises above 250mm the screen will start to run until the differential falls below 100mm.

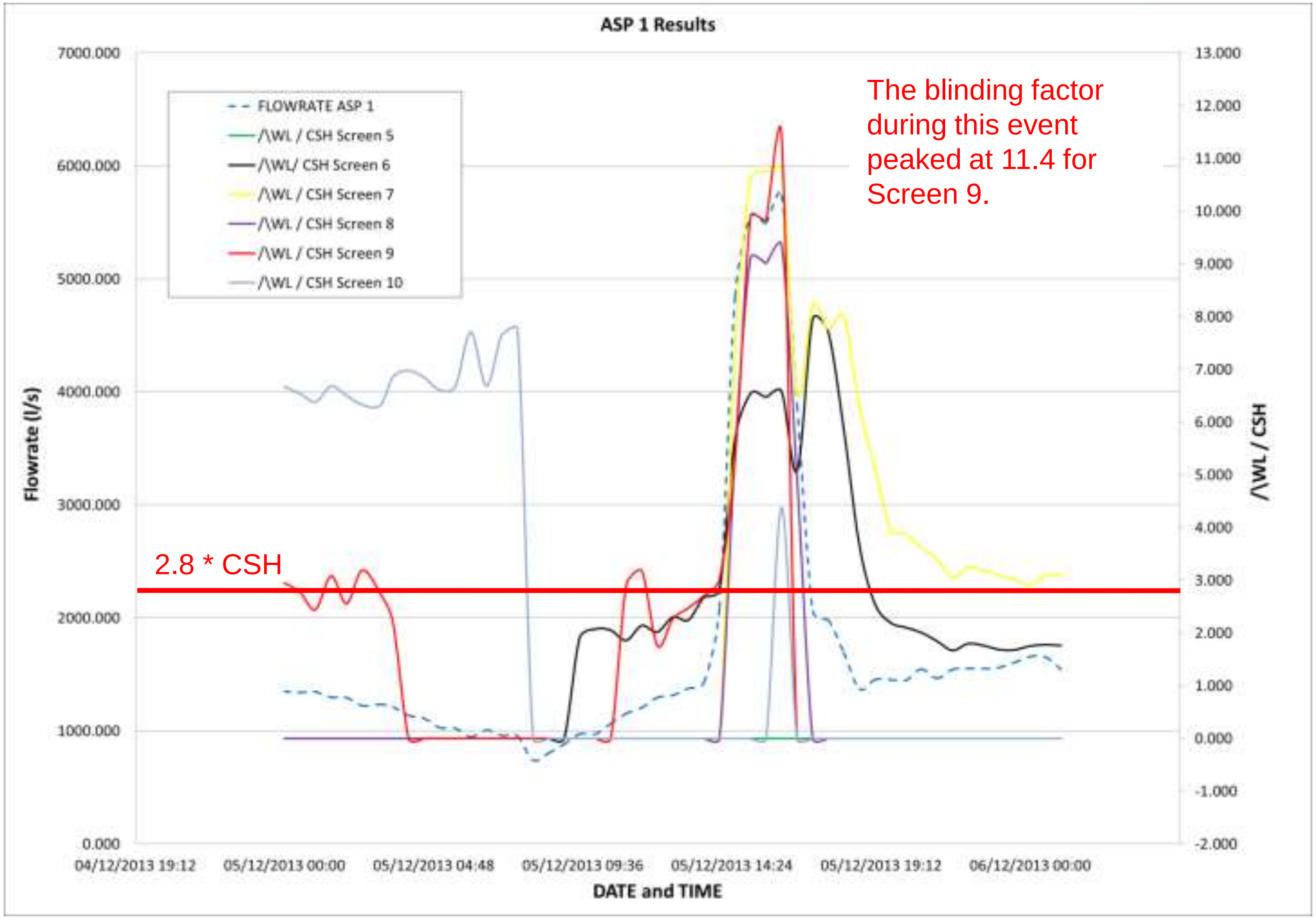
Screens Loading & Headloss Investigation
- Flow & Screen Loading Rate Data 05 Dec 13



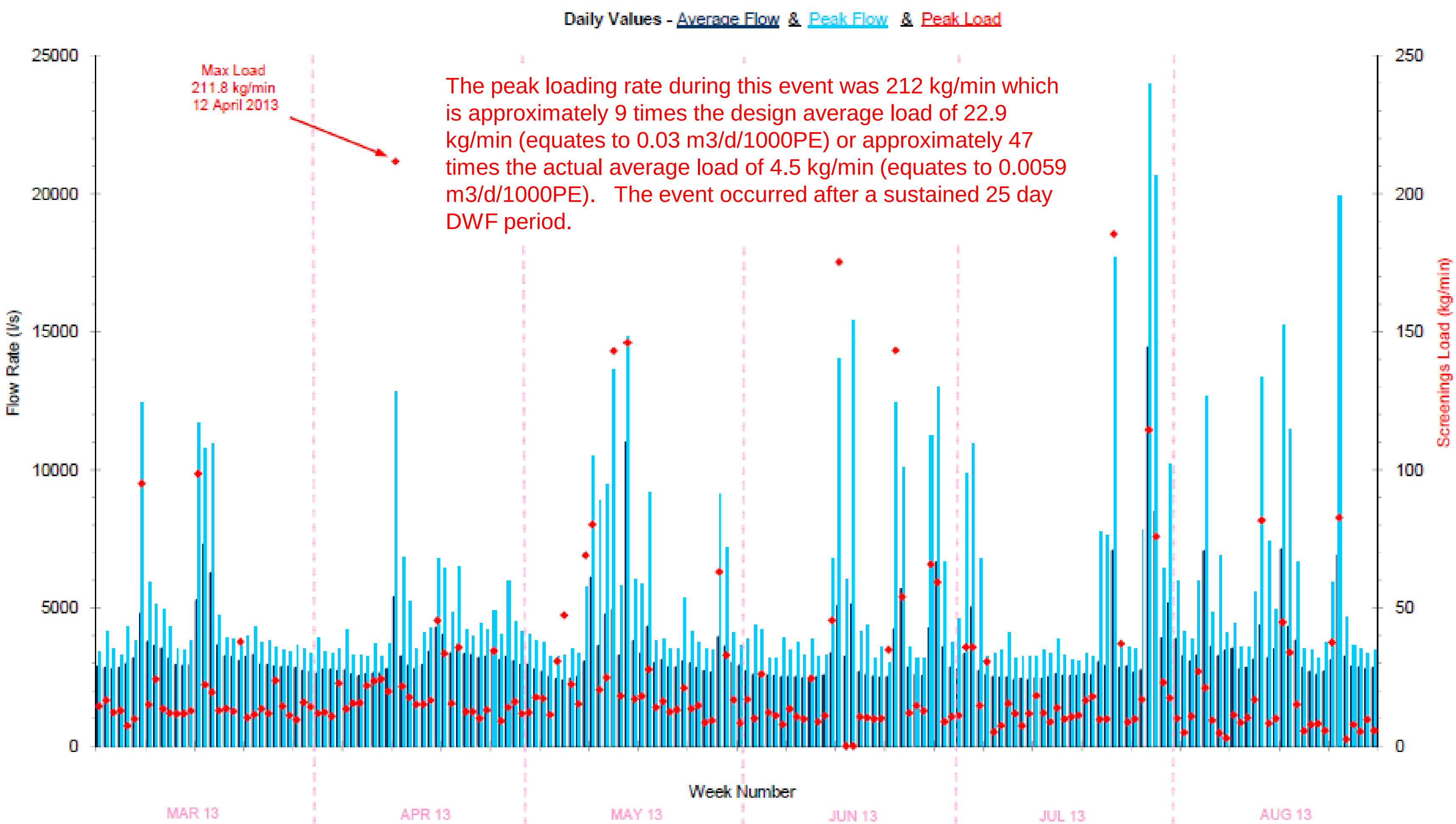
Screens Loading & Headloss Investigation - Flow & Screen Headloss Data 05 Dec 13



Screens Loading & Headloss Investigation - Flow & Screen Headloss Data 05 Dec 13



Screens Loading & Headloss Investigation
- Average Flow, Peak Flow & Screen Loading Rate Data



Screens Loading & Headloss Investigation - Conclusions

•High loads generally coincide with high flows but the highest loads did not necessarily coincide with the highest flows.

•There was clear evidence of first flush events, with the largest peak load recorded after a sustained 25 day DWF period. However, the storm flow during this event peaked at 12854 l/s which is much less than the maximum flow rate recoded during the survey period which was 23949 l/s. This suggests first flush loads can be triggered even by 'averaged sized' loads.

•The value for average load found during the survey period was 0.0059 m3/d/1000PE which is considerably lower than the UU Asset Standard design value of 0.03 m3/d/1000PE.

• The highest peak loading rate during the survey was 212 kg/min which is approximately 47 times the actual measured average load of 4.5 kg/min (equates to 0.0059 m3/d/1000PE). However, it is only 9 times the design average load value recommended in the UU Asset Standard of 22.9 kg/min (equates to 0.03 m3/d/1000PE). UU Asset Standard guidance would apply a Peaking Factor of between 50 to 80 to the design average load which in this case would be a large over-prediction.

•Calculations have determined that recorded headlosses during a first flush event were approximately equal to 11*CSH which is much higher than the 2.8*CSH methodology applied by UU.

Other Inlet Works Performance Studies - Grit Efficiency Testing

Previously no way of assessing the efficiency of the grit removal systems.

Smith & Loveless from the U.S. had a method for measuring the grit removal efficiency from an operational plant. Between the 8th - 10th October 2013, S&L carried out grit efficiency testing at Davyhulme WwTW.

Samples taken at 6 places across the influent and effluent channels.

Samples transferred to a muffle furnace to vaporise all organics

Samples passed through sieves of various sizes to determine weight of the particle graduation for both influent and effluent

Test allows us to understand the grit removal efficiency and the cross-channel distribution of grit.

Other Inlet Works Performance Studies - Grit Efficiency Testing

Detritor Grit Removal Unit #1 Test #1 Grit Removal Efficiency		Grit Collected (g) Influent	Grit Collected (g) Effluent
300 Microns	98.5%	849.9	12.5
212 Microns	98.6%	308.0	4.3
149 Microns	97.5%	106.7	2.7
106 Microns	81.4%	8.6	1.6
Residual	-14.3%	1.4	1.6
Overall	**98.2%**	**1,274.6**	**22.7**

Detritor Grit Removal Unit #1 Test #2 Grit Removal Efficiency		Grit Collected (g) Influent	Grit Collected (g) Effluent
300 Microns	98.2%	733.7	12.9
212 Microns	97.3%	225.6	6.2
149 Microns	96.6%	97.9	3.3
106 Microns	86.8%	6.8	0.9
Residual	28.6%	1.4	1.0
Overall	**97.7%**	**1,065.4**	**24.3**

- Tests showed efficiencies were within the performance criteria of asset standard.
- Tests undertaken in low flows - <25% of maximum design flow

Performance should be better at such low flows!

Thank You. Any Questions?