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Effects of blockage and relative coarseness on clear water bridge pier scour

Sebastian Tejada
University of Windsor

EFFECTS OF BLOCKAGE AND RELATIVE COARSENESS ON CLEAR WATER BRIDGE PIER SCOUR

By

Sebastian Tejada

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By

Sebastian Tejada

APPROVED BY:

_____

Dr. R. Barron
Department of Mathematics and Statistics & Department of Mechanical, Automotive and Materials Engineering

_____

Dr. R. Carriveau
Department of Civil and Environmental Engineering

_____

Dr. R. Balachandar, Principal Advisor
Department of Civil and Environmental Engineering

_____

Dr. T. Bolisetti, Co-Advisor
Department of Civil and Environmental Engineering

December 19th, 2013

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ABSTRACT

Clear water pier scour experiments were conducted in the laboratory to analyze the effects that blockage ratio and relative coarseness have on bridge pier scour depth. For these tests, the blockage ratio and relative coarseness were kept constant for each of the four different sand bed materials and a constant water depth was maintained for all experiments. The flow shallowness varies from values in the narrow pier range for the two coarser sediments to values of very narrow piers for the two finer sediments.

The blockage ratio and relative coarseness were each increased four times, and kept in a range such that it did not make them the controlling factor for the scouring, but still a contributing factor.

The parameters effecting scour were evaluated and compared with the equilibrium bridge pier scour depth. A relationship involving relative coarseness with flow shallowness and equilibrium scour hole depth was found.

DEDICATION

To my Family

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NOMENCLATURE

B	Flume width
C_c	Coefficient of gradation
C_u	Coefficient of uniformity
D	Pier diameter
d_s	Scour hole depth
d_{se}	Equilibrium scour hole depth
d_x	Diameter of bed material of which x% is finer by weight
Fr	Froude number
g	Acceleration due to gravity
H	Flow depth
K_1	Corrections for pier shape
K_2	Correction for angle of attack of flow
K_3	Correction for bed form
K_4	Correction for armouring
Re	Reynolds number
S	Strouhal number
Sh	Pier shape
SI	International system of units
t	Time
T	Height of sediment deposit

U Mean approach flow velocity

U_c Threshold velocity for transition from clear-water to live-bed conditions

W Width of sediment deposit

v Water viscosity

ρ Water density

ρ_s Sediment density

σ_g Sediment non-uniformity

ASTM American Society of Testing and Materials

CHAPTER 1

INTRODUCTION

Local scour on bridge piers and abutments has been a major concern among engineers for many years because of the elevated number of failures and damages that this mechanism provokes, especially at locations with seasonal flooding events (FHWA-Hydraulic Engineering Circular No. 18, 2012). The subject of scour has been studied by many researchers (Melville and Sutherland 1988, Sheppard and Miller 2006, Ettema et al., 2006), and some very important advances in prediction and management of the scouring process have been developed. Equations such as the HEC-18 equation (Ettema et al. 2011), also known as the Colorado State University equation (1993), and equations developed by Ettema et al. (1998), Melville and Sutherland (1988), Melville and Coleman (2000) and Sheppard et al. (2011) are currently the most used when it comes to design. They are just a few in the long list of scour depth prediction equations available to bridge design Engineers.

Advances in the field of scour prediction and management have led to greater precision, but have simultaneously become more complicated due to the number of variables and parameters that affect local scour.

These developed equations have been undergoing change in order to incorporate the latest research and refine their predictions that, up to date, have been very conservative.

Over-estimation of the scour hole leads to overly-conservative foundation design that causes construction costs to rise and sometimes make projects economically unfeasible. This concern makes scour investigation a priority for designers.

This research investigates a set of parameters that is not included in the current equations and will determine how, if at all, these parameters contribute to the formation of the scour hole, even though they are not the principal driving mechanism of the scouring process. This will be achieved through a series of experimental tests.

Additionally, through lab and field research, it has been determined that local scour is very site-specific, this being one of the reasons for the over-estimation provided by the current equations. Bridge piers in the field are defined by a large number of parameters which differ greatly from site to site; hence, the equations must attempt to incorporate the changing parameters and factors that make a site unique.

1.1 Objectives

The objectives of the present investigation will be to continue and add to the ongoing research and analysis that is being conducted at the University of Windsor on the subject of bridge pier scour.it is anticipated that the results will contribute to the ever changing understanding and evaluation of the scour process and its prediction methods, while exploring different and new approaches to the problem of design over-estimation. Specifically, the objectives of this thesis are:

- To conduct clear water scour experiments on four different non-cohesive materials; maintaining a constant blockage ratio and relative coarseness for each of the experiments.
- To compare and analyze the scour holes and look for similarities in proportions (size, shape, depth), among the four sands under the same constant parameters in each of the series.
- To contribute to the research on scour being done at the University of Windsor in hopes of producing a refined equation or introducing a complementary parameter to the existing equations in order to better predict scour depth and to better understand the scouring process.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Bridge Pier Scour

Bridge pier scour is generally understood as the lowering of the river bed due to erosion and hence exposing the foundations of piers that are under the influence of the flow. The depth of a scour hole is a measure of how much material is removed from the river bed due to this erosion; and how much is the difference in elevation of the river bed from where it was before the scouring commenced (Melville and Coleman 2000).

Pier scour is the number one cause of bridge foundation exposure and failure in rivers with seasonal flooding (FHWA-Hydraulic Engineering Circular No. 18, 2012). It is a major concern for engineering designers and construction engineers due to the potential loss of life that a collapse bridge can bring and also due to the high costs associated with bridge repair and upgrade.

2.2 Scour Process

2.2.1 Types of scour

Scour is a process that involves many parameters and variables. Therefore, it is difficult to obtain a single equation or prediction method that can accurately calculate scour depth for all conditions and situations.

2.2.1.1 General Scour

General scour occurs under normal geomorphic and fluvial processes, usually over considerably long periods of time. They are the normal erosion Human-imposed structures causing obstructions of flow are not present when general scour is considered.

2.2.1.2 Contraction Scour

Contraction scour occurs when a bridge pier or abutment causes the flow channel to constrict, thus changing the parameters of flow. In this case flow velocity increases, leading to scour.

Also, contraction scour can be caused by placing a bridge in a natural contraction of the channel.

2.2.1.3 Local Scour

Local scour is caused when piers or abutments are introduced to a channel and cause interference with the flow. Scour is formed immediately at the foot of the piers or abutments.

2.2.2 Water Velocity

Flow velocity (U) is the driving force of the scour process. Other parameters such as average sand particle size (d_{50}), pier diameter (D) or water depth (H) have significant effect on the resultant scour depth (d_{se}), but if the water in the system is not moving at an adequate velocity or intensity, scouring will not occur.

2.2.3 The Horseshoe Vortex

A scour hole is formed by the creation of vortices, pressure gradients and wakes as the water travels around a pier or obstacle on a watercourse (Hodi, 2009). Depending on the flow intensity (U), these vortices and pressure gradients begin to take effect on the material surrounding the pier base, causing formation of the scour hole. The mechanics of the scour hole formation are shown in Figure 1.

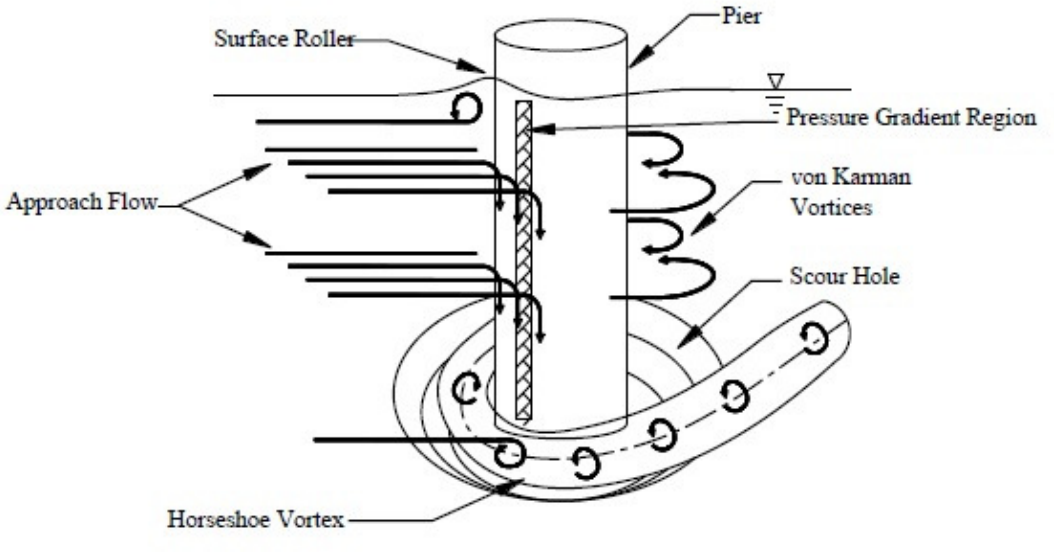

Figure 1. Scour process (Hodi 2009)

Figure 1 depicts how the approach flow interacts with an obstacle (in this case, a circular pier). The water flows and moves around the pier and causes a series of vortices and eddies; most prominent of these are the horseshoe vortex and the von Karman vortices that shed in the wake of the pier.

The formation and causes for the horseshoe vortex are explained in detail by Ozturk et al. (2008) as follows:

"Whenever a boundary layer encounters a wall mounted object of sufficient size, the stream wise adverse pressure gradients lead the approach flow boundary layer to detach from the base plate and to roll

up, causing a circulation of the fluid near the junction region which is defined as a horseshoe vortex."

The scour hole starts to form at the base of the pier and gains in size and depth with time. The turbulent flow is created when the flow encounters an obstacle and the vortices and eddies created are responsible for the pier scour process. The depth, shape, location and size of the scour hole itself are subject to other parameters; among them are the bed material, the flow intensity, pier shape, water depth, the flow's angle of attack on the pier, and width of the channel.

The creation of the scour hole is not the focus of this research; the subject has been approached by many authors, among them are Dey and Raikar (2007) and Ozturk et al. (2008). This research focuses on the variations on a fully-developed scour hole caused by combined changes of some of the parameters mentioned above.

Experimental investigations on the effects of scour on piers have been conducted since the 1950's Sheppard et al. (2004). Recent investigations include work by Sheppard and Miller in 2006 and Sheppard et al. in 2011. Early work discovered that the local scour process around a pier or obstacle could be separated into two different

mechanisms depending on the flow intensity: clear water scour and live bed scour.

2.2.4 Clear Water Scour

Clear water scour occurs when the flow intensity (U) is below the critical flow intensity (U_c), which is the velocity at which incipient motion of the bed particles occurs. U_c is a parameter that is associated with a specific particle size, and therefore changes for each sand bed. Having a flow intensity below the critical intensity means that there is no general motion of sand particles beyond the immediate vicinity of the pier; hence, the name "clear water", because the sediments are only disturbed, transported and deposited downstream of the scour hole and do not continue flowing down the channel as suspended sediment, which would make the water "cloudy".

2.2.5 Live Bed Scour

Live bed scour occurs when the flow intensity (U) is higher than the critical flow intensity (U_c). The sand particles are lifted from the bed and transported with the flow. When an obstacle in the flow is reached, the scour process is very similar to the process discussed earlier; the horseshoe vortex forms and a scour hole is then created. However, sand particles are both being carried out of the scour hole by

the horseshoe vortex and new particles that were suspended in the flow are being reintroduced into the scour hole. Equilibrium is reached when the amount of particles that enter the scour hole equals the amount that is being taken out. Figure 2 below provides a schematic of the changeover from clear water scour to live bed scour with increasing flow velocity.

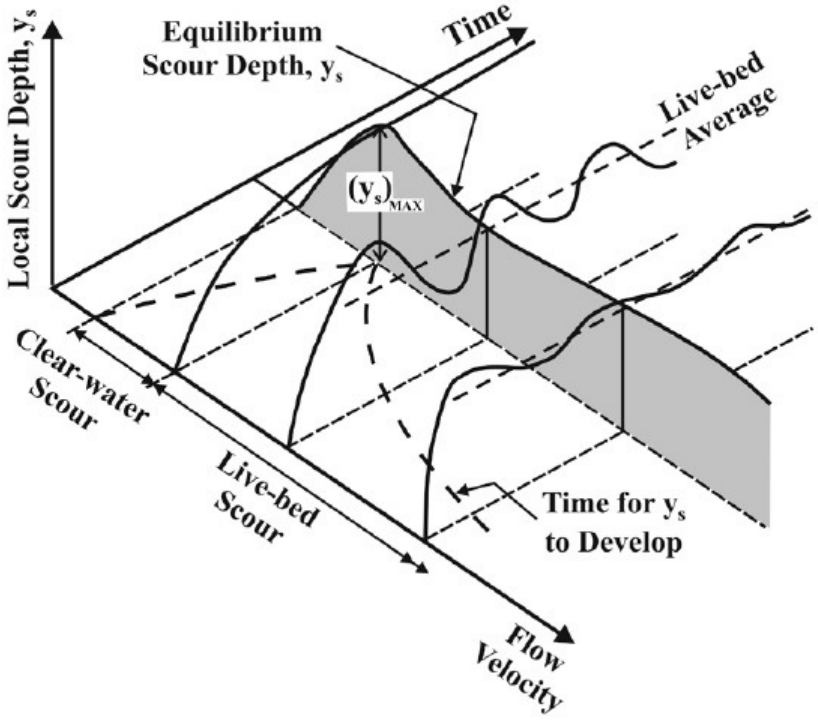

Figure 2. Local scour variation with flow velocity

(Melville & Coleman 2000)

2.3 Parameters Affecting Scour

The difficulty in predicting the extent and depth a scour hole can achieve occurs mainly because of the number of different parameters that have an effect on the process. These parameters can also be dependent on each other. This cross-connection of parameters makes the estimation of scour a difficult task. When trying to comprehend experimentally the effect one or more parameters have on the process, one runs the risk of not taking into consideration an additional parameter that might have a relevant influence on the results, therefore obtaining results for a specific situation and not a general occurrence. This is the main reason that research is still being conducted and parameters that once were not being considered are now being investigated.

The parameters affecting the scour process can be subdivided into four categories; parameters influenced by the pier: (diameter D, shape Sh, and angle of attack θ); parameters influenced by the flow: (water depth H, flow intensity U, water density ρ, viscosity v and gravity, g); parameters influenced by the sediment: (median grain size d_{50}, sediment non-uniformity σ_g and density of bed material ρ_s); and time

variation of the scour hole, t. Thus, the dependence of the scour hole depth, d_s, on these parameters can be expressed as:

$$d_s = f\left(D, Sh, \theta, H, U, \rho, \nu, g, d_{50}, \sigma_g, \rho_s, t\right) \quad (1)$$

After conducting a dimensional analysis on various parameters, a functional dependence was determined, resulting in combinations of the independent variables showing the relationships that have a significant effect on scour. These dimensionless parameters shown in Eq. (2) are widely used in the scour prediction equations.

$$\frac{d_{se}}{D} = f\left(\frac{D}{B}, \frac{D}{d_{50}}, \frac{H}{D}, \frac{U}{U_c}, F_r, R_e, Sh, \theta, \sigma_g\right) \quad (2)$$

The time variation parameter for the scour hole does not appear in Eq. (2) and the parameter for maximum scour depth (d_s) has been replaced by the parameter for maximum scour depth at equilibrium conditions (d_{se}). In this non dimensionalization, it is assumed that the scour hole has reached a point of equilibrium, achieved by allowing enough time to pass so that changes in depth are negligible and hence the time parameter is no longer a variable. In scour experimentation, the Reynolds number R_e is maintained high enough to guarantee

turbulent conditions of flow and the Froude number F_r is maintained low enough to ensure sub-critical flow conditions.

2.3.1 Blockage Ratio (D/B)

The blockage ratio is the relationship between the diameter of the pier and the width of the channel. Existing prediction equations do not account for blockage ratios and their effect on scour.

2.3.2 Relative Coarseness (D/d_{50})

Relative coarseness is the relationship between the diameter of the pier and the median diameter of the bed particles. It is significant in lab experiments because of scale factors. Ratios that are either too small (<8) or too big (>50) change the scour process. Other factors like erosion at the sides of the pier come into play when the ratio is too small or become negligible when they are too big (Ettema et al. 2011). Investigations made by Lee and Sturm (2009), compiling data from a wide range of studies, derived a trend for the influence of relative coarseness on scour depth (Figure 3).

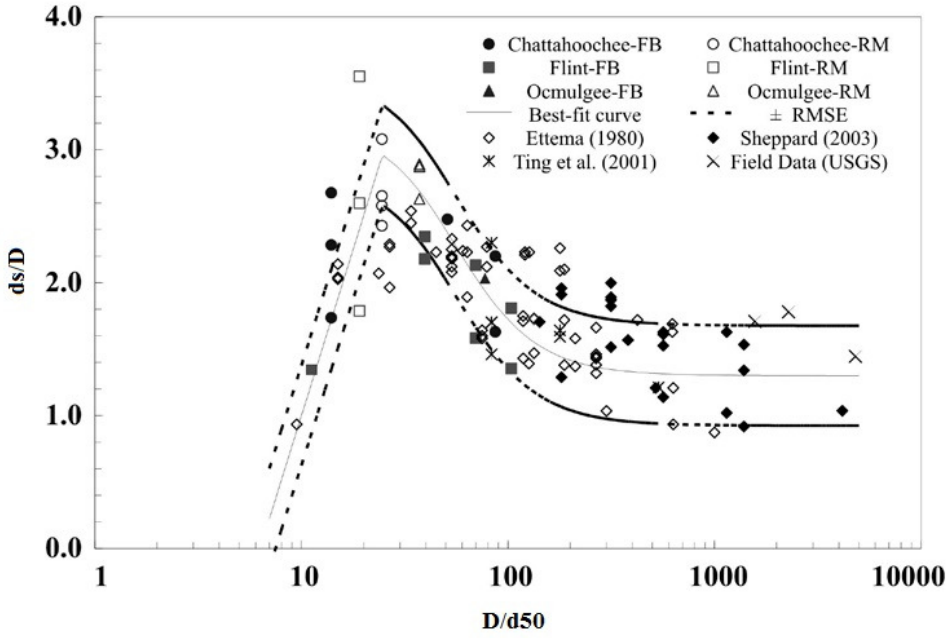

Figure 3. Influence of sediment size D/d_{50} on local scour (Lee and Sturm 2009)

2.3.3 Flow Shallowness (H/D)

The geometric scale of the pier flow field and the potential maximum scour depth are defined by this parameter. The flow shallowness is categorized into three classes of H/D (Melville and Coleman 2000). The three classes of flow shallowness were deduced from laboratory experiments and data and are as follows:

- Narrow piers: These piers are defined as cases where flow depths (H) are large compared to the pier width (D); the depth

of the scour hole increases in proportion to the pier width, and it is not affected by the water depth.

- Wide piers: For this case, the scour depth increases as the water depth also increases, and the pier width has no influence on the scour depth.
- Intermediate piers: The scour depth for these kinds of piers is influenced by both the flow water depth and the width of the pier.

Figure 4 shows data from previous experiments conducted at the University of Windsor and that obtained by Ettema et al. (2006).

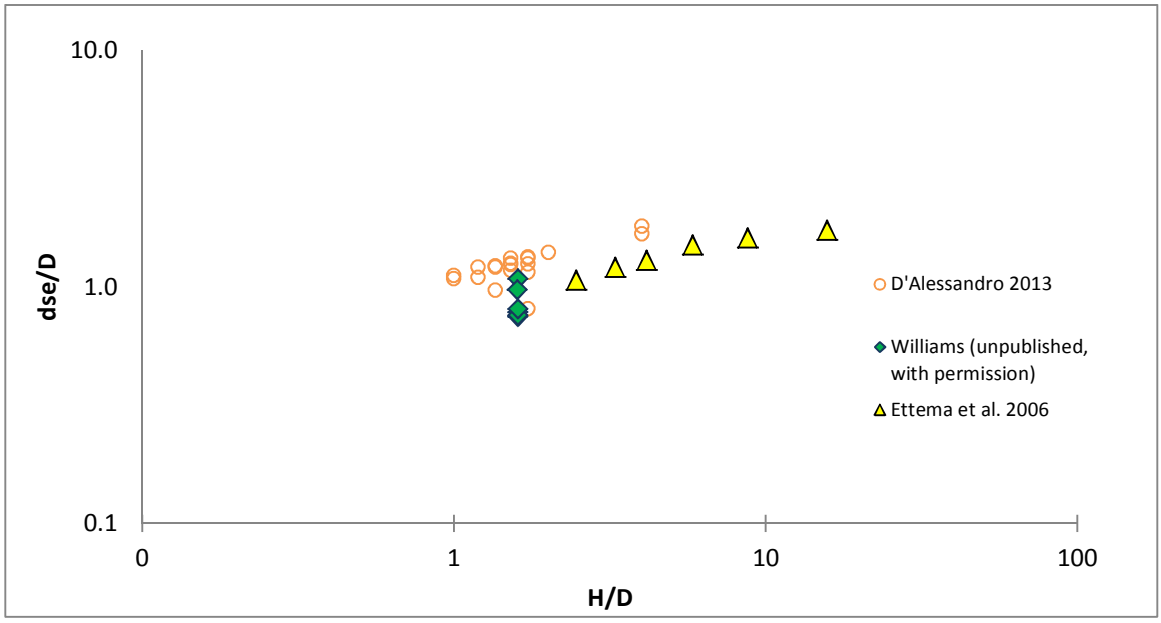

Figure 4. Influence of flow shallowness on local scour, previous studies

2.3.4 Aspect Ratio (B/H)

The relationship associated with water depth and channel width is one parameter that is not considered most times in scour research. The effects that secondary currents may cause to the scour geometry when the aspect ratio is below six are not taken into account in most prediction equations (Nezu and Nakagawa 1993). These currents may become an affecting factor for situations with a high blockage ratio.

2.3.5 Sediment Non-Uniformity (σ_g)

This parameter is also known as the geometric standard deviation of the bed particle size distribution, and is defined as:

$$\sigma_g = \left(\frac{d_{84}}{d_{16}}\right)^{0.5} \quad (3)$$

This parameter shows how well-graded a sediment is. Its value should be below 1.5 for the sediment to be well-graded. The sediment non-uniformity is very influential on the scour hole depth especially at flow velocities below the critical velocity threshold. It has been shown by Chiew (1984) that armouring caused by larger particles reduces the depth of scour when in the clear water range of flow. These larger particles create a layer over the smaller particle size sand and stop the movement of these smaller particles that otherwise would have been eroded by the flow.

2.3.6 Pier Characteristic and Shape (Sh)

The characteristics and shape of the pier are very influential to the scouring process. The flow field changes dramatically with different shapes causing alteration in the flow separation and subsequent formation of vortices and eddies (Ettema et al. 2011).

2.3.7 Angle of Attack (θ)

The angle of attack between the flow and the pier is another sensitive parameter especially for non-cylindrical piers. An angle of attack of zero ($\theta=0°$) refers to the flow hitting the pier perpendicularly. As the angle increases, the effective frontal width of the pier also increases and this has a direct effect on the scouring.

For this research, circular piers were chosen to simplify and mitigate the effects that the shape of the pier and angle of attack bring into the process.

2.3.8 Time (t)

Scour is a process that is time dependent. For fine sediments, the equilibrium scour depth (d_{se}) is reached much faster for live bed conditions than it is for clear water scour. Under clear water conditions, the equilibrium scour depth is approached asymptotically,

with 50% to 80% of the scour hole depth being formed in the first 10% of the time to equilibrium (Melville and Chiew 1999).

In this study, experimentation was conducted to allow the scour hole to reach a point of equilibrium. Each test was run continuously for 48 hours, enough time to confirm that the scour hole has reached a point where the depth increase was negligible.

2.4 Scour Depth (d_s) Prediction Methods

The extensive research conducted on scour over the years has seen the development of many scour predicting equations; the leading and most employed equations in design are:

(1) The Colorado State University equation (CSU), also known as the HEC-18 equation, was developed by Richardson and Davis in 1990 and described in the Federal Highway Administration, Hydraulic Circular No. 18 – 2012 report as:

$$\frac{d_s}{D} = 2K_1K_2K_3K_4\left[\frac{H^{0.35}}{D}F_r{}^{0.43}\right] \quad (4)$$

where

K_1 = Correction for pier shape (K_1 = 1 for circular piers)

K_2 = Correction for angle of attack of flow (K_2 = 1 for direct approach flow θ=0°)

K_3 = Correction for bed form (K_3 = 1.1 for clear water scour)

K_4 = Correction for armouring (K_4 = 1 for no armouring)

F_r = Froude number $F_r = {}^{U}/_{(gH)^{0.5}}$

The CSU equation is one of the most used design equations today. It rarely under-predicts scour and through comparisons with field measurements it has been recommended for both clear water and live bed scour, hence its extensive use. The limitations of the CSU equation are due to the variable parameters, which only include H, D and U.

(2) The Sheppard-Melville method described in Sheppard et al. (2011) is an improvement of a series of previous equations. It follows the same parameter approach from the Melville (1997) method and then builds on the method proposed by Sheppard and Miller (2006). It uses an effective pier diameter D*, which is the diameter of a circular pier that will have the same equilibrium scour depth as the structure analyzed under the same flow and sediment conditions (Ettema et al. 2011). The equation is as follows:

$$\frac{d_s}{D^*} = 2.5 f_1\left(\frac{H}{D^*}\right) f_2\left(\frac{U}{U_c}\right) f_3\left(\frac{D^*}{d_{50}}\right) \quad (5)$$

where

D^* = effective pier diameter

$$f_1\left(\frac{H}{D^*}\right) = tanh\left[\left(\frac{H}{D^*}\right)^{0.4}\right] \quad (6)$$

$$f_2\left(\frac{U}{U_c}\right) = \left\{1 - 1.2\left[Ln\left(\frac{U}{U_c}\right)\right]^2\right\} \quad (7)$$

$$f_3\left(\frac{D^*}{d_{50}}\right) = \left[\frac{\left(\frac{D^*}{d_{50}}\right)}{0.4\left(\frac{D^*}{d_{50}}\right)^{1.2} + 10.6\left(\frac{D^*}{d_{50}}\right)^{-0.13}}\right] \quad (8)$$

The Sheppard-Melville method reconciles the flow field and the erosion process at piers better than the CSU method as it takes better account of the flow-pier, the flow-sediment and the pier-sediment interactions.

The motivation for the current research is to experimentally investigate the interconnections and influences that the parameters affecting pier scour have on each other; and in doing so, improve on the methods of prediction. Most of the recent research has focused on how the various parameters interact on the same sediment bed; drawing conclusions that only apply to a specific case. This research intends to investigate the interactions that the multiple parameters have on four sediment beds, and how they relate to each other in a more general scenario of changing river beds.

CHAPTER 3

EXPERIMENTAL SETUP AND METHODOLOGY

3.1 Open Channel Flume

The experiments were carried out in a recirculating open channel flume located at the Ed Lumley Centre for Engineering Innovation, University of Windsor. The flume is 12 m long, 1.22 m wide and 0.91 m deep.

The channel was modified to carry out the desired experiments (Figure 5). First a wooden box (to match the width of the channel, depth of 200 mm and length of 3.6 m) was placed to contain the sand bed that was going to be used. A 2.5 m long wooden ramp preceded the sand bed to allow for a smooth transition of the flow from the flume bottom to the sand bed. At the upstream section of the channel, flow straighteners that cover the entire cross-section of the flume were placed to reduce the turbulence in the flow.

The experiments for this research required four different channel widths; this was achieved by placing side walls with the desired spacing along the length of the sand box. These walls were properly

braced so that they remained level and perpendicular to the sand bed (Figure 5).

Before each experiment the sediment bed was carefully leveled and slowly saturated with water and the flume filled to the desired water depth. The water velocity was then slowly adjusted to the required velocity and the experiment was conducted for 48 hours. An Acoustic Doppler Velocimeter (ADV) built by Nortek was used to measure the water velocity in the flow. Seeding particles were introduced to improve the signal quality. The Vectrino II software along with a Matlab algorithm were used to process the data.

Once each experiment was completed, the water was drained carefully to ensure no disruption of the bed particles inside the scour hole. The scour geometry data was acquired by mounting a laser digital point gauge (Leica DISTO E7400x) on a biaxial motorized traverse system placed on top of the flume, allowing full range of movement along the geometry of the scour hole.

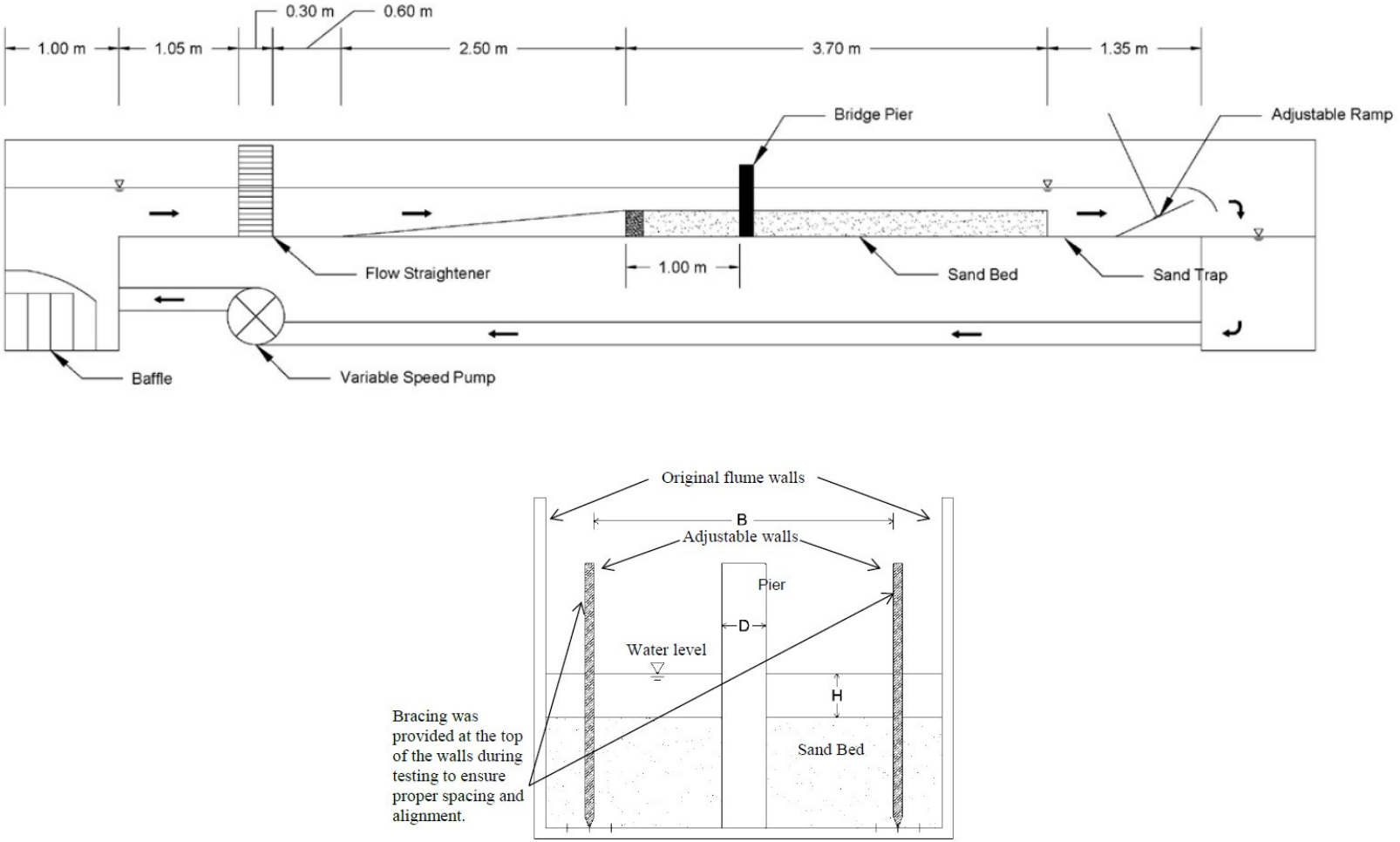

Figure 5. Schematic of flume and cross section (D'Alessandro 2013)

The water pump used was a 20-HP, 80-ft. head pump controlled electronically by a dial that changes the frequency, thus increasing or decreasing the flow velocity.

Calibration of the pump was done using a V-notch weir with a 60-degree angle opening located at the downstream end of the flume. The Kindsvater-Shen equation (USBR Water Measuring Manual 1997) was used to analyze the data obtained from the flume:

$$Q = 4.28 * C * \tan\left(\frac{\emptyset}{2}\right) * (h + k)^{5/2} \quad (9)$$

where

Q = the discharge (cfs)

C = the discharge coefficient

Φ = the notch angle (degrees)

h = the head (ft)

k = the head correction factor (ft)

Figure 6 was used to translate water velocity into pump frequency for each of the experimental series in this research.

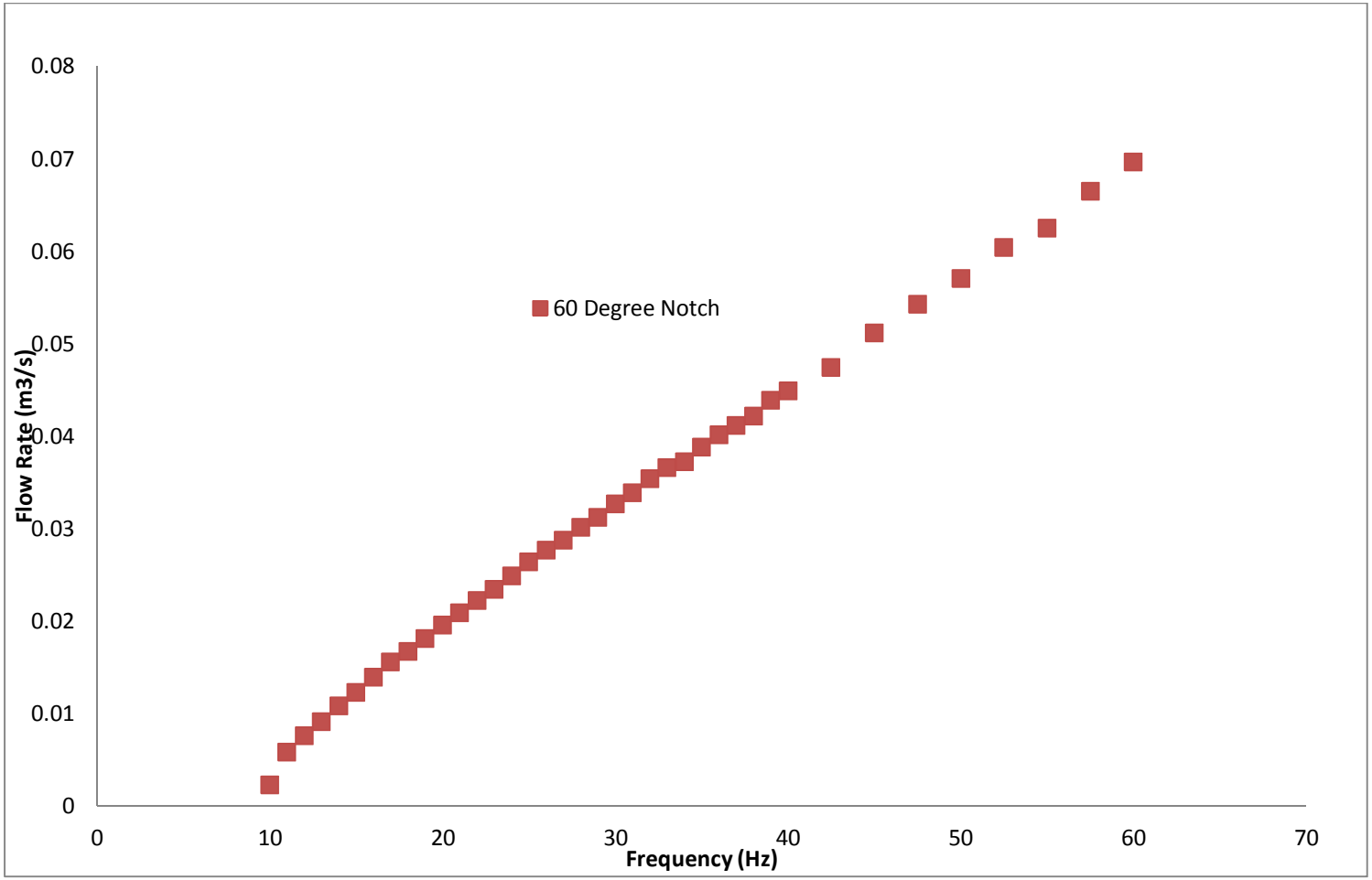

Figure 6. V-Notch weir pump calibration curve

3.2 Sediment Bed Material

Laboratory experiments were carried out for four non-cohesive sediments (sands). Each sand was subjected to an ASTM C-136 sieve granulometric analysis in order to determine the median sediment diameter (d_{50}) and the sediment non-uniformity (σ_g). Table 1 and Figure 7 show the results from these analyses. Figure 7 provides the percentages of material passing each of the sieve openings used in the granulometric analysis, thus generating a curve of how much material has a certain size. The sands were named Fine, Medium-Fine, Medium-Coarse and Coarse for analytical purposes.

Table 1. Sieve Analysis Parameters

Sand	d_{50}	d_{30}	d_{10}	d_{60}	d_{16}	d_{84}	C_u	C_c	σ_c
Fine	0.50	0.47	0.43	0.51	0.44	0.60	1.17	0.99	1.16
M-Fine	0.77	0.63	0.49	0.83	0.54	0.96	1.70	0.98	1.34
M-Coarse	1.63	1.41	1.16	1.74	1.25	2.03	1.50	0.98	1.28
Coarse	2.41	2.09	1.48	2.57	1.78	3.01	1.74	1.15	1.30

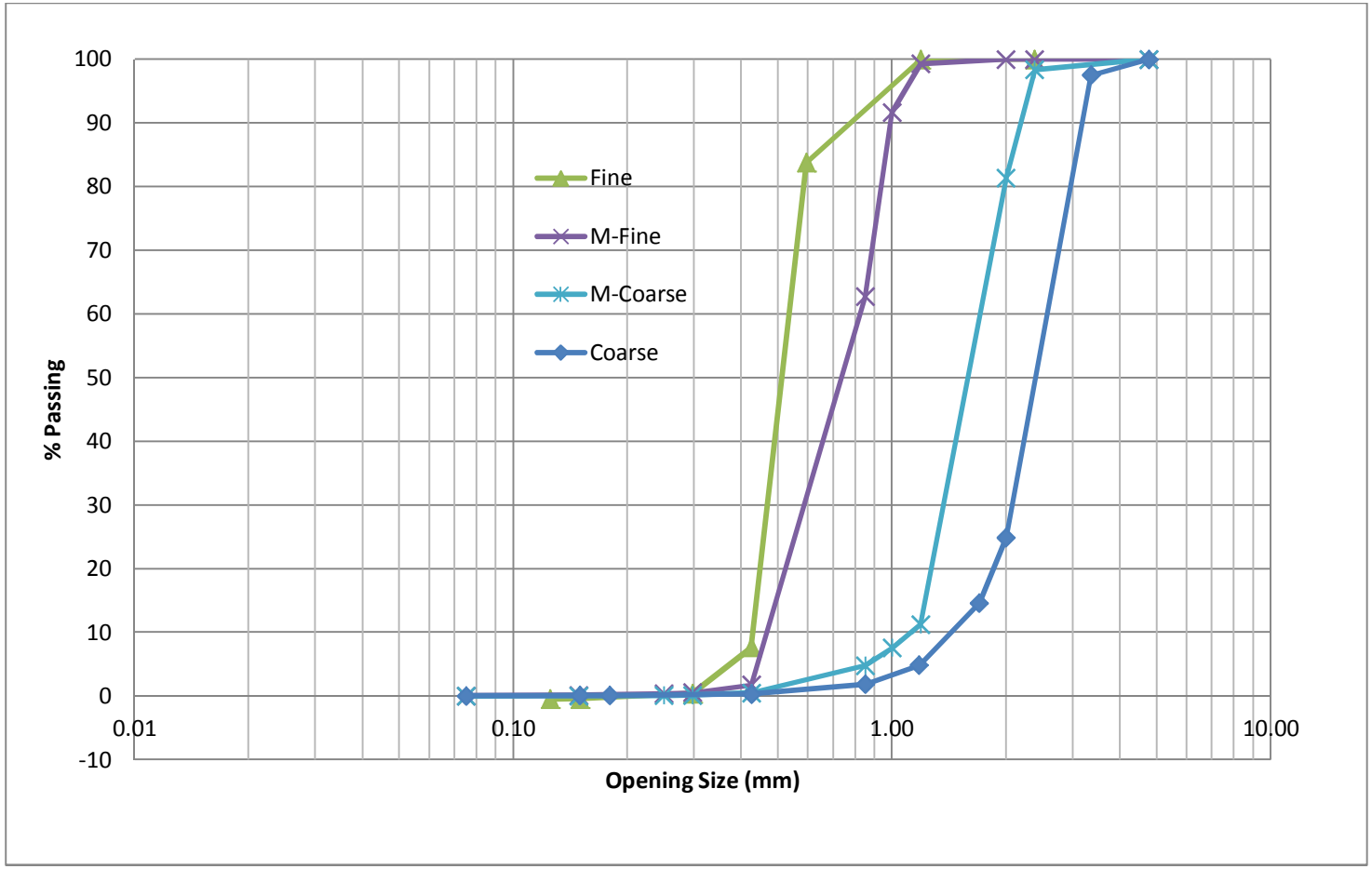

Figure 7. ASTM granulometric analysis

3.3 Parameter Setup

There were several challenges involved in the experimental design. As previously described, the proposed operational range suggested by the literature for some of the parameters could not be satisfied in every experiment due to constraints with the pump. Some experiments required a water depth that exceeded the pump's ability to reach the required flow velocities, if a constant flow velocity were to be maintained in all the tests. Accordingly, it was decided that the water depth (H) would be kept constant at 120 mm for all experiments. This constant water depth resulted in variation in flow shallowness (H/D) and aspect ratio (B/H) between the experiments. In order to better comprehend the effects these variations would have on the scour process, a preliminary set of experiments was carried out for control purposes. This set was entitled "Phase 1" of experimentation, in which the aforementioned parameters were kept constant at the proposed operational ranges.

3.4 Experiments

The Fine sand was chosen to conduct the tests for Phase 1. Previous experiments conducted by D'Alessandro (2013) using this sediment showed that changes made to the controlling parameters in the system translated into noticeable effects on the results. The operational parameter values used in Phase 1 were H/D=3.3 and B/H=6, with D/d_{50} as the only normalized parameter varying in each experiment.

Table 2. Phase 1 Experiments Initial Data

Phase 1				
Experiment	**1**	**2**	**3**	**4**
d_{50} (mm)	0.51			
D/B (%)	5			
D (mm)	12.70	19.05	25.40	38.10
B (mm)	254	381	508	762
H (mm)	42.3	63.5	84.7	127.0
D/d_{50}	25	37	50	75
B/H	6			
H/D	3.3	3.3	3.3	3.3
U/U_c	0.85			
U (m/s)	0.22			
R_e	9313	13970	18627	27940
F_r	0.34	0.28	0.24	0.20

The experiments in Phase 1 were set up by placing sidewalls in the flume at a distance such that the desired blockage ratio was achieved

in relation to the diameter of each pier used. The water elevation was changed for each of the experiments to ensure a constant value of H/D. The Reynolds number was maintained high enough such that fully turbulent conditions prevailed and the Froude number was maintained low enough to maintain sub-critical flow conditions.

Phase 2 experiments consisted of fifteen experiments. For this phase, the pier diameter (D) was changed to increase the blockage ratio and relative coarseness. This was done four times for each of the sand beds, with the exception of the Coarse sand, for which blockage ratio was changed only thrice, (D/B=15% was not conducted). In changing pier diameter to achieve the desired blockage, the width of the flume stayed constant and needed to be changed only once for each sand. Table 3 provides the specifications for these experiments.

After each set of experiments was concluded, the sand was changed, the flume cleaned and then the next sand was placed to start the process all over again. Once all the experiments were conducted, the data was grouped in the corresponding series and analyzed to fulfill the objectives of this study.

Table 3. Phase 2 Experiments

Series 1				
	Fine	M-Fine	M-Coarse	Coarse
d_{50} (mm)	0.51	0.77	1.63	2.40
B (mm)	259	391	830	1220
D (mm)	13.0	19.6	41.5	61.0
D/B (%)	5	5	5	5
D/d_{50}	25.4	25.4	25.4	25.4
H (mm)	120			
B/H	2.2	3.3	6.9	10.2
H/D	9.3	6.1	2.9	2.0
F_r (densimetric)	2.44	2.30	2.32	2.19
R_e	26849	31062	45417	52288

Series 2				
	Fine	M-Fine	M-Coarse	Coarse
d_{50} (mm)	0.51	0.77	1.63	2.40
B (mm)	259	391	830	1220
D (mm)	19.4	29.4	62.3	91.5
D/B (%)	7.5	7.5	7.5	7.5
D/d_{50}	38.1	38.1	38.1	38.1
H (mm)	120			
B/H	2.2	3.3	6.9	10.2
H/D	6.2	4.1	1.9	1.3
F_r (densimetric)	2.44	2.30	2.32	2.19
R_e	26849	31062	45417	52288

Series 3				
	Fine	M-Fine	M-Coarse	Coarse
d_{50} (mm)	0.51	0.77	1.63	2.40
B (mm)	259	391	830	1220
D (mm)	25.9	39.1	83.0	122
D/B (%)	10	10	10	10
D/d_{50}	50.8	50.8	50.8	50.8
H (mm)	120			
B/H	2.2	3.3	6.9	10.2
H/D	4.6	3.1	1.4	1.0
F_r (densimetric)	2.44	2.30	2.32	2.19
R_e	26849	31062	45417	52288

Series 4				
	Fine	M-Fine	M-Coarse	Coarse
d_{50} (mm)	0.51	0.77	1.63	2.40
B (mm)	259	391	830	1220
D (mm)	38.9	58.7	124.6	183
D/B (%)	15	15	15	15
D/d_{50}	76.3	76.3	76.3	76.3
H (mm)	120			
B/H	2.2	3.3	6.9	10.2
H/D	3.1	2.0	1.0	0.7
F_r (densimetric)	2.44	2.30	2.32	2.19
R_e	26849	31062	45417	52288

CHAPTER 4

RESULTS AND ANALYSIS

4.1 Phase 1 Results

Phase 1 experiments were conducted to provide a better understanding of the interactions between parameters by isolating the effect of relative coarseness (D/d_{50}). One may recall that the following parameters are held constant: blockage ratio D/B= 5%, flow shallowness H/D= 3.3 and aspect ratio B/H= 6. This was done so that the effect of blockage and any possible secondary flow effects will be minimised. Further, the flow fields at different pier diameters can be compared and are in the narrow pier range. The results of the Phase 1 experiments are shown in the following two graphs. The dimensionless scour plan view is shown in Figure 8 and the dimensionless centreline profile view is shown in Figure 9.

The figures clearly show that the largest non dimensional geometry is obtained in the experiment with the smallest pier diameter. The general shape of the scour holes in Figure 8 are very similar; a semicircle upstream of the pier, which then forms a heart shape downstream of the pier. In Figure 8, the scour hole depths produced

by the smaller piers are wider than those produced by the two larger piers. Also, the downstream wake sediment disturbance is larger at the two smaller diameters.

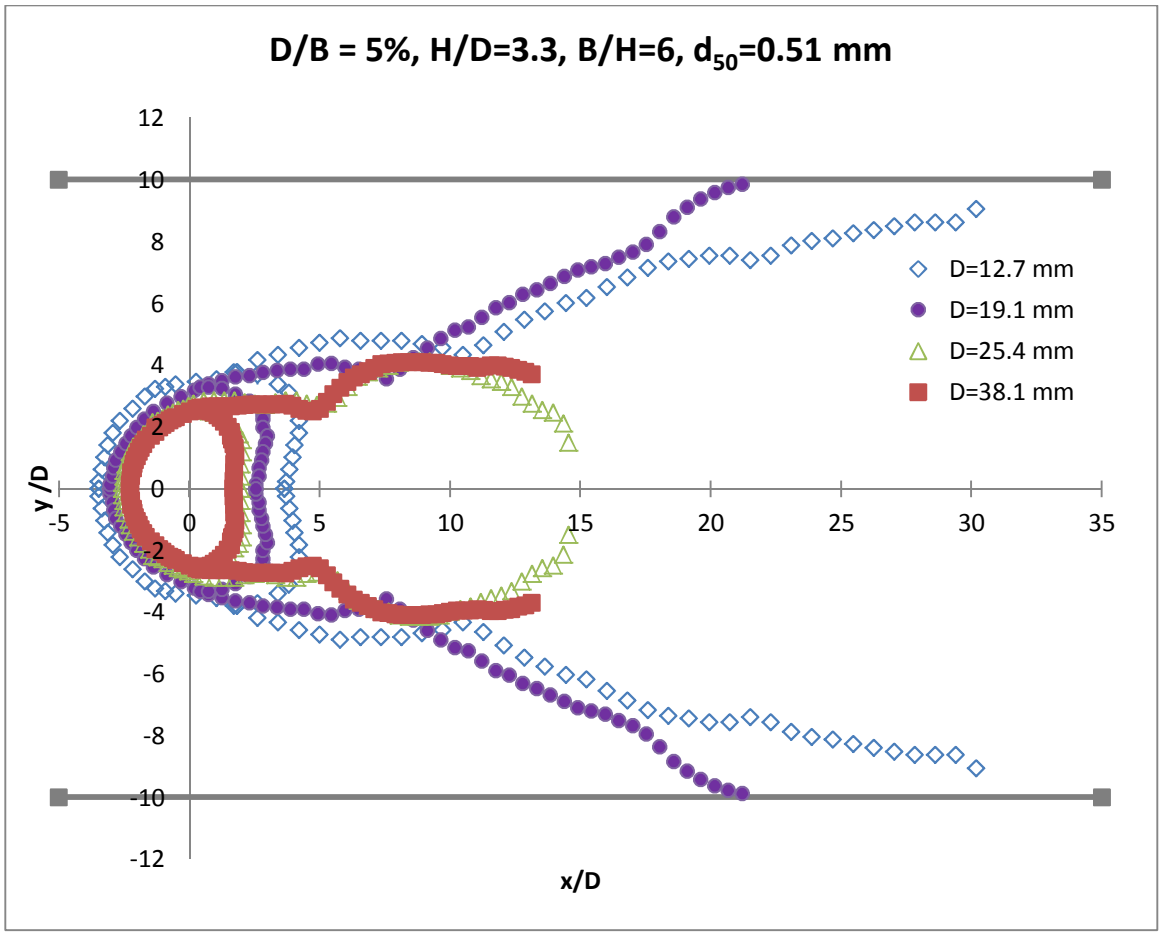

Figure 8. Phase 1 – Plan View

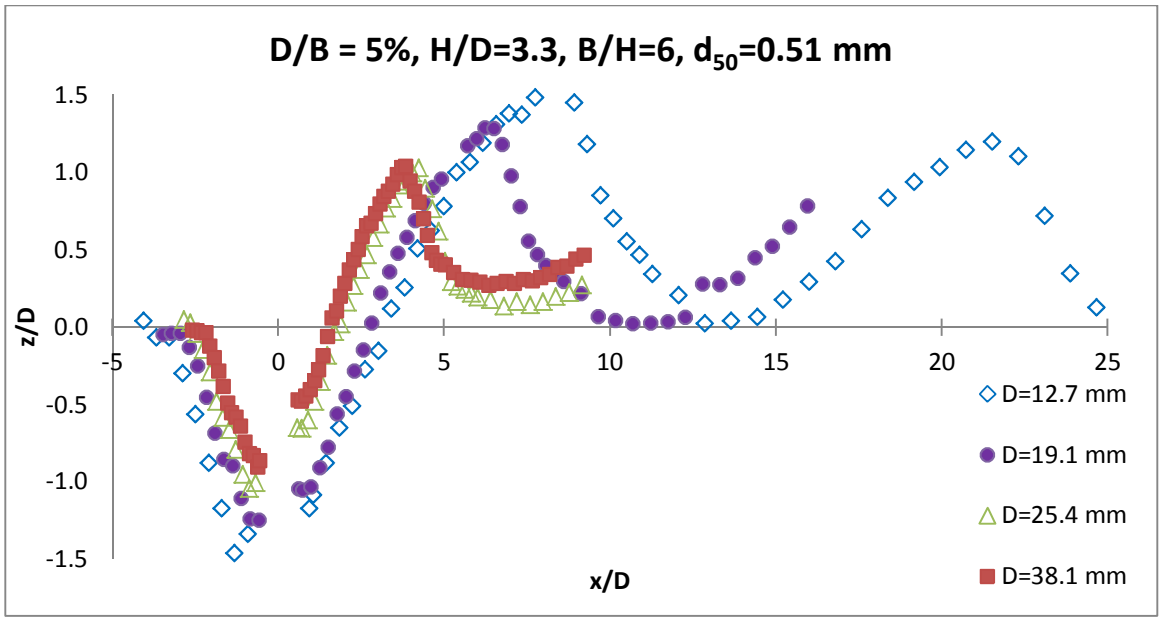

Figure 9. Phase 1 – Centreline Scour Profile

Pier diameter has a direct influence on wake vortices and eddies generation. The Strouhal number (S) describes the influence of pier diameter and flow velocity on the frequency of vortex shedding,

$$S = \frac{nD}{U} \tag{10}$$

where

S= Strouhal number

n= frequency of vortex shedding

For piers in similar conditions of flow (same flow intensity), the shedding frequency (n) is inversely proportional to pier diameter; which means that smaller piers placed in the same flow generate

eddies and vortices at a greater rate (Ettema et al. 2006). This explains why the two smaller pier diameters created scour geometries different from the two larger pier diameters. Though blockage ratio may not influence d_{se} directly, these results indicated that it can influence the spread of the scour geometry as in the present results.

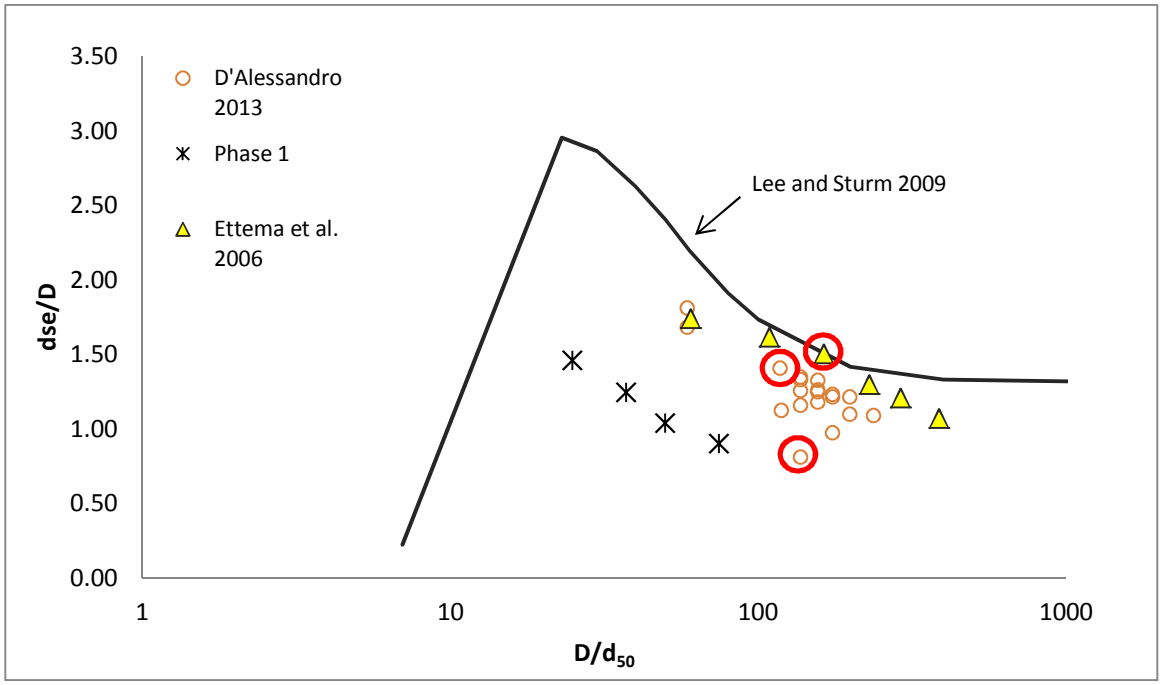

Figure 10. Influence of relative coarseness on local scour (Phase 1)

The relevant scour parameters for Phase 1 were kept constant except for relative coarseness; its influence on local scour is shown on Figure 10. The trend reported by Lee and Sturm (2009) is provided as baseline case to compare with the present results. The present results show a decreasing trend with increasing D/d_{50}. It is important to note

that values for d_{se}/D obtained in Phase 1 are much lower than the trend line suggested by Lee and Sturm (2009). The local scour depth values obtained by other authors shown in Figure 10 are also below the trend line, and no scour depth stabilization is achieved for values of $D/d_{50}>150$. The Lee and Sturm (2009) trend line was calculated by applying corrections for shape, angle of attack, flow intensity and water depth, which were not applied for Phase 1 or the other data in Figure 10.

As several of the influencing parameters were held constant in Phase 1, one would expect that the variation of d_{se}/D in Figure 10 is solely due to the increase in relative coarseness. This suggests that all the other results in the figure may be influenced by some of the parameters that were held constant in the present tests.

To expand on the previous statement, results from previous authors with parameters similar to those used in Phase 1 were chosen. Figure 10 highlights three data points in red circles with these similarities. The two tests of D'Alessandro (2013) with D/B values of 4.9 and 5.7, H/D values of 2 and 1.7 and B/H=10 were chosen. The one from Ettema et al. (2006) had D/B=5.7, H/D=5.8 and B/H=3. These results conform to low blockage and are in the narrow pier range.

The two data points from D'Alessandro (2013) show that small changes in the H/D have significant impact on local scour depth (d_{se}/D values of 1.41 and 0.81). From the data point taken from Ettema et al. (2006), there are two controlling parameters. A high value H/D and a low value of B/H that increases local scour depth by the introduction of secondary currents. All these different results from data with close experimental conditions reaffirms that experimental research on scour has overlooked certain important parameters and most empirical equations over-predict local scour depth.

4.2 Phase 2 Results

Phase 2 experiments are subdivided into four series as shown in Table 3. Series 1 has the smallest value of blockage ratio and relative coarseness, and Series 4 has the largest value of the two parameters.

4.2.1 Series 1: B/D= 5% D/d_{50}= 25

Experiments in Series 1 were carried out at a constant blockage ratio B/D of 5% and a relative coarseness D/d_{50} value of 25. These values were obtained by adjusting the distance between the side walls and size of the pier for each of the four sands to obtain the desired dimensions. Measurements of the scour holes generated were taken

and profile and plan view graphs were made for each of the experiments in the series. Also, photographs were taken at the end of each experiment (Figure 11).

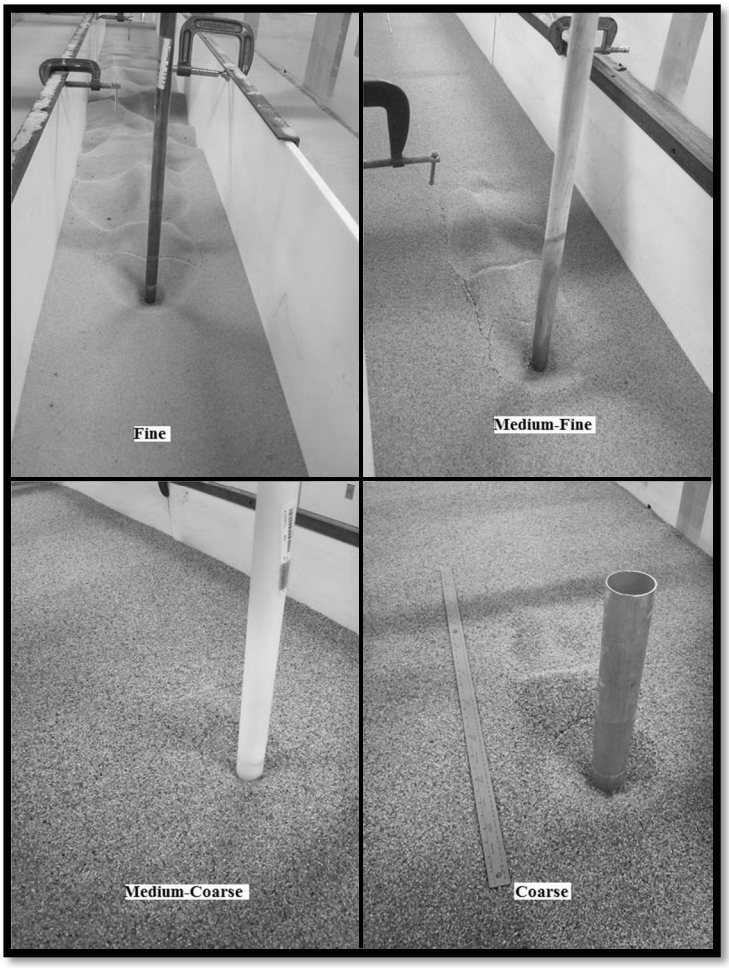

Figure 11. Series 1 profile photos

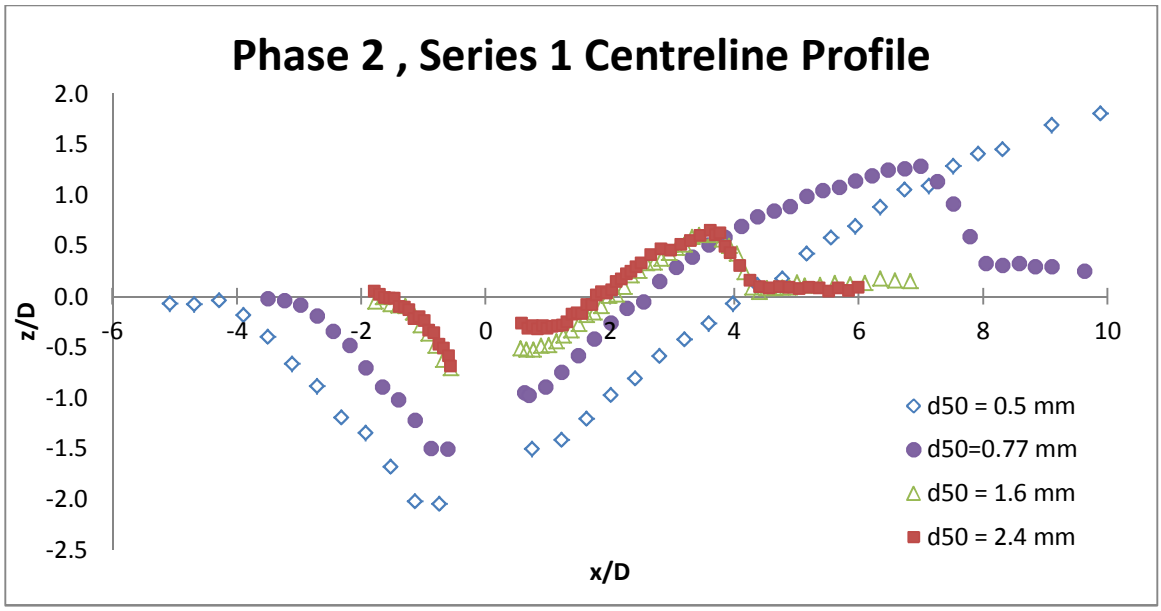

Figure 12. Series 1 centreline profile graph

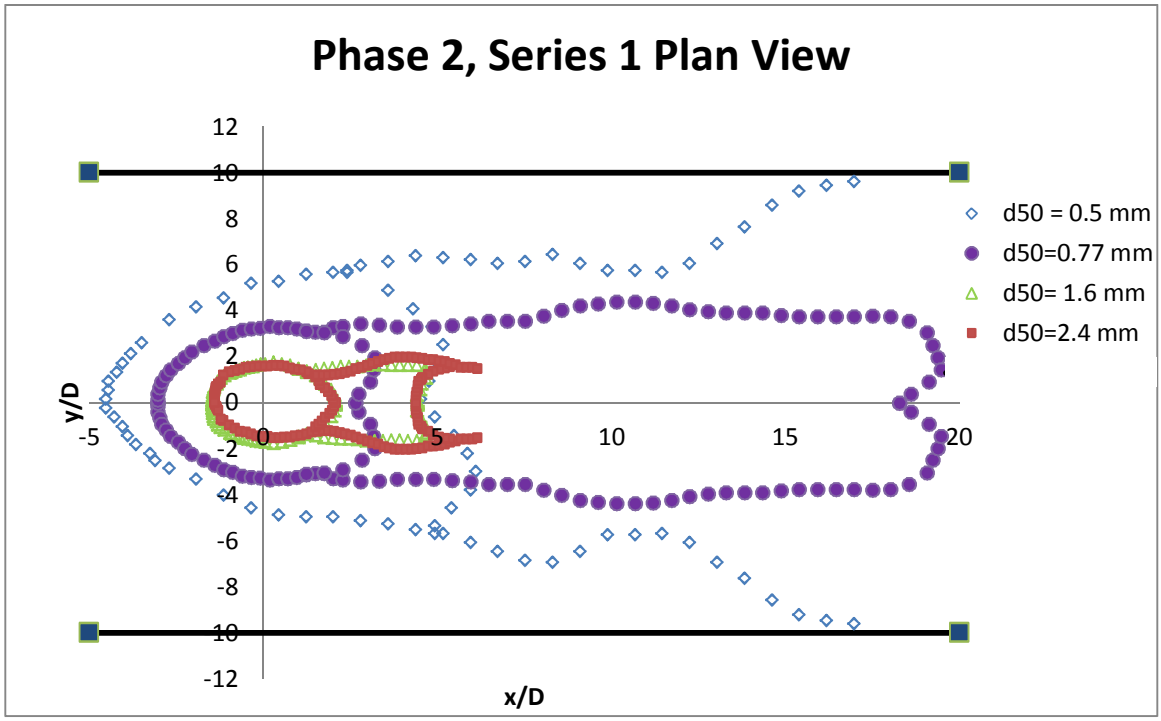

Figure 13. Series 1 plan view graph

Figure 12 shows a clear distinction in size between the scour holes made in the coarser sands and in the finer sands. The scour in the finer sands is much larger. The scour hole generated in the Fine sand is 8D in length, while in the Medium-Fine sand it is 5D. Further, in the coarser sands, the scour holes are almost identical in shape and length, with the scour hole measuring approximately 4D in length. Likewise, the scour depths shown in Figure 12 follow the above described trend. The deepest hole at 2D was generated in the Fine sand, followed by the Medium-Fine at 1.5D, and the flow generated a scour hole 0.7D deep in the two coarser sands. Figure 13 shows a much larger difference in the plan view geometry between the finer sands. The scour width generated in the Fine sand is twice as large as in the Medium-Fine sand. Their shape is very similar up until x/D=10D where the Fine sand widens and reaches the side walls and the Medium-Fine sand continues in the direction of the flow without reaching the side walls. The flow in the Medium-Coarse and Coarse sand generated a geometry which is half the size of the one produced in the Medium-Fine sand, and have the same shape and size when analyzed non dimensionally.

Series 1 falls entirely into the narrow pier category (H/D>1.4), wherein the scour is influenced by the pier diameter and is not

affected by water depth (Melville and Coleman 2000). It should be noted in Series 1, H/D is different in each of the tests. The value of H/D is decreasing while the pier diameter is increasing. The present series would indicate that the equilibrium scour depth decreases with pier diameter.

4.2.2 Series 2: B/D= 7.5% D/d_{50}=38

Series 2 has a 50% increase from Series 1 in both the blockage ratio and relative coarseness. The forthcoming photographs (Figure 14) and graphs (Figures 15 and 16) are presented in the same manner as Series 1.

Figure 14. Series 2 profile photos

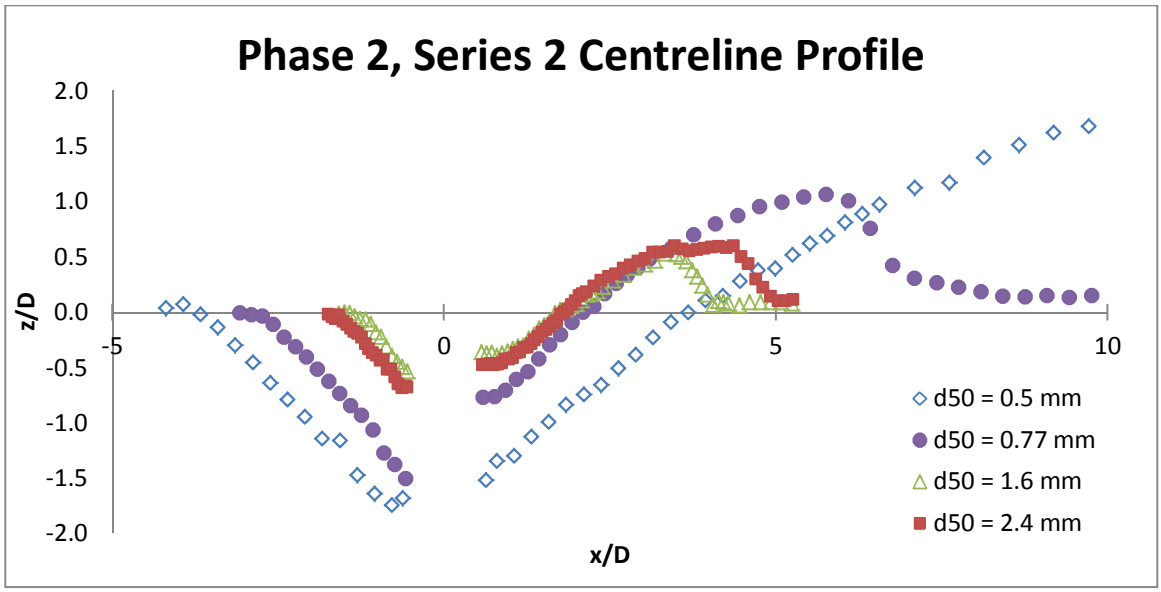

Figure 15. Series 2 centreline profile graph

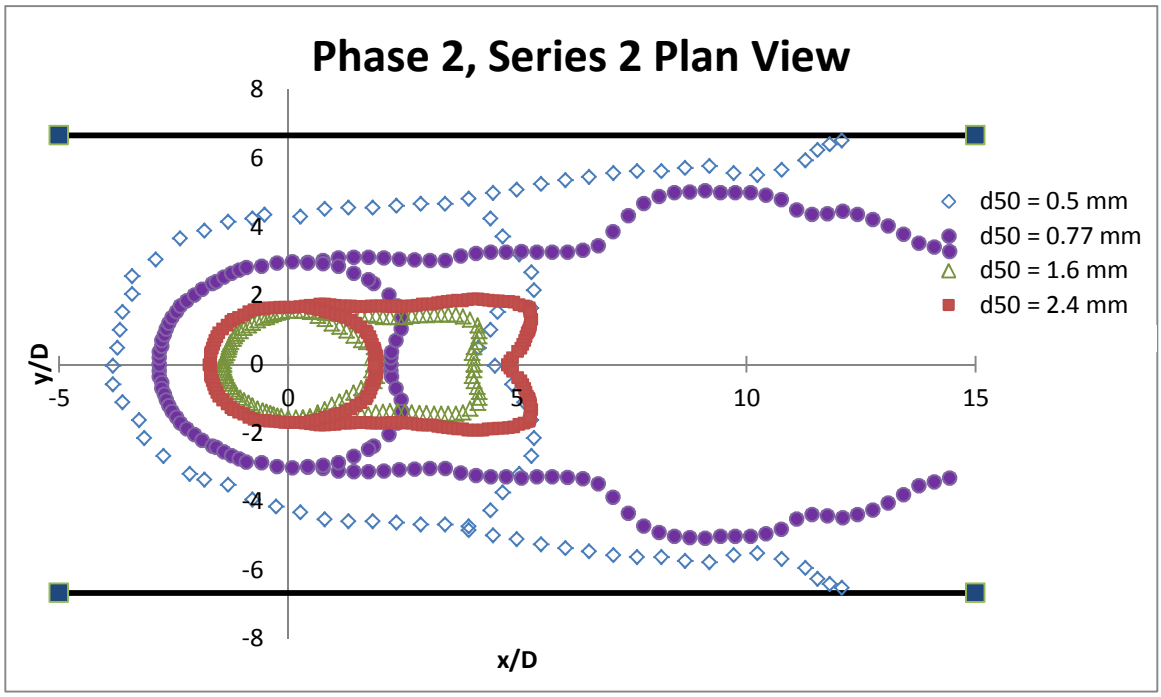

Figure 16. Series 2 plan view graph

The results observed from Series 2 are similar to those of Series 1 at a larger D/d_{50}. Figure 15 shows a clear distinction in geometry between

the coarser sands and the finer sands. The Medium-Coarse and Coarse sands have almost an identical profile geometry up to x/D=2.5D. The two finer sands behave similarly; they differ in scour hole size and depth, the Medium-Fine sand profile geometry is half the size of the Fine sand. The effects of different d_{50} are very noticeable in these graphs though the relative coarseness is held constant. Figure 16 shows the influence that different particle sizes and pier diameters have on the geometry of the scour. The flow generates large scour holes in the two finer sands. The Fine sand geometry reaches the side walls at about x/D=12D and the Medium-Fine sand scour came close to reaching the side walls. Similar to Series 1, the two larger sands have a similar geometry and size of scour hole, with a scour length and width of approximately 4D.

Series 2 experiments fall in the narrow piers range. The two coarser sands have a value of H/D that is close to 1.9 for the Medium-Coarse sand and 1.3 for the Coarse sand. The finer sands have values of H/D of 6.2 for the Fine sand and 4.1 for the Medium-Fine sand. The influence of H/D will be discussed in an upcoming section.

4.2.3 Series 3: B/D= 10% D/d_{50}= 51

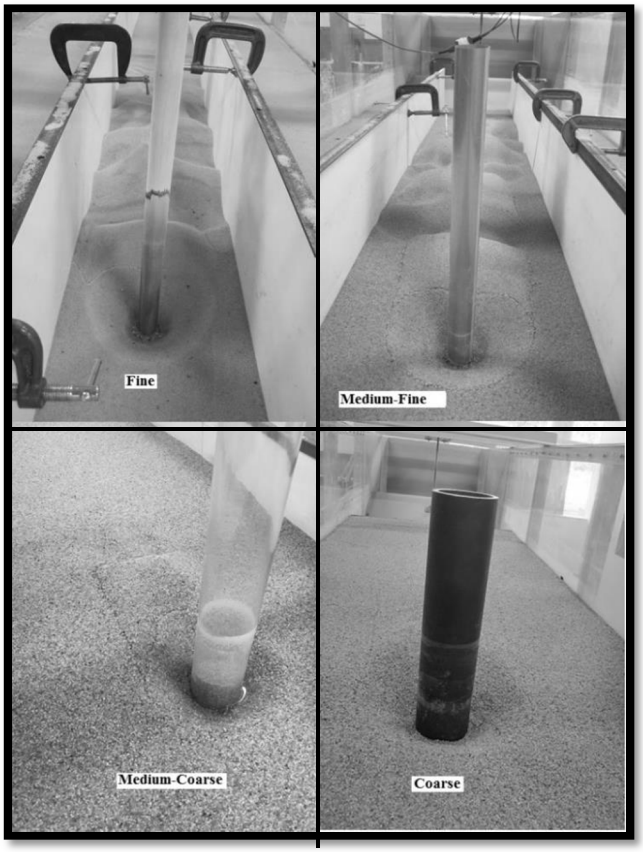

Figure 17. Series 3 profile photos

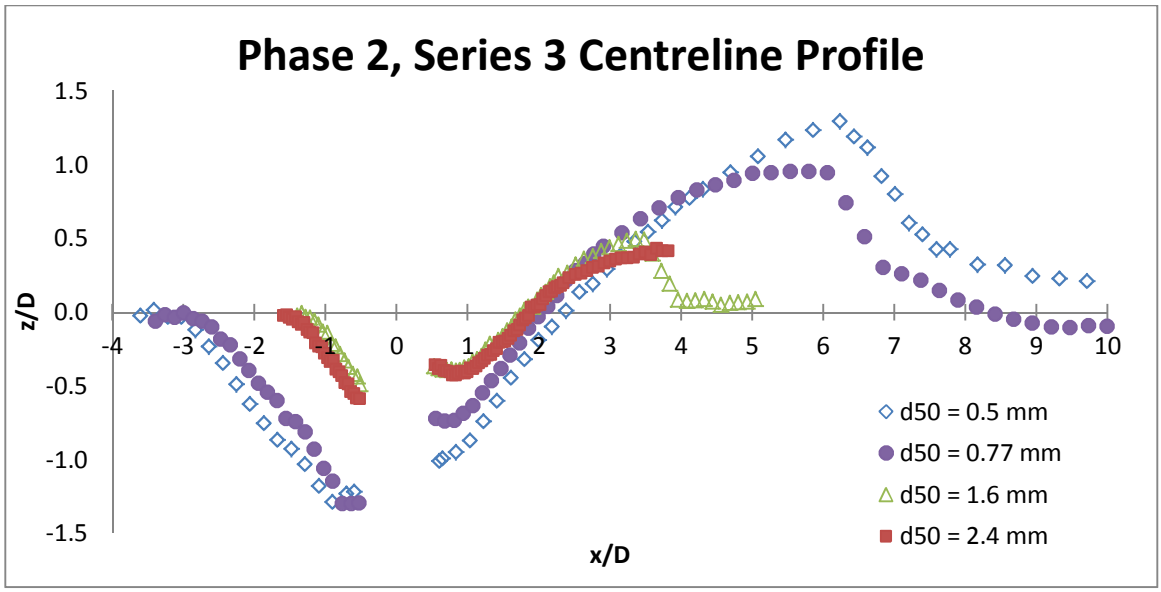

Figure 18. Series 3 centreline profile graph

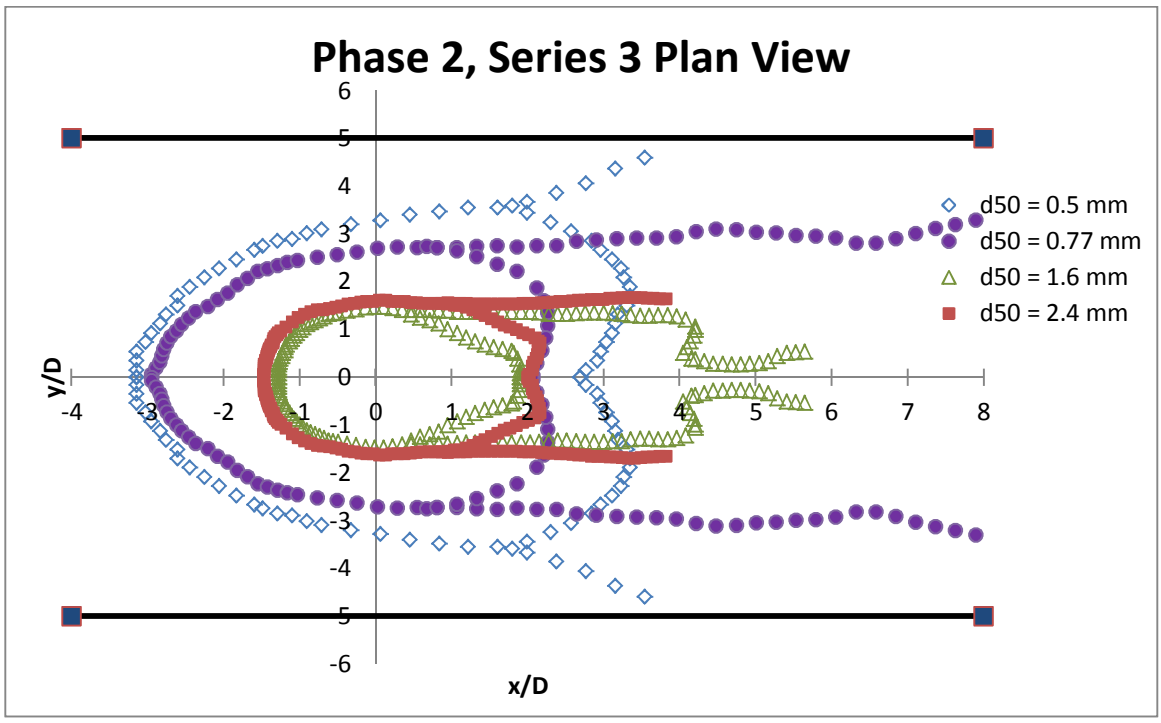

Figure 19. Series 3 plan view graph

Results from Series 3 continue to show a clear difference in behaviour between the coarser sands and the finer sands, but it also shows a closer similarity between the two finer sands. Figure 18 shows almost identical scour geometry for the two finer sands in both depth and length. Figure 19 shows this similar behaviour much clearer, the finer sands have a scour geometry that is very close in size and shape, more than it has been in the previous two series. Only in the Fine sand did the flow generate a scour geometry that was affected by the side walls. In the Medium–Fine sand, the flow generated a geometry that reaches approximately 3D in width and did not reach the side walls. In the coarser sands, the flow generated an almost identical non dimensional geometry; size and shape are consistent with Series 1 and 2, with an almost circular scour hole of diameter 4D, and scour geometries that show no influence from the side walls. The size of the scour hole generated in the two finer sands is approximately double the size in the coarser sands.

4.2.4 Series 4: B/D= 15% D/d_{50}= 76

Series 4 was conducted in three sediments. Experiments with the Coarse sand were not conducted.

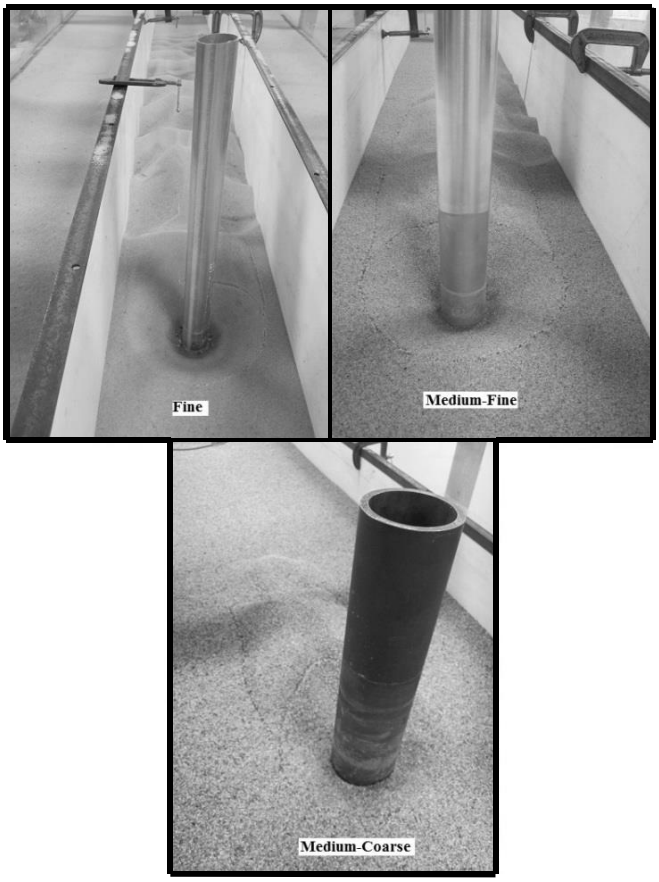

Figure 20. Series 4 profile photos

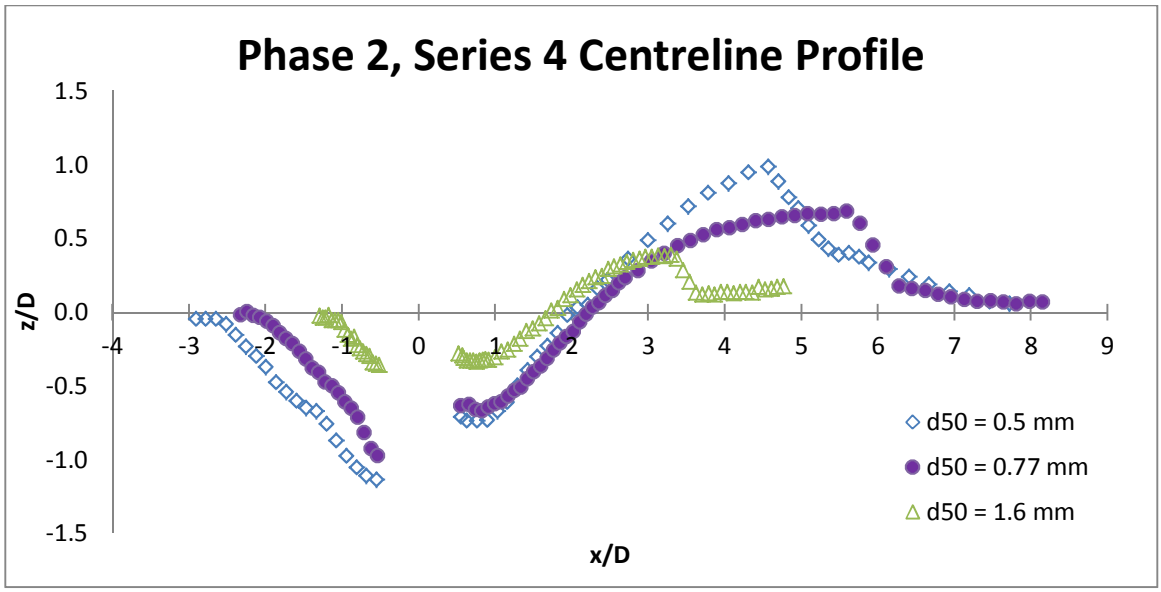

Figure 21. Series 4 centreline profile graph

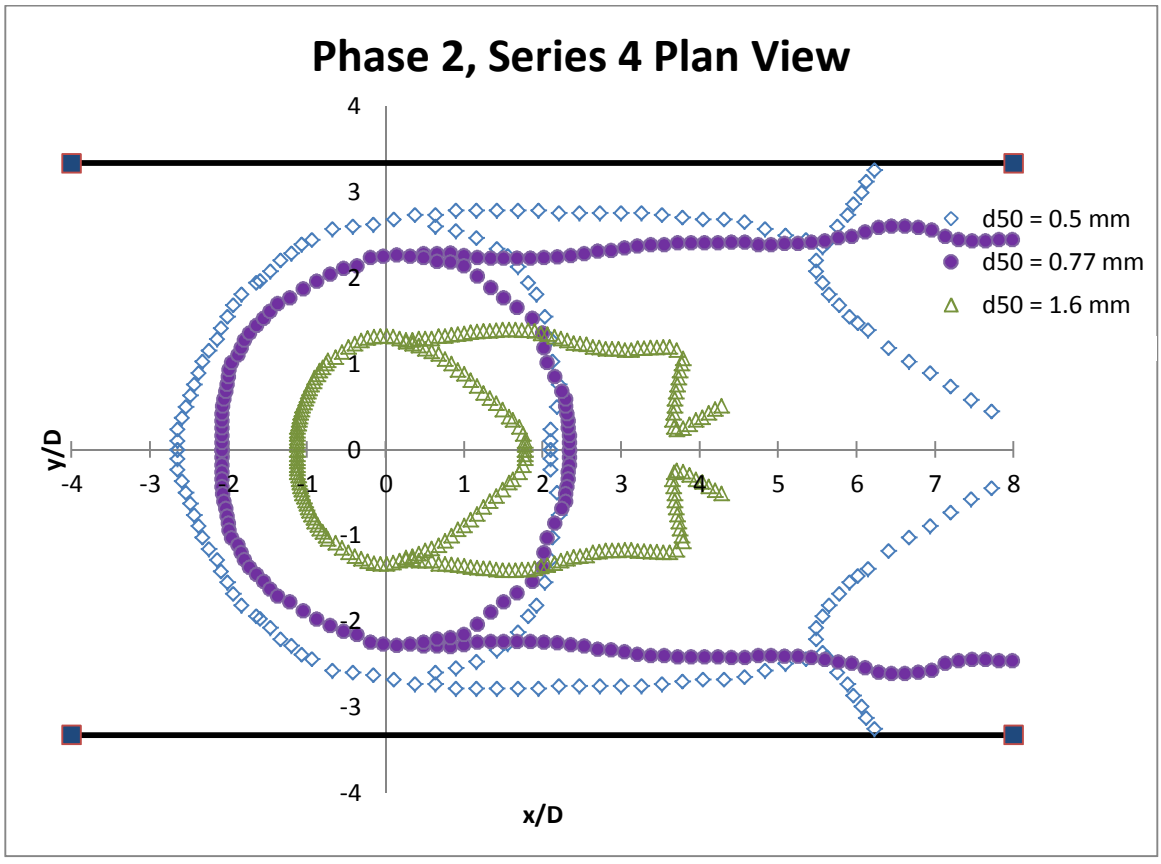

Figure 22. Series 4 plan view graph

Series 4 displays the same distinction between the sands that was observed in the previous series; the finer sands behave very similar to one another; the Fine sand geometry is still larger than the Medium-Fine. The Medium-Coarse sand created smaller non dimensional scour geometry like in Series 1 to 3. In Figure 21, the upstream portion of scour hole shows three evenly spread sands from finer to coarser. The depths however are very different, the Fine sand created a hole 1.2D deep; the Medium-Fine was 1.0D deep and the Medium-Coarse was approximately 0.4D deep. From Figure 22 however, the distinction between the sands is still very clear; the two finer sands have very similar and large geometries and only the Fine sand is affected by the side walls. The Medium-Coarse sand created a scour geometry that is approximately one third of the geometry generated by the fine sand.

The presence of the high blockage ratio in Series 4 can be clearly seen in Figure 20. These pictures show the proximity to the walls and the degree of obstruction that just a 15% blockage introduces.

4.3 Phase 2 Analysis

The results obtained from the experiments in Phase 2 are shown in Table 4. The values of the equilibrium scour depth (d_{se}) and the normalized equilibrium scour depth (d_{se}/D) are shown in the table.

Table 4. Phase 2 Results

	d_{se} (mm)				d_{se}/D			
D/B	**Fine**	**M-Fine**	**M-Coarse**	**Coarse**	**Fine**	**M-Fine**	**M-Coarse**	**Coarse**
5%	26.0	28.6	29.4	43.2	2.04	1.50	0.71	0.69
7.5%	33.2	45.0	33.6	61.2	1.74	1.50	0.53	0.68
10%	33.3	49.4	40.5	71.4	1.31	1.30	0.49	0.59
15%	43.2	56.8	43.8		1.11	0.98	0.36	

Table 4 indicates that at a given blockage, equilibrium scour depth increases with increasing sand size. However, it should be noted that this is not due to the effect of the sand size but is due to the increase in diameter of the pier. In order to maintain the same blockage and the same relative coarseness throughout the series, D had to be increased. The results become clear when viewed in a non dimensional form. The relative scour depth decreases with increasing sand size. For any given sand (say Fine), the relative depth decreases with blockage ratio as the corresponding D/d_{50} has been increased.

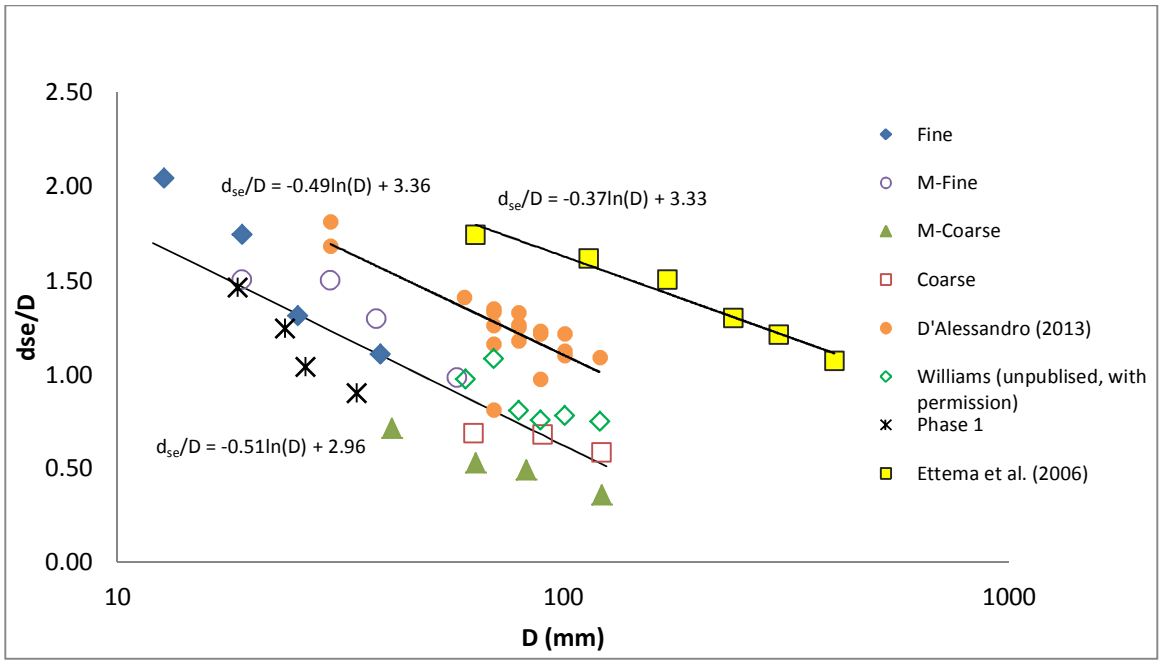

Figure 23. Influence of pier diameter on local scour – Phase 2

Ettema et al. (2006) notes that pier diameter alone is an important parameter as it determines the frequency of vortex shedding. The frequency of eddy formation has a direct relationship with the increase in sediment entrainment and movement; the rate is inversely proportional to pier diameter, which means that for similar flow conditions, smaller diameters generate more eddies and vortices, thus increasing scour. Figure 23 illustrates a decrease in local scour depth with an increase of pier diameter. The three distinct trends shown in the figure correspond to different flow conditions in each of the data sets shown. Phase 2 experiments maintain a constant H and a constant U/U_c for all the sands. Even if each sand has a different flow

velocity, the figure shows consistency in the data with the findings of Ettema et al. 2006, suggesting that the influence of pier diameter is relevant. However, comparing the present data set to that of D'Alessandro (2013), for very similar values of H and U/U_c, the results are different. This indicates that the relative coarseness can influence the scour depth for similar conditions of flow.

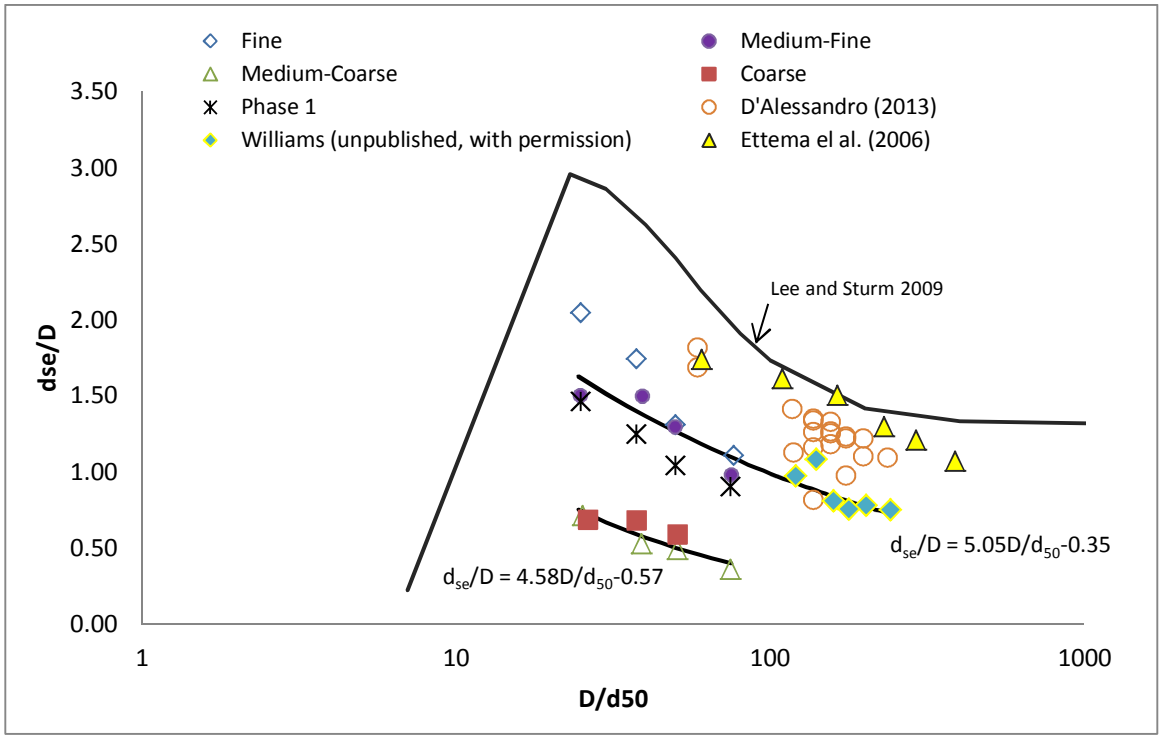

Figure 24. Influence of relative coarseness on local scour - Phase 2

Curve fits were established for the d_{se}/D generated in the coarse and fine sands used in the present experiments (Figure 24). The two trends show the effect of the particle size on the depth of the scour

hole. Results from Series 1 through 4 show that piers placed in different sediments with equal D/d_{50} do not have a similar d_{se}/D for values of $D/d_{50}<100$. Relative coarseness does not fully describe the behaviour of the scour hole when H/D varies. The local scour depth for each of the series is then a function of H/D and not just D/d_{50}.

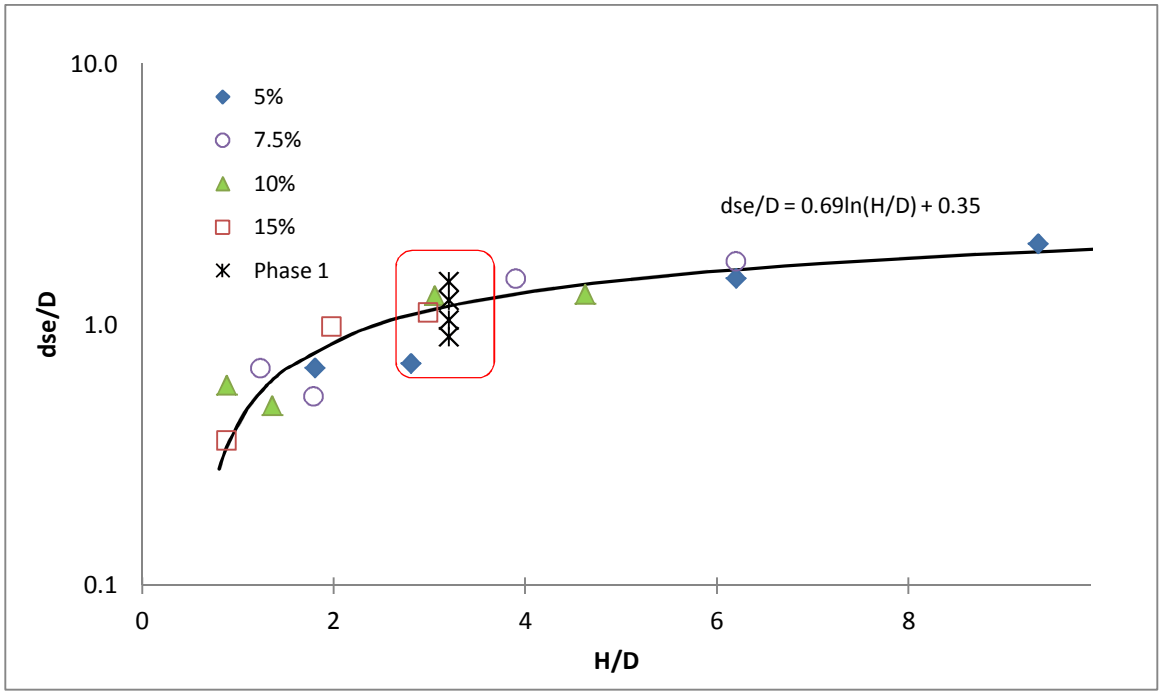

Figure 25. Influence of flow shallowness on local scour - Phase 2

The effects of flow shallowness on local scour depth for Phase 2 are shown in Figure 25. The trend line created was obtained by grouping the data from all series. It shows an increasing value of d_{se}/D with H/D. This trend is in accordance with Melville and Coleman (2000). The effects of blockage ratio and relative coarseness are not visible in

Figure 25. The data points inside the highlighted area have different values of D/B and D/d_{50}, but similar H/D. Phase 1 has changing D/d_{50} and D/B of 5%. The scatter of points with the same H/D and different D/B and D/d_{50} suggests that for the range of 1<H/D<6 the effects of blockage and relative coarseness are negligible.

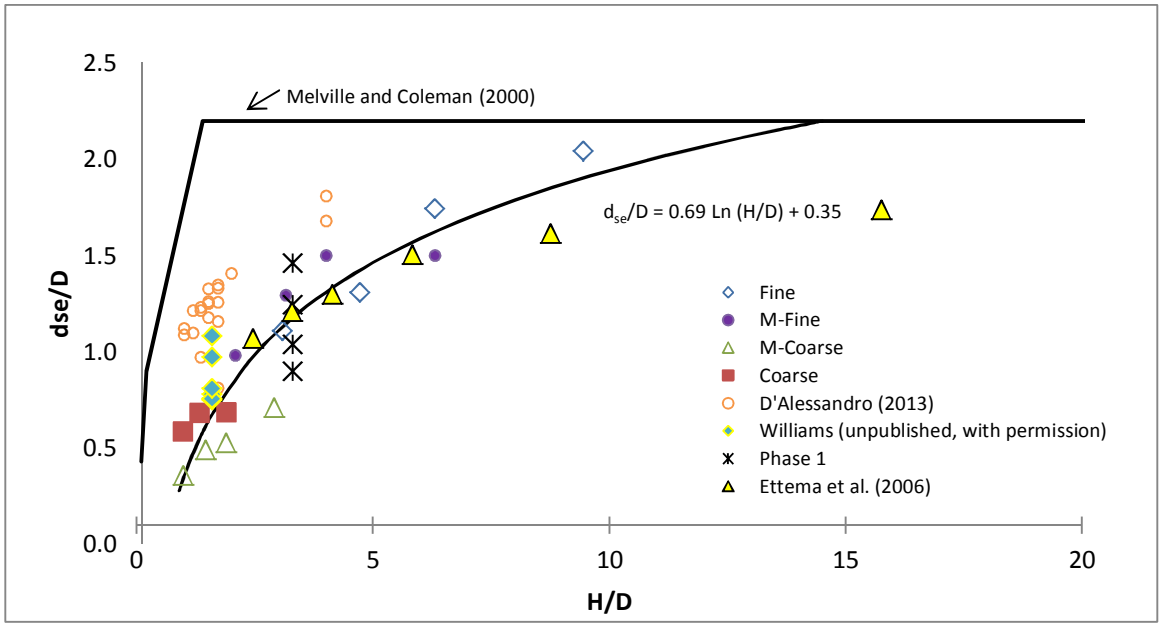

Figure 26. Influence of flow shallowness on local scour – multiple studies

Figure 26 is similar to Figure 25 but includes the results from other studies. It is clear that the effect of D/d_{50} continues to present itself when all results are collectively viewed. In an effort to absorb the effects of D/d_{50}, the results are plotted by combining H/D and D/d_{50}, (Figure 27).

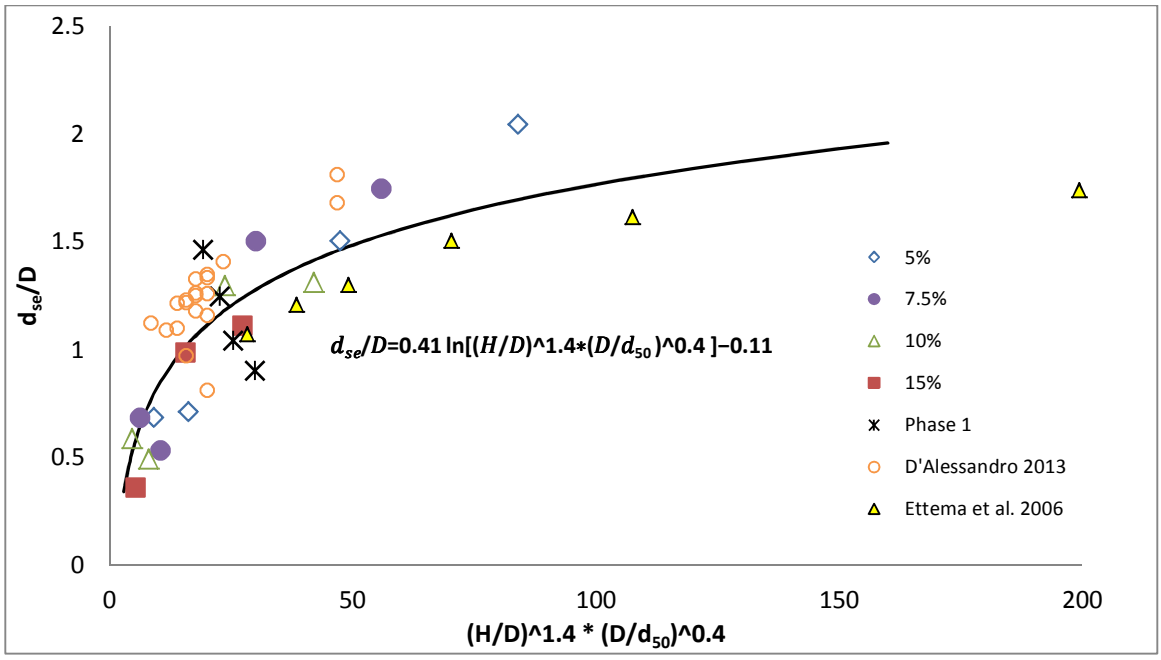

Figure 27. Influence of (H/D)*(D/d_{50}) on Local Scour

It should be noted that H/D is expected to play a more dominant role, at least in the lower range of H/D. This is represented by the larger power of the exponent used to describe its role in the results. It appears that for a fairly broad range of H/D and D/d_{50}, the results can be reasonably collapsed onto a single curve with the following equation:

$$\frac{d_{se}}{D} = 0.41 \ln\left[\left(\frac{H}{D}\right)^{1.4} * \left(\frac{D}{d_{50}}\right)^{0.4}\right] - 0.11 \qquad (10)$$

The trend line obtained in Figure 27 shows a much better fit to the broad range of values than the trend line in Figure 26.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The objective of this study was to investigate the effects that relative coarseness and blockage ratio has on bridge pier scour under clear water conditions. The study was carried out in two phases. Phase 1 experiments were carried out at a low blockage, constant aspect ratio, constant H/D with varying D/d_{50}. Phase 2 experiments were carried out over a wider range of blockage ratios and had four series of tests. Each series was conducted at a constant D/d_{50}.

- For small values of relative coarseness ($D/d_{50}<100$) the median sand size has a very significant impact on the depth of the scour hole when the values of H/D are low (<6).
- Particle size, water depth and pier diameter are influential in affecting the geometry and depth of the scour holes. The effects are more noticeable in finer sands. The results show a clear distinction in behaviour between the finer sands and the coarser sands when subjected to similar conditions of flow and pier

diameter; suggesting a particle size threshold to differentiate between fine sand behaviour and coarse sand behaviour.

- The relationship between pier diameter and the frequency of vortex shedding makes H/D that much more important on the scouring process.
- Influence of pier diameter is more relevant than size of sediment particle on scour depth, for similar conditions of flow.
- Piers placed in different sediments with equal D/d_{50} do not have a d_{se}/D similarity for values of $D/d_{50}<100$. Relative coarseness alone does not fully describe the behaviour of the scour hole when H/D varies.
- Blockage ratio was found to have minimal influence on local scour depth for low values of relative coarseness ($D/d_{50}<100$).
- A combination of H/D and D/d_{50} provides for a better description of the variation of maximum depth of scour for a range of test conditions.

5.2 Recommendations

Further local scour depth investigation and experimentation should be carried out with a wider range of flow shallowness values. Its influence on local scour depth was found to be significant and to study its effects on larger piers and different relatives coarseness should contribute significantly in the development of an improved scour prediction equation.

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APPENDICES

Appendix A – Summary of Experimental Results

Phase 1

Phase 1				
Experiment	**1**	**2**	**3**	**4**
d50 (mm)	0.51			
D/B %	5			
D (mm)	12.70	19.05	25.40	38.10
B (mm)	254	381	508	762
H (mm)	42.3	63.5	84.7	127.0
D/d50	25	37	50	75
B/H >= 6	6			
H/D > 3	3.3	3.3	3.3	3.3
μ/μc	0.85			
μ (m/s)	0.22			
Re h > 10000	9313	13970	18627	27940
Fr < 1	0.341	0.279	0.241	0.197
Dse/D	**1.46**	**1.25**	**1.04**	**0.90**

Phase 2

Series 1				
	Fine	**M-Fine**	**M-Coarse**	**Coarse**
d50 (mm)	0.51	0.77	1.6	2.4
B (mm)	259.3	391.4	830.4	1220
D (mm)	13.0	19.6	41.5	61.0
D/B (%)	5	5	5	5
D/D50	25.42	25.42	25.42	25.42
H (mm)	120			
B/H	2.2	3.3	6.9	10.2
H/D	9.3	6.1	2.9	2.0
Frd	2.440	2.298	2.316	2.191
dse/D	**2.00**	**1.46**	**0.71**	**0.71**

Series 2				
	Fine	**M-Fine**	**M-Coarse**	**Coarse**
d50 (mm)	0.51	0.77	1.6	2.4
B (mm)	259.3	391.4	830.4	1220
D (mm)	19.4	29.4	62.3	91.5
D/B (%)	7.5	7.5	7.5	7.5
D/D50	38.13	38.13	38.13	38.13
H (mm)	120			
B/H	2.2	3.3	6.9	10.2
H/D	6.2	4.1	1.9	1.3
Frd	2.440	2.298	2.316	2.191
dse/D	**1.71**	**1.53**	**0.54**	**0.67**

Series 3				
	Fine	**M-Fine**	**M-Coarse**	**Coarse**
d50 (mm)	0.51	0.77	1.6	2.4
B (mm)	259.3	391.4	830.4	1220
D (mm)	25.9	39.1	83.0	122
D/B (%)	10	10	10	10
D/D50	50.83	50.83	50.83	50.83
H (mm)	120			
B/H	2.2	3.3	6.9	10.2
H/D	4.6	3.1	1.4	1.0
Frd	2.440	2.298	2.316	2.191
dse/D	**1.28**	**1.26**	**0.49**	**0.59**

Series 4				
	Fine	**M-Fine**	**M-Coarse**	**Coarse**
d50 (mm)	0.51	0.77	1.6	2.4
B (mm)	259.3	391.4	830.4	1220
D (mm)	38.9	58.7	124.6	183
D/B (%)	15	15	15	15
D/D50	76.25	76.25	76.25	76.25
H (mm)	120			
B/H	2.2	3.3	6.9	10.2
H/D	3.1	2.0	1.0	0.7
Frd	2.440	2.298	2.316	2.191
dse/D	**1.11**	**0.97**	**0.35**	

Appendix B – Experimental Results

Phase 1

Experiment	No	P1-1
Pier Diameter	D (mm)	12.7
Channel Width	B (mm)	254
Water Height	H (mm)	42.3
Median Grain Size	d50 (mm)	0.51
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	5
Flow Shallowness	H/D	3.3
Relative Coarseness	D/d50	24.9
Aspect Ratio	B/H	6
Equilibrium Scour Depth	dse/D	1.46

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-51.75	0.53	-4.07	0.04
-46.75	-0.87	-3.68	-0.07
-41.75	-0.87	-3.29	-0.07
-36.75	-3.77	-2.89	-0.30
-31.75	-7.17	-2.50	-0.56
-26.75	-11.17	-2.11	-0.88
-21.75	-14.87	-1.71	-1.17
-16.75	-18.57	-1.32	-1.46
-11.75	-16.97	-0.93	-1.34
11.75	-14.87	0.93	-1.17
13.25	-13.77	1.04	-1.08
18.25	-11.17	1.44	-0.88
23.25	-8.27	1.83	-0.65
28.25	-6.47	2.22	-0.51
33.25	-3.47	2.62	-0.27
38.25	-1.97	3.01	-0.15
43.25	1.53	3.41	0.12
48.25	3.23	3.80	0.25
53.25	6.43	4.19	0.51
58.25	7.93	4.59	0.62
63.25	9.93	4.98	0.78
68.25	12.73	5.37	1.00
73.25	13.53	5.77	1.07
78.25	15.13	6.16	1.19
83.25	16.63	6.56	1.31
88.25	17.53	6.95	1.38
93.25	17.43	7.34	1.37
98.25	18.83	7.74	1.48
103.25	19.13	8.13	1.51

Edge Contour

x (mm)	y (mm)	x/D	y/D
-44.25	0.00	-3.48	0.00
-44.25	-3.00	-3.48	-0.24
-42.75	-8.00	-3.37	-0.63
-41.25	-13.00	-3.25	-1.02
-39.75	-18.00	-3.13	-1.42
-37.25	-23.00	-2.93	-1.81
-33.75	-28.00	-2.66	-2.20
-27.75	-33.00	-2.19	-2.60
-21.75	-38.00	-1.71	-2.99
-16.75	-41.00	-1.32	-3.23
-11.75	-42.00	-0.93	-3.31
-6.75	-43.00	-0.53	-3.39
3.25	-44.00	0.26	-3.46
13.25	-45.00	1.04	-3.54
23.25	-48.00	1.83	-3.78
33.25	-53.00	2.62	-4.17
43.25	-55.00	3.41	-4.33
53.25	-58.00	4.19	-4.57
63.25	-60.00	4.98	-4.72
73.25	-62.00	5.77	-4.88
83.25	-61.00	6.56	-4.80
93.25	-61.00	7.34	-4.80
103.25	-61.00	8.13	-4.80
113.25	-59.50	8.92	-4.69
123.25	-58.00	9.70	-4.57
133.25	-55.00	10.49	-4.33
143.25	-59.00	11.28	-4.65
153.25	-64.50	12.07	-5.08
163.25	-69.50	12.85	-5.47

108.25	19.73	8.52	1.55
113.25	18.43	8.92	1.45
118.25	15.03	9.31	1.18
123.25	10.83	9.70	0.85
128.25	8.93	10.10	0.70
133.25	7.03	10.49	0.55
138.25	5.93	10.89	0.47
143.25	4.33	11.28	0.34
153.25	2.63	12.07	0.21
163.25	0.33	12.85	0.03
173.25	0.53	13.64	0.04
183.25	0.83	14.43	0.07
193.25	2.23	15.22	0.18
203.25	3.73	16.00	0.29
213.25	5.43	16.79	0.43
223.25	8.03	17.58	0.63
233.25	10.63	18.37	0.84
243.25	11.93	19.15	0.94
253.25	13.13	19.94	1.03
263.25	14.53	20.73	1.14
273.25	15.23	21.52	1.20
283.25	14.03	22.30	1.10
293.25	9.13	23.09	0.72
303.25	4.43	23.88	0.35
313.25	1.63	24.67	0.13

173.25	-73.00	13.64	-5.75
183.25	-76.50	14.43	-6.02
193.25	-78.50	15.22	-6.18
203.25	-83.00	16.00	-6.54
213.25	-87.00	16.79	-6.85
223.25	-91.00	17.58	-7.17
233.25	-93.50	18.37	-7.36
243.25	-94.50	19.15	-7.44
253.25	-96.00	19.94	-7.56
263.25	-96.00	20.73	-7.56
273.25	-94.00	21.52	-7.40
283.25	-96.00	22.30	-7.56
293.25	-100.00	23.09	-7.87
303.25	-102.00	23.88	-8.03
313.25	-103.00	24.67	-8.11
323.25	-105.00	25.45	-8.27
333.25	-106.50	26.24	-8.39
343.25	-108.00	27.03	-8.50
353.25	-109.50	27.81	-8.62
363.25	-109.50	28.60	-8.62
373.25	-109.50	29.39	-8.62
383.25	-115.00	30.18	-9.06
21.75	-48.00	1.71	-3.78
23.25	-48.00	1.83	-3.78
33.25	-47.00	2.62	-3.70
43.25	-43.00	3.41	-3.39
48.25	-39.50	3.80	-3.11
53.25	-32.50	4.19	-2.56
53.25	-28.00	4.19	-2.20
53.25	-23.00	4.19	-1.81
51.25	-18.00	4.04	-1.42
50.25	-13.00	3.96	-1.02
48.75	-8.00	3.84	-0.63
47.25	-3.00	3.72	-0.24
46.25	0.00	3.64	0.00
-44.25	0.00	-3.48	0.00
-44.25	3.00	-3.48	0.24
-42.75	8.00	-3.37	0.63
-41.25	13.00	-3.25	1.02
-39.75	18.00	-3.13	1.42
-37.25	23.00	-2.93	1.81
-33.75	28.00	-2.66	2.20
-27.75	33.00	-2.19	2.60
-21.75	38.00	-1.71	2.99
-16.75	41.00	-1.32	3.23
-11.75	42.00	-0.93	3.31
-6.75	43.00	-0.53	3.39
3.25	44.00	0.26	3.46
13.25	45.00	1.04	3.54
23.25	48.00	1.83	3.78
33.25	53.00	2.62	4.17
43.25	55.00	3.41	4.33
53.25	58.00	4.19	4.57
63.25	60.00	4.98	4.72

73.25	62.00	5.77	4.88
83.25	61.00	6.56	4.80
93.25	61.00	7.34	4.80
103.25	61.00	8.13	4.80
113.25	59.50	8.92	4.69
123.25	58.00	9.70	4.57
133.25	55.00	10.49	4.33
143.25	59.00	11.28	4.65
153.25	64.50	12.07	5.08
163.25	69.50	12.85	5.47
173.25	73.00	13.64	5.75
183.25	76.50	14.43	6.02
193.25	78.50	15.22	6.18
203.25	83.00	16.00	6.54
213.25	87.00	16.79	6.85
223.25	91.00	17.58	7.17
233.25	93.50	18.37	7.36
243.25	94.50	19.15	7.44
253.25	96.00	19.94	7.56
263.25	96.00	20.73	7.56
273.25	94.00	21.52	7.40
283.25	96.00	22.30	7.56
293.25	100.00	23.09	7.87
303.25	102.00	23.88	8.03
313.25	103.00	24.67	8.11
323.25	105.00	25.45	8.27
333.25	106.50	26.24	8.39
343.25	108.00	27.03	8.50
353.25	109.50	27.81	8.62
363.25	109.50	28.60	8.62
373.25	109.50	29.39	8.62
383.25	115.00	30.18	9.06
21.75	48.00	1.71	3.78
23.25	48.00	1.83	3.78
33.25	47.00	2.62	3.70
43.25	43.00	3.41	3.39
48.25	39.50	3.80	3.11
53.25	32.50	4.19	2.56
53.25	28.00	4.19	2.20
53.25	23.00	4.19	1.81
51.25	18.00	4.04	1.42
50.25	13.00	3.96	1.02
48.75	8.00	3.84	0.63
47.25	3.00	3.72	0.24
46.25	0.00	3.64	0.00

Experiment	No	P1-2
Pier Diameter	D (mm)	19.1
Channel Width	B (mm)	381
Water Height	H (mm)	63.5
Median Grain Size	d50 (mm)	0.51
Flow Intensity	U/Uc	0.85

Duration	hr	48
Blockage Ratio	D/B (%)	5
Flow Shallowness	H/D	3.3
Relative Coarseness	D/d50	37.4
Aspect Ratio	B/H	6
Equilibrium Scour Depth	dse/D	1.24

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-66.50	-0.83	-3.49	-0.04
-61.50	-0.73	-3.23	-0.04
-56.50	-0.73	-2.97	-0.04
-51.50	-2.43	-2.70	-0.13
-46.50	-4.73	-2.44	-0.25
-41.50	-8.63	-2.18	-0.45
-36.50	-13.03	-1.92	-0.68
-31.50	-16.23	-1.65	-0.85
-26.50	-17.03	-1.39	-0.89
-21.50	-21.03	-1.13	-1.10
-16.50	-23.53	-0.87	-1.24
-11.50	-23.73	-0.60	-1.25
11.50	-19.83	0.60	-1.04
13.50	-20.03	0.71	-1.05
18.50	-19.63	0.97	-1.03
23.50	-17.23	1.23	-0.90
28.50	-14.73	1.50	-0.77
33.50	-10.63	1.76	-0.56
38.50	-8.53	2.02	-0.45
43.50	-5.33	2.28	-0.28
48.50	-2.73	2.55	-0.14
53.50	0.57	2.81	0.03
58.50	4.27	3.07	0.22
63.50	6.87	3.33	0.36
68.50	9.17	3.60	0.48
73.50	11.07	3.86	0.58
78.50	13.17	4.12	0.69
83.50	15.27	4.38	0.80
88.50	17.27	4.65	0.91
93.50	18.27	4.91	0.96
108.50	22.37	5.70	1.17
113.50	23.27	5.96	1.22
118.50	24.57	6.22	1.29
123.50	24.47	6.48	1.28
128.50	22.57	6.75	1.18
133.50	18.67	7.01	0.98
138.50	14.87	7.27	0.78
143.50	10.67	7.53	0.56
148.50	8.97	7.80	0.47
153.50	7.67	8.06	0.40
158.50	6.67	8.32	0.35
163.50	5.67	8.58	0.30
173.50	4.17	9.11	0.22

Edge Contour

x (mm)	y (mm)	x/D	y/D
-58.50	0.00	-3.07	0.00
-58.50	-3.00	-3.07	-0.16
-56.50	-8.00	-2.97	-0.42
-55.50	-13.00	-2.91	-0.68
-54.00	-18.00	-2.83	-0.94
-50.50	-23.00	-2.65	-1.21
-46.50	-28.00	-2.44	-1.47
-43.00	-33.00	-2.26	-1.73
-38.50	-38.00	-2.02	-1.99
-33.00	-43.00	-1.73	-2.26
-26.50	-48.00	-1.39	-2.52
-16.50	-53.00	-0.87	-2.78
-6.50	-57.00	-0.34	-2.99
3.50	-61.00	0.18	-3.20
13.50	-65.00	0.71	-3.41
23.50	-67.00	1.23	-3.52
33.50	-69.00	1.76	-3.62
43.50	-70.00	2.28	-3.67
53.50	-72.00	2.81	-3.78
63.50	-73.00	3.33	-3.83
73.50	-74.00	3.86	-3.88
83.50	-74.00	4.38	-3.88
93.50	-77.00	4.91	-4.04
103.50	-77.50	5.43	-4.07
113.50	-75.00	5.96	-3.94
123.50	-74.00	6.48	-3.88
133.50	-72.00	7.01	-3.78
143.50	-68.00	7.53	-3.57
153.50	-74.00	8.06	-3.88
163.50	-81.00	8.58	-4.25
173.50	-87.00	9.11	-4.57
183.50	-93.00	9.63	-4.88
193.50	-98.00	10.16	-5.14
203.50	-100.00	10.68	-5.25
213.50	-106.00	11.21	-5.56
223.50	-112.00	11.73	-5.88
233.50	-115.00	12.26	-6.04
243.50	-120.00	12.78	-6.30
253.50	-123.00	13.31	-6.46
263.50	-127.00	13.83	-6.67
273.50	-131.00	14.36	-6.88
283.50	-135.00	14.88	-7.09
293.50	-137.00	15.41	-7.19

183.50	1.37	9.63	0.07
193.50	0.87	10.16	0.05
203.50	0.47	10.68	0.02
213.50	0.57	11.21	0.03
223.50	0.67	11.73	0.03
233.50	1.27	12.26	0.07
243.50	5.37	12.78	0.28
253.50	5.27	13.31	0.28
263.50	6.07	13.83	0.32
273.50	8.57	14.36	0.45
283.50	9.97	14.88	0.52
293.50	12.37	15.41	0.65
303.50	14.97	15.93	0.79

303.50	-139.00	15.93	-7.30
313.50	-143.00	16.46	-7.51
323.50	-146.00	16.98	-7.66
333.50	-151.00	17.51	-7.93
343.50	-159.00	18.03	-8.35
353.50	-168.00	18.56	-8.82
363.50	-174.00	19.08	-9.13
373.50	-179.00	19.61	-9.40
383.50	-183.00	20.13	-9.61
393.50	-186.00	20.66	-9.76
403.50	-188.00	21.18	-9.87
7.50	-63.00	0.39	-3.31
13.50	-63.00	0.71	-3.31
23.50	-62.00	1.23	-3.25
33.50	-58.50	1.76	-3.07
43.50	-54.00	2.28	-2.83
53.50	-46.00	2.81	-2.41
53.50	-43.00	2.81	-2.26
53.50	-38.00	2.81	-1.99
56.50	-33.00	2.97	-1.73
55.50	-28.00	2.91	-1.47
53.50	-23.00	2.81	-1.21
52.50	-18.00	2.76	-0.94
50.50	-13.00	2.65	-0.68
50.50	-8.00	2.65	-0.42
48.50	-3.00	2.55	-0.16
48.50	0.00	2.55	0.00
-58.50	0.00	-3.07	0.00
-58.50	3.00	-3.07	0.16
-56.50	8.00	-2.97	0.42
-55.50	13.00	-2.91	0.68
-54.00	18.00	-2.83	0.94
-50.50	23.00	-2.65	1.21
-46.50	28.00	-2.44	1.47
-43.00	33.00	-2.26	1.73
-38.50	38.00	-2.02	1.99
-33.00	43.00	-1.73	2.26
-26.50	48.00	-1.39	2.52
-16.50	53.00	-0.87	2.78
-6.50	57.00	-0.34	2.99
3.50	61.00	0.18	3.20
13.50	65.00	0.71	3.41
23.50	67.00	1.23	3.52
33.50	69.00	1.76	3.62
43.50	70.00	2.28	3.67
53.50	72.00	2.81	3.78
63.50	73.00	3.33	3.83
73.50	74.00	3.86	3.88
83.50	74.00	4.38	3.88
93.50	77.00	4.91	4.04
103.50	77.50	5.43	4.07
113.50	75.00	5.96	3.94
123.50	74.00	6.48	3.88
133.50	72.00	7.01	3.78

143.50	68.00	7.53	3.57
153.50	74.00	8.06	3.88
163.50	81.00	8.58	4.25
173.50	87.00	9.11	4.57
183.50	93.00	9.63	4.88
193.50	98.00	10.16	5.14
203.50	100.00	10.68	5.25
213.50	106.00	11.21	5.56
223.50	112.00	11.73	5.88
233.50	115.00	12.26	6.04
243.50	120.00	12.78	6.30
253.50	123.00	13.31	6.46
263.50	127.00	13.83	6.67
273.50	131.00	14.36	6.88
283.50	135.00	14.88	7.09
293.50	137.00	15.41	7.19
303.50	139.00	15.93	7.30
313.50	143.00	16.46	7.51
323.50	146.00	16.98	7.66
333.50	151.00	17.51	7.93
343.50	159.00	18.03	8.35
353.50	168.00	18.56	8.82
363.50	174.00	19.08	9.13
373.50	179.00	19.61	9.40
383.50	183.00	20.13	9.61
393.50	186.00	20.66	9.76
403.50	188.00	21.18	9.87
7.50	63.00	0.39	3.31
13.50	63.00	0.71	3.31
23.50	62.00	1.23	3.25
33.50	58.50	1.76	3.07
43.50	54.00	2.28	2.83
53.50	46.00	2.81	2.41
53.50	43.00	2.81	2.26
53.50	38.00	2.81	1.99
56.50	33.00	2.97	1.73
55.50	28.00	2.91	1.47
53.50	23.00	2.81	1.21
52.50	18.00	2.76	0.94
50.50	13.00	2.65	0.68
50.50	8.00	2.65	0.42
48.50	3.00	2.55	0.16
48.50	0.00	2.55	0.00

Experiment	No	P1-3
Pier Diameter	D (mm)	25.4
Channel Width	B (mm)	508
Water Height	H (mm)	84.7
Median Grain Size	d50 (mm)	0.51
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	5
Flow Shallowness	H/D	3.3
Relative Coarseness	D/d50	49.8

Aspect Ratio	B/H	6
Equilibrium Scour Depth	dse/D	1.04

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-72.50	1.27	-2.85	0.05
-67.50	0.77	-2.66	0.03
-62.50	-1.03	-2.46	-0.04
-57.50	-3.73	-2.26	-0.15
-52.50	-7.33	-2.07	-0.29
-47.50	-12.23	-1.87	-0.48
-42.50	-14.83	-1.67	-0.58
-37.50	-16.83	-1.48	-0.66
-32.50	-20.03	-1.28	-0.79
-27.50	-24.13	-1.08	-0.95
-22.50	-26.43	-0.89	-1.04
-17.50	-25.53	-0.69	-1.01
14.50	-16.53	0.57	-0.65
17.50	-16.63	0.69	-0.65
22.50	-15.23	0.89	-0.60
27.50	-12.23	1.08	-0.48
32.50	-8.93	1.28	-0.35
37.50	-4.63	1.48	-0.18
42.50	-0.73	1.67	-0.03
47.50	0.47	1.87	0.02
52.50	4.07	2.07	0.16
57.50	6.87	2.26	0.27
62.50	9.47	2.46	0.37
67.50	11.87	2.66	0.47
72.50	14.67	2.85	0.58
77.50	16.87	3.05	0.66
82.50	19.57	3.25	0.77
87.50	21.07	3.44	0.83
92.50	23.27	3.64	0.92
97.50	23.97	3.84	0.94
102.50	25.37	4.04	1.00
107.50	26.17	4.23	1.03
112.50	22.77	4.43	0.90
117.50	19.47	4.63	0.77
122.50	15.77	4.82	0.62
127.50	10.77	5.02	0.42
132.50	7.47	5.22	0.29
137.50	6.67	5.41	0.26
142.50	6.17	5.61	0.24
147.50	5.57	5.81	0.22
152.50	4.97	6.00	0.20
162.50	4.47	6.40	0.18
172.50	3.47	6.79	0.14
182.50	4.17	7.19	0.16
192.50	3.67	7.58	0.14
202.50	4.17	7.97	0.16
212.50	5.07	8.37	0.20

Edge Contour

x (mm)	y (mm)	x/D	y/D
-65.00	0.00	-2.56	0.00
-65.00	-5.00	-2.56	-0.20
-64.00	-10.00	-2.52	-0.39
-64.00	-15.00	-2.52	-0.59
-62.00	-20.00	-2.44	-0.79
-59.00	-25.00	-2.32	-0.98
-58.00	-30.00	-2.28	-1.18
-55.00	-35.00	-2.17	-1.38
-50.00	-40.00	-1.97	-1.57
-45.00	-45.00	-1.77	-1.77
-39.00	-50.00	-1.54	-1.97
-36.00	-55.00	-1.42	-2.17
-31.00	-56.00	-1.22	-2.20
-26.00	-58.00	-1.02	-2.28
-21.00	-61.00	-0.83	-2.40
-16.00	-63.00	-0.63	-2.48
-11.00	-65.00	-0.43	-2.56
-6.00	-66.00	-0.24	-2.60
-1.00	-68.00	-0.04	-2.68
4.00	-70.00	0.16	-2.76
14.00	-72.00	0.55	-2.83
24.00	-73.00	0.94	-2.87
34.00	-73.00	1.34	-2.87
44.00	-73.00	1.73	-2.87
54.00	-71.00	2.13	-2.80
64.00	-70.00	2.52	-2.76
74.00	-69.00	2.91	-2.72
84.00	-71.00	3.31	-2.80
94.00	-73.00	3.70	-2.87
104.00	-73.00	4.09	-2.87
114.00	-70.00	4.49	-2.76
124.00	-69.00	4.88	-2.72
134.00	-70.00	5.28	-2.76
144.00	-75.00	5.67	-2.95
154.00	-84.00	6.06	-3.31
164.00	-92.00	6.46	-3.62
174.00	-96.00	6.85	-3.78
184.00	-99.00	7.24	-3.90
194.00	-101.00	7.64	-3.98
204.00	-104.00	8.03	-4.09
214.00	-105.00	8.43	-4.13
224.00	-105.00	8.82	-4.13
234.00	-105.00	9.21	-4.13
244.00	-104.00	9.61	-4.09
254.00	-101.00	10.00	-3.98
264.00	-99.00	10.39	-3.90
274.00	-97.00	10.79	-3.82

222.50	5.67	8.76	0.22
232.50	6.97	9.15	0.27

284.00	-93.00	11.18	-3.66
294.00	-90.00	11.57	-3.54
304.00	-88.00	11.97	-3.46
314.00	-84.00	12.36	-3.31
324.00	-76.00	12.76	-2.99
334.00	-70.00	13.15	-2.76
344.00	-65.00	13.54	-2.56
354.00	-63.00	13.94	-2.48
364.00	-54.00	14.33	-2.13
369.00	-38.00	14.53	-1.50
-6.00	-65.00	-0.24	-2.56
-1.00	-65.00	-0.04	-2.56
4.00	-65.00	0.16	-2.56
9.00	-65.00	0.35	-2.56
14.00	-65.00	0.55	-2.56
19.00	-64.00	0.75	-2.52
24.00	-63.00	0.94	-2.48
29.00	-62.00	1.14	-2.44
34.00	-59.00	1.34	-2.32
39.00	-55.00	1.54	-2.17
44.00	-49.00	1.73	-1.93
48.00	-45.00	1.89	-1.77
51.00	-40.00	2.01	-1.57
51.00	-30.00	2.01	-1.18
50.00	-20.00	1.97	-0.79
50.00	-10.00	1.97	-0.39
50.00	0.00	1.97	0.00
-65.00	0.00	-2.56	0.00
-65.00	5.00	-2.56	0.20
-64.00	10.00	-2.52	0.39
-64.00	15.00	-2.52	0.59
-62.00	20.00	-2.44	0.79
-59.00	25.00	-2.32	0.98
-58.00	30.00	-2.28	1.18
-55.00	35.00	-2.17	1.38
-50.00	40.00	-1.97	1.57
-45.00	45.00	-1.77	1.77
-39.00	50.00	-1.54	1.97
-36.00	55.00	-1.42	2.17
-31.00	56.00	-1.22	2.20
-26.00	58.00	-1.02	2.28
-21.00	61.00	-0.83	2.40
-16.00	63.00	-0.63	2.48
-11.00	65.00	-0.43	2.56
-6.00	66.00	-0.24	2.60
-1.00	68.00	-0.04	2.68
4.00	70.00	0.16	2.76
14.00	72.00	0.55	2.83
24.00	73.00	0.94	2.87
34.00	73.00	1.34	2.87
44.00	73.00	1.73	2.87
54.00	71.00	2.13	2.80
64.00	70.00	2.52	2.76
74.00	69.00	2.91	2.72

84.00	71.00	3.31	2.80
94.00	73.00	3.70	2.87
104.00	73.00	4.09	2.87
114.00	70.00	4.49	2.76
124.00	69.00	4.88	2.72
134.00	70.00	5.28	2.76
144.00	75.00	5.67	2.95
154.00	84.00	6.06	3.31
164.00	92.00	6.46	3.62
174.00	96.00	6.85	3.78
184.00	99.00	7.24	3.90
194.00	101.00	7.64	3.98
204.00	104.00	8.03	4.09
214.00	105.00	8.43	4.13
224.00	105.00	8.82	4.13
234.00	105.00	9.21	4.13
244.00	104.00	9.61	4.09
254.00	101.00	10.00	3.98
264.00	99.00	10.39	3.90
274.00	97.00	10.79	3.82
284.00	93.00	11.18	3.66
294.00	90.00	11.57	3.54
304.00	88.00	11.97	3.46
314.00	84.00	12.36	3.31
324.00	76.00	12.76	2.99
334.00	70.00	13.15	2.76
344.00	65.00	13.54	2.56
354.00	63.00	13.94	2.48
364.00	54.00	14.33	2.13
369.00	38.00	14.53	1.50
-6.00	65.00	-0.24	2.56
-1.00	65.00	-0.04	2.56
4.00	65.00	0.16	2.56
9.00	65.00	0.35	2.56
14.00	65.00	0.55	2.56
19.00	64.00	0.75	2.52
24.00	63.00	0.94	2.48
29.00	62.00	1.14	2.44
34.00	59.00	1.34	2.32
39.00	55.00	1.54	2.17
44.00	49.00	1.73	1.93
48.00	45.00	1.89	1.77
51.00	40.00	2.01	1.57
51.00	30.00	2.01	1.18
50.00	20.00	1.97	0.79
50.00	10.00	1.97	0.39
50.00	0.00	1.97	0.00

Experiment No P1-4
Pier Diameter D (mm) 38.1

Channel Width	B (mm)	762
Water Height	H (mm)	127
Median Grain Size	d50 (mm)	0.51
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	5
Flow Shallowness	H/D	3.3
Relative Coarseness	D/d50	74.7
Aspect Ratio	B/H	6
Equilibrium Scour Depth	dse/D	0.90

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-99.00	-0.57	-2.60	-0.01
-94.00	-0.77	-2.47	-0.02
-89.00	-1.27	-2.34	-0.03
-84.00	-1.27	-2.20	-0.03
-79.00	-4.57	-2.07	-0.12
-74.00	-7.37	-1.94	-0.19
-69.00	-10.67	-1.81	-0.28
-64.00	-14.47	-1.68	-0.38
-59.00	-18.67	-1.55	-0.49
-54.00	-20.97	-1.42	-0.55
-49.00	-22.07	-1.29	-0.58
-44.00	-24.27	-1.15	-0.64
-39.00	-28.17	-1.02	-0.74
-34.00	-31.07	-0.89	-0.82
-29.00	-31.57	-0.76	-0.83
-24.00	-34.37	-0.63	-0.90
-22.00	-32.87	-0.58	-0.86
22.00	-17.87	0.58	-0.47
26.00	-18.07	0.68	-0.47
31.00	-16.87	0.81	-0.44
36.00	-15.37	0.94	-0.40
41.00	-13.17	1.08	-0.35
46.00	-10.37	1.21	-0.27
51.00	-6.87	1.34	-0.18
56.00	-2.17	1.47	-0.06
61.00	2.33	1.60	0.06
66.00	4.03	1.73	0.11
71.00	7.63	1.86	0.20
76.00	10.93	1.99	0.29
81.00	14.23	2.13	0.37
86.00	16.63	2.26	0.44
91.00	19.23	2.39	0.50
96.00	22.43	2.52	0.59
101.00	25.03	2.65	0.66
106.00	25.73	2.78	0.68
111.00	28.03	2.91	0.74
116.00	30.43	3.04	0.80
121.00	32.33	3.18	0.85

Edge Contour

x (mm)	y (mm)	x/D	y/D
-87.00	0.00	-2.28	0.00
-87.00	-5.00	-2.28	-0.13
-86.00	-10.00	-2.26	-0.26
-85.00	-15.00	-2.23	-0.39
-85.00	-20.00	-2.23	-0.52
-82.50	-25.00	-2.17	-0.66
-81.50	-30.00	-2.14	-0.79
-79.00	-35.00	-2.07	-0.92
-76.50	-40.00	-2.01	-1.05
-74.00	-45.00	-1.94	-1.18
-70.50	-50.00	-1.85	-1.31
-67.00	-55.00	-1.76	-1.44
-63.00	-60.00	-1.65	-1.57
-56.00	-65.00	-1.47	-1.71
-49.50	-70.00	-1.30	-1.84
-49.00	-75.00	-1.29	-1.97
-44.00	-75.00	-1.15	-1.97
-39.00	-78.00	-1.02	-2.05
-34.00	-81.00	-0.89	-2.13
-29.00	-84.00	-0.76	-2.20
-24.00	-86.00	-0.63	-2.26
-19.00	-88.00	-0.50	-2.31
-9.00	-92.00	-0.24	-2.41
1.00	-95.00	0.03	-2.49
11.00	-98.50	0.29	-2.59
21.00	-100.00	0.55	-2.62
31.00	-101.00	0.81	-2.65
41.00	-101.00	1.08	-2.65
51.00	-101.00	1.34	-2.65
61.00	-101.00	1.60	-2.65
71.00	-102.00	1.86	-2.68
81.00	-103.00	2.13	-2.70
91.00	-104.00	2.39	-2.73
101.00	-104.00	2.65	-2.73
111.00	-104.00	2.91	-2.73
121.00	-104.00	3.18	-2.73
131.00	-104.00	3.44	-2.73
141.00	-104.50	3.70	-2.74

126.00	33.53	3.31	0.88
131.00	35.23	3.44	0.92
136.00	37.63	3.57	0.99
141.00	39.43	3.70	1.03
146.00	39.63	3.83	1.04
151.00	36.13	3.96	0.95
156.00	33.53	4.09	0.88
161.00	30.83	4.23	0.81
166.00	26.73	4.36	0.70
171.00	22.63	4.49	0.59
176.00	18.43	4.62	0.48
181.00	16.53	4.75	0.43
186.00	15.63	4.88	0.41
191.00	15.43	5.01	0.41
201.00	13.53	5.28	0.36
211.00	11.73	5.54	0.31
221.00	11.63	5.80	0.31
231.00	11.23	6.06	0.29
241.00	10.33	6.33	0.27
251.00	10.83	6.59	0.28
261.00	11.33	6.85	0.30
271.00	10.93	7.11	0.29
281.00	11.83	7.38	0.31
291.00	11.43	7.64	0.30
301.00	12.33	7.90	0.32
311.00	13.13	8.16	0.34
321.00	14.73	8.43	0.39
331.00	15.13	8.69	0.40
341.00	16.83	8.95	0.44
351.00	17.73	9.21	0.47

151.00	-102.00	3.96	-2.68
161.00	-98.50	4.23	-2.59
171.00	-96.00	4.49	-2.52
181.00	-95.00	4.75	-2.49
191.00	-98.50	5.01	-2.59
201.00	-107.00	5.28	-2.81
211.00	-116.00	5.54	-3.04
221.00	-124.00	5.80	-3.25
231.00	-131.00	6.06	-3.44
241.00	-137.00	6.33	-3.60
251.00	-141.00	6.59	-3.70
261.00	-145.00	6.85	-3.81
271.00	-149.00	7.11	-3.91
281.00	-153.00	7.38	-4.02
291.00	-154.00	7.64	-4.04
301.00	-155.00	7.90	-4.07
311.00	-156.00	8.16	-4.09
321.00	-156.00	8.43	-4.09
331.00	-156.00	8.69	-4.09
341.00	-156.00	8.95	-4.09
351.00	-155.00	9.21	-4.07
361.00	-155.00	9.48	-4.07
371.00	-153.50	9.74	-4.03
381.00	-152.00	10.00	-3.99
391.00	-151.00	10.26	-3.96
401.00	-151.00	10.52	-3.96
411.00	-151.00	10.79	-3.96
421.00	-149.00	11.05	-3.91
431.00	-150.00	11.31	-3.94
441.00	-151.50	11.57	-3.98
451.00	-151.50	11.84	-3.98
461.00	-150.00	12.10	-3.94
471.00	-149.00	12.36	-3.91
481.00	-146.00	12.62	-3.83
491.00	-144.00	12.89	-3.78
501.00	-141.00	13.15	-3.70
16.00	-100.00	0.42	-2.62
21.00	-98.00	0.55	-2.57
26.00	-96.00	0.68	-2.52
31.00	-95.00	0.81	-2.49
36.00	-93.00	0.94	-2.44
41.00	-90.00	1.08	-2.36
46.00	-87.00	1.21	-2.28
51.00	-82.00	1.34	-2.15
56.00	-76.00	1.47	-1.99
61.00	-70.00	1.60	-1.84
61.00	-65.00	1.60	-1.71
63.00	-60.00	1.65	-1.57
65.00	-55.00	1.71	-1.44
66.50	-50.00	1.75	-1.31
68.00	-40.00	1.78	-1.05
66.00	-30.00	1.73	-0.79
66.00	-20.00	1.73	-0.52
65.00	-10.00	1.71	-0.26

65.00	0.00	1.71	0.00
-87.00	0.00	-2.28	0.00
-87.00	5.00	-2.28	0.13
-86.00	10.00	-2.26	0.26
-85.00	15.00	-2.23	0.39
-85.00	20.00	-2.23	0.52
-82.50	25.00	-2.17	0.66
-81.50	30.00	-2.14	0.79
-79.00	35.00	-2.07	0.92
-76.50	40.00	-2.01	1.05
-74.00	45.00	-1.94	1.18
-70.50	50.00	-1.85	1.31
-67.00	55.00	-1.76	1.44
-63.00	60.00	-1.65	1.57
-56.00	65.00	-1.47	1.71
-49.50	70.00	-1.30	1.84
-49.00	75.00	-1.29	1.97
-44.00	75.00	-1.15	1.97
-39.00	78.00	-1.02	2.05
-34.00	81.00	-0.89	2.13
-29.00	84.00	-0.76	2.20
-24.00	86.00	-0.63	2.26
-19.00	88.00	-0.50	2.31
-9.00	92.00	-0.24	2.41
1.00	95.00	0.03	2.49
11.00	98.50	0.29	2.59
21.00	100.00	0.55	2.62
31.00	101.00	0.81	2.65
41.00	101.00	1.08	2.65
51.00	101.00	1.34	2.65
61.00	101.00	1.60	2.65
71.00	102.00	1.86	2.68
81.00	103.00	2.13	2.70
91.00	104.00	2.39	2.73
101.00	104.00	2.65	2.73
111.00	104.00	2.91	2.73
121.00	104.00	3.18	2.73
131.00	104.00	3.44	2.73
141.00	104.50	3.70	2.74
151.00	102.00	3.96	2.68
161.00	98.50	4.23	2.59
171.00	96.00	4.49	2.52
181.00	95.00	4.75	2.49
191.00	98.50	5.01	2.59
201.00	107.00	5.28	2.81
211.00	116.00	5.54	3.04
221.00	124.00	5.80	3.25
231.00	131.00	6.06	3.44
241.00	137.00	6.33	3.60
251.00	141.00	6.59	3.70
261.00	145.00	6.85	3.81
271.00	149.00	7.11	3.91
281.00	153.00	7.38	4.02
291.00	154.00	7.64	4.04

301.00	155.00	7.90	4.07
311.00	156.00	8.16	4.09
321.00	156.00	8.43	4.09
331.00	156.00	8.69	4.09
341.00	156.00	8.95	4.09
351.00	155.00	9.21	4.07
361.00	155.00	9.48	4.07
371.00	153.50	9.74	4.03
381.00	152.00	10.00	3.99
391.00	151.00	10.26	3.96
401.00	151.00	10.52	3.96
411.00	151.00	10.79	3.96
421.00	149.00	11.05	3.91
431.00	150.00	11.31	3.94
441.00	151.50	11.57	3.98
451.00	151.50	11.84	3.98
461.00	150.00	12.10	3.94
471.00	149.00	12.36	3.91
481.00	146.00	12.62	3.83
491.00	144.00	12.89	3.78
501.00	141.00	13.15	3.70
16.00	100.00	0.42	2.62
21.00	98.00	0.55	2.57
26.00	96.00	0.68	2.52
31.00	95.00	0.81	2.49
36.00	93.00	0.94	2.44
41.00	90.00	1.08	2.36
46.00	87.00	1.21	2.28
51.00	82.00	1.34	2.15
56.00	76.00	1.47	1.99
61.00	70.00	1.60	1.84
61.00	65.00	1.60	1.71
63.00	60.00	1.65	1.57
65.00	55.00	1.71	1.44
66.50	50.00	1.75	1.31
68.00	40.00	1.78	1.05
66.00	30.00	1.73	0.79
66.00	20.00	1.73	0.52
65.00	10.00	1.71	0.26
65.00	0.00	1.71	0.00

Phase 2

Experiment	No	P2S1-F
Pier Diameter	D (mm)	12.7
Channel Width	B (mm)	259

Water Height	H (mm)	120
Median Grain Size	d50 (mm)	0.51
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	5
Flow Shallowness	H/D	9.3
Relative Coarseness	D/d50	24.9
Aspect Ratio	B/H	2.2
Equilibrium Scour Depth	dse/D	2.00

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-64.50	-0.87	-5.08	-0.07
-59.50	-0.97	-4.69	-0.08
-54.50	-0.47	-4.29	-0.04
-49.50	-2.37	-3.90	-0.19
-44.50	-5.07	-3.50	-0.40
-39.50	-8.47	-3.11	-0.67
-34.50	-11.27	-2.72	-0.89
-29.50	-15.17	-2.32	-1.19
-24.50	-17.07	-1.93	-1.34
-19.50	-21.37	-1.54	-1.68
-14.50	-25.67	-1.14	-2.02
-9.50	-25.97	-0.75	-2.04
9.50	-19.07	0.75	-1.50
15.50	-17.97	1.22	-1.41
20.50	-15.37	1.61	-1.21
25.50	-12.37	2.01	-0.97
30.50	-10.27	2.40	-0.81
35.50	-7.47	2.80	-0.59
40.50	-5.37	3.19	-0.42
45.50	-3.37	3.58	-0.27
50.50	-0.87	3.98	-0.07
55.50	1.43	4.37	0.11
60.50	2.23	4.76	0.18
65.50	5.33	5.16	0.42
70.50	7.33	5.55	0.58
75.50	8.83	5.94	0.70
80.50	11.23	6.34	0.88
85.50	13.33	6.73	1.05
90.50	13.83	7.13	1.09

Edge Contour

x (mm)	y (mm)	x/D	y/D
30.50	73.00	2.40	5.75
25.50	72.00	2.01	5.67
15.50	71.00	1.22	5.59
5.50	67.00	0.43	5.28
-4.50	66.00	-0.35	5.20
-14.50	58.00	-1.14	4.57
-24.50	53.00	-1.93	4.17
-34.50	46.00	-2.72	3.62
-44.50	33.00	-3.50	2.60
-48.50	27.00	-3.82	2.13
-51.50	22.00	-4.06	1.73
-53.50	17.00	-4.21	1.34
-56.50	12.00	-4.45	0.94
-56.50	7.00	-4.45	0.55
-57.50	2.00	-4.53	0.16
-57.50	-3.00	-4.53	-0.24
-54.50	-8.00	-4.29	-0.63
-51.50	-13.00	-4.06	-1.02
-49.50	-18.00	-3.90	-1.42
-46.50	-23.00	-3.66	-1.81
-41.50	-28.00	-3.27	-2.20
-39.50	-32.00	-3.11	-2.52
-34.50	-36.00	-2.72	-2.83
-24.50	-42.00	-1.93	-3.31
-14.50	-51.00	-1.14	-4.02
-4.50	-58.00	-0.35	-4.57
5.50	-62.00	0.43	-4.88
15.50	-63.00	1.22	-4.96
25.50	-63.00	2.01	-4.96

95.50	16.33	7.52	1.29
100.50	17.83	7.91	1.40
105.50	18.43	8.31	1.45
115.50	21.43	9.09	1.69
125.50	22.93	9.88	1.81
135.50	20.33	10.67	1.60
145.50	11.73	11.46	0.92
155.50	5.93	12.24	0.47
165.50	3.53	13.03	0.28
175.50	1.13	13.82	0.09
185.50	0.43	14.61	0.03
195.50	0.43	15.39	0.03
205.50	0.53	16.18	0.04
215.50	0.43	16.97	0.03
225.50	1.53	17.76	0.12
235.50	2.33	18.54	0.18
245.50	3.03	19.33	0.24
255.50	5.03	20.12	0.40
265.50	5.93	20.91	0.47
275.50	6.93	21.69	0.55
285.50	10.03	22.48	0.79
295.50	12.73	23.27	1.00
305.50	13.93	24.06	1.10
315.50	17.03	24.84	1.34
325.50	19.03	25.63	1.50
335.50	20.03	26.42	1.58
345.50	21.63	27.20	1.70
355.50	22.43	27.99	1.77
365.50	18.23	28.78	1.44
375.50	13.73	29.57	1.08
385.50	10.73	30.35	0.85
395.50	9.33	31.14	0.73

35.50	-65.00	2.80	-5.12
45.50	-67.00	3.58	-5.28
55.50	-70.00	4.37	-5.51
65.50	-72.00	5.16	-5.67
75.50	-77.00	5.94	-6.06
85.50	-82.00	6.73	-6.46
95.50	-87.00	7.52	-6.85
105.50	-88.00	8.31	-6.93
115.50	-82.00	9.09	-6.46
125.50	-73.00	9.88	-5.75
135.50	-73.00	10.67	-5.75
145.50	-72.00	11.46	-5.67
155.50	-77.00	12.24	-6.06
165.50	-88.00	13.03	-6.93
175.50	-97.00	13.82	-7.64
185.50	-109.00	14.61	-8.58
195.50	-117.00	15.39	-9.21
205.50	-120.00	16.18	-9.45
215.50	-122.00	16.97	-9.61
62.50	-72.00	4.92	-5.67
62.50	-68.00	4.92	-5.35
68.50	-58.00	5.39	-4.57
75.50	-48.00	5.94	-3.78
77.50	-38.00	6.10	-2.99
74.50	-28.00	5.87	-2.20
69.50	-18.00	5.47	-1.42
62.50	-8.00	4.92	-0.63
57.50	2.00	4.53	0.16
60.50	12.00	4.76	0.94
63.50	22.00	5.00	1.73
65.50	32.00	5.16	2.52
61.50	42.00	4.84	3.31
54.50	52.00	4.29	4.09
45.50	62.00	3.58	4.88
30.50	72.00	2.40	5.67
35.50	76.00	2.80	5.98
45.50	78.00	3.58	6.14
55.50	81.00	4.37	6.38
65.50	80.00	5.16	6.30
75.50	79.00	5.94	6.22
85.50	77.00	6.73	6.06
95.50	78.00	7.52	6.14
105.50	82.00	8.31	6.46

115.50	77.00	9.09	6.06
125.50	73.00	9.88	5.75
135.50	73.00	10.67	5.75
145.50	72.00	11.46	5.67
155.50	77.00	12.24	6.06
165.50	88.00	13.03	6.93
175.50	97.00	13.82	7.64
185.50	109.00	14.61	8.58
195.50	117.00	15.39	9.21
205.50	120.00	16.18	9.45
215.50	122.00	16.97	9.61

Experiment	No	P2S1-MF
Pier Diameter	D (mm)	19.1
Channel Width	B (mm)	391
Water Height	H (mm)	120
Median Grain Size	d50 (mm)	0.77
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	5
Flow Shallowness	H/D	9.3
Relative Coarseness	D/d50	24.9
Aspect Ratio	B/H	3.3
Equilibrium Scour Depth	dse/D	1.46

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-66.75	-0.33	-3.50	-0.02
-61.75	-0.73	-3.24	-0.04
-56.75	-1.63	-2.98	-0.09
-51.75	-3.63	-2.72	-0.19
-46.75	-6.53	-2.45	-0.34
-41.75	-9.13	-2.19	-0.48
-36.75	-13.43	-1.93	-0.71
-31.75	-16.93	-1.67	-0.89
-26.75	-19.43	-1.40	-1.02
-21.75	-23.23	-1.14	-1.22
-16.75	-28.53	-0.88	-1.50
-11.75	-28.63	-0.62	-1.50

Edge Contour

x (mm)	y (mm)	x/D	y/D
-57.75	0.00	-3.03	0.00
-57.75	-2.50	-3.03	-0.13
-57.75	-7.50	-3.03	-0.39
-56.75	-12.50	-2.98	-0.66
-55.75	-17.50	-2.93	-0.92
-53.25	-22.50	-2.80	-1.18
-50.75	-27.50	-2.66	-1.44
-46.75	-32.50	-2.45	-1.71
-43.25	-37.50	-2.27	-1.97
-39.25	-42.50	-2.06	-2.23
-32.75	-47.50	-1.72	-2.49
-26.75	-51.50	-1.40	-2.70

11.75	-18.03	0.62	-0.95	-21.75	-55.00	-1.14	-2.89
13.25	-18.53	0.70	-0.97	-16.75	-57.50	-0.88	-3.02
18.25	-17.03	0.96	-0.89	-11.75	-60.50	-0.62	-3.18
23.25	-14.23	1.22	-0.75	-6.75	-61.50	-0.35	-3.23
28.25	-11.13	1.48	-0.58	-1.75	-62.00	-0.09	-3.25
33.25	-7.93	1.75	-0.42	3.25	-63.50	0.17	-3.33
38.25	-4.93	2.01	-0.26	8.25	-62.50	0.43	-3.28
43.25	-2.23	2.27	-0.12	13.25	-62.50	0.70	-3.28
48.25	-1.03	2.53	-0.05	18.25	-61.50	0.96	-3.23
53.25	2.87	2.80	0.15	23.25	-59.50	1.22	-3.12
58.25	5.47	3.06	0.29	28.25	-58.50	1.48	-3.07
63.25	7.37	3.32	0.39	33.25	-58.50	1.75	-3.07
68.25	9.77	3.58	0.51	38.25	-62.50	2.01	-3.28
73.25	11.17	3.85	0.59	43.25	-63.50	2.27	-3.33
78.25	13.17	4.11	0.69	53.25	-65.50	2.80	-3.44
83.25	14.97	4.37	0.79	63.25	-64.50	3.32	-3.39
88.25	16.07	4.63	0.84	73.25	-63.00	3.85	-3.31
93.25	16.87	4.90	0.89	83.25	-63.00	4.37	-3.31
98.25	18.87	5.16	0.99	93.25	-63.00	4.90	-3.31
103.25	19.97	5.42	1.05	103.25	-64.00	5.42	-3.36
108.25	20.57	5.68	1.08	113.25	-65.50	5.94	-3.44
113.25	21.77	5.94	1.14	123.25	-67.50	6.47	-3.54
118.25	22.67	6.21	1.19	133.25	-67.50	6.99	-3.54
123.25	23.77	6.47	1.25	143.25	-67.50	7.52	-3.54
128.25	24.07	6.73	1.26	153.25	-72.00	8.04	-3.78
133.25	24.47	6.99	1.28	163.25	-76.50	8.57	-4.02
138.25	21.67	7.26	1.14	173.25	-80.50	9.09	-4.23
143.25	17.37	7.52	0.91	183.25	-82.00	9.62	-4.30
148.25	11.27	7.78	0.59	193.25	-83.50	10.14	-4.38
153.25	6.27	8.04	0.33	203.25	-83.50	10.67	-4.38
158.25	5.87	8.31	0.31	213.25	-82.50	11.19	-4.33
163.25	6.27	8.57	0.33	223.25	-80.50	11.72	-4.23
168.25	5.67	8.83	0.30	233.25	-77.50	12.24	-4.07
173.25	5.57	9.09	0.29	243.25	-75.50	12.77	-3.96
183.25	4.77	9.62	0.25	253.25	-74.50	13.29	-3.91
193.25	4.07	10.14	0.21	263.25	-74.50	13.82	-3.91
203.25	3.67	10.67	0.19	273.25	-74.50	14.34	-3.91
213.25	3.87	11.19	0.20	283.25	-72.50	14.87	-3.81
223.25	4.57	11.72	0.24	293.25	-71.50	15.39	-3.75
233.25	5.37	12.24	0.28	303.25	-71.50	15.92	-3.75
243.25	6.57	12.77	0.34	313.25	-71.50	16.44	-3.75
253.25	7.47	13.29	0.39	323.25	-71.50	16.97	-3.75
263.25	8.57	13.82	0.45	333.25	-72.00	17.49	-3.78

273.25	10.17	14.34	0.53
283.25	11.27	14.87	0.59
293.25	12.07	15.39	0.63
303.25	12.77	15.92	0.67
313.25	11.77	16.44	0.62
323.25	11.17	16.97	0.59
333.25	11.47	17.49	0.60
343.25	7.37	18.02	0.39
353.25	3.07	18.54	0.16
363.25	1.87	19.07	0.10
373.25	2.47	19.59	0.13
383.25	4.27	20.12	0.22

343.25	-71.50	18.02	-3.75
353.25	-67.50	18.54	-3.54
363.25	-58.00	19.07	-3.04
366.25	-47.50	19.23	-2.49
369.25	-37.50	19.38	-1.97
370.75	-27.50	19.46	-1.44
364.25	-17.50	19.12	-0.92
354.25	-7.50	18.60	-0.39
348.25	0.00	18.28	0.00
50.25	0.00	2.64	0.00
52.25	-7.50	2.74	-0.39
58.25	-17.50	3.06	-0.92
60.25	-27.50	3.16	-1.44
60.75	-37.50	3.19	-1.97
53.75	-47.50	2.82	-2.49
43.25	-55.00	2.27	-2.89
33.25	-58.00	1.75	-3.04
23.25	-59.00	1.22	-3.10
-57.75	0.00	-3.03	0.00
-57.75	2.50	-3.03	0.13
-57.75	7.50	-3.03	0.39
-56.75	12.50	-2.98	0.66
-55.75	17.50	-2.93	0.92
-53.25	22.50	-2.80	1.18
-50.75	27.50	-2.66	1.44
-46.75	32.50	-2.45	1.71
-43.25	37.50	-2.27	1.97
-39.25	42.50	-2.06	2.23
-32.75	47.50	-1.72	2.49
-26.75	51.50	-1.40	2.70
-21.75	55.00	-1.14	2.89
-16.75	57.50	-0.88	3.02
-11.75	60.50	-0.62	3.18
-6.75	61.50	-0.35	3.23
-1.75	62.00	-0.09	3.25
3.25	63.50	0.17	3.33
8.25	62.50	0.43	3.28
13.25	62.50	0.70	3.28
18.25	61.50	0.96	3.23
23.25	59.50	1.22	3.12
28.25	58.50	1.48	3.07
33.25	58.50	1.75	3.07
38.25	62.50	2.01	3.28

43.25	63.50	2.27	3.33
53.25	65.50	2.80	3.44
63.25	64.50	3.32	3.39
73.25	63.00	3.85	3.31
83.25	63.00	4.37	3.31
93.25	63.00	4.90	3.31
103.25	64.00	5.42	3.36
113.25	65.50	5.94	3.44
123.25	67.50	6.47	3.54
133.25	67.50	6.99	3.54
143.25	67.50	7.52	3.54
153.25	72.00	8.04	3.78
163.25	76.50	8.57	4.02
173.25	80.50	9.09	4.23
183.25	82.00	9.62	4.30
193.25	83.50	10.14	4.38
203.25	83.50	10.67	4.38
213.25	82.50	11.19	4.33
223.25	80.50	11.72	4.23
233.25	77.50	12.24	4.07
243.25	75.50	12.77	3.96
253.25	74.50	13.29	3.91
263.25	74.50	13.82	3.91
273.25	74.50	14.34	3.91
283.25	72.50	14.87	3.81
293.25	71.50	15.39	3.75
303.25	71.50	15.92	3.75
313.25	71.50	16.44	3.75
323.25	71.50	16.97	3.75
333.25	72.00	17.49	3.78
343.25	71.50	18.02	3.75
353.25	67.50	18.54	3.54
363.25	58.00	19.07	3.04
366.25	47.50	19.23	2.49
369.25	37.50	19.38	1.97
370.75	27.50	19.46	1.44
364.25	17.50	19.12	0.92
354.25	7.50	18.60	0.39
348.25	0.00	18.28	0.00
50.25	0.00	2.64	0.00
52.25	7.50	2.74	0.39
58.25	17.50	3.06	0.92
60.25	27.50	3.16	1.44

60.75	37.50	3.19	1.97
53.75	47.50	2.82	2.49
43.25	55.00	2.27	2.89
33.25	58.00	1.75	3.04
23.25	59.00	1.22	3.10

Experiment	No	P2S1-MC
Pier Diameter	D (mm)	41.5
Channel Width	B (mm)	830
Water Height	H (mm)	120
Median Grain Size	d50 (mm)	1.63
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	5
Flow Shallowness	H/D	2.9
Relative Coarseness	D/d50	24.9
Aspect Ratio	B/H	6.9
Equilibrium Scour Depth	dse/D	0.71

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-73.25	-2.27	-1.77	-0.05
-68.25	-0.37	-1.65	-0.01
-63.25	-3.07	-1.53	-0.07
-58.25	-3.77	-1.41	-0.09
-53.25	-3.87	-1.29	-0.09
-48.25	-6.47	-1.17	-0.16
-43.25	-11.67	-1.05	-0.28
-38.25	-15.17	-0.93	-0.37
-33.25	-20.07	-0.81	-0.49
-28.25	-25.87	-0.68	-0.63
-23.25	-29.37	-0.56	-0.71
23.25	-21.27	0.56	-0.51
26.75	-21.67	0.65	-0.52
31.75	-21.77	0.77	-0.53
36.75	-20.07	0.89	-0.49
41.75	-19.77	1.01	-0.48
46.75	-18.37	1.13	-0.44
51.75	-15.97	1.25	-0.39
56.75	-13.97	1.37	-0.34

Edge Contour

x (mm)	y (mm)	x/D	y/D
-60.75	0.00	-1.47	0.00
-60.75	-4.00	-1.47	-0.10
-60.75	-9.00	-1.47	-0.22
-60.25	-14.00	-1.46	-0.34
-60.25	-19.00	-1.46	-0.46
-59.75	-24.00	-1.45	-0.58
-58.75	-29.00	-1.42	-0.70
-55.25	-34.00	-1.34	-0.82
-53.75	-39.00	-1.30	-0.94
-51.25	-44.00	-1.24	-1.07
-46.25	-49.00	-1.12	-1.19
-39.75	-54.00	-0.96	-1.31
-38.25	-55.00	-0.93	-1.33
-33.25	-57.00	-0.81	-1.38
-28.25	-59.50	-0.68	-1.44
-23.25	-63.00	-0.56	-1.53
-18.25	-64.50	-0.44	-1.56
-13.25	-65.50	-0.32	-1.59
-8.25	-68.00	-0.20	-1.65

61.75	-11.37	1.50	-0.28
66.75	-7.57	1.62	-0.18
71.75	-6.67	1.74	-0.16
76.75	-3.97	1.86	-0.10
81.75	0.23	1.98	0.01
86.75	0.63	2.10	0.02
91.75	3.93	2.22	0.10
96.75	8.43	2.34	0.20
101.75	10.43	2.46	0.25
106.75	13.43	2.58	0.33
111.75	13.73	2.71	0.33
116.75	15.43	2.83	0.37
121.75	17.73	2.95	0.43
126.75	19.73	3.07	0.48
131.75	20.93	3.19	0.51
136.75	24.13	3.31	0.58
141.75	25.03	3.43	0.61
146.75	25.83	3.55	0.63
151.75	25.03	3.67	0.61
156.75	23.03	3.80	0.56
161.75	20.43	3.92	0.49
166.75	17.43	4.04	0.42
171.75	9.83	4.16	0.24
176.75	3.53	4.28	0.09
181.75	1.83	4.40	0.04
186.75	3.43	4.52	0.08
191.75	3.43	4.64	0.08
196.75	3.53	4.76	0.09
201.75	3.63	4.88	0.09
206.75	5.73	5.01	0.14
211.75	4.33	5.13	0.10
221.75	4.53	5.37	0.11
231.75	5.43	5.61	0.13
241.75	4.83	5.85	0.12
251.75	5.43	6.10	0.13
261.75	7.13	6.34	0.17
271.75	6.33	6.58	0.15
281.75	6.13	6.82	0.15

-3.25	-69.50	-0.08	-1.68
1.75	-70.00	0.04	-1.69
11.75	-73.00	0.28	-1.77
21.75	-70.00	0.53	-1.69
31.75	-67.00	0.77	-1.62
41.75	-62.00	1.01	-1.50
51.75	-57.00	1.25	-1.38
61.75	-59.00	1.50	-1.43
71.75	-62.00	1.74	-1.50
81.75	-63.50	1.98	-1.54
91.75	-65.00	2.22	-1.57
101.75	-65.00	2.46	-1.57
111.75	-65.50	2.71	-1.59
121.75	-68.00	2.95	-1.65
131.75	-68.50	3.19	-1.66
141.75	-68.50	3.43	-1.66
151.75	-67.00	3.67	-1.62
161.75	-67.00	3.92	-1.62
171.75	-68.00	4.16	-1.65
181.75	-68.00	4.40	-1.65
191.75	-62.00	4.64	-1.50
192.25	-59.00	4.65	-1.43
192.75	-54.00	4.67	-1.31
192.75	-44.00	4.67	-1.07
187.75	-34.00	4.55	-0.82
185.75	-24.00	4.50	-0.58
181.75	-14.00	4.40	-0.34
182.75	-4.00	4.42	-0.10
182.75	0.00	4.42	0.00
85.75	0.00	2.08	0.00
85.75	-4.00	2.08	-0.10
84.25	-14.00	2.04	-0.34
80.25	-24.00	1.94	-0.58
72.75	-34.00	1.76	-0.82
67.75	-44.00	1.64	-1.07
61.75	-49.50	1.50	-1.20
51.75	-55.00	1.25	-1.33
41.75	-60.50	1.01	-1.46
-60.75	0.00	-1.47	0.00
-60.75	4.00	-1.47	0.10
-60.75	9.00	-1.47	0.22
-60.25	14.00	-1.46	0.34
-60.25	19.00	-1.46	0.46

-59.75	24.00	-1.45	0.58
-58.75	29.00	-1.42	0.70
-55.25	34.00	-1.34	0.82
-53.75	39.00	-1.30	0.94
-51.25	44.00	-1.24	1.07
-46.25	49.00	-1.12	1.19
-39.75	54.00	-0.96	1.31
-38.25	55.00	-0.93	1.33
-33.25	57.00	-0.81	1.38
-28.25	59.50	-0.68	1.44
-23.25	63.00	-0.56	1.53
-18.25	64.50	-0.44	1.56
-13.25	65.50	-0.32	1.59
-8.25	68.00	-0.20	1.65
-3.25	69.50	-0.08	1.68
1.75	70.00	0.04	1.69
11.75	73.00	0.28	1.77
21.75	70.00	0.53	1.69
31.75	67.00	0.77	1.62
41.75	62.00	1.01	1.50
51.75	57.00	1.25	1.38
61.75	59.00	1.50	1.43
71.75	62.00	1.74	1.50
81.75	63.50	1.98	1.54
91.75	65.00	2.22	1.57
101.75	65.00	2.46	1.57
111.75	65.50	2.71	1.59
121.75	68.00	2.95	1.65
131.75	68.50	3.19	1.66
141.75	68.50	3.43	1.66
151.75	67.00	3.67	1.62
161.75	67.00	3.92	1.62
171.75	68.00	4.16	1.65
181.75	68.00	4.40	1.65
191.75	62.00	4.64	1.50
192.25	59.00	4.65	1.43
192.75	54.00	4.67	1.31
192.75	44.00	4.67	1.07
187.75	34.00	4.55	0.82
185.75	24.00	4.50	0.58
181.75	14.00	4.40	0.34
182.75	4.00	4.42	0.10
182.75	0.00	4.42	0.00

85.75	0.00	2.08	0.00
85.75	4.00	2.08	0.10
84.25	14.00	2.04	0.34
80.25	24.00	1.94	0.58
72.75	34.00	1.76	0.82
67.75	44.00	1.64	1.07
61.75	49.50	1.50	1.20
51.75	55.00	1.25	1.33
41.75	60.50	1.01	1.46

Experiment	No	P2S1-C
Pier Diameter	D (mm)	61
Channel Width	B (mm)	1220
Water Height	H (mm)	120
Median Grain Size	d50 (mm)	2.4
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	5
Flow Shallowness	H/D	2.0
Relative Coarseness	D/d50	24.9
Aspect Ratio	B/H	10.2
Equilibrium Scour Depth	dse/D	0.71

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-113.00	3.33	-1.79	0.05
-108.00	1.33	-1.71	0.02
-103.00	-0.67	-1.63	-0.01
-98.00	-0.87	-1.56	-0.01
-93.00	-0.87	-1.48	-0.01
-88.00	-5.87	-1.40	-0.09
-83.00	-6.47	-1.32	-0.10
-78.00	-7.87	-1.24	-0.12
-73.00	-13.47	-1.16	-0.21
-68.00	-12.57	-1.08	-0.20
-63.00	-14.87	-1.00	-0.24
-58.00	-20.67	-0.92	-0.33
-53.00	-22.57	-0.84	-0.36
-48.00	-29.37	-0.76	-0.47
-43.00	-31.87	-0.68	-0.51

Edge Contour

x (mm)	y (mm)	x/D	y/D
-88.00	0.00	-1.40	0.00
-88.00	-4.00	-1.40	-0.06
-86.00	-9.00	-1.37	-0.14
-85.00	-14.00	-1.35	-0.22
-83.00	-19.00	-1.32	-0.30
-73.00	-48.00	-1.16	-0.76
-63.00	-60.00	-1.00	-0.95
-53.00	-69.00	-0.84	-1.10
-43.00	-77.00	-0.68	-1.22
-33.00	-79.00	-0.52	-1.25
-23.00	-85.00	-0.37	-1.35
-13.00	-89.00	-0.21	-1.41
-3.00	-92.00	-0.05	-1.46
7.00	-92.00	0.11	-1.46
17.00	-95.00	0.27	-1.51

-38.00	-36.57	-0.60	-0.58
-36.00	-43.17	-0.57	-0.69
36.00	-16.47	0.57	-0.26
42.00	-19.47	0.67	-0.31
47.00	-18.07	0.75	-0.29
52.00	-19.97	0.83	-0.32
57.00	-18.17	0.90	-0.29
62.00	-19.77	0.98	-0.31
67.00	-18.57	1.06	-0.29
72.00	-18.07	1.14	-0.29
77.00	-17.47	1.22	-0.28
82.00	-15.77	1.30	-0.25
87.00	-10.67	1.38	-0.17
92.00	-10.17	1.46	-0.16
97.00	-10.57	1.54	-0.17
102.00	-4.87	1.62	-0.08
107.00	-5.07	1.70	-0.08
112.00	1.03	1.78	0.02
117.00	3.13	1.86	0.05
122.00	2.33	1.94	0.04
127.00	4.33	2.02	0.07
132.00	9.33	2.10	0.15
137.00	11.23	2.17	0.18
142.00	14.33	2.25	0.23
147.00	15.73	2.33	0.25
152.00	18.63	2.41	0.30
157.00	20.83	2.49	0.33
167.00	26.13	2.65	0.41
177.00	29.63	2.81	0.47
187.00	29.03	2.97	0.46
197.00	32.43	3.13	0.51
207.00	35.03	3.29	0.56
217.00	38.13	3.44	0.61
227.00	41.13	3.60	0.65
232.00	38.43	3.68	0.61
237.00	39.73	3.76	0.63
242.00	31.23	3.84	0.50
247.00	27.43	3.92	0.44
257.00	19.43	4.08	0.31
267.00	10.43	4.24	0.17
277.00	6.43	4.40	0.10
287.00	5.33	4.56	0.08
297.00	6.43	4.71	0.10

27.00	-95.00	0.43	-1.51
37.00	-94.00	0.59	-1.49
47.00	-93.00	0.75	-1.48
57.00	-90.00	0.90	-1.43
67.00	-88.00	1.06	-1.40
77.00	-84.00	1.22	-1.33
87.00	-79.00	1.38	-1.25
97.00	-77.00	1.54	-1.22
107.00	-76.00	1.70	-1.21
117.00	-76.00	1.86	-1.21
127.00	-78.00	2.02	-1.24
137.00	-81.00	2.17	-1.29
147.00	-84.00	2.33	-1.33
157.00	-88.00	2.49	-1.40
167.00	-94.00	2.65	-1.49
177.00	-98.00	2.81	-1.56
187.00	-103.00	2.97	-1.63
197.00	-109.00	3.13	-1.73
207.00	-113.00	3.29	-1.79
217.00	-119.00	3.44	-1.89
227.00	-123.00	3.60	-1.95
237.00	-126.00	3.76	-2.00
247.00	-126.00	3.92	-2.00
257.00	-126.00	4.08	-2.00
267.00	-126.00	4.24	-2.00
277.00	-124.00	4.40	-1.97
287.00	-123.00	4.56	-1.95
297.00	-118.00	4.71	-1.87
94.00	-65.00	1.49	-1.03
99.00	-59.00	1.57	-0.94
105.00	-49.00	1.67	-0.78
111.00	-39.00	1.76	-0.62
119.00	-29.00	1.89	-0.46
124.00	-19.00	1.97	-0.30
127.00	-9.00	2.02	-0.14
131.00	1.00	2.08	0.02
126.00	11.00	2.00	0.17
123.00	21.00	1.95	0.33
117.00	31.00	1.86	0.49
111.00	41.00	1.76	0.65
102.00	51.00	1.62	0.81
99.00	61.00	1.57	0.97
93.00	71.00	1.48	1.13

307.00	5.73	4.87	0.09
317.00	4.93	5.03	0.08
327.00	5.73	5.19	0.09
337.00	5.63	5.35	0.09
347.00	3.53	5.51	0.06
357.00	5.33	5.67	0.08
367.00	3.83	5.83	0.06
377.00	5.93	5.98	0.09

81.00	81.00	1.29	1.29
-78.00	-44.00	-1.24	-0.70
77.00	85.00	1.22	1.35
67.00	90.00	1.06	1.43
57.00	93.00	0.90	1.48
47.00	96.00	0.75	1.52
37.00	101.00	0.59	1.60
27.00	103.00	0.43	1.63
17.00	103.00	0.27	1.63
7.00	102.00	0.11	1.62
-3.00	101.00	-0.05	1.60
-13.00	101.00	-0.21	1.60
-23.00	100.00	-0.37	1.59
-33.00	98.00	-0.52	1.56
-43.00	93.00	-0.68	1.48
-53.00	89.00	-0.84	1.41
-63.00	85.00	-1.00	1.35
-73.00	77.00	-1.16	1.22
-78.00	57.00	-1.24	0.90
-83.00	52.00	-1.32	0.83
-86.00	46.00	-1.37	0.73
-87.00	41.00	-1.38	0.65
-87.00	36.00	-1.38	0.57
-88.00	31.00	-1.40	0.49
-88.00	26.00	-1.40	0.41
-89.00	21.00	-1.41	0.33
-89.00	16.00	-1.41	0.25
-89.00	11.00	-1.41	0.17
-89.00	6.00	-1.41	0.10
-89.00	1.00	-1.41	0.02
307.00	-118.00	4.87	-1.87
317.00	-116.00	5.03	-1.84
327.00	-113.00	5.19	-1.79
337.00	-108.00	5.35	-1.71
347.00	-104.00	5.51	-1.65
357.00	-98.00	5.67	-1.56
367.00	-98.00	5.83	-1.56
377.00	-98.00	5.98	-1.56
387.00	-95.00	6.14	-1.51
337.00	-99.00	5.35	-1.57
327.00	-96.00	5.19	-1.52
317.00	-93.00	5.03	-1.48
307.00	-88.00	4.87	-1.40

297.00	-78.00	4.71	-1.24
287.00	-70.00	4.56	-1.11
285.00	-64.00	4.52	-1.02
280.00	-59.00	4.44	-0.94
279.00	-49.00	4.43	-0.78
279.00	-39.00	4.43	-0.62
277.00	-29.00	4.40	-0.46
275.00	-19.00	4.37	-0.30
275.00	-9.00	4.37	-0.14
275.00	0.00	4.37	0.00
97.00	77.00	1.54	1.22
107.00	76.00	1.70	1.21
117.00	76.00	1.86	1.21
127.00	78.00	2.02	1.24
137.00	81.00	2.17	1.29
147.00	84.00	2.33	1.33
157.00	88.00	2.49	1.40
167.00	94.00	2.65	1.49
177.00	98.00	2.81	1.56
187.00	103.00	2.97	1.63
197.00	109.00	3.13	1.73
207.00	113.00	3.29	1.79
217.00	119.00	3.44	1.89
227.00	123.00	3.60	1.95
237.00	126.00	3.76	2.00
247.00	126.00	3.92	2.00
257.00	126.00	4.08	2.00
267.00	126.00	4.24	2.00
277.00	124.00	4.40	1.97
287.00	123.00	4.56	1.95
297.00	118.00	4.71	1.87
337.00	99.00	5.35	1.57
327.00	96.00	5.19	1.52
317.00	93.00	5.03	1.48
307.00	88.00	4.87	1.40
297.00	78.00	4.71	1.24
287.00	70.00	4.56	1.11
285.00	64.00	4.52	1.02
280.00	59.00	4.44	0.94
279.00	49.00	4.43	0.78
279.00	39.00	4.43	0.62
277.00	29.00	4.40	0.46
275.00	19.00	4.37	0.30

275.00	9.00	4.37	0.14
275.00	0.00	4.37	0.00
307.00	118.00	4.87	1.87
317.00	116.00	5.03	1.84
327.00	113.00	5.19	1.79
337.00	108.00	5.35	1.71
347.00	104.00	5.51	1.65
357.00	98.00	5.67	1.56
367.00	98.00	5.83	1.56
377.00	98.00	5.98	1.56
387.00	95.00	6.14	1.51

Experiment	No	P2S2-F
Pier Diameter	D (mm)	19.4
Channel Width	B (mm)	259
Water Height	H (mm)	120
Median Grain Size	d50 (mm)	0.51
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	7.5
Flow Shallowness	H/D	6.2
Relative Coarseness	D/d50	38.1
Aspect Ratio	B/H	2.2
Equilibrium Scour Depth	dse/D	1.71

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-80.00	0.77	-4.20	0.04
-75.00	1.37	-3.94	0.07
-70.00	-0.43	-3.67	-0.02
-65.00	-2.63	-3.41	-0.14
-60.00	-5.63	-3.15	-0.30
-55.00	-8.63	-2.89	-0.45
-50.00	-12.13	-2.62	-0.64
-45.00	-15.03	-2.36	-0.79
-40.00	-18.03	-2.10	-0.95
-35.00	-21.73	-1.84	-1.14
-30.00	-22.13	-1.57	-1.16
-25.00	-28.03	-1.31	-1.47

Edge Contour

x (mm)	y (mm)	x/D	y/D
-10.00	83.00	-0.52	4.36
-15.00	81.00	-0.79	4.25
-25.00	79.00	-1.31	4.15
-35.00	74.00	-1.84	3.88
-45.00	70.00	-2.36	3.67
-55.00	58.00	-2.89	3.04
-65.00	49.00	-3.41	2.57
-65.00	39.00	-3.41	2.05
-69.00	29.00	-3.62	1.52
-70.00	19.00	-3.67	1.00
-71.00	9.00	-3.73	0.47
-73.00	-1.00	-3.83	-0.05

-20.00	-31.23	-1.05	-1.64
-15.00	-33.23	-0.79	-1.74
-12.00	-32.03	-0.63	-1.68
12.00	-28.93	0.63	-1.52
15.00	-25.63	0.79	-1.35
20.00	-24.73	1.05	-1.30
25.00	-21.43	1.31	-1.13
30.00	-18.93	1.57	-0.99
35.00	-15.93	1.84	-0.84
40.00	-14.13	2.10	-0.74
45.00	-12.53	2.36	-0.66
50.00	-9.63	2.62	-0.51
55.00	-7.33	2.89	-0.38
60.00	-4.33	3.15	-0.23
65.00	-1.73	3.41	-0.09
70.00	-0.03	3.67	0.00
75.00	2.07	3.94	0.11
80.00	2.77	4.20	0.15
85.00	5.37	4.46	0.28
90.00	7.17	4.72	0.38
95.00	7.57	4.99	0.40
100.00	9.87	5.25	0.52
105.00	11.87	5.51	0.62
110.00	13.17	5.77	0.69
115.00	15.47	6.04	0.81
120.00	16.97	6.30	0.89
125.00	18.57	6.56	0.97
135.00	21.47	7.09	1.13
145.00	22.37	7.61	1.17
155.00	26.57	8.14	1.39
165.00	28.87	8.66	1.52
175.00	30.87	9.19	1.62
185.00	32.07	9.71	1.68
195.00	33.07	10.24	1.74
205.00	27.27	10.76	1.43
215.00	19.37	11.29	1.02
225.00	12.77	11.81	0.67
235.00	11.47	12.34	0.60
245.00	10.57	12.86	0.55
255.00	9.97	13.39	0.52
265.00	8.47	13.91	0.44
275.00	7.67	14.44	0.40

-73.00	-11.00	-3.83	-0.58
-69.00	-21.00	-3.62	-1.10
-62.00	-31.00	-3.25	-1.63
-60.00	-41.00	-3.15	-2.15
-52.00	-51.00	-2.73	-2.68
-41.00	-61.00	-2.15	-3.20
-35.00	-64.00	-1.84	-3.36
-25.00	-67.00	-1.31	-3.52
-15.00	-75.00	-0.79	-3.94
-5.00	-79.00	-0.26	-4.15
5.00	-82.00	0.26	-4.30
15.00	-86.00	0.79	-4.51
25.00	-87.00	1.31	-4.57
35.00	-87.00	1.84	-4.57
45.00	-88.00	2.36	-4.62
55.00	-89.00	2.89	-4.67
65.00	-89.00	3.41	-4.67
75.00	-92.00	3.94	-4.83
85.00	-95.00	4.46	-4.99
95.00	-97.00	4.99	-5.09
105.00	-100.00	5.51	-5.25
115.00	-102.00	6.04	-5.35
125.00	-104.00	6.56	-5.46
135.00	-106.00	7.09	-5.56
145.00	-107.00	7.61	-5.62
155.00	-107.00	8.14	-5.62
165.00	-109.00	8.66	-5.72
175.00	-110.00	9.19	-5.77
185.00	-106.00	9.71	-5.56
195.00	-105.00	10.24	-5.51
205.00	-108.00	10.76	-5.67
215.00	-113.00	11.29	-5.93
220.00	-119.00	11.55	-6.25
225.00	-122.00	11.81	-6.40
230.00	-124.00	12.07	-6.51
75.00	-90.00	3.94	-4.72
84.00	-81.00	4.41	-4.25
89.00	-71.00	4.67	-3.73
96.00	-61.00	5.04	-3.20
101.00	-51.00	5.30	-2.68
102.00	-41.00	5.35	-2.15
101.00	-31.00	5.30	-1.63
98.00	-21.00	5.14	-1.10

93.00	-11.00	4.88	-0.58
86.00	-1.00	4.51	-0.05
79.00	9.00	4.15	0.47
84.00	19.00	4.41	1.00
87.00	29.00	4.57	1.52
5.00	82.00	0.26	4.30
15.00	86.00	0.79	4.51
25.00	87.00	1.31	4.57
35.00	87.00	1.84	4.57
45.00	88.00	2.36	4.62
55.00	89.00	2.89	4.67
65.00	89.00	3.41	4.67
75.00	92.00	3.94	4.83
85.00	95.00	4.46	4.99
95.00	97.00	4.99	5.09
105.00	100.00	5.51	5.25
115.00	102.00	6.04	5.35
125.00	104.00	6.56	5.46
135.00	106.00	7.09	5.56
145.00	107.00	7.61	5.62
155.00	107.00	8.14	5.62
165.00	109.00	8.66	5.72
175.00	110.00	9.19	5.77
185.00	106.00	9.71	5.56
195.00	105.00	10.24	5.51
205.00	108.00	10.76	5.67
215.00	113.00	11.29	5.93
220.00	119.00	11.55	6.25
225.00	122.00	11.81	6.40
230.00	124.00	12.07	6.51
84.00	81.00	4.41	4.25
89.00	71.00	4.67	3.73
96.00	61.00	5.04	3.20
101.00	51.00	5.30	2.68
102.00	41.00	5.35	2.15
101.00	31.00	5.30	1.63

Experiment	No	P2S2-MF
Pier Diameter	D (mm)	29.4
Channel Width	B (mm)	391
Water Height	H (mm)	120
Median Grain Size	d50	0.77

		(mm)
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	7.5
Flow Shallowness	H/D	4.1
Relative Coarseness	D/d50	38.1
Aspect Ratio	B/H	3.3
Equilibrium Scour Depth	dse/D	1.53

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-92.50	-0.03	-3.08	0.00
-87.50	-0.63	-2.92	-0.02
-82.50	-0.93	-2.75	-0.03
-77.50	-3.23	-2.58	-0.11
-72.50	-6.73	-2.42	-0.22
-67.50	-9.33	-2.25	-0.31
-62.50	-12.03	-2.08	-0.40
-57.50	-15.33	-1.92	-0.51
-52.50	-18.63	-1.75	-0.62
-47.50	-22.03	-1.58	-0.73
-42.50	-25.33	-1.42	-0.84
-37.50	-27.93	-1.25	-0.93
-32.50	-31.83	-1.08	-1.06
-27.50	-38.03	-0.92	-1.27
-22.50	-41.23	-0.75	-1.37
-17.50	-45.03	-0.58	-1.50
17.50	-23.03	0.58	-0.77
22.50	-22.83	0.75	-0.76
27.50	-21.13	0.92	-0.70
32.50	-18.13	1.08	-0.60
37.50	-16.03	1.25	-0.53
42.50	-12.53	1.42	-0.42
47.50	-8.73	1.58	-0.29
52.50	-5.93	1.75	-0.20
57.50	-2.73	1.92	-0.09
62.50	0.17	2.08	0.01
67.50	1.67	2.25	0.06
72.50	5.17	2.42	0.17
77.50	7.97	2.58	0.27
82.50	10.17	2.75	0.34

Edge Contour

x (mm)	z (mm)	x/D	z/D
-84.50	0.00	-2.82	0.00
-84.50	-6.00	-2.82	-0.20
-84.50	-11.00	-2.82	-0.37
-83.00	-16.00	-2.77	-0.53
-83.00	-21.00	-2.77	-0.70
-81.50	-26.00	-2.72	-0.87
-80.00	-31.00	-2.67	-1.03
-78.50	-36.00	-2.62	-1.20
-76.50	-41.00	-2.55	-1.37
-73.50	-46.00	-2.45	-1.53
-71.00	-51.00	-2.37	-1.70
-66.50	-56.00	-2.22	-1.87
-61.50	-61.00	-2.05	-2.03
-56.50	-66.00	-1.88	-2.20
-50.00	-71.00	-1.67	-2.37
-47.50	-72.50	-1.58	-2.42
-42.50	-76.50	-1.42	-2.55
-37.50	-79.50	-1.25	-2.65
-32.50	-82.50	-1.08	-2.75
-27.50	-85.00	-0.92	-2.83
-17.50	-86.00	-0.58	-2.87
-7.50	-89.00	-0.25	-2.97
2.50	-90.00	0.08	-3.00
12.50	-89.50	0.42	-2.98
22.50	-91.00	0.75	-3.03
32.50	-93.00	1.08	-3.10
42.50	-93.50	1.42	-3.12
52.50	-93.50	1.75	-3.12
62.50	-93.00	2.08	-3.10
72.50	-92.00	2.42	-3.07

87.50	12.27	2.92	0.41
92.50	14.47	3.08	0.48
102.50	17.47	3.42	0.58
112.50	21.17	3.75	0.71
122.50	24.07	4.08	0.80
132.50	26.37	4.42	0.88
142.50	28.67	4.75	0.96
152.50	29.97	5.08	1.00
162.50	31.37	5.42	1.05
172.50	32.07	5.75	1.07
182.50	30.37	6.08	1.01
192.50	22.87	6.42	0.76
202.50	12.77	6.75	0.43
212.50	9.27	7.08	0.31
222.50	8.07	7.42	0.27
232.50	6.87	7.75	0.23
242.50	5.57	8.08	0.19
252.50	4.37	8.42	0.15
262.50	4.27	8.75	0.14
272.50	4.57	9.08	0.15
282.50	4.17	9.42	0.14
292.50	4.57	9.75	0.15
302.50	4.87	10.08	0.16
312.50	4.27	10.42	0.14
322.50	3.27	10.75	0.11
332.50	3.47	11.08	0.12
342.50	2.57	11.42	0.09
352.50	3.47	11.75	0.12
362.50	4.27	12.08	0.14
372.50	5.47	12.42	0.18
382.50	7.17	12.75	0.24

82.50	-91.50	2.75	-3.05
92.50	-91.00	3.08	-3.03
102.50	-91.00	3.42	-3.03
112.50	-95.00	3.75	-3.17
122.50	-97.00	4.08	-3.23
132.50	-98.00	4.42	-3.27
142.50	-98.00	4.75	-3.27
152.50	-99.00	5.08	-3.30
162.50	-98.00	5.42	-3.27
172.50	-98.00	5.75	-3.27
182.50	-98.50	6.08	-3.28
192.50	-100.00	6.42	-3.33
202.50	-104.00	6.75	-3.47
212.50	-116.00	7.08	-3.87
222.50	-130.00	7.42	-4.33
232.50	-141.00	7.75	-4.70
242.50	-147.00	8.08	-4.90
252.50	-150.00	8.42	-5.00
262.50	-151.00	8.75	-5.03
272.50	-152.00	9.08	-5.07
282.50	-150.00	9.42	-5.00
292.50	-150.00	9.75	-5.00
302.50	-150.00	10.08	-5.00
312.50	-148.00	10.42	-4.93
322.50	-144.00	10.75	-4.80
332.50	-135.00	11.08	-4.50
342.50	-131.00	11.42	-4.37
352.50	-132.00	11.75	-4.40
362.50	-134.00	12.08	-4.47
372.50	-131.00	12.42	-4.37
382.50	-127.00	12.75	-4.23
392.50	-121.00	13.08	-4.03
402.50	-114.00	13.42	-3.80
412.50	-106.00	13.75	-3.53
422.50	-102.50	14.08	-3.42
432.50	-99.00	14.42	-3.30
67.00	0.00	2.23	0.00
67.00	-6.00	2.23	-0.20
67.50	-11.00	2.25	-0.37
70.50	-21.00	2.35	-0.70
73.50	-31.00	2.45	-1.03
74.00	-41.00	2.47	-1.37
71.00	-51.00	2.37	-1.70

65.50	-61.00	2.18	-2.03
55.50	-71.00	1.85	-2.37
52.50	-74.00	1.75	-2.47
42.50	-80.00	1.42	-2.67
32.50	-86.00	1.08	-2.87
22.50	-88.00	0.75	-2.93
12.50	-89.00	0.42	-2.97
-84.50	0.00	-2.82	0.00
-84.50	6.00	-2.82	0.20
-84.50	11.00	-2.82	0.37
-83.00	16.00	-2.77	0.53
-83.00	21.00	-2.77	0.70
-81.50	26.00	-2.72	0.87
-80.00	31.00	-2.67	1.03
-78.50	36.00	-2.62	1.20
-76.50	41.00	-2.55	1.37
-73.50	46.00	-2.45	1.53
-71.00	51.00	-2.37	1.70
-66.50	56.00	-2.22	1.87
-61.50	61.00	-2.05	2.03
-56.50	66.00	-1.88	2.20
-50.00	71.00	-1.67	2.37
-47.50	72.50	-1.58	2.42
-42.50	76.50	-1.42	2.55
-37.50	79.50	-1.25	2.65
-32.50	82.50	-1.08	2.75
-27.50	85.00	-0.92	2.83
-17.50	86.00	-0.58	2.87
-7.50	89.00	-0.25	2.97
2.50	90.00	0.08	3.00
12.50	89.50	0.42	2.98
22.50	91.00	0.75	3.03
32.50	93.00	1.08	3.10
42.50	93.50	1.42	3.12
52.50	93.50	1.75	3.12
62.50	93.00	2.08	3.10
72.50	92.00	2.42	3.07
82.50	91.50	2.75	3.05
92.50	91.00	3.08	3.03
102.50	91.00	3.42	3.03
112.50	95.00	3.75	3.17
122.50	97.00	4.08	3.23
132.50	98.00	4.42	3.27

142.50	98.00	4.75	3.27
152.50	99.00	5.08	3.30
162.50	98.00	5.42	3.27
172.50	98.00	5.75	3.27
182.50	98.50	6.08	3.28
192.50	100.00	6.42	3.33
202.50	104.00	6.75	3.47
212.50	116.00	7.08	3.87
222.50	130.00	7.42	4.33
232.50	141.00	7.75	4.70
242.50	147.00	8.08	4.90
252.50	150.00	8.42	5.00
262.50	151.00	8.75	5.03
272.50	152.00	9.08	5.07
282.50	150.00	9.42	5.00
292.50	150.00	9.75	5.00
302.50	150.00	10.08	5.00
312.50	148.00	10.42	4.93
322.50	144.00	10.75	4.80
332.50	135.00	11.08	4.50
342.50	131.00	11.42	4.37
352.50	132.00	11.75	4.40
362.50	134.00	12.08	4.47
372.50	131.00	12.42	4.37
382.50	127.00	12.75	4.23
392.50	121.00	13.08	4.03
402.50	114.00	13.42	3.80
412.50	106.00	13.75	3.53
422.50	102.50	14.08	3.42
432.50	99.00	14.42	3.30
67.00	0.00	2.23	0.00
67.00	6.00	2.23	0.20
67.50	11.00	2.25	0.37
70.50	21.00	2.35	0.70
73.50	31.00	2.45	1.03
74.00	41.00	2.47	1.37
71.00	51.00	2.37	1.70
65.50	61.00	2.18	2.03
55.50	71.00	1.85	2.37
52.50	74.00	1.75	2.47
42.50	80.00	1.42	2.67
32.50	86.00	1.08	2.87
22.50	88.00	0.75	2.93

12.50	89.00	0.42	2.97

Experiment	No	P2S2-MC
Pier Diameter	D (mm)	62.3
Channel Width	B (mm)	830
Water Height	H (mm)	120
Median Grain Size	d50 (mm)	1.63
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	7.5
Flow Shallowness	H/D	1.9
Relative Coarseness	D/d50	38.1
Aspect Ratio	B/H	6.9
Equilibrium Scour Depth	dse/D	0.54

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-100.00	-1.00	-1.59	-0.02
-95.00	-0.20	-1.51	0.00
-90.00	-0.50	-1.43	-0.01
-85.00	-2.20	-1.35	-0.03
-80.00	-3.80	-1.27	-0.06
-75.00	-4.20	-1.19	-0.07
-70.00	-6.80	-1.11	-0.11
-65.00	-11.60	-1.03	-0.18
-60.00	-14.20	-0.95	-0.23
-55.00	-19.50	-0.87	-0.31
-50.00	-24.90	-0.79	-0.40
-45.00	-28.30	-0.71	-0.45
-40.00	-31.20	-0.63	-0.50
-35.00	-33.60	-0.56	-0.53
35.00	-22.60	0.56	-0.36
40.00	-23.50	0.63	-0.37
45.00	-23.30	0.71	-0.37
50.00	-24.90	0.79	-0.40
55.00	-23.40	0.87	-0.37
60.00	-22.40	0.95	-0.36
65.00	-21.10	1.03	-0.33
70.00	-19.60	1.11	-0.31
75.00	-19.00	1.19	-0.30

Edge Contour

x (mm)	y (mm)	x/D	y/D
-89.00	0.00	-1.41	0.00
-89.00	-6.00	-1.41	-0.10
-88.50	-11.00	-1.40	-0.17
-86.00	-16.00	-1.37	-0.25
-84.50	-21.00	-1.34	-0.33
-83.00	-26.00	-1.32	-0.41
-81.50	-31.00	-1.29	-0.49
-81.00	-36.00	-1.29	-0.57
-79.50	-41.00	-1.26	-0.65
-76.00	-46.00	-1.21	-0.73
-74.00	-51.00	-1.17	-0.81
-71.00	-56.00	-1.13	-0.89
-66.00	-61.00	-1.05	-0.97
-61.00	-66.00	-0.97	-1.05
-55.00	-71.00	-0.87	-1.13
-49.00	-76.00	-0.78	-1.21
-42.00	-81.00	-0.67	-1.29
-35.00	-85.50	-0.56	-1.36
-30.00	-87.00	-0.48	-1.38
-25.00	-90.00	-0.40	-1.43
-20.00	-92.00	-0.32	-1.46
-15.00	-94.50	-0.24	-1.50
-10.00	-96.00	-0.16	-1.52

80.00	-15.20	1.27	-0.24
85.00	-13.10	1.35	-0.21
90.00	-9.30	1.43	-0.15
95.00	-7.40	1.51	-0.12
100.00	-5.60	1.59	-0.09
105.00	-0.70	1.67	-0.01
110.00	1.20	1.75	0.02
115.00	1.80	1.83	0.03
120.00	3.50	1.90	0.06
125.00	4.40	1.98	0.07
130.00	6.80	2.06	0.11
135.00	10.10	2.14	0.16
140.00	10.40	2.22	0.17
145.00	11.80	2.30	0.19
150.00	14.50	2.38	0.23
160.00	18.00	2.54	0.29
170.00	21.50	2.70	0.34
180.00	25.20	2.86	0.40
190.00	27.20	3.02	0.43
200.00	29.30	3.17	0.47
210.00	33.20	3.33	0.53
220.00	33.00	3.49	0.52
225.00	31.60	3.57	0.50
230.00	29.00	3.65	0.46
235.00	23.90	3.73	0.38
240.00	20.10	3.81	0.32
245.00	15.10	3.89	0.24
250.00	10.10	3.97	0.16
255.00	4.10	4.05	0.07
260.00	6.30	4.13	0.10
265.00	5.80	4.21	0.09
270.00	4.80	4.29	0.08
280.00	3.90	4.44	0.06
290.00	5.50	4.60	0.09
300.00	5.60	4.76	0.09
310.00	5.80	4.92	0.09
320.00	5.70	5.08	0.09
330.00	5.10	5.24	0.08

0.00	-98.00	0.00	-1.56
10.00	-98.50	0.16	-1.56
20.00	-98.50	0.32	-1.56
30.00	-96.50	0.48	-1.53
40.00	-95.50	0.63	-1.52
50.00	-94.50	0.79	-1.50
60.00	-94.00	0.95	-1.49
70.00	-92.00	1.11	-1.46
80.00	-92.00	1.27	-1.46
90.00	-91.50	1.43	-1.45
100.00	-91.50	1.59	-1.45
110.00	-91.50	1.75	-1.45
120.00	-89.00	1.90	-1.41
130.00	-87.00	2.06	-1.38
140.00	-86.00	2.22	-1.37
150.00	-86.00	2.38	-1.37
160.00	-87.00	2.54	-1.38
170.00	-89.00	2.70	-1.41
180.00	-90.00	2.86	-1.43
190.00	-90.00	3.02	-1.43
200.00	-91.00	3.17	-1.44
210.00	-91.00	3.33	-1.44
220.00	-91.00	3.49	-1.44
230.00	-91.00	3.65	-1.44
240.00	-88.00	3.81	-1.40
250.00	-82.00	3.97	-1.30
260.00	-71.00	4.13	-1.13
262.00	-61.00	4.16	-0.97
262.00	-51.00	4.16	-0.81
259.00	-41.00	4.11	-0.65
255.00	-31.00	4.05	-0.49
252.00	-21.00	4.00	-0.33
255.00	-11.00	4.05	-0.17
255.00	0.00	4.05	0.00
117.00	0.00	1.86	0.00
114.50	-11.00	1.82	-0.17
121.00	-21.00	1.92	-0.33
118.00	-31.00	1.87	-0.49
107.50	-41.00	1.71	-0.65
100.00	-44.00	1.59	-0.70
90.00	-52.00	1.43	-0.83
80.00	-62.00	1.27	-0.98
70.00	-68.50	1.11	-1.09

60.00	-75.00	0.95	-1.19
50.00	-83.00	0.79	-1.32
40.00	-89.00	0.63	-1.41
30.00	-96.00	0.48	-1.52
20.00	-98.50	0.32	-1.56
-89.00	0.00	-1.41	0.00
-89.00	6.00	-1.41	0.10
-88.50	11.00	-1.40	0.17
-86.00	16.00	-1.37	0.25
-84.50	21.00	-1.34	0.33
-83.00	26.00	-1.32	0.41
-81.50	31.00	-1.29	0.49
-81.00	36.00	-1.29	0.57
-79.50	41.00	-1.26	0.65
-76.00	46.00	-1.21	0.73
-74.00	51.00	-1.17	0.81
-71.00	56.00	-1.13	0.89
-66.00	61.00	-1.05	0.97
-61.00	66.00	-0.97	1.05
-55.00	71.00	-0.87	1.13
-49.00	76.00	-0.78	1.21
-42.00	81.00	-0.67	1.29
-35.00	85.50	-0.56	1.36
-30.00	87.00	-0.48	1.38
-25.00	90.00	-0.40	1.43
-20.00	92.00	-0.32	1.46
-15.00	94.50	-0.24	1.50
-10.00	96.00	-0.16	1.52
0.00	98.00	0.00	1.56
10.00	98.50	0.16	1.56
20.00	98.50	0.32	1.56
30.00	96.50	0.48	1.53
40.00	95.50	0.63	1.52
50.00	94.50	0.79	1.50
60.00	94.00	0.95	1.49
70.00	92.00	1.11	1.46
80.00	92.00	1.27	1.46
90.00	91.50	1.43	1.45
100.00	91.50	1.59	1.45
110.00	91.50	1.75	1.45
120.00	89.00	1.90	1.41
130.00	87.00	2.06	1.38
140.00	86.00	2.22	1.37

150.00	86.00	2.38	1.37
160.00	87.00	2.54	1.38
170.00	89.00	2.70	1.41
180.00	90.00	2.86	1.43
190.00	90.00	3.02	1.43
200.00	91.00	3.17	1.44
210.00	91.00	3.33	1.44
220.00	91.00	3.49	1.44
230.00	91.00	3.65	1.44
240.00	88.00	3.81	1.40
250.00	82.00	3.97	1.30
260.00	71.00	4.13	1.13
262.00	61.00	4.16	0.97
262.00	51.00	4.16	0.81
259.00	41.00	4.11	0.65
255.00	31.00	4.05	0.49
252.00	21.00	4.00	0.33
255.00	11.00	4.05	0.17
255.00	0.00	4.05	0.00
117.00	0.00	1.86	0.00
114.50	11.00	1.82	0.17
121.00	21.00	1.92	0.33
118.00	31.00	1.87	0.49
107.50	41.00	1.71	0.65
100.00	44.00	1.59	0.70
90.00	52.00	1.43	0.83
80.00	62.00	1.27	0.98
70.00	68.50	1.11	1.09
60.00	75.00	0.95	1.19
50.00	83.00	0.79	1.32
40.00	89.00	0.63	1.41
30.00	96.00	0.48	1.52
20.00	98.50	0.32	1.56

Experiment	No	P2S2-C
Pier Diameter	D (mm)	91.5
Channel Width	B (mm)	1220
Water Height	H (mm)	120
Median Grain Size	d50 (mm)	2.4
Flow Intensity	U/Uc	0.85
Duration	hr	48

Blockage Ratio	D/B (%)	7.5
Flow Shallowness	H/D	1.3
Relative Coarseness	D/d50	38.1
Aspect Ratio	B/H	10.2
Equilibrium Scour Depth	dse/D	0.67

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-158.00	-1.43	-1.76	-0.02
-153.00	-3.33	-1.70	-0.04
-148.00	-4.83	-1.64	-0.05
-143.00	-1.63	-1.59	-0.02
-138.00	-6.93	-1.53	-0.08
-133.00	-9.43	-1.48	-0.10
-128.00	-12.63	-1.42	-0.14
-123.00	-15.33	-1.37	-0.17
-118.00	-17.03	-1.31	-0.19
-113.00	-19.83	-1.26	-0.22
-108.00	-25.23	-1.20	-0.28
-103.00	-29.23	-1.14	-0.32
-98.00	-32.33	-1.09	-0.36
-93.00	-34.63	-1.03	-0.38
-88.00	-38.53	-0.98	-0.43
-83.00	-38.33	-0.92	-0.43
-78.00	-45.93	-0.87	-0.51
-73.00	-45.93	-0.81	-0.51
-68.00	-52.33	-0.76	-0.58
-63.00	-58.03	-0.70	-0.64
-58.00	-61.23	-0.64	-0.68
-53.00	-59.83	-0.59	-0.66
-51.00	-60.63	-0.57	-0.67
51.00	-42.23	0.57	-0.47
57.00	-42.13	0.63	-0.47
62.00	-41.33	0.69	-0.46
67.00	-42.53	0.74	-0.47
72.00	-42.13	0.80	-0.47
77.00	-40.63	0.86	-0.45
82.00	-37.93	0.91	-0.42
87.00	-37.53	0.97	-0.42
92.00	-36.73	1.02	-0.41
97.00	-32.73	1.08	-0.36

Edge Contour

x (mm)	y (mm)	x/D	y/D
-156.00	0.00	-1.73	0.00
-154.00	-3.00	-1.71	-0.03
-154.00	-8.00	-1.71	-0.09
-154.00	-13.00	-1.71	-0.14
-153.50	-18.00	-1.71	-0.20
-153.00	-23.00	-1.70	-0.26
-153.00	-28.00	-1.70	-0.31
-152.00	-33.00	-1.69	-0.37
-150.00	-43.00	-1.67	-0.48
-147.00	-53.00	-1.63	-0.59
-145.00	-63.00	-1.61	-0.70
-141.00	-73.00	-1.57	-0.81
-137.00	-83.00	-1.52	-0.92
-129.00	-93.00	-1.43	-1.03
-121.00	-103.00	-1.34	-1.14
-113.00	-113.00	-1.26	-1.26
-108.00	-118.00	-1.20	-1.31
-98.00	-124.00	-1.09	-1.38
-88.00	-130.00	-0.98	-1.44
-78.00	-138.00	-0.87	-1.53
-68.00	-144.00	-0.76	-1.60
-58.00	-146.00	-0.64	-1.62
-48.00	-147.00	-0.53	-1.63
-38.00	-148.00	-0.42	-1.64
-28.00	-149.00	-0.31	-1.66
-18.00	-150.00	-0.20	-1.67
-8.00	-151.00	-0.09	-1.68
2.00	-151.00	0.02	-1.68
12.00	-151.00	0.13	-1.68
22.00	-152.00	0.24	-1.69
32.00	-153.00	0.36	-1.70
42.00	-155.00	0.47	-1.72
52.00	-156.00	0.58	-1.73

102.00	-31.93	1.13	-0.35
107.00	-28.13	1.19	-0.31
112.00	-27.63	1.24	-0.31
117.00	-25.43	1.30	-0.28
122.00	-22.13	1.36	-0.25
127.00	-19.53	1.41	-0.22
132.00	-15.73	1.47	-0.17
137.00	-13.53	1.52	-0.15
142.00	-11.43	1.58	-0.13
147.00	-8.43	1.63	-0.09
152.00	-6.63	1.69	-0.07
157.00	-1.53	1.74	-0.02
162.00	0.57	1.80	0.01
167.00	2.77	1.86	0.03
172.00	6.57	1.91	0.07
177.00	9.57	1.97	0.11
182.00	13.67	2.02	0.15
187.00	15.47	2.08	0.17
192.00	17.07	2.13	0.19
202.00	21.57	2.24	0.24
212.00	26.17	2.36	0.29
222.00	29.37	2.47	0.33
232.00	31.67	2.58	0.35
242.00	36.17	2.69	0.40
252.00	38.77	2.80	0.43
262.00	41.97	2.91	0.47
272.00	43.87	3.02	0.49
282.00	49.37	3.13	0.55
292.00	49.27	3.24	0.55
302.00	49.77	3.36	0.55
312.00	54.27	3.47	0.60
322.00	51.87	3.58	0.58
332.00	50.27	3.69	0.56
342.00	51.47	3.80	0.57
352.00	52.07	3.91	0.58
362.00	53.17	4.02	0.59
372.00	53.77	4.13	0.60
382.00	53.07	4.24	0.59
392.00	54.67	4.36	0.61
402.00	45.37	4.47	0.50
412.00	39.77	4.58	0.44
422.00	27.37	4.69	0.30
432.00	20.57	4.80	0.23
62.00	-158.00	0.69	-1.76
72.00	-158.00	0.80	-1.76
82.00	-157.00	0.91	-1.74
92.00	-156.00	1.02	-1.73
102.00	-154.00	1.13	-1.71
112.00	-153.00	1.24	-1.70
122.00	-153.00	1.36	-1.70
132.00	-152.00	1.47	-1.69
142.00	-152.00	1.58	-1.69
152.00	-152.00	1.69	-1.69
162.00	-153.00	1.80	-1.70
172.00	-153.00	1.91	-1.70
182.00	-153.00	2.02	-1.70
192.00	-153.00	2.13	-1.70
202.00	-152.00	2.24	-1.69
212.00	-152.00	2.36	-1.69
222.00	-152.00	2.47	-1.69
232.00	-153.00	2.58	-1.70
242.00	-153.00	2.69	-1.70
252.00	-156.00	2.80	-1.73
262.00	-158.00	2.91	-1.76
272.00	-159.00	3.02	-1.77
282.00	-159.00	3.13	-1.77
292.00	-162.00	3.24	-1.80
302.00	-164.00	3.36	-1.82
312.00	-165.00	3.47	-1.83
322.00	-167.00	3.58	-1.86
332.00	-169.00	3.69	-1.88
342.00	-168.00	3.80	-1.87
352.00	-171.00	3.91	-1.90
362.00	-172.00	4.02	-1.91
372.00	-172.00	4.13	-1.91
382.00	-171.00	4.24	-1.90
392.00	-169.00	4.36	-1.88
402.00	-168.00	4.47	-1.87
412.00	-167.00	4.58	-1.86
422.00	-166.00	4.69	-1.84
432.00	-165.00	4.80	-1.83
442.00	-163.00	4.91	-1.81
452.00	-157.00	5.02	-1.74
462.00	-153.00	5.13	-1.70
472.00	-148.00	5.24	-1.64
472.00	-92.00	5.24	-1.02

442.00	13.07	4.91	0.15
452.00	9.47	5.02	0.11
462.00	9.67	5.13	0.11
472.00	10.57	5.24	0.12

471.00	-88.00	5.23	-0.98
469.00	-83.00	5.21	-0.92
466.00	-73.00	5.18	-0.81
463.00	-63.00	5.14	-0.70
460.00	-53.00	5.11	-0.59
456.00	-43.00	5.07	-0.48
42.00	-149.00	0.47	-1.66
52.00	-147.00	0.58	-1.63
62.00	-143.00	0.69	-1.59
72.00	-139.00	0.80	-1.54
82.00	-137.00	0.91	-1.52
92.00	-132.00	1.02	-1.47
102.00	-128.00	1.13	-1.42
112.00	-123.00	1.24	-1.37
122.00	-117.00	1.36	-1.30
132.00	-108.00	1.47	-1.20
142.00	-99.00	1.58	-1.10
152.00	-89.00	1.69	-0.99
154.00	-83.00	1.71	-0.92
160.00	-73.00	1.78	-0.81
162.00	-63.00	1.80	-0.70
164.00	-53.00	1.82	-0.59
168.00	-43.00	1.87	-0.48
170.00	-38.00	1.89	-0.42
170.00	-33.00	1.89	-0.37
171.00	-28.00	1.90	-0.31
173.00	-23.00	1.92	-0.26
173.00	-18.00	1.92	-0.20
173.00	-13.00	1.92	-0.14
173.00	-8.00	1.92	-0.09
170.00	-3.00	1.89	-0.03
168.00	2.00	1.87	0.02
473.00	-143.00	5.26	-1.59
477.00	-118.00	5.30	-1.31
475.00	-131.00	5.28	-1.46
475.00	-125.00	5.28	-1.39
475.00	-103.00	5.28	-1.14
474.00	-98.00	5.27	-1.09
475.00	-113.00	5.28	-1.26
475.00	-108.00	5.28	-1.20
473.00	-138.00	5.26	-1.53
-156.00	0.00	-1.73	0.00
-154.00	3.00	-1.71	0.03

-154.00	8.00	-1.71	0.09
-154.00	13.00	-1.71	0.14
-153.50	18.00	-1.71	0.20
-153.00	23.00	-1.70	0.26
-153.00	28.00	-1.70	0.31
-152.00	33.00	-1.69	0.37
-150.00	43.00	-1.67	0.48
-147.00	53.00	-1.63	0.59
-145.00	63.00	-1.61	0.70
-141.00	73.00	-1.57	0.81
-137.00	83.00	-1.52	0.92
-129.00	93.00	-1.43	1.03
-121.00	103.00	-1.34	1.14
-113.00	113.00	-1.26	1.26
-108.00	118.00	-1.20	1.31
-98.00	124.00	-1.09	1.38
-88.00	130.00	-0.98	1.44
-78.00	138.00	-0.87	1.53
-68.00	144.00	-0.76	1.60
-58.00	146.00	-0.64	1.62
-48.00	147.00	-0.53	1.63
-38.00	148.00	-0.42	1.64
-28.00	149.00	-0.31	1.66
-18.00	150.00	-0.20	1.67
-8.00	151.00	-0.09	1.68
2.00	151.00	0.02	1.68
12.00	151.00	0.13	1.68
22.00	152.00	0.24	1.69
32.00	153.00	0.36	1.70
42.00	155.00	0.47	1.72
52.00	156.00	0.58	1.73
62.00	158.00	0.69	1.76
72.00	158.00	0.80	1.76
82.00	157.00	0.91	1.74
92.00	156.00	1.02	1.73
102.00	154.00	1.13	1.71
112.00	153.00	1.24	1.70
122.00	153.00	1.36	1.70
132.00	152.00	1.47	1.69
142.00	152.00	1.58	1.69
152.00	152.00	1.69	1.69
162.00	153.00	1.80	1.70
172.00	153.00	1.91	1.70

182.00	153.00	2.02	1.70
192.00	153.00	2.13	1.70
202.00	152.00	2.24	1.69
212.00	152.00	2.36	1.69
222.00	152.00	2.47	1.69
232.00	153.00	2.58	1.70
242.00	153.00	2.69	1.70
252.00	156.00	2.80	1.73
262.00	158.00	2.91	1.76
272.00	159.00	3.02	1.77
282.00	159.00	3.13	1.77
292.00	162.00	3.24	1.80
302.00	164.00	3.36	1.82
312.00	165.00	3.47	1.83
322.00	167.00	3.58	1.86
332.00	169.00	3.69	1.88
342.00	168.00	3.80	1.87
352.00	171.00	3.91	1.90
362.00	172.00	4.02	1.91
372.00	172.00	4.13	1.91
382.00	171.00	4.24	1.90
392.00	169.00	4.36	1.88
402.00	168.00	4.47	1.87
412.00	167.00	4.58	1.86
422.00	166.00	4.69	1.84
432.00	165.00	4.80	1.83
442.00	163.00	4.91	1.81
452.00	157.00	5.02	1.74
462.00	153.00	5.13	1.70
472.00	148.00	5.24	1.64
472.00	92.00	5.24	1.02
471.00	88.00	5.23	0.98
469.00	83.00	5.21	0.92
466.00	73.00	5.18	0.81
463.00	63.00	5.14	0.70
460.00	53.00	5.11	0.59
456.00	43.00	5.07	0.48
42.00	149.00	0.47	1.66
52.00	147.00	0.58	1.63
62.00	143.00	0.69	1.59
72.00	139.00	0.80	1.54
82.00	137.00	0.91	1.52
92.00	132.00	1.02	1.47

102.00	128.00	1.13	1.42
112.00	123.00	1.24	1.37
122.00	117.00	1.36	1.30
132.00	108.00	1.47	1.20
142.00	99.00	1.58	1.10
152.00	89.00	1.69	0.99
154.00	83.00	1.71	0.92
160.00	73.00	1.78	0.81
162.00	63.00	1.80	0.70
164.00	53.00	1.82	0.59
168.00	43.00	1.87	0.48
170.00	38.00	1.89	0.42
170.00	33.00	1.89	0.37
171.00	28.00	1.90	0.31
173.00	23.00	1.92	0.26
173.00	18.00	1.92	0.20
173.00	13.00	1.92	0.14
173.00	8.00	1.92	0.09
170.00	3.00	1.89	0.03
168.00	-2.00	1.87	-0.02
473.00	143.00	5.26	1.59
477.00	118.00	5.30	1.31
475.00	131.00	5.28	1.46
475.00	125.00	5.28	1.39
475.00	103.00	5.28	1.14
474.00	98.00	5.27	1.09
475.00	113.00	5.28	1.26
475.00	108.00	5.28	1.20
473.00	138.00	5.26	1.53
430.00	0.00	4.78	0.00
435.00	9.00	4.83	0.10
440.00	18.00	4.89	0.20
450.00	35.00	5.00	0.39
430.00	0.00	4.78	0.00
435.00	-9.00	4.83	-0.10
440.00	-18.00	4.89	-0.20
450.00	-35.00	5.00	-0.39

Experiment No P2S3-F

Pier Diameter D (mm) 25.9

Channel Width	B (mm)	259
Water Height	H (mm)	120
Median Grain Size	d50 (mm)	0.51
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	10
Flow Shallowness	H/D	4.6
Relative Coarseness	D/d50	50.8
Aspect Ratio	B/H	2.2
Equilibrium Scour Depth	dse/D	1.28

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-93.50	-0.60	-3.61	-0.02
-88.50	0.40	-3.42	0.02
-83.50	-0.80	-3.22	-0.03
-78.50	-0.80	-3.03	-0.03
-73.50	-3.10	-2.84	-0.12
-68.50	-6.00	-2.64	-0.23
-63.50	-8.90	-2.45	-0.34
-58.50	-12.60	-2.26	-0.49
-53.50	-16.10	-2.07	-0.62
-48.50	-19.50	-1.87	-0.75
-43.50	-22.40	-1.68	-0.86
-38.50	-24.00	-1.49	-0.93
-33.50	-26.70	-1.29	-1.03
-28.50	-30.50	-1.10	-1.18
-23.50	-33.30	-0.91	-1.29
-18.50	-31.80	-0.71	-1.23
-15.50	-31.50	-0.60	-1.22
15.50	-26.10	0.60	-1.01
16.50	-25.70	0.64	-0.99
21.50	-24.50	0.83	-0.95
26.50	-22.50	1.02	-0.87
31.50	-19.20	1.22	-0.74
36.50	-15.60	1.41	-0.60
41.50	-11.50	1.60	-0.44
46.50	-8.30	1.80	-0.32
51.50	-4.90	1.99	-0.19
56.50	-2.50	2.18	-0.10
61.50	0.30	2.37	0.01

Edge Contour

x (mm)	y (mm)	x/D	y/D
-81.50	0.00	-3.15	0.00
-81.50	-4.00	-3.15	-0.15
-81.50	-9.00	-3.15	-0.35
-81.50	-14.00	-3.15	-0.54
-78.50	-19.00	-3.03	-0.73
-76.50	-24.00	-2.95	-0.93
-73.50	-29.00	-2.84	-1.12
-71.50	-34.00	-2.76	-1.31
-67.50	-39.00	-2.61	-1.51
-67.50	-44.00	-2.61	-1.70
-63.50	-49.00	-2.45	-1.89
-58.50	-54.00	-2.26	-2.08
-53.50	-59.00	-2.07	-2.28
-47.50	-64.00	-1.83	-2.47
-41.50	-69.00	-1.60	-2.66
-38.50	-71.00	-1.49	-2.74
-33.50	-74.00	-1.29	-2.86
-28.50	-75.00	-1.10	-2.90
-23.50	-78.00	-0.91	-3.01
-18.50	-80.00	-0.71	-3.09
-8.50	-83.00	-0.33	-3.20
1.50	-85.00	0.06	-3.28
11.50	-88.00	0.44	-3.40
21.50	-90.00	0.83	-3.47
31.50	-92.00	1.22	-3.55
41.50	-92.00	1.60	-3.55
51.50	-95.00	1.99	-3.67
61.50	-100.00	2.37	-3.86

66.50	3.50	2.57	0.14
71.50	5.00	2.76	0.19
76.50	7.60	2.95	0.29
81.50	10.00	3.15	0.39
86.50	12.40	3.34	0.48
91.50	14.10	3.53	0.54
96.50	16.10	3.73	0.62
101.50	18.50	3.92	0.71
106.50	20.10	4.11	0.78
111.50	21.60	4.31	0.83
121.50	24.60	4.69	0.95
131.50	27.40	5.08	1.06
141.50	30.30	5.46	1.17
151.50	32.00	5.85	1.24
161.50	33.50	6.24	1.29
166.50	30.90	6.43	1.19
171.50	28.90	6.62	1.12
176.50	23.90	6.81	0.92
181.50	20.70	7.01	0.80
186.50	15.70	7.20	0.61
191.50	13.60	7.39	0.53
196.50	11.10	7.59	0.43
201.50	11.10	7.78	0.43
211.50	8.40	8.17	0.32
221.50	8.30	8.55	0.32
231.50	6.40	8.94	0.25
241.50	5.90	9.32	0.23
251.50	5.50	9.71	0.21
261.50	4.50	10.10	0.17
271.50	4.30	10.48	0.17
281.50	4.70	10.87	0.18

71.50	-105.00	2.76	-4.05
81.50	-113.00	3.15	-4.36
91.50	-119.00	3.53	-4.59
46.50	-93.00	1.80	-3.59
51.50	-89.00	1.99	-3.44
59.50	-84.00	2.30	-3.24
66.50	-79.00	2.57	-3.05
73.50	-74.00	2.84	-2.86
76.50	-69.00	2.95	-2.66
80.50	-64.00	3.11	-2.47
83.50	-59.00	3.22	-2.28
84.50	-54.00	3.26	-2.08
86.50	-49.00	3.34	-1.89
86.50	-44.00	3.34	-1.70
85.50	-39.00	3.30	-1.51
82.50	-34.00	3.19	-1.31
81.50	-29.00	3.15	-1.12
80.50	-24.00	3.11	-0.93
78.50	-19.00	3.03	-0.73
76.50	-14.00	2.95	-0.54
75.50	-9.00	2.92	-0.35
71.50	-4.00	2.76	-0.15
69.50	0.00	2.68	0.00
-81.50	0.00	-3.15	0.00
-81.50	4.00	-3.15	0.15
-81.50	9.00	-3.15	0.35
-81.50	14.00	-3.15	0.54
-78.50	19.00	-3.03	0.73
-76.50	24.00	-2.95	0.93
-73.50	29.00	-2.84	1.12
-71.50	34.00	-2.76	1.31
-67.50	39.00	-2.61	1.51
-67.50	44.00	-2.61	1.70
-63.50	49.00	-2.45	1.89
-58.50	54.00	-2.26	2.08
-53.50	59.00	-2.07	2.28
-47.50	64.00	-1.83	2.47
-41.50	69.00	-1.60	2.66
-38.50	71.00	-1.49	2.74
-33.50	74.00	-1.29	2.86
-28.50	75.00	-1.10	2.90
-23.50	78.00	-0.91	3.01
-18.50	80.00	-0.71	3.09

-8.50	83.00	-0.33	3.20
1.50	85.00	0.06	3.28
11.50	88.00	0.44	3.40
21.50	90.00	0.83	3.47
31.50	92.00	1.22	3.55
41.50	92.00	1.60	3.55
51.50	95.00	1.99	3.67
61.50	100.00	2.37	3.86
71.50	105.00	2.76	4.05
81.50	113.00	3.15	4.36
91.50	119.00	3.53	4.59
46.50	93.00	1.80	3.59
51.50	89.00	1.99	3.44
59.50	84.00	2.30	3.24
66.50	79.00	2.57	3.05
73.50	74.00	2.84	2.86
76.50	69.00	2.95	2.66
80.50	64.00	3.11	2.47
83.50	59.00	3.22	2.28
84.50	54.00	3.26	2.08
86.50	49.00	3.34	1.89
86.50	44.00	3.34	1.70
85.50	39.00	3.30	1.51
82.50	34.00	3.19	1.31
81.50	29.00	3.15	1.12
80.50	24.00	3.11	0.93
78.50	19.00	3.03	0.73
76.50	14.00	2.95	0.54
75.50	9.00	2.92	0.35
71.50	4.00	2.76	0.15
69.50	0.00	2.68	0.00

Experiment	No	P2S3-MF
Pier Diameter	D (mm)	39.1
Channel Width	B (mm)	391
Water Height	H (mm)	120
Median Grain Size	d50 (mm)	0.77
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	10
Flow Shallowness	H/D	3.1

Relative Coarseness	D/d50	50.8
Aspect Ratio	B/H	3.3
Equilibrium Scour Depth	dse/D	1.26

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-129.50	-2.30	-3.40	-0.06
-124.50	-0.60	-3.27	-0.02
-119.50	-1.30	-3.14	-0.03
-114.50	0.00	-3.01	0.00
-109.50	-1.60	-2.87	-0.04
-104.50	-2.30	-2.74	-0.06
-99.50	-3.70	-2.61	-0.10
-94.50	-6.80	-2.48	-0.18
-89.50	-8.40	-2.35	-0.22
-84.50	-12.00	-2.22	-0.31
-79.50	-15.00	-2.09	-0.39
-74.50	-18.20	-1.96	-0.48
-69.50	-20.60	-1.82	-0.54
-64.50	-22.80	-1.69	-0.60
-59.50	-27.30	-1.56	-0.72
-54.50	-28.20	-1.43	-0.74
-49.50	-30.90	-1.30	-0.81
-44.50	-35.30	-1.17	-0.93
-39.50	-40.30	-1.04	-1.06
-34.50	-43.50	-0.91	-1.14
-29.50	-49.40	-0.77	-1.30
-24.50	-49.40	-0.64	-1.30
-20.50	-49.20	-0.54	-1.29
20.50	-27.30	0.54	-0.72
25.50	-28.00	0.67	-0.73
30.50	-27.90	0.80	-0.73
35.50	-26.10	0.93	-0.69
40.50	-24.00	1.06	-0.63
45.50	-20.70	1.19	-0.54
50.50	-17.60	1.33	-0.46
55.50	-14.40	1.46	-0.38
60.50	-11.00	1.59	-0.29
65.50	-7.80	1.72	-0.20
70.50	-4.10	1.85	-0.11
75.50	-1.00	1.98	-0.03

Edge Contour

x (mm)	y (mm)	x/D	y/D
-112.50	0.00	-2.95	0.00
-112.50	2.50	-2.95	0.07
-110.50	7.50	-2.90	0.20
-108.50	12.50	-2.85	0.33
-107.50	17.50	-2.82	0.46
-106.50	22.50	-2.80	0.59
-105.00	27.50	-2.76	0.72
-103.00	32.50	-2.70	0.85
-100.00	37.50	-2.62	0.98
-97.50	42.50	-2.56	1.12
-94.00	47.50	-2.47	1.25
-90.50	52.50	-2.38	1.38
-84.50	56.50	-2.22	1.48
-79.50	62.50	-2.09	1.64
-74.50	67.50	-1.96	1.77
-69.50	74.00	-1.82	1.94
-64.50	79.00	-1.69	2.07
-59.50	84.50	-1.56	2.22
-54.50	87.00	-1.43	2.28
-49.50	89.50	-1.30	2.35
-44.50	92.00	-1.17	2.41
-39.50	93.50	-1.04	2.45
-29.50	96.00	-0.77	2.52
-19.50	98.00	-0.51	2.57
-9.50	100.00	-0.25	2.62
0.50	103.00	0.01	2.70
10.50	104.00	0.28	2.73
20.50	103.50	0.54	2.72
30.50	103.50	0.80	2.72
40.50	103.50	1.06	2.72
50.50	104.50	1.33	2.74
60.50	105.00	1.59	2.76
70.50	104.00	1.85	2.73
80.50	105.00	2.11	2.76
90.50	105.00	2.38	2.76

80.50	1.50	2.11	0.04
85.50	4.30	2.24	0.11
90.50	8.30	2.38	0.22
95.50	10.90	2.51	0.29
100.50	12.60	2.64	0.33
105.50	15.10	2.77	0.40
110.50	17.10	2.90	0.45
120.50	20.50	3.16	0.54
130.50	24.20	3.43	0.64
140.50	27.00	3.69	0.71
150.50	29.70	3.95	0.78
160.50	31.70	4.21	0.83
170.50	33.00	4.48	0.87
180.50	34.20	4.74	0.90
190.50	36.00	5.00	0.94
200.50	36.20	5.26	0.95
210.50	36.50	5.52	0.96
220.50	36.50	5.79	0.96
230.50	36.10	6.05	0.95
240.50	28.40	6.31	0.75
250.50	19.60	6.57	0.51
260.50	11.60	6.84	0.30
270.50	10.00	7.10	0.26
280.50	8.30	7.36	0.22
290.50	5.70	7.62	0.15
300.50	3.20	7.89	0.08
310.50	1.40	8.15	0.04
320.50	-0.40	8.41	-0.01
330.50	-1.70	8.67	-0.04
340.50	-2.70	8.94	-0.07
350.50	-3.70	9.20	-0.10
360.50	-3.90	9.46	-0.10
370.50	-3.40	9.72	-0.09
380.50	-3.50	9.99	-0.09
390.50	-2.40	10.25	-0.06

100.50	108.50	2.64	2.85
110.50	109.50	2.90	2.87
120.50	110.50	3.16	2.90
130.50	111.00	3.43	2.91
140.50	111.50	3.69	2.93
150.50	112.50	3.95	2.95
160.50	116.50	4.21	3.06
170.50	118.50	4.48	3.11
180.50	118.00	4.74	3.10
190.50	116.00	5.00	3.04
200.50	115.50	5.26	3.03
210.50	113.50	5.52	2.98
220.50	113.00	5.79	2.97
230.50	111.00	6.05	2.91
240.50	107.00	6.31	2.81
250.50	107.00	6.57	2.81
260.50	110.50	6.84	2.90
270.50	115.00	7.10	3.02
280.50	119.00	7.36	3.12
290.50	122.00	7.62	3.20
300.50	125.50	7.89	3.29
310.50	128.50	8.15	3.37
320.50	130.00	8.41	3.41
330.50	130.00	8.67	3.41
340.50	128.00	8.94	3.36
350.50	125.00	9.20	3.28
360.50	121.50	9.46	3.19
370.50	117.50	9.72	3.08
380.50	113.50	9.99	2.98
390.50	116.00	10.25	3.04
400.50	114.00	10.51	2.99
410.50	113.00	10.77	2.97
420.50	112.00	11.04	2.94
430.50	111.50	11.30	2.93
440.50	111.00	11.56	2.91
450.50	111.00	11.82	2.91
460.50	111.00	12.09	2.91
470.50	109.00	12.35	2.86
480.50	109.00	12.61	2.86
490.50	109.00	12.87	2.86
500.50	106.00	13.14	2.78
510.50	106.00	13.40	2.78
520.50	107.50	13.66	2.82

25.50	104.50	0.67	2.74
30.50	103.50	0.80	2.72
40.50	101.00	1.06	2.65
50.50	96.50	1.33	2.53
60.50	90.50	1.59	2.38
70.50	84.50	1.85	2.22
80.50	71.50	2.11	1.88
84.00	61.50	2.20	1.61
86.00	51.50	2.26	1.35
86.00	41.50	2.26	1.09
85.00	31.50	2.23	0.83
83.00	21.50	2.18	0.56
80.50	11.50	2.11	0.30
78.50	1.50	2.06	0.04
78.00	0.00	2.05	0.00
-112.50	0.00	-2.95	0.00
-112.50	-2.50	-2.95	-0.07
-110.50	-7.50	-2.90	-0.20
-108.50	-12.50	-2.85	-0.33
-107.50	-17.50	-2.82	-0.46
-106.50	-22.50	-2.80	-0.59
-105.00	-27.50	-2.76	-0.72
-103.00	-32.50	-2.70	-0.85
-100.00	-37.50	-2.62	-0.98
-97.50	-42.50	-2.56	-1.12
-94.00	-47.50	-2.47	-1.25
-90.50	-52.50	-2.38	-1.38
-84.50	-56.50	-2.22	-1.48
-79.50	-62.50	-2.09	-1.64
-74.50	-67.50	-1.96	-1.77
-69.50	-74.00	-1.82	-1.94
-64.50	-79.00	-1.69	-2.07
-59.50	-84.50	-1.56	-2.22
-54.50	-87.00	-1.43	-2.28
-49.50	-89.50	-1.30	-2.35
-44.50	-92.00	-1.17	-2.41
-39.50	-93.50	-1.04	-2.45
-29.50	-96.00	-0.77	-2.52
-19.50	-98.00	-0.51	-2.57
-9.50	-100.00	-0.25	-2.62
0.50	-103.00	0.01	-2.70
10.50	-104.00	0.28	-2.73
20.50	-103.50	0.54	-2.72

30.50	-103.50	0.80	-2.72
40.50	-103.50	1.06	-2.72
50.50	-104.50	1.33	-2.74
60.50	-105.00	1.59	-2.76
70.50	-104.00	1.85	-2.73
80.50	-105.00	2.11	-2.76
90.50	-105.00	2.38	-2.76
100.50	-108.50	2.64	-2.85
110.50	-109.50	2.90	-2.87
120.50	-110.50	3.16	-2.90
130.50	-111.00	3.43	-2.91
140.50	-111.50	3.69	-2.93
150.50	-112.50	3.95	-2.95
160.50	-116.50	4.21	-3.06
170.50	-118.50	4.48	-3.11
180.50	-118.00	4.74	-3.10
190.50	-116.00	5.00	-3.04
200.50	-115.50	5.26	-3.03
210.50	-113.50	5.52	-2.98
220.50	-113.00	5.79	-2.97
230.50	-111.00	6.05	-2.91
240.50	-107.00	6.31	-2.81
250.50	-107.00	6.57	-2.81
260.50	-110.50	6.84	-2.90
270.50	-115.00	7.10	-3.02
280.50	-119.00	7.36	-3.12
290.50	-122.00	7.62	-3.20
300.50	-125.50	7.89	-3.29
310.50	-128.50	8.15	-3.37
320.50	-130.00	8.41	-3.41
330.50	-130.00	8.67	-3.41
340.50	-128.00	8.94	-3.36
350.50	-125.00	9.20	-3.28
360.50	-121.50	9.46	-3.19
370.50	-117.50	9.72	-3.08
380.50	-113.50	9.99	-2.98
390.50	-116.00	10.25	-3.04
400.50	-114.00	10.51	-2.99
410.50	-113.00	10.77	-2.97
420.50	-112.00	11.04	-2.94
430.50	-111.50	11.30	-2.93
440.50	-111.00	11.56	-2.91
450.50	-111.00	11.82	-2.91

460.50	-111.00	12.09	-2.91
470.50	-109.00	12.35	-2.86
480.50	-109.00	12.61	-2.86
490.50	-109.00	12.87	-2.86
500.50	-106.00	13.14	-2.78
510.50	-106.00	13.40	-2.78
520.50	-107.50	13.66	-2.82
25.50	-104.50	0.67	-2.74
30.50	-103.50	0.80	-2.72
40.50	-101.00	1.06	-2.65
50.50	-96.50	1.33	-2.53
60.50	-90.50	1.59	-2.38
70.50	-84.50	1.85	-2.22
80.50	-71.50	2.11	-1.88
84.00	-61.50	2.20	-1.61
86.00	-51.50	2.26	-1.35
86.00	-41.50	2.26	-1.09
85.00	-31.50	2.23	-0.83
83.00	-21.50	2.18	-0.56
80.50	-11.50	2.11	-0.30
78.50	-1.50	2.06	-0.04
78.00	0.00	2.05	0.00

Experiment	No	P2S3-MC
Pier Diameter	D (mm)	83
Channel Width	B (mm)	830
Water Height	H (mm)	120
Median Grain Size	d50 (mm)	1.63
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	10
Flow Shallowness	H/D	1.45
Relative Coarseness	D/d50	50.8
Aspect Ratio	B/H	6.9
Equilibrium Scour Depth	dse/D	0.49

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-116.50	-2.10	-1.40	-0.03
-111.50	-0.70	-1.34	-0.01

Edge Contour

x (mm)	y (mm)	x/D	y/D
-106.50	0.00	-1.28	0.00
-106.50	-7.00	-1.28	-0.08

-106.50	-2.70	-1.28	-0.03
-101.50	-3.10	-1.22	-0.04
-96.50	-4.80	-1.16	-0.06
-91.50	-7.10	-1.10	-0.09
-86.50	-11.00	-1.04	-0.13
-81.50	-11.60	-0.98	-0.14
-76.50	-17.80	-0.92	-0.21
-71.50	-19.40	-0.86	-0.23
-66.50	-23.70	-0.80	-0.29
-61.50	-27.20	-0.74	-0.33
-56.50	-30.80	-0.68	-0.37
-51.50	-34.80	-0.62	-0.42
-46.50	-36.30	-0.56	-0.44
-43.50	-40.50	-0.52	-0.49
43.50	-30.50	0.52	-0.37
48.50	-31.40	0.58	-0.38
53.50	-32.40	0.64	-0.39
58.50	-32.70	0.70	-0.39
63.50	-32.40	0.77	-0.39
68.50	-33.10	0.83	-0.40
73.50	-32.50	0.89	-0.39
78.50	-31.00	0.95	-0.37
83.50	-30.60	1.01	-0.37
88.50	-28.00	1.07	-0.34
93.50	-26.40	1.13	-0.32
98.50	-24.50	1.19	-0.30
103.50	-21.00	1.25	-0.25
108.50	-17.90	1.31	-0.22
113.50	-18.20	1.37	-0.22
118.50	-15.80	1.43	-0.19
123.50	-13.40	1.49	-0.16
128.50	-10.40	1.55	-0.13
133.50	-8.10	1.61	-0.10
138.50	-4.30	1.67	-0.05
143.50	-2.10	1.73	-0.03
148.50	1.40	1.79	0.02
153.50	3.00	1.85	0.04
158.50	2.90	1.91	0.03
163.50	6.90	1.97	0.08
168.50	9.40	2.03	0.11
173.50	11.20	2.09	0.13
178.50	14.50	2.15	0.17
183.50	16.60	2.21	0.20

-106.50	-12.00	-1.28	-0.14
-106.50	-17.00	-1.28	-0.20
-106.50	-22.00	-1.28	-0.27
-105.50	-27.00	-1.27	-0.33
-104.50	-32.00	-1.26	-0.39
-103.00	-37.00	-1.24	-0.45
-102.00	-42.00	-1.23	-0.51
-99.50	-47.00	-1.20	-0.57
-99.00	-52.00	-1.19	-0.63
-98.00	-57.00	-1.18	-0.69
-94.50	-62.00	-1.14	-0.75
-92.50	-67.00	-1.11	-0.81
-89.50	-72.00	-1.08	-0.87
-87.00	-77.00	-1.05	-0.93
-83.50	-82.00	-1.01	-0.99
-80.00	-87.00	-0.96	-1.05
-75.50	-92.00	-0.91	-1.11
-71.50	-96.00	-0.86	-1.16
-66.50	-99.00	-0.80	-1.19
-61.50	-102.50	-0.74	-1.23
-56.50	-106.00	-0.68	-1.28
-51.50	-110.00	-0.62	-1.33
-46.50	-111.00	-0.56	-1.34
-41.50	-112.00	-0.50	-1.35
-31.50	-116.00	-0.38	-1.40
-21.50	-117.50	-0.26	-1.42
-11.50	-121.00	-0.14	-1.46
-1.50	-122.00	-0.02	-1.47
8.50	-122.00	0.10	-1.47
18.50	-120.00	0.22	-1.45
28.50	-117.00	0.34	-1.41
38.50	-117.00	0.46	-1.41
48.50	-117.00	0.58	-1.41
58.50	-117.00	0.70	-1.41
68.50	-116.00	0.83	-1.40
78.50	-116.00	0.95	-1.40
88.50	-114.00	1.07	-1.37
98.50	-113.50	1.19	-1.37
108.50	-113.00	1.31	-1.36
118.50	-113.00	1.43	-1.36
128.50	-113.00	1.55	-1.36
138.50	-113.00	1.67	-1.36
148.50	-113.00	1.79	-1.36

188.50	20.30	2.27	0.24
198.50	22.00	2.39	0.27
208.50	26.90	2.51	0.32
218.50	29.90	2.63	0.36
228.50	31.60	2.75	0.38
238.50	34.30	2.87	0.41
248.50	36.50	2.99	0.44
258.50	38.40	3.11	0.46
268.50	40.20	3.23	0.48
278.50	41.20	3.36	0.50
288.50	41.00	3.48	0.49
298.50	32.90	3.60	0.40
308.50	23.40	3.72	0.28
318.50	16.10	3.84	0.19
328.50	7.00	3.96	0.08
338.50	6.30	4.08	0.08
348.50	6.70	4.20	0.08
358.50	7.50	4.32	0.09
368.50	5.80	4.44	0.07
378.50	4.10	4.56	0.05
388.50	5.40	4.68	0.07
398.50	5.60	4.80	0.07
408.50	5.80	4.92	0.07
418.50	7.40	5.04	0.09

158.50	-113.00	1.91	-1.36
168.50	-113.00	2.03	-1.36
178.50	-112.00	2.15	-1.35
188.50	-110.00	2.27	-1.33
198.50	-110.00	2.39	-1.33
208.50	-110.00	2.51	-1.33
218.50	-111.00	2.63	-1.34
228.50	-112.00	2.75	-1.35
238.50	-112.00	2.87	-1.35
248.50	-112.00	2.99	-1.35
258.50	-111.00	3.11	-1.34
268.50	-110.50	3.23	-1.33
278.50	-108.00	3.36	-1.30
288.50	-106.50	3.48	-1.28
298.50	-106.50	3.60	-1.28
308.50	-108.00	3.72	-1.30
318.50	-108.00	3.84	-1.30
328.50	-105.50	3.96	-1.27
338.50	-100.50	4.08	-1.21
348.50	-87.50	4.20	-1.05
348.50	-82.00	4.20	-0.99
347.50	-72.00	4.19	-0.87
343.50	-62.00	4.14	-0.75
339.50	-52.00	4.09	-0.63
335.50	-42.00	4.04	-0.51
344.50	-32.00	4.15	-0.39
348.50	-31.00	4.20	-0.37
358.50	-28.00	4.32	-0.34
368.50	-23.00	4.44	-0.28
378.50	-23.00	4.56	-0.28
388.50	-22.00	4.68	-0.27
398.50	-22.00	4.80	-0.27
408.50	-23.00	4.92	-0.28
418.50	-24.00	5.04	-0.29
428.50	-28.00	5.16	-0.34
438.50	-37.00	5.28	-0.45
448.50	-42.00	5.40	-0.51
458.50	-43.00	5.52	-0.52
468.50	-44.00	5.64	-0.53
157.50	0.00	1.90	0.00
157.50	-7.00	1.90	-0.08
157.50	-12.00	1.90	-0.14
156.50	-22.00	1.89	-0.27

154.50	-32.00	1.86	-0.39
150.50	-42.00	1.81	-0.51
148.50	-46.00	1.79	-0.55
138.50	-48.50	1.67	-0.58
128.50	-52.00	1.55	-0.63
118.50	-56.50	1.43	-0.68
108.50	-62.00	1.31	-0.75
98.50	-69.00	1.19	-0.83
88.50	-77.00	1.07	-0.93
78.50	-83.00	0.95	-1.00
68.50	-94.00	0.83	-1.13
58.50	-99.00	0.70	-1.19
48.50	-103.50	0.58	-1.25
38.50	-109.50	0.46	-1.32
-106.50	0.00	-1.28	0.00
-106.50	7.00	-1.28	0.08
-106.50	12.00	-1.28	0.14
-106.50	17.00	-1.28	0.20
-106.50	22.00	-1.28	0.27
-105.50	27.00	-1.27	0.33
-104.50	32.00	-1.26	0.39
-103.00	37.00	-1.24	0.45
-102.00	42.00	-1.23	0.51
-99.50	47.00	-1.20	0.57
-99.00	52.00	-1.19	0.63
-98.00	57.00	-1.18	0.69
-94.50	62.00	-1.14	0.75
-92.50	67.00	-1.11	0.81
-89.50	72.00	-1.08	0.87
-87.00	77.00	-1.05	0.93
-83.50	82.00	-1.01	0.99
-80.00	87.00	-0.96	1.05
-75.50	92.00	-0.91	1.11
-71.50	96.00	-0.86	1.16
-66.50	99.00	-0.80	1.19
-61.50	102.50	-0.74	1.23
-56.50	106.00	-0.68	1.28
-51.50	110.00	-0.62	1.33
-46.50	111.00	-0.56	1.34
-41.50	112.00	-0.50	1.35
-31.50	116.00	-0.38	1.40
-21.50	117.50	-0.26	1.42
-11.50	121.00	-0.14	1.46

-1.50	122.00	-0.02	1.47
8.50	122.00	0.10	1.47
18.50	120.00	0.22	1.45
28.50	117.00	0.34	1.41
38.50	117.00	0.46	1.41
48.50	117.00	0.58	1.41
58.50	117.00	0.70	1.41
68.50	116.00	0.83	1.40
78.50	116.00	0.95	1.40
88.50	114.00	1.07	1.37
98.50	113.50	1.19	1.37
108.50	113.00	1.31	1.36
118.50	113.00	1.43	1.36
128.50	113.00	1.55	1.36
138.50	113.00	1.67	1.36
148.50	113.00	1.79	1.36
158.50	113.00	1.91	1.36
168.50	113.00	2.03	1.36
178.50	112.00	2.15	1.35
188.50	110.00	2.27	1.33
198.50	110.00	2.39	1.33
208.50	110.00	2.51	1.33
218.50	111.00	2.63	1.34
228.50	112.00	2.75	1.35
238.50	112.00	2.87	1.35
248.50	112.00	2.99	1.35
258.50	111.00	3.11	1.34
268.50	110.50	3.23	1.33
278.50	108.00	3.36	1.30
288.50	106.50	3.48	1.28
298.50	106.50	3.60	1.28
308.50	108.00	3.72	1.30
318.50	108.00	3.84	1.30
328.50	105.50	3.96	1.27
338.50	100.50	4.08	1.21
348.50	87.50	4.20	1.05
348.50	82.00	4.20	0.99
347.50	72.00	4.19	0.87
343.50	62.00	4.14	0.75
339.50	52.00	4.09	0.63
335.50	42.00	4.04	0.51
344.50	32.00	4.15	0.39
348.50	31.00	4.20	0.37

358.50	28.00	4.32	0.34
368.50	23.00	4.44	0.28
378.50	23.00	4.56	0.28
388.50	22.00	4.68	0.27
398.50	22.00	4.80	0.27
408.50	23.00	4.92	0.28
418.50	24.00	5.04	0.29
428.50	28.00	5.16	0.34
438.50	37.00	5.28	0.45
448.50	42.00	5.40	0.51
458.50	43.00	5.52	0.52
468.50	44.00	5.64	0.53
157.50	0.00	1.90	0.00
157.50	7.00	1.90	0.08
157.50	12.00	1.90	0.14
156.50	22.00	1.89	0.27
154.50	32.00	1.86	0.39
150.50	42.00	1.81	0.51
148.50	46.00	1.79	0.55
138.50	48.50	1.67	0.58
128.50	52.00	1.55	0.63
118.50	56.50	1.43	0.68
108.50	62.00	1.31	0.75
98.50	69.00	1.19	0.83
88.50	77.00	1.07	0.93
78.50	83.00	0.95	1.00
68.50	94.00	0.83	1.13
58.50	99.00	0.70	1.19
48.50	103.50	0.58	1.25
38.50	109.50	0.46	1.32

Experiment	No	P2S3-C
Pier Diameter	D (mm)	122
Channel Width	B (mm)	1220
Water Height	H (mm)	120
Median Grain Size	d50 (mm)	2.4
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	10
Flow Shallowness	H/D	0.98
Relative Coarseness	D/d50	50.8

Aspect Ratio	B/H	10.2
Equilibrium Scour Depth	dse/D	0.59

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-195.00	-2.60	-1.60	-0.02
-190.00	-2.10	-1.56	-0.02
-185.00	-4.00	-1.52	-0.03
-180.00	-5.60	-1.48	-0.05
-175.00	-3.20	-1.43	-0.03
-170.00	-7.70	-1.39	-0.06
-165.00	-9.90	-1.35	-0.08
-160.00	-8.20	-1.31	-0.07
-155.00	-14.20	-1.27	-0.12
-150.00	-15.90	-1.23	-0.13
-145.00	-16.50	-1.19	-0.14
-140.00	-25.30	-1.15	-0.21
-135.00	-27.60	-1.11	-0.23
-130.00	-28.20	-1.07	-0.23
-125.00	-33.80	-1.02	-0.28
-120.00	-37.20	-0.98	-0.30
-115.00	-40.60	-0.94	-0.33
-110.00	-39.20	-0.90	-0.32
-105.00	-46.80	-0.86	-0.38
-100.00	-48.80	-0.82	-0.40
-95.00	-51.90	-0.78	-0.43
-90.00	-58.00	-0.74	-0.48
-85.00	-59.10	-0.70	-0.48
-80.00	-65.50	-0.66	-0.54
-75.00	-66.90	-0.61	-0.55
-70.00	-70.60	-0.57	-0.58
-65.00	-71.40	-0.53	-0.59
65.00	-43.00	0.53	-0.35
70.00	-46.40	0.57	-0.38
75.00	-43.90	0.61	-0.36
80.00	-47.70	0.66	-0.39
85.00	-48.30	0.70	-0.40
90.00	-48.90	0.74	-0.40
95.00	-51.50	0.78	-0.42
100.00	-51.40	0.82	-0.42
105.00	-50.10	0.86	-0.41

Edge Contour

x (mm)	y (mm)	x/D	y/D
-181.00	0.00	-1.48	0.00
-181.00	-4.00	-1.48	-0.03
-181.00	-9.00	-1.48	-0.07
-180.00	-14.00	-1.48	-0.11
-180.00	-19.00	-1.48	-0.16
-180.00	-24.00	-1.48	-0.20
-180.00	-29.00	-1.48	-0.24
-180.00	-34.00	-1.48	-0.28
-178.00	-39.00	-1.46	-0.32
-178.00	-44.00	-1.46	-0.36
-176.00	-49.00	-1.44	-0.40
-176.00	-54.00	-1.44	-0.44
-175.00	-59.00	-1.43	-0.48
-174.00	-64.00	-1.43	-0.52
-173.00	-69.00	-1.42	-0.57
-172.00	-74.00	-1.41	-0.61
-170.00	-79.00	-1.39	-0.65
-168.00	-84.00	-1.38	-0.69
-165.00	-89.00	-1.35	-0.73
-165.00	-94.00	-1.35	-0.77
-164.00	-99.00	-1.34	-0.81
-162.00	-104.00	-1.33	-0.85
-159.00	-109.00	-1.30	-0.89
-157.00	-114.00	-1.29	-0.93
-153.00	-119.00	-1.25	-0.98
-145.00	-129.00	-1.19	-1.06
-135.00	-143.00	-1.11	-1.17
-125.00	-153.00	-1.02	-1.25
-115.00	-162.00	-0.94	-1.33
-105.00	-168.00	-0.86	-1.38
-95.00	-173.00	-0.78	-1.42
-85.00	-174.00	-0.70	-1.43
-75.00	-176.00	-0.61	-1.44
-65.00	-180.00	-0.53	-1.48
-55.00	-183.00	-0.45	-1.50
-45.00	-188.00	-0.37	-1.54

110.00	-48.60	0.90	-0.40	-35.00	-189.00	-0.29	-1.55
115.00	-50.00	0.94	-0.41	-25.00	-193.00	-0.20	-1.58
120.00	-49.10	0.98	-0.40	-15.00	-194.00	-0.12	-1.59
125.00	-46.00	1.02	-0.38	-5.00	-195.00	-0.04	-1.60
130.00	-46.20	1.07	-0.38	5.00	-197.00	0.04	-1.61
135.00	-44.10	1.11	-0.36	15.00	-197.00	0.12	-1.61
140.00	-41.60	1.15	-0.34	25.00	-195.00	0.20	-1.60
145.00	-40.10	1.19	-0.33	35.00	-195.00	0.29	-1.60
150.00	-37.60	1.23	-0.31	45.00	-194.00	0.37	-1.59
155.00	-35.40	1.27	-0.29	55.00	-192.00	0.45	-1.57
160.00	-34.90	1.31	-0.29	65.00	-191.00	0.53	-1.57
165.00	-31.40	1.35	-0.26	75.00	-190.00	0.61	-1.56
170.00	-29.70	1.39	-0.24	85.00	-189.00	0.70	-1.55
175.00	-24.50	1.43	-0.20	95.00	-189.00	0.78	-1.55
180.00	-23.90	1.48	-0.20	105.00	-190.00	0.86	-1.56
185.00	-23.80	1.52	-0.20	115.00	-191.00	0.94	-1.57
190.00	-21.40	1.56	-0.18	125.00	-190.00	1.02	-1.56
195.00	-19.00	1.60	-0.16	135.00	-190.00	1.11	-1.56
200.00	-15.20	1.64	-0.12	145.00	-189.00	1.19	-1.55
205.00	-13.90	1.68	-0.11	155.00	-188.00	1.27	-1.54
210.00	-10.40	1.72	-0.09	165.00	-188.00	1.35	-1.54
215.00	-5.90	1.76	-0.05	175.00	-188.00	1.43	-1.54
220.00	-4.50	1.80	-0.04	185.00	-188.00	1.52	-1.54
225.00	-2.50	1.84	-0.02	195.00	-188.00	1.60	-1.54
230.00	4.30	1.89	0.04	205.00	-188.00	1.68	-1.54
235.00	4.40	1.93	0.04	215.00	-188.00	1.76	-1.54
240.00	6.20	1.97	0.05	225.00	-188.00	1.84	-1.54
245.00	6.60	2.01	0.05	235.00	-190.00	1.93	-1.56
250.00	11.30	2.05	0.09	245.00	-190.00	2.01	-1.56
255.00	14.10	2.09	0.12	255.00	-190.00	2.09	-1.56
260.00	17.20	2.13	0.14	265.00	-191.00	2.17	-1.57
265.00	17.60	2.17	0.14	275.00	-192.00	2.25	-1.57
270.00	20.50	2.21	0.17	285.00	-193.00	2.34	-1.58
275.00	21.40	2.25	0.18	295.00	-194.00	2.42	-1.59
280.00	22.30	2.30	0.18	305.00	-195.00	2.50	-1.60
285.00	24.60	2.34	0.20	315.00	-196.00	2.58	-1.61
295.00	28.60	2.42	0.23	325.00	-197.00	2.66	-1.61
305.00	31.30	2.50	0.26	335.00	-198.00	2.75	-1.62
315.00	32.60	2.58	0.27	345.00	-200.00	2.83	-1.64
325.00	34.70	2.66	0.28	355.00	-200.00	2.91	-1.64
335.00	37.10	2.75	0.30	365.00	-200.00	2.99	-1.64
345.00	38.40	2.83	0.31	375.00	-202.00	3.07	-1.66
355.00	40.80	2.91	0.33	385.00	-203.00	3.16	-1.66

365.00	42.80	2.99	0.35
375.00	44.00	3.07	0.36
385.00	45.20	3.16	0.37
395.00	45.10	3.24	0.37
405.00	46.00	3.32	0.38
415.00	48.60	3.40	0.40
425.00	50.20	3.48	0.41
435.00	47.80	3.57	0.39
445.00	53.20	3.65	0.44
455.00	51.20	3.73	0.42
465.00	51.10	3.81	0.42

395.00	-204.00	3.24	-1.67
405.00	-205.00	3.32	-1.68
415.00	-205.00	3.40	-1.68
425.00	-204.00	3.48	-1.67
435.00	-203.00	3.57	-1.66
445.00	-203.00	3.65	-1.66
455.00	-201.00	3.73	-1.65
465.00	-201.00	3.81	-1.65
105.00	-189.00	0.86	-1.55
115.00	-188.00	0.94	-1.54
125.00	-185.00	1.02	-1.52
135.00	-184.00	1.11	-1.51
145.00	-180.00	1.19	-1.48
155.00	-173.00	1.27	-1.42
165.00	-165.00	1.35	-1.35
175.00	-158.00	1.43	-1.30
185.00	-150.00	1.52	-1.23
195.00	-142.00	1.60	-1.16
205.00	-134.00	1.68	-1.10
215.00	-129.00	1.76	-1.06
225.00	-123.00	1.84	-1.01
235.00	-115.00	1.93	-0.94
245.00	-110.00	2.01	-0.90
255.00	-102.00	2.09	-0.84
260.00	-94.00	2.13	-0.77
263.00	-89.00	2.16	-0.73
262.00	-79.00	2.15	-0.65
260.00	-69.00	2.13	-0.57
259.00	-59.00	2.12	-0.48
257.00	-49.00	2.11	-0.40
253.00	-39.00	2.07	-0.32
251.00	-29.00	2.06	-0.24
251.00	-19.00	2.06	-0.16
246.00	-9.00	2.02	-0.07
244.00	1.00	2.00	0.01
-181.00	0.00	-1.48	0.00
-181.00	4.00	-1.48	0.03
-181.00	9.00	-1.48	0.07
-180.00	14.00	-1.48	0.11
-180.00	19.00	-1.48	0.16
-180.00	24.00	-1.48	0.20
-180.00	29.00	-1.48	0.24
-180.00	34.00	-1.48	0.28

-178.00	39.00	-1.46	0.32
-178.00	44.00	-1.46	0.36
-176.00	49.00	-1.44	0.40
-176.00	54.00	-1.44	0.44
-175.00	59.00	-1.43	0.48
-174.00	64.00	-1.43	0.52
-173.00	69.00	-1.42	0.57
-172.00	74.00	-1.41	0.61
-170.00	79.00	-1.39	0.65
-168.00	84.00	-1.38	0.69
-165.00	89.00	-1.35	0.73
-165.00	94.00	-1.35	0.77
-164.00	99.00	-1.34	0.81
-162.00	104.00	-1.33	0.85
-159.00	109.00	-1.30	0.89
-157.00	114.00	-1.29	0.93
-153.00	119.00	-1.25	0.98
-145.00	129.00	-1.19	1.06
-135.00	143.00	-1.11	1.17
-125.00	153.00	-1.02	1.25
-115.00	162.00	-0.94	1.33
-105.00	168.00	-0.86	1.38
-95.00	173.00	-0.78	1.42
-85.00	174.00	-0.70	1.43
-75.00	176.00	-0.61	1.44
-65.00	180.00	-0.53	1.48
-55.00	183.00	-0.45	1.50
-45.00	188.00	-0.37	1.54
-35.00	189.00	-0.29	1.55
-25.00	193.00	-0.20	1.58
-15.00	194.00	-0.12	1.59
-5.00	195.00	-0.04	1.60
5.00	197.00	0.04	1.61
15.00	197.00	0.12	1.61
25.00	195.00	0.20	1.60
35.00	195.00	0.29	1.60
45.00	194.00	0.37	1.59
55.00	192.00	0.45	1.57
65.00	191.00	0.53	1.57
75.00	190.00	0.61	1.56
85.00	189.00	0.70	1.55
95.00	189.00	0.78	1.55
105.00	190.00	0.86	1.56

115.00	191.00	0.94	1.57
125.00	190.00	1.02	1.56
135.00	190.00	1.11	1.56
145.00	189.00	1.19	1.55
155.00	188.00	1.27	1.54
165.00	188.00	1.35	1.54
175.00	188.00	1.43	1.54
185.00	188.00	1.52	1.54
195.00	188.00	1.60	1.54
205.00	188.00	1.68	1.54
215.00	188.00	1.76	1.54
225.00	188.00	1.84	1.54
235.00	190.00	1.93	1.56
245.00	190.00	2.01	1.56
255.00	190.00	2.09	1.56
265.00	191.00	2.17	1.57
275.00	192.00	2.25	1.57
285.00	193.00	2.34	1.58
295.00	194.00	2.42	1.59
305.00	195.00	2.50	1.60
315.00	196.00	2.58	1.61
325.00	197.00	2.66	1.61
335.00	198.00	2.75	1.62
345.00	200.00	2.83	1.64
355.00	200.00	2.91	1.64
365.00	200.00	2.99	1.64
375.00	202.00	3.07	1.66
385.00	203.00	3.16	1.66
395.00	204.00	3.24	1.67
405.00	205.00	3.32	1.68
415.00	205.00	3.40	1.68
425.00	204.00	3.48	1.67
435.00	203.00	3.57	1.66
445.00	203.00	3.65	1.66
455.00	201.00	3.73	1.65
465.00	201.00	3.81	1.65
105.00	189.00	0.86	1.55
115.00	188.00	0.94	1.54
125.00	185.00	1.02	1.52
135.00	184.00	1.11	1.51
145.00	180.00	1.19	1.48
155.00	173.00	1.27	1.42
165.00	165.00	1.35	1.35

175.00	158.00	1.43	1.30
185.00	150.00	1.52	1.23
195.00	142.00	1.60	1.16
205.00	134.00	1.68	1.10
215.00	129.00	1.76	1.06
225.00	123.00	1.84	1.01
235.00	115.00	1.93	0.94
245.00	110.00	2.01	0.90
255.00	102.00	2.09	0.84
260.00	94.00	2.13	0.77
263.00	89.00	2.16	0.73
262.00	79.00	2.15	0.65
260.00	69.00	2.13	0.57
259.00	59.00	2.12	0.48
257.00	49.00	2.11	0.40
253.00	39.00	2.07	0.32
251.00	29.00	2.06	0.24
251.00	19.00	2.06	0.16
246.00	9.00	2.02	0.07
244.00	-1.00	2.00	-0.01

Experiment	No	P2S4-F
Pier Diameter	D (mm)	38.9
Channel Width	B (mm)	259
Water Height	H (mm)	120
Median Grain Size	d50 (mm)	0.51
Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	15
Flow Shallowness	H/D	3.1
Relative Coarseness	D/d50	76.3
Aspect Ratio	B/H	2.2
Equilibrium Scour Depth	dse/D	1.11

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-111.00	-1.77	-2.91	-0.05
-106.00	-1.77	-2.78	-0.05
-101.00	-1.77	-2.65	-0.05
-96.00	-3.07	-2.52	-0.08
-91.00	-5.87	-2.39	-0.15
-86.00	-8.87	-2.26	-0.23

Edge Contour

x (mm)	y (mm)	x/D	y/D
-101.00	0.00	-2.65	0.00
-101.00	4.00	-2.65	0.10
-101.00	9.00	-2.65	0.24
-99.00	14.00	-2.60	0.37
-97.00	19.00	-2.55	0.50
-95.00	24.00	-2.49	0.63

-81.00	-11.27	-2.13	-0.30	-93.00	29.00	-2.44	0.76
-76.00	-14.17	-1.99	-0.37	-91.00	34.00	-2.39	0.89
-71.00	-18.17	-1.86	-0.48	-89.00	39.00	-2.34	1.02
-66.00	-20.57	-1.73	-0.54	-86.00	44.00	-2.26	1.15
-61.00	-22.97	-1.60	-0.60	-82.00	49.00	-2.15	1.29
-56.00	-24.77	-1.47	-0.65	-80.00	54.00	-2.10	1.42
-51.00	-25.57	-1.34	-0.67	-77.00	59.00	-2.02	1.55
-46.00	-28.77	-1.21	-0.76	-74.00	64.00	-1.94	1.68
-41.00	-33.07	-1.08	-0.87	-70.00	69.00	-1.84	1.81
-36.00	-37.07	-0.94	-0.97	-63.00	74.00	-1.65	1.94
-31.00	-40.07	-0.81	-1.05	-61.00	75.00	-1.60	1.97
-26.00	-42.17	-0.68	-1.11	-56.00	79.00	-1.47	2.07
-21.00	-43.17	-0.55	-1.13	-51.00	84.00	-1.34	2.20
21.00	-26.97	0.55	-0.71	-46.00	87.00	-1.21	2.28
24.00	-28.07	0.63	-0.74	-41.00	91.00	-1.08	2.39
29.00	-27.97	0.76	-0.73	-36.00	93.00	-0.94	2.44
34.00	-27.87	0.89	-0.73	-26.00	98.00	-0.68	2.57
39.00	-25.57	1.02	-0.67	-16.00	99.00	-0.42	2.60
44.00	-23.27	1.15	-0.61	-6.00	100.00	-0.16	2.62
49.00	-18.87	1.29	-0.50	4.00	102.00	0.10	2.68
54.00	-14.97	1.42	-0.39	14.00	104.00	0.37	2.73
59.00	-11.57	1.55	-0.30	24.00	104.00	0.63	2.73
64.00	-8.67	1.68	-0.23	34.00	106.00	0.89	2.78
69.00	-5.37	1.81	-0.14	44.00	106.00	1.15	2.78
74.00	-0.67	1.94	-0.02	54.00	106.00	1.42	2.78
79.00	1.23	2.07	0.03	64.00	106.00	1.68	2.78
84.00	1.83	2.20	0.05	74.00	106.00	1.94	2.78
89.00	6.13	2.34	0.16	84.00	105.00	2.20	2.76
94.00	8.33	2.47	0.22	94.00	105.00	2.47	2.76
104.00	13.73	2.73	0.36	104.00	105.00	2.73	2.76
114.00	18.53	2.99	0.49	114.00	105.00	2.99	2.76
124.00	22.93	3.25	0.60	124.00	105.00	3.25	2.76
134.00	27.43	3.52	0.72	134.00	104.00	3.52	2.73
144.00	30.83	3.78	0.81	144.00	103.00	3.78	2.70
154.00	33.33	4.04	0.87	154.00	102.00	4.04	2.68
164.00	36.13	4.30	0.95	164.00	102.00	4.30	2.68
174.00	37.53	4.57	0.99	174.00	101.00	4.57	2.65
179.00	33.83	4.70	0.89	184.00	98.00	4.83	2.57
184.00	29.63	4.83	0.78	194.00	95.00	5.09	2.49
189.00	26.83	4.96	0.70	204.00	93.00	5.35	2.44
194.00	22.43	5.09	0.59	214.00	92.00	5.62	2.41
199.00	18.83	5.22	0.49	219.00	99.00	5.75	2.60
204.00	16.43	5.35	0.43	224.00	104.00	5.88	2.73

209.00	14.83	5.49	0.39
214.00	15.33	5.62	0.40
219.00	14.23	5.75	0.37
224.00	12.83	5.88	0.34
234.00	11.23	6.14	0.29
244.00	9.13	6.40	0.24
254.00	7.23	6.67	0.19
264.00	5.33	6.93	0.14
274.00	4.33	7.19	0.11
284.00	2.73	7.45	0.07
294.00	2.23	7.72	0.06

227.00	109.00	5.96	2.86
231.00	114.00	6.06	2.99
233.00	119.00	6.12	3.12
237.00	124.00	6.22	3.25
212.00	90.00	5.56	2.36
209.00	84.00	5.49	2.20
209.00	79.00	5.49	2.07
212.00	74.00	5.56	1.94
215.00	69.00	5.64	1.81
220.00	64.00	5.77	1.68
225.00	59.00	5.91	1.55
229.00	56.00	6.01	1.47
234.00	53.00	6.14	1.39
244.00	45.00	6.40	1.18
254.00	39.00	6.67	1.02
264.00	34.00	6.93	0.89
274.00	28.00	7.19	0.73
284.00	22.00	7.45	0.58
294.00	17.00	7.72	0.45
80.00	0.00	2.10	0.00
80.00	4.00	2.10	0.10
80.00	9.00	2.10	0.24
83.00	19.00	2.18	0.50
84.00	29.00	2.20	0.76
81.00	39.00	2.13	1.02
80.00	49.00	2.10	1.29
77.00	59.00	2.02	1.55
73.00	69.00	1.92	1.81
69.00	74.00	1.81	1.94
64.00	81.00	1.68	2.13
59.00	86.00	1.55	2.26
54.00	89.00	1.42	2.34
44.00	94.00	1.15	2.47
34.00	97.00	0.89	2.55
24.00	99.00	0.63	2.60
-101.00	0.00	-2.65	0.00
-101.00	-4.00	-2.65	-0.10
-101.00	-9.00	-2.65	-0.24
-99.00	-14.00	-2.60	-0.37
-97.00	-19.00	-2.55	-0.50
-95.00	-24.00	-2.49	-0.63
-93.00	-29.00	-2.44	-0.76
-91.00	-34.00	-2.39	-0.89

-89.00	-39.00	-2.34	-1.02
-86.00	-44.00	-2.26	-1.15
-82.00	-49.00	-2.15	-1.29
-80.00	-54.00	-2.10	-1.42
-77.00	-59.00	-2.02	-1.55
-74.00	-64.00	-1.94	-1.68
-70.00	-69.00	-1.84	-1.81
-63.00	-74.00	-1.65	-1.94
-61.00	-75.00	-1.60	-1.97
-56.00	-79.00	-1.47	-2.07
-51.00	-84.00	-1.34	-2.20
-46.00	-87.00	-1.21	-2.28
-41.00	-91.00	-1.08	-2.39
-36.00	-93.00	-0.94	-2.44
-26.00	-98.00	-0.68	-2.57
-16.00	-99.00	-0.42	-2.60
-6.00	-100.00	-0.16	-2.62
4.00	-102.00	0.10	-2.68
14.00	-104.00	0.37	-2.73
24.00	-104.00	0.63	-2.73
34.00	-106.00	0.89	-2.78
44.00	-106.00	1.15	-2.78
54.00	-106.00	1.42	-2.78
64.00	-106.00	1.68	-2.78
74.00	-106.00	1.94	-2.78
84.00	-105.00	2.20	-2.76
94.00	-105.00	2.47	-2.76
104.00	-105.00	2.73	-2.76
114.00	-105.00	2.99	-2.76
124.00	-105.00	3.25	-2.76
134.00	-104.00	3.52	-2.73
144.00	-103.00	3.78	-2.70
154.00	-102.00	4.04	-2.68
164.00	-102.00	4.30	-2.68
174.00	-101.00	4.57	-2.65
184.00	-98.00	4.83	-2.57
194.00	-95.00	5.09	-2.49
204.00	-93.00	5.35	-2.44
214.00	-92.00	5.62	-2.41
219.00	-99.00	5.75	-2.60
224.00	-104.00	5.88	-2.73
227.00	-109.00	5.96	-2.86
231.00	-114.00	6.06	-2.99

233.00	-119.00	6.12	-3.12
237.00	-124.00	6.22	-3.25
212.00	-90.00	5.56	-2.36
209.00	-84.00	5.49	-2.20
209.00	-79.00	5.49	-2.07
212.00	-74.00	5.56	-1.94
215.00	-69.00	5.64	-1.81
220.00	-64.00	5.77	-1.68
225.00	-59.00	5.91	-1.55
229.00	-56.00	6.01	-1.47
234.00	-53.00	6.14	-1.39
244.00	-45.00	6.40	-1.18
254.00	-39.00	6.67	-1.02
264.00	-34.00	6.93	-0.89
274.00	-28.00	7.19	-0.73
284.00	-22.00	7.45	-0.58
294.00	-17.00	7.72	-0.45
80.00	0.00	2.10	0.00
80.00	-4.00	2.10	-0.10
80.00	-9.00	2.10	-0.24
83.00	-19.00	2.18	-0.50
84.00	-29.00	2.20	-0.76
81.00	-39.00	2.13	-1.02
80.00	-49.00	2.10	-1.29
77.00	-59.00	2.02	-1.55
73.00	-69.00	1.92	-1.81
69.00	-74.00	1.81	-1.94
64.00	-81.00	1.68	-2.13
59.00	-86.00	1.55	-2.26
54.00	-89.00	1.42	-2.34
44.00	-94.00	1.15	-2.47
34.00	-97.00	0.89	-2.55
24.00	-99.00	0.63	-2.60

Experiment	No	P2S4-MF
Pier Diameter	D (mm)	58.7
Channel Width	B (mm)	391
Water Height	H (mm)	120
Median Grain Size	d50 (mm)	0.77
Flow Intensity	U/Uc	0.85
Duration	hr	48

Blockage Ratio	D/B (%)	15
Flow Shallowness	H/D	2
Relative Coarseness	D/d50	76.3
Aspect Ratio	B/H	3.3
Equilibrium Scour Depth	dse/D	0.97

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-137.00	-0.83	-2.33	-0.01
-132.00	0.47	-2.25	0.01
-127.00	-1.13	-2.16	-0.02
-122.00	-2.03	-2.08	-0.03
-117.00	-3.53	-1.99	-0.06
-112.00	-5.13	-1.91	-0.09
-107.00	-7.93	-1.82	-0.14
-102.00	-10.23	-1.74	-0.17
-97.00	-12.23	-1.65	-0.21
-92.00	-15.33	-1.57	-0.26
-87.00	-18.43	-1.48	-0.31
-82.00	-21.93	-1.40	-0.37
-77.00	-23.73	-1.31	-0.40
-72.00	-27.73	-1.23	-0.47
-67.00	-29.23	-1.14	-0.50
-62.00	-31.93	-1.06	-0.54
-57.00	-35.53	-0.97	-0.61
-52.00	-38.03	-0.89	-0.65
-47.00	-41.63	-0.80	-0.71
-42.00	-47.73	-0.72	-0.81
-37.00	-54.03	-0.63	-0.92
-32.00	-56.83	-0.55	-0.97
32.00	-36.93	0.55	-0.63
38.00	-36.63	0.65	-0.62
43.00	-38.63	0.73	-0.66
48.00	-39.13	0.82	-0.67
53.00	-37.63	0.90	-0.64
58.00	-36.33	0.99	-0.62
63.00	-35.43	1.07	-0.60
68.00	-33.13	1.16	-0.56
73.00	-30.93	1.24	-0.53
78.00	-29.73	1.33	-0.51
83.00	-26.43	1.41	-0.45
88.00	-23.63	1.50	-0.40

Edge Contour

x (mm)	y (mm)	x/D	y/D
-123.00	0.00	-2.10	0.00
-123.00	-5.00	-2.10	-0.09
-123.00	-10.00	-2.10	-0.17
-123.00	-15.00	-2.10	-0.26
-123.00	-20.00	-2.10	-0.34
-123.00	-25.00	-2.10	-0.43
-122.50	-30.00	-2.09	-0.51
-121.50	-35.00	-2.07	-0.60
-120.00	-40.00	-2.04	-0.68
-119.00	-45.00	-2.03	-0.77
-118.00	-50.00	-2.01	-0.85
-117.50	-55.00	-2.00	-0.94
-115.50	-60.00	-1.97	-1.02
-111.00	-65.00	-1.89	-1.11
-108.50	-70.00	-1.85	-1.19
-106.00	-75.00	-1.81	-1.28
-102.00	-80.00	-1.74	-1.36
-97.00	-85.00	-1.65	-1.45
-91.50	-90.00	-1.56	-1.53
-87.00	-95.00	-1.48	-1.62
-81.00	-100.00	-1.38	-1.70
-72.00	-104.00	-1.23	-1.77
-62.00	-110.00	-1.06	-1.87
-52.00	-115.50	-0.89	-1.97
-42.00	-120.00	-0.72	-2.04
-32.00	-124.00	-0.55	-2.11
-22.00	-126.00	-0.37	-2.15
-12.00	-131.50	-0.20	-2.24
-2.00	-132.50	-0.03	-2.26
8.00	-133.50	0.14	-2.27
18.00	-132.50	0.31	-2.26
28.00	-134.00	0.48	-2.28
38.00	-134.00	0.65	-2.28
48.00	-134.50	0.82	-2.29

93.00	-21.23	1.58	-0.36	58.00	-133.00	0.99	-2.27
98.00	-18.13	1.67	-0.31	68.00	-131.50	1.16	-2.24
103.00	-14.83	1.75	-0.25	78.00	-131.00	1.33	-2.23
108.00	-12.13	1.84	-0.21	88.00	-131.00	1.50	-2.23
113.00	-9.63	1.93	-0.16	98.00	-131.00	1.67	-2.23
118.00	-7.43	2.01	-0.13	108.00	-131.00	1.84	-2.23
123.00	-3.73	2.10	-0.06	118.00	-131.50	2.01	-2.24
128.00	-0.63	2.18	-0.01	128.00	-132.00	2.18	-2.25
133.00	2.17	2.27	0.04	138.00	-133.00	2.35	-2.27
138.00	3.97	2.35	0.07	148.00	-134.00	2.52	-2.28
143.00	6.87	2.44	0.12	158.00	-136.00	2.69	-2.32
148.00	8.77	2.52	0.15	168.00	-136.50	2.86	-2.33
153.00	11.77	2.61	0.20	178.00	-138.00	3.03	-2.35
158.00	13.77	2.69	0.23	188.00	-139.50	3.20	-2.38
168.00	16.77	2.86	0.29	198.00	-140.50	3.37	-2.39
178.00	20.47	3.03	0.35	208.00	-140.50	3.54	-2.39
188.00	23.57	3.20	0.40	218.00	-141.50	3.71	-2.41
198.00	26.67	3.37	0.45	228.00	-141.50	3.88	-2.41
208.00	28.77	3.54	0.49	238.00	-141.50	4.05	-2.41
218.00	30.97	3.71	0.53	248.00	-141.50	4.22	-2.41
228.00	32.87	3.88	0.56	258.00	-142.00	4.40	-2.42
238.00	33.87	4.05	0.58	268.00	-142.00	4.57	-2.42
248.00	35.07	4.22	0.60	278.00	-140.50	4.74	-2.39
258.00	36.67	4.40	0.62	288.00	-140.50	4.91	-2.39
268.00	37.07	4.57	0.63	298.00	-141.00	5.08	-2.40
278.00	37.97	4.74	0.65	308.00	-141.00	5.25	-2.40
288.00	38.47	4.91	0.66	318.00	-142.00	5.42	-2.42
298.00	39.37	5.08	0.67	328.00	-143.00	5.59	-2.44
308.00	38.97	5.25	0.66	338.00	-145.00	5.76	-2.47
318.00	39.47	5.42	0.67	348.00	-146.00	5.93	-2.49
328.00	40.27	5.59	0.69	358.00	-149.00	6.10	-2.54
338.00	35.57	5.76	0.61	368.00	-152.00	6.27	-2.59
348.00	26.77	5.93	0.46	378.00	-153.00	6.44	-2.61
358.00	18.27	6.10	0.31	388.00	-153.00	6.61	-2.61
368.00	10.67	6.27	0.18	398.00	-152.00	6.78	-2.59
378.00	9.57	6.44	0.16	408.00	-150.50	6.95	-2.56
388.00	8.77	6.61	0.15	418.00	-146.00	7.12	-2.49
398.00	7.37	6.78	0.13	428.00	-144.00	7.29	-2.45
408.00	6.17	6.95	0.11	438.00	-143.00	7.46	-2.44
418.00	5.17	7.12	0.09	448.00	-143.00	7.63	-2.44
428.00	4.47	7.29	0.08	458.00	-144.00	7.80	-2.45
438.00	4.77	7.46	0.08	468.00	-144.00	7.97	-2.45
448.00	4.27	7.63	0.07	478.00	-143.00	8.14	-2.44

458.00	3.57	7.80	0.06
468.00	4.37	7.97	0.07
478.00	4.17	8.14	0.07

137.00	0.00	2.33	0.00
137.00	-5.00	2.33	-0.09
137.00	-10.00	2.33	-0.17
136.00	-15.00	2.32	-0.26
136.00	-20.00	2.32	-0.34
135.00	-25.00	2.30	-0.43
134.00	-30.00	2.28	-0.51
134.00	-35.00	2.28	-0.60
131.50	-40.00	2.24	-0.68
126.00	-50.00	2.15	-0.85
120.50	-60.00	2.05	-1.02
118.00	-70.00	2.01	-1.19
117.00	-80.00	1.99	-1.36
109.50	-90.00	1.87	-1.53
98.00	-97.50	1.67	-1.66
88.00	-104.00	1.50	-1.77
78.00	-111.00	1.33	-1.89
68.00	-119.00	1.16	-2.03
58.00	-126.00	0.99	-2.15
48.00	-128.50	0.82	-2.19
38.00	-129.00	0.65	-2.20
28.00	-131.50	0.48	-2.24
-123.00	0.00	-2.10	0.00
-123.00	5.00	-2.10	0.09
-123.00	10.00	-2.10	0.17
-123.00	15.00	-2.10	0.26
-123.00	20.00	-2.10	0.34
-123.00	25.00	-2.10	0.43
-122.50	30.00	-2.09	0.51
-121.50	35.00	-2.07	0.60
-120.00	40.00	-2.04	0.68
-119.00	45.00	-2.03	0.77
-118.00	50.00	-2.01	0.85
-117.50	55.00	-2.00	0.94
-115.50	60.00	-1.97	1.02
-111.00	65.00	-1.89	1.11
-108.50	70.00	-1.85	1.19
-106.00	75.00	-1.81	1.28
-102.00	80.00	-1.74	1.36
-97.00	85.00	-1.65	1.45
-91.50	90.00	-1.56	1.53
-87.00	95.00	-1.48	1.62
-81.00	100.00	-1.38	1.70

-72.00	104.00	-1.23	1.77
-62.00	110.00	-1.06	1.87
-52.00	115.50	-0.89	1.97
-42.00	120.00	-0.72	2.04
-32.00	124.00	-0.55	2.11
-22.00	126.00	-0.37	2.15
-12.00	131.50	-0.20	2.24
-2.00	132.50	-0.03	2.26
8.00	133.50	0.14	2.27
18.00	132.50	0.31	2.26
28.00	134.00	0.48	2.28
38.00	134.00	0.65	2.28
48.00	134.50	0.82	2.29
58.00	133.00	0.99	2.27
68.00	131.50	1.16	2.24
78.00	131.00	1.33	2.23
88.00	131.00	1.50	2.23
98.00	131.00	1.67	2.23
108.00	131.00	1.84	2.23
118.00	131.50	2.01	2.24
128.00	132.00	2.18	2.25
138.00	133.00	2.35	2.27
148.00	134.00	2.52	2.28
158.00	136.00	2.69	2.32
168.00	136.50	2.86	2.33
178.00	138.00	3.03	2.35
188.00	139.50	3.20	2.38
198.00	140.50	3.37	2.39
208.00	140.50	3.54	2.39
218.00	141.50	3.71	2.41
228.00	141.50	3.88	2.41
238.00	141.50	4.05	2.41
248.00	141.50	4.22	2.41
258.00	142.00	4.40	2.42
268.00	142.00	4.57	2.42
278.00	140.50	4.74	2.39
288.00	140.50	4.91	2.39
298.00	141.00	5.08	2.40
308.00	141.00	5.25	2.40
318.00	142.00	5.42	2.42
328.00	143.00	5.59	2.44
338.00	145.00	5.76	2.47
348.00	146.00	5.93	2.49

358.00	149.00	6.10	2.54
368.00	152.00	6.27	2.59
378.00	153.00	6.44	2.61
388.00	153.00	6.61	2.61
398.00	152.00	6.78	2.59
408.00	150.50	6.95	2.56
418.00	146.00	7.12	2.49
428.00	144.00	7.29	2.45
438.00	143.00	7.46	2.44
448.00	143.00	7.63	2.44
458.00	144.00	7.80	2.45
468.00	144.00	7.97	2.45
478.00	143.00	8.14	2.44
137.00	0.00	2.33	0.00
137.00	5.00	2.33	0.09
137.00	10.00	2.33	0.17
136.00	15.00	2.32	0.26
136.00	20.00	2.32	0.34
135.00	25.00	2.30	0.43
134.00	30.00	2.28	0.51
134.00	35.00	2.28	0.60
131.50	40.00	2.24	0.68
126.00	50.00	2.15	0.85
120.50	60.00	2.05	1.02
118.00	70.00	2.01	1.19
117.00	80.00	1.99	1.36
109.50	90.00	1.87	1.53
98.00	97.50	1.67	1.66
88.00	104.00	1.50	1.77
78.00	111.00	1.33	1.89
68.00	119.00	1.16	2.03
58.00	126.00	0.99	2.15
48.00	128.50	0.82	2.19
38.00	129.00	0.65	2.20
28.00	131.50	0.48	2.24

Experiment	No	P2S4-MC
Pier Diameter	D (mm)	124
Channel Width	B (mm)	830
Water Height	H (mm)	120
Median Grain Size	d50 (mm)	1.63

Flow Intensity	U/Uc	0.85
Duration	hr	48
Blockage Ratio	D/B (%)	15
Flow Shallowness	H/D	0.96
Relative Coarseness	D/d50	76.3
Aspect Ratio	B/H	2.3
Equilibrium Scour Depth	dse/D	0.35

Centreline Profile

x (mm)	z (mm)	x/D	z/D
-158.50	-2.90	-1.30	-0.02
-153.50	-4.30	-1.26	-0.04
-148.50	-4.40	-1.22	-0.04
-143.50	-2.40	-1.18	-0.02
-138.50	-6.60	-1.14	-0.05
-133.50	-6.40	-1.09	-0.05
-128.50	-6.70	-1.05	-0.05
-123.50	-8.30	-1.01	-0.07
-118.50	-14.30	-0.97	-0.12
-113.50	-18.80	-0.93	-0.15
-108.50	-21.90	-0.89	-0.18
-103.50	-20.50	-0.85	-0.17
-98.50	-27.20	-0.81	-0.22
-93.50	-29.80	-0.77	-0.24
-88.50	-32.40	-0.73	-0.27
-83.50	-34.80	-0.68	-0.29
-78.50	-36.50	-0.64	-0.30
-73.50	-41.70	-0.60	-0.34
-68.50	-42.60	-0.56	-0.35
-63.50	-43.80	-0.52	-0.36
63.50	-34.00	0.52	-0.28
69.50	-35.80	0.57	-0.29
71.50	-37.80	0.59	-0.31
76.50	-39.80	0.63	-0.33
81.50	-39.80	0.67	-0.33
86.50	-39.90	0.71	-0.33
91.50	-40.90	0.75	-0.34
96.50	-40.10	0.79	-0.33
101.50	-39.30	0.83	-0.32
106.50	-39.10	0.87	-0.32
111.50	-39.50	0.91	-0.32

Edge Contour

x (mm)	y (mm)	x/D	y/D
-137.50	0.00	-1.13	0.00
-137.50	-7.00	-1.13	-0.06
-137.50	-12.00	-1.13	-0.10
-137.50	-17.00	-1.13	-0.14
-137.50	-22.00	-1.13	-0.18
-137.50	-27.00	-1.13	-0.22
-137.50	-32.00	-1.13	-0.26
-135.50	-37.00	-1.11	-0.30
-135.00	-42.00	-1.11	-0.34
-133.50	-47.00	-1.09	-0.39
-133.00	-52.00	-1.09	-0.43
-130.50	-57.00	-1.07	-0.47
-129.50	-62.00	-1.06	-0.51
-127.00	-67.00	-1.04	-0.55
-124.50	-72.00	-1.02	-0.59
-122.50	-77.00	-1.00	-0.63
-120.50	-82.00	-0.99	-0.67
-119.00	-87.00	-0.98	-0.71
-116.00	-92.00	-0.95	-0.75
-112.50	-97.00	-0.92	-0.80
-111.00	-102.00	-0.91	-0.84
-106.50	-107.00	-0.87	-0.88
-103.00	-112.00	-0.84	-0.92
-98.50	-117.00	-0.81	-0.96
-93.50	-122.00	-0.77	-1.00
-90.00	-127.00	-0.74	-1.04
-78.00	-132.00	-0.64	-1.08
-68.50	-139.00	-0.56	-1.14
-58.50	-146.00	-0.48	-1.20
-48.50	-151.00	-0.40	-1.24
-38.50	-155.00	-0.32	-1.27

121.50	-37.50	1.00	-0.31	-28.50	-158.50	-0.23	-1.30
131.50	-32.50	1.08	-0.27	-18.50	-161.00	-0.15	-1.32
141.50	-30.70	1.16	-0.25	-8.50	-162.00	-0.07	-1.33
151.50	-26.00	1.24	-0.21	1.50	-162.00	0.01	-1.33
161.50	-22.20	1.32	-0.18	11.50	-160.50	0.09	-1.32
171.50	-15.80	1.41	-0.13	21.50	-157.50	0.18	-1.29
181.50	-13.70	1.49	-0.11	31.50	-156.00	0.26	-1.28
191.50	-9.10	1.57	-0.07	41.50	-156.00	0.34	-1.28
201.50	-5.20	1.65	-0.04	51.50	-157.50	0.42	-1.29
211.50	1.10	1.73	0.01	61.50	-157.50	0.50	-1.29
221.50	3.50	1.82	0.03	71.50	-158.00	0.59	-1.30
231.50	10.60	1.90	0.09	81.50	-162.00	0.67	-1.33
241.50	13.90	1.98	0.11	91.50	-162.00	0.75	-1.33
251.50	18.80	2.06	0.15	101.50	-163.00	0.83	-1.34
261.50	22.40	2.14	0.18	111.50	-164.00	0.91	-1.34
271.50	25.70	2.23	0.21	121.50	-165.00	1.00	-1.35
281.50	28.60	2.31	0.23	131.50	-167.00	1.08	-1.37
291.50	30.10	2.39	0.25	141.50	-167.50	1.16	-1.37
301.50	35.80	2.47	0.29	151.50	-168.50	1.24	-1.38
311.50	37.60	2.55	0.31	161.50	-168.50	1.32	-1.38
321.50	39.40	2.64	0.32	171.50	-170.00	1.41	-1.39
331.50	41.80	2.72	0.34	181.50	-171.00	1.49	-1.40
341.50	43.40	2.80	0.36	191.50	-171.00	1.57	-1.40
351.50	44.20	2.88	0.36	201.50	-171.00	1.65	-1.40
361.50	46.00	2.96	0.38	211.50	-170.00	1.73	-1.39
371.50	45.60	3.05	0.37	221.50	-170.00	1.82	-1.39
381.50	47.10	3.13	0.39	231.50	-168.50	1.90	-1.38
391.50	46.50	3.21	0.38	241.50	-165.50	1.98	-1.36
401.50	47.20	3.29	0.39	251.50	-164.00	2.06	-1.34
411.50	44.00	3.37	0.36	261.50	-161.00	2.14	-1.32
421.50	34.90	3.45	0.29	271.50	-158.00	2.23	-1.30
431.50	25.20	3.54	0.21	281.50	-155.00	2.31	-1.27
441.50	15.90	3.62	0.13	291.50	-152.00	2.39	-1.25
451.50	14.70	3.70	0.12	301.50	-151.00	2.47	-1.24
461.50	15.70	3.78	0.13	311.50	-150.00	2.55	-1.23
471.50	14.80	3.86	0.12	321.50	-146.00	2.64	-1.20
481.50	16.70	3.95	0.14	331.50	-145.00	2.72	-1.19
491.50	16.80	4.03	0.14	341.50	-143.00	2.80	-1.17
501.50	15.70	4.11	0.13	351.50	-143.00	2.88	-1.17
511.50	16.70	4.19	0.14	361.50	-143.00	2.96	-1.17
521.50	16.80	4.27	0.14	371.50	-142.00	3.05	-1.16
531.50	16.10	4.36	0.13	381.50	-142.00	3.13	-1.16
541.50	20.90	4.44	0.17	391.50	-144.00	3.21	-1.18

551.50	18.90	4.52	0.15
561.50	19.20	4.60	0.16
571.50	21.10	4.68	0.17
581.50	21.70	4.77	0.18

401.50	-144.00	3.29	-1.18
411.50	-145.00	3.37	-1.19
421.50	-145.00	3.45	-1.19
431.50	-146.00	3.54	-1.20
441.50	-146.00	3.62	-1.20
451.50	-142.00	3.70	-1.16
461.50	-130.00	3.78	-1.07
459.50	-122.00	3.77	-1.00
456.50	-112.00	3.74	-0.92
455.00	-102.00	3.73	-0.84
452.50	-92.00	3.71	-0.75
450.50	-82.00	3.69	-0.67
449.00	-72.00	3.68	-0.59
449.00	-62.00	3.68	-0.51
446.50	-52.00	3.66	-0.43
445.00	-42.00	3.65	-0.34
447.50	-32.00	3.67	-0.26
451.50	-29.00	3.70	-0.24
461.50	-31.00	3.78	-0.25
471.50	-36.00	3.86	-0.30
481.50	-42.00	3.95	-0.34
491.50	-46.00	4.03	-0.38
501.50	-52.00	4.11	-0.43
511.50	-58.00	4.19	-0.48
521.50	-62.00	4.27	-0.51
216.00	0.00	1.77	0.00
216.50	-7.00	1.77	-0.06
216.50	-12.00	1.77	-0.10
213.50	-22.00	1.75	-0.18
207.50	-32.00	1.70	-0.26
197.50	-42.00	1.62	-0.34
191.50	-47.00	1.57	-0.39
181.50	-57.00	1.49	-0.47
171.50	-66.00	1.41	-0.54
161.50	-73.00	1.32	-0.60
151.50	-81.00	1.24	-0.66
141.50	-91.00	1.16	-0.75
131.50	-99.00	1.08	-0.81
121.50	-107.50	1.00	-0.88
111.50	-113.00	0.91	-0.93
101.50	-122.00	0.83	-1.00
91.50	-129.00	0.75	-1.06
81.50	-136.00	0.67	-1.11

71.50	-140.00	0.59	-1.15
61.50	-143.00	0.50	-1.17
51.50	-147.50	0.42	-1.21
41.50	-151.00	0.34	-1.24
31.50	-153.00	0.26	-1.25
-137.50	0.00	-1.13	0.00
-137.50	7.00	-1.13	0.06
-137.50	12.00	-1.13	0.10
-137.50	17.00	-1.13	0.14
-137.50	22.00	-1.13	0.18
-137.50	27.00	-1.13	0.22
-137.50	32.00	-1.13	0.26
-135.50	37.00	-1.11	0.30
-135.00	42.00	-1.11	0.34
-133.50	47.00	-1.09	0.39
-133.00	52.00	-1.09	0.43
-130.50	57.00	-1.07	0.47
-129.50	62.00	-1.06	0.51
-127.00	67.00	-1.04	0.55
-124.50	72.00	-1.02	0.59
-122.50	77.00	-1.00	0.63
-120.50	82.00	-0.99	0.67
-119.00	87.00	-0.98	0.71
-116.00	92.00	-0.95	0.75
-112.50	97.00	-0.92	0.80
-111.00	102.00	-0.91	0.84
-106.50	107.00	-0.87	0.88
-103.00	112.00	-0.84	0.92
-98.50	117.00	-0.81	0.96
-93.50	122.00	-0.77	1.00
-90.00	127.00	-0.74	1.04
-78.00	132.00	-0.64	1.08
-68.50	139.00	-0.56	1.14
-58.50	146.00	-0.48	1.20
-48.50	151.00	-0.40	1.24
-38.50	155.00	-0.32	1.27
-28.50	158.50	-0.23	1.30
-18.50	161.00	-0.15	1.32
-8.50	162.00	-0.07	1.33
1.50	162.00	0.01	1.33
11.50	160.50	0.09	1.32
21.50	157.50	0.18	1.29
31.50	156.00	0.26	1.28

41.50	156.00	0.34	1.28
51.50	157.50	0.42	1.29
61.50	157.50	0.50	1.29
71.50	158.00	0.59	1.30
81.50	162.00	0.67	1.33
91.50	162.00	0.75	1.33
101.50	163.00	0.83	1.34
111.50	164.00	0.91	1.34
121.50	165.00	1.00	1.35
131.50	167.00	1.08	1.37
141.50	167.50	1.16	1.37
151.50	168.50	1.24	1.38
161.50	168.50	1.32	1.38
171.50	170.00	1.41	1.39
181.50	171.00	1.49	1.40
191.50	171.00	1.57	1.40
201.50	171.00	1.65	1.40
211.50	170.00	1.73	1.39
221.50	170.00	1.82	1.39
231.50	168.50	1.90	1.38
241.50	165.50	1.98	1.36
251.50	164.00	2.06	1.34
261.50	161.00	2.14	1.32
271.50	158.00	2.23	1.30
281.50	155.00	2.31	1.27
291.50	152.00	2.39	1.25
301.50	151.00	2.47	1.24
311.50	150.00	2.55	1.23
321.50	146.00	2.64	1.20
331.50	145.00	2.72	1.19
341.50	143.00	2.80	1.17
351.50	143.00	2.88	1.17
361.50	143.00	2.96	1.17
371.50	142.00	3.05	1.16
381.50	142.00	3.13	1.16
391.50	144.00	3.21	1.18
401.50	144.00	3.29	1.18
411.50	145.00	3.37	1.19
421.50	145.00	3.45	1.19
431.50	146.00	3.54	1.20
441.50	146.00	3.62	1.20
451.50	142.00	3.70	1.16
461.50	130.00	3.78	1.07

459.50	122.00	3.77	1.00
456.50	112.00	3.74	0.92
455.00	102.00	3.73	0.84
452.50	92.00	3.71	0.75
450.50	82.00	3.69	0.67
449.00	72.00	3.68	0.59
449.00	62.00	3.68	0.51
446.50	52.00	3.66	0.43
445.00	42.00	3.65	0.34
447.50	32.00	3.67	0.26
451.50	29.00	3.70	0.24
461.50	31.00	3.78	0.25
471.50	36.00	3.86	0.30
481.50	42.00	3.95	0.34
491.50	46.00	4.03	0.38
501.50	52.00	4.11	0.43
511.50	58.00	4.19	0.48
521.50	62.00	4.27	0.51
216.00	0.00	1.77	0.00
216.50	7.00	1.77	0.06
216.50	12.00	1.77	0.10
213.50	22.00	1.75	0.18
207.50	32.00	1.70	0.26
197.50	42.00	1.62	0.34
191.50	47.00	1.57	0.39
181.50	57.00	1.49	0.47
171.50	66.00	1.41	0.54
161.50	73.00	1.32	0.60
151.50	81.00	1.24	0.66
141.50	91.00	1.16	0.75
131.50	99.00	1.08	0.81
121.50	107.50	1.00	0.88
111.50	113.00	0.91	0.93
101.50	122.00	0.83	1.00
91.50	129.00	0.75	1.06
81.50	136.00	0.67	1.11
71.50	140.00	0.59	1.15
61.50	143.00	0.50	1.17
51.50	147.50	0.42	1.21
41.50	151.00	0.34	1.24
31.50	153.00	0.26	1.25

VITA AUCTORIS

NAME:	Sebastian Tejada
PLACE OF BIRTH:	Medellin, Colombia
YEAR OF BIRTHD:	1980
EDUCATION:	Colegio Colombo Britanico, Medellin, Colombia 1998. Escuela de Ingeniería de Antioquia, B.A.Sc., Medellin, Colombia 2004. University of Windsor, M.A.Sc., Windsor, Ontario, Canada.
MEMBERSHIP:	Consejo Profesional Nacional de Ingeniería (COPINA), Colombia 2004. Professional Engineers of Ontario. Application in Process.