M.Sc. Thesis

PHYSICAL MODEL STUDY OF EFFECTIVENESS OF SPUR UNDER VARIOUS FLOW CONDITIONS

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ABSTRACT

The number of river training structures are used for stabilization of any river. To stabilize the river any one or the combination of these structures are used. Spurs also called groynes or spur dikes or transverse dikes are very important river training works which are used for the protection of river banks and stable the river morphology. Spurs are also used to change the course of the flow at desired pattern.

In this study physical model of spur was built at different angles, spacing and different geometry to check the effectiveness of the spur. Total 24 experiments were carried out at three different discharges that were 0.75 cusec, 1 cusec and 1.5 cusec respectively. A channel was constructed in the physical model testing laboratory at Center of Excellence in Water Resources Engineering, UET Lahore Pakistan. In this study three different cases were discussed. Firstly three orientations of spur which is used at 90 degree (deflecting spur), 60 degree (repelling spur) and 120 degree (attracting spur) were constructed. Secondly, different cases of spacing between the spurs were discussed. In first case three spurs in series was constructed and in second case two spurs in series were constructed in straight channel and analyzed the more effective spacing for river banks protection. Thirdly, different spur geometry like T-Spur, J-spur and Hockey spur was constructed. In all experiments scouring pattern, deposition and erosion was analyzed near all the spurs with the help of the surfer software. Direction of velocity currents and velocity distribution was also observed with the help of digital current meter near all the orientations, spacing and geometries of spur at different discharges.

This physical modeling of spur showed that when discharge was gradually increased the erosion or deposition and bed morphology changed rapidly near all orientations, geometries and near the first spur when series of spur was used in spacing. According to velocity currents the most appropriate angle is 90 degree in straight channels and for creation of water pockets for banks protection at upstream side the 60 degree angle is most suitable which repel the velocity currents as well. Similarly for creation of water pockets for bank protection on downstream, 120 degree angle is the most suitable.

In case of spacing, results showed that in 1^{st} case of spacing when three spur spacing was used in series, discharge increase gradually then erosion also increased near first spur and deposition occur near 2^{nd} and 3^{rd} spur and between them. In 2^{nd} case of spacing when two spur spacing was used in series by removing the middle spur then same behavior was observed as in three spur spacing. The results shows that middle spur are not much effective for banks protection in straight channel.

This study shows that geometry of the spur is used for specific functions according to the site morphology conditions. According to the results T-spur is used where bank protection needed for shorter length at both side of the structure by creating the water pockets both side of the T-spur, J-spur and hockey spur are used to divert the flow of water at specific direction and also used for banks protection for shorter length at downstream of the structure by accumulation of sediment.

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Engr. Muhammad Amjad Saleem

Dedicated to my Father (Late)

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Chapter I

INTRODUCTION

There are various river training works which are used to stabilize any river specifically for those rivers which are braided. For the stabilization of rivers, any one or combination of these river training works are used. These all river engineering structures are constructed on a river to lead the flow in the river in a proper direction, to control and stabilize the river bed configuration for save movements of floods and river sediments (Nazim, 2010).

River training works are the structural measures which are constructed for the improvement of a river and its banks. River training is a significant component in the stoppage and mitigation of impressive floods and for controlling the general floods, as well as in other events such as for safe passage of floods below the bridge. River training works also decrease sediment transportation, lessen bed and bank erosion. (Colombo, 2002).

River training works are of the following types:

- Spurs
- Embankments
- Guide banks
- Artificial cut off

1.1 Spur

Spur is also called groynes, spur dikes and transverse dike widely used training works. Spurs are constructed transverse to the river flow spreading from the bank in to the river. Spurs train the river along the chosen course to diminish the concentration of flow at the point of attack. It is also used to create a slack flow for silting up the area in the vicinity and protect the bank by keeping away the flow from it. (Sharma, 2008)

Spurs are river engineering elements used to protect river banks from erosion and to concentrate flow to the river axis. Today spurs are also employed for promoting environmental conditions along a river bank. These elements are characterized by a large variety of geometrical parameters of which none is definitely fixed. (Gisonni and Hager, 2008).

Single spur is built on the Saskatchewan River in the vicinity of the pike lake for the purpose of water intake at specified direction as shown Fig 1.1. Similarly, Odra River in Poland and Missouri river in North of Saint Louis series of spur are used at both side of the bank for the protection and flow at regular pattern as shown in Fig (1.2 a, b)

Figure 1.1: Single spur on the Saskatchewan River in the vicinity of the pike lake water intake

Figure 1.2 a) Odra river in Poland (source: iihr.uiowa.edu) b) Missouri River, North of Saint Louis (source: Criss, 2002)

The spurs are structures built from the bank of the river and goes in to the river. The angle between the spur and the bank of the river depends upon the purpose of the spur at specific location. In design of the geometry of spur, the main consideration are length of the spur, spacing of the spur, height of the crest and the possible erosion at the head of the spur. For the stabilization of the bank of the river, the construction of spur in series is more effective. For single spur the bank protection is not much effective. (Nazim, 2010).

Spur may be constructed of permanent materials or semi-permanent or temporary permanent material such as masonry, concrete, or earth and stone. Semi-permanent materials such as steel or timber sheet piling, gabions, timber fencing or temporary material such as weighted brushwood fascines. Spur may be built at right angles to the bank or current, or angled upstream or downstream. The effect of the spur is to reduce the current along the stream bank, thereby reducing the erosive capability of the stream and in some cases inducing sedimentation between dikes. (Ronald 1983)

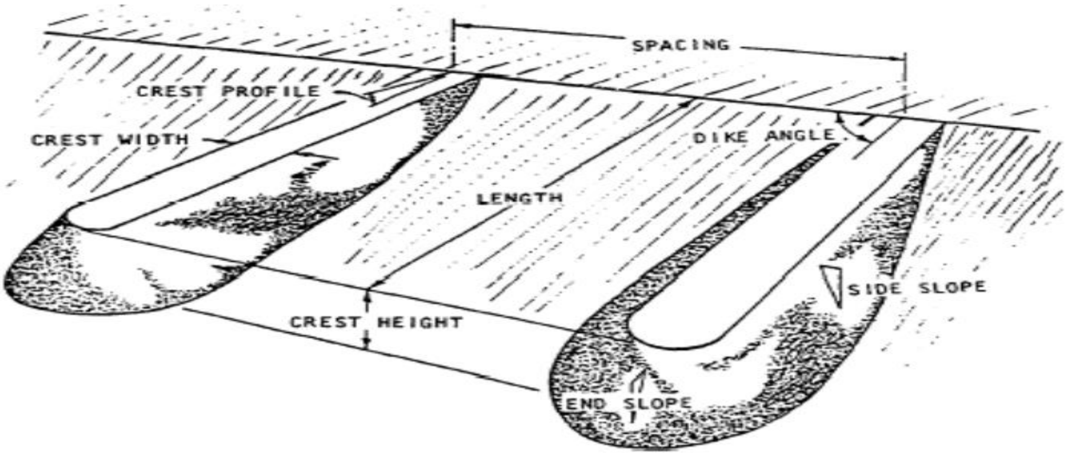


Figure 1.3: Systematic illustration of spur field showing the most important design parameters (USACE, 1980)

The types of spur depend upon the following parameters.

- Method and material of construction:
    - Permeable spur
    - Impermeable spur
- Height of spur with respect to water level
    - Submerged spur
    - Non-submerged spur
- Function that can be performed:
    - Attracting
    - Deflecting.
    - Repelling
- Shape of spur:
    - T- shaped
    - Hockey type
    - Kinked type (Garg, 2013)

1.1.1 Impermeable Spur

Impermeable spurs are used to deflect the water currents away from the eroded region of the river and guided the river in to more appropriate path. Due to low water velocity along the spur, sedimentation take place between the spur which strengthen the river bank. (Nazim, 2010).

Impermeable spurs does not permit appreciable flow through body of spur. These spur may be constructed using different types of materials such as core of Sand, Gravel and soil which exist in the river bed, which protected the sides and tops by strong armor of stone pitching or concrete blocks. The spur section is designed according to the materials used and velocity of flow. The head of the spur should have a special protection. Impermeable spur is constructed to deflect, attract and repel the water flow from the river bank along a chosen course. (Sharma, 2008).

1.1.2 Permeable Spur

Permeable spur contains a sequence of piles and these piles may be of steel, RCC or bamboo. Generally, permeable spurs are mostly used to slow down the flowing current and the erosive force. (Nazim, 2010). Permeable spur are permitted to restrict flow through them. Permeable spur consists of timber stakes or piles driven. For depths slightly below the anticipated deepest scour, timber pieces are joined together to form a frame work. Space between them is filled up with brush wood or branches of trees. The toe of the spur is protected by a mattress of stones or other materials. (Sharma, 2008). Permeable spur slow down the currents of flow. It is temporary in nature and is damaged by floating debris. Permeable spur is best suited for that river which is sediment carrying and these spur are preferred in hilly areas. (Indian road congress, 1997)

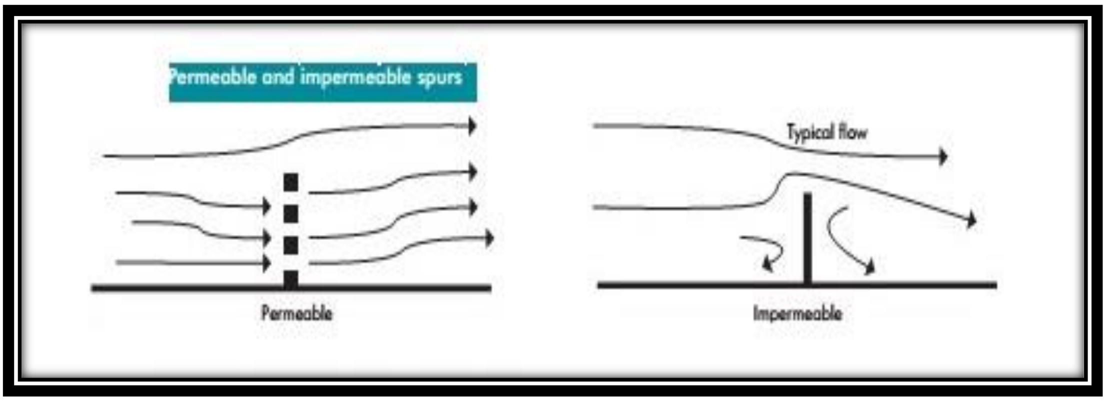


Figure 1.4: Permeable and impermeable spurs

1.1.3 Submerged Spur

Submerged spur are constructed under high flow conditions. Generally, permeable spur is in submerged condition. If it is not in submerged condition, then floating debris generate additional pressure on the piles and their gathering increase the flowing velocity which cause create the extra scouring at the piles foot. So, permeable spur is best suited at submerged condition. Submerged spur normally top level is higher than the normal level of water but this structure is submerged during high floods. (Nazim, 2010).

1.1.4 Non-submerged Spur

Non-submerged spur is constructed above the normal water level and remain higher during high flood conditions. This spur is made of permanent material and this structure is made according to requirement and function that can be performed. It may also be attracting, repelling or deflecting. (Indian road congress, 1997)

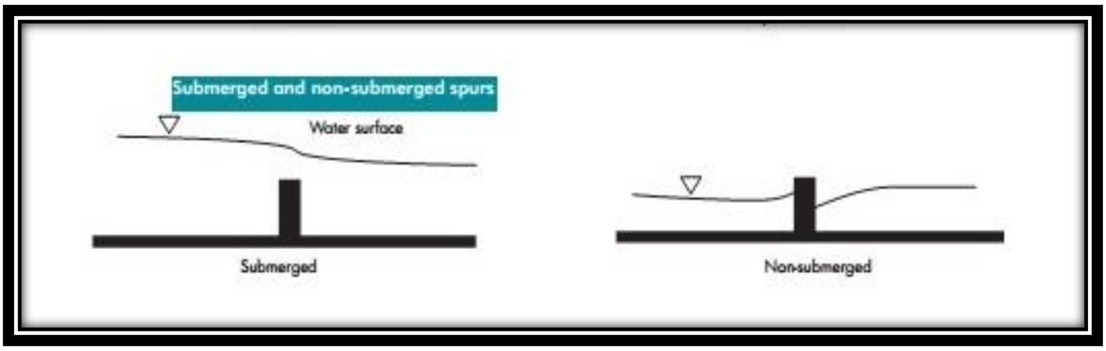


Figure 1.5: Submerged and non-submerged spurs

1.1.5 Attracting Spur:

Attracting spurs attract the water to flow toward the river bank. In this type, spurs are pointed toward the downstream of the flow. These types of spurs are never used when the river bank is in concave shape (Nazim, 2010). In the rivers, the banks where there is a heavy attack of the water flow then attracting spur is constructed on the opposite river bank, and repelling spur on the bank which is affected to heavy flow. (Indian road congress, 1997)

1.1.6 Repelling Spur

Repelling spur is designed in such manner that it deflects the water currents away from the bank of the river. In this type of spur, it is pointed towards upstream side and scouring holes are formed away from the river bank and near the nose of the spur. Repelling spur is generally constructed on the concave bank. (Nazim, 2010).

1.1.7 Deflecting Spur

Deflecting spur is constructed where there is change the flow direction without repelling the flow. Its alignment is perpendicular to the bank of the river. Deflecting spurs are mostly used on the convex type banks. This spur is shorter in length. (Sharma, 2008).

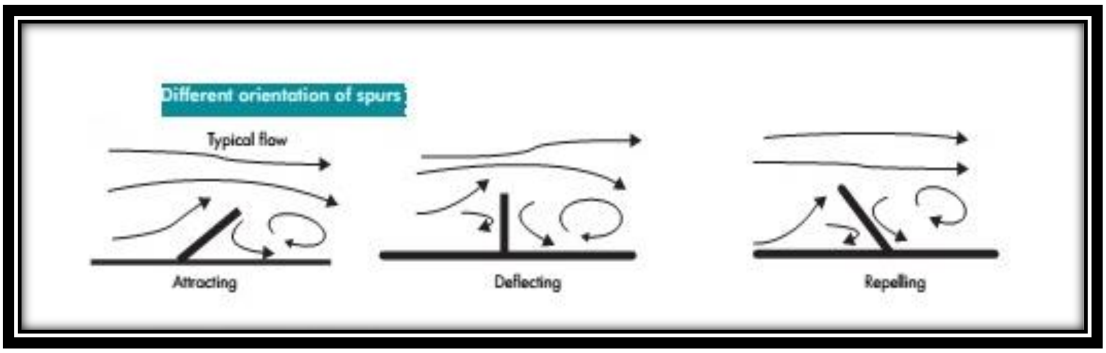


Figure 1.6: Attracting, deflecting and repelling spurs

Spurs are much more effective when constructed is in series. They create a pool of nearly still water between them which resist the current and gradually accumulate the silt, forming a permanent bank line in course of time. Spur length is normally taken as the length between the bank and the tip of the spur. Length of spurs is normally governed by the width of the river, reach to be protected, and flow conditions at the affected reach. Longer spurs might show an impact on the opposite bank. Moreover, longer spurs might be more susceptible to scour, and stronger river attack, resulting in more problems of maintenance. The length of spur depends upon the position of the existing bank line or the designed or expected bank line of the trained river. In erodible rivers too long spurs are liable to damage and failure. In such cases, the best result can be obtained by starting with a shorter length and to extend the spur gradually, as silting then proceeds. However, no general rule can be formulated for fixing the length of the spur. It depends upon the exigencies arising in a specific case.

The location, length and spacing of spurs depend on various parameters like river geometry, flow conditions, curvature of rivers channel and location of permanent structures, meander pattern, and other socio-economic restraints. The length of spurs and spacing of the spurs have a direct bearing on the length of the protected bank.

Each spur can protect a certain length, so primary factor governing the spacing between two adjacent spur is the length of the spur. Spacing is generally 2 to 2.5 times the length of spur at convex banks. Spacing between the spur is equal to the length of the spur for a concave bank. T-shaped spurs are generally placed 800 m apart with the T-head on a regular curved or straight line. (Shrama, 2008).

Spurs upset the equilibrium of river and they require heavy repair after every floods. Spur are may be more effective when constructed in series. The factors which influence the selection and design of spurs are as follows

- Flow velocity of the river
- Character of bed material like sand, silt, shingle or boulders carried by the rivers
- Waterway width at high water level.
- Depth of waterway

It may be noted that at the end, spurs should be constructed after model studies. Their design is not much amenable theoretical investigation, it has to be checked and tested with in model study. (Gisonni, 2008).

1.2 Problem Statement

Rivers flow pattern through alluvium are caused by continuous meandering. A lot of agricultural and urban land wasted due to this continuous meandering. Same phenomena occurred in river of Punjab. The River Indus when passing through the lower areas of the Punjab which have capacity to carry the discharge of all the rivers which flows in Pakistan, caused continuous erosion which creates a lot of problems for agriculture and people living in the specific areas located along the both banks of the river. So river training works like guide banks, embankments, spurs and artificial cut off are standard Structural River training technique to protect river banks from erosion to concentrate the flow to the river center and to promote sustainable ecological conditions along the river shores. In these an important river training work Spur also called groynes, spur dikes and transverse dike, are most widely used river training works. Spurs train the river along the desired path to reduce the concentration of flow at the point of attack. It also used to create a slack flow for silting up the area in the vicinity and protect the bank by keep away the flow from it, so spur is very important river training work.

The population rate of Pakistan is quickly increasing day by day and the ratio between agricultural land and population is decreasing due to the higher population. So we don't want to lose even one inch of our land which is required for agricultural purposes.so spur is an important river training structure against the erosion action because of feeding canals, distributaries and rivers need proper protection. Spur is also used where river change their flow pattern especially in the plains areas of the country in flooding seasons.

Spur is very Heavy River training work so it is carefully designed and its parameters are carefully considered because of a lot of investment, material and labor is required. If the spur is made directly, then in case of its failure, it is difficult to change its design or location. Thus making a model and testing in the laboratory results in the saving of human labor and material and also obtains the desired results by several different experiments. This research study covers the problem of spur for the protection of flood bund, agricultural land, population and canal system to change the river direction by using the physical model of spur and study its effectiveness.

The use of spur is extensive; no definitive hydraulic design criteria have been developed. Design continues to be based primarily on experience and judgment within specific geographical areas. This is primarily due to the wide range of variables affecting the performance of the spur and the varying importance of these variables with specific applications. Parameters affecting spur design include location, length, width, depth, crest profile, orientation angle and spacing of the spur. The location, length, width, depth, crest profile, orientation angle and spacing of spurs depends on various parameters like river geometry, flow conditions, curvature of rivers channel, location of permanent structures, meander pattern, and other socio-economic restraints.

1.3 Objectives

This study is proposed for spur study with following specific objectives.

- Construction of physical model of spur in model testing lab of CEWRE UET Lahore.
- Study different parameters related to spur design and operations.
- To investigate the geometry of spur on its effectiveness for river training

1.4 Study Area

The physical model of spur to check the effectiveness of this structure was constructed in the Model Testing Laboratory in Centre of Excellence in Water Resources Engineering. The dimensions of model testing lab are (160x60) feet and available discharge is 2cusecs. This physical model was constructed within the limits of available discharge and space. Firstly, an experimental channel was constructed in the lab after that the model of spur in the experimental channel was constructed at different orientations, spacing and geometry. In this channel spur was made at different angle, spacing and geometry and check the effectiveness of this structure at three different unit discharges. This model will also be useful for students for their future study.

Figure 1.7: Model Tray Laboratory at CEWRE, UET

1.5 Utilization of Research

The utilization of proposed study was to develop the physical model in Model Testing Lab of center of excellence in water resources engineering within the limits of available space, discharge and funds. The physical model of the spur was constructed to discuss its effectiveness and to check the different parameters related to spur design, operation. This study was proposed to analyze the effect of the different orientation, different spur spacing and multiple geometries of the spur in real field. This study is useful for optimal design of river training structure Spur. The results of the study were helpful to decide the size of spur structure with respect to different flow regimes in natural channels. The proposed study may be helpful for further research in design and operation river training works.

Chapter II

LITERATURE REVIEW

Gandhi et al. (2015) stated that river is the mother of evolution and almost main world's evolutions has grown at the panels of river. River flows on its normal way. It creates its own path and its path is called uncontrolled path. Its uncontrolled path is impairment the banks of the river and several villages are evacuated which exist near the bank of the river due to enlargement in the water level. This occurs because river alters its path or overtopping from the bank. It occurs in the absence of river training work around the bank of the river. Every year, large investment is wasted due to unrestrained movement of river. If proper river training works like guide bunds, spur, embankments are constructed for save movement of river and for stable the river banks, so significance of river training works has been felt. River training works stable a river within a proper channel and along a specific alignment for a different purpose. River training works deal with behavior, control and training of rivers.

Tariq et al. (2011) studied that flooding is the utmost shocking natural danger in Pakistan and recent pervious flooding has demonstrated its severeness. Floods are common throughout the country but their characteristics change from area to area. In this research analyzed the flooding behavior of the major rivers and flood management at the national level. The major cause of flood in Pakistan is monsoon rainfall. Fluvial floods in the Indus River have produced main economic losses. Pakistan's government has spent massive resources on relief operations and flood protection managements since 1947. Many structural and non-structural measures and their joint efficiency must be examined and optimized for supplementary effective flood protection management.

Akhter (2013) studied the Indus basin flood management with Asian bank development according to author Indus river is a main river in Asia with nine major rivers which is 2800 km long. In the Indus basin the most important cause of flood is monsoonal rainfall. 21 floods occurred between 1950 and 2010 in the Indus basin the greatest flood occurred in 2010 which was killed 8887 people and destroyed 109822 village. For the protection of floods many river training work was constructed on major rivers of Pakistan on which 1440 spurs that have been built since 1960 to protect the major towns and important infrastructure. River training works have been constructed at main places to control vigorously meandering channels and to save erodible beds and banks from erosion. The main spurs and other river training works which constructed since 1960 as shown in table 2.1

Table 2.1: Levees and spurs on major rivers

Province	**Levees (km)**	**Spurs (No)**
Punjab	3332	496
Sindh	2422	46
Khyber Pakhtunkhwa	352	186
Baluchistan	697	682
Total	6803	1440

Source: (Government of Pakistan, Ministry of water and power, Federal Flood Commission (2011). Annual Report 2010. Islamabad.)

When the old Tori bund was broken in flood of 2010 in Pakistan. It caused a huge flow of water to inundate Ghouspur town and its surrounding areas. In this floods damaged a large part of the Punjab and Sindh. It was decided to strengthen the most susceptible point of the old Tori Bund. In 2013 total thirteen spur were constructed across the one-km-long stretch on the bund. Recently four more spurs was constructed at that point given the high pressure of water that hits the banks. The reason is that this point was declared utmost weak was because the river alter its flow here. The thickness of each spur ranges among 30 to 40 feet.

Rahman et al. (2012) studied that river behavior plays the important role in social and economic domain of the state. Bangladesh suffered seriously flooding condition in the monsoon season. Bank of the river and scouring of the bed connected with waterway confluences and turns. In sense of economic, social, technical and environmental, point of view, river training works are very significant (bank destruction and its defensive measures) for maintainable river management. River training structure is practiced in Bangladesh from 1960s particularly in the Jamuna and the Ganges rivers. Dynamic erosion and scouring was seized to variation the situation, leading to damage of limited valued property of Bangladesh. Five forms of river bank training structures were designated at different reaches. Hydro morphological features of the main rivers and the structure performance were being assessed not only in practical point of view but also in social, economic and environmental features. Materials of the bank of the main rivers were commonly contains non-cohesive sediment like silt, sand and some quantity of clay, which is extremely vulnerable to erosion.

Copeland (1983) stated that spur is an important river training work which used is widely all over the world to develop the navigation, control the flood and defend erodible banks. Spur can also be defined as extended obstruction which has one side on bank of the stream and other one end proud in to the current of the stream. Spur may be permeable which permit the water to pass and compact the velocity and spur may be impermeable which completely blocks the flow. Spurs may be constructed of permanent and semi-permanent material such as timber sheet pilling, steel, gabions, concrete, sand, soil and stone. Although spur is widely used river training work but no definite hydraulic design measures have been established because a lot of factors and parameters involved in designing of the spur which changed according to sight, river morphology. The hydraulic design of spur based on experience and judgment of specific geographical location because a lot of variables affect the performance of the spur. The variables which influence the spur design are width, length, angle, crest profile and spacing of the spur and as well as depth, width, velocity and bed material of the channel.

Copeland (1983) concluded that the ratio between spacing and length when high and may be effective in case of concave banks. This ratio between length and spacing of the spur is determined by previous knowledge in similar situations or site specific model studies. Spur was aligned normal to the bank or slightly aligned on upstream or downstream side which has slightly effect on bank erosion in the model study. The physical model of spur at specific site study will offer useful knowledge with respect to velocity reduction counter to the bank of the channel.

Mohammad et al. (2015) checked the performance of river spur which was installed in Sezar and Kashkan River in province of lorestan of Iran. Different equations used proposed by Ahmad(1953),Neil(1973),Khosla(1953), Zagjloul(1973) and Liu(1972) to predict the scouring depth at spur and result showed that spur performed their work properly which was constructed on both rivers. The spacing and length of the spur was suitable in Sezar River but in case of Kashkan River it was not suited due to improper lateral wall angle, poor pier foundation and poor material.

Gupta et al. (2012) constructed physical model of spur of selected site of Kosi river along the western canal between 0 - 4.237km because of large portion of this bank and one spur which exist at 2.25km damaged change during flood of 2001.The distorted hydraulic model of two spurs was constructed at 3.5km and 3.75km along the bank of the Kosi river. The result showed that two spurs helped to repel the flow and decrease the flow concentration on the present spur which was located at 2.25 km.

Mojtaba et al. (2009) studied the two types of spur which is blade and bar type for the protection of the outer bank of the river by the physical model approach. The experiment showed that permeable spur in both blade and bar types spur are effective for the protection of outer bank. The result showed that blade spurs are more efficient but they created scouring around the spur. Finally the combination of both blade and bar type of spurs was related as the best protection of the outer bank of the river.

Jiang et al. (2013) studied the permeable spur. Permeable spur is an advanced type of spurs. The permeable spur application was analyzed in Netherlands to perform the some experiences on this spur field during the practice on the Rhine and Jumna River (Bangladesh). It was concluded that permeable spur was the best spur and best alternative for the river training structure in the lower yellow river

Sobhan et al. (1999) stated that spur is widely used river training work for protection of bank. The spacing among successive spurs depends upon bank shape, flow of the river and economics. The decision of spacing for specific kind of spur and for certain problem can be done by studying the physical model before actual physical construction. Generally, for bank protection spacing between successive spur was 2 to 2.5 times the actual length of the spur. When series of spur used for longer bank protection, higher spacing can also be used. The result of the model study indicated that spacing among the spur was 4.5 to 5 times of the length of the spur to make the bank feasible.

Richardson et al. (1975) described that the length of the spur mainly depends upon the location, economy, purpose and spacing. If length of the spur is taken short then spacing between spur should also shorter and vice versa. One spur which is perpendicular to the bank, protect the length of the bank which is 3 to 4 times the length of the spur. Spacing is directly related to the length of the spur, flow velocity, angle α, curvature of the bank and purpose of the spur. Spacing between the spur is equal to the 1.5 to 2L mostly used to gain deep waterway for navigation. L is the upstream expected length of the spur in to the flow and spacing equal to 2 to 6L used for the protection of the bank. For short spurs the spacing equal to 1 to 10L most widely used successfully and economically where the banks of the river were protected with vegetation or riprap.

Seed (1997) concluded that the spacing between the spurs along the bank of the river depends upon the length of the spur and protection required. An extensive range of approvals was adopted issued by different authors with the favorite spacing ranging from 1 to 6 times of the length of the spur. A lot of recommendations are shown in table 2.2.

Table 2.2: Recommended Spur Spacing

References	Type of bank	Spacing	Comments
Richardson and simsons 1973	Concave	4 to 6l	General practice
Grant	Concave	3 l	General practice
Unecafe	Concave	1l	General practice
Unecafe	Convex	2 to 2.5 l	General practice
Los angles district 1980	Concave	1.5 l	Bank may need riprap
Los angles district 1980	Convex	2.5 l	Bank may need riprap
Los angles district 1980	Stright	2 l	Bank may need riprap
Neil,1973	Either	2 to 4 l	General practice
Copeland,1983	Concave	Up to 3 l	Bank may need riprap
Maccaferi,1980	Convex	6l	Gabions
Maccaferi,1980	Concave	4 l	Gabions
Alverz, 1989	Concave2.5 to 4 l		Maximum siltation
Bognar and hanco 1989	Either	1.2 l	Maximum siltation

Source: (HR report, SR229)

BWDB (1993) stated that the spacing between the successive spur depends not only upon length of the spur, but also depends on the orientation of the flowing velocity, spur purpose and curvature of the bank of the river. Generally spacing among the spur is 2 to 3 times the length of spurs. This rule is mostly adopted for the protection of the bank. A single spur can save the bank 4 to 5 times the length of the spur. The recommended spacing between the spur was 2.5 to 3 times the length of the spur for the protection of the bank. Spur placed closer to concave banks and in case of convex bank the spacing among the spur slightly increased.

Kumar et al. (2015) studied about the foundation of the spur and discuss the scouring depth near the spur structure. The scouring depth can easily predicted by water depth, spur orientation, intensity of the discharge, effective length of the spur and sediment size parameters. These parameters helped for the designing the depth of the foundation of the spur and also helps to take the protection measures to escape the scouring exploit.

Anwar et al. (2012) performed an experiment for the analysis of the placement of the spur on the bend of the river. A good placement of the spur on the bend of the river can protect the bank for longer time. The result of the experiment showed that If spur is placed at 1/4 upstream of curves bend which have radius equal to 40m give best control to the flow of the river and if spur is placed on the bend of the river which have radius equal to 30m, the spur in upstream of curves bend give best result to control river flow. In this experiment they also found the relationship between spur length factor (L/B) and protection factor (D/B) and result showed that if the length factor (L/B) is equal to 1/5 of the width of the river, then it will give better effect against protection factor than another length factor of the spur.

Ravindra et al. (2012) stated that river change their flow pattern continuously which created a lot of problem for agricultural as well as village land. The river training work and anti-erosion work are essential for stabilization of the banks of the river and flow of the river along desired pattern. Spur are widely used for river training work as anti-erosion structure. Spacing and length of the spurs are very important factor which influence on the performance of the spur. These two parameters depend upon river characteristics, construction cost, purpose of the spur and maintenance. As thumb rule is Spacing/length is equal to 2.5 to 5 normally adopted for the protection of the bank of the river. This thumb rule is verified by graphical analysis and by constructing the spur in field. However, spur indicated wide variations for safety margin for the protection of the bank of the river.

Hager et al. (2008) explained that spurs are very important river training work used for the protection of the river banks and flows the river in regular pattern. It is also used for enhancing the environmental situations along the bank of the river. Spurs were made by considering the number of geometrical parameters, which is not exactly fixed. In this research they investigated the failure mode of the spur. The results showed that first two spurs required an appropriate riprap protection for enhancing the uniform scour situations along the whole spur reach. This research also investigated the impacts of a variety of factors on the flow of the spur like spur spacing, height, length, diameter and number of riprap rows along with granulometric and hydraulic parameters. Design equations were also established which are based on experimental movement to calculate riprap failure in positions of the former set of variables.

When the river narrow or the alignment of the banks of the river cannot be reduced then groynes are not be used. Groynes are also not used where opposite bank is bare to diagonal flows which caused a lot of erosion. In such circumstances continuous longitudinal safety is required. The groynes effectiveness based on its location, resources available and its design. The success of groynes installation also depends upon the upstream start point and the termination point of the downstream side. After selecting the spur length the important factor is to consider the protection of the opposite river bank. Generally, spur length should not be greater than 1/5 times of the width of the river and never less than the 2.5 times of the scouring depth.

Alauddin et al. (2011) concluded that a spur is an important river repair structure. An impermeable spur is an unstable structure in high floods and permeable spur could not divert the flow of water accurately. Since the current demands four important spur structures, they are tested in the laboratory to check their fluvial responses with combination of some ground information. The groins performance is confirmed by three important features: deposition in the spur field (stability of the bank) scouring near the spur (stability of the structure) and channel bed erosion (navigability). The result showed that combined groins lessen the local scouring as compared the conventional blocked structure and caused slow deceleration of water flow in the direction of the land.

Bisri et al. (2013) worked on modeling of the groin placement on the bend of the river to calculate the volume of the sedimentation which was accumulated on the groin field. In this research mathematical modeling was done by finite difference method. This research used 450 different cases in which various combination of the groyne like different length, position, and radius and flow velocities used and suitability coefficients obtained from the simulation of data by the regression analysis.

Ibrahim, (2014) investigated the impact of oriented spur on the scouring and deposition process in the straight rivers. Numerical and physical model were used at a same time and total 27 experiments were conducted in which three angle of spur 60, 90 and 120 degree were used with contraction ratios 1.10, 1.15 and 0.20 respectively at the downstream channel side to check the effect of these angle on the geometry of scouring on diminishing erosion end-to-end to the bank of the stream. Results were analyzed graphically and percentage of errors among the derived results was stated to describe the enough compatibility among the models which were used. To evaluate the silting and scouring parameters simple formulas were derived.

Solari et al. (2017) stated that spur dikes are the river training structure which were used to divert the flow from erodible wall and give the suitable path for flow, control the flood and protect the external banks. Spur dikes were also used to decrease the water erosion force and the transportation power of sediment. In this research a channel and spur dike related to the model of Heltz laboratory have been simulated by using flow-3D numerical model and RNG turbulence model also used for turbulence modeling. Around the inclined spur dike a turbulent flow field created and checked the effect of angle of spur dike, hydraulic condition and investigated the sedimentation pattern around the spur dike. The results showed that angle of the spur dike directly affected the length as well as width of the sedimentation area. When angle of the spur dike increase from 90 to 120 degree then the width as well as length of the sedimentation area increases from 71 to 92% respectively.

Oosting et al. (2015) concluded that many styles of river training structures were used in the spectrum of the spurs. One of the style from this spectrum use of the short spurs that angled toward downwards from the upper edge of the bank of the structure and mid-stream scouring away from the spur. This style of spur was referred to as repelling spur. This research described that the hydraulic characteristics of this pattern of spur based on 2D modeling and several example of repelling spur were constructed along the Bow River in the city of Calgary after June 2013 floods in Alberta for the protection of the bank.

Chapter III

METHODOLOGY

Spur is very important river training structure which is used in river engineering for the protection of bank of the river and divert the flow of water at desired course, establish the river morphology at constant pattern. It is very heavy and expensive river training Work. So spur is carefully designed and its affected parameter should be carefully considered.

In this study, effectiveness of spur was checked by at different orientation like deflecting repelling as well as attracting spur at angle of 90, 60 and 120 degree respectively. The angles was taken at upstream side of the structure. In second case two classes of spacing of spur were analyzed by constructing the three spur in series and then two spur in series. Spacing between he spur was studied to analyze the protection of banks in straight channel. In the last three most prominent geometry of spur was studied.

An experimental setup was established in model tray hall which is located in CEWRE, UET Lahore. The physical model of the spur which discussed in that study was not a model at specific site. The constructed model was prospective model of the spur to check its effectiveness at different orientation, spacing and different geometries at different flow rates.

Main parameters studied to check the effectiveness of spur are given below:

- Direction of water currents near all the spur
- Scouring pattern near the all the spur

- Deposition and erosion near the spur
- Flowing velocity distribution in the experimental channel
- Flow depth observation with the help of vertical rod.
- Spacing between the spur for the protection of banks in the river

3.1 Experimental Layout

The main steps of the methodology consist of following main points.

i. The experimental layout consists of number of outcomes, first of all the experimental channel was constructed in the Model Testing Hall. This channel was constructed according to available space and discharge. After constructing the channel, checked the stability of the channel at maximum discharge that is 2 cusec. The experimental channel was run about two hours continuously for stabilization at maximum available discharge.

ii. In this study 24 experiments was carried out at three different discharges 0.75cusec, 1 cusec and 1.5cusec or 0.15 cusec/m, 0.20 cusec/m and 0.30 cusec/m respectively. First orientation of spur was discussed at angle of 60, 90 and 120 degree and angle was taken at upstream side of the structure. After that two different case of spacing between the spur was discussed at same three different flow discharges. In the last three different geometry of spur, T-Spur, J-Spur and Hockey Spur were constructed which was also studied at same three flow discharges.

iii. For the measurement of the discharge in the channel a V-Notch was installed at upstream of the channel. Flow velocity in the channel at three discharges was measured at different locations with the help of the digital current meter. The flow depth was also measured at different locations in the channel by inserting the vertical rod in the channel. To study scouring pattern, erosion and deposition near all the structure a measured mesh, which was placed size was 10×10 cm^2 was constructed. Mesh was put above the channel after running the each experiment and values of deposition and erosion was noted.

iv. The observed data was plotted in the surfer software. In the surfer three axes were made. Deposition or erosion values was put on x-axis, values of length of the channel was put on y-axis and values of width of the channel was put on z-axis which gave scouring pattern and contouring map of the bed near all the spurs.

v. In the last comparison study was carried out at three different discharges and direction of velocity current was also studied with the help of the blue color in all orientation, spacing as well as geometry of the spur. These all results were checked in the next chapter to conclude the effectiveness of spur.

3.1.1 Experimental Channel

The experimental channel in the Model Tray hall was constructed as shown in Fig 3.1. The main dimensions of the channel are given in table 3.1

Table 3.1: Dimensions of the experimental channel

Specification	**Dimension**
Length of the channel	7 m
Width of the channel	1.5 m
Depth of the channel	0.4 m
Bed slope	0.001
Side slope	1:1.04
Bed material	Sand

Figure 3.1: Experimental channel constructed in MT- Hall

3.1.2 V- Notch Weir

Discharge was measured by using V- notch weir which was installed at up- stream of the channel as shown in Fig 3.1. The discharge capacity was two cusecs.

Discharge was measured by following formula:

$$Q = 8/15\ C_d\ 2gH^{5/2} \tag{1.1}$$

Q = Discharge

C_d = discharge coefficient

H = depth of water over V- Notch.

3.1.3 Digital Current Meter

Digital current meter was used to measure the flow velocity at different locations like upstream, downstream and nose of the spur at different flow discharges. Vertical rod was also inserted at upstream and downstream of the channel to measure the flow depth at different flow rates. This was a digital current meter which gives the flow velocity at different location in the channel.

Figure 3.2: Digital current meter

3.1.4 Mesh

A mesh was constructed to measure the scouring pattern in the channel around the spur at different discharges as shown in Fig 3.4. In this mesh the mesh size is 10 cm×10 cm. Mesh measure the erosion and deposition near the structure by putting the mesh on the bank in every experiment.

Length of the rectangular mesh = L = 2.75 m

Width of the rectangular channel = W= 1.20 m

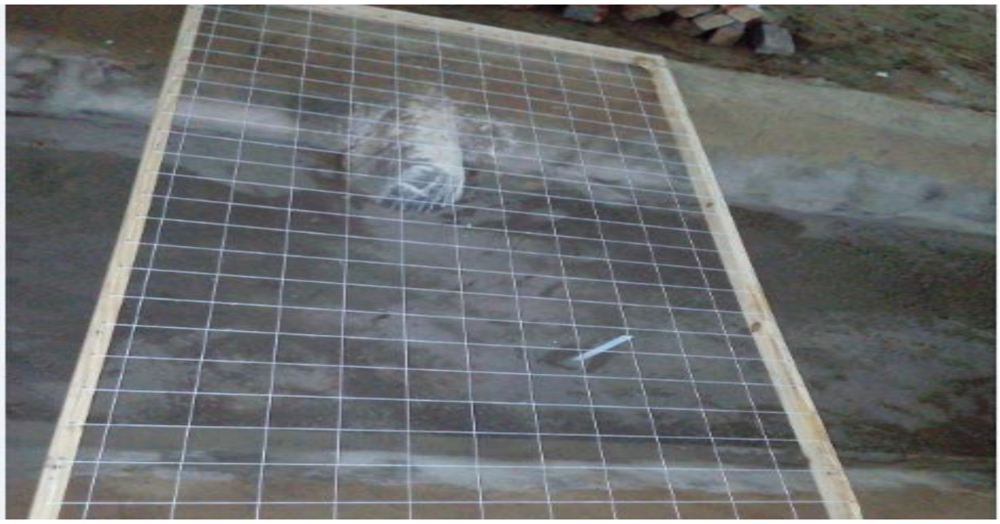


Figure 3.3: Measured Mesh

3.1.5 Surfer software

The values were noted with the help of mesh. These values were plotted using surfer software by making the three axes. Surfer software gives the contouring and scouring pattern near all the structure of the bed at three different discharges.

3.1.6 Available Discharge

Available discharge = 2 cusec

Bed material = sand

Spur Specifications

Spur length ratio= β = b/B=0.25

Here,

b = length of the spur

B = width of the channel

So, dimension of the spur, which were constructed in the channel are shown in table 3.2.:

Table 3.2: Dimensions of spur

Specifications	**Dimensions**
Length of the spur	L = 0.37 m
Height of the spur	H = 0.30 m
Spur base thickness	B = 0.25 m
Spur top thickness	T = 0.10 m

3.2 Orientation Study of the Spur

For the orientation of the spur, three types of orientation were constructed in the channel at angle of 60 90 and 120 degree respectively and studied the scouring pattern, deflection of water currents near all orientation and velocity profile near the structure.

Three different flow rates were taken and total nine experiments were carried out for the study of orientation of the spurs.

3.2.1 Deflecting spur

The deflecting spur was constructed at the angle of 90 degree as shown in the Fig 3.5. The deflecting spur used to deflect the water flow away from the river bank. This spur perpendicular to the bank of the channel. The main specifications of first three experiments of deflecting spur are shown in the table 3.3:

Table 3.3: Specification of experiments of deflecting spur

Specifications		**Dimensions**	
Angle		90 degree	
Bed level		39.5 cm	
Specifications	**Experiment No 1**	**Experiment No 2**	**Experiment No 3**
Discharge	0.75 cusec	1 cusec	1.5 cusec
Unit discharge	0.15 cusec	0.20 cusec	0.30 cusec
Flow depth	0.07 m	0.10 m	0.11 m

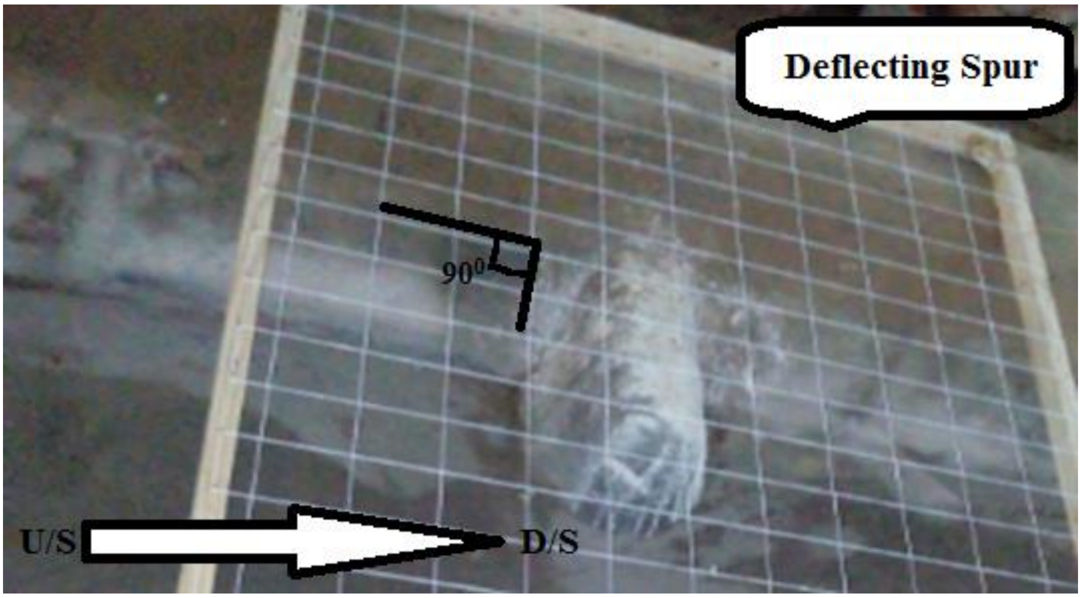


Figure 3.4: Spur type: deflecting (Angle 90 degree)

3.2.2 Repelling spur

The repelling spur was constructed at the angle of 60 degree as shown in the Fig 3.5. The repelling spurs direction was towards upstream side of the channel. This structure create water pocket on the upstream side and repel the flow away from the bank. The main specifications of experiments of repelling spur spurs are shown in the table 3.4:

Table 3.4: Specifications of experiments of repelling spur

Specifications		**Dimensions**	
Angle		60 degree	
Bed level		40 cm	
Specifications	**Experiment No 3**	**Experiment No 4**	**Experiment No 5**
Discharge	0.75 cusec	1 cusec	1.5 cusec
Unit discharge	0.15 cusec	0.20 cusec	0.30 cusec
Flow depth	0.07 m	0.10 m	0.11 m

Figure 3.5: Spur type: repelling spur (Angle 60)

3.2.3 Attracting spur

The attracting spur was constructed at the angle of 120 degree as shown in the Fig 3.6. The attracting spurs direction was towards downstream side of the channel. This structure create water pocket on the downstream side and attract the flow toward the bank on upstream side. The main specifications of experiments of attracting spur are shown in the table 3.5:

Table 3.5: Specifications of experiments of attracting spur

Specifications		**Dimensions**	
Angle		60 degree	
Bed level		39.5 cm	
Specifications	**Experiment No 3**	**Experiment No 4**	**Experiment No 5**
Discharge	0.75 cusec	1 cusec	1.5 cusec
Unit discharge	0.15 cusec	0.20 cusec	0.30 cusec
Flow depth	0.07 m	0.10 m	0.11 m

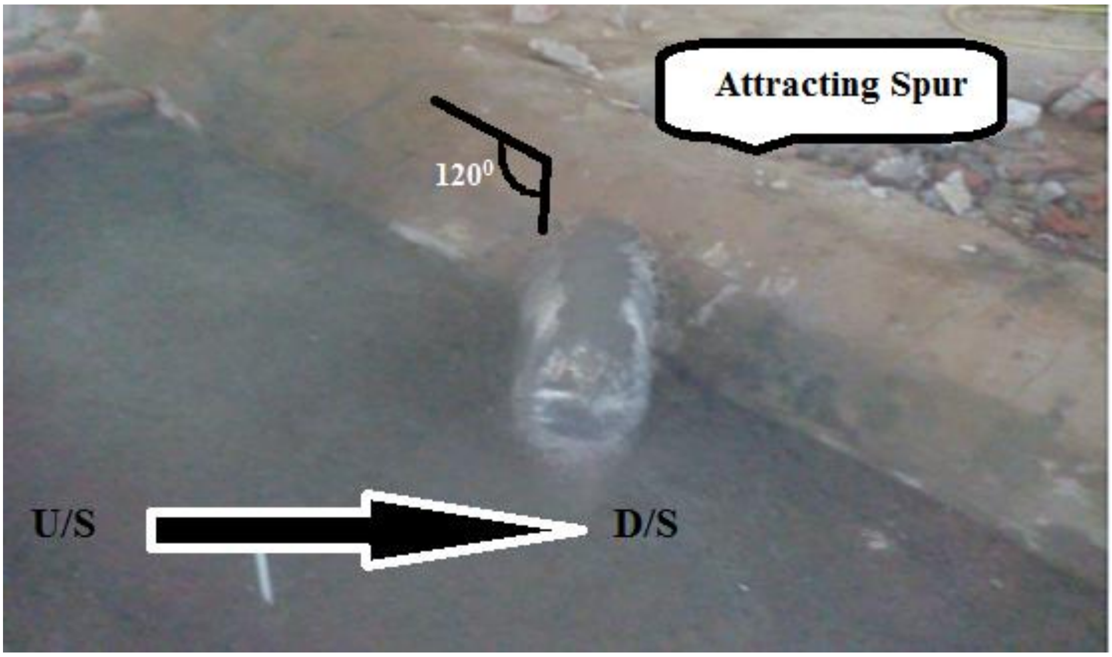


Figure 3.6: Spur type: Attracting spur (Angle 120 degree)

3.3 Study of Spur Spacing

Spacing is very important factor in designing of the spur. A series of spur is constructed in the river by taken the recommended spacing for bank protection at desired length. When the series of spur constructed in line by taken the different spacing the flow velocity reduced between the spur which accumulate the sediment between the spur. When accumulation of sediment takes place, bank of river become stronger up to desired length.

Spur spacing are very important factor for the protection of banks. Generally for the protection of convex banks the spacing are taken 2 to 3 times of the length of the spur and in case of concave bank the spacing between the spur more than convex banks. (R.K Shrma). The recommended spacing between spurs by the different researchers at concave, convex and straight channel shown in table 2.2.

In this study to discuss the spacing between the spur a straight channel was used to analyze the protection of bank. In first approach three spur were constructed in series by keeping spacing 2.25 time of the length of the spur between the spur. In second approach the two spur were constructed in series by removal central spur. Now Spacing become double which is 4.50 time of the length of the spur between the spur. In both approaches observed the deposition of sediment between the spur for the protection of bank, direction of velocity currents and flow velocity in the channel at different locations at three different flow rates.

In the last a comparison study was carried out in both approaches of spacing and analyzed the changing in all parameters which was takes place in both case of spacing between the spur.

3.3.1 Three Spur in Series

First three spurs in series was constructed in the channel at an angle of 90 degree as shown in Fig 3.7. The recommended spacing was taken 2.25 time of the total length of the spur. The main dimensions are three spurs spacing are shown in the table 3.6:

Table 3.6: Dimensions of three spur spacing

Specifications	**Dimensions**
Spacing between the spur	2.25 ×L Where L = length of spur
Spacing	S=2.25×0.37 m = 0.83 m
Length of the spur	L = 0.37 m
Height of the spur	H = 0.30 m
Spur base thickness	B = 0.25 m
Spur top thickness	T = 0.10 m

The specifications of experiments in three spurs spacing are shown in the table 3.7:

Table 3.7: Specifications of experiment of three spur in series

Specifications		**Dimensions**	
Angle		90 degree	
Bed level		39.5 cm	
Specifications	**Experiment No 10**	**Experiment No 11**	**Experiment No 12**
Discharge	0.75 cusec	1 cusec	1.5 cusec
Unit discharge	0.15 cusec	0.20 cusec	0.30 cusec
Flow depth	0.07 m	0.10 m	0.11 m

Figure 3.7: Series of three Spur spacing

3.3.2 Two Spurs in Series

Two spurs in series were constructed in the channel at an angle of 90 degree as shown in Fig 3.8. Their recommended spacing was taken 4.5 time of the total length of the spur. The main dimensions of two spur spacing are shown in the table 3.8:

Table 3.8: Dimensions of two spur spacing

Specifications	**Dimensions**
Spacing between the spur	2×2.25×L Where L= Length of spur
Spacing	S= 2×2.25×0.37=1.665 m
Length of the spur	L = 0.37 m
Height of the spur	H = 0.30 m
Spur base thickness	B = 0.25 m
Spur top thickness	T = 0.10 m

The specifications of experiments two spur spacing are shown in the table 3.9:

Table 3.9: Specifications of experiments of two spur spacing

Specifications	**Dimensions**		
Angle	90 degree		
Bed level	39.5 cm		
Specifications	**Experiment No 10**	**Experiment No 11**	**Experiment No 12**
Discharge	0.75 cusec	1 cusec	1.5 cusec
Unit discharge	0.15 cusec	0.20 cusec	0.30 cusec
Flow depth	0.07 m	0.10 m	0.11 m

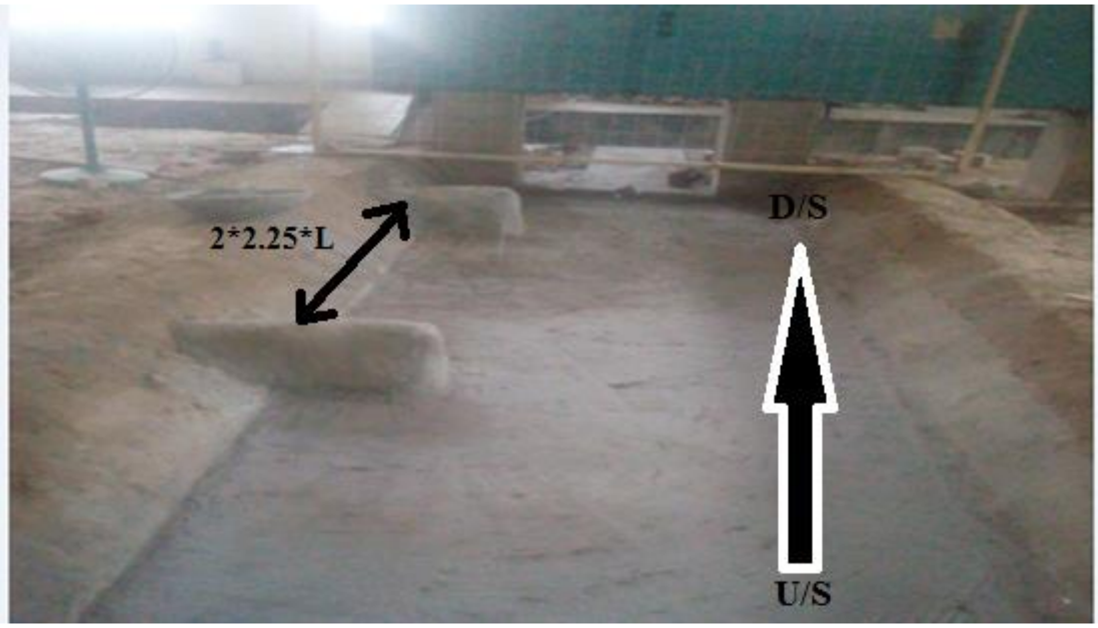


Figure 3.8: Series of two spur spacing

3.4 Geometry of the Spur

Geometry of spur is also important characteristic of spur which is used for different purpose. Specific geometry which is used in the river depends upon the function that can be performed from that geometry. Geometry of spur are used to train the river at specific direction Geometry of the spur used also depends upon the morphology of the river, site characteristics of river. T- Spur, J-Spur, hockey spur and inverted hockey spur are widely used geometries of the spur in river engineering structures.

In this study three different geometries of the spur were discussed. The physical model of T-Spur, J-Spur and Hockey spur was made. Scouring pattern, deposition, erosion, pattern of water currents and flow velocity distribution profile in the channel near all geometries was studied. Total nine experiments were carried out, three experiment of each geometry at three different discharges was discussed.

3.4.1 T-Spur

T-Spur was constructed in the channel with T-Head at angle of 90 degree as shown in the Fig 3.9. The water pockets were created on both side of the structure and flow velocity decrease near the structure. T-Spur was used to deflect the flow at specific direction. The main dimension of T-Spur is shown in the table 3.10:

Table 3.10: Dimensions of T-Spur

Specifications	**Dimensions**
Length of the spur	L = 0.37 m
Height of the spur	H = 0.30 m
Spur base thickness	B = 0.25 m
Spur top thickness	T = 0.10 m
Length of T- head	l = 0.4 m
Angle between spur and T- head	90 degree

The specifications of experiments of T-Spur is shown in the table 3.11:

Table 3.11: Specifications of experiments of T-Spur

Specifications		**Dimensions**	
Angle of T-Head		90 degree	
Bed level		40 cm	
Specifications	**Experiment No 16**	**Experiment No 17**	**Experiment No 18**
Discharge	0.75 cusec	1 cusec	1.5 cusec
Unit discharge	0.15 cusec	0.20 cusec	0.30 cusec
Flow depth	0.07 m	0.10 m	0.11 m

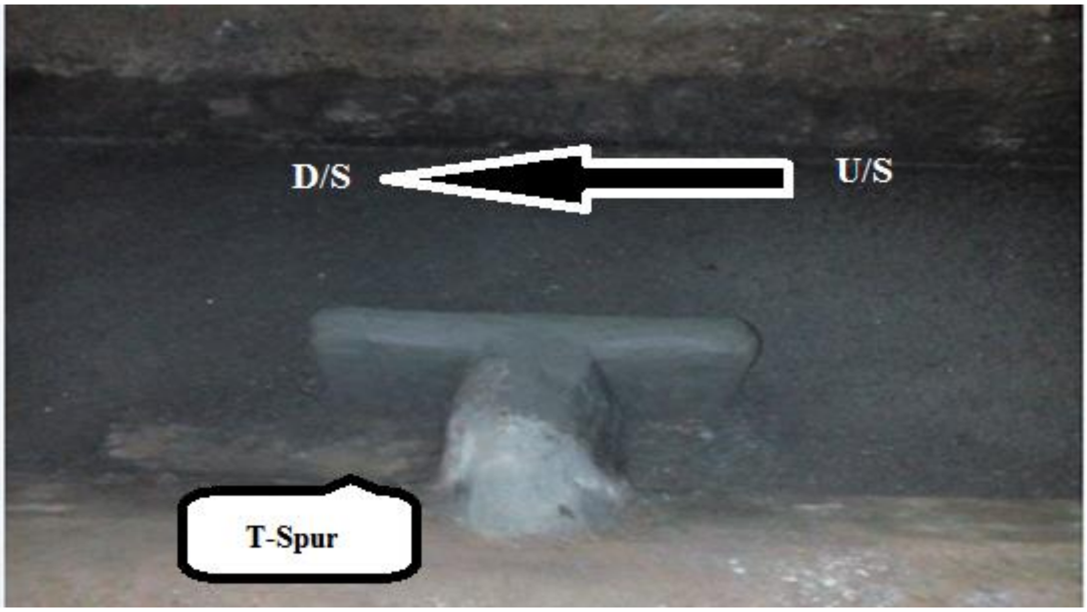


Figure 3.9 T- spur (90 degree)

3.4.2 J – Spur

J-Spur was constructed in the channel with J-Head at angle of 90 degree as shown in the Fig 3.10. The water pockets were created on downstream side of the structure and flow velocity decrease near the structure. J-Spur was used to deflect the flow at specific direction. The main dimension of J-Spur is shown in the table 3.12:

Table 3.12: Dimensions of J-Spur

Specifications	**Dimensions**
Length of the spur	L = 0.37 m
Height of the spur	H = 0.30 m
Spur base thickness	B = 0.25 m
Spur top thickness	T = 0.10 m
Length of T- head	l = 0.15 m
Angle between spur and J- head	90 degree

The specifications of experiments of J-Spur are shown in the table 3.13:

Table 3.13: Specifications of experiments of J-Spur

Specifications		**Dimensions**	
Angle of J-Head		90 degree	
Bed level		40 cm	
Specifications	**Experiment No 19**	**Experiment No 20**	**Experiment No 21**
Discharge	0.75 cusec	1 cusec	1.5 cusec
Unit discharge	0.15 cusec	0.20 cusec	0.30 cusec
Flow depth	0.07 m	0.10 m	0.11 m

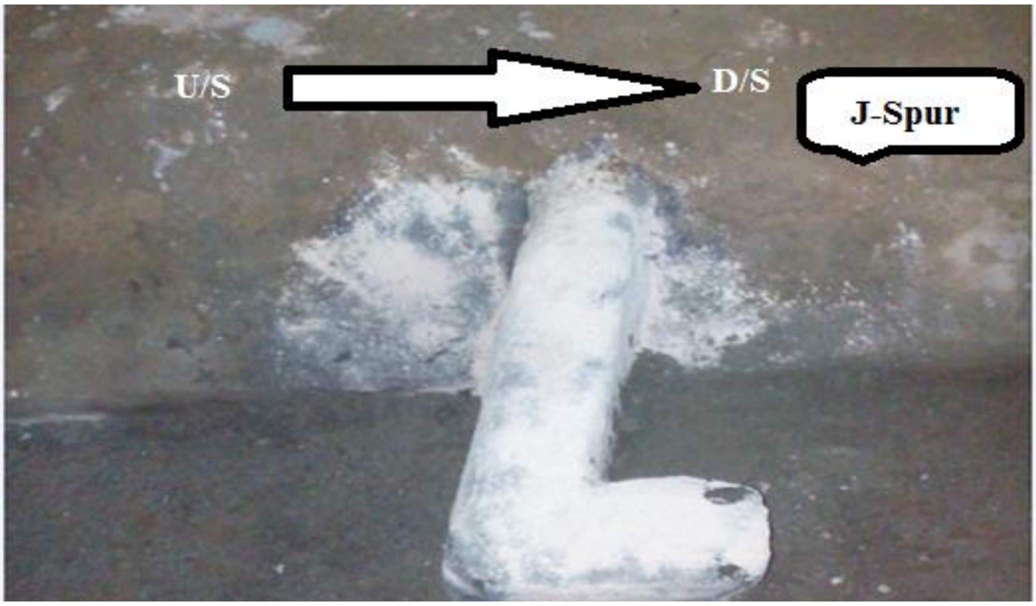


Figure 3.10: J-Spur

3.4.3 Hockey Spur

Hockey-Spur was constructed in the channel with hockey-head at angle of 45 degree as shown in the Fig 3.11. The water pockets were created on downstream side of the structure and flow velocity was decreased near the structure. Hockey-Spur was used to deflect the flow at specific direction. The deflection of water currents was easy in the hockey spur. The main dimensions of hockey-Spur are shown in the table 3.14:

Table 3.14: Dimensions of Hockey Spur

Specifications	**Dimensions**
Length of the spur	L = 0.37 m
Height of the spur	H = 0.30 m
Spur base thickness	B = 0.25 m
Spur top thickness	T = 0.10 m
Length of Hockey- head	l = 0.20 m
Top thickness of hockey head	t = 0.07 m
Angle between the spur and the head of the hockey	45 degree

The specifications of experiments of hockey spur are shown in the table 3.15:

Table 3.15: Specifications of experiments of Hockey Spur

Specifications		**Dimensions**	
Angle of Hockey-Head		45 degree	
Bed level		39 cm	
Specifications	**Experiment No 22**	**Experiment No 23**	**Experiment No 24**
Discharge	0.75 cusec	1 cusec	1.5 cusec
Unit discharge	0.15 cusec	0.20 cusec	0.30 cusec
Flow depth	0.07 m	0.10 m	0.11 m

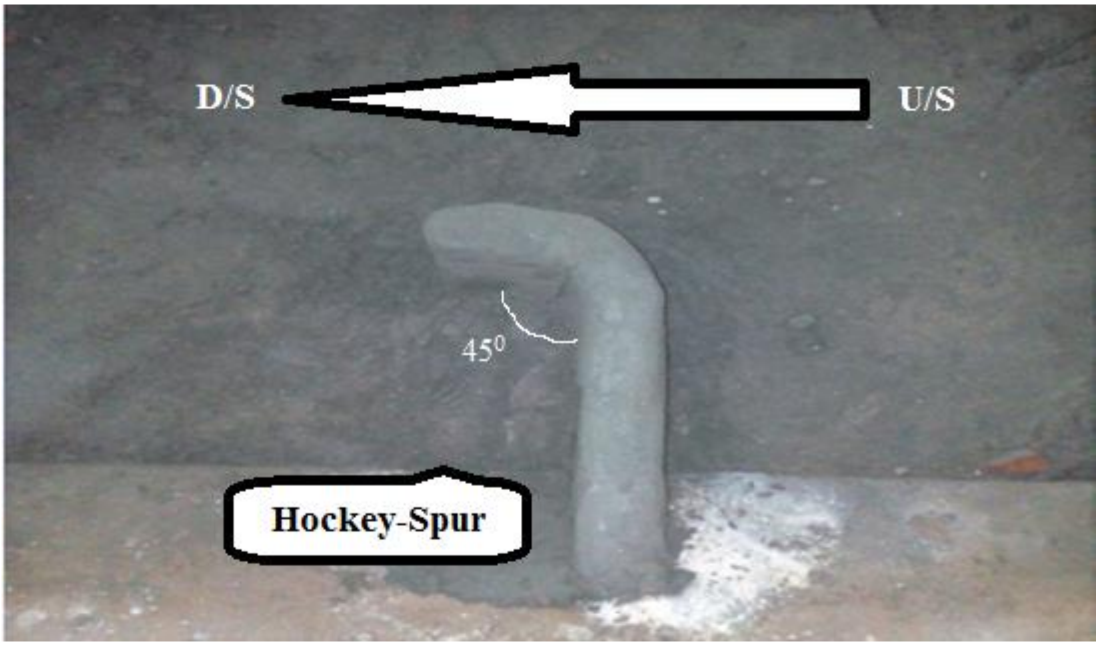


Figure 3.11: Hockey Spur

All experiments were carried out in the experimental channel one by one. First of all three spurs orientation was studied after that spur spacing was discussed and in the last geometry of the spur was studied. Each experiment was run ultimately for two hours on every discharge. After completion of each experiment, the scouring pattern near the structure was measured with the help of measured mesh.

When the experiment proceed, velocity was measured with the help of the digital current meter at different locations in the channel near the spur and note all the velocity values to draw the velocity distribution profile near the structure which is discussed in the chapter 4. Similarly, to check the direction of flow currents near the spur, blue dye was mixed in the flowing water for observing the direction of the velocity currents at different orientations and geometries of the spur. Water pocket were also observed which was created between the spur in case of spacing study of the spur at every flow rates. Flow depth also observed by inserting the vertical rod in the channel.

Chapter IV

RESULTS AND DISCUSSIONS

Scouring pattern, erosion, deposition, direction of water currents and flow velocity was observed during the experiment. The experiment was run at three different values of discharges which were 0.75 cusec, 1 cusec and 1.5 cusec or 0.15 cusec/m, 0.20 cusec/m and 0.30 cusec/m respectively. Scouring pattern, deposition or erosion and contour map of the bed was made of each experiment by using surfer software. Velocity distribution in the channel at different location at each discharge was observed with the help of digital current meter. Velocity profile was designed at each flow rate. For the observation of direction of water currents which deflected blue dye was mixed in the flowing water during each experiment. Flow depth at each discharge was measured with the help of vertical rod which inserted in the channel at different location in the channel.

4.1 Orientation of the Spur

To orientation of spur nine experiment were performed. Three orientations were studied in nine experiments at three different flow discharges. First orientation was constructed at an angle of 90 degree which was deflecting spur. Second orientation was constructed at an angle of 60 degree which was repelling spur. Third orientation was constructed at angle of 120 degree which was attracting spur.

4.1.1 Deflecting spur

In case of deflecting spur at an angle 90 degree three experiments was carried out. Each experiment was run almost two hours. During experiment velocities were measured by digital current meter. Flow depth was observed with the help of vertical rod.

4.1.1.1 Experiment No 1

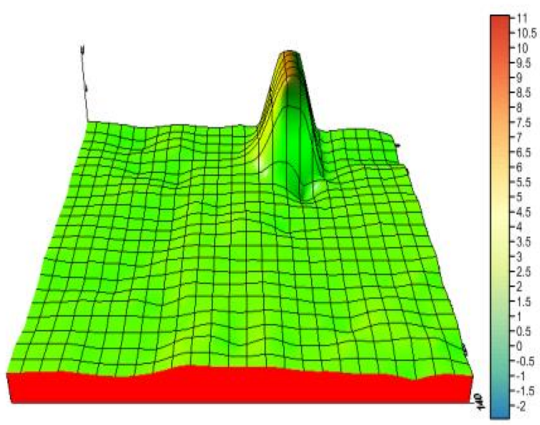
Experiment one was carried out at the minimum discharge 0.75 cusec. The specification of that experiment as shown in table 4.1

Table 4.1: Specification of experiment No 1

Spur type = deflecting	Unit discharge = q= 0.15 cusec/m
Angle = 90 degree	Level of the bed = 40 cm
Discharge = 0.75 cusec	Flow depth = 3 inch = 0.07 m

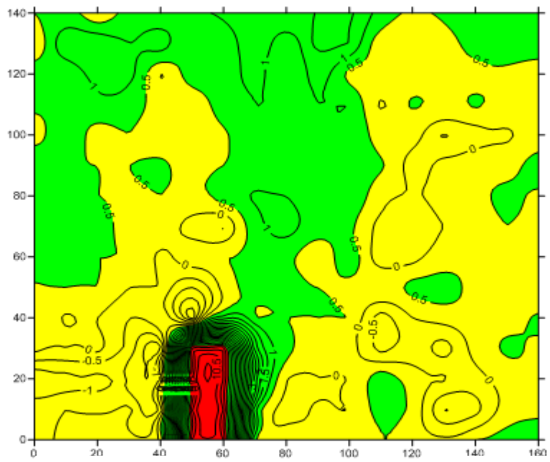
Scouring pattern

The scouring pattern and contour map were developed obtained from the surfer software as shown in Fig 4.1 and 4.2. This Fig shows that at the unit discharge 0.15 cusec/m the bed profile near the structure were slightly changed. Erosion takes place at upstream side of the deflecting spur as well as near the nose of the structure. Deposition was observed at downstream of the structure.



d/s u/s

Figure 4.1: Scouring of bed of Deflecting spur at 0.15 cusec/m



u/s d/s

Figure 4.2: Contour map of deflecting spur at 0.15 cusec/m

Direction of velocity currents

Velocity currents were deflected at the upstream side of the deflection spur. The direction velocity currents near the structure were observed by blue dye water at upstream side of the structure. The water currents change their direction when strike on the structure at upstream side as shown in Fig 4.3.

Figure 4.3: Direction of velocity currents at 0.15 cusec/m

Velocity Distribution Profile

Velocity distribution in the channel at different locations was also observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.15 cusec/m shown in the Fig 4.4. This Fig shows that velocity slow down at upstream side of the channel which increases slightly at the nose of the spur and almost become zero at downstream of the structure. The profile shows that flow velocity increases continuously when going farther to the spur.

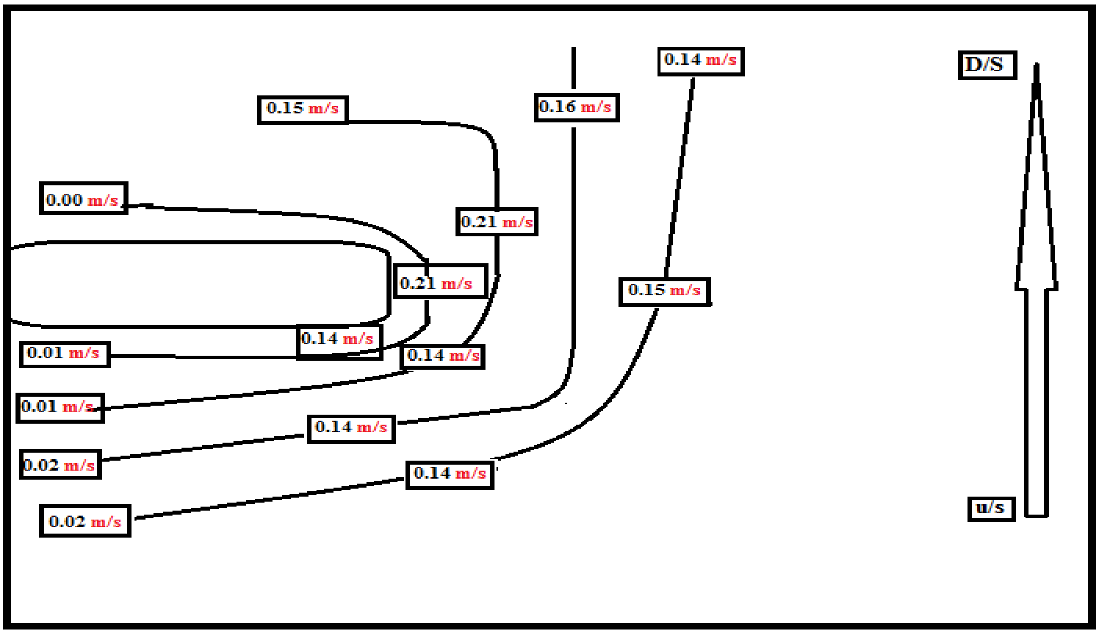


Figure 4.4: Velocity distribution at 0.15 cusec/m of deflecting spur

4.1.1.2 Experiment No 2

Experiment two was carried out at the medium discharge at 1 cusec. The specification of that experiment as shown in table 4.2

Table 4.2: Specification of experiment No 2

Spur type: deflecting	Unit discharge = 0.20 cusec/m
Angle = 90 degree	Flow depth = 4 inch = 0.10 m
Discharge = 1 cusec	Level of the bed = 40 cm

Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.5 and 4.6.This Fig shows that at the unit discharge 0.20 cusec/m the bed profile near the structure were more changed than at 0.15 cusec/m discharge. Erosion takes place at upstream side of the deflecting spur as well as near the nose of the structure which increased slightly by increase the unit discharge. Deposition was observed at downstream of the structure.

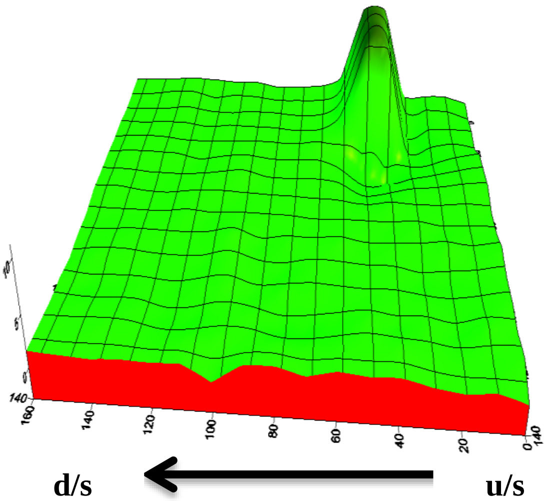


Figure 4.5: Scouring of bed of deflecting spur at 0.20 cusec/m

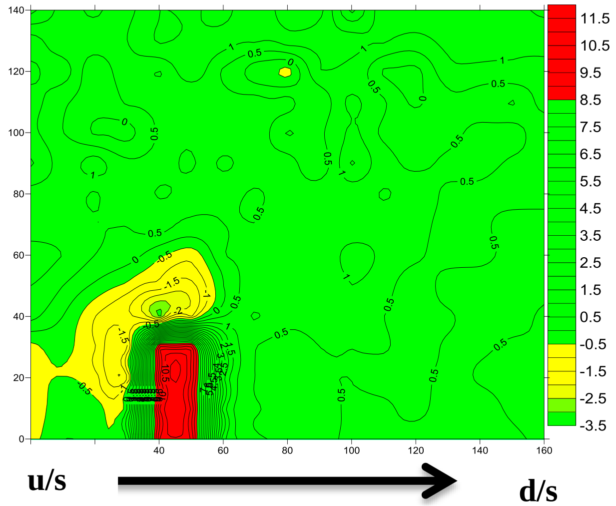


Figure 4.6: Contour map of Deflecting spur at 0.20 cusec/m

Direction of velocity currents

Velocity currents were deflected at the upstream side of the deflection spur The direction velocity currents near the structure were observed by blue dye water at upstream side of the structure The water currents change their direction when strike on the structure at upstream side more rapidly at 0.20 cusec/m as shown in Fig 4.7.

Figure 4.7: Direction of velocity currents at 0.20 cusec/m

Velocity Distribution Profile

Velocity distribution in the channel at different locations was also observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.20 cusec/m shown in the Fig 4.8. This Fig shows that velocity increased in the channel when unit discharge increased. Velocity slow down at upstream side of the channel which increases slightly at the nose of the spur and almost become zero at downstream of the structure. The profile also show that flow velocity increases continuously when going farther to the spur. Strike velocity at nose of the spur was more than as compared to 0.15 cusec/m discharge.

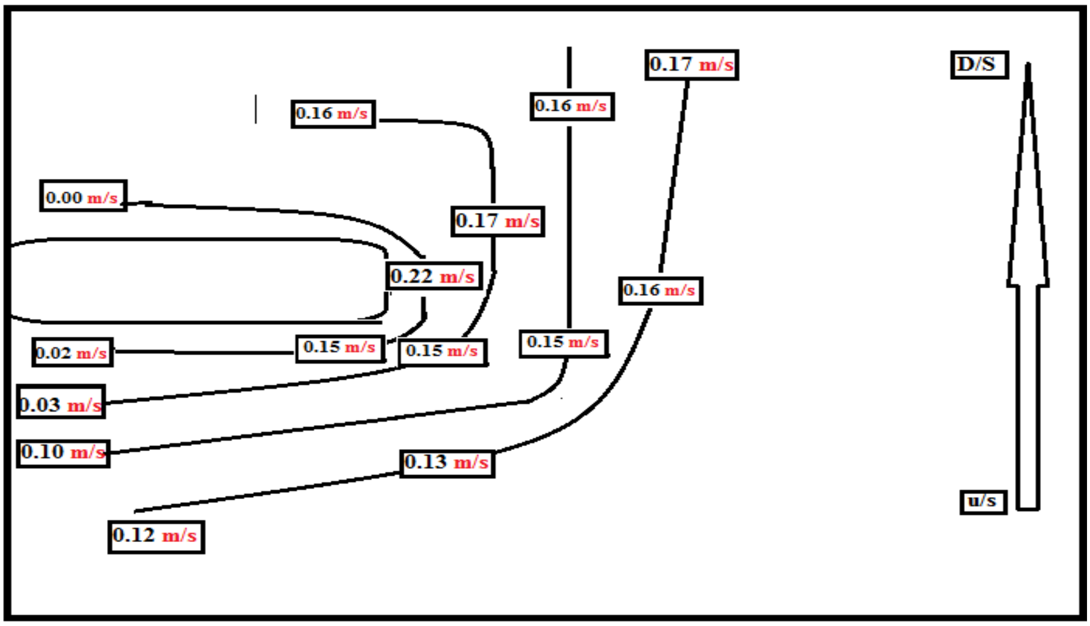


Figure 4.8: Velocity distribution at 0.20 cusecs/m of deflecting spur

4.1.1.3 Experiment No 3

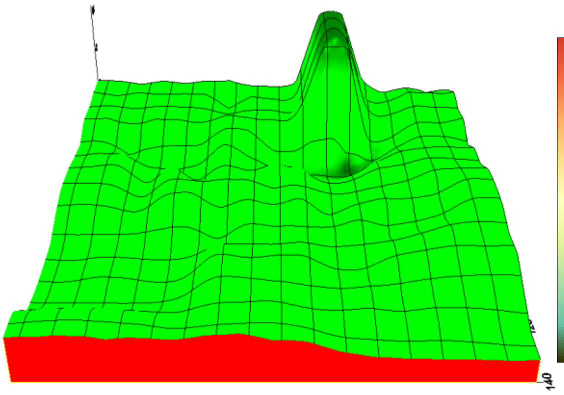
Experiment three was carried out at the maximum discharge at 1.5 cusec. The specification of that experiment as shown in table 4.3

Table 4.3: Specification of experiment No 3

Spur type: deflecting	Unit discharge = 0.30 cusec/m
Angle =90 degree	Flow depth = 4 inch = 0.10 m
Discharge = 1.5 cusec	Bed level = 40 cm

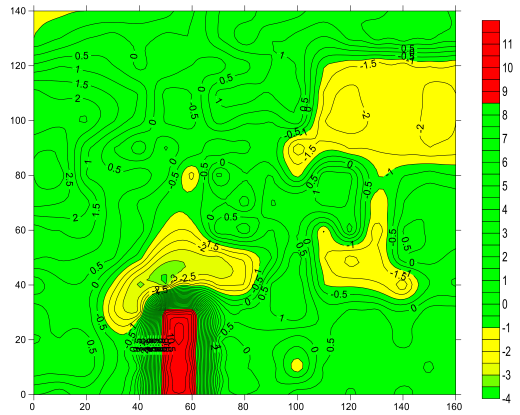
Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.9 and 4.10.The Fig shows that at the unit discharge 0.30 cusec/m the bed profile near the structure were rapidly changed than at 0.20 cusec/m discharge. Erosion at upstream side and near the nose of the structure also increased by increase the unit discharge. The result shows that when unit discharge increases scouring pattern of the bed was also changed rapidly.



d/s u/s

Figure 4.9: Scouring of bed of deflecting spur at 0.30 cusec/m



u/s d/s

Figure 4.10: Contour map of deflecting spur at 0.30 cusec/m

Direction of velocity currents

Velocity currents were deflected at the upstream side of the deflection spur. The direction velocity currents near the structure were observed the blue dye water at upstream side of the structure. The water currents change their direction when strike on the structure at upstream side more rapidly at 0.30 cusec than 0.20cusec/m and 0.15 cusec/m as shown in Fig 4.11.

Figure 4.11: Direction of velocity currents at 0.30 cusec/m

Velocity Distribution Profile

Velocity distribution in the channel at different locations was also observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.30 cusec/m shown in the Fig 4.12. This Fig shows that velocity increased in the channel when unit discharge increased. Velocity slow down at upstream side of the channel which increases rapidly at the nose of the spur and slow down at downstream of the structure. The profile also show that flow velocity increases continuously when going farther to the spur. Strike velocity at nose of the spur was more than as compared to 0.20 cusec/m and 0.15 cusec/m discharges.

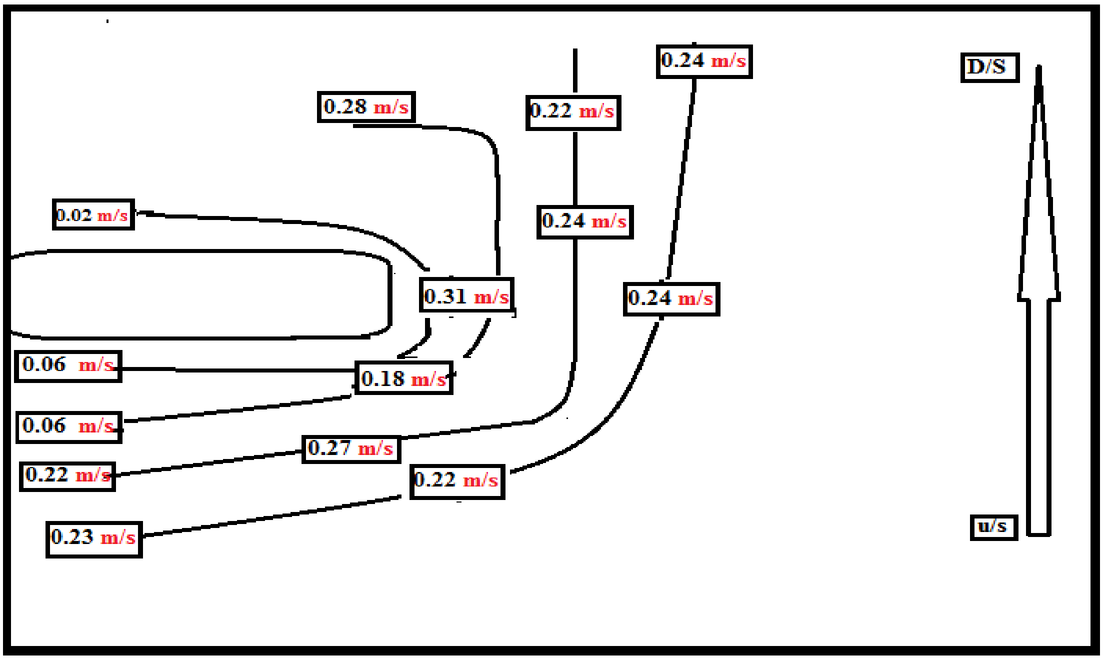


Figure 4.12: Velocity distribution at 0.30 cusecs/m of deflecting spur

4.1.1.4 Comparison of Erosion and Deposition near Deflecting Spur

When three experiment of deflecting spur was completed at three different unit discharges. A comparison of erosion and deposition near deflecting spur studied was carried out. The location of deposition and erosion were taken near the spur as shown in Fig 4.13.

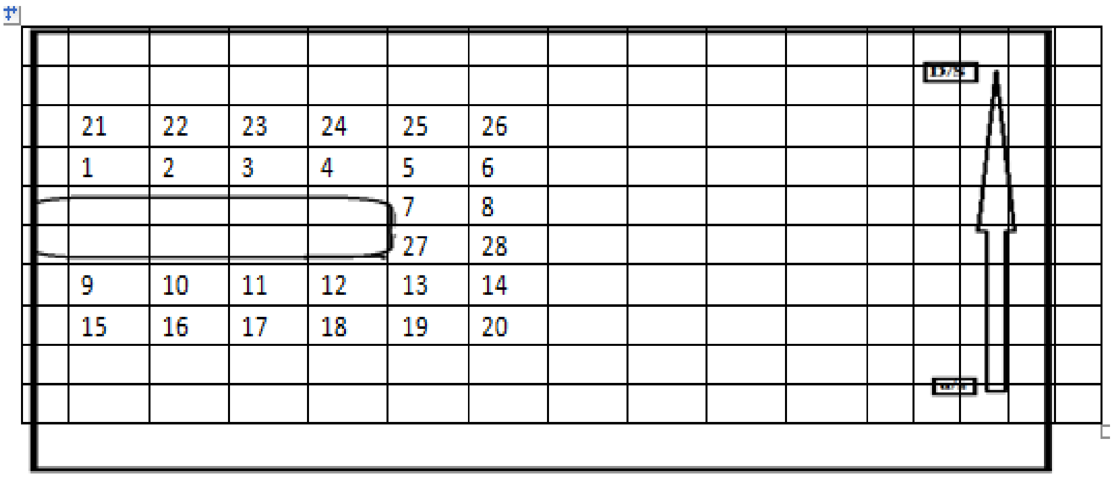


Figure 4.13: Deposition and erosion location near the deflecting spur

The Fig 4.14 shows the behavior of erosion and deposition near the deflecting spur. Result shows that when unit discharge was gradually increased then erosion and deposition was also increased. This Fig also shows that at 0.15 cusec/m unit discharge only deposition takes place near the spur because flow velocity was low. When unit discharge increases 0.20 cusec/m and then 0.30 cusec/m then erosion takes place near the structure.

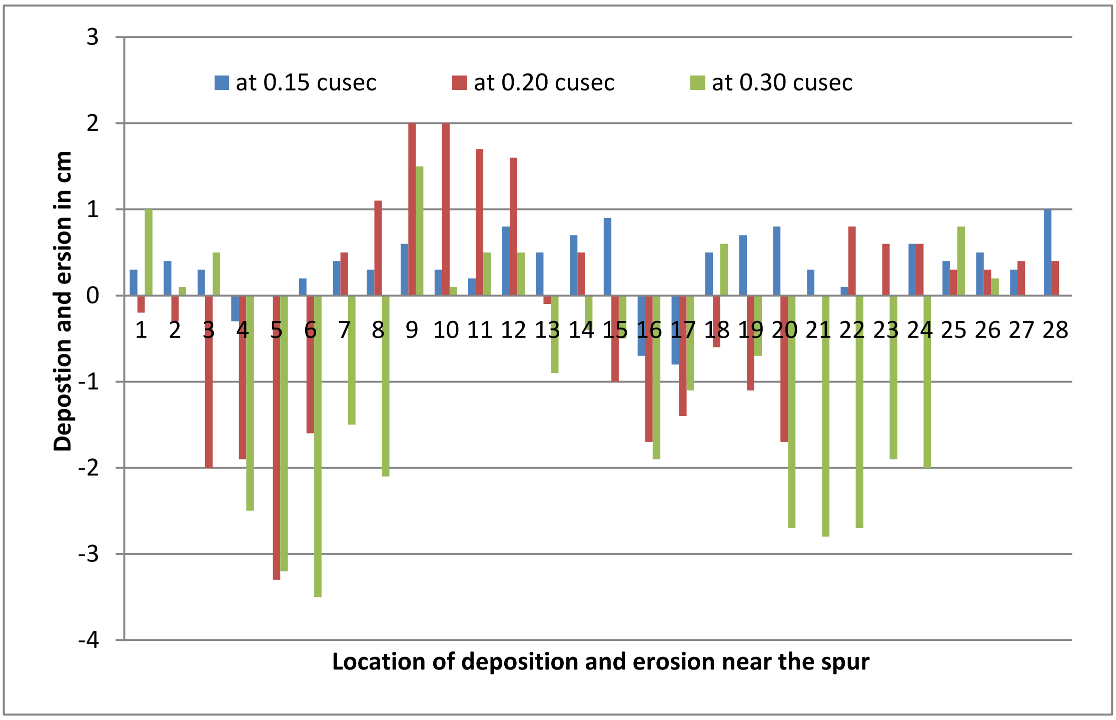


Figure 4.14: Spur (Deflecting) from Experiment 1 to 3

4.1.2 Repelling spur

In case of repelling spur at an angle 60 degree three experiments was carried out. Each experiment was run almost two hours. During experiment velocity were measured by digital current meter. Flow depth was observed with the help of vertical rod.

4.1.2.1 Experiment No 4

Experiment four was carried out at the minimum discharge 0.75 cusec. The specifications of that experiment as shown in table 4.4.

Table 4.4: Specification of experiment No 4

Spur type = repelling spur	Unit discharge = q= 0.15 cusec/m
Angle = 60 degree	Level of the bed = 39.5 cm
Discharge = 0.75 cusec	Flow depth = 3 inch = 0.07 m

Scouring pattern

The scouring pattern and contouring map were developed using surfer software as shown in Fig 4.15 and 4.16.This Fig shows that at the unit discharge 0.15 cusec/m the bed profile near the structure were slightly changed. Deposition takes place at upstream side of the repelling spur erosion takes place near the nose of the structure. Deposition also observed at downstream of the structure.

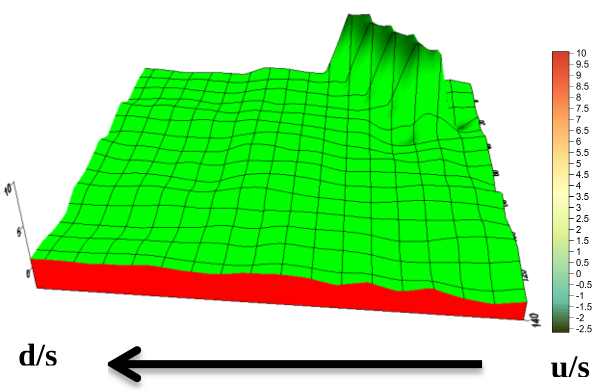


Figure 4.15: Scouring of bed of repelling spur at 0.15 cusec/m

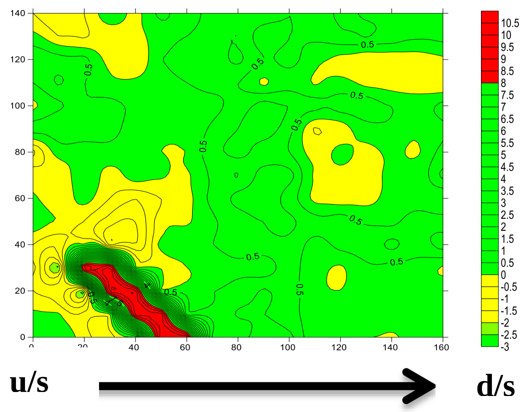


Figure 4.16: Contour Map of repelling Spur at 0.15 cusec/m

Direction of velocity currents

Velocity currents were repelled at the upstream side of the repelling spur. The direction velocity currents near the structure were observed by blue dye water color at upstream side of the structure. The velocity currents at upstream side were created water pocket and the velocity currents were strike on the nose of the spur repelled away the structure and change their direction as shown in Fig 4.17.

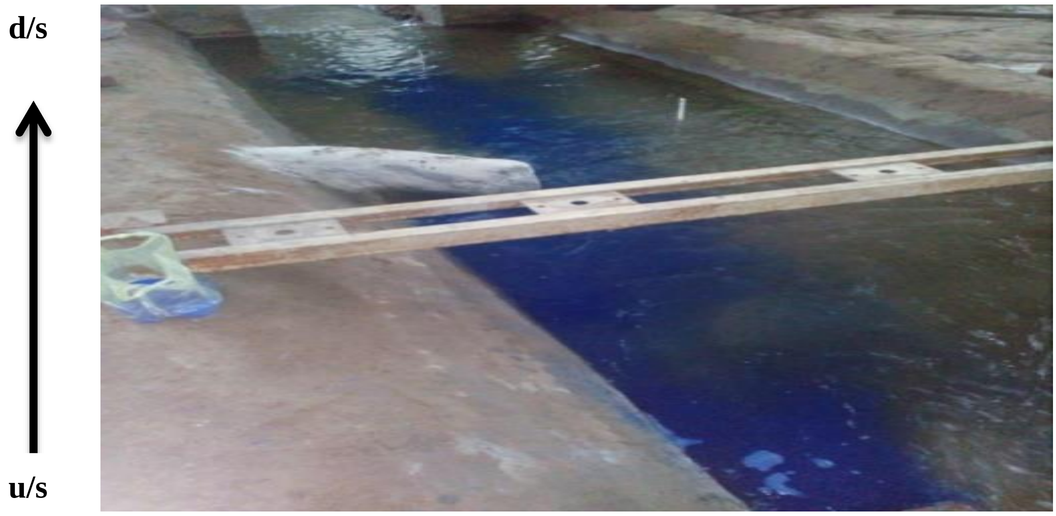


Figure 4.17: Direction of velocity currents of repelling spur at 0.15 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were also observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.15 cusec/m shown in the Fig 4.18. This Fig shows that flow velocity was zero at upstream side of the channel due to creation the water pocket The flow velocity were increased slightly at the nose of the spur and then slow down at downstream of the structure. The profile also shows that flow velocity increases continuously when going farther to the repelling spur.

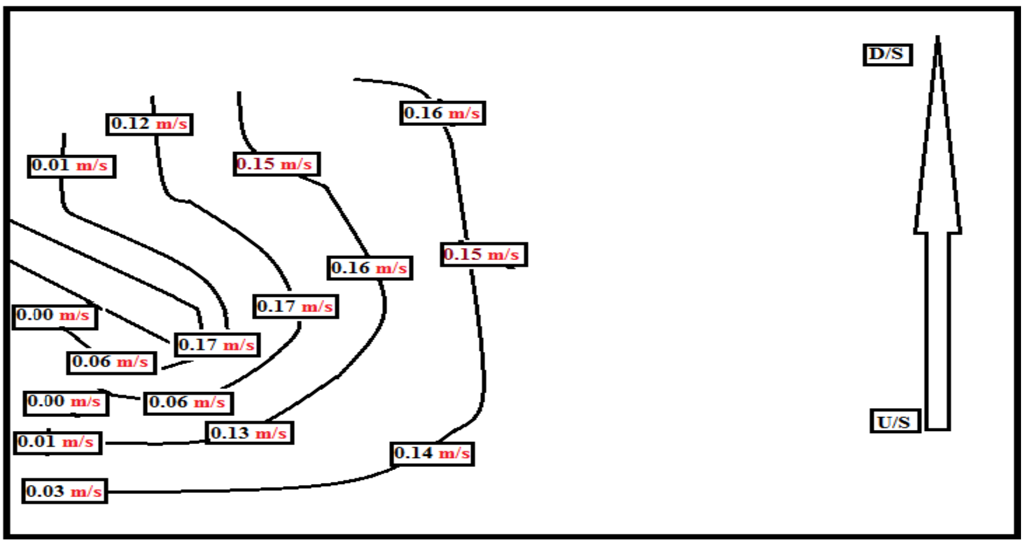


Figure 4.18: Velocity distribution at 0.15 cusec/m of repelling spur

4.1.2.2 Experiment No 5

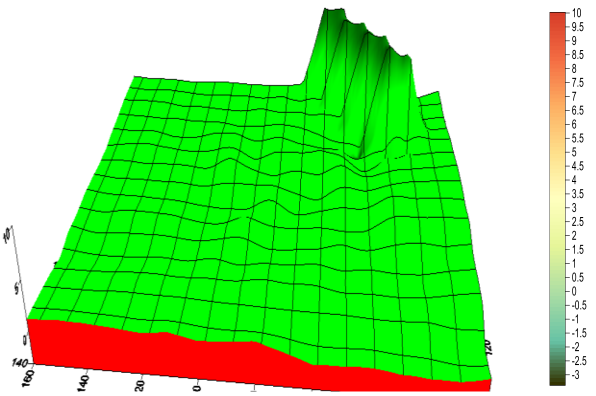
Experiment five was carried out at the medium discharge 1 cusec. The specifications of that experiment as shown in table 4 5.

Table 4.5: Specification of experiment No 5

Spur type: Repelling spur	Unit discharge = 0.20 cusec/m
Angle = 60 degree	Flow depth = 4 inch = 0.101 m
Discharge = 1 cusec	Bed level = 39.5 cm

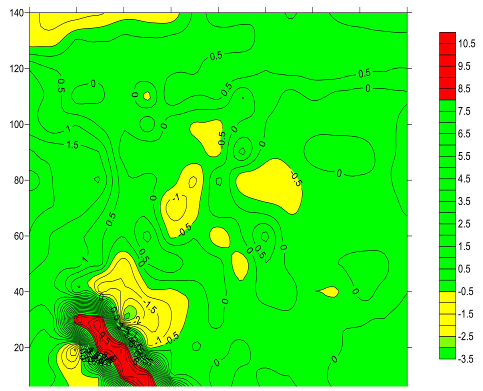
Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.19 and 4.20. This Fig shows that at the unit discharge 0.20 cusec/m the bed profile near the structure were more changed than at 0.15 cusec/m discharge. Deposition takes place at upstream side of the repelling spur. Erosion takes place near the nose of the structure which increased slightly by increase the unit discharge. Deposition also observed at the downstream side of the structure.



d/s ← u/s

Figure 4.19: Scouring of bed of repelling spur at 0.20 cusec/m



u/s → d/s

Figure 4.20: Contour map of repelling spur at 0.20 cusec/m

Direction of velocity currents

Velocity currents were deflected at the upstream side of the repelling spur. The direction velocity currents near the structure were observed by blue dye water color at upstream side of the structure. The velocity currents at upstream side were created water pocket and the velocity currents were strike on the nose of the spur repelled away the structure and change their direction as shown in Fig 4.21.the speed of repulsion of water currents were more that as compared to the 0.15 cusec/m.

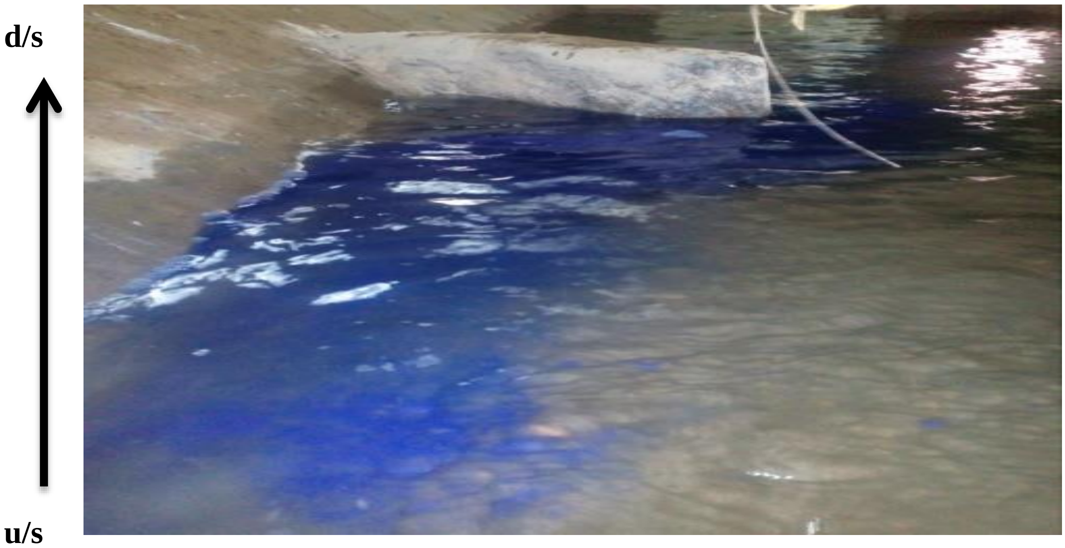


Figure 4.21: Direction of velocity currents of repelling spur at 0.20 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were also observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.20 cusec/m of repelling spur as shown in the Fig 4.22. This Fig shows that flow velocity zero at upstream side of the spur due to creation of water pocket The flow velocity were increased slightly at the nose of the spur and then slow down at downstream of the structure. The profile also shows that flow velocity increases continuously when going farther to the repelling spur. The flow velocity increased in the channel when unit discharge was increased from 0.15 cusec/m to 0.20 cusec/m.

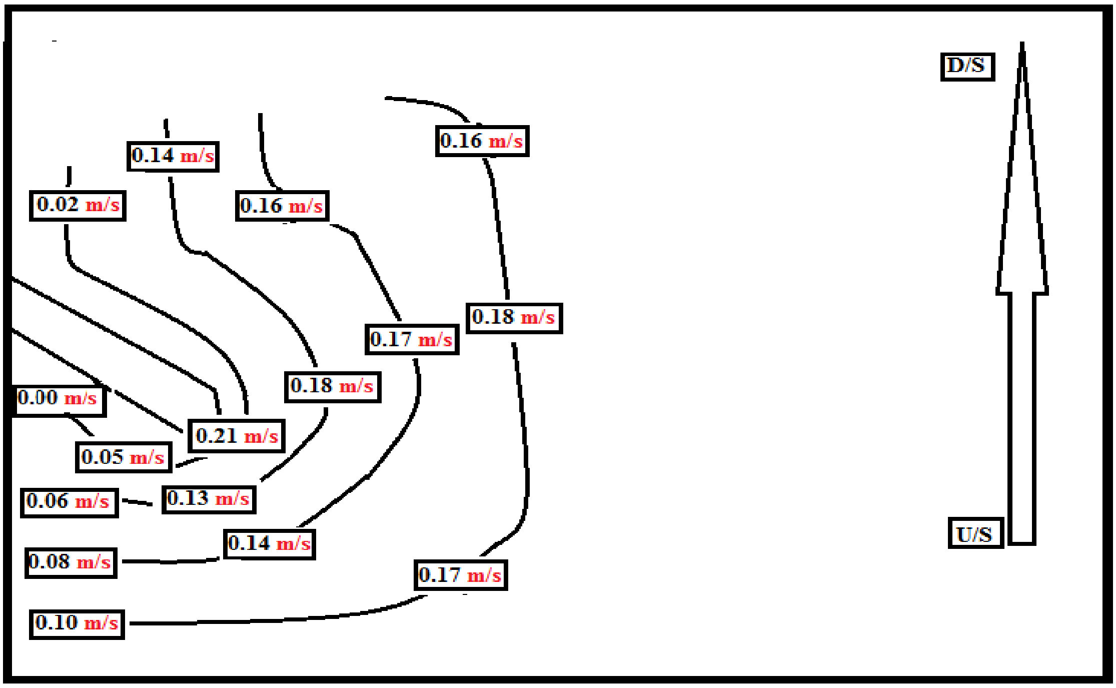


Figure 4.22: Velocity distribution at 0.20 cusec/m of repelling spur

4.1.2.3 Experiment No 6

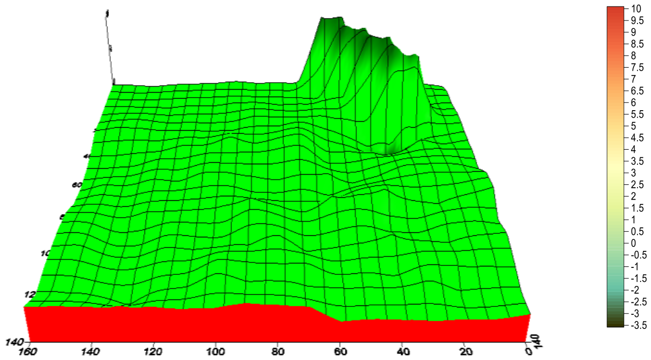
Experiment six was carried out at the maximum discharge 1.5 cusec. The specifications of that experiment as shown in table 4.6.

Table 4.6: Specification of experiment No 6

Spur type: Repelling spur	Unit discharge = 0.30 cusec/m
Angle = 60 degree	Flow depth = 4.5 inch = 0.1143 m
Discharge = 1.5 cusec	Bed level = 39.5 cm

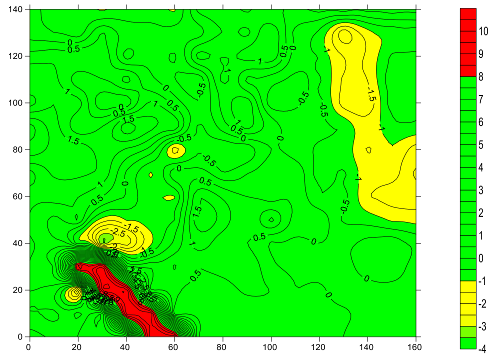
Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.23 and 4.24.This Fig shows that at the unit discharge 0.30 cusec/m the bed profile near the structure were rapidly changed than at 0.20 cusec/m discharge. Deposition takes place at upstream side of the repelling spur. Erosion takes place near



d/s u/s

Figure 4.23: Scouring of bed of repelling spur at 0.30 cusec/m



u/s d/s

Figure 4.24: Contour map of repelling Spur at 0.30 cusec/m

the nose of the structure and increased by increase the unit discharge. The result shows that when unit discharge increases scouring pattern was also changed rapidly.

Direction of velocity currents

Velocity currents were deflected at the upstream side of the repelling spur. The direction velocity currents near the structure were observed by blue dye water color at upstream side of the structure. The velocity currents at upstream side were created water pocket and the velocity currents which strike on the nose of the spur deflected away the structure and change their direction as shown in Fig 4.25. The speed of velocity currents were increased when unit discharge increased from 0.20 cusec/m to 0.30 cusec/m.

d/s

u/s

Figure 4.25: Direction of velocity currents of repelling spur at 0.30 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were also observed with the help of digital current meter. Velocity profile of repelling spur at unit discharge 0.30 cusec/m as shown in the Fig 4.26. This Fig shows that flow velocity was zero at upstream side of the spur due to creation of water pocket. The flow velocity were increased slightly at the nose of the spur and then slow down at downstream of the structure. The profile also shows that flow velocity increases continuously when going farther to the repelling spur. The flow velocity increased in the channel when unit discharge was increased from 0.15 cusec/m to 0.20 cusec/m and then 0.30 cusec/m.

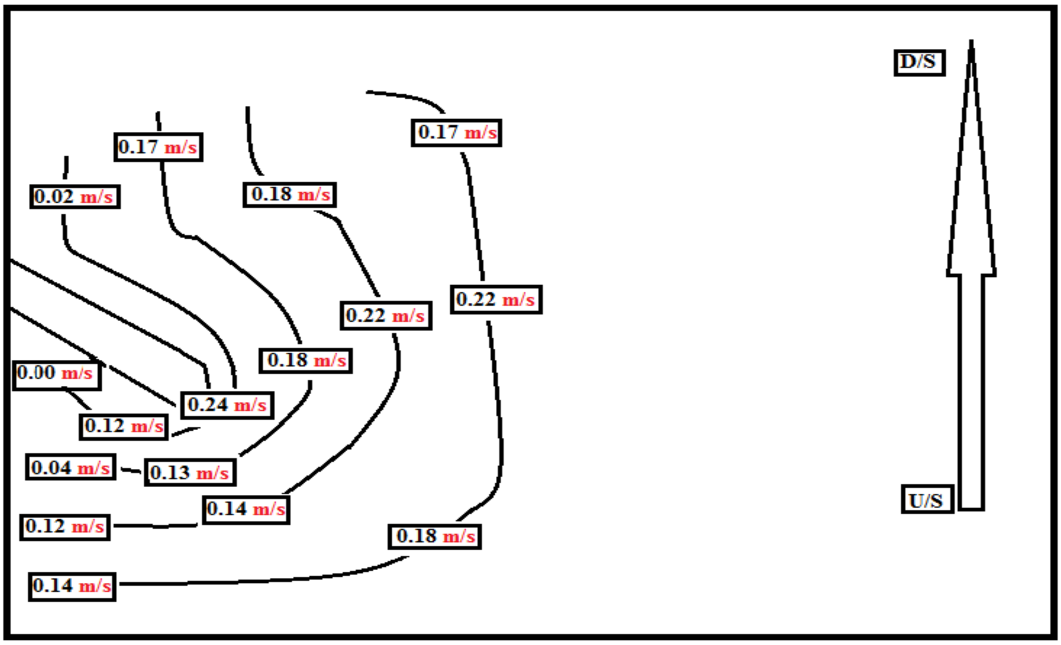


Figure 4.26: Velocity distribution at 0.30 cusec/m of repelling spur

4.1.2.4 Comparison of Erosion and Deposition near Repelling Spur

When three experiment of repelling spur was completed at three different unit discharges. A comparison of erosion and deposition near repelling spur was analyzed.

The location of deposition and erosion were taken near the spur as shown in Fig 4.27

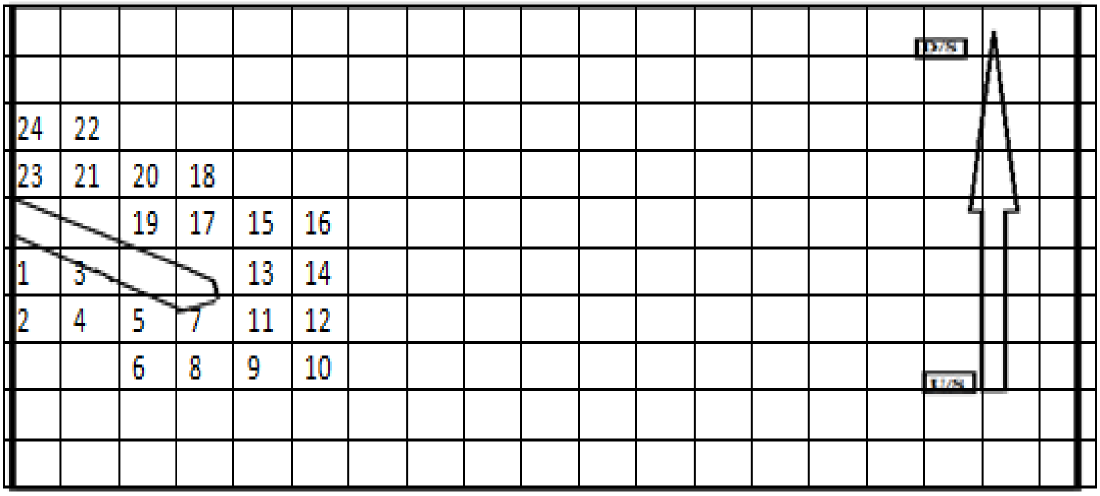


Figure 4.27: Deposition and erosion location near the repelling spur

The Fig 4.28 shows the behavior of erosion and deposition near the repelling spur. Result shows that when unit discharge was gradually increased then erosion and deposition was also increased. This Fig also shows that at 0.15 cusec/m unit discharge erosion takes place at small level near the spur because flow velocity was low. When unit discharge increases 0.20 cusec/m and then 0.30 cusec/m then erosion takes place at large extent near the repelling spur.

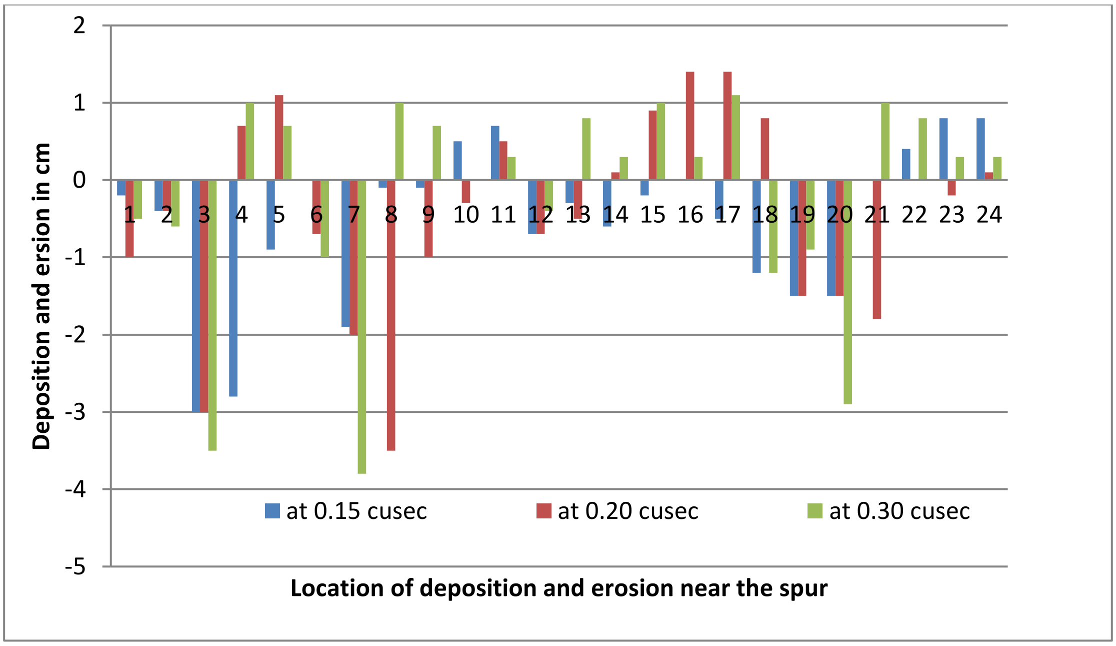


Figure 4.28: Pattern of erosion and deposition spur (Repelling) from Experiment 4 to 6

4.1.3 Attracting spur

In case of attracting spur at an angle 120 degree three experiments was carried out. Each experiment was run almost two hours. During experiment velocity were measured by digital current meter. Flow depth was observed with the help of vertical rod.

4.1.3.1 Experiment No 7

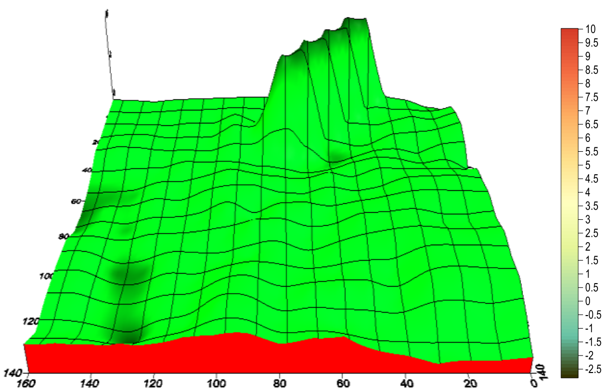
Experiment seven was carried out at the minimum discharge 0.75 cusec. The specifications of that experiment as shown in table 4.7.

Table 4.7: Specification of experiment No 7

Spur type: Attracting spurs	Unit discharge = 0.15 cusec/m
Angle = 120 degree	Flow depth = 3 inch = 0.07 m
Discharge = 0.75 cusec	Bed level = 39 cm

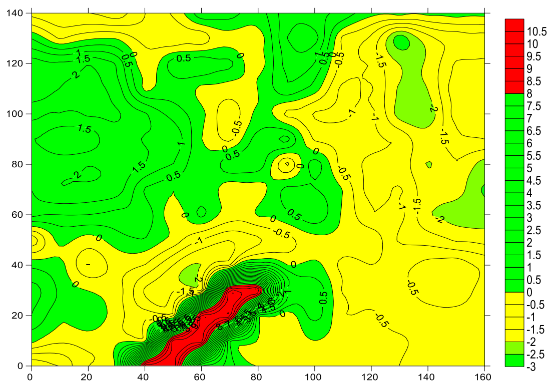
Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.29 and 4.30.This Fig shows that at the unit discharge 0.15 cusec/m the bed profile near the attracting spur were slightly changed. Erosion takes place at upstream



d/s ← u/s

Figure 4.29: Scouring of bed of attracting spur at 0.15 cusec/m



u/s → d/s

Figure 4.30: Contour map of attracting spur at 0.15 cusec/m

side of the attracting spur as well as near the nose of the structure. Deposition was observed at downstream of the spur

Direction of velocity currents

Velocity currents were attracted at the upstream side of the attracting spur. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the structure. The velocity currents at upstream side were attracted toward the structure and change their direction as shown in Fig 4.31.the speed of deflection of velocity currents were normally at the 0.15 cusec/m

Figure 4.31: Deflection of velocity currents of attracting spur at 0.15 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were also observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.15 cusec/m of attracting spur as shown in the Fig 4.32 .the velocity profile shows that flow velocity minimum at upstream side of the spur. The flow velocity were increased slightly near the spur and then become zero at downstream of the structure due to water pocket. The profile also shows that flow velocity increases continuously when going farther to the repelling spur.

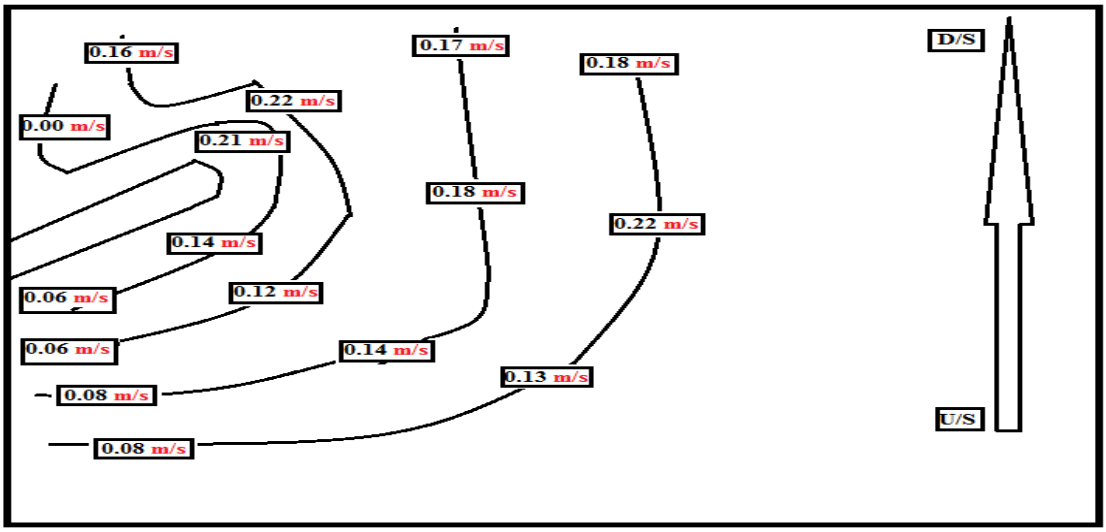


Figure 4.32: Velocity distribution at 0.15 cusec/m of attracting spur

4.1.3.2 Experiment No 8

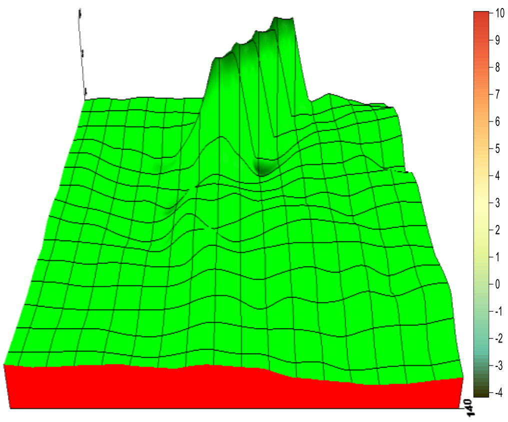
Experiment eight was carried out at the medium discharge 1 cusec. The specifications of that experiment as shown in table 4.8.

Table 4.8: Specification of experiment No 8

Spur type: Attracting spurs	Unit discharge = 0.20 cusec/m
Angle = 120 degree	Flow depth = 4 inch = 0.101 m
Discharge = 1 cusec	Bed level = 39 cm

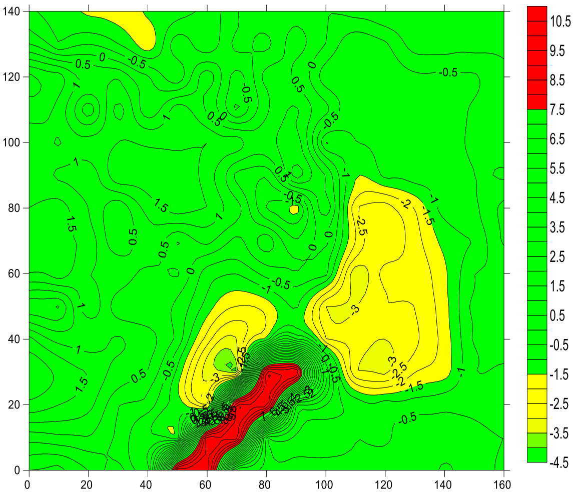
Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.33 and 4.34.This Fig shows that at the unit discharge 0.20 cusec/m the bed profile near the attracting spur were more changed as compared to 0.15 cusec/m. Erosion takes place at upstream side of the attracting spur as well as near the nose of the structure. Deposition was observed at downstream of the spur.



d/s ← u/s

Figure 4.33: Scouring of bed of attracting spur at 0.20 cusec/m



u/s → d/s

Figure 4.34: Contour map of attracting spur at 0.20 cusec/m

Direction of velocity currents

Velocity currents were attracted at the upstream side of the attracting spur. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the structure. The velocity currents at upstream side were attracted toward the structure and change their direction as shown in Fig 4.35.the speed of deflection of velocity currents were slightly larger than at 0.20 cusec as compared to the 0.15 cusec/m

d/s ↑ u/s

Figure 4.35: Direction of velocity currents of attracting spur at 0.20 cusec/m discharge

Velocity Distribution Profile

Velocity distributions in the channel at different locations were also observed with the help of digital current meter. Velocity profile at unit discharge 0.20 cusec/m of attracting spur as shown in the Fig 4.36. This Fig shows the flow velocity at upstream side of the spur was increased at larger extent as well as at the nose of the spur as compared to 0.15 cusec/m. The flow velocity become zero at downstream of the structure. The profile also shows that flow velocity increases continuously when going farther to the attracting spur. The flow velocity increased in the channel when unit discharge was increased from 0.15 cusec/m to 0.20 cusec/m.

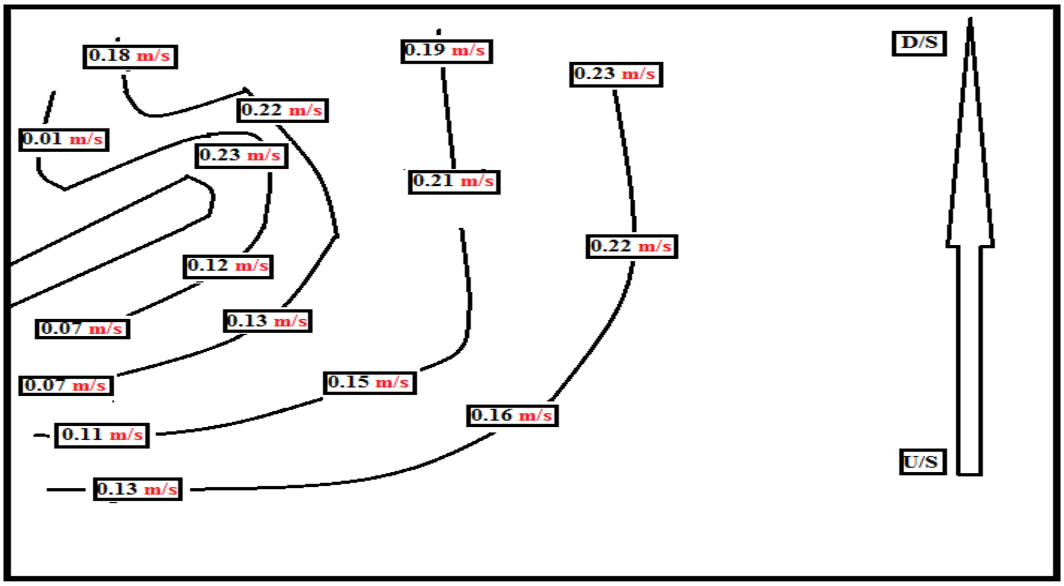


Figure 4.36: Velocity distribution at 0.20 cusec/m of attracting spur

4.1.3.3 Experiment No 9

Experiment nine was carried out at the maximum discharge 1.5 cusec. The specifications of that experiment as shown in table 4.9.

Table 4.9: Specification of experiment No 9

Spur type: Attracting spurs	Unit discharge = 0.30 cusec/m
Angle = 120 degree	Flow depth = 4.5 inch = 0.1143m
Discharge = 1.5 cusec	Bed level = 39 cm

Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.37 and 4.38. This Fig shows that at the unit discharge 0.30 cusec/m the bed profile near the attracting spur were changed at large extent Erosion takes place at upstream side of the attracting spur as well as near the nose of the structure. Deposition was observed at downstream of the spur. The bed profile changed more than 0.15 cusec/m as well as 0.20 cusec/m discharge.

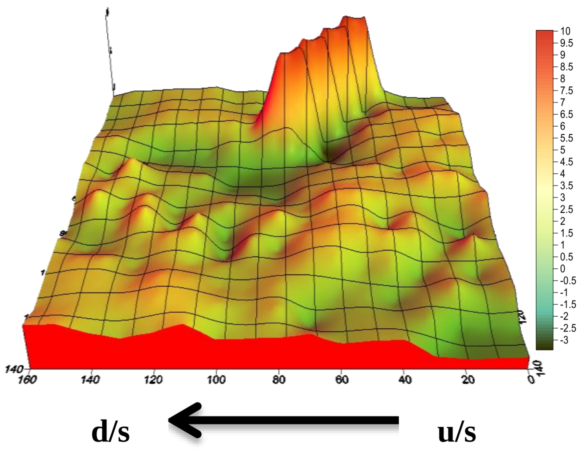


Figure 4.37: Scouring of bed of attracting spur at 0.30 cusec

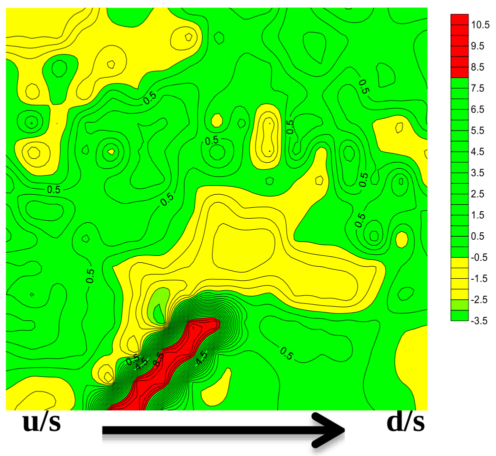


Figure 4.38: Contour map of attracting spur at 0.30 cusec/m

Direction of velocity current

Velocity currents were attracted at the upstream side of the attracting spur. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the structure. The velocity currents at upstream side were attracted toward the structure and change their direction as shown in Fig 4.39.the speed of deflection of velocity currents were larger than at 0.30 cusec as compared to the 0.15 cusec/m as well as 0.20 cusec/m.

Figure 4.39: Direction of velocity currents of attracting spur at 0.30 cusec/m discharge

Velocity Distribution Profile

Velocity distributions in the channel at different locations were also observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.30 cusec/m of attracting spur as shown in the Fig 4.40 This Fig shows the flow velocity at upstream side of the spur was increased at larger extent as well as at the nose of the spur as compared to 0.20 cusec. The velocity become zero at downstream of the structure. The profile also shows that flow velocity increases continuously when going farther to the repelling spur. The flow velocity increased in the channel when unit discharge was increased from 0.15 cusec/m to 0.20 cusec/m and then 0.30 cusec/m.

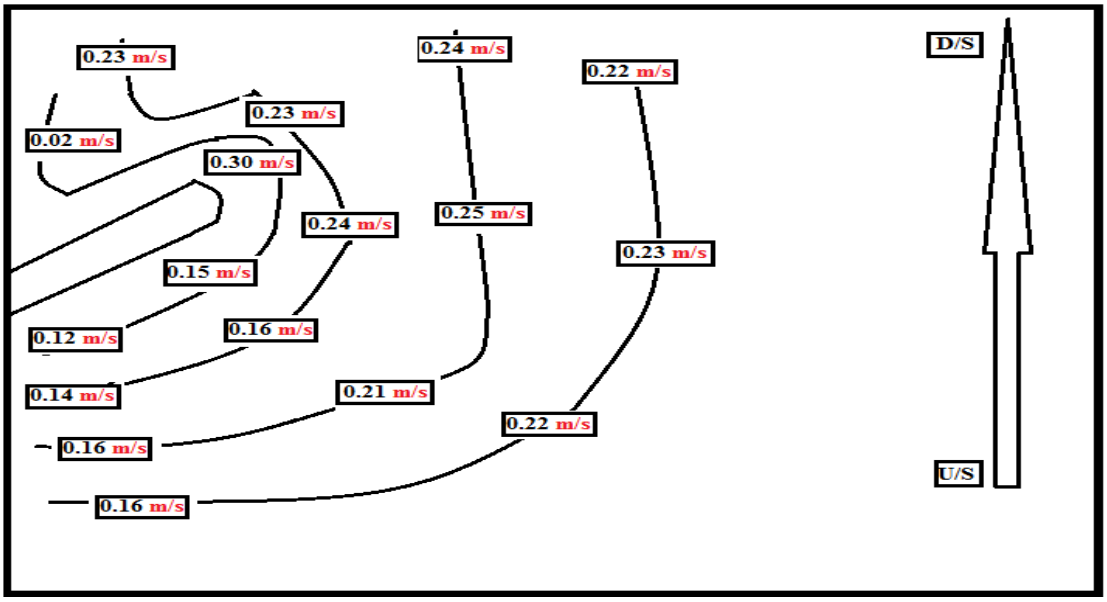


Figure 4.40: Velocity distribution at 0.30 cusec/m of attracting spur

4.1.3.4 Comparison of Erosion and Deposition near Attracting Spur

When three experiment of attracting spur was completed at three different unit discharges. A comparison of erosion and deposition near attracting spur was analyzed. The location of deposition and erosion were taken near the spur as shown in Fig 4.41.

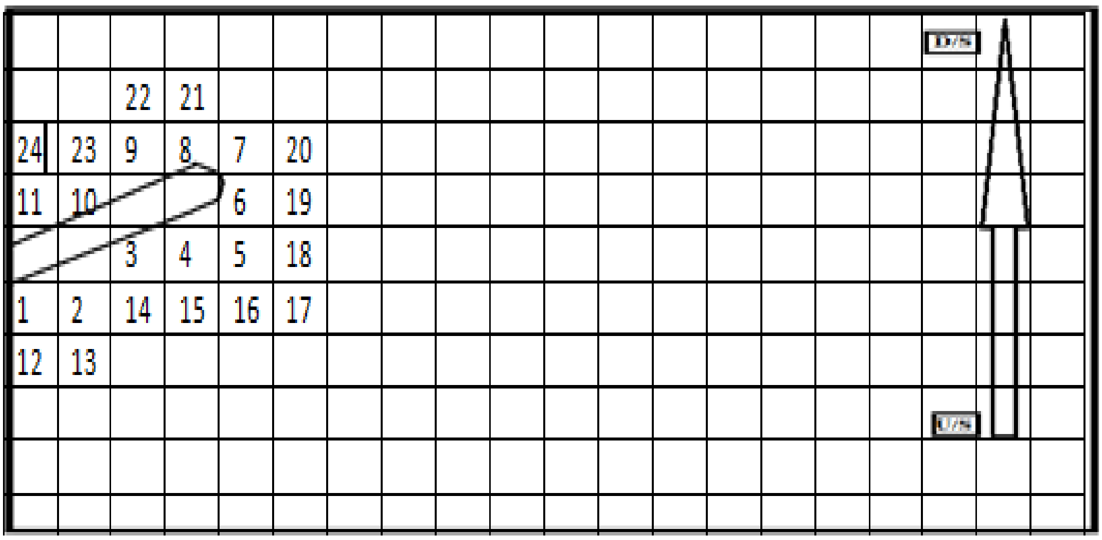


Figure 4.41: Deposition and erosion location near the attracting spur

The Fig 4.42 shows the behavior of erosion and deposition near the attracting spur. Result shows that when unit discharge was gradually increased then erosion and deposition was also increased. This Fig also shows that erosion takes place mostly at the upstream as well as near the nose of the attracting spur. When unit discharge increases 0.20 cusec/m and then 0.30 cusec/m then erosion takes place at large extent near the attracting spur.

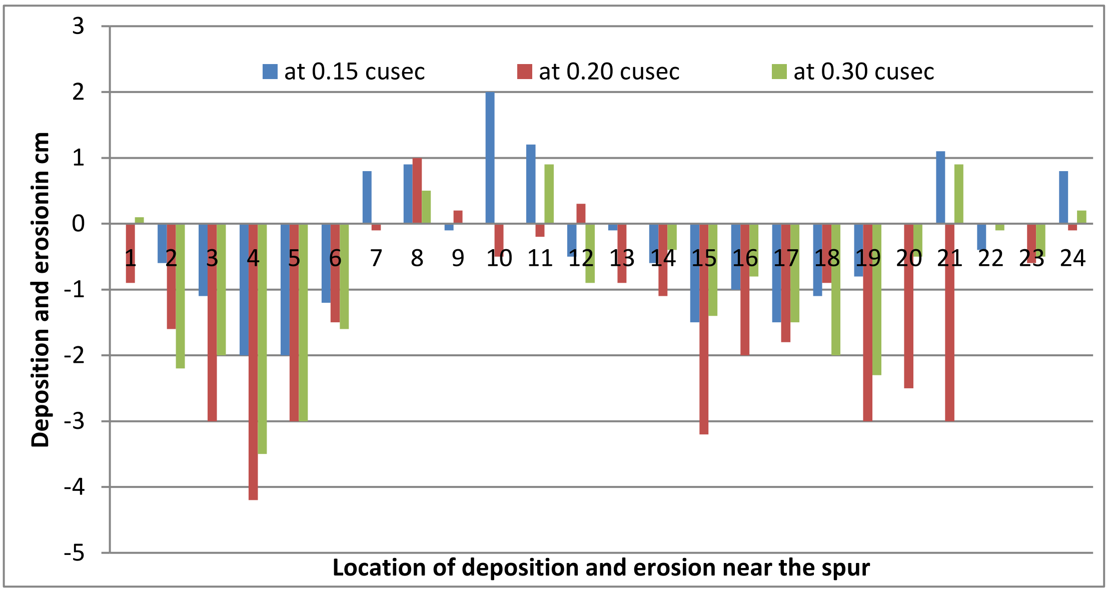


Figure 4.42: Deposition and erosion Spur (Attracting) from Experiment 7 to 9

4.2 Spur Spacing

Spacing between the spur is an important factor which influence the performance of the spur. The series of spur is used with suitable spacing for the protection of the bank in the river. The series of spur is used when certain length of the bank is protected at the season of high floods.

4.2.1 Three Spur in Series

Three spur was constructed in the channel with recommended spacing which is 2.25 time of the total length of the spur and run the channel at three different unit discharges. The unit discharges were 0.75 cusec, 1 cusec and 1.5 cusec respectively. See the scouring and deposition of sediment between the spur, and analyzed the how spacing are help in protection of the bank and direction of flow currents also checked.

4.2.1.1 Experiment No 10

Experiment ten was carried out at the minimum discharge 0.75 cusec. The specification of that experiment as shown in table 4.10

Table 4.10: Specification of experiment no 10

Spur type: three spur in series	Flow depth = 3 inch = 0.07 m
Angle 90 degree	Bed level = 39.5 cm
Unit discharge = 0.15 cusec/m	Discharge = 0.75 cusec

Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.43 and 4.44.This Fig shows that at the unit discharge 0.15 cusec/m the bed profile near all three spurs were slightly changed. This Fig also shows that sedimentation was occur between the spur. Erosion takes place at the noes of all three spurs.

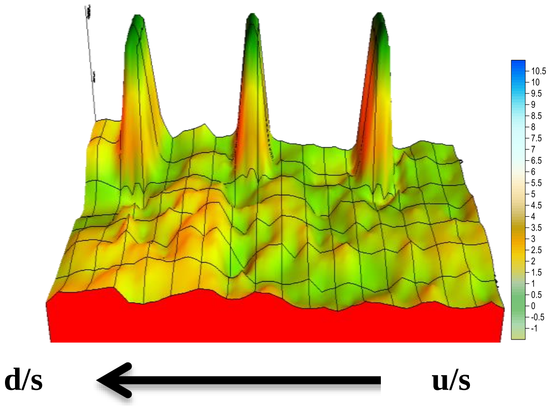


Figure 4.43: Scouring of bed in three spurs at 0.15 cusec/m

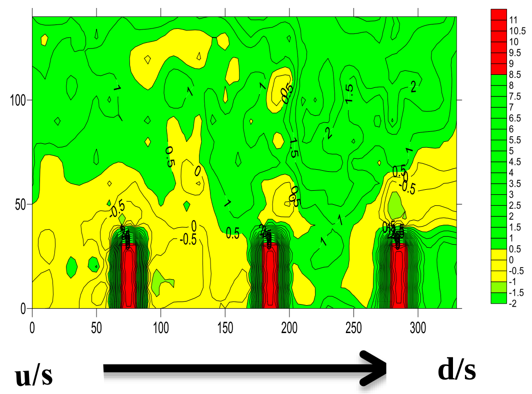


Figure 4.44: Contour Map of bed in three spurs at 0.15cusec/m

Direction of velocity currents

Velocity currents were deflected at the upstream side of the first spur.as shown in Fig 4.45. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the first spur. This Fig shows that velocity currents at upstream side were deflected remain outside at the second as well as third spur

Figure 4.45: Direction of velocity currents in three spurs at 0.15 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were also observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.15 cusec/m of all three spur in the channel as shown in the Fig 4.46 This Fig shows the flow velocity at upstream side of the spur was slow and increased at larger extent at the nose of the first spur. The velocity between the spur almost zero due to creation of water pockets. The velocity was increased when flow goes away all the structures.

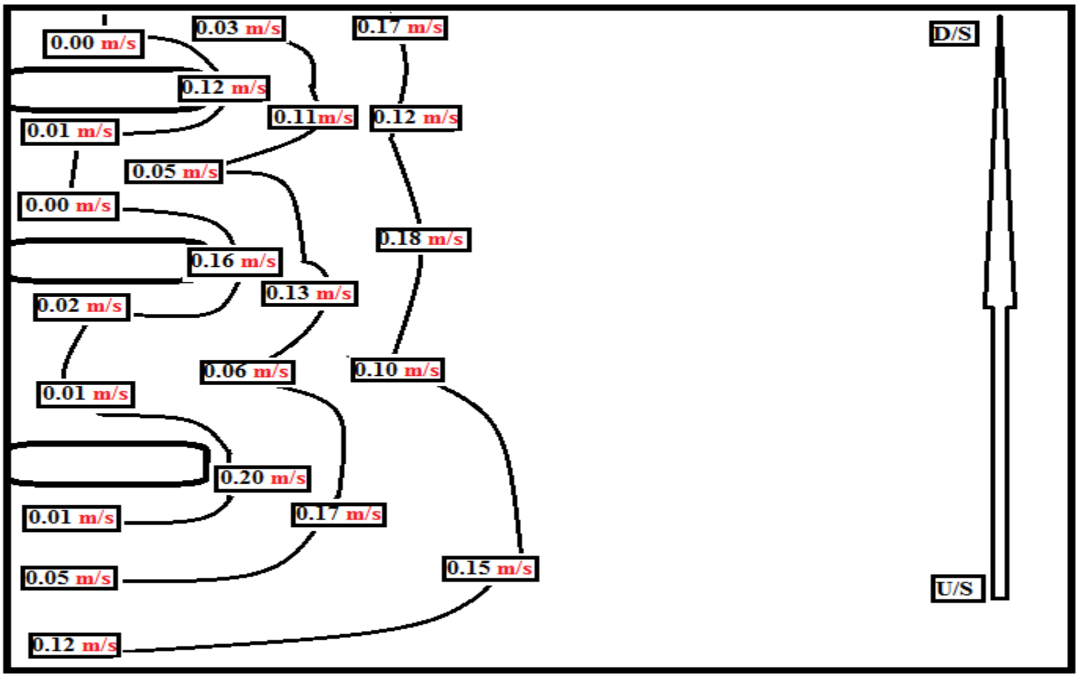


Figure 4.46: Velocity distribution at 0.15 cusecs/m when three spur in series

4.2.1.2 Experiment No 11

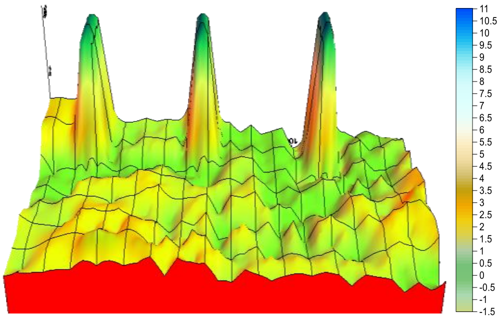
Experiment eleven was carried out at the medium discharge 1 cusec. The specification of that experiment as shown in table 4.11

Table 4.11: Specification of experiment no 11

Spur type: three spur in series	Unit discharge = 0.20 cusec/m
Angle 90 degree	Flow depth = 4 inch = 0.101 m
Discharge = 1 cusec	Bed level = 39.5 cm

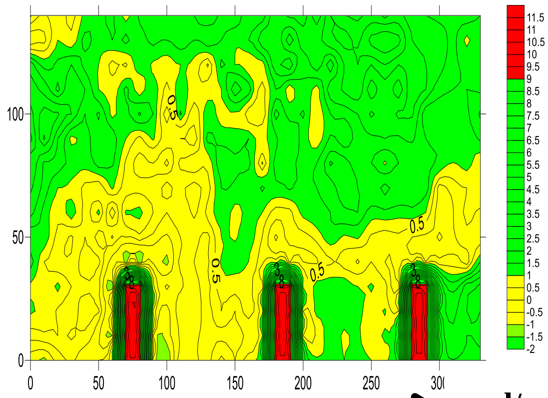
Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.47 and 4.48. This Fig shows that at the unit discharge 0.20 cusec/m the bed profile was changed which larger than as compared to 0.15 cusec/m. This Fig also shows that sedimentation was occur between the spurs and sedimentation was more at downstream side of last spur. Erosion takes place at the noes and in front of all three



d/s ← u/s

Figure 4.47: Scouring of bed in three spurs at 0.20 cusec/m



u/s → d/s

Figure 4.48: Contour map in three spurs at 0.20 cusec/m

spurs.

.Direction of velocity currents

Velocity currents were deflected at the upstream side of the first spur.as shown in Fig 4.49. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the first spur. This Fig shows that velocity currents at upstream side were deflected. The deflection currents were made water pockets between the spurs.

d/s ↑ u/s

Figure 4.49: Direction of velocity currents in three spur at 0.20 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.20 cusec/m of all three spur in the channel as shown in the Fig 4.50 This Fig shows the flow velocity at upstream side of the spur was slow and increased at larger extent at the nose of the first spur .the velocity between the spur almost zero due to creation of water pockets. The velocity was increased when flow goes away all the structures. In velocity distribution the velocity was more as compared to 0.15 cusec/m.

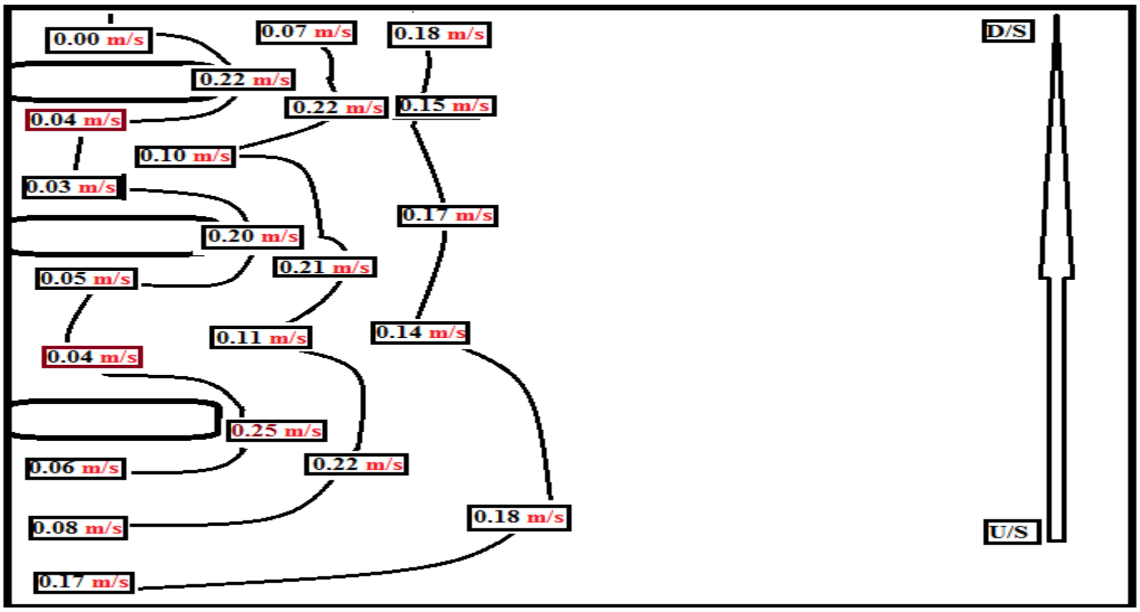


Figure 4.50: Velocity distribution at 0.20 cusec/m when three spur in series

4.2.1.3 Experiment No 12

Experiment twelve was carried out at the maximum discharge 1.5 cusec. The specification of that experiment as shown in table 4.12

Table 4.12: Specification of experiment no 12

Spur type: three spurs in series	Unit discharge = 0.30 cusec/m
Angle 90 degree	Flow depth = 4.5 inch = 0.1143 m
Discharge = 1.5 cusec	Bed level = 39.5 cm

Scouring pattern

The scouring pattern and contour map were obtained from the surfer software as shown in Fig 4.51 and 4.52. This Fig shows that at the unit discharge 0.30 cusec/m the bed profile was changed at large extent than as compared to 0.20 cusec/m. This Fig also shows that sedimentation was occur between the spurs and sedimentation was more between the spurs and downstream side of last spur. Erosion takes place at the nose and in front of all three spurs.

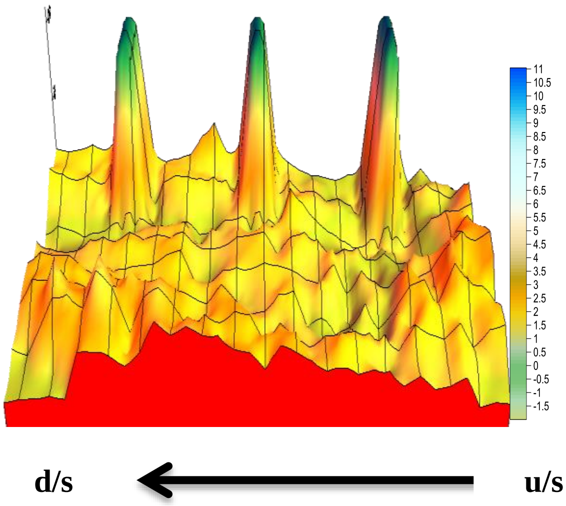


Figure 4.51: Scouring of bed in three spurs at 0.30 cusec/m

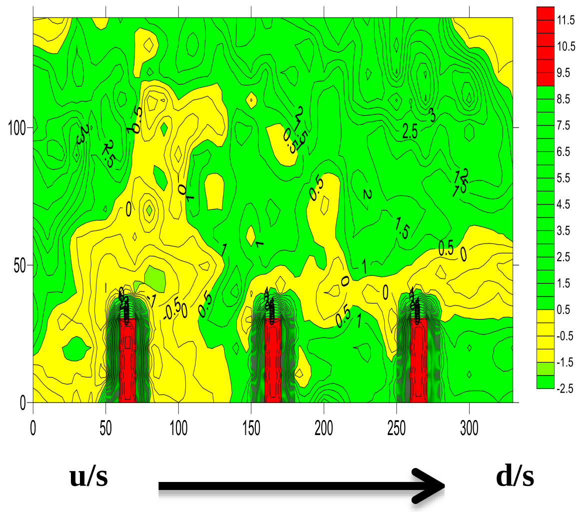


Figure 4.52: Contour map in 0.30 cusec/m

Direction of velocity currents

Velocity currents were deflected at the upstream side of the first spur.as shown in Fig 4.53. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the first spur. This Fig shows that velocity currents at upstream side were deflected .the velocity currents was made water pockets between the spurs.

Figure 4.53: Direction of velocity currents in three spur at 0.30 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.30 cusec/m of all three spur in the channel as shown in the Fig 4.54 This Fig shows the flow velocity at upstream side of the spur was high and increased at larger extent at the nose of the first spur .the velocity between the spur almost zero due to creation of water pockets. The velocity was increased when flow goes away all the structures. The velocity in the channel was larger at 0.30 cusec as compared to 0.20 cusec/m and 0.15 cusec/m.

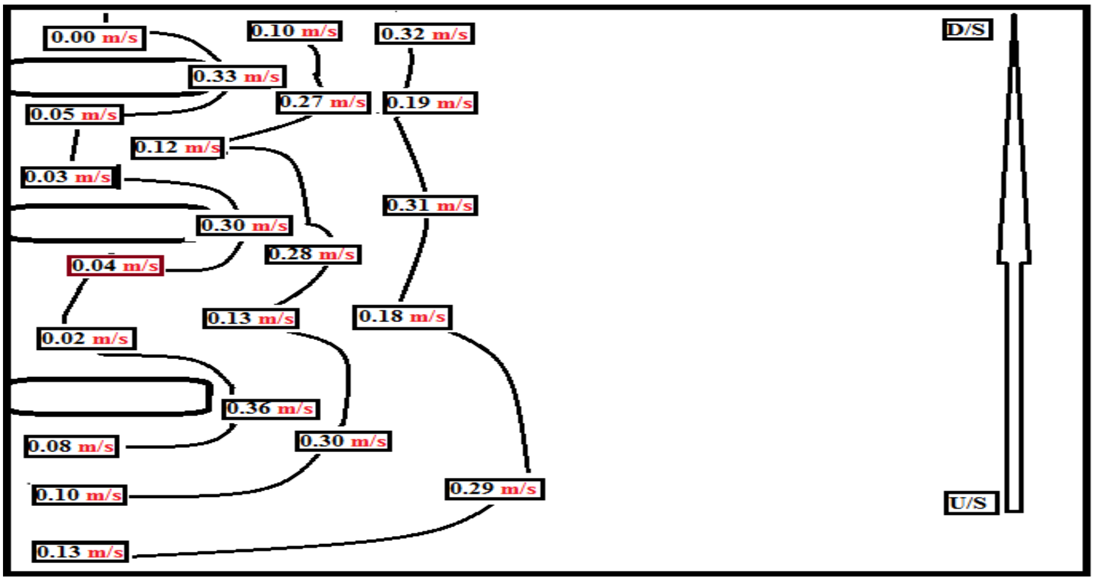


Figure 4.54: Velocity distribution at 0.30 cusec/m when three spur in series

4.2.1.4 Comparison of erosion and deposition in three spur series

When three spurs in series were constructed then the pattern of erosion and deposition near all spurs as well as between the spur was obtained. A comparison study of erosion and deposition was analyzed at three different discharges. For this purpose, location of deposition or erosion was taken near all the spur are also shown in Fig.4.55

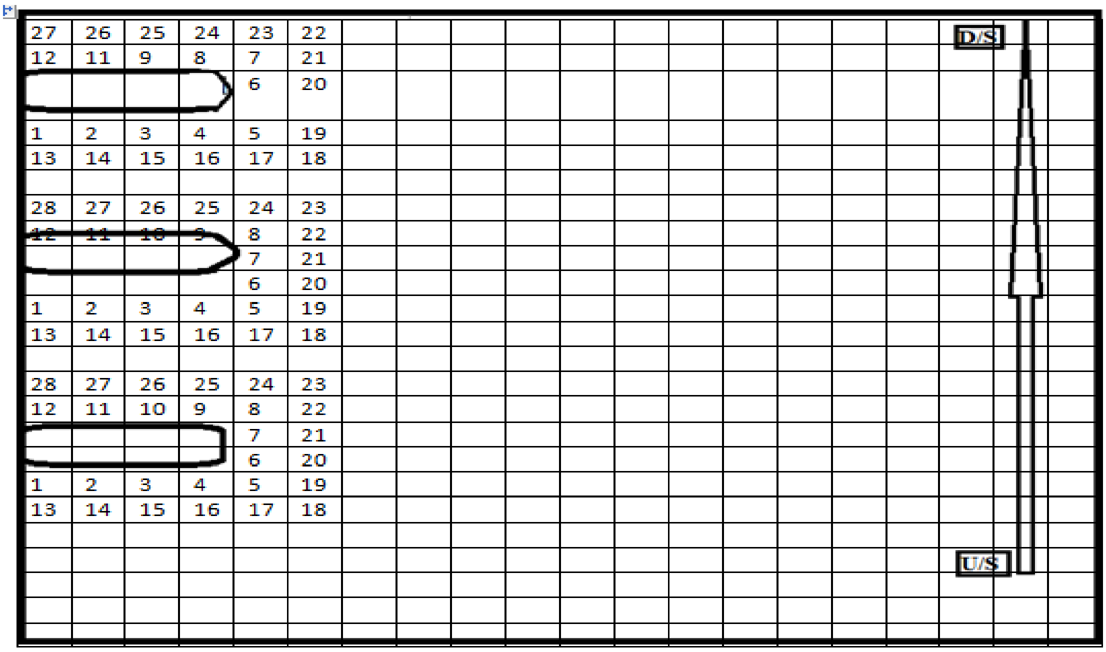


Figure 4.55: Location of deposition and erosion near all three spurs

The Fig shows in 4.56 shows the behavior of deposition or erosion near the 1st spur in case of three spur spacing. This Fig shows that near the 1st spur only erosion takes place which gradually increased when unit discharge gradually increased

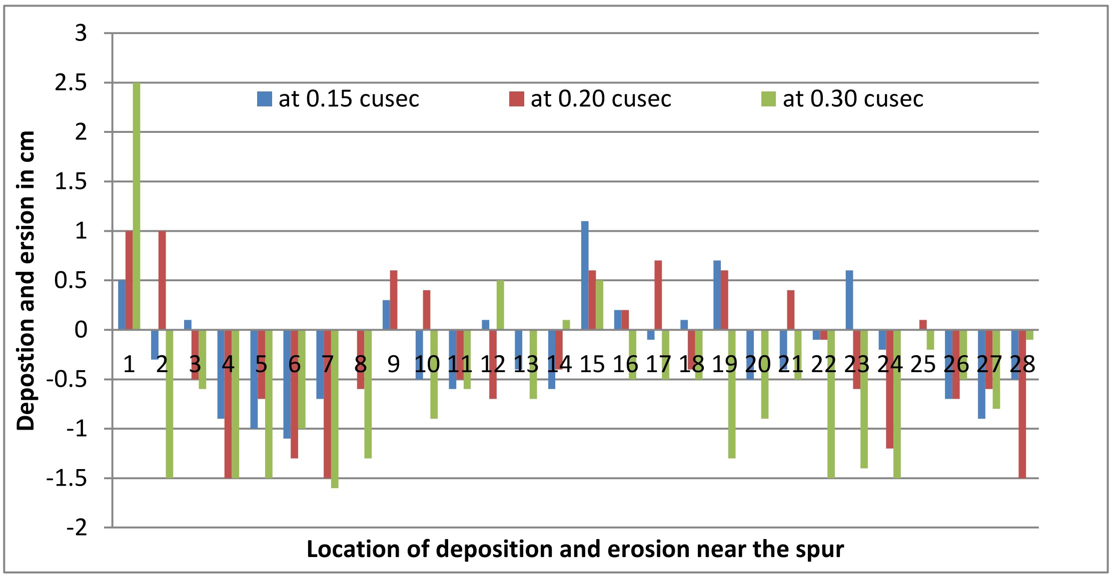


Figure 4.56: Pattern of erosion and deposition near Spur (1) at three spur series from experiment 10 to 12

The Fig 4.57 shows the behavior of deposition or erosion near the 2nd spur in case of three spur spacing. This Fig shows that near the 2nd spur only deposition takes place near the spur as well as between two first spur which gradually increased when unit discharge increased.

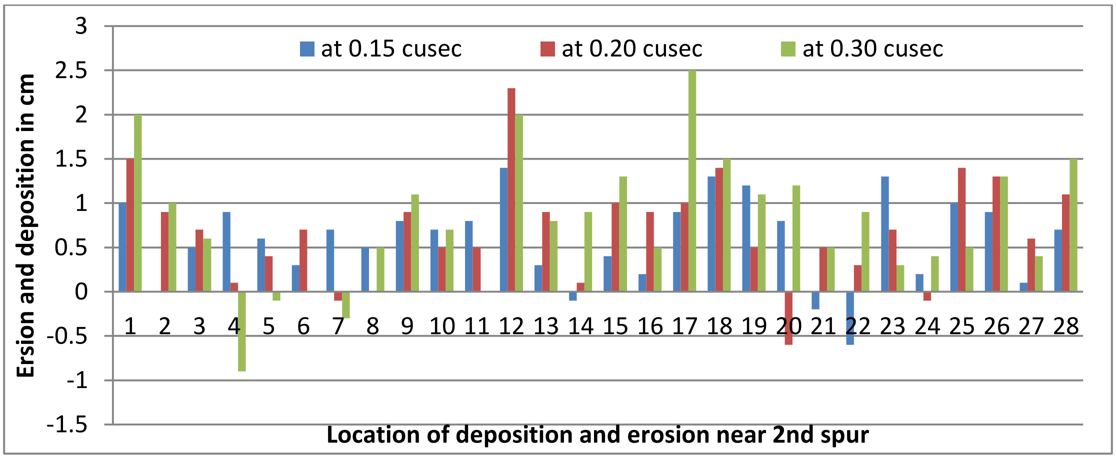


Figure 4.57: Pattern of deposition and erosion near Spur (2).at three spur series from experiment 10 to 12

Similarly Fig 4.58 shows the behavior of deposition or erosion near the 3rd spur in case of three spur spacing. This Fig shows that near the 3rd spur only deposition takes place near the spur as well as between second two spur which gradually increased when unit discharge gradually increased. This Fig also shows that deposition at large extent as compared to 2nd spur in case of three spur spacing.

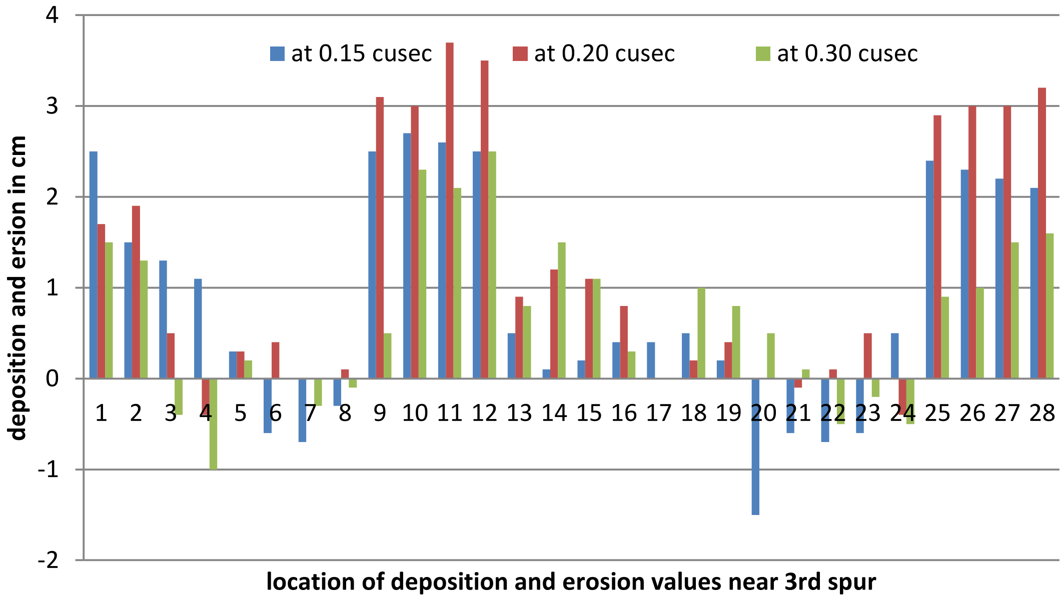


Figure 4.58: Pattern of deposition and erosion near Spur (3).at three spur series from experiment no 10 to 12

4.2.2 Two Spur in Series:

In further experiment of spacing the middle spur removed and now checked the same things. Two spurs were constructed in the channel with recommended spacing which is 4.50 time of the length of the spur. The unit discharges were 0.75 cusec, 1 cusec and 1.5 cusec respectively See the scouring and deposition of sediment between the spur, and analyzed the how this spacing are help in protection of the bank and direction of flow currents also checked.

4.2.2.1 Experiment No 13

Experiment thirteen was carried out at the minimum discharge 0.75 cusec. The specifications of that experiment as shown in table 4.13.

Table 4.13: Specification of experiment No 13

Spur type: two spur in series	discharge = Q= 0.75 cusec
Angle of spur = 90	Unit discharge = q = 0.15 cusec/m
Level of the bed = 39.5 cm	Flow Depth = h= 0.07m

Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.59 and 4.60. This Fig shows that at the unit discharge 0.15 cusec/m the bed profile near all two spurs were slightly changed. This Fig also shows that sedimentation was occur between the spur. Erosion takes place at the noes of all two spurs.

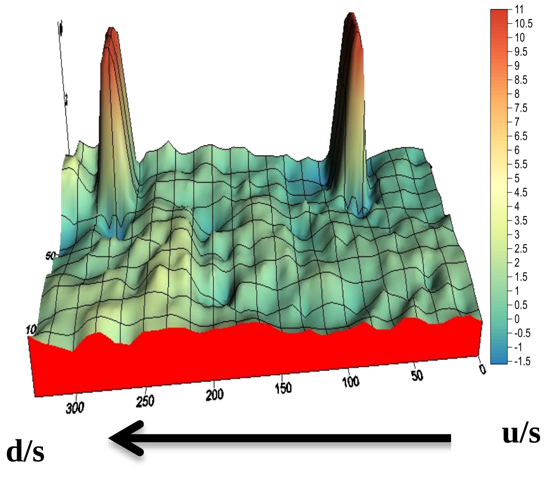


Figure 4.59: Scouring of bed in two spurs at 0.15 cusec/m

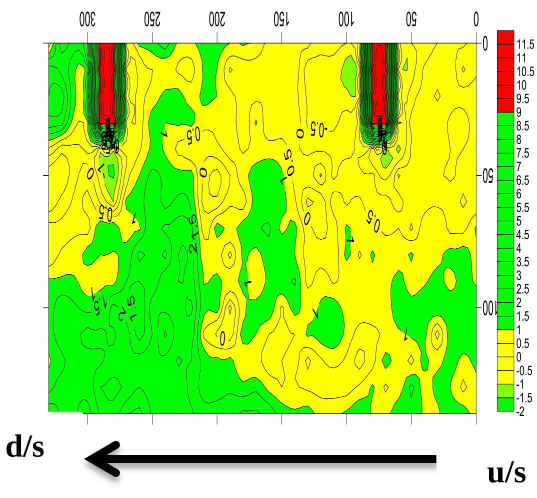


Figure 4.60: Contour map in two spur at 0.15 cusec/m

Direction of velocity current

Velocity currents were deflected at the upstream side of the first spur.as shown in Fig 4.61. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the first spur. This Fig shows that velocity currents at upstream side were deflected remain outside at the second spur.

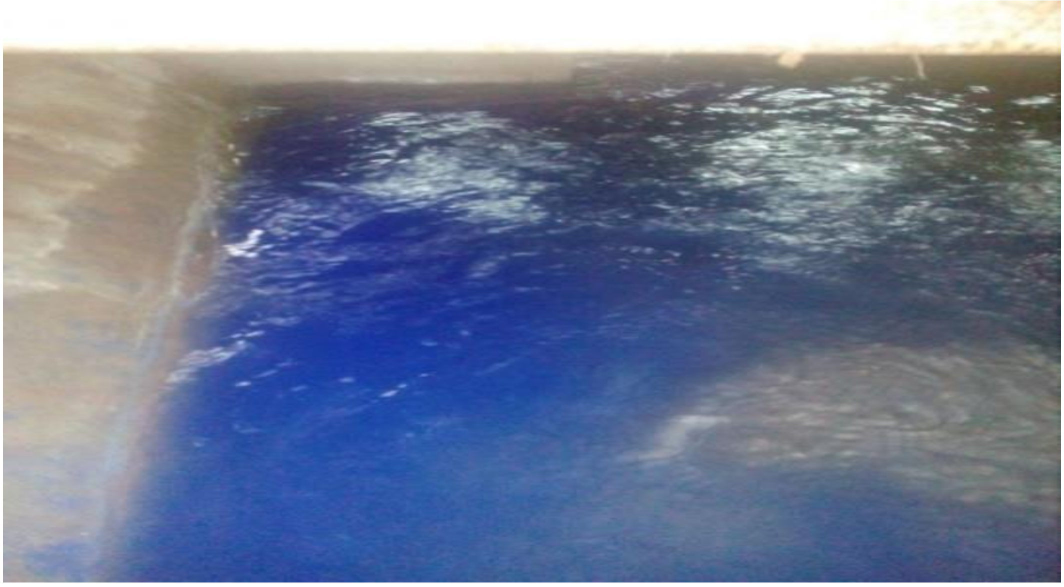


Figure 4.61: Direction of velocity currents in two spurs at 0.15 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were also observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.15 cusec/m of all three spur in the channel as shown in the Fig 4.62 This Fig shows the flow velocity at upstream side of the spur was slow and increased at larger extent at the nose of the first spur. The velocity between the spur almost zero due to creation of water pockets. The velocity was increased when flow goes away all the structures.

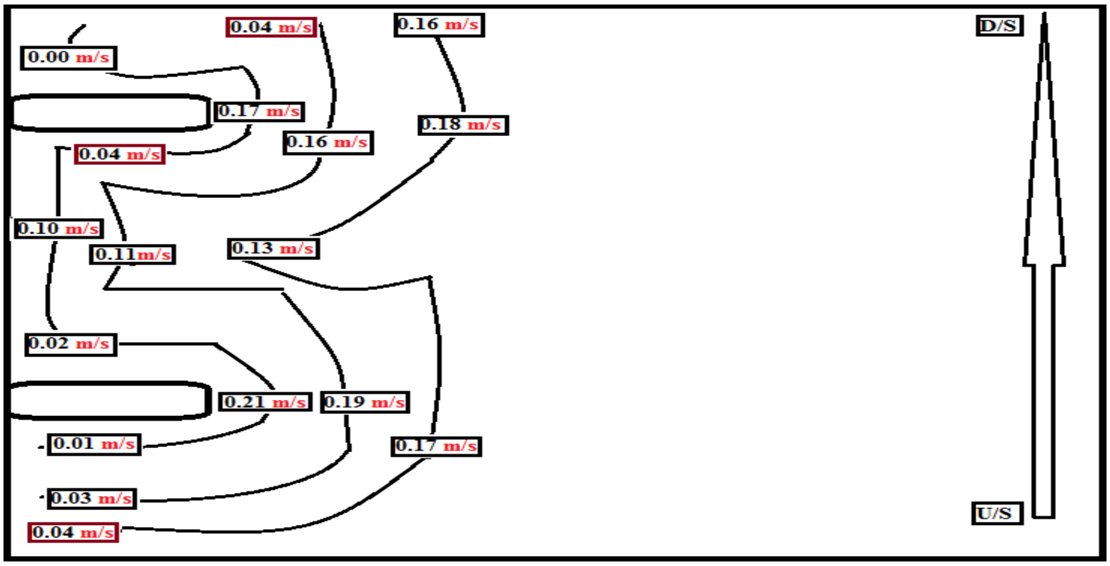


Figure 4.62: Velocity distribution at 0.15 cusec/m when two spur in series

4.2.2.2 Experiment No 14

Experiment fourteen was carried out at the maximum discharge 1 cusec. The specification of that experiment as shown in table 4.14

Table 4.14: Specification of experiment No 14

Spur type: two spurs in series	Level of the bed = 39.5 cm
Angle of spur = 90	Unit discharge = q = 0.20 cusec/m
Discharge = Q= 1 cusec	Flow depth = h= 0.10 m

Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.63 and 4.64. This Fig shows that at the unit discharge 0.20 cusec/m the bed profile was changed which larger than as compared to 0.15 cusec/m. This Fig also shows that sedimentation was occur between the spurs and sedimentation was more at downstream side of last spur. Erosion takes place at the noes and in front of all two spurs

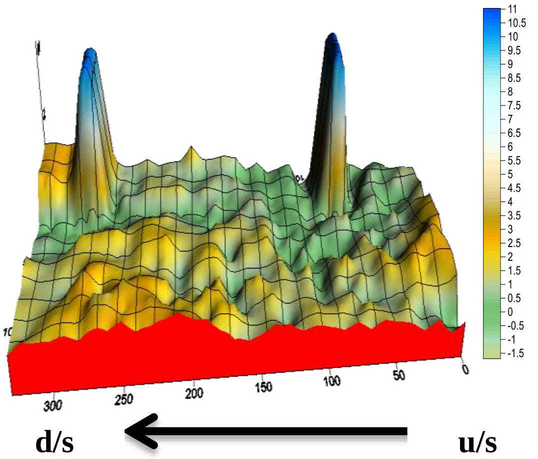


Figure 4.63: Scouring of bed in two spurs at 0.20 cusec/m

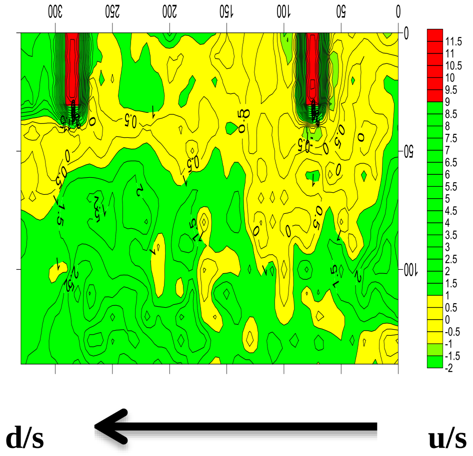


Figure 4.64: Contour map in two spurs at 0.20 cusec/m

Direction of velocity currents

Velocity currents were deflected at the upstream side of the first spur.as shown in Fig 4.65. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the first spur. This Fig shows that water currents at upstream side were deflected. The velocity currents were made water pockets between the spurs.

Figure 4.65: Direction of velocity currents in two spurs at 0.20 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.20 cusec/m of all three spur in the channel as shown in the Fig 4.66 This Fig shows the flow velocity at upstream side of the spur was slow and increased at larger extent at the nose of the first spur. The velocity between the spur almost zero due to creation of water pockets. The velocity was increased when flow goes away all the structures. In velocity distribution the velocity was more as compared to 0.15 cusec/m.

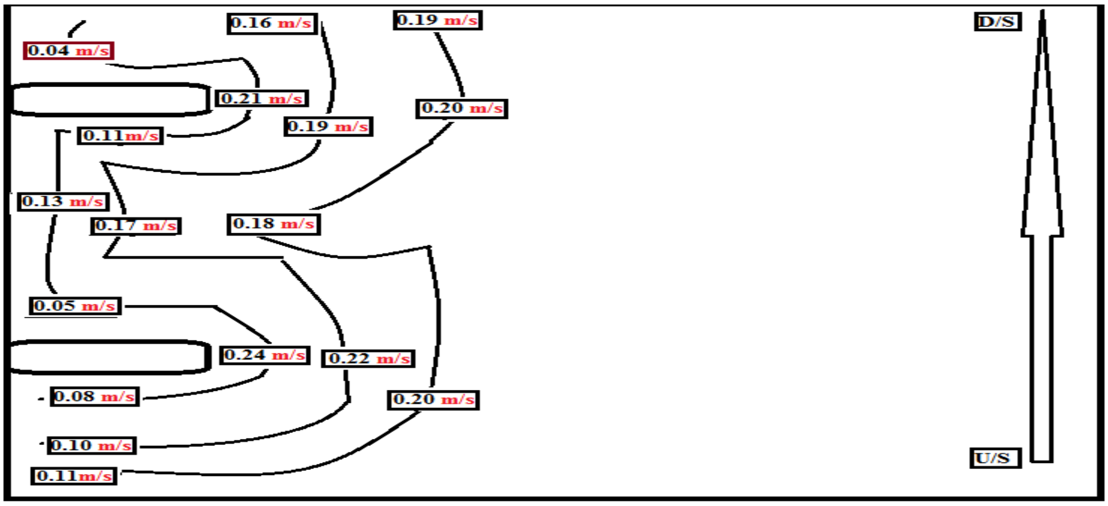


Figure 4.66: Velocity distribution at 0.20 cusec/m when two spur in series

4.2.2.3 Experiment No 15

Experiment fifteen was carried out at the maximum discharge 1.5 cusec. The specifications of that experiment as shown in table 4.15.

Table 4.15: Specification of experiment No 15

Spur type: two spurs in series	Discharge = Q= 1.5 cusec
Angle of spur = 90	Level of the bed = 39.5 cm
Unit discharge = q = 0.30 cusec/m	Flow depth = h= 0.11 m

Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.67 and 4.68. This Fig shows that at the unit discharge 0.30 cusec the bed profile was changed at large extent than as compared to 0.20 cusec. This Fig also shows that sedimentation was occur between the spurs and sedimentation was more between the spurs and downstream side of last spur. Erosion takes place at the noes and in front of all three spurs.

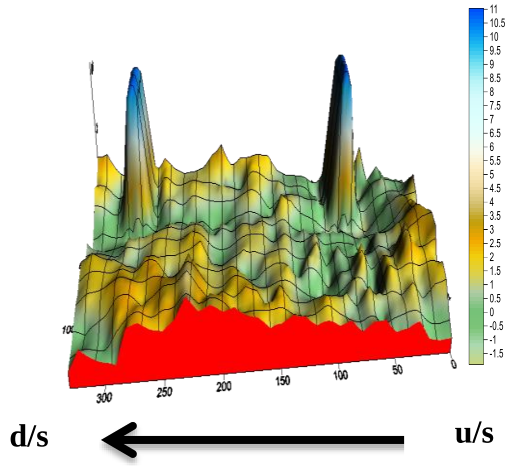


Figure 4.67: Scouring of bed in two spurs at 0.30 cusec/m

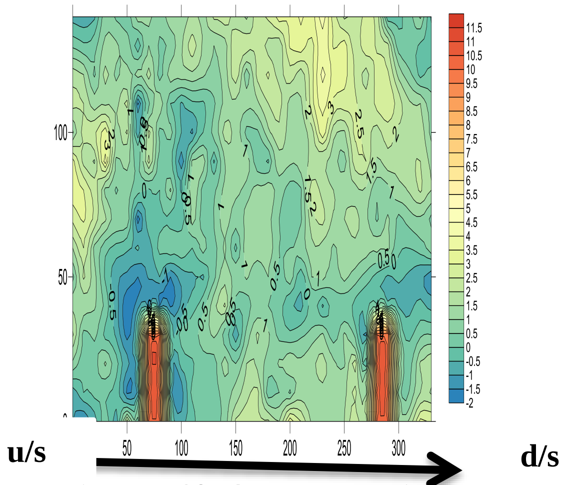


Figure 4.68: Contour map in two spurs at 0.30 cusec/m

Direction of velocity currents

Velocity currents were deflected at the upstream side of the first spur.as shown in Fig 4.69. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the first spur. This Fig shows that velocity currents at upstream side were deflected and. the deflection currents were made water pockets between the spurs.

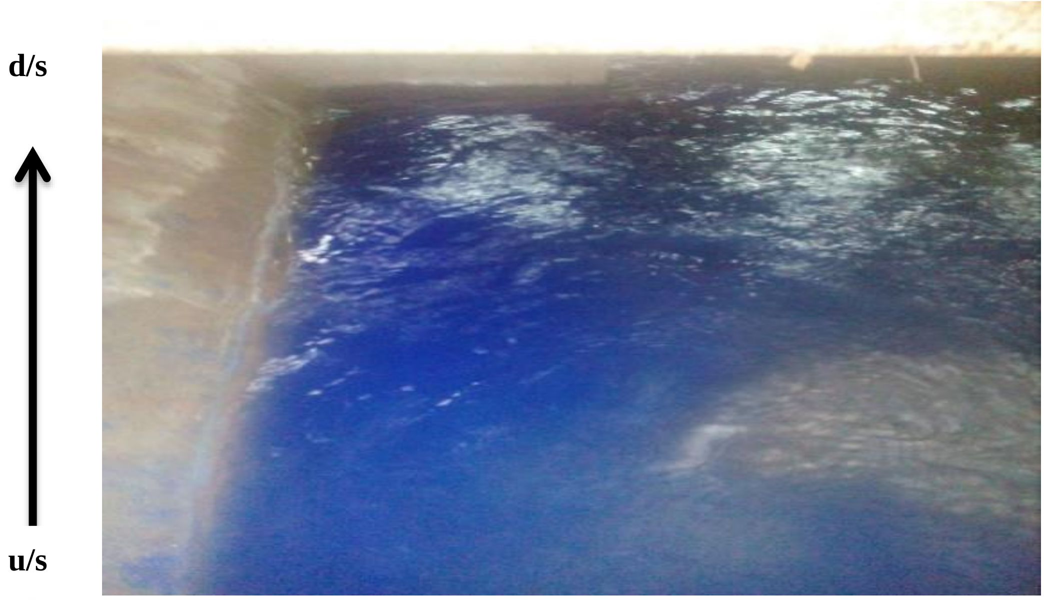


Figure 4.69: Direction of velocity currents in two spurs at 0.30 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.30 cusec/m of all three spur in the channel as shown in the Fig 4.70 This Fig also shows the flow velocity at upstream side of the spur was high and increased at larger extent at the nose of the first spur. The velocity between the spur almost zero due to creation of water pockets. The velocity was increased when flow goes away all the structures. The velocity in the channel was larger at 0.30 cusec as compared to 0.20 cusec/m and 0.15 cusec/m.

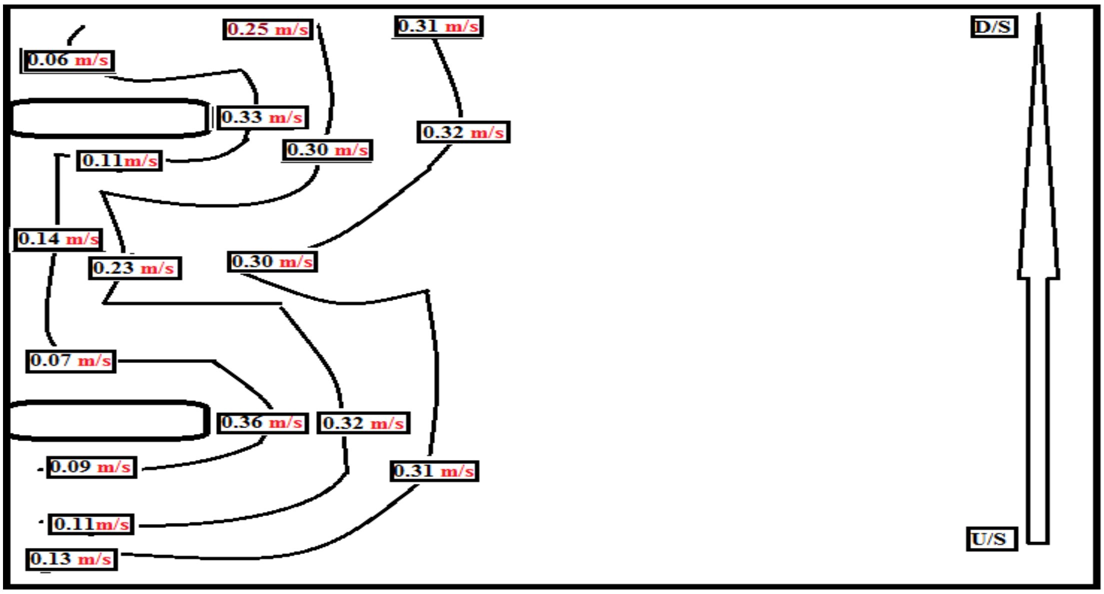


Figure 4.70: Velocity distribution at 0.30 cusec/m when two spur in series

4.2.2.4 Comparison of Erosion and Deposition in two Spurs series

When two spurs are in series was constructed then the pattern of erosion and deposition near all spurs as well as between the spur was obtained. A comparison study of erosion and deposition was analyzed at three different discharges. For this purpose, location of deposition or erosion was taken near all the spur are also shown in Fig.4.71

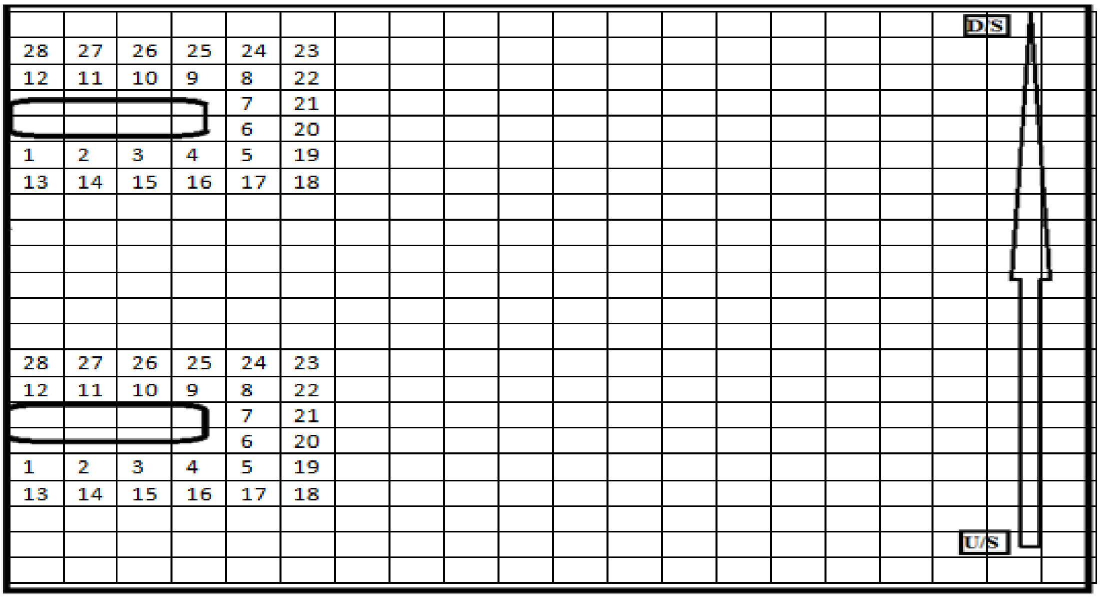


Figure 4.71: Location deposition and erosion near all two spurs

The Fig 4.72 shows the behavior of deposition or erosion near the 1st spur in case of two spur spacing. This Fig shows that near the 1st spur only erosion takes place which gradually increased when unit discharge gradually increased

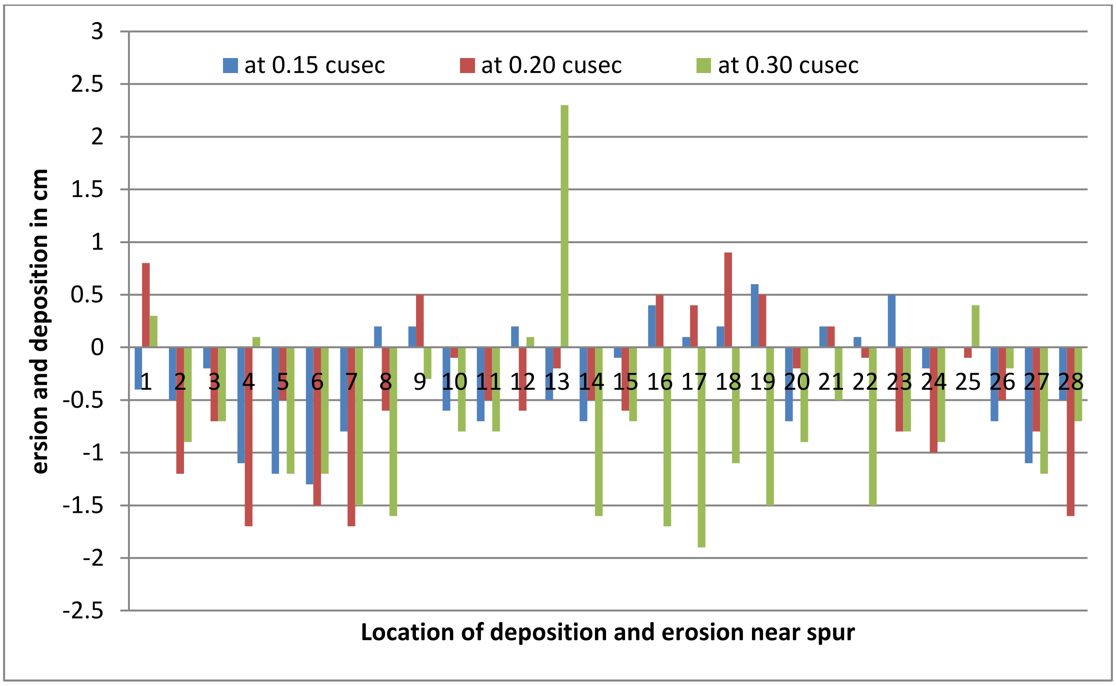


Figure 4.72: Erosion and deposition near Spur (1) at two spur series from experiment 13 to 15

The Fig 4.73 shows the behavior of deposition or erosion near the 2nd spur in case of two spur spacing. This Fig shows that near the 2nd spur only deposition takes place near the spur as well as between the two spur which gradually increased when unit discharge gradually increased.

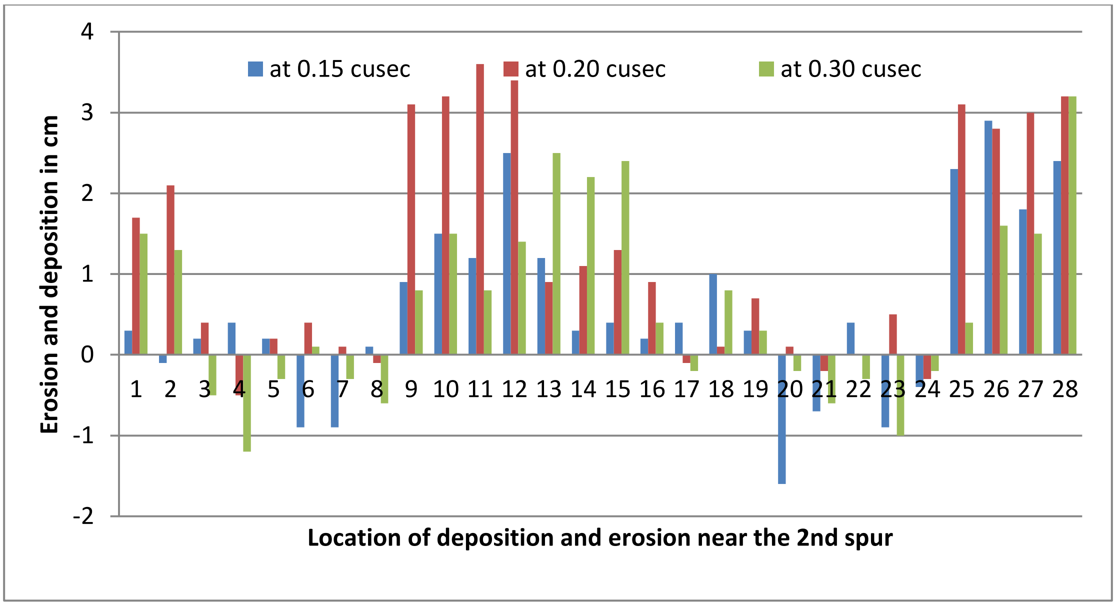


Figure 4.73: Deposition and erosion near Spur (2) at two spur series from experiment 13 to 15

4.3 Geometry of the Spur

Different geometry of the spur is used as river training works in rivers to train the river flow at desired pattern. In this study three different most prominent used geometry of the spur was discussed. See the same parameters and behaviors in these geometries at three different unit discharges.

4.3.1 T-Spur

T-Spur was constructed in the channel to check the erosion and deposition near the structure.

4.3.1.1 Experiment No 16

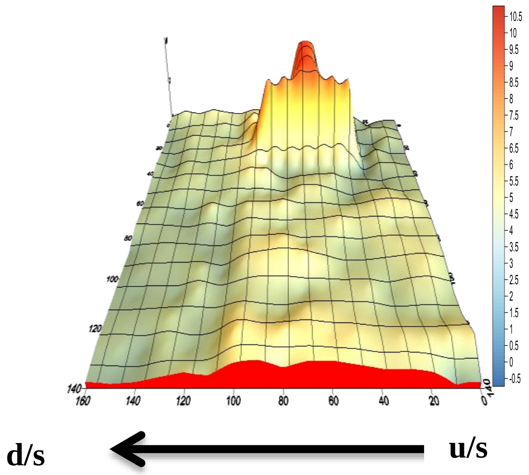
Experiment sixteen was carried out at the minimum discharge 0.75 cusec. The specifications of that experiment as shown in table 4.16.

Table 4.16: Specification of experiment No 16

Spur type: T-Spur	Discharge = Q= 0.75 cusec
Angle of T-Head = 90 degree	Unit discharge = q = 0.15 cusec/m
Level of the bed = 40 cm	Flow depth=h=0.07m

Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.74 and 4.75. This Fig shows that at the unit discharge 0.15 cusec/m the bed profile was changed at some extent. This Fig also shows that sedimentation was occur both water pockets at the T-Head. Erosion takes place at the noes and in front of the spur.



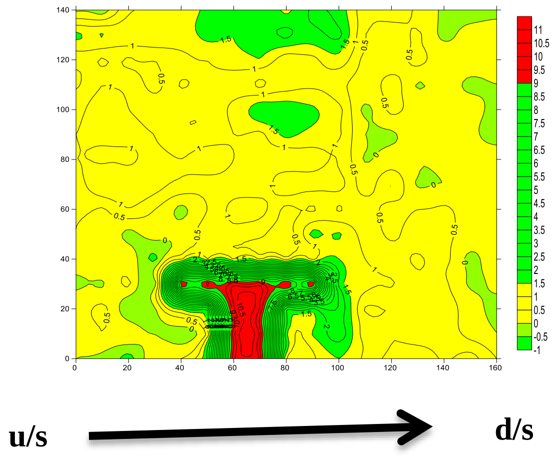


Figure 4.74: Scouring of bed of T-Spur at 0.15 cusec/m	Figure 4.75: Contour map of T-Spur at 0.15 cusec/m

Direction of velocity currents

Water currents were deflected at the upstream side of the first spur.as shown in Fig 4.76. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the first spur. This Fig shows that velocity currents at upstream side as well as downstream side create water pocket. The water currents were deflected near the T-head of the T-Spur.

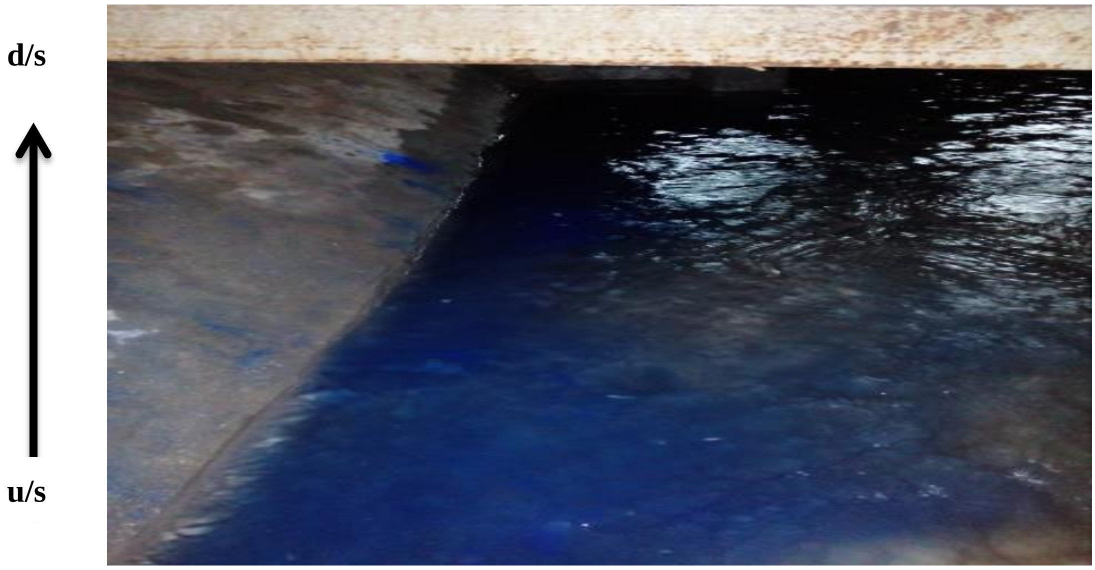


Figure 4.76: Direction of velocity currents in T-spur at 0.15 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.15 cusec/m of T-Spur in the channel as shown in the Fig 4.77 This Fig shows the flow velocity at upstream side of the spur and downstream side almost zero due to creation of water pockets. Some velocity increased at the T-Head and away the structure.

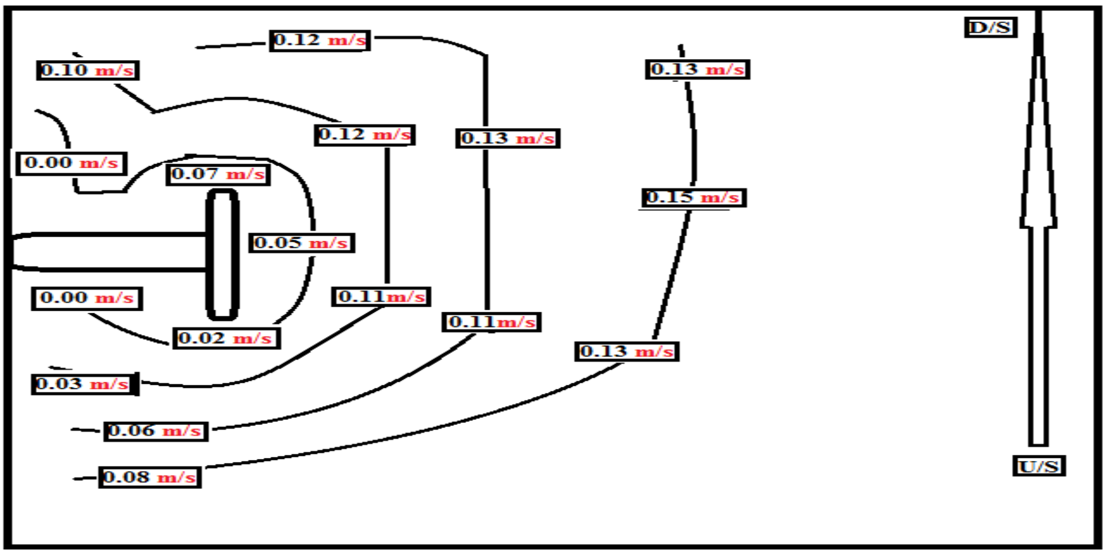


Figure 4.77: Velocity distribution at 0.15 cusec/m of T-Spur

4.3.1.2 Experiment No 17

Experiment seventeen was carried out at the medium discharge 1 cusec. The specifications of that experiment as shown in table 4.17.

Table 4.17: Specification of experiment No 17

Spur type : T-Spur	Unit discharge = q = 0.20 cusec/m
Angle of T-Head = 90 degree	Discharge = Q= 1 cusec
Level of the bed = 40 cm	Flow depth = h= 0.10 m

Scouring pattern

The scouring pattern and contour map were developed using the surfer software as shown in Fig 4.78 and 4.79. This Fig shows that at the unit discharge 0.20 cusec/m the bed profile was changed at large extent.as compared to 0.15 cusec/m. This Fig shows that sedimentation was occur both side water pockets at the T-Head. Erosion takes place at the noes and in front of the spur.

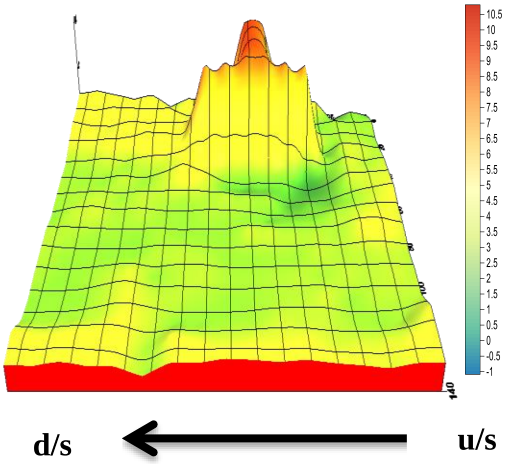


Figure 4.78: Scouring of bed of T-Spur at 0.20 cusec/m

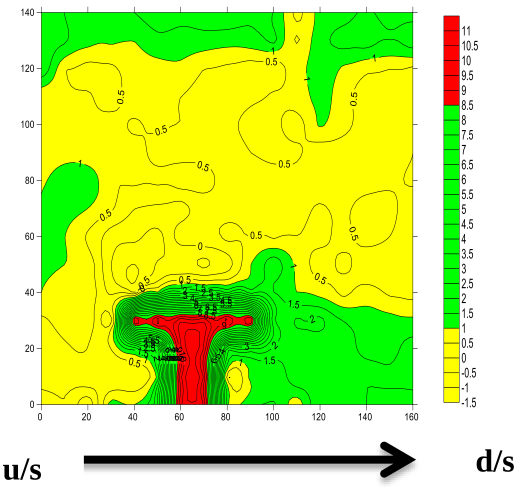


Figure 4.79: Contour map of T-Spur at 0.20 cusec/m

Direction of velocity currents

Velocity currents were deflected at the upstream side of the first spur.as shown in Fig 4.80. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the first spur. This Fig shows that velocity currents at upstream side as well as downstream side create water pocket. The velocity currents were deflected near the T-Head of the T-Spur. The deflection of current was more speed as compared to 0.20 cusec/m.

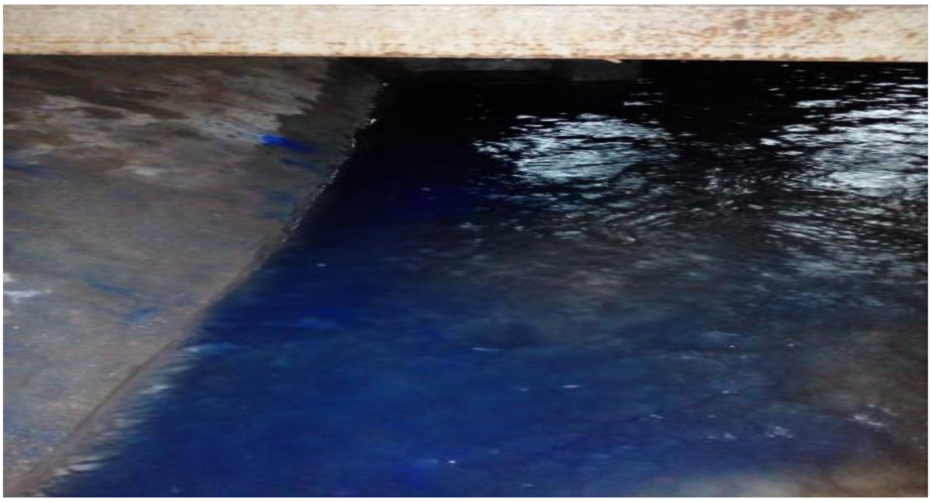


Figure 4.80: Direction of velocity currents in T-Spur at 0.20 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.20 cusec/m of T-Spur in the channel as shown in the Fig 4.81 .This Fig shows the flow velocity at upstream side of the spur and downstream side almost zero due to creation of water pockets. Some velocity increased at the T-Head and away the structure. The velocity was more in the channel as compared 0.15 cusec/m.

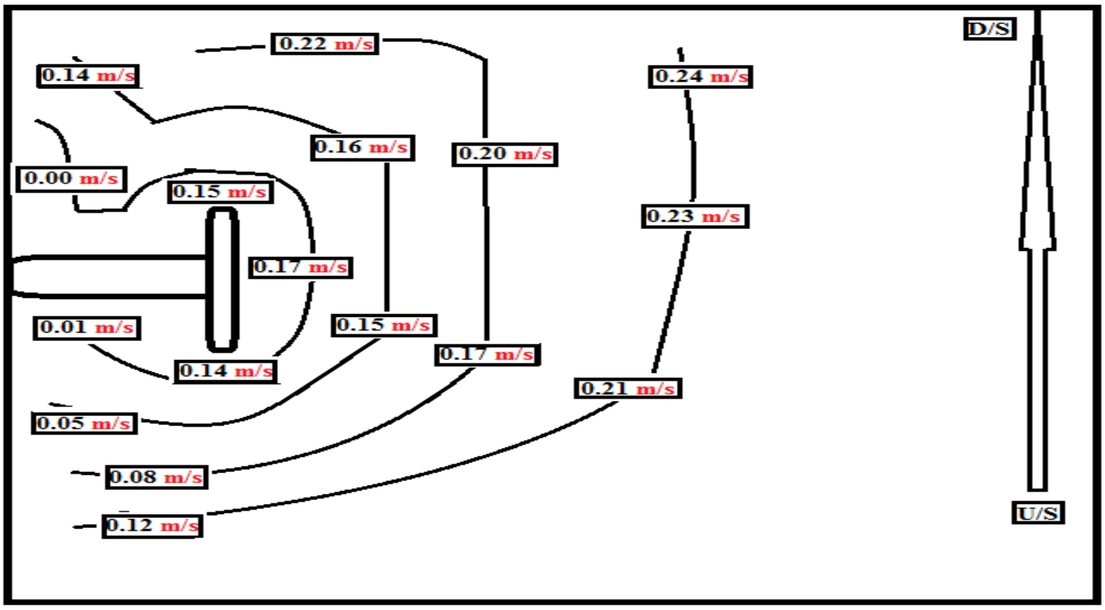


Figure 4.81: Velocity distribution at 0.20 cusec/m of T-Spur

4.3.1.3 Experiment No 18

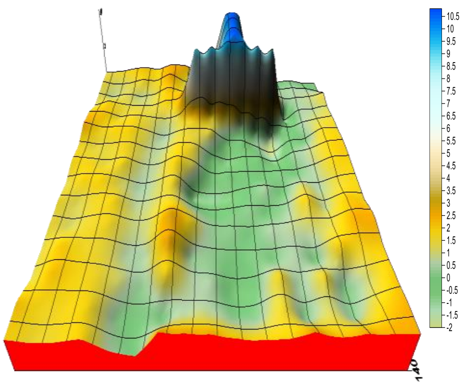
Experiment eighteen was carried out at the maximum discharge 1.5 cusec. The specifications of that experiment as shown in table 4.18.

Table 4.18: Specification of experiment No 18

Spur type : T-Spur	Discharge = Q= 1.5 cusec
Angle of T-Head = 90 degree	Unit discharge = q = 0.30 cusec/m
Level of the bed = 40 cm	Flow depth = h= 0.11 m

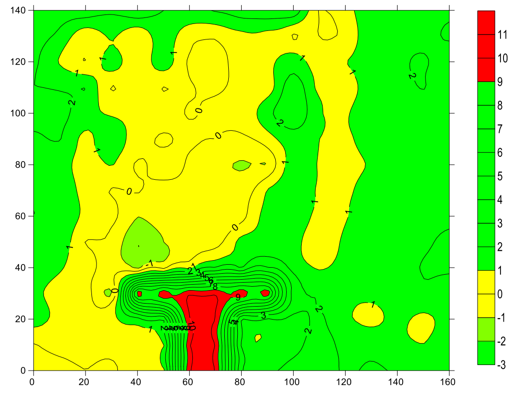
Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.82 and 4.83. This Fig shows that at the unit discharge 0.30 cusec/m the bed profile was changed at large extent.as compared to 0.20 cusec. This Fig also shows that sedimentation was occur both side water pockets at the T-Head. Erosion takes place at the noes and in front of the spur



d/s ← u/s

Figure 4.82: Scouring of bed of T-Spur at o.30 cusec/m



u/s → d/s

Figure 4.83: Contour map of T-Spur at 0.30 cusec/m

Direction of velocity currents

Velocity currents were deflected at the upstream side of the first spur.as shown in Fig 4.84. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the first spur. This Fig shows that velocity currents at upstream side as well as downstream side create water pocket. The velocity currents were deflected near the T-Head of the T-Spur. The deflection of current has greater velocity as compared to 0.20 cusec/m as well as 0.15 cusec/m

d/s

u/s

Figure 4.84: Direction of velocity currents in T-Spur at 0.30 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.30 cusec/m of T-Spur in the channel as shown in the Fig 4.85 This Fig shows the flow velocity at upstream side of the spur and downstream side almost zero due to creation of water pockets. Some velocity increased at the T-Head and away the structure. The velocity was more in the channel as compared to 0.15 cusec/m and 0.20 cusec/m.

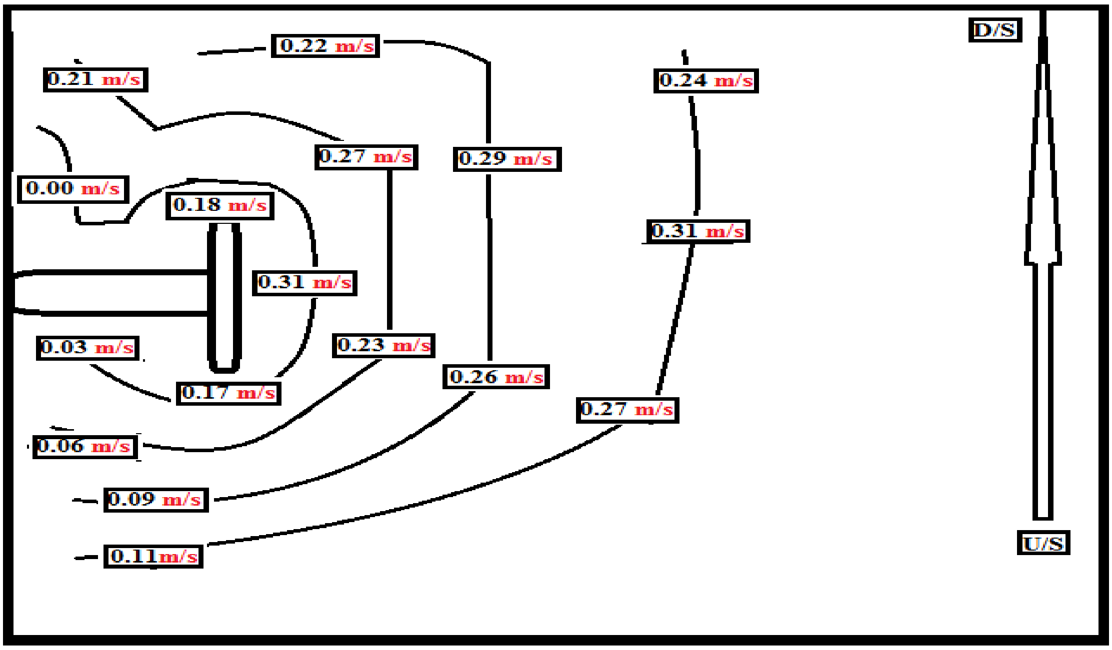


Figure 4.85: Velocity distribution at 0.30 cusec/m of T-Spur

4.3.1.4 Comparison of Erosion and Deposition in T-Spur

Spur was constructed and the pattern of erosion and deposition was observed near T-Spur. A comparison study of erosion and deposition was analyzed at three different discharges. For this purpose, location of deposition or erosion was taken near T-spur are also shown in Fig.4.86

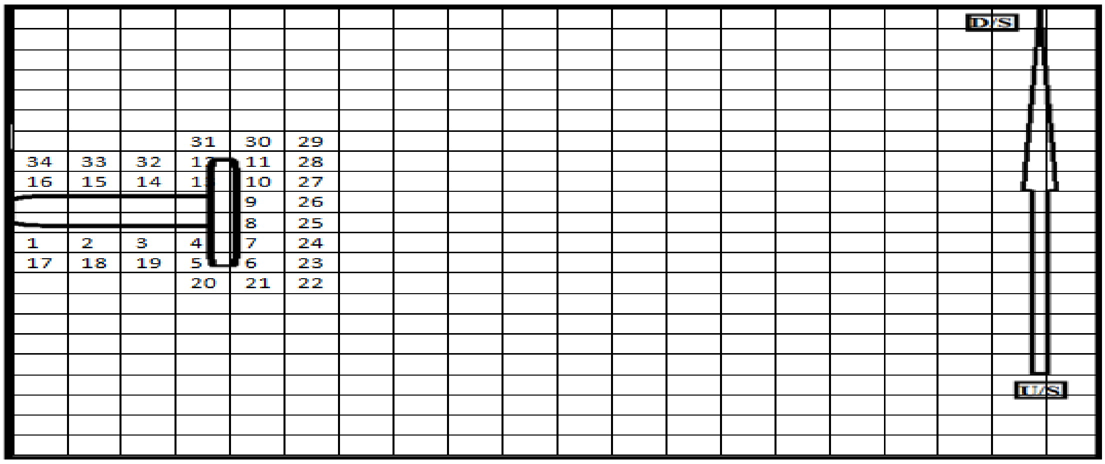


Figure 4.86: Location of deposition and erosion near T-spur

The Fig 4.86 shows the behavior of deposition or erosion near T-Spur. This graph shows that due to creation of water pockets near T-Head deposition takes place near the structure. Deposition was increased when unit discharges increased.

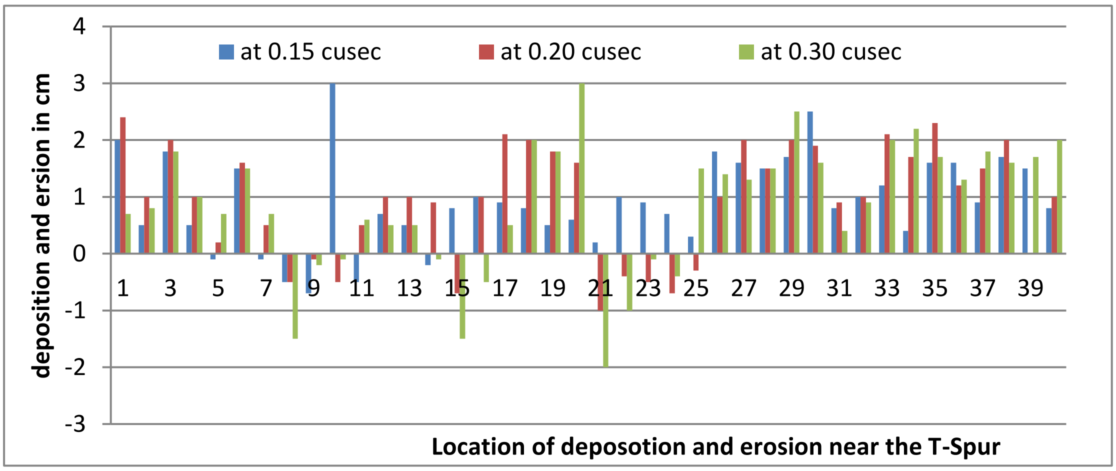


Figure 4.87: Deposition and erosion near T Spur at three-unit discharges from experiment 16 to 18

4.3.2 J-Spur

In second geometry J-Spur was constructed in the channel to check the erosion and deposition near the structure

4.3.2.1 Experiment No 19

Experiment nineteen was carried out at the minimum discharge 0.75 cusec. The specifications of that experiment as shown in table 4.19

Table 4.19: Specification of experiment No 19

Spur type: J-spur	Discharge = Q= 0.75 cusec
angle of J-Head = 90 degree	Unit discharge = q = 0.15 cusec/m
Level of the bed = 40 cm	Flow depth = h= 0.07 m

Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.88 and 4.89.This Fig shows that at the unit discharge 0.15 cusec/m the bed profile was changed at some extent. This Fig shows that erosion takes place near the J-Head and in front of structure at little extent.

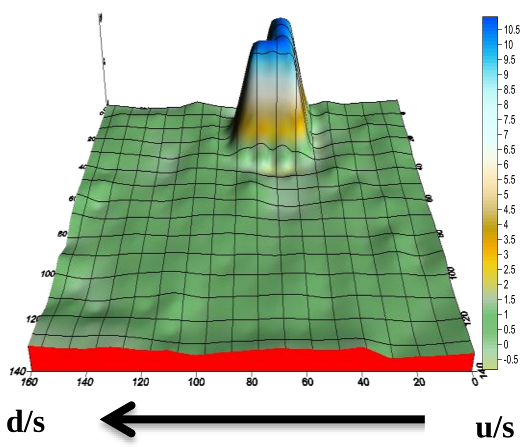


Figure 4.88: Scouring of bed of J-Spur at 0.15 cusec/m

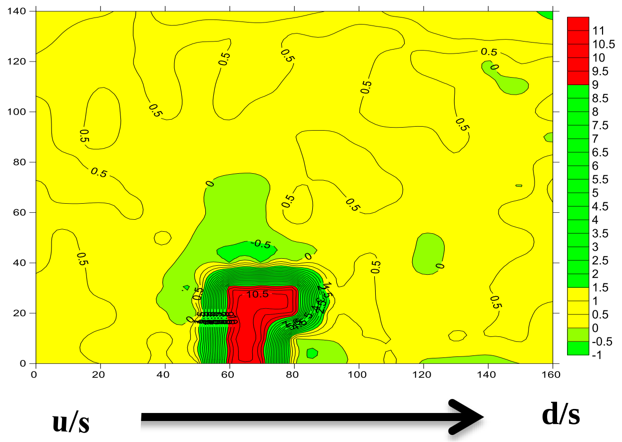


Figure 4.89: Contour map of J-Spur at 0.15 cusec/m

Direction of velocity currents

Velocity currents were deflected at the upstream side of the J- spur.as shown in Fig 4.90. The direction of water currents near the structure were observed by blue dye water color at upstream side of the first spur. This Fig shows that velocity currents were deflected at specific pattern and deflection of currents was large near the J-Head.

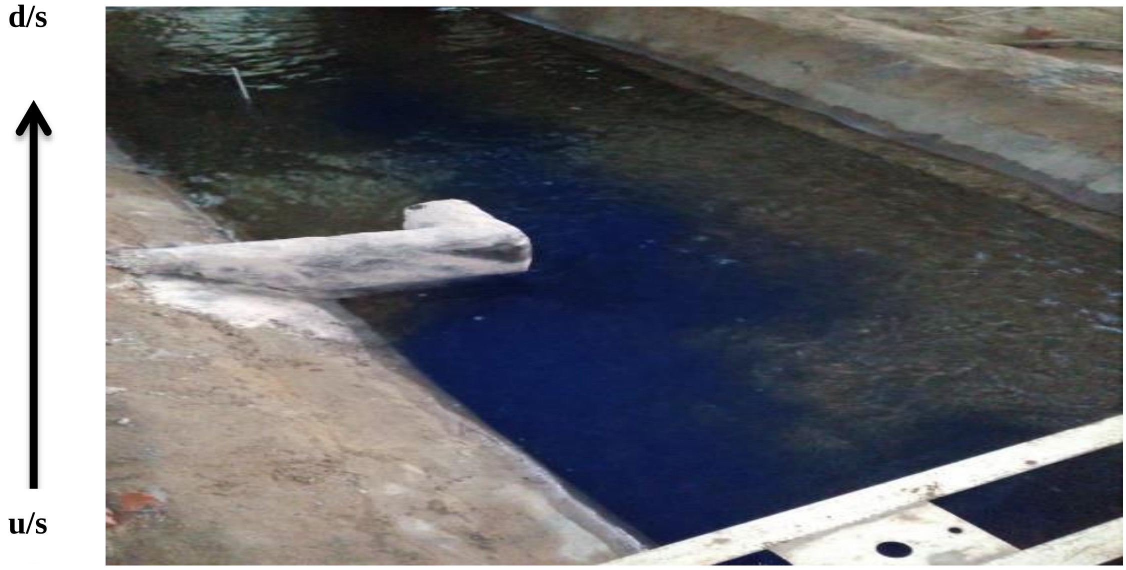


Figure 4.90: Direction of currents velocity J-Spur at 0.15 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.15 cusec/m of

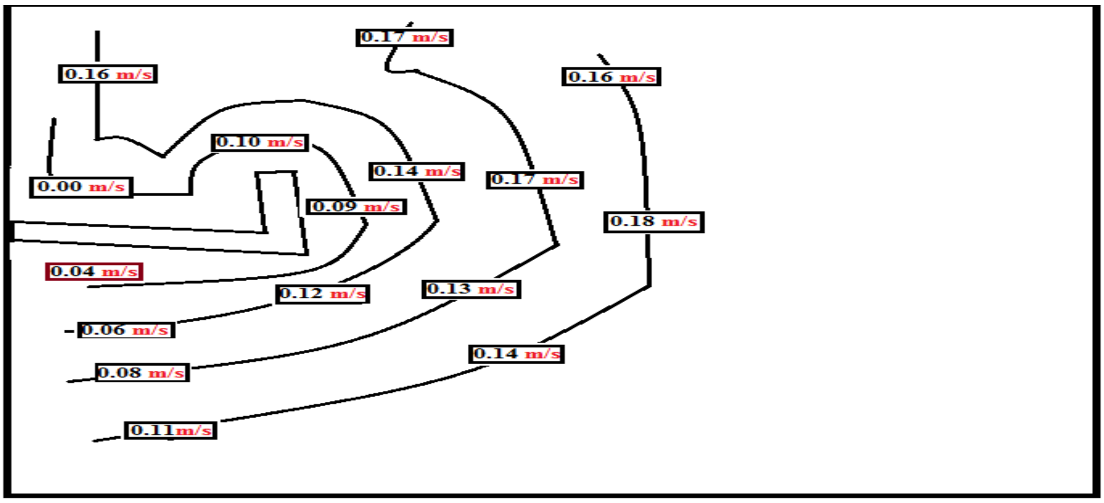


Figure 4.91: Velocity distribution at 0.15 cusec/m of J-Spur

J-Spur in the channel as shown in the Fig 4.91 This Fig shows the flow velocity at upstream side of the spur was low which increased near the nose of the J-Head. The velocity almost zero due to creation of water pockets.at downstream side

4.3.2.2 Experiment No 20

Experiment twenty was carried out at the medium discharge at 1 cusec. The specifications of that experiment as shown in table 4.20

Table 4.20: Specification of experiment No 20

Spur type: J-spur	Discharge = Q= 1 cusec
angle of J-Head = 90 degree	Unit discharge = q = 0.20 cusec/m
Level of the bed = 40 cm	Flow depth = h= 0.10 m

Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.92 and 4.93. This Fig shows that at the unit discharge 0.20 cusec/m the bed profile was changed at large extent. This Fig also shows that erosion takes place near the J-Head and in front of structure at large extent as compared to 0.15 cusec/m.

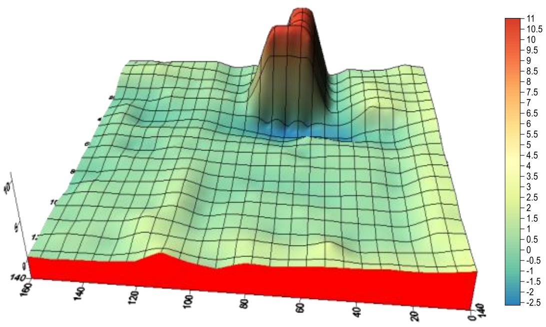


Figure 4.92: Scouring of bed in J-Spur at o.20 cusec/m

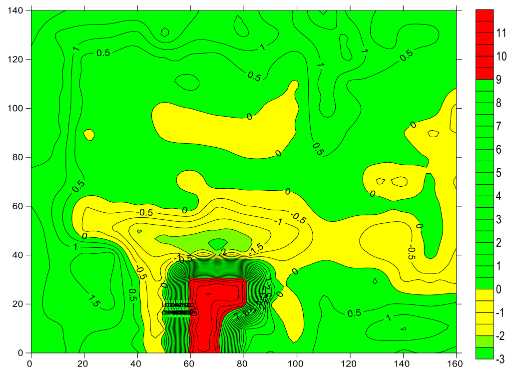


Figure 4.93: Contour map in J-Spur at o.20 cusec/m

Direction of velocity currents

Water currents were deflected at the upstream side of the J- spur.as shown in Fig 4.94. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the first spur. This Fig shows that velocity currents were deflected at specific pattern and deflection of currents was large near the J-Head. The deflection of velocity currents was more than as compared the 0.15 cusec/m.

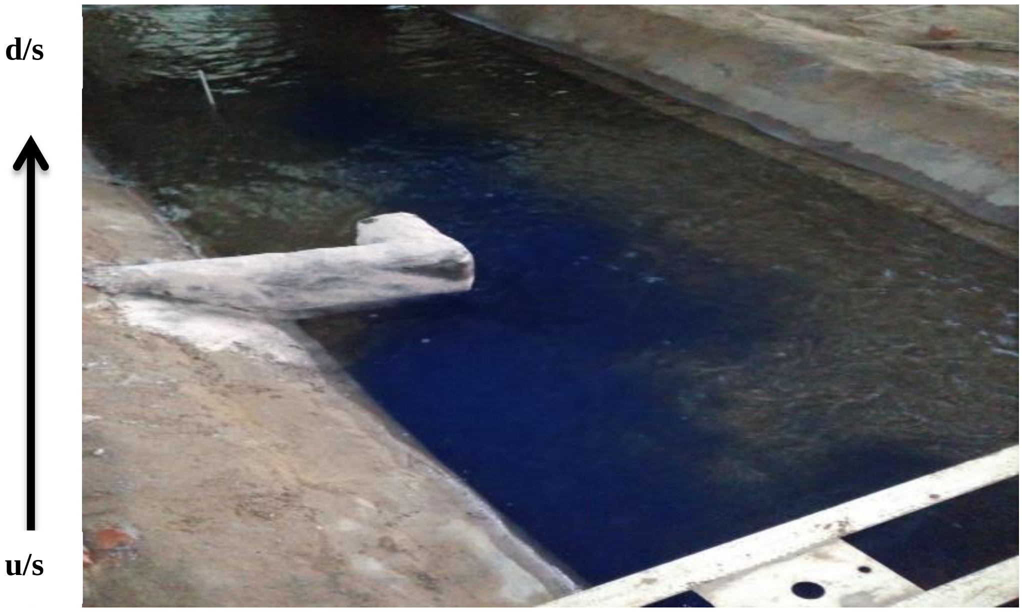


Figure 4.94: Direction of velocity currents in J-Spur at 0.20 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.20 cusec/m of J-Spur in the channel as shown in the Fig 4.95 This Fig shows the flow velocity at upstream side of the spur was low which increased near the nose of the J-Head. The velocity was almost zero due to creation of water pockets.at downstream side. The velocity was more than as compared to 0.15 cusec/m.

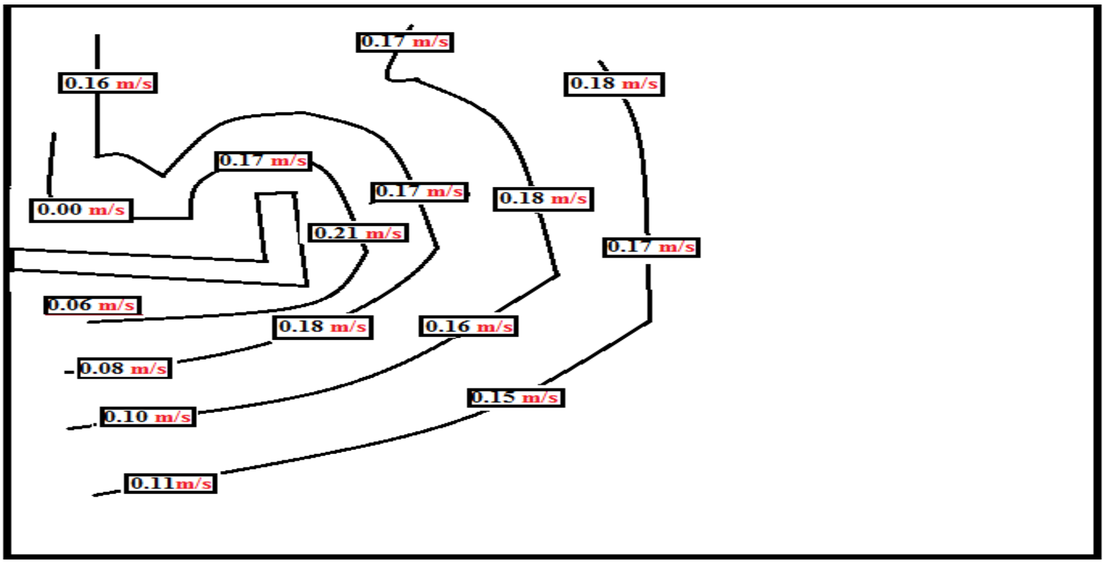


Figure 4.95: Velocity distribution at 0.20 cusec/m of J-Spur

4.3.2.3 Experiment No 21

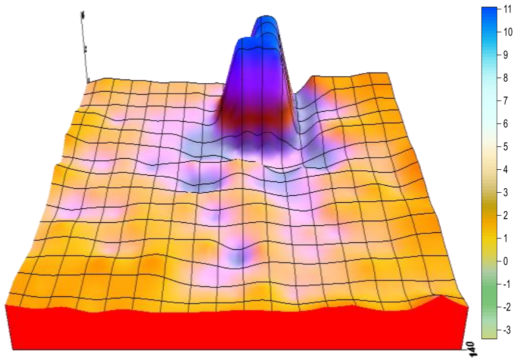
Experiment twenty one was carried out at the maximum discharge at 1.5 cusec. The specifications of that experiment as shown in table 4.21

Table 4.21: Specification of experiment No 21

spur type: J-spur	Discharge = Q= 1.5 cusec
angle of J-Head = 90 degree	Unit discharge = q = 0.30 cusec/m
Level of the bed = 40 cm	Flow depth = h= 0.11 m

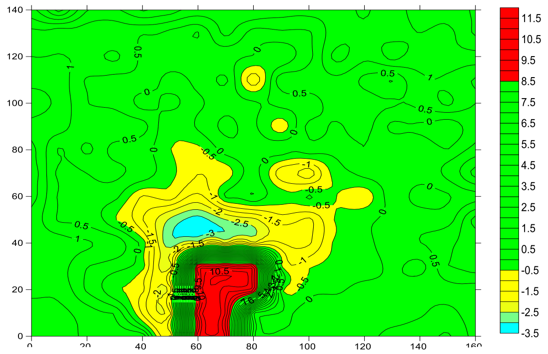
Scouring pattern

The scouring pattern and contour map were developed using surfer software as shown in Fig 4.96 and 4.97.This Fig shows that at the unit discharge 0.30 cusec/m the bed profile was abruptly changed. This Fig also shows that erosion takes place near the J-Head and in front of structure at large extent as compared to 0.20 cusec/m.



d/s ← u/s

Figure 4.96: Scouring of bed of J-Spur at 0.30 cusec/m



u/s → d/s

Figure 4.97: Contour map of J-Spur at 0.30 cusec/m

Direction of velocity currents

Water currents were deflected at the upstream side of the J- spur.as shown in Fig 4.98. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the first spur. This Fig shows that velocity currents were deflected at specific pattern and deflection of currents was large near the J-Head. The deflection of velocity currents was more than as compared the 0.20 cusec/m.

d/s ↑ u/s

Figure 4.98: Direction of velocity currents in J-Spur at 0.30 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.30 cusec of J-Spur in the channel as shown in the Fig 4.99 This Fig shows the flow velocity at upstream side of the spur was low which increased near the nose of the J-Head. The velocity was almost zero due to creation of water pockets.at downstream side. The velocity was more as compared to 0.20 cusec in the channel.

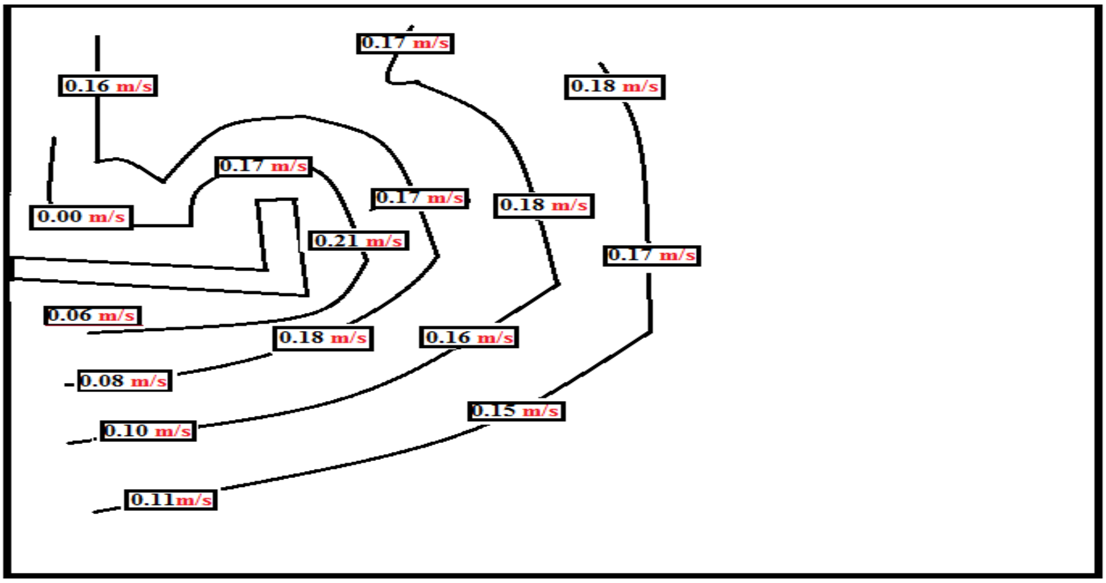


Figure 4.99: Velocity distribution at 0.30 cusecs of J-Spur

4.3.2.4 Comparison of Erosion and Deposition in J-Spur

J-Spur was constructed and saw the pattern of erosion and deposition near J-Spur. A comparison study of erosion and deposition was analyzed at three different discharges. For this purpose, location of deposition or erosion was taken near J-spur are also shown in Fig.4.100

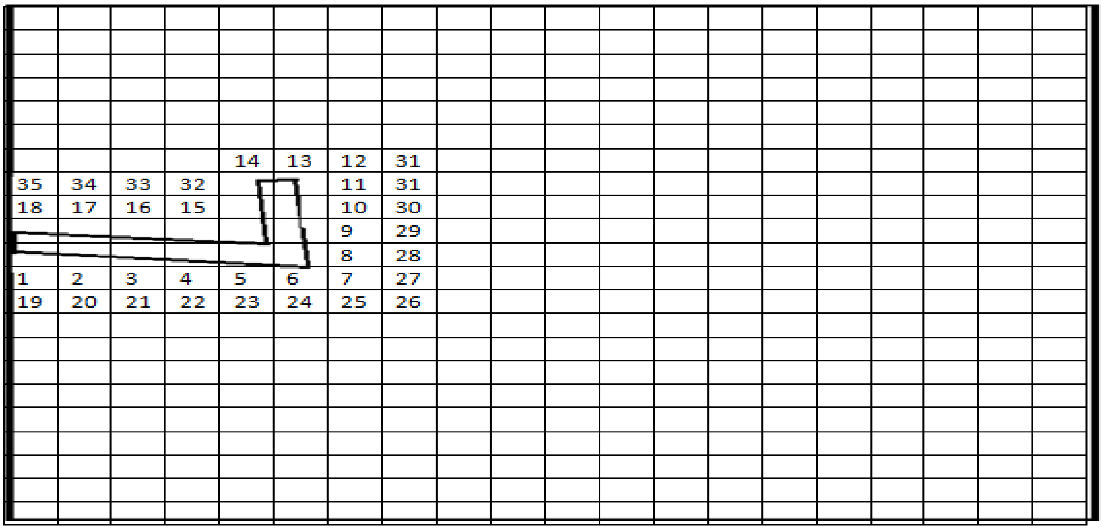


Figure 4.100: Location of deposition and erosion near J-spur

The Fig 4.101 shows the behavior of deposition or erosion near J-Spur the Fig shows that due to creation of water pockets at downstream side deposition takes place. This Fig also shows that at upstream side of the J-Spur and at the nose of J-Head erosion takes place which increased gradually when unit discharge increased.

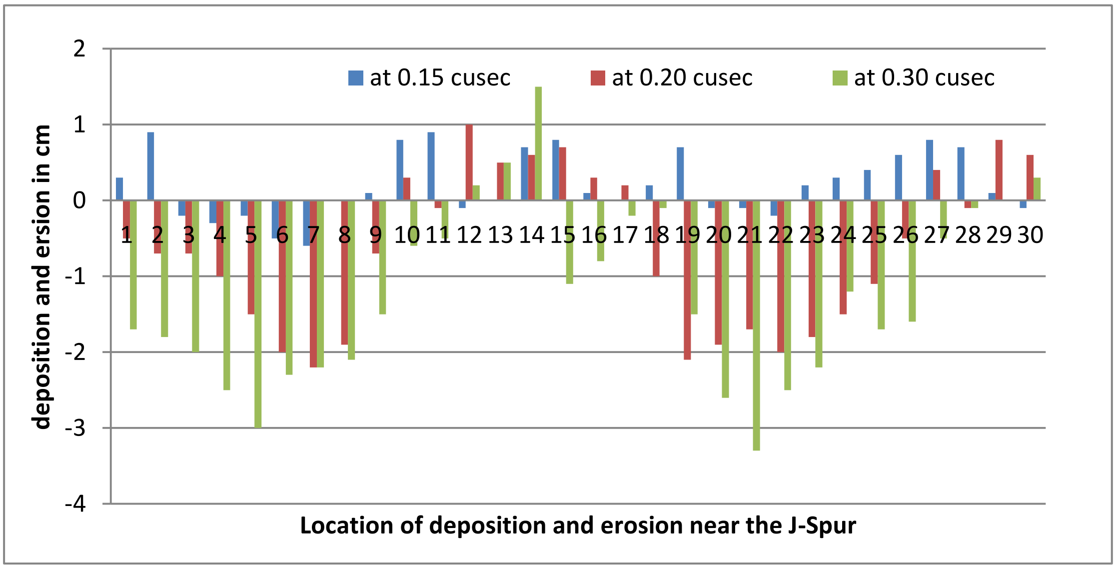


Figure 4.101: Deposition or erosion near Spur (J) at three unit discharges from experiment 19 to 21

4.3.3 Hockey Spur

In third geometry Hockey-Spur was constructed in the channel to check the erosion and deposition near the Hockey spur.

4.3.3.1 Experiment No 22

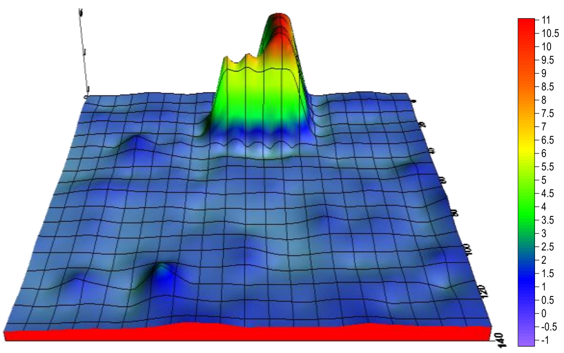
Experiment twenty-two was carried out at the minimum discharge 0.75 cusec. The specifications of that experiment as shown in table 4.22

Table 4.22: Specification of experiment No 22

spur type: hockey spur	Discharge = Q= 0.75 cusec
angle of hockey head = 45 degree	Unit discharge = q = 0.15 cusec/m
Level of the bed = 39 cm	Flow depth = h= 0.07 m

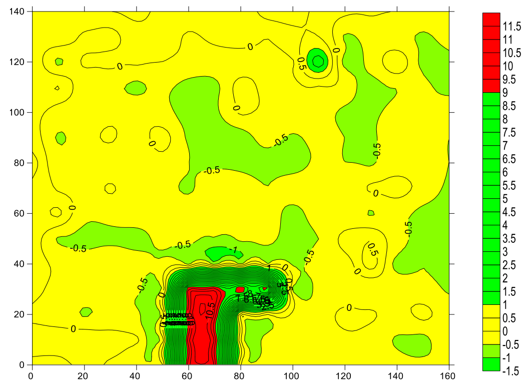
Scouring pattern

The scouring pattern and contour map were developed using the surfer software as shown in Fig 4.102 and 4. 103. This Fig shows that at the unit discharge 0.15 cusec the bed profile was changed at some extent. This Fig also shows that erosion takes place near the Hockey-Head and in front of structure at little extent



d/s ← u/s

Figure 4.102: Scouring of bed of hockey spur at 0.15 cusec/m



u/s → d/s

Figure 4.103: Contour map of hockey spur at 0.15 cusec/m

Direction of velocity currents

Velocity currents were deflected at the upstream side of the hockey- spur.as shown in Fig 4.104. The direction of velocity currents near the structure were observed blue dye water color at upstream side of the spur. This Fig shows that currents were deflected at specific pattern and deflection of currents was large near the hockey-Head. The deflection of velocity currents was easy in hockey spur.

d/s

u/s

Figure 4.104: Direction of Deflection currents in hockey spur at 0.15 cusec/m.

Velocity Distribution Profile

Velocity distributions in the channel at different locations were observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.15 cusec/m of hockey-Spur in the channel as shown in the Fig 4.105 This Fig shows the flow velocity at upstream side of the spur was low which increased near the nose of the hockey-head. The velocity almost zero due to creation of water pockets.at downstream side

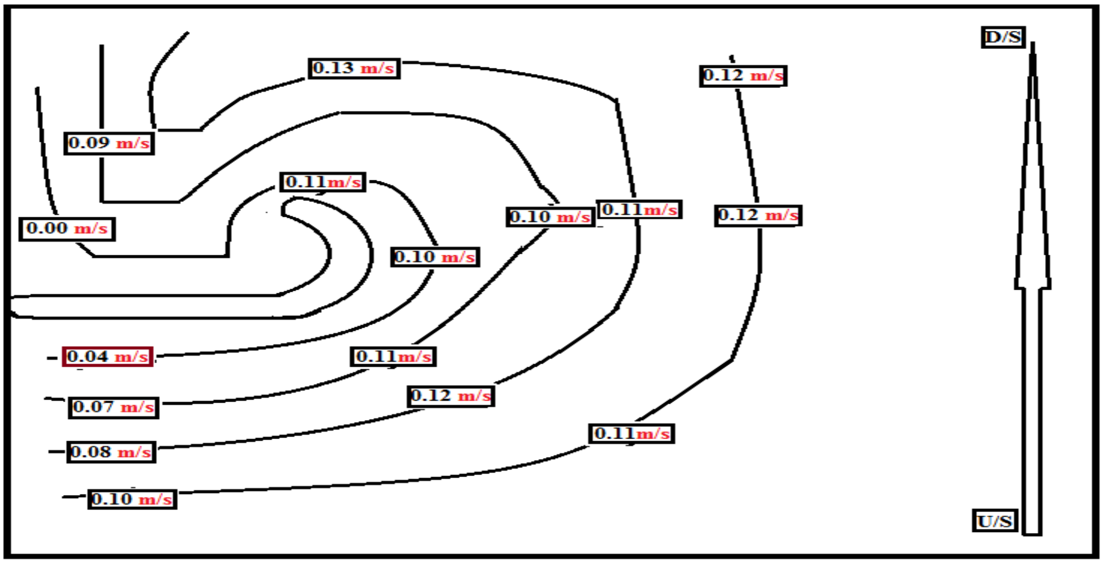


Figure 4.105: Velocity distribution at 0.15 cusec/m of Hockey-Spur

4.3.3.2 Experiment No 23

Experiment twenty three was carried out at the medium discharge 1 cusec. The specifications of that experiment as shown in table 4.23

Table 4.23: Specification of experiment No 23

spur type: hockey spur	Discharge = Q= 1 cusec
angle of hockey head = 45 degree	Unit discharge = q = 0.20 cusec/m
Level of the bed = 39 cm	Flow depth = h= 0.10 m

Scouring pattern

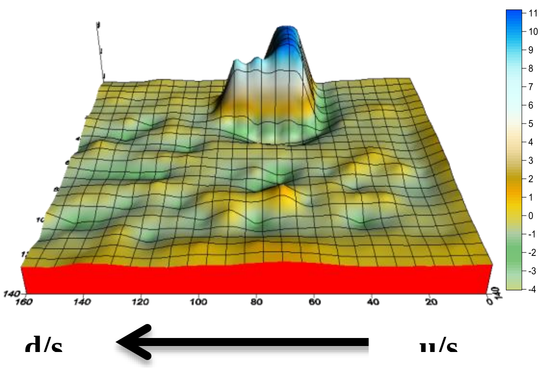


Figure 4.106: Scouring of bed of hockey spur at 0.20 cusec/m

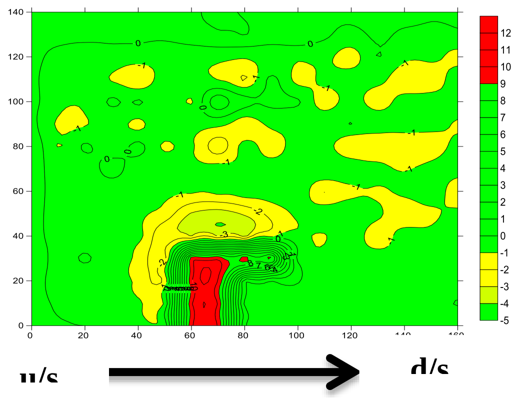


Figure 4.107: Contour map of hockey spur at 0.20 cusec/m

The scouring pattern and contour map were developed using the surfer software as shown in Fig 4.106 and 4.107.This Fig shows that at the unit discharge 0.20 cusec/m the bed profile was changed at large extent. This Fig shows that erosion takes place near the hockey-Head and in front of structure at large extent as compared to 0.15 cusec/m

Direction of velocity currents

Water currents were deflected at the upstream side of the hockey- spur.as shown in Fig 4.108. The direction of water currents near the structure were observed by blue dye water color at upstream side of the spur. This Fig shows that velocity currents were deflected at specific pattern and deflection of currents was large near the hockey-Head. The deflection of water currents was easy in hockey spur and more than as compared to 0.15 cusec/m.

Figure 4.108: Direction of Deflection currents in hockey spur at 0.20 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.20 cusec/m of hockey-Spur in the channel as shown in the Fig 4.109 This Fig shows the flow velocity at upstream side of the spur was low which increased near the nose of the hockey-head. The velocity was almost zero due to creation of water pockets.at downstream side. The velocity was more in the channel as compared to 0.15 cusec/m.

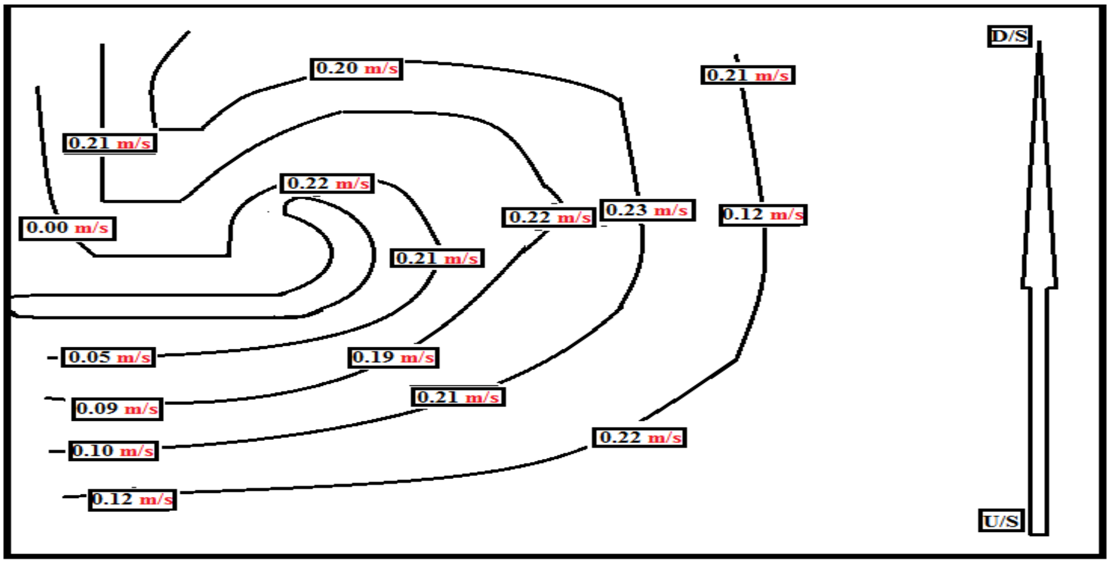


Figure 4.109: Velocity distribution at 0.20 cusec/m of Hockey-Spur

4.3.3.3 Experiment No 24

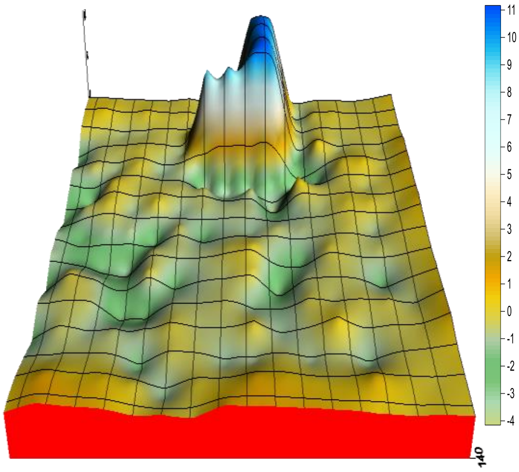
Experiment twenty-four was carried out at the maximum discharge 1.5 cusec. The specifications of that experiment as shown in table 4.24

Table 4.24: Specification of experiment No 24

Spur type: hockey spur	Discharge = Q= 1.5 cusec
angle of hockey head = 45 degree	Unit discharge = q = 0.30 cusec/m
Level of the bed = 39 cm	Flow depth = h= 0.11 m

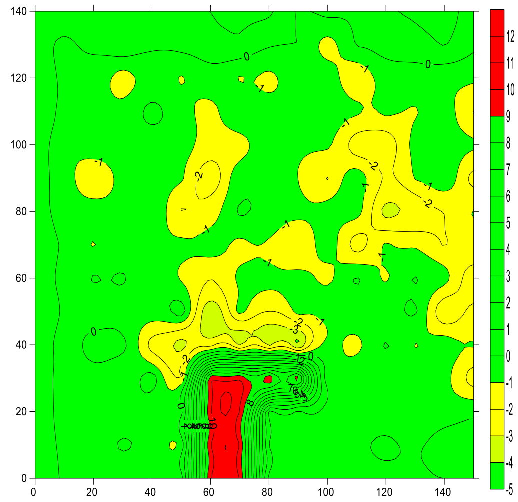
Scouring pattern

The scouring pattern and contour map were developed using the surfer software as shown in Fig 4.110 and 4.111.This Fig shows that at the unit discharge 0.30 cusec/m the bed profile was abruptly changed at large extent. This Fig also shows that erosion takes place near the hockey-Head and in front of structure at large extent as compared to 0.20 cusec



d/s ← u/s

Figure 4.110: Scouring of bed of hockey spur at 0.30 cusec/m



u/s → d/s

Figure 4.111: Contour map of hockey spur at 0.30 cusec/m

Direction of velocity currents

Velocity currents were deflected at the upstream side of the hockey- spur.as shown in Fig 4.112. The direction of velocity currents near the structure were observed by blue dye water color at upstream side of the spur. This Fig shows that currents were deflected at specific pattern and deflection of currents was large near the hockey-Head. The deflection of velocity currents was easy in hockey spur and more than as compared to 0.20 cusec/m.

Figure 4.112: Direction of water currents in hockey spur at 0.30 cusec/m

Velocity Distribution Profile

Velocity distributions in the channel at different locations were observed with the help of digital current meter. Velocity distribution profile at unit discharge 0.30 cusec/m of hockey-Spur in the channel as shown in the Fig 4.113 This Fig shows the flow velocity at upstream side of the spur was low which increased near the nose of the hockey-head. The velocity was almost zero due to creation of water pockets.at downstream side. The velocity was more in the channel as compared to 0.20 cusec/m

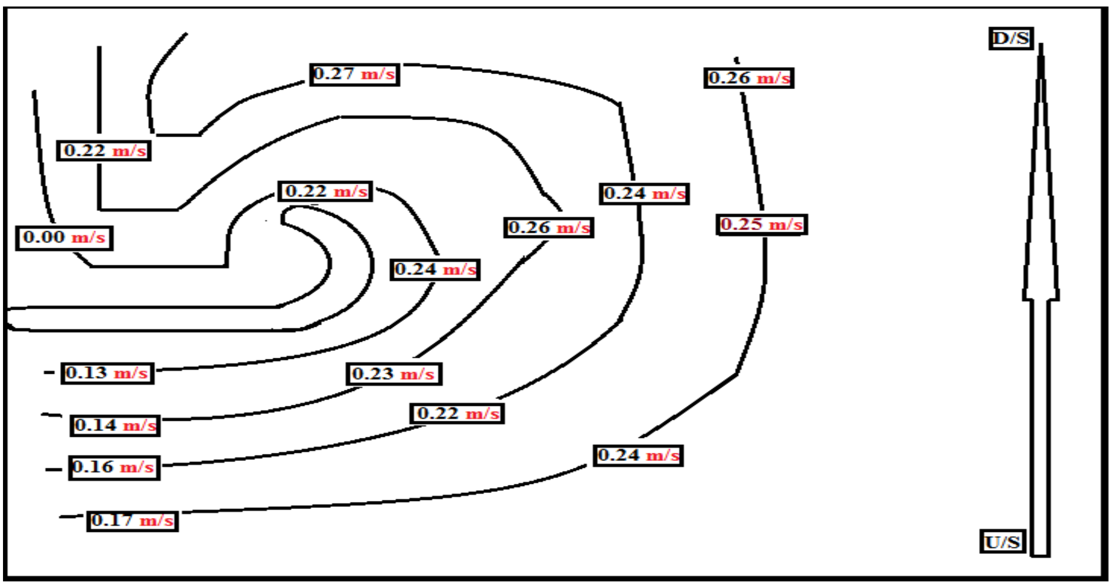


Figure 4.113: Velocity distribution at 0.30 cusec/m of Hockey-Spur

4.3.3.4 Comparison of Erosion and Deposition in Hockey-Spur

Hockey-Spur was constructed and saw the pattern of erosion and deposition near hockey-Spur. A comparison study of erosion and deposition was analyzed at three different discharges. For this purpose location of deposition or erosion was taken near the spur are also shown in Fig.4.114

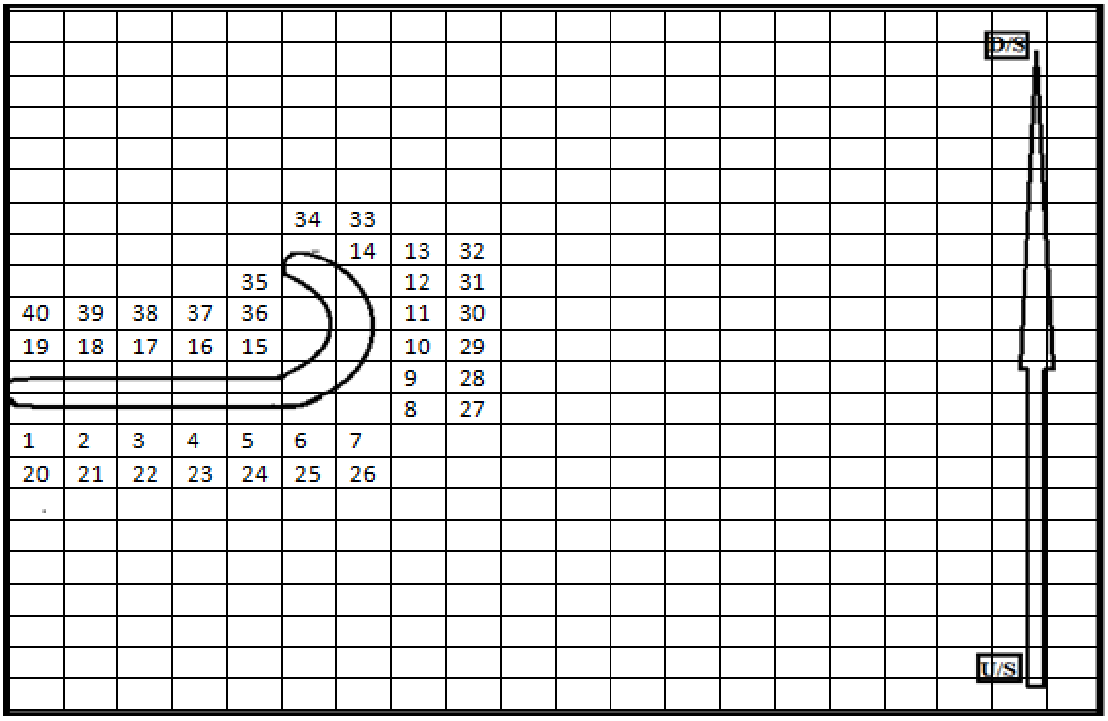


Figure 4.114: Location of deposition and erosion near hockey-spur

The Fig as shown Fig 4.115 shows the behavior of deposition or erosion near Hockey-Spur. This Fig shows that shows that at upstream side of the hockey-Spur and at the nose of hockey-Head erosion takes place which increased gradually when unit discharge increased. This Fig shows that the erosion was very less at downstream side of the structure.

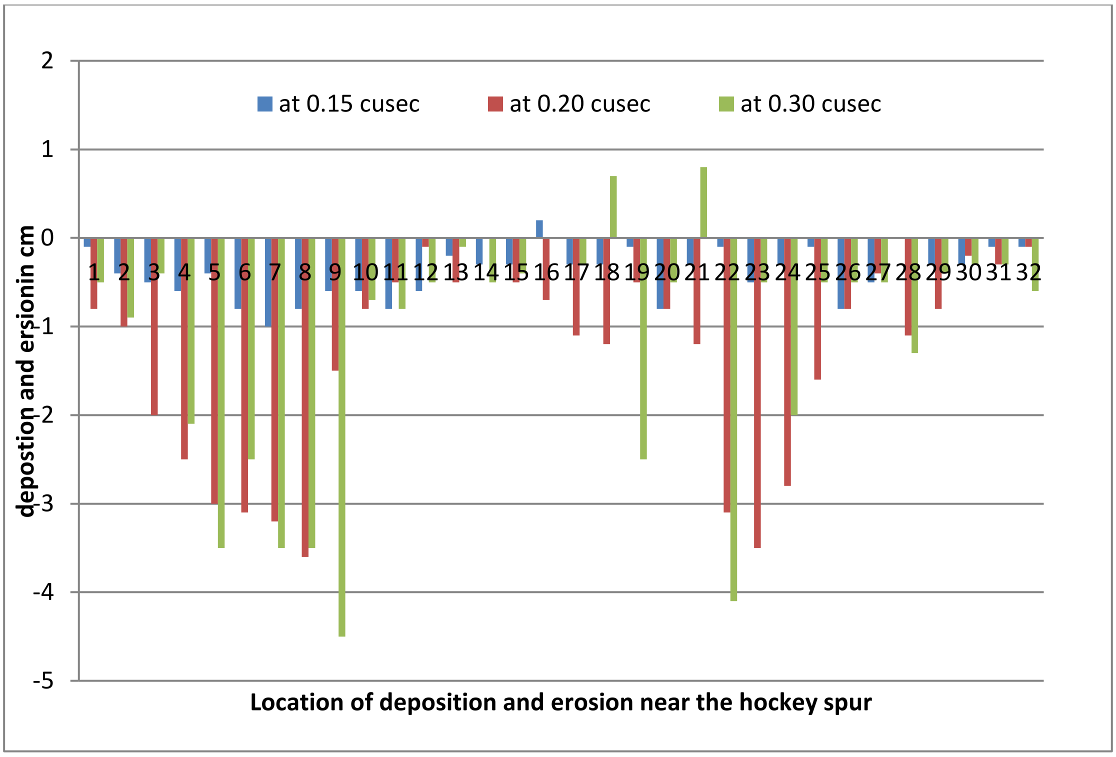


Figure 4.115: Deposition and erosion near Spur (Hockey) at three unit discharges

These was the 24 experiment in which different orientations, spur spacing and different geometries was studied at three different unit discharges which is 0.15 cusec/m, 0.20 cusec/m and 0.30 cusec/m to check the effectiveness of spur.

4.4 Summary of the results

In this research 24 experiment was carried to analyze the orientation at three different orientation, spacing between the spur in straight channel for the protection of banks and the end most widely used geometries of the spur was discussed. The summary of results of all experiments as shown in table 4.25.

Table 4.25: Summery of all the experiments

Experiment No	Spur type	Discharge(cusec)	Max velocity(m/s)	Flow depth (m)	Remarks
1, 2 ,3	Deflecting (90 degree)	0.75,1, 1.5	0.10,0.21,0.30	0.07, 0.10,0.11	Used deflect the flow
4,5,6	Repelling (60 degree)	0.75,1, 1.5	0.10,0.21,0.30	0.07, 0.10,0.11	Repel the water near the nose and create the water pockets at u/s side of the structure.
7 , 8 , 9	Attracting (120degree)	0.75,1, 1.5	0.10,0.21,0.30	0.07, 0.10,0.11	Attract the water currents and create a water pocket on d/s of structure
10 ,11 ,12	Three spur spacing	0.75,1, 1.5	0.10,0.21,0.30	0.07, 0.10,0.11	In three spur series conclude that sedimentation occur between the spur and increased when discharge increased
13,14.15	Two spur spacing	0.75,1, 1.5	0.10,0.21,0.30	0.07, 0.10,0.11	In two spur series conclude that sedimentation occur between the spur and increased when discharge increased

16,17,18	T-Spur	0.75,1, 1.5	0.10,0.21,0.30	0.07, 0.10,0.11	Used deflect the water currents near the nose and create water pocket both side of structure
19,20,21	J-Spur	0.75,1, 1.5	0.10,0.21,0.30	0.07, 0.10,0.11	Used the water currents in specific direction
22,23,24	Hockey spur	0.75,1, 1.5	0.10,0.21,0.30	0.07, 0.10,0.11	Used the water currents in specific direction

4.5 Discussion

First nine experiment was discussed the orientation of the spur. The results shows that deflecting spur used only deflect the velocity currents far the banks which is constructed at angle of 90 degree. The deflecting spur is most suitable only deflect the velocity current. Repelling spur at angle of 60 degree repel the water currents at upstream side near the nose of the spur. Repelling spur was creates water pockets at upstream of structure. Attracting spur at angle of 120 degree attract the flow near the bank at upstream side and water pocket create at downstream of the structure. Results shows that deposition create at upstream as well as downstream but erosion takes place near the nose of the structure. Deposition and erosion increased when discharge increased gradually.

Next six experiment was discussed the spacing between the spur. In first case three spur was constructed in series in straight channel for the protection of banks. The results shows that at 1st spur erosion was takes place and increased when discharge increased. But in 2nd and 3rd spur deposition was takes place between the spur which increased when discharge increased gradually. Which shows that spacing between the spur used for the protection of banks at certain length. In 2nd case the middle spur was removed then observed the same parameters and experiments shows that middle spur are not much effective in straight channel for bank protection.

Last nine experiment was discussed the three most prominent geometry of the spur. The results shows that geometry of the spur was used for specific purpose at the site. Mostly geometry of the spur are used to divert the flow at specified direction. In case of T-Spur the deposition takes place at both side of the structure and erosion takes place near the

T-Head which increased when discharge increased gradually. In case of J-spur water pockets create at downstream of the structure and deposition create at both side but erosion takes place near the nose of the structure which increased gradually when discharge increased. In case of hockey spur water currents divert at specified direction and erosion takes place near the hockey head which increased when discharge increased gradually.

Chapter V

CONCLUSIONS AND RECOMENDATIONS

5.1 Conclusions

- When unit discharge increased the erosion and bed morphology changed rapidly near all orientations, geometry and first spur in case when series of spur is used in spacing.
- For deflecting away the velocity currents from the banks, hockey spur is most effective and for banks strengthen on both side upstream as well as downstream the T-spur is most suitable geometry.
- To deflect the velocity current the most appropriate angle is 90 degree in straight channel and for creation of water pockets at upstream side 60 degree angle is most suitable which repel the velocity currents as well. Similarly for creation of water pockets on downstream the 120 degree angle is most suitable.
- In spacing, when discharge increased gradually then erosion also increased near first spur but deposition takes place near the 2^{nd} and 3^{rd} spur and between them for strengthen the banks of channel.
- In straight channel middle spur are not much effective for the protection of banks, result shows if middle spur is removed in three spur series then results are same for the banks protection.

5.2 Recommendations

- More precise results can be achieved if this research can be done on large scale by using high discharge.
- In this research cemented material was used. Further study should also be done by using different materials.
- 3-D modeling should be done for detailed analysis under different hydraulic and flow conditions.

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ANNEXURE

ANNEXURE-A

(Bed elevations near all spurs at three different unit discharges)

Table A-1: Bed elevations of deflecting spur at 0.15 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	-1	20	10	-0.6	40	30	-1.9	60	60	0.5	80	80	1	100	100	1	120	120	0.3	140	140	1
0	10	-0.7	20	20	-1.2	40	40	0	60	70	-0.6	80	90	0.5	100	110	1	120	130	0.3	150	0	0.8
0	20	-1.5	20	30	0.2	40	50	0	60	80	0.8	80	100	0.7	100	120	0.3	120	140	0.4	150	10	0.2
0	30	0.2	20	40	0	40	60	-0.1	60	90	0.5	80	110	1	100	130	1.5	130	0	0.1	150	20	0.3
0	40	0.5	20	50	0.5	40	70	0.2	60	100	0.4	80	120	0.5	100	140	1.6	130	10	-1.1	150	30	0.6
0	50	0.4	20	60	0.5	40	80	0.5	60	110	0.7	80	130	0.5	110	0	0.5	130	20	0.1	150	40	0.3
0	60	1	20	70	0.8	40	90	0.6	60	120	0.7	80	140	1.5	110	10	0.7	130	30	-0.8	150	50	0.1
0	70	0.6	20	80	0.5	40	100	0.2	60	130	0.5	90	0	0.1	110	20	0.9	130	40	0.2	150	60	0.3
0	80	0.6	20	90	0.5	40	110	0.3	60	140	1.1	90	10	0.1	110	30	-0.7	130	50	0.8	150	70	0.5
0	90	1	20	100	0.2	40	120	-0.1	70	0	0.4	90	20	0	110	40	-0.8	130	60	0.2	150	80	0.6
0	100	0.2	20	110	0.9	40	130	1.3	70	10	1	90	30	0.2	110	50	0.5	130	70	0	150	90	0.3
0	110	0.6	20	120	1.2	40	140	0.7	70	20	2.7	90	40	0.5	110	60	-0.4	130	80	0.1	150	100	-0.1
0	120	0.8	20	130	1.4	50	0	10	70	30	2.2	90	50	0.5	110	70	-0.2	130	90	0.2	150	110	0.4
0	130	0	20	140	0	50	10	10	70	40	0.5	90	60	0	110	80	0.1	130	100	-0.6	150	120	0.4
0	140	0.5	30	0	-0.3	50	20	10	70	50	0.8	90	70	0.7	110	90	0.6	130	110	0.5	150	130	0.8
10	0	-0.2	30	10	-0.3	50	30	10	70	60	0.7	90	80	0.6	110	100	0.2	130	120	0.2	150	140	0.9

10	10	-0.5	30	20	-1	50	40	-2.5	70	70	0.8	90	90	0.9	110	110	-0.1	130	130	0.2	160	0	1
10	20	-1.2	30	30	-0.6	50	50	-1	70	80	1.1	90	100	0.7	110	120	0.3	130	140	0.6	160	10	0.3
10	30	0	30	40	-0.5	50	60	0.4	70	90	0.5	90	110	1	110	130	0.1	140	0	0.5	160	20	0.5
10	40	-0.1	30	50	0	50	70	-0.2	70	100	1	90	120	1.2	110	140	0.8	140	10	-0.7	160	30	0.4
10	50	0.5	30	60	0.5	50	80	0.4	70	110	1	90	130	1.7	120	0	0.3	140	20	-0.2	160	40	0.6
10	60	0.8	30	70	0.2	50	90	0.3	70	120	1.2	90	140	1.5	120	10	0.4	140	30	0.2	160	50	0
10	70	0.5	30	80	0.4	50	100	0.4	70	130	1.5	100	0	0.2	120	20	0.3	140	40	0.4	160	60	0.2
10	80	0.8	30	90	0.5	50	110	0.2	70	140	1.5	100	10	0	120	30	-0.3	140	50	0.3	160	70	0.4
10	90	0.5	30	100	0.5	50	120	0.8	80	0	0.5	100	20	0	120	40	0	140	60	0.4	160	80	0.4
10	100	1	30	110	0.8	50	130	0.5	80	10	-0.1	100	30	0.2	120	50	0.7	140	70	0.3	160	90	0.8
10	110	0.5	30	120	1.2	50	140	1	80	20	0	100	40	0.5	120	60	-0.2	140	80	0.4	160	100	0.2
10	120	0.5	30	130	1	60	0	10	80	30	0.7	100	50	0.4	120	70	-0.1	140	90	0.4	160	110	0.2
10	130	1.5	30	140	0.7	60	20	10	80	40	0.5	100	60	0.9	120	80	0	140	100	-0.2	160	120	0.1
10	140	0.7	40	0	0	60	30	10	80	50	0.8	100	70	0.6	120	90	-0.2	140	110	0.6	160	130	0.9
20	0	0	40	10	-1	60	40	1.2	80	60	0.6	100	80	1	120	100	0.2	140	120	0.3	160	140	0.8
20	0	0	40	20	-1	60	50	0.2	80	70	1.3	100	90	0.8	120	110	0.6	140	130	0.8			

Table A-2: Bed elevations of deflecting spur at 0.20 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
-0.8	0	0	0.5	20	20	0.5	40	40	0.9	70	60	1.4	90	80	1.2	110	100
-0.9	10	0	0.5	30	20	0	50	40	0.4	80	60	-0.1	100	80	0.8	120	100
-0.7	20	0	0.6	40	20	0.5	60	40	0.7	90	60	0.2	110	80	1.3	130	100
-0.7	30	0	0.6	50	20	0.5	70	40	0.6	100	60	0	120	80	-0.2	140	100
1	40	0	0.5	60	20	0.6	80	40	0.7	110	60	0.7	130	80			
1.1	50	0	0.7	70	20	1.2	90	40	0.4	120	60	0.4	140	80			
1.2	60	0	0.7	80	20	0.5	100	40	1.6	130	60	0	0	90			
1.7	70	0	0.8	90	20	0.7	110	40	1.5	140	60	-0.1	10	90			
1.9	80	0	-0.1	100	20	0.4	120	40	-0.2	0	70	-0.5	20	90			
1.6	90	0	0.8	110	20	1.3	130	40	-0.3	10	70	-0.3	30	90			
1.2	100	0	-0.8	120	20	1.7	140	40	-2	20	70	0	40	90			
1.1	110	0	1.3	130	20	0	0	50	-1.9	30	70	0.5	50	90			
1.6	120	0	1.8	140	20	0	10	50	-1.4	40	70	1	60	90			
1.2	130	0	0.4	0	30	0	20	50	-0.6	50	70	0.8	70	90			
0.7	140	0	0.4	10	30	0	30	50	0.3	60	70	0.7	80	90			
0.7	0	10	0.3	20	30	-1.6	40	50	0.5	70	70	0.8	90	90			

0.6	10	10	0.3	30	30	-1.7	50	50	1	80	70	0.5	100	90			
0.5	20	10	1.1	40	30	-0.9	60	50	0.6	90	70	0.6	110	90			
0.5	30	10	0.8	50	30	0.4	70	50	-0.3	100	70	1.4	120	90			
0.7	40	10	0.6	60	30	0.6	80	50	0.6	110	70	0.6	130	90			
0.6	50	10	0.5	70	30	0.4	90	50	0.9	120	70	0.7	140	90			
0.5	60	10	0.4	80	30	0.5	100	50	1	130	70	-0.7	0	100			
0.7	70	10	0.7	90	30	0.5	110	50	0.8	140	70	-0.9	10	100			
0.7	80	10	0.8	100	30	1.4	120	50	-0.1	0	80	-0.5	20	100			
0	90	10	0.8	110	30	1.4	130	50	0	10	80	-0.7	30	100			
0.4	100	10	-0.4	120	30	1.4	140	50	-0.7	20	80	0.7	40	100			
0	110	10	1.1	130	30	0	0	60	-0.9	30	80	1	50	100			
1	120	10	1	140	30	0	10	60	-1	40	80	1.3	60	100			
1.2	130	10	0.6	0	40	0	20	60	-0.1	50	80	0.6	70	100			
0.7	140	10	0.6	10	40	-3.3	40	60	0.5	60	80	0.8	80	100			
0.2	0	20	0.5	20	40	-1.1	50	60	0.5	70	80	1.6	90	100			
0.3	10	20	0.5	30	40	-0.4	60	60	0.4	80	80	1.1	100	100			

Table A-3:Bed elevations of deflecting spur at 0.30 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	-0.5	20	20	0.7	40	40	-3.2	60	60	-1.4	80	80	0	100	100	1	120	120	-1.5	140	140	1.6
0	10	1	20	30	0.3	40	50	-0.7	60	70	-0.8	80	90	-0.7	100	110	1.4	120	130	1.2	150	0	0.8
0	20	0.4	20	40	0.4	40	60	0.3	60	80	-1.8	80	100	0.1	100	120	1	120	140	1.4	150	10	0.4
0	30	1	20	50	0.9	40	70	-0.1	60	90	-0.2	80	110	1.4	100	130	0.8	130	0	0.8	150	20	0.8
0	40	-0.5	20	60	1.7	40	80	1	60	100	-0.7	80	120	0.2	100	140	1.7	130	10	0.6	150	30	0.9
0	50	1.1	20	70	2.2	40	90	-1	60	110	-0.5	80	130	2	110	0	0.8	130	20	0.7	150	40	-0.5
0	60	1.2	20	80	0.9	40	100	0.8	60	120	0	80	140	1.1	110	10	0.6	130	30	0.8	150	50	0.3
0	70	2.7	20	90	1.1	40	110	1	60	130	0	90	0	0.1	110	20	0.4	130	40	-1.4	150	60	0.4
0	80	3	20	100	2.6	40	120	-0.2	60	140	-0.1	90	10	0.3	110	30	0.3	130	50	-1.8	150	70	0.4
0	90	2.9	20	110	1.8	40	130	-0.1	70	0	0.5	90	20	0.2	110	40	-1	130	60	-2	150	80	-0.2
0	100	2	20	120	0.8	40	140	-0.9	70	10	0.5	90	30	1	110	50	-1.5	130	70	-1.6	150	90	-2
0	110	2.2	20	130	0	50	0	10	70	20	0.1	90	40	1.1	110	60	-1.6	130	80	-1	150	100	-2.2
0	120	0.6	20	140	-1	50	10	10	70	30	1.5	90	50	-0.6	110	70	1.2	130	90	-1.6	150	110	-2.1
0	130	-1	30	0	-0.9	50	20	10	70	40	-2.1	90	60	-0.1	110	80	1.4	130	100	-1.9	150	120	-1.5
0	140	-1	30	10	-0.4	50	30	10	70	50	-2.7	90	70	1.1	110	90	-1.2	130	110	-1.5	150	130	1.7
10	0	-0.9	30	20	-0.5	50	40	-3.5	70	60	1	90	80	0.6	110	100	-2	130	120	-2	150	140	1.5
10	10	0.9	30	30	-1.9	50	50	-2.7	70	70	-0.1	90	90	-0.1	110	110	-1.6	130	130	1.8	160	0	0.9

10	20	0.5	30	40	-1.1	50	60	-1.2	70	80	1.3	90	100	0	110	120	-1	130	140	1.2	160	10	0.9
10	30	0.2	30	50	0.6	50	70	-0.7	70	90	-1	90	110	1	110	130	0.4	140	0	0.3	160	20	0.6
10	40	0.4	30	60	0.6	50	80	0.2	70	100	0.8	90	120	1	110	140	1.2	140	10	0.9	160	30	0.8
10	50	1.1	30	70	0.6	50	90	0.6	70	110	1.2	90	130	1	120	0	0.4	140	20	0.3	160	40	-0.6
10	60	1.5	30	80	0.7	50	100	-0.6	70	120	-0.4	90	140	1.9	120	10	0.7	140	30	0.1	160	50	-0.2
10	70	2.5	30	90	0	50	110	-0.7	70	130	1	100	0	0.9	120	20	0.6	140	40	-2.5	160	60	0.3
10	80	3.3	30	100	1.6	50	120	0.5	70	140	1	100	10	-1.5	120	30	0.7	140	50	0.5	160	70	0.4
10	90	2.9	30	110	1.4	50	130	0.2	80	0	0	100	20	-0.3	120	40	-1.1	140	60	0.6	160	80	-0.5
10	100	2.4	30	120	0.5	50	140	-0.7	80	10	0	100	30	1.5	120	50	-2.2	140	70	0	160	90	-1.8
10	110	1.8	30	130	0.3	60	0	10	80	20	0.2	100	40	1.4	120	60	1.4	140	80	-0.5	160	100	-2
10	120	1	30	140	-1	60	10	10	80	30	0.8	100	50	1.4	120	70	0.9	140	90	-1.8	160	110	-2
10	130	-0.5	40	0	1	60	20	10	80	40	-2	100	60	0.6	120	80	1.2	140	100	-1.5	160	120	-1.6
10	140	-1.1	40	10	0.1	60	30	10	80	50	-1.9	100	70	1	120	90	-1.6	140	110	-1.5	160	130	1.3
20	0	-0.2	40	20	0.5	60	40	-1.5	80	60	1.5	100	80	-1.3	120	100	-2.2	140	120	-1.9	160	140	1.4
20	10	1	40	30	-2.5	60	50	-2.8	80	70	-0.9	100	90	-2.5	120	110	-2.1	140	130	1.9			

Table A-4:Bed elevations of repelling spur at 0.15 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	0	20	20	-3	40	40	-1.5	60	60	-0.2	80	80	1.2	100	100	1	120	120	-0.2	140	140	0.8
0	10	0.1	20	30	10	40	50	-1.5	60	70	-0.1	80	90	1	100	110	0.3	120	130	0.9	150	0	0.2
0	20	-0.5	20	40	0	40	60	-1	60	80	0	80	100	0.7	100	120	0.8	120	140	1.1	150	10	0.4
0	30	-0.2	20	50	-0.5	40	70	0.4	60	90	0.1	80	110	0.5	100	130	0.5	130	0	0	150	20	0.4
0	40	-0.5	20	60	0.3	40	80	0.1	60	100	0.3	80	120	1.2	100	140	0.5	130	10	0.5	150	30	0.2
0	50	0.5	20	70	0.5	40	90	0.1	60	110	0.5	80	130	1	110	0	0	130	20	0.2	150	40	0.8
0	60	0.1	20	80	0	40	100	0.4	60	120	0.7	80	140	1	110	10	0.2	130	30	0.4	150	50	0.8
0	70	-0.1	20	90	1	40	110	0.1	60	130	0.5	90	0	1.2	110	20	0.1	130	40	0.8	150	60	0.3
0	80	-1.2	20	100	0.5	40	120	-0.5	60	140	0.1	90	10	1	110	30	0.2	130	50	0.4	150	70	0.1
0	90	0.8	20	110	0.5	40	130	-0.2	70	0	0.7	90	20	1.1	110	40	0.2	130	60	-0.2	150	80	-0.1
0	100	-0.2	20	120	0.7	40	140	-0.2	70	10	0.8	90	30	0.1	110	50	0.7	130	70	-0.3	150	90	0
0	110	0.5	20	130	-0.6	50	0	10	70	20	0.5	90	40	0.8	110	60	-0.2	130	80	-0.2	150	100	0.4
0	120	1	20	140	-0.5	50	10	10	70	30	0.2	90	50	1	110	70	-0.1	130	90	0.3	150	110	-0.4
0	130	0.2	30	0	-0.7	50	20	-0.1	70	40	0.5	90	60	1.3	110	80	-0.3	130	100	0.9	150	120	-0.3
0	140	-0.5	30	10	-0.4	50	30	0	70	50	0.4	90	70	1.2	110	90	-0.6	130	110	-0.2	150	130	0.6
10	0	0.5	30	20	10	50	40	0.3	70	60	0.7	90	80	0.7	110	100	0.7	130	120	-0.5	150	140	1
10	10	0.1	30	30	10	50	50	-0.1	70	70	0.6	90	90	1.3	110	110	-0.1	130	130	1.1	160	0	0.3

10	20	-0.6	30	40	-1.9	50	60	-0.5	70	80	0.9	90	100	1.3	110	120	0.1	130	140	0.9	160	10	0.4
10	30	-2.8	30	50	-1.2	50	70	0.1	70	90	0.6	90	110	-0.2	110	130	0.6	140	0	-0.1	160	20	0.2
10	40	-0.9	30	60	-0.5	50	80	0	70	100	0.3	90	120	0.5	110	140	0.7	140	10	0.3	160	30	-0.1
10	50	0	30	70	-0.3	50	90	0.1	70	110	0.7	90	130	0	120	0	0.1	140	20	0.5	160	40	1.3
10	60	-0.5	30	80	0.3	50	100	0	70	120	0.6	90	140	0.9	120	10	0.3	140	30	0.3	160	50	0.7
10	70	-0.5	30	90	0.8	50	110	0.3	70	130	0.8	100	0	1.2	120	20	0	140	40	1.2	160	60	0
10	80	0.3	30	100	0.7	50	120	0.5	70	140	0.8	100	10	0.7	120	30	-0.1	140	50	0.3	160	70	1.2
10	90	0.9	30	110	0.1	50	130	0.3	80	0	0.8	100	20	0.8	120	40	0.7	140	60	0.2	160	80	0.7
10	100	0.4	30	120	-0.2	50	140	0.7	80	10	1.1	100	30	0.7	120	50	0.9	140	70	0.2	160	90	0.4
10	110	1.1	30	130	-0.3	60	0	10	80	20	0.7	100	40	0.9	120	60	-0.3	140	80	0.1	160	100	0.7
10	120	0.7	30	140	0.5	60	10	0.5	80	30	0.4	100	50	1.2	120	70	-0.1	140	90	0.4	160	110	-0.5
10	130	-0.5	40	0	-0.2	60	20	0.4	80	40	0.8	100	60	0.7	120	80	0.3	140	100	0.5	160	120	-0.1
10	140	-1	40	10	10	60	30	0	80	50	0.7	100	70	1.3	120	90	-0.4	140	110	-0.3	160	130	0.7
20	0	-0.2	40	20	10	60	40	0.3	80	60	1.2	100	80	0.5	120	100	0.8	140	120	-0.4	160	140	1
20	10	-0.3	40	30	-0.1	60	50	-0.1	80	70	0.4	100	90	0.7	120	110	0.2	140	130	0.9	140	140	0.8

Table A-5: Bed elevations of repelling spur at 0.20 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	0.5	20	20	-3	40	40	-1.5	40	40	-1.5	80	80	0.7	100	100	0	120	120	0.8	140	140	1.3
0	10	0.5	20	30	10	40	50	-1.5	40	50	-1.5	80	90	-0.7	100	110	0.5	120	130	0.7	150	0	0
0	20	0.5	20	40	-0.7	40	60	0	40	60	0	80	100	-0.7	100	120	0.5	120	140	0.8	150	10	0.1
0	30	0.9	20	50	1.4	40	70	0.1	40	70	0.1	80	110	0.7	100	130	0.7	130	0	-0.1	150	20	0.4
0	40	1.4	20	60	1	40	80	0.1	40	80	0.1	80	120	0.9	100	140	0.5	130	10	0.1	150	30	0
0	50	1.6	20	70	1.8	40	90	-0.4	40	90	-0.4	80	130	0.1	110	0	0.1	130	20	-0.1	150	40	-0.1
0	60	2	20	80	1.6	40	100	0	40	100	0	80	140	1	110	10	0	130	30	0	150	50	0.1
0	70	2.1	20	90	1.7	40	110	0.5	40	110	0.5	90	0	0	110	20	-0.2	130	40	-0.6	150	60	-0.1
0	80	1.9	20	100	1	40	120	0	40	120	0	90	10	-0.1	110	30	-0.1	130	50	0	150	70	-0.3
0	90	2.1	20	110	-0.3	40	130	0.2	40	130	0.2	90	20	0.2	110	40	0.3	130	60	-0.2	150	80	-0.1
0	100	1.2	20	120	0.5	40	140	-0.7	40	140	-0.7	90	30	-0.4	110	50	-0.2	130	70	-0.3	150	90	-0.2
0	110	1.2	20	130	0.1	50	0	10	50	0	10	90	40	-0.5	110	60	-0.5	130	80	-0.2	150	100	-0.4
0	120	1	20	140	-1.3	50	10	10	50	10	10	90	50	-1	110	70	-0.6	130	90	0.4	150	110	-0.2
0	130	-0.9	30	0	-0.7	50	20	-1	50	20	-1	90	60	0	110	80	-0.7	130	100	-0.3	150	120	0.6
0	140	-0.7	30	10	-0.4	50	30	-1.8	50	30	-1.8	90	70	0	110	90	-0.3	130	110	-0.2	150	130	0.8
10	0	-0.5	30	20	10	50	40	-0.6	50	40	-0.6	90	80	-1.1	110	100	-0.4	130	120	0.9	150	140	1.4
10	10	0.2	30	30	10	50	50	0.5	50	50	0.5	90	90	1.3	110	110	-0.3	130	130	0.8	160	0	0.2

10	20	0.1	30	40	-2	50	60	1.3	50	60	1.3	90	100	0.1	110	120	0.7	130	140	1.1	160	10	0.3
10	30	0.7	30	50	0.8	50	70	0.4	50	70	0.4	90	110	-0.6	110	130	0.8	140	0	0.1	160	20	0.3
10	40	1.1	30	60	0.6	50	80	0.2	50	80	0.2	90	120	0.9	110	140	1.1	140	10	0.3	160	30	0.1
10	50	1.4	30	70	1.2	50	90	-0.5	50	90	-0.5	90	130	0.2	120	0	0	140	20	0.3	160	40	0
10	60	1.4	30	80	2.1	50	100	1	50	100	1	90	140	0.7	120	10	-0.1	140	30	-0.1	160	50	-0.3
10	70	2	30	90	1.5	50	110	-0.8	50	110	-0.8	100	0	0	120	20	0	140	40	0.1	160	60	-0.2
10	80	2	30	100	0.4	50	120	0.5	50	120	0.5	100	10	0.1	120	30	-0.2	140	50	0.3	160	70	0.1
10	90	1.9	30	110	-0.1	50	130	0.1	50	130	0.1	100	20	-0.3	120	40	-0.5	140	60	-0.4	160	80	0.3
10	100	0.5	30	120	0.1	50	140	-0.8	50	140	-0.8	100	30	-0.5	120	50	-0.3	140	70	-0.1	160	90	0.2
10	110	0.9	30	130	0	60	0	10	60	0	10	100	40	0.5	120	60	-0.1	140	80	-0.1	160	100	0.4
10	120	0.5	30	140	-1.1	60	10	-0.3	60	10	-0.3	100	50	0.5	120	70	-0.3	140	90	0.5	160	110	-0.1
10	130	-0.8	40	0	-1	60	20	0	60	20	0	100	60	1.3	120	80	-0.3	140	100	-0.4	160	120	0.5
10	140	-1.3	40	10	10	60	30	-1	60	30	-1	100	70	-0.3	120	90	0.3	140	110	-0.3	160	130	0.9
20	0	-0.3	40	20	10	60	40	-0.7	60	40	-0.7	100	80	-1	120	100	-0.2	140	120	0.7	160	140	1.2
20	10	-0.5	40	30	-3.5	60	50	1	60	50	1	100	90	-0.3	120	110	0.1	140	130	0.7			

Table A-6: Bed elevations of repelling spur at 0.30 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z		X	Y	Z	X	Y	Z
0	0	-0.3	20	20	-3.5	40	40	-2.9	60	60	-1.1	80	80	-1	100	100	-0.9		120	120	-0.5	140	140	0.7
0	10	0.5	20	30	10	40	50	-0.9	60	70	0.5	80	90	0.3	100	110	-0.3		120	130	-0.6	150	0	-0.1
0	20	0.5	20	40	-1	40	60	0	60	80	-1.9	80	100	0.7	100	120	1.5		120	140	0.7	150	10	-0.2
0	30	1	20	50	1.1	40	70	-0.1	60	90	1.5	80	110	1.2	100	130	1.5		130	0	0	150	20	-0.1
0	40	1.1	20	60	1	40	80	0.9	60	100	0.3	80	120	1	100	140	0.5		130	10	0.1	150	30	0.2
0	50	1	20	70	1.6	40	90	2.5	60	110	-0.5	80	130	0.5	110	0	0.2		130	20	-0.3	150	40	0.4
0	60	1.1	20	80	1.9	40	100	-0.5	60	120	-0.6	80	140	0.9	110	10	0.3		130	30	-0.2	150	50	-1.1
0	70	0.8	20	90	0.5	40	110	1.3	60	130	-0.3	90	0	0.2	110	20	0		130	40	-0.1	150	60	-1.7
0	80	2.4	20	100	1.3	40	120	-0.8	60	140	-1.1	90	10	0.2	110	30	-0.1		130	50	-0.6	150	70	-1.2
0	90	2.7	20	110	0.1	40	130	-0.2	70	0	0.3	90	20	0.6	110	40	-0.2		130	60	-0.3	150	80	-1
0	100	0.7	20	120	1	40	140	-0.9	70	10	0.3	90	30	1	110	50	0.3		130	70	-0.4	150	90	-0.6
0	110	1.5	20	130	-0.9	50	0	10	70	20	0.4	90	40	0.5	110	60	0.4		130	80	-0.7	150	100	-0.2
0	120	0.7	20	140	-0.8	50	10	10	70	30	0.5	90	50	0.5	110	70	0.5		130	90	-0.5	150	110	-0.1
0	130	-0.3	30	0	-0.4	50	20	0.7	70	40	1.3	90	60	0.5	110	80	-0.3		130	100	-1.8	150	120	-0.4
0	140	-0.2	30	10	-0.6	50	30	1	70	50	2	90	70	0	110	90	-0.2		130	110	-1.6	150	130	-0.9
10	0	0.1	30	20	10	50	40	-1.1	70	60	1.5	90	80	-1	110	100	-0.6		130	120	-1.5	150	140	0.8
10	10	0.7	30	30	10	50	50	-0.5	70	70	0.3	90	90	1.3	110	110	-0.7		130	130	-2.5	160	0	0

10	20	0.3	30	40	-3.8	50	60	-0.9	70	80	-0.5	90	100	1.4	110	120	-0.3		130	140	0.8	160	10	0
10	30	1	30	50	-1.2	50	70	-1.1	70	90	-0.6	90	110	-0.2	110	130	-0.2		140	0	-0.3	160	20	-0.1
10	40	0.7	30	60	0.5	50	80	0.3	70	100	-0.5	90	120	1.2	110	140	0.4		140	10	-0.1	160	30	-0.2
10	50	0.3	30	70	1.4	50	90	1.7	70	110	-1	90	130	0.3	120	0	0.1		140	20	-0.2	160	40	-0.1
10	60	1.2	30	80	1.3	50	100	1.1	70	120	1.3	90	140	1.1	120	10	0.2		140	30	0.3	160	50	-1.2
10	70	1.6	30	90	1	50	110	0.1	70	130	-0.3	100	0	0.5	120	20	0.1		140	40	0.2	160	60	-1.8
10	80	1.8	30	100	-0.5	50	120	-0.1	70	140	0.7	100	10	0.4	120	30	-0.1		140	50	-0.7	160	70	-2.1
10	90	1.7	30	110	0.5	50	130	-0.2	80	0	0.3	100	20	0.5	120	40	0		140	60	-1.5	160	80	-1.8
10	100	1.5	30	120	0.9	50	140	-0.8	80	10	0.4	100	30	0.1	120	50	0.4		140	70	-1.3	160	90	-0.6
10	110	1.1	30	130	0.6	60	0	10	80	20	0.2	100	40	-0.1	120	60	-0.5		140	80	-1.6	160	100	-0.3
10	120	0.9	30	140	-1.1	60	10	0	80	30	0.7	100	50	1.7	120	70	-0.8		140	90	-1.3	160	110	-0.3
10	130	-0.5	40	0	-0.5	60	20	0.8	80	40	0.5	100	60	0.2	120	80	-0.6		140	100	-2	160	120	-0.4
10	140	-0.8	40	10	10	60	30	1.1	80	50	1.3	100	70	0.5	120	90	-0.4		140	110	-1.5	160	130	-0.8
20	0	0	40	20	10	60	40	0.1	80	60	0.9	100	80	0	120	100	-0.3		140	120	-1.4	160	140	0.7
20	10	0.8	40	30	1	60	50	-0.5	80	70	-0.5	100	90	0.3	120	110	-0.4		140	130	-1.2			

Table A-7: Bed elevations of attracting spur at 0.15 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z		X	Y	Z	X	Y	Z
0	0	-2	20	20	0.5	40	40	-0.5	60	60	0.7	80	80	0.9	100	100	-1.1		120	120	-1	140	140	0.2
0	10	0.2	20	30	0	40	50	0.5	60	70	0.5	80	90	0.8	100	110	0.3		120	130	-1.1	150	0	-0.6
0	20	1	20	40	-1.1	40	60	0.9	60	80	0	80	100	0.2	100	120	1		120	140	0.2	150	10	-0.7
0	30	1.3	20	50	-0.3	40	70	0.4	60	90	0	80	110	0	100	130	1.8		130	0	-0.5	150	20	-0.6
0	40	0.4	20	60	1	40	80	1.5	60	100	0.2	80	120	-0.4	100	140	1.1		130	10	-0.4	150	30	-0.3
0	50	-1.5	20	70	1.9	40	90	1.4	60	110	-0.2	80	130	-0.4	110	0	-0.3		130	20	-0.8	150	40	-0.1
0	60	1.2	20	80	2	40	100	1.6	60	120	1	80	140	0.2	110	10	-0.2		130	30	-0.7	150	50	-1.6
0	70	1.5	20	90	1	40	110	-0.2	60	130	-1	90	0	-0.2	110	20	-0.5		130	40	-0.6	150	60	-2.2
0	80	1.9	20	100	2.1	40	120	-0.5	60	140	1	90	10	-0.1	110	30	-0.6		130	50	-1.1	150	70	-1.7
0	90	1.5	20	110	2	40	130	-0.7	70	0	0.8	90	20	-0.4	110	40	-0.7		130	60	-0.8	150	80	-1.5
0	100	2.2	20	120	2	40	140	-1	70	10	0.2	90	30	0.9	110	50	-0.2		130	70	-0.9	150	90	-1.1
0	110	1.7	20	130	-0.1	50	0	10	70	20	10	90	40	0	110	60	-0.1		130	80	-1.2	150	100	-0.7
0	120	1.8	20	140	-1.5	50	10	10	70	30	10	90	50	-0.8	110	70	0		130	90	-1	150	110	-0.6
0	130	0.5	30	0	0	50	20	-1.1	70	40	-1.2	90	60	0.4	110	80	-0.8		130	100	-2.3	150	120	-0.9
0	140	-1.2	30	10	-0.1	50	30	-1.5	70	50	-1.5	90	70	0.7	110	90	-0.7		130	110	-2.1	150	130	-1.4
10	0	-1.5	30	20	-0.2	50	40	-1.5	70	60	-0.2	90	80	-1.3	110	100	-1.1		130	120	-2	150	140	0.3
10	10	-0.4	30	30	-0.2	50	50	-0.1	70	70	-0.5	90	90	1.3	110	110	-1.2		130	130	-3	160	0	-0.5

10	20	0	30	40	-0.3	50	60	-0.4	70	80	1	90	100	-0.7	110	120	-0.8		130	140	0.3	160	10	-0.5
10	30	0.4	30	50	0.3	50	70	0	70	90	-0.7	90	110	1	110	130	-0.7		140	0	-0.8	160	20	-0.6
10	40	0.2	30	60	0.8	50	80	1	70	100	-0.9	90	120	1.2	110	140	0.9		140	10	-0.6	160	30	-0.7
10	50	0.2	30	70	1.8	50	90	1.5	70	110	-0.3	90	130	1.5	120	0	-0.4		140	20	-0.7	160	40	-0.6
10	60	1	30	80	1.9	50	100	0.8	70	120	0.7	90	140	1.3	120	10	-0.3		140	30	-0.2	160	50	-1.7
10	70	2	30	90	1.9	50	110	0.3	70	130	-0.2	100	0	-0.2	120	20	-0.4		140	40	-0.3	160	60	-2.3
10	80	1.8	30	100	2.1	50	120	0.9	70	140	0.8	100	10	0	120	30	-0.6		140	50	-1.2	160	70	-2.6
10	90	1	30	110	1.8	50	130	-1	80	0	0	100	20	0.8	120	40	-0.5		140	60	-2	160	80	-2.3
10	100	2	30	120	1.5	50	140	-0.4	80	10	0	100	30	1.1	120	50	-0.1		140	70	-1.8	160	90	-1
10	110	2	30	130	0	60	0	1.2	80	20	-0.1	100	40	0.2	120	60	-1		140	80	-2.1	160	100	-0.8
10	120	1.6	30	140	-1.9	60	10	10	80	30	10	100	50	-0.2	120	70	-1.3		140	90	-1.8	160	110	-0.8
10	130	-0.6	40	0	10	60	20	10	80	40	0.8	100	60	1	120	80	-1.1		140	100	-2.5	160	120	-0.9
10	140	-1.5	40	10	-0.6	60	30	-2	80	50	-1.1	100	70	0.5	120	90	-0.9		140	110	-2	160	130	-1.3
20	0	-0.5	40	20	-0.6	60	40	-2	80	60	0.1	100	80	0.9	120	100	-0.8		140	120	-1.9	160	140	0.2
20	10	-0.2	40	30	-1.6	60	50	-1	80	70	-0.3	100	90	-0.6	120	110	-0.9		140	130	-1.7			

Table A-8: Bed elevations of attracting spur at 0.20 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	-1	20	20	1.2	40	40	0.8	60	60	-0.8	80	80	-1.1	100	100	-1.6	120	120	-0.9	140	140	0.2
0	10	0.2	20	30	1.5	40	50	0	60	70	0.7	80	90	-0.5	100	110	0.2	120	130	-0.6	150	0	-0.3
0	20	1.9	20	40	0.6	40	60	0.4	60	80	1.5	80	100	0.8	100	120	-0.9	120	140	0.5	150	10	-0.4
0	30	2.5	20	50	1.5	40	70	1	60	90	1.2	80	110	0.4	100	130	0	130	0	-0.2	150	20	-0.6
0	40	1.7	20	60	1	40	80	1.2	60	100	1.5	80	120	0.8	100	140	0	130	10	-0.2	150	30	-0.5
0	50	-0.4	20	70	1.4	40	90	1.8	60	110	0.4	80	130	-0.2	110	0	-0.4	130	20	-0.7	150	40	-0.4
0	60	1.5	20	80	1	40	100	1.4	60	120	1	80	140	0.2	110	10	-0.5	130	30	-2	150	50	-0.3
0	70	2	20	90	0.6	40	110	0	60	130	-1	90	0	0	110	20	-0.6	130	40	-2.6	150	60	-0.5
0	80	1.5	20	100	1.2	40	120	0.1	60	140	-0.9	90	10	-0.6	110	30	-3	130	50	-2.5	150	70	-1
0	90	1.1	20	110	-0.5	40	130	-2	70	0	-0.2	90	20	0.2	110	40	-2.5	130	60	-2.4	150	80	-0.6
0	100	1	20	120	1	40	140	-1.4	70	10	10	90	30	10	110	50	-3	130	70	-2.2	150	90	-0.5
0	110	1.8	20	130	-0.5	50	0	10	70	20	10	90	40	-0.1	110	60	-3.5	130	80	-2	150	100	-0.3
0	120	2.2	20	140	-1.6	50	10	-1.6	70	30	-4.2	90	50	-0.9	110	70	-2	130	90	-0.7	150	110	-0.4
0	130	0	30	0	0.3	50	20	-1.1	70	40	-3	90	60	0	110	80	-2.5	130	100	-0.6	150	120	-0.6
0	140	-0.9	30	10	-0.1	50	30	-1.1	70	50	-2	90	70	-0.5	110	90	-1.5	130	110	-0.9	150	130	0.2
10	0	-1.2	30	20	0	50	40	-0.1	70	60	-1	90	80	-1.9	110	100	-1	130	120	-0.6	150	140	0.1

10	10	0.4	30	30	0.8	50	50	-0.1	70	70	-0.2	90	90	1.9	110	110	-0.8	130	130	0.3	160	0	-0.6
10	20	1.5	30	40	1.1	50	60	0.6	70	80	0.8	90	100	1.3	110	120	-0.9	130	140	0.3	160	10	-0.5
10	30	1.9	30	50	0.1	50	70	-0.1	70	90	-0.2	90	110	1.1	110	130	-1	140	0	-0.6	160	20	-0.7
10	40	0.8	30	60	0.9	50	80	1.8	70	100	1.4	90	120	0.4	110	140	0.2	140	10	-0.3	160	30	-0.6
10	50	-0.6	30	70	0	50	90	2	70	110	-1.2	90	130	0.8	120	0	-0.3	140	20	-0.6	160	40	-0.3
10	60	1.9	30	80	0	50	100	1.3	70	120	-0.8	90	140	0.4	120	10	-0.6	140	30	-1.8	160	50	-0.2
10	70	1.5	30	90	2	50	110	1.4	70	130	0.2	100	0	-0.3	120	20	-0.7	140	40	-1.8	160	60	-0.5
10	80	1.8	30	100	1.5	50	120	-1	70	140	0	100	10	-0.7	120	30	-3.2	140	50	-1.7	160	70	0.1
10	90	0.9	30	110	1.8	50	130	0	80	0	-0.1	100	20	0	120	40	-3	140	60	-1.6	160	80	0.2
10	100	1.6	30	120	1	50	140	-1.2	80	10	-0.5	100	30	1	120	50	-2.5	140	70	-1.3	160	90	-0.6
10	110	1.3	30	130	-1	60	0	10	80	20	10	100	40	-2.5	120	60	-2.2	140	80	-0.7	160	100	-0.2
10	120	1.8	30	140	-1.7	60	10	10	80	30	10	100	50	-3	120	70	-3	140	90	-0.8	160	110	-0.3
10	130	-1	40	0	-0.9	60	20	-3	80	40	-1.5	100	60	-0.3	120	80	-2.8	140	100	-0.9	160	120	-0.1
10	140	-1.2	40	10	-0.9	60	30	-3.2	80	50	-1.8	100	70	0.2	120	90	-0.8	140	110	-0.8	160	130	0.1
20	0	-0.5	40	20	-0.1	60	40	-2.2	80	60	-0.3	100	80	1	120	100	-0.9	140	120	-0.7	160	140	0.4
20	10	0.5	40	30	0.5	60	50	-1.2	80	70	1	100	90	0.5	120	110	-0.6	140	130	0.3			

Table A-9: Bed elevations of attracting spur at 0.30 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z		X	Y	Z	X	Y	Z
0	0	-1	20	20	0.8	40	40	0.2	60	60	0	80	80	-0.2	100	100	-2.1		120	120	1.5	140	140	0.5
0	10	-0.2	20	30	1	40	50	-0.5	60	70	0.2	80	90	1.6	100	110	0		120	130	1.6	150	0	-0.1
0	20	0.4	20	40	1.2	40	60	1	60	80	1.6	80	100	-1	100	120	-0.1		120	140	0.5	150	10	-0.5
0	30	1.8	20	50	0.8	40	70	0.8	60	90	1	80	110	0	100	130	0.9		130	0	0.2	150	20	-0.6
0	40	1	20	60	1	40	80	1.2	60	100	1.6	80	120	0.5	100	140	-0.2		130	10	0.3	150	30	-0.4
0	50	1.2	20	70	1.8	40	90	-0.9	60	110	1	80	130	0.7	110	0	0.5		130	20	0.6	150	40	0.7
0	60	-0.2	20	80	-0.3	40	100	1.5	60	120	-0.8	80	140	0	110	10	0.4		130	30	0.3	150	50	0
0	70	0.2	20	90	-0.6	40	110	0.4	60	130	-0.8	90	0	0	110	20	0.6		130	40	-1.9	150	60	-1.1
0	80	1.5	20	100	-1.1	40	120	-1.7	60	140	-0.6	90	10	-0.1	110	30	0.7		130	50	-1.3	150	70	0.6
0	90	-0.1	20	110	-0.2	40	130	-0.8	70	0	0.2	90	20	-0.1	110	40	-1.6		130	60	0	150	80	1.8
0	100	-0.5	20	120	0.5	40	140	-0.2	70	10	0	90	30	0.5	110	50	-1.8		130	70	-0.3	150	90	-0.7
0	110	0	20	130	-2.2	50	0	0	70	20	0	90	40	-0.5	110	60	-0.3		130	80	1.5	150	100	-1.1
0	120	0	20	140	-2.3	50	10	0	70	30	0	90	50	-2.3	110	70	-0.8		130	90	2.1	150	110	0.9
0	130	-2.1	30	0	0.1	50	20	-2	70	40	-1.6	90	60	-2.2	110	80	-0.5		130	100	0	150	120	0.9
0	140	-2.1	30	10	0	50	30	-1.4	70	50	-1.5	90	70	-1	110	90	1.4		130	110	-0.5	150	130	0.7
10	0	-1.1	30	20	0.6	50	40	-1.2	70	60	-0.8	90	80	-0.3	110	100	1.4		130	120	0.5	150	140	1.5
10	10	-0.8	30	30	0.4	50	50	-1.3	70	70	-0.2	90	90	0	110	110	0		130	130	1	160	0	-0.8

10	20	0.9	30	40	0.5	50	60	0.7	70	80	-0.4	90	100	0.8	110	120	1.1		130	140	-0.1	160	10	-0.6
10	30	1.6	30	50	0.8	50	70	0.7	70	90	0	90	110	-0.2	110	130	1.4		140	0	0	160	20	-0.9
10	40	0.4	30	60	-0.2	50	80	1.8	70	100	1	90	120	-0.2	110	140	1.5		140	10	-0.3	160	30	-0.5
10	50	1.2	30	70	0.8	50	90	1.5	70	110	0.8	90	130	0	120	0	0.2		140	20	-0.1	160	40	0.4
10	60	0.2	30	80	0.6	50	100	1.5	70	120	0	90	140	-0.1	120	10	0.2		140	30	0.1	160	50	0.4
10	70	2.1	30	90	1.2	50	110	-0.5	70	130	-1.8	100	0	-0.2	120	20	0.5		140	40	-0.6	160	60	1
10	80	-0.2	30	100	1.1	50	120	-0.6	70	140	0.5	100	10	-0.3	120	30	0.4		140	50	-1.1	160	70	0.5
10	90	-2	30	110	-1.6	50	130	-0.6	80	0	-0.4	100	20	0.2	120	40	-1.7		140	60	2	160	80	-1
10	100	1.2	30	120	-0.7	50	140	-0.3	80	10	-0.5	100	30	0.9	120	50	-1.5		140	70	0.7	160	90	-1.1
10	110	-1.5	30	130	-0.5	60	0	0.9	80	20	0	100	40	-0.3	120	60	-0.2		140	80	-0.3	160	100	0.6
10	120	-0.8	30	140	-2.1	60	10	0	80	30	0	100	50	-1.8	120	70	-0.2		140	90	-0.4	160	110	0.5
10	130	-2.1	40	0	0	60	20	0	80	40	0	100	60	-2.4	120	80	-1.2		140	100	-0.6	160	120	0.3
10	140	-2.2	40	10	-2.2	60	30	-3.5	80	50	-2	100	70	-1.1	120	90	-1.1		140	110	1	160	130	0.2
20	0	-0.9	40	20	-0.4	60	40	-3	80	60	-2.1	100	80	0.2	120	100	1.1		140	120	1	160	140	1.4
20	10	-0.7	40	30	0.3	60	50	-0.8	80	70	-2	100	90	-2.1	120	110	0.5		140	130	0.8			

Table A-10: Bed elevations of three spur spacing at 0.15 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	-0.1	20	20	0.1	40	40	-0.1	60	60	-0.1	80	80	0.9	100	100	0.8	120	120	0.2	140	140	1
0	10	-0.1	20	30	0.1	40	50	0.5	60	70	0.6	80	90	0.9	100	110	0.7	120	130	0.4	150	0	0
0	20	0.4	20	40	0.1	40	60	0.5	60	80	0.7	80	100	1	100	120	0.3	120	140	0.8	150	10	0.1
0	30	0.3	20	50	0.2	40	70	0.7	60	90	0.9	80	110	0.5	100	130	0.5	130	0	0	150	20	0.3
0	40	0.2	20	60	0.5	40	80	0.8	60	100	1.6	80	120	0.1	100	140	1.5	130	10	-0.8	150	30	0.1
0	50	0.5	20	70	0.2	40	90	1.1	60	110	1.2	80	130	0.9	110	0	-0.2	130	20	-0.7	150	40	0.8
0	60	1.1	20	80	1.3	40	100	1.3	60	120	0.6	80	140	1.2	110	10	-1	130	30	-0.8	150	50	0.9
0	70	1.2	20	90	0.9	40	110	1.4	60	130	0.8	90	0	0.1	110	20	-0.9	130	40	0	150	60	1.1
0	80	1	20	100	1.4	40	120	1.1	60	140	1.4	90	10	-0.6	110	30	-0.9	130	50	0.4	150	70	1
0	90	1.5	20	110	1.2	40	130	0.9	70	0	0	90	20	-0.5	110	40	0.2	130	60	-0.6	150	80	1.4
0	100	1.5	20	120	1.5	40	140	1.1	70	10	0	90	30	0.3	110	50	0	130	70	0.5	150	90	1.1
0	110	1.4	20	130	0.9	50	0	-0.4	70	20	0	90	40	0	110	60	0.7	130	80	0.4	150	100	0.3
0	120	0.8	20	140	1.1	50	10	-0.6	70	30	0	90	50	-0.1	110	70	0.3	130	90	0.2	150	110	0.5
0	130	0.8	30	0	0.3	50	20	1.1	70	40	-1.1	90	60	0.7	110	80	0.1	130	100	0.7	150	120	0.6
0	140	1	30	10	0.4	50	30	0.2	70	50	-0.5	90	70	0.9	110	90	0.2	130	110	1	150	130	0.3
10	0	0	30	20	0.7	50	40	-0.1	70	60	0.4	90	80	0.3	110	100	1.5	130	120	-0.1	150	140	1.1

10	10	-0.5	30	30	0.4	50	50	0.1	70	70	0.5	90	90	1.1	110	110	1.5	130	130	0.2	160	0	0.3
10	20	0.1	30	40	0.3	50	60	0.3	70	80	0.6	90	100	0.6	110	120	0.6	130	140	1.1	160	10	-0.1
10	30	-0.4	30	50	0.1	50	70	1.1	70	90	1	90	110	0.3	110	130	0	140	0	-0.1	160	20	0.4
10	40	0.1	30	60	0.5	50	80	1	70	100	0.7	90	120	-0.1	110	140	1.2	140	10	0.2	160	30	0.2
10	50	0.4	30	70	0.9	50	90	0.8	70	110	0.8	90	130	0.7	120	0	-0.3	140	20	0.1	160	40	0.9
10	60	0.1	30	80	1	50	100	0.9	70	120	1	90	140	1.4	120	10	-0.8	140	30	0.4	160	50	1.3
10	70	0.1	30	90	1.3	50	110	1.1	70	130	0.5	100	0	-0.5	120	20	-0.8	140	40	0.2	160	60	1.2
10	80	1.1	30	100	1.5	50	120	0.5	70	140	1	100	10	-0.9	120	30	-0.7	140	50	0.5	160	70	1.6
10	90	1.1	30	110	1.6	50	130	1.6	80	0	0	100	20	-0.7	120	40	0.1	140	60	0.8	160	80	1.5
10	100	1.3	30	120	1	50	140	1.5	80	10	0	100	30	0	120	50	0.7	140	70	1.2	160	90	1.3
10	110	1	30	130	1	60	0	0.5	80	20	0	100	40	-0.2	120	60	-0.5	140	80	0.9	160	100	1.4
10	120	0.7	30	140	1	60	10	-0.3	80	30	0	100	50	0.6	120	70	-0.1	140	90	1.7	160	110	0.4
10	130	0.3	40	0	-0.2	60	20	0.1	80	40	-0.7	100	60	0.6	120	80	0.5	140	100	1.5	160	120	0.5
10	140	1.5	40	10	0	60	30	-0.9	80	50	-0.4	100	70	1	120	90	1	140	110	0.7	160	130	1
20	0	0.1	40	20	0.4	60	40	-1	80	60	-0.1	100	80	1	120	100	0.9	140	120	0.9	160	140	1.7
20	10	0.3	40	30	0	60	50	0.7	80	70	0.7	100	90	0.7	120	110	1.2	140	130	0.5	170	0	1
170	10	0	190	30	0	210	50	1.3	230	70	2.3	250	90	1.4	270	110	2.4	290	130	2.3	330	0	1.9
170	20	0.5	190	40	0.7	210	60	1.5	230	80	1.5	250	100	1.1	270	120	2	290	140	2.4	330	10	2.1

170	30	0.9	190	50	-0.2	210	70	2	230	90	2.6	250	110	1.3	270	130	1.9	300	0	2.5	330	20	1.9
170	40	0.6	190	60	0.2	210	80	2.5	230	100	2.7	250	120	2.3	270	140	1.4	300	10	2.6	330	30	2.1
170	50	1.2	190	70	1.2	210	90	2.5	230	110	2.9	250	130	2.1	280	0	0	300	20	2.7	330	40	0.3
170	60	1	190	80	0	210	100	2.6	230	120	2.5	250	140	1.5	280	10	0	300	30	2.5	330	50	-0.9
170	70	1.3	190	90	0.9	210	110	2.5	230	130	2.3	260	0	0.5	280	20	0	300	40	-0.3	330	60	-0.6
170	80	0.7	190	100	-0.5	210	120	1.8	230	140	2.1	260	10	0.1	280	30	0	300	50	-0.7	330	70	0.2
170	90	0.4	190	110	-0.2	210	130	2.1	240	0	1.3	260	20	0.2	280	40	-0.6	300	60	-0.3	330	80	0.3
170	100	1.3	190	120	1.5	210	140	2.3	240	10	0.5	260	30	0.4	280	50	-1.5	300	70	0	330	90	0.5
170	110	1.2	190	130	1.3	220	0	0.6	240	20	0.7	260	40	0.4	280	60	-0.8	300	80	0.7	330	100	0.6
170	120	0.7	190	140	1.7	220	10	0.5	240	30	1.3	260	50	0.5	280	70	1.5	300	90	1.4	330	110	0.8
170	130	1.5	200	0	1.4	220	20	1.1	240	40	0.8	260	60	1.4	280	80	1.1	300	100	1.6	330	120	0.9
170	140	2.1	200	10	0.8	220	30	0.9	240	50	1.6	260	70	0.8	280	90	2.6	300	110	2.2	330	130	1.2
180	0	0	200	20	0.7	220	40	0.5	240	60	1.7	260	80	1.4	280	100	2.4	300	120	1.5	330	140	1.4
180	10	0	200	30	0.8	220	50	1	240	70	2.2	260	90	1.3	280	110	1.9	300	130	1.7			
180	20	0	200	40	0.5	220	60	1.7	240	80	1.7	260	100	1.6	280	120	1.9	300	140	2.3			
180	30	0	200	50	-0.6	220	70	2.1	240	90	1.6	260	110	2.5	280	130	2.6	320	0	2.1			
180	40	0.3	200	60	-0.1	220	80	2.4	240	100	2.3	260	120	2.5	280	140	2.5	320	10	2.2			
180	50	0.8	200	70	1.2	220	90	2.6	240	110	1.9	260	130	2.3	290	0	0	320	20	2.3			

180	60	0.3	200	80	0.7	220	100	1.9	240	120	2.2	260	140	1.3	290	10	0	320	30	2.4			
180	70	1.5	200	90	1.5	220	110	2.4	240	130	2.1	270	0	2.5	290	20	0	320	40	0.5			
180	80	1.3	200	100	1.2	220	120	2.1	240	140	1.9	270	10	1.5	290	30	0	320	50	-0.6			
180	90	0.9	200	110	-0.3	220	130	2.2	250	0	1.1	270	20	1.3	290	40	-0.7	320	60	-0.5			
180	100	0.7	200	120	1	220	140	2.4	250	10	0.3	270	30	1.1	290	50	-0.6	320	70	0.4			
180	110	1.2	200	130	0.9	230	0	1.7	250	20	0.4	270	40	0.3	290	60	-0.4	320	80	0.5			
180	120	0.5	200	140	1.7	230	10	0.7	250	30	0.1	270	50	0.2	290	70	1.3	320	90	1.3			
180	130	0.9	210	0	0.7	230	20	1	250	40	0.5	270	60	1	290	80	1.2	320	100	1.5			
180	140	2.2	210	10	0.1	230	30	1.2	250	50	1.2	270	70	0.4	290	90	1	320	110	1.4			
190	0	0	210	20	0.9	230	40	0.9	250	60	1.5	270	80	1.1	290	100	1.4	320	120	1.1			
190	10	0	210	30	1	230	50	1.5	250	70	0.7	270	90	0.8	290	110	2.3	320	130	1.5			
190	20	0	210	40	0.2	230	60	1.5	250	80	2.1	270	100	1.1	290	120	1.6	320	140	2.2			

Table A-11: Bed elevations of three spur spacing at 0.20 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	-1.5	20	20	0.5	40	40	-0.5	60	60	-0.6	80	80	0.3	100	100	-0.5	120	120	1.2	140	140	2.5
0	10	-0.6	20	30	-0.3	40	50	-0.5	60	70	-0.1	80	90	0.5	100	110	0.5	120	130	1.3	150	0	2
0	20	1	20	40	1	40	60	-0.3	60	80	1	80	100	-0.6	100	120	1.5	120	140	1.4	150	10	1
0	30	2	20	50	1.3	40	70	1	60	90	2.5	80	110	-1.5	100	130	1.5	130	0	0.2	150	20	0.6
0	40	1.5	20	60	1	40	80	1	60	100	2.1	80	120	1.3	100	140	1.2	130	10	0.1	150	30	-0.9
0	50	0.5	20	70	2.5	40	90	1	60	110	0.5	80	130	-0.5	110	0	-0.3	130	20	0.4	150	40	-0.1
0	60	1.4	20	80	3.5	40	100	0.9	60	120	1.9	80	140	1.4	110	10	0	130	30	1.2	150	50	1.1
0	70	2.8	20	90	1.5	40	110	1.5	60	130	0.9	90	0	-0.1	110	20	-0.2	130	40	1.5	150	60	0
0	80	3.5	20	100	2.5	40	120	1	60	140	1.1	90	10	-0.8	110	30	0.4	130	50	0.1	150	70	0.8
0	90	3	20	110	1.1	40	130	0.7	70	0	0	90	20	-0.5	110	40	-0.4	130	60	1.5	150	80	1.3
0	100	1.1	20	120	0.5	40	140	0.5	70	10	0	90	30	-0.2	110	50	-0.5	130	70	0.5	150	90	1
0	110	2	20	130	0.5	50	0	2.5	70	20	0	90	40	-1.5	110	60	-0.1	130	80	0.4	150	100	1.6
0	120	1.9	20	140	-0.8	50	10	-1.5	70	30	0	90	50	-1.4	110	70	1.4	130	90	0.7	150	110	-0.1
0	130	0.5	30	0	0.3	50	20	-0.6	70	40	-1.6	90	60	0.5	110	80	1.4	130	100	-0.5	150	120	2
0	140	-0.6	30	10	-0.1	50	30	-1.5	70	50	-0.5	90	70	0	110	90	1	130	110	0.5	150	130	2.4
10	0	-1	30	20	1	50	40	-1.5	70	60	0.1	90	80	1	110	100	-1	130	120	0.5	150	140	2.9

10	10	0.1	30	30	-0.1	50	50	-1.3	70	70	0	90	90	0	110	110	0	130	130	0.9	160	0	0
10	20	0	30	40	0.5	50	60	-0.5	70	80	-0.1	90	100	1	110	120	1.3	130	140	2	160	10	0
10	30	0.5	30	50	0.1	50	70	1.1	70	90	0	90	110	-1.1	110	130	2.5	140	0	0.8	160	20	0
10	40	1	30	60	0	50	80	0.5	70	100	0.5	90	120	1.4	110	140	1.6	140	10	0.9	160	30	0
10	50	1.9	30	70	1.5	50	90	1.3	70	110	1.5	90	130	0.7	120	0	-0.2	140	20	1.3	160	40	0
10	60	2.6	30	80	2.5	50	100	2.5	70	120	0.3	90	140	1.5	120	10	0.4	140	30	0.5	160	50	1.2
10	70	3	30	90	4.1	50	110	2.3	70	130	0.5	100	0	-0.5	120	20	0.5	140	40	2.5	160	60	1.5
10	80	2.9	30	100	3.5	50	120	1.3	70	140	0.5	100	10	-0.9	120	30	1	140	50	1.5	160	70	1.5
10	90	2	30	110	1.3	50	130	0.8	80	0	0.5	100	20	0	120	40	0.4	140	60	1.2	160	80	1.5
10	100	2.1	30	120	2	50	140	0.3	80	10	-0.6	100	30	0.3	120	50	-0.7	140	70	1.3	160	90	0.9
10	110	1.9	30	130	1.5	60	0	0	80	20	-0.9	100	40	-1	120	60	1	140	80	1	160	100	0.5
10	120	1.6	30	140	1	60	10	0	80	30	0	100	50	-0.7	120	70	0.5	140	90	1.4	160	110	1.2
10	130	0.1	40	0	-0.7	60	20	0	80	40	-1.3	100	60	0.4	120	80	0.1	140	100	1.8	160	120	0.7
10	140	-0.5	40	10	0.1	60	30	0	80	50	-1.5	100	70	-0.4	120	90	1.3	140	110	0.9	160	130	2.5
20	0	-0.7	40	20	0.5	60	40	-1	80	60	-0.3	100	80	-0.5	120	100	0.1	140	120	1.1	160	140	1.5
20	10	0.3	40	30	-0.5	60	50	-0.9	80	70	-2	100	90	-1.5	120	110	-0.2	140	130	2.6	170	0	0
170	10	0	190	30	0.5	210	50	-0.5	230	70	2	250	90	1.6	270	110	5.1	290	130	1.5	330	0	1.7
170	20	0	190	40	0.4	210	60	0.6	230	80	2	250	100	2.7	270	120	5.1	290	140	-0.3	330	10	1.3

170	30	0	190	50	0.3	210	70	0.5	230	90	1.6	250	110	4.1	270	130	3.5	300	0	2	330	20	2.1
170	40	-0.3	190	60	0.6	210	80	0.2	230	100	1.6	250	120	1.4	270	140	2.5	300	10	0.9	330	30	0.6
170	50	0.5	190	70	0.3	210	90	1.5	230	110	3.7	250	130	1.2	280	0	2.5	300	20	1.6	330	40	-0.6
170	60	1.3	190	80	1	210	100	1.4	230	120	4.1	250	140	1.7	280	10	2.1	300	30	0.6	330	50	-1.5
170	70	1.5	190	90	1.5	210	110	1.4	230	130	3.7	260	0	0	280	20	2.3	300	40	-0.8	330	60	0.9
170	80	1.1	190	100	2.2	210	120	1.5	230	140	4.3	260	10	0	280	30	0.5	300	50	-0.4	330	70	0.5
170	90	0.2	190	110	2.1	210	130	3.5	240	0	0.8	260	20	0	280	40	-0.1	300	60	0.3	330	80	1.5
170	100	0.3	190	120	2	210	140	4	240	10	1.5	260	30	0	280	50	-0.5	300	70	0.7	330	90	1.4
170	110	1.5	190	130	1.5	220	0	1.3	240	20	1.1	260	40	0	280	60	1.2	300	80	2	330	100	1
170	120	2.5	190	140	3.5	220	10	1.1	240	30	0.3	260	50	0.5	280	70	1	300	90	2.4	330	110	0.5
170	130	2	200	0	3.5	220	20	1.5	240	40	0	260	60	1.5	280	80	0.5	300	100	1.5	330	120	0.4
170	140	2.5	200	10	0.5	220	30	1.1	240	50	1	260	70	1.9	280	90	1.3	300	110	4.9	330	130	-0.4
180	0	2	200	20	1.5	220	40	0.3	240	60	1.3	260	80	1.1	280	100	1.8	300	120	3.5	330	140	-0.5
180	10	0	200	30	0	220	50	1.2	240	70	1.5	260	90	1.2	280	110	3	300	130	0.1			
180	20	0.7	200	40	-0.5	220	60	1.5	240	80	1.4	260	100	2.5	280	120	2.9	300	140	-0.1			
180	30	1.1	200	50	0.8	220	70	1.6	240	90	1.2	260	110	2.9	280	130	2.6	320	0	1.5			
180	40	0.5	200	60	0.4	220	80	2.3	240	100	1.3	260	120	4.1	280	140	2.5	320	10	1.4			
180	50	0.9	200	70	-0.1	220	90	1.7	240	110	3.5	260	130	3.6	290	0	1.6	320	20	1.7			

180	60	1.2	200	80	0.1	220	100	1.8	240	120	3.5	260	140	2.3	290	10	1.5	320	30	0.5			
180	70	1	200	90	1.2	220	110	3	240	130	3.1	270	0	0	290	20	1	320	40	0			
180	80	1.2	200	100	1	220	120	3	240	140	2.5	270	10	0	290	30	0.9	320	50	-1.1			
180	90	0.1	200	110	1	220	130	2.8	250	0	1.5	270	20	0	290	40	-0.5	320	60	0.4			
180	100	1.2	200	120	2.5	220	140	3.5	250	10	1.3	270	30	0	290	50	-0.2	320	70	1			
180	110	2.3	200	130	3	230	0	1	250	20	-0.4	270	40	-0.3	290	60	1	320	80	2.2			
180	120	2.7	200	140	3.5	230	10	1.4	250	30	-1	270	50	0.1	290	70	0.8	320	90	2			
180	130	2	210	0	2.6	230	20	1.6	250	40	0.2	270	60	0.9	290	80	1.1	320	100	2.5			
180	140	2.7	210	10	1	230	30	0.9	250	50	0.8	270	70	1.5	290	90	2.5	320	110	1.3			
190	0	1.5	210	20	1.4	230	40	-0.5	250	60	1	270	80	0.8	290	100	2.3	320	120	0			
190	10	0.4	210	30	0.3	230	50	1.1	250	70	1.7	270	90	2.3	290	110	3	320	130	-0.2			
190	20	1.3	210	40	-0.6	230	60	1.1	250	80	1.3	270	100	2.5	290	120	3.7	320	140	-0.3			

Table A-12: Bed elevations of three spur spacing at 0.30 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	-0.1	20	20	0.2	40	40	0.2	60	60	-0.3	80	80	1.1	100	100	0.8	120	120	0.4	140	140	1.1
0	10	-0.1	20	30	-0.1	40	50	0.4	60	70	0.5	80	90	0.9	100	110	0.9	120	130	0.3	150	0	0.2
0	20	0.4	20	40	0	40	60	0.3	60	80	0.9	80	100	0.8	100	120	0.4	120	140	0.8	150	10	0.4
0	30	0.3	20	50	-0.1	40	70	0.8	60	90	1.1	80	110	0.4	100	130	0.2	130	0	0.2	150	20	0.1
0	40	0.2	20	60	0.4	40	80	0.6	60	100	1.5	80	120	0.3	100	140	1.1	130	10	-0.9	150	30	0.3
0	50	0.5	20	70	0.3	40	90	0.9	60	110	0.9	80	130	1.1	110	0	-0.1	130	20	-0.6	150	40	0.7
0	60	0.1	20	80	1.2	40	100	1.4	60	120	0.8	80	140	0.9	110	10	-0.8	130	30	-0.6	150	50	1.1
0	70	1.1	20	90	0.7	40	110	1.2	60	130	0.6	90	0	0.2	110	20	-0.8	130	40	-0.2	150	60	1.2
0	80	0.8	20	100	1.4	40	120	1.2	60	140	1.5	90	10	-0.7	110	30	-0.7	130	50	0.4	150	70	0.8
0	90	0.9	20	110	1.3	40	130	0.7	70	0	10	90	20	-0.6	110	40	-0.1	130	60	-0.7	150	80	1.5
0	100	1.4	20	120	1.4	40	140	0.9	70	10	10	90	30	0.2	110	50	-0.2	130	70	0.3	150	90	1.3
0	110	1.3	20	130	1	50	0	-0.5	70	20	10	90	40	0.2	110	60	0.9	130	80	0.2	150	100	0.4
0	120	1.2	20	140	1.3	50	10	-0.7	70	30	10	90	50	0.1	110	70	0.2	130	90	0.3	150	110	0.3
0	130	0.9	30	0	0	50	20	-0.1	70	40	-1.3	90	60	0.6	110	80	0.1	130	100	0.6	150	120	0.5
0	140	0.8	30	10	0.2	50	30	0.4	70	50	-0.7	90	70	0.8	110	90	0.4	130	110	1.1	150	130	0.5
10	0	0.1	30	20	0.6	50	40	0.1	70	60	0.2	90	80	0.4	110	100	1.3	130	120	-0.2	150	140	1.3

10	10	-0.6	30	30	0.2	50	50	0.2	70	70	0.4	90	90	0.9	110	110	1.4	130	130	0.4	160	0	0.3
10	20	0.2	30	40	0.4	50	60	0.4	70	80	0.6	90	100	0.7	110	120	0.7	130	140	1.3	160	10	0.1
10	30	-0.3	30	50	0	50	70	-0.1	70	90	0.9	90	110	0.3	110	130	0.2	140	0	0.1	160	20	0.5
10	40	0	30	60	0.4	50	80	1.1	70	100	0.6	90	120	-0.3	110	140	1	140	10	0.4	160	30	0
10	50	0.2	30	70	1	50	90	0.7	70	110	0.5	90	130	0.6	120	0	-0.4	140	20	0.2	160	40	0.7
10	60	-0.1	30	80	0.9	50	100	1.1	70	120	1.3	90	140	1.5	120	10	-0.6	140	30	0.5	160	50	1.5
10	70	0.3	30	90	1.2	50	110	1.1	70	130	0.4	100	0	-0.5	120	20	-0.7	140	40	0.1	160	60	1.2
10	80	1.3	30	100	1.4	50	120	0.3	70	140	0.8	100	10	-1.1	120	30	-0.6	140	50	0.3	160	70	1.6
10	90	1.2	30	110	-0.3	50	130	1.7	80	0	10	100	20	-0.7	120	40	-0.1	140	60	0.6	160	80	1.4
10	100	1.1	30	120	0.8	50	140	1.4	80	10	10	100	30	0	120	50	1.1	140	70	1.2	160	90	1.1
10	110	1.3	30	130	1.2	60	0	-0.4	80	20	10	100	40	-0.2	120	60	-0.5	140	80	1	160	100	1.5
10	120	0.8	30	140	0.9	60	10	-0.5	80	30	10	100	50	0.5	120	70	-0.2	140	90	1.6	160	110	0.5
10	130	0.3	40	0	-0.2	60	20	-0.2	80	40	-0.8	100	60	0.4	120	80	0.3	140	100	1.3	160	120	0.2
10	140	1.3	40	10	0.1	60	30	-1.1	80	50	0.2	100	70	1.1	120	90	0.9	140	110	0.5	160	130	0.8
20	0	0.1	40	20	0.2	60	40	-1.2	80	60	0.1	100	80	1.2	120	100	1.1	140	120	0.8	160	140	1.9
20	10	0.4	40	30	0.2	60	50	0.6	80	70	0.6	100	90	0.6	120	110	1.3	140	130	0.5	170	0	1
170	10	0.2	190	30	0.9	210	50	-0.2	230	70	2.3	250	90	1.5	270	110	2.3	290	130	2.5	330	0	0.1
170	20	0.4	190	40	0.9	210	60	-0.3	230	80	2.5	250	100	2.4	270	120	2.1	290	140	2.1	330	10	2.3

170	30	1.1	190	50	0	210	70	0.1	230	90	2.5	250	110	2	270	130	2.5	300	0	2.5	330	20	2.5
170	40	0.5	190	60	0.4	210	80	0.5	230	100	2.1	250	120	2.4	270	140	1.5	300	10	1.2	330	30	2.4
170	50	1.4	190	70	1	210	90	0.9	230	110	2.3	250	130	2.3	280	0	10	300	20	1.5	330	40	0.4
170	60	1.2	190	80	-0.2	210	100	1.1	230	120	1.9	250	140	2.1	280	10	10	300	30	0.9	330	50	-0.8
170	70	1.5	190	90	0.9	210	110	0.3	230	130	2.4	260	0	1.2	280	20	10	300	40	0.1	330	60	-1
170	80	0.7	190	100	-0.7	210	120	1.4	230	140	2.2	260	10	0.3	280	30	10	300	50	0.4	330	70	0.3
170	90	0.5	190	110	-0.4	210	130	1.2	240	0	1.9	260	20	0.4	280	40	-0.9	300	60	0.8	330	80	0
170	100	1.1	190	120	1.2	210	140	1.7	240	10	0.5	260	30	0.2	280	50	-1.6	300	70	0.2	330	90	1.1
170	110	1	190	130	1.4	220	0	0.9	240	20	1.2	260	40	0.4	280	60	-1	300	80	1.3	330	100	1.2
170	120	0.6	190	140	1.9	220	10	0.2	240	30	1	260	50	1	280	70	1.5	300	90	0.6	330	110	1.2
170	130	1.4	200	0	1.4	220	20	0.7	240	40	0.9	260	60	1.3	280	80	0.9	300	100	1.3	330	120	0.9
170	140	2.1	200	10	1	220	30	1.2	240	50	1.4	260	70	0.9	280	90	0.8	300	110	2.2	330	130	1.2
180	0	1.1	200	20	1	220	40	0	240	60	1.2	260	80	2.2	280	100	2.2	300	120	1.8	330	140	2.5
180	10	0.2	200	30	0.6	220	50	1.3	240	70	2.1	260	90	1.5	280	110	1.9	300	130	1.7			
180	20	0.4	200	40	0.4	220	60	1.4	240	80	1.3	260	100	1	280	120	2.1	300	140	1.2			
180	30	0	200	50	-0.8	220	70	2.2	240	90	2.5	260	110	1.2	280	130	2.7	320	0	2.4			
180	40	0.4	200	60	-0.4	220	80	2.4	240	100	2.4	260	120	2.2	280	140	2.3	320	10	1.8			
180	50	0.9	200	70	1.4	220	90	2.3	240	110	3.1	260	130	2	290	0	10	320	20	2.9			

180	60	0.1	200	80	0.6	220	100	2.7	240	120	2.4	260	140	1.3	290	10	10	320	30	2.3			
180	70	1.3	200	90	1.3	220	110	2.4	240	130	2.2	270	0	0.3	290	20	10	320	40	-0.4			
180	80	1.1	200	100	1.4	220	120	2	240	140	2.1	270	10	-0.1	290	30	10	320	50	-0.9			
180	90	1.3	200	110	-0.1	220	130	1.8	250	0	1.3	270	20	0.2	290	40	-0.9	320	60	-0.3			
180	100	0.9	200	120	1.2	220	140	2.1	250	10	0.5	270	30	0.4	290	50	-0.7	320	70	0.2			
180	110	1.4	200	130	1.1	230	0	0.9	250	20	0.7	270	40	0.2	290	60	-0.1	320	80	0.6			
180	120	0.5	200	140	1.9	230	10	0.4	250	30	1.4	270	50	0.3	290	70	1.5	320	90	1.1			
180	130	1.1	210	0	1.3	230	20	1.3	250	40	1.1	270	60	1.2	290	80	1	320	100	1.9			
180	140	2.1	210	10	1.1	230	30	1.1	250	50	1.7	270	70	0.6	290	90	0.8	320	110	2			
190	0	1	210	20	1.2	230	40	0.3	250	60	1.9	270	80	1.2	290	100	1.5	320	120	1.3			
190	10	-0.1	210	30	0.6	230	50	1.2	250	70	2	270	90	1.5	290	110	2.1	320	130	1.9			
190	20	0.7	210	40	0.2	230	60	1.6	250	80	1.9	270	100	1.8	290	120	1.9	320	140	1.9			

Table A-13: Bed elevations of two spur spacing at 0.15 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	-0.6	20	20	0.5	40	40	0.8	60	60	-0.8	80	80	-0.3	100	100	-0.5	120	120	1.3	140	140	1.8
0	10	0	20	30	1	40	50	0.5	60	70	0.9	80	90	0.2	100	110	0.1	120	130	1.3	150	0	0
0	20	1	20	40	-0.1	40	60	0.4	60	80	1.5	80	100	2.2	100	120	0.6	120	140	1.2	150	10	-0.3
0	30	1.1	20	50	0.5	40	70	0.2	60	90	1.6	80	110	0.4	100	130	1.5	130	0	-0.4	150	20	0.2
0	40	1.6	20	60	0.3	40	80	1	60	100	1	80	120	1.5	100	140	1.3	130	10	-0.3	150	30	0.6
0	50	1.2	20	70	0.8	40	90	0	60	110	0.9	80	130	1	110	0	0.2	130	20	0	150	40	1.1
0	60	2.4	20	80	1.6	40	100	1.3	60	120	0.5	80	140	1.5	110	10	0.3	130	30	-0.4	150	50	0.7
0	70	2.5	20	90	1.8	40	110	1.8	60	130	1.3	90	0	-0.6	110	20	0.5	130	40	-0.2	150	60	0.9
0	80	2.7	20	100	3.3	40	120	1.1	60	140	1.5	90	10	-0.5	110	30	-0.3	130	50	-0.1	150	70	1.2
0	90	2	20	110	1.5	40	130	1.7	70	0	10	90	20	-0.1	110	40	0	130	60	0.9	150	80	1.5
0	100	2.5	20	120	1.5	40	140	1.1	70	10	10	90	30	0.5	110	50	0.2	130	70	0	150	90	1
0	110	2.6	20	130	0.8	50	0	-0.2	70	20	10	90	40	-0.6	110	60	0.3	130	80	0.3	150	100	0.8
0	120	2.2	20	140	1.2	50	10	-0.5	70	30	10	90	50	-0.1	110	70	-0.2	130	90	1.5	150	110	2.3
0	130	-0.7	30	0	-0.1	50	20	-0.6	70	40	-1.5	90	60	0.5	110	80	0.9	130	100	1.6	150	120	1.2
0	140	0.9	30	10	0.5	50	30	0.5	70	50	-0.2	90	70	0.1	110	90	0	130	110	1.3	150	130	1.1
10	0	-1.4	30	20	0.2	50	40	0.4	70	60	1.3	90	80	-0.1	110	100	1.8	130	120	1	150	140	1.2

10	10	0.2	30	30	0.3	50	50	0.9	70	70	0.3	90	90	1.2	110	110	1.3	130	130	0	160	0	1.1
10	20	1.2	30	40	-0.2	50	60	-0.1	70	80	0.5	90	100	1.4	110	120	1.2	130	140	1.8	160	10	-0.1
10	30	0.7	30	50	-0.3	50	70	1	70	90	1.2	90	110	1.3	110	130	1.7	140	0	0.5	160	20	1.2
10	40	0.3	30	60	1.3	50	80	-0.2	70	100	1	90	120	1.1	110	140	1.5	140	10	0.1	160	30	0.7
10	50	1.3	30	70	0.6	50	90	1.6	70	110	1.6	90	130	1.7	120	0	-0.1	140	20	0.3	160	40	0.2
10	60	1.5	30	80	1.5	50	100	2.2	70	120	0.2	90	140	1	120	10	0.3	140	30	0.7	160	50	1.2
10	70	2	30	90	1	50	110	1.9	70	130	1.9	100	0	-1.6	120	20	0.1	140	40	1	160	60	1.4
10	80	2.2	30	100	2.5	50	120	0.8	70	140	0.9	100	10	-0.8	120	30	0	140	50	0.8	160	70	1.3
10	90	3.5	30	110	2.7	50	130	1	80	0	10	100	20	-0.5	120	40	0.2	140	60	1.4	160	80	1.5
10	100	3.1	30	120	1.8	50	140	1.3	80	10	10	100	30	-0.1	120	50	0.1	140	70	1.7	160	90	1.4
10	110	2.5	30	130	0.4	60	0	0.8	80	20	10	100	40	-1	120	60	-0.4	140	80	1.9	160	100	0.2
10	120	1.5	30	140	0.5	60	10	-1.2	80	30	10	100	50	-0.8	120	70	0.8	140	90	1.1	160	110	1.9
10	130	-0.4	40	0	-0.7	60	20	-0.7	80	40	-1.7	100	60	-0.2	120	80	-0.6	140	100	0.8	160	120	0.4
10	140	0.2	40	10	0.2	60	30	-1.7	80	50	0.2	100	70	0.9	120	90	-0.2	140	110	1.2	160	130	1.3
20	0	-0.4	40	20	1.2	60	40	-0.5	80	60	1.1	100	80	-0.5	120	100	0.8	140	120	1.8	160	140	0.8
20	10	0.3	40	30	0.5	60	50	0.5	80	70	0.4	100	90	0.2	120	110	1	140	130	1.3	170	0	1.3
170	10	0.8	190	30	1.2	210	50	0.9	230	70	2.2	250	90	1.4	270	110	1.4	290	130	2.5	330	0	3.2
170	20	0.9	190	40	-0.1	210	60	1.2	230	80	2.3	250	100	1.8	270	120	2.1	290	140	2.2	330	10	2.9

170	30	0.2	190	50	0.4	210	70	1.5	230	90	1	250	110	2.2	270	130	3.9	300	0	3.4	330	20	3
170	40	0.3	190	60	0.5	210	80	1.3	230	100	1.6	250	120	3.7	270	140	2.5	300	10	3.6	330	30	3.2
170	50	0.4	190	70	1.4	210	90	0.4	230	110	2.6	250	130	2.4	280	0	10	300	20	3.2	330	40	0.1
170	60	1.2	190	80	1.7	210	100	0.5	230	120	2.5	250	140	2.9	280	10	10	300	30	3.1	330	50	0.2
170	70	1.5	190	90	2.2	210	110	0.7	230	130	3.3	260	0	0.9	280	20	10	300	40	-0.1	330	60	0.7
170	80	-0.3	190	100	1.1	210	120	2.1	230	140	2.4	260	10	1.1	280	30	10	300	50	0	330	70	0.4
170	90	1.1	190	110	0.5	210	130	2.2	240	0	1.4	260	20	1.3	280	40	0.4	300	60	-0.4	330	80	1.7
170	100	-0.1	190	120	2.7	210	140	3.2	240	10	1.1	260	30	0.9	280	50	0.1	300	70	0.9	330	90	1.9
170	110	0.1	190	130	1	220	0	1	240	20	1.3	260	40	-0.1	280	60	1.4	300	80	1.4	330	100	1.2
170	120	0.6	190	140	2.6	220	10	1.2	240	30	1.2	260	50	0.1	280	70	1.9	300	90	1.5	330	110	1.5
170	130	2.4	200	0	2.3	220	20	1	240	40	0.1	260	60	1.3	280	80	1.6	300	100	0.9	330	120	1.4
170	140	1	200	10	0.5	220	30	1.4	240	50	1.2	260	70	2.3	280	90	2	300	110	1.1	330	130	1.4
180	0	1.1	200	20	0.4	220	40	0.4	240	60	1.8	260	80	1.1	280	100	2.7	300	120	2	330	140	1.2
180	10	0.7	200	30	0.7	220	50	1.5	240	70	2.1	260	90	1.8	280	110	3.4	300	130	2.4			
180	20	1.1	200	40	0.2	220	60	1.3	240	80	2.1	260	100	2.2	280	120	2.8	300	140	1.9			
180	30	0.8	200	50	0.4	220	70	1.8	240	90	1.9	260	110	2.4	280	130	2.4	320	0	3.2			
180	40	0.9	200	60	1.1	220	80	2.6	240	100	1.8	260	120	2.8	280	140	1.8	320	10	3			
180	50	-0.7	200	70	1.3	220	90	1.7	240	110	2.8	260	130	3.8	290	0	10	320	20	2.8			

180	60	1.3	200	80	1.3	220	100	1.3	240	120	3	260	140	2.3	290	10	10	320	30	3.1			
180	70	1.6	200	90	1.4	220	110	2.3	240	130	2.9	270	0	1.7	290	20	10	320	40	-0.3			
180	80	1.5	200	100	1.5	220	120	1.2	240	140	2.1	270	10	2.1	290	30	10	320	50	0.5			
180	90	2.2	200	110	1.4	220	130	2.8	250	0	1	270	20	0.4	290	40	0.1	320	60	0.9			
180	100	1.5	200	120	1.6	220	140	2.8	250	10	0.5	270	30	-0.5	290	50	-0.2	320	70	0.4			
180	110	2.3	200	130	2.3	230	0	0.8	250	20	0.4	270	40	0.2	290	60	1.1	320	80	1.2			
180	120	2.3	200	140	2.7	230	10	0.9	250	30	0.9	270	50	0.7	290	70	2	320	90	1.1			
180	130	2.4	210	0	1.1	230	20	1.2	250	40	0.4	270	60	1.4	290	80	1.6	320	100	1.2			
180	140	1.7	210	10	0.5	230	30	1.4	250	50	0.8	270	70	2.1	290	90	1.5	320	110	1.4			
190	0	1.1	210	20	1.3	230	40	0.1	250	60	1.4	270	80	1.4	290	100	0.8	320	120	1.2			
190	10	0.4	210	30	1.5	230	50	1.1	250	70	1.4	270	90	2	290	110	2.4	320	130	1			
190	20	0.8	210	40	0	230	60	2	250	80	1.2	270	100	2.7	290	120	2.2	320	140	2			

Table A-14: Bed elevations of two spur spacing at 0.20 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	-1	20	20	0.3	40	40	-0.7	60	60	-0.4	80	80	0	100	100	-0.5	120	120	1.1	170	10	2.2
0	10	-0.8	20	30	0.6	40	50	-0.9	60	70	-1.8	80	90	0.1	100	110	-0.6	120	130	1.4	170	20	1.4
0	20	0.9	20	40	1.1	40	60	-0.2	60	80	0.2	80	100	0.3	100	120	1.3	120	140	1.3	170	30	1.6
0	30	2.1	20	50	1.2	40	70	0.9	60	90	0.2	80	110	1.4	100	130	1.4	130	0	0.2	170	40	0.7
0	40	1.4	20	60	0.8	40	80	0.4	60	100	-1	80	120	0.2	100	140	1.1	130	10	0.3	170	50	0.5
0	50	0.3	20	70	2.4	40	90	0.8	60	110	-1.6	80	130	0.4	110	0	-0.1	130	20	0.2	170	60	1.2
0	60	1.5	20	80	2.3	40	100	1.1	60	120	1.2	80	140	0.5	110	10	0.2	130	30	1.1	170	70	1.3
0	70	2.6	20	90	1.4	40	110	1.3	60	130	-0.5	90	0	0.1	110	20	-0.1	130	40	1.4	170	80	1.2
0	80	3.3	20	100	2.4	40	120	0.8	60	140	1.3	90	10	-0.8	110	30	0.3	130	50	0.3	170	90	0.1
0	90	3.2	20	110	1.1	40	130	1.1	70	0	10	90	20	-0.8	110	40	-0.2	130	60	0.2	170	100	0.4
0	100	0.9	20	120	0.4	40	140	0.4	70	10	10	90	30	-0.3	110	50	-0.6	130	70	0.5	170	110	1.4
0	110	2.2	20	130	0.3	50	0	2.3	70	20	10	90	40	-1.6	110	60	0	130	80	0.4	170	120	2.2
0	120	1.8	20	140	-0.6	50	10	-1.6	70	30	10	90	50	-1.5	110	70	1.3	130	90	-0.6	170	130	2.1
0	130	0.4	30	0	0.4	50	20	-0.7	70	40	-1.2	90	60	0.4	110	80	1.5	130	100	0.7	170	140	2.3
0	140	-0.7	30	10	0	50	30	-1.7	70	50	-0.9	90	70	-0.2	110	90	1.1	130	110	0.4	180	0	2.1
10	0	-1.5	30	20	1.1	50	40	-1.9	70	60	-0.8	90	80	1.1	110	100	-1.1	130	120	0.9	180	10	0.1

10	10	0	30	30	-0.2	50	50	-1.1	70	70	0	90	90	0.2	110	110	-0.1	130	130	1	180	20	0.7
10	20	0.1	30	40	0.4	50	60	-0.4	70	80	-0.1	90	100	0.8	110	120	1.4	130	140	2.1	180	30	1.1
10	30	0.3	30	50	-0.1	50	70	1	70	90	2.2	90	110	0	110	130	2.4	140	0	0.7	180	40	0.5
10	40	1.2	30	60	0.1	50	80	0.8	70	100	2.2	90	120	1.4	110	140	1.6	140	10	0.7	180	50	1
10	50	2.1	30	70	1.6	50	90	1.3	70	110	0.4	90	130	0.5	120	0	0.1	140	20	1.4	180	60	1.4
10	60	2.5	30	80	0.8	50	100	2.1	70	120	1.8	90	140	1.5	120	10	0.4	140	30	0.2	180	70	1.1
10	70	3.1	30	90	3.8	50	110	2.2	70	130	1	100	0	-0.7	120	20	0.3	140	40	2.1	180	80	1.4
10	80	3	30	100	3.4	50	120	1.2	70	140	1.2	100	10	-1.2	120	30	0.8	140	50	1.4	180	90	-0.1
10	90	1.8	30	110	1.4	50	130	0.8	80	0	10	100	20	-0.2	120	40	0.3	140	60	1.1	180	100	1.4
10	100	2.2	30	120	1.8	50	140	0.2	80	10	10	100	30	0.4	120	50	-0.6	140	70	1.4	180	110	2
10	110	2	30	130	1.2	60	0	0.3	80	20	10	100	40	-0.9	120	60	0.8	140	80	1.2	180	120	2.6
10	120	1.5	30	140	0.9	60	10	-0.9	80	30	10	100	50	-0.8	120	70	0.1	140	90	1	180	130	1.8
10	130	0.1	40	0	-0.9	60	20	-0.7	80	40	-1.5	100	60	0.5	120	80	0.2	140	100	1.8	180	140	2.6
10	140	-0.8	40	10	-0.2	60	30	0.1	80	50	-0.5	100	70	-0.5	120	90	1.4	140	110	1.1	190	0	1.5
20	0	-0.8	40	20	0.3	60	40	-1.2	80	60	0.2	100	80	-0.6	120	100	0	140	120	1.2	190	10	0.5
20	10	0.2	40	30	-0.6	60	50	-1.5	80	70	-0.2	100	90	-1.5	120	110	-0.1	140	130	1.2	190	20	1.1
190	30	0.3	210	50	-0.5	230	70	2.2	250	90	0.7	270	110	2.1	290	130	2.2						
190	40	0.2	210	60	0.8	230	80	1.8	250	100	1.4	270	120	1.7	290	140	-0.4						

190	50	0.1	210	70	0.4	230	90	1.5	250	110	2.8	270	130	2.9	300	0	1.4						
190	60	0.5	210	80	0.4	230	100	3.5	250	120	3.2	270	140	2.7	300	10	0.8						
190	70	0.5	210	90	1.3	230	110	3.8	250	130	3.3	280	0	10	300	20	1.5						
190	80	0.8	210	100	1.2	230	120	4.2	250	140	1.9	280	10	10	300	30	0.8						
190	90	1.4	210	110	1.4	230	130	3.9	260	0	2.5	280	20	10	300	40	-0.6						
190	100	2	210	120	1.6	230	140	4.4	260	10	2.2	280	30	10	300	50	-0.3						
190	110	2.2	210	130	3.4	240	0	1	260	20	2.4	280	40	0.1	300	60	0.1						
190	120	1.8	210	140	3.6	240	10	1.2	260	30	0.4	280	50	-0.2	300	70	0.3						
190	130	1.5	220	0	1.4	240	20	1.1	260	40	-0.2	280	60	1.2	300	80	1.4						
190	140	3.3	220	10	1.1	240	30	0.1	260	50	0.8	280	70	0.4	300	90	1.6						
200	0	3.4	220	20	1.4	240	40	0.2	260	60	1.4	280	80	0.5	300	100	1.8						
200	10	0.4	220	30	0.7	240	50	0.8	260	70	1.7	280	90	1.4	300	110	2.3						
200	20	1.5	220	40	0.2	240	60	0.9	260	80	1.3	280	100	1.7	300	120	1.3						
200	30	0.1	220	50	1	240	70	1.4	260	90	2.4	280	110	2.7	300	130	0.1						
200	40	-0.5	220	60	1.4	240	80	1.5	260	100	2.7	280	120	2.7	300	140	-0.1						
200	50	1	220	70	1.8	240	90	1.2	260	110	2.6	280	130	2.4	320	0	3.2						
200	60	0.5	220	80	2.4	240	100	1.6	260	120	2.4	280	140	2.38	320	10	1.5						
200	70	0	220	90	1.6	240	110	2.8	260	130	2.2	290	0	10	320	20	1.6						

200	80	0.2	220	100	1.7	240	120	3.3	260	140	2.1	290	10	10	320	30	0.4						
200	90	1.1	220	110	2.8	240	130	2.9	270	0	1.5	290	20	10	320	40	-0.2						
200	100	1.2	220	120	2.8	240	140	2.7	270	10	1.3	290	30	10	320	50	-1						
200	110	1.3	220	130	2.7	250	0	1.5	270	20	-0.5	290	40	-0.3	320	60	0.3						
200	120	2.4	220	140	3.2	250	10	1.3	270	30	-1.2	290	50	-0.6	320	70	0.9						
200	130	3.1	230	0	1.1	250	20	0.9	270	40	-0.3	290	60	1.2	320	80	2.1						
200	140	3	230	10	1.4	250	30	1.1	270	50	0.3	290	70	1.1	320	90	2						
210	0	2.5	230	20	1.8	250	40	0.1	270	60	1.3	290	80	0.8	320	100	1.8						
210	10	1.2	230	30	1.1	250	50	1.2	270	70	1.1	290	90	1.9	320	110	1.5						
210	20	1.1	230	40	-0.6	250	60	1.2	270	80	1.4	290	100	2.3	320	120	-0.2						
210	30	0.4	230	50	1.2	250	70	1.5	270	90	2.5	290	110	3	320	130	-0.1						
210	40	-0.7	230	60	1.3	250	80	1.4	270	100	2.2	290	120	2.6	320	140	1.1						

Table A-15: Bed elevations of two spur spacing at 0.30 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	0	20	20	-0.5	40	40	0.8	60	60	1.2	80	80	0.5	100	100	1.2	120	120	0.2	140	140	-0.1
0	10	0	20	30	0.7	40	50	0.2	60	70	0.8	80	90	1.7	100	110	0.6	120	130	0.1	150	0	1.3
0	20	0.3	20	40	0.5	40	60	-0.2	60	80	1	80	100	1.9	100	120	1.4	120	140	0.9	150	10	0.3
0	30	-0.1	20	50	-0.2	40	70	0.9	60	90	1	80	110	0.7	100	130	2.2	130	0	1.5	150	20	0.2
0	40	0.2	20	60	1	40	80	1	60	100	1.2	80	120	0.6	100	140	1.8	130	10	0.6	150	30	-0.1
0	50	0.5	20	70	1.5	40	90	0.5	60	110	0.7	80	130	2.2	110	0	0.9	130	20	0.7	150	40	-0.2
0	60	0.6	20	80	0.8	40	100	0.6	60	120	1.3	80	140	1.3	110	10	0.7	130	30	0.5	150	50	0.2
0	70	0.8	20	90	1.2	40	110	1.1	60	130	1.5	90	0	0.9	110	20	0.4	130	40	0.4	150	60	0.3
0	80	1	20	100	1	40	120	0.8	60	140	2	90	10	1.6	110	30	1.2	130	50	0.8	150	70	0.4
0	90	1	20	110	0.9	40	130	1.3	70	0	10	90	20	1.6	110	40	1	130	60	0.5	150	80	0.2
0	100	0.8	20	120	0.4	40	140	1.2	70	10	10	90	30	10	110	50	0.8	130	70	-0.1	150	90	0.1
0	110	0.4	20	130	1.4	50	0	2	70	20	10	90	40	0.6	110	60	0.7	130	80	0	150	100	0.2
0	120	0.6	20	140	0.9	50	10	0.5	70	30	10	90	50	1.8	110	70	0.2	130	90	0.2	150	110	-0.1
0	130	1.7	30	0	0.5	50	20	1.8	70	40	0.8	90	60	0.4	110	80	-0.1	130	100	0.3	150	120	0.2
0	140	-0.1	30	10	0	50	30	10	70	50	0.7	90	70	1.2	110	90	0	130	110	-0.1	150	130	0.3
10	0	-0.1	30	20	-0.1	50	40	1	70	60	1.3	90	80	0.7	110	100	-0.2	130	120	0.7	150	140	-0.3

10	10	0.5	30	30	-0.5	50	50	1	70	70	0.6	90	90	1.3	110	110	0.2	130	130	0.6	160	0	0.5
10	20	0.7	30	40	-0.7	50	60	0.5	70	80	0.9	90	100	1.6	110	120	0.3	130	140	0.4	160	10	0
10	30	-0.1	30	50	0.3	50	70	0.7	70	90	0.8	90	110	0.9	110	130	0.5	140	0	0.9	160	20	-0.1
10	40	0.5	30	60	0.5	50	80	1.5	70	100	2	90	120	0.8	110	140	0.6	140	10	0.7	160	30	0.1
10	50	0.3	30	70	1.3	50	90	0.6	70	110	0.3	90	130	1.8	120	0	1.1	140	20	0.9	160	40	0.4
10	60	0.4	30	80	1.2	50	100	0.5	70	120	1.5	90	140	2.1	120	10	1	140	30	0.6	160	50	0.3
10	70	1.5	30	90	1	50	110	0.9	70	130	1.9	100	0	1.5	120	20	0.5	140	40	0.7	160	60	0
10	80	0.9	30	100	0.7	50	120	1	70	140	2	100	10	2.5	120	30	1.1	140	50	0.7	160	70	0.2
10	90	1.1	30	110	0.3	50	130	1.7	80	0	0.8	100	20	2.5	120	40	0.7	140	60	0.6	160	80	0.4
10	100	1.4	30	120	0.5	50	140	1.6	80	10	1.5	100	30	1.7	120	50	0.4	140	70	0	160	90	-0.3
10	110	1	30	130	1.5	60	0	10	80	20	1.7	100	40	1.5	120	60	0.3	140	80	0.2	160	100	-0.1
10	120	0.4	30	140	1.2	60	10	10	80	30	10	100	50	1.6	120	70	1.1	140	90	0.3	160	110	0
10	130	1.6	40	0	0.5	60	20	10	80	40	0.5	100	60	0.4	120	80	0.3	140	100	0.2	160	120	0.1
10	140	-0.4	40	10	-0.1	60	30	10	80	50	0.3	100	70	1.3	120	90	-0.1	140	110	0.1	160	130	0.2
20	0	-0.8	40	20	1.5	60	40	0.9	80	60	0.3	100	80	1	120	100	0.7	140	120	0.3	160	140	-0.1
20	10	0.5	40	30	10	60	50	0.9	80	70	1.6	100	90	1.1	120	110	0.8	140	130	-0.2			
0	0	-0.4	20	20	0.6	40	40	-1.5	60	60	-0.4	80	80	-1.1	100	100	3	120	120	1	140	140	1.6
0	10	-0.1	20	30	0.5	40	50	-2	60	70	-0.2	80	90	-0.2	100	110	2.8	120	130	0.1	150	0	1.5

0	20	1.5	20	40	0.5	40	60	-1	60	80	-0.1	80	100	0.3	100	120	1.9	120	140	0.5	150	10	1
0	30	1.1	20	50	-0.1	40	70	0.1	60	90	0.2	80	110	0.2	100	130	-0.2	130	0	2.2	150	20	0.7
0	40	1.5	20	60	0.8	40	80	-0.2	60	100	-0.1	80	120	0.6	100	140	2.9	130	10	1.8	150	30	2
0	50	1.7	20	70	0.6	40	90	0.3	60	110	0.1	80	130	0.7	110	0	2.6	130	20	0.7	150	40	2.1
0	60	2	20	80	0.5	40	100	0.7	60	120	-0.2	80	140	2.6	110	10	2.7	130	30	1.2	150	50	1.7
0	70	1.9	20	90	0.6	40	110	0.6	60	130	0.2	90	0	1.8	110	20	2.2	130	40	1.7	150	60	1.3
0	80	1.8	20	100	1.2	40	120	0.3	60	140	1.9	90	10	1.3	110	30	2	130	50	1.9	150	70	1.7
0	90	1.7	20	110	2.1	40	130	-0.1	70	0	10	90	20	1.7	110	40	0.9	130	60	1.7	150	80	1.9
0	100	2.5	20	120	-0.1	40	140	2.9	70	10	10	90	30	10	110	50	0.4	130	70	1.8	150	90	1.1
0	110	2	20	130	0.1	50	0	0.7	70	20	10	90	40	3	110	60	0.7	130	80	1.1	150	100	1
0	120	2.2	20	140	2.7	50	10	0.8	70	30	10	90	50	1.4	110	70	0.8	130	90	1.8	150	110	2.1
0	130	2.5	30	0	-0.3	50	20	1.8	70	40	2	90	60	1.5	110	80	0.9	130	100	1.7	150	120	2.2
0	140	2.6	30	10	0.3	50	30	10	70	50	-0.4	90	70	1.1	110	90	1	130	110	1.4	150	130	1.7
10	0	-0.4	30	20	0.7	50	40	-0.5	70	60	-1	90	80	-1.1	110	100	1.1	130	120	1.6	150	140	1.5
10	10	0.4	30	30	-1.5	50	50	-1	70	70	-0.1	90	90	0.5	110	110	0.6	130	130	1.8	160	0	1.4
10	20	0.8	30	40	-0.2	50	60	-0.2	70	80	-1	90	100	1.8	110	120	0.2	130	140	2	160	10	1.5
10	30	0.6	30	50	-0.1	50	70	-0.3	70	90	0	90	110	0.2	110	130	0	140	0	1.9	160	20	1.3
10	40	1.1	30	60	0.4	50	80	0.5	70	100	0.2	90	120	0.7	110	140	-0.1	140	10	1.2	160	30	1.2

10	50	1.7	30	70	-0.1	50	90	-0.2	70	110	-0.1	90	130	0.6	120	0	1.8	140	20	1.2	160	40	2.2
10	60	1.8	30	80	1.1	50	100	0.6	70	120	-0.5	90	140	2.7	120	10	1.6	140	30	1.4	160	50	2.5
10	70	1.8	30	90	2	50	110	-0.1	70	130	0.1	100	0	2.5	120	20	1.1	140	40	1.3	160	60	1.6
10	80	1.4	30	100	0.9	50	120	1.8	70	140	2.1	100	10	1.5	120	30	1.2	140	50	1.9	160	70	1.9
10	90	2.1	30	110	-0.2	50	130	1.6	80	0	2	100	20	1.6	120	40	1.3	140	60	1.4	160	80	1.2
10	100	2.5	30	120	1.8	50	140	2	80	10	1.7	100	30	2.5	120	50	1.2	140	70	1.3	160	90	1.6
10	110	1.9	30	130	1.1	60	0	10	80	20	1.6	100	40	1.5	120	60	0.9	140	80	1.9	160	100	1.5
10	120	0.9	30	140	2.2	60	10	10	80	30	10	100	50	1.3	120	70	0.7	140	90	1.6	160	110	1.2
10	130	1.8	40	0	1	60	20	10	80	40	1.8	100	60	1.7	120	80	0.4	140	100	1.5	160	120	1.1
10	140	2.6	40	10	0.7	60	30	10	80	50	1.5	100	70	2	120	90	0.7	140	110	1.6	160	130	2.2
20	0	0	40	20	1.5	60	40	0.5	80	60	-0.4	100	80	1.7	120	100	0.9	140	120	1.8	160	140	1.9
20	10	0.5	40	30	10	60	50	-0.1	80	70	-0.6	100	90	1.6	120	110	0.5	140	130	1.7			

Table A-16: Bed elevations of T-spur at 0.15 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	-0.4	20	20	0.6	40	40	-1.5	60	60	-0.4	80	80	-1.1	100	100	3	120	120	1	140	140	1.6
0	10	-0.1	20	30	0.5	40	50	-2	60	70	-0.2	80	90	-0.2	100	110	2.8	120	130	0.1	150	0	1.5
0	20	1.5	20	40	0.5	40	60	-1	60	80	-0.1	80	100	0.3	100	120	1.9	120	140	0.5	150	10	1
0	30	1.1	20	50	-0.1	40	70	0.1	60	90	0.2	80	110	0.2	100	130	-0.2	130	0	2.2	150	20	0.7
0	40	1.5	20	60	0.8	40	80	-0.2	60	100	-0.1	80	120	0.6	100	140	2.9	130	10	1.8	150	30	2
0	50	1.7	20	70	0.6	40	90	0.3	60	110	0.1	80	130	0.7	110	0	2.6	130	20	0.7	150	40	2.1
0	60	2	20	80	0.5	40	100	0.7	60	120	-0.2	80	140	2.6	110	10	2.7	130	30	1.2	150	50	1.7
0	70	1.9	20	90	0.6	40	110	0.6	60	130	0.2	90	0	1.8	110	20	2.2	130	40	1.7	150	60	1.3
0	80	1.8	20	100	1.2	40	120	0.3	60	140	1.9	90	10	1.3	110	30	2	130	50	1.9	150	70	1.7
0	90	1.7	20	110	2.1	40	130	-0.1	70	0	10	90	20	1.7	110	40	0.9	130	60	1.7	150	80	1.9
0	100	2.5	20	120	-0.1	40	140	2.9	70	10	10	90	30	10	110	50	0.4	130	70	1.8	150	90	1.1
0	110	2	20	130	0.1	50	0	0.7	70	20	10	90	40	3	110	60	0.7	130	80	1.1	150	100	1
0	120	2.2	20	140	2.7	50	10	0.8	70	30	10	90	50	1.4	110	70	0.8	130	90	1.8	150	110	2.1
0	130	2.5	30	0	-0.3	50	20	1.8	70	40	2	90	60	1.5	110	80	0.9	130	100	1.7	150	120	2.2
0	140	2.6	30	10	0.3	50	30	10	70	50	-0.4	90	70	1.1	110	90	1	130	110	1.4	150	130	1.7
10	0	-0.4	30	20	0.7	50	40	-0.5	70	60	-1	90	80	-1.1	110	100	1.1	130	120	1.6	150	140	1.5

10	10	0.4	30	30	-1.5	50	50	-1	70	70	-0.1	90	90	0.5	110	110	0.6	130	130	1.8	160	0	1.4
10	20	0.8	30	40	-0.2	50	60	-0.2	70	80	-1	90	100	1.8	110	120	0.2	130	140	2	160	10	1.5
10	30	0.6	30	50	-0.1	50	70	-0.3	70	90	0	90	110	0.2	110	130	0	140	0	1.9	160	20	1.3
10	40	1.1	30	60	0.4	50	80	0.5	70	100	0.2	90	120	0.7	110	140	-0.1	140	10	1.2	160	30	1.2
10	50	1.7	30	70	-0.1	50	90	-0.2	70	110	-0.1	90	130	0.6	120	0	1.8	140	20	1.2	160	40	2.2
10	60	1.8	30	80	1.1	50	100	0.6	70	120	-0.5	90	140	2.7	120	10	1.6	140	30	1.4	160	50	2.5
10	70	1.8	30	90	2	50	110	-0.1	70	130	0.1	100	0	2.5	120	20	1.1	140	40	1.3	160	60	1.6
10	80	1.4	30	100	0.9	50	120	1.8	70	140	2.1	100	10	1.5	120	30	1.2	140	50	1.9	160	70	1.9
10	90	2.1	30	110	-0.2	50	130	1.6	80	0	2	100	20	1.6	120	40	1.3	140	60	1.4	160	80	1.2
10	100	2.5	30	120	1.8	50	140	2	80	10	1.7	100	30	2.5	120	50	1.2	140	70	1.3	160	90	1.6
10	110	1.9	30	130	1.1	60	0	10	80	20	1.6	100	40	1.5	120	60	0.9	140	80	1.9	160	100	1.5
10	120	0.9	30	140	2.2	60	10	10	80	30	10	100	50	1.3	120	70	0.7	140	90	1.6	160	110	1.2
10	130	1.8	40	0	1	60	20	10	80	40	1.8	100	60	1.7	120	80	0.4	140	100	1.5	160	120	1.1
10	140	2.6	40	10	0.7	60	30	10	80	50	1.5	100	70	2	120	90	0.7	140	110	1.6	160	130	2.2
20	0	0	40	20	1.5	60	40	0.5	80	60	-0.4	100	80	1.7	120	100	0.9	140	120	1.8	160	140	1.9
20	10	0.5	40	30	10	60	50	-0.1	80	70	-0.6	100	90	1.6	120	110	0.5	140	130	1.7			

Table A-17: Bed elevations of T-spur at 0.20 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	0.8	20	20	0.9	40	40	0.2	60	60	-0.2	80	80	0.4	100	100	0.5	120	120	0.2	140	140	1.3
0	10	0.6	20	30	0.2	40	50	0.7	60	70	-0.3	80	90	0.5	100	110	0.4	120	130	0.9	150	0	0
0	20	0.5	20	40	0.3	40	60	0	60	80	0.3	80	100	0.5	100	120	0.2	120	140	1.2	150	10	0.6
0	30	0.7	20	50	0.2	40	70	0.5	60	90	0.4	80	110	0.4	100	130	0.3	130	0	-0.2	150	20	0.6
0	40	0.3	20	60	0.2	40	80	0.3	60	100	0.6	80	120	0.5	100	140	0.7	130	10	0.6	150	30	0.6
0	50	0.4	20	70	0.9	40	90	0.4	60	110	0.7	80	130	0.4	110	0	0.6	130	20	0.2	150	40	0.6
0	60	0.5	20	80	0.2	40	100	0.6	60	120	0.6	80	140	1.2	110	10	0.5	130	30	0.1	150	50	0.2
0	70	0.4	20	90	0.9	40	110	0.7	60	130	0.5	90	0	-0.1	110	20	0.4	130	40	0.2	150	60	1
0	80	0.7	20	100	0.8	40	120	0.6	60	140	1.3	90	10	0.1	110	30	0.2	130	50	0.1	150	70	-0.1
0	90	0.8	20	110	0.5	40	130	0.7	70	0	10	90	20	0.9	110	40	0.4	130	60	0.2	150	80	0.4
0	100	0.9	20	120	0.4	40	140	1.5	70	10	10	90	30	0.8	110	50	0.5	130	70	0.4	150	90	0.2
0	110	0.3	20	130	0.2	50	0	0.3	70	20	10	90	40	0.1	110	60	0.4	130	80	0.5	150	100	0.4
0	120	0.4	20	140	0.6	50	10	0.9	70	30	10	90	50	0.3	110	70	0.7	130	90	0.6	150	110	-0.2
0	130	0.8	30	0	0.3	50	20	-0.2	70	40	-0.6	90	60	0.2	110	80	0.3	130	100	0.5	150	120	0.6
0	140	0.9	30	10	0.4	50	30	-0.3	70	50	-0.2	90	70	0.4	110	90	0.4	130	110	0.5	150	130	1.1
10	0	0.6	30	20	0.2	50	40	-0.2	70	60	-0.1	90	80	0.7	110	100	0.7	130	120	0.3	150	140	1.4

10	10	0.6	30	30	0.3	50	50	-0.1	70	70	-0.2	90	90	0.6	110	110	0.8	130	130	1.1	160	0	0.2
10	20	0.8	30	40	0.5	50	60	0.1	70	80	0.2	90	100	0.2	110	120	0.9	130	140	1.5	160	10	0.1
10	30	0.9	30	50	0.1	50	70	0.1	70	90	0.2	90	110	0.5	110	130	0.2	140	0	-0.3	160	20	0.3
10	40	0.7	30	60	0.7	50	80	0.2	70	100	0.3	90	120	0.4	110	140	1.2	140	10	0.5	160	30	0.7
10	50	0.6	30	70	0.4	50	90	0.3	70	110	0.6	90	130	0.5	120	0	-0.1	140	20	0.4	160	40	0.7
10	60	0.4	30	80	0.2	50	100	0.4	70	120	0.7	90	140	1	120	10	0.4	140	30	0.5	160	50	0.8
10	70	0.7	30	90	0.2	50	110	0.3	70	130	0.6	100	0	0.1	120	20	0.3	140	40	0.4	160	60	0.9
10	80	0.6	30	100	0.3	50	120	0.2	70	140	1.4	100	10	0.5	120	30	0.2	140	50	0.2	160	70	1.2
10	90	0.2	30	110	0.4	50	130	0.6	80	0	0	100	20	0.7	120	40	-0.2	140	60	0.4	160	80	0.8
10	100	0.1	30	120	0.5	50	140	1.2	80	10	-0.1	100	30	0.8	120	50	-0.1	140	70	0.4	160	90	-0.2
10	110	0.4	30	130	0.5	60	0	10	80	20	10	100	40	0.6	120	60	0.4	140	80	0.2	160	100	0.9
10	120	0.2	30	140	0.4	60	10	10	80	30	10	100	50	0.4	120	70	0.2	140	90	0.4	160	110	0.4
10	130	0.4	40	0	0.7	60	20	10	80	40	0	100	60	0.5	120	80	0.3	140	100	0.2	160	120	0.3
10	140	0.7	40	10	0.8	60	30	10	80	50	0.2	100	70	0.7	120	90	0.4	140	110	0.1	160	130	1.3
20	0	0.5	40	20	0.1	60	40	-0.5	80	60	0.9	100	80	0.7	120	100	0.6	140	120	-0.1	160	140	1.6
20	10	0.3	40	30	0	60	50	-0.1	80	70	0.5	100	90	0.4	120	110	0.7	140	130	1.2			

Table A-18: Bed elevations of T-spur at 0.30 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	1.5	20	20	1.3	40	40	-1	60	60	0.5	80	80	0	100	100	-0.1	120	120	1.6	140	140	0.4
0	10	1.6	20	30	1.6	40	50	-2.1	60	70	-0.5	80	90	-0.5	100	110	-0.1	120	130	1.5	150	0	0.5
0	20	1.7	20	40	1.7	40	60	0	60	80	0.4	80	100	0.4	100	120	0.2	120	140	0.7	150	10	1.2
0	30	1.8	20	50	-0.6	40	70	0.4	60	90	-0.3	80	110	0.4	100	130	0.9	130	0	0.7	150	20	0.4
0	40	1.9	20	60	-0.5	40	80	0.3	60	100	0	80	120	0.7	100	140	1.1	130	10	1.2	150	30	-0.6
0	50	2	20	70	0.5	40	90	0.3	60	110	0.7	80	130	1.6	110	0	0.9	130	20	0.3	150	40	0.2
0	60	1.5	20	80	0	40	100	0.2	60	120	0.3	80	140	1.5	110	10	0.7	130	30	0.6	150	50	0.4
0	70	1.3	20	90	-0.1	40	110	0.4	60	130	1.2	90	0	0.6	110	20	0.6	130	40	-0.6	150	60	0.2
0	80	1.6	20	100	0.4	40	120	0	60	140	1.6	90	10	0.8	110	30	0.5	130	50	-0.8	150	70	0.1
0	90	1.7	20	110	0.2	40	130	0.8	70	0	10	90	20	-0.1	110	40	-0.1	130	60	0.4	150	80	0
0	100	1.8	20	120	0.3	40	140	1.8	70	10	10	90	30	0.3	110	50	-0.2	130	70	-0.6	150	90	-0.6
0	110	1.5	20	130	1.2	50	0	-0.5	70	20	10	90	40	-0.7	110	60	0.4	130	80	0.2	150	100	0.5
0	120	1.9	20	140	1.9	50	10	-0.7	70	30	10	90	50	-1.5	110	70	0	130	90	0.1	150	110	0.4
0	130	2.1	30	0	0.5	50	20	-0.7	70	40	-2.2	90	60	-0.3	110	80	0.5	130	100	0.4	150	120	0.2
0	140	2.5	30	10	1	50	30	-1	70	50	-2	90	70	0.1	110	90	0.9	130	110	0.3	150	130	0.7
10	0	1.8	30	20	1.7	50	40	-1.5	70	60	-1	90	80	0	110	100	1.2	130	120	0.7	150	140	0.2

10	10	1.6	30	30	1.5	50	50	-1.9	70	70	0.3	90	90	-0.1	110	110	1.3	130	130	0.2	160	0	0.3
10	20	1.2	30	40	1.9	50	60	0.2	70	80	0.3	90	100	-0.2	110	120	1.1	130	140	0.5	160	10	1
10	30	1.3	30	50	-1	50	70	0.2	70	90	-0.4	90	110	0.5	110	130	1.3	140	0	0.3	160	20	0.6
10	40	1.3	30	60	-0.1	50	80	0.2	70	100	0.2	90	120	0.6	110	140	2.2	140	10	1.6	160	30	-0.7
10	50	0.9	30	70	0.5	50	90	-0.1	70	110	0.3	90	130	1.2	120	0	0.8	140	20	0.5	160	40	-0.6
10	60	0.8	30	80	0.4	50	100	-0.2	70	120	0.2	90	140	0.5	120	10	0.9	140	30	-0.6	160	50	-0.5
10	70	1.3	30	90	0.3	50	110	0.5	70	130	1.3	100	0	0	120	20	0.1	140	40	-0.7	160	60	-0.4
10	80	1.4	30	100	0.2	50	120	0.4	70	140	1.3	100	10	-0.2	120	30	0.2	140	50	-1	160	70	-0.6
10	90	1.7	30	110	0.3	50	130	2.2	80	0	0.5	100	20	-0.1	120	40	-0.3	140	60	0.2	160	80	-0.3
10	100	1.6	30	120	0.4	50	140	1.7	80	10	1	100	30	0.4	120	50	-0.3	140	70	-0.7	160	90	-0.5
10	110	1.8	30	130	1.1	60	0	10	80	20	10	100	40	-0.5	120	60	0.2	140	80	0.3	160	100	-0.7
10	120	1.9	30	140	2	60	10	10	80	30	10	100	50	-1.1	120	70	0.4	140	90	0	160	110	0.1
10	130	1.4	40	0	0.6	60	20	10	80	40	-1.9	100	60	-0.2	120	80	0.2	140	100	0.3	160	120	0.3
10	140	2.1	40	10	0.7	60	30	10	80	50	-1.8	100	70	0.1	120	90	0.4	140	110	0.4	160	130	0.2
20	0	0.8	40	20	0.3	60	40	-2	80	60	-0.5	100	80	0.1	120	100	0.7	140	120	0.5	160	140	0.4
20	10	1.1	40	30	0.2	60	50	-1.7	80	70	0.2	100	90	0	120	110	0.3	140	130	0.6			

Table A-19: Bed elevations of J-spur at 0.15 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	1.9	20	20	0.4	40	40	-0.1	60	60	-1.7	80	80	0.4	100	100	0.2	120	120	1.1	140	140	1.9
0	10	1.8	20	30	0.5	40	50	-1.5	60	70	-1	80	90	0.1	100	110	0.7	120	130	1.5	150	0	1.1
0	20	1.3	20	40	1.1	40	60	-1.1	60	80	-0.7	80	100	0.1	100	120	0.3	120	140	1.6	150	10	0.7
0	30	1.5	20	50	0.3	40	70	0.4	60	90	0.1	80	110	-1.6	100	130	0.4	130	0	0.7	150	20	0.3
0	40	1.4	20	60	0.3	40	80	0.2	60	100	-0.2	80	120	0	100	140	1.2	130	10	0.2	150	30	1
0	50	1.3	20	70	0.5	40	90	0.8	60	110	0.1	80	130	0.2	110	0	0.5	130	20	0.1	150	40	0.9
0	60	1.8	20	80	1.2	40	100	-0.3	60	120	0.3	80	140	1.5	110	10	0.3	130	30	0.1	150	50	0.2
0	70	1.9	20	90	0.7	40	110	0.4	60	130	-0.1	90	0	0.3	110	20	-0.1	130	40	0.4	150	60	-0.1
0	80	1.7	20	100	0.5	40	120	0.4	60	140	1.3	90	10	0	110	30	-0.2	130	50	0.2	150	70	0.7
0	90	1.3	20	110	0.4	40	130	0.5	70	0	10	90	20	-0.5	110	40	-0.3	130	60	0.3	150	80	0
0	100	1.8	20	120	1	40	140	2.1	70	10	10	90	30	-0.6	110	50	-0.4	130	70	0.4	150	90	-0.5
0	110	1.3	20	130	0.6	50	0	-1.7	70	20	10	90	40	-1.5	110	60	-0.5	130	80	0.4	150	100	1.2
0	120	1	20	140	1.5	50	10	-1.8	70	30	10	90	50	-1.2	110	70	-0.2	130	90	-0.2	150	110	0.9
0	130	0.8	30	0	1.3	50	20	-2	70	40	-2.2	90	60	-0.2	110	80	0.2	130	100	0.6	150	120	1.4
0	140	1.8	30	10	1	50	30	-2.5	70	50	-2.5	90	70	-1.5	110	90	0.4	130	110	-0.1	150	130	1.3
10	0	1.9	30	20	-0.5	50	40	-3	70	60	0.2	90	80	0.4	110	100	0.7	130	120	1.8	150	140	1.6

10	10	1.7	30	30	0.2	50	50	-2.6	70	70	-1	90	90	-1	110	110	0.9	130	130	1.3	160	0	0.3
10	20	1.4	30	40	1	50	60	-0.6	70	80	0.3	90	100	0.2	110	120	1.8	130	140	1.1	160	10	0.2
10	30	1.2	30	50	-0.5	50	70	-0.3	70	90	0.7	90	110	1	110	130	1.3	140	0	0.8	160	20	0.2
10	40	1.3	30	60	0.2	50	80	-0.5	70	100	0.4	90	120	-0.5	110	140	1.2	140	10	0.4	160	30	1.3
10	50	0.4	30	70	0.7	50	90	-0.5	70	110	0.7	90	130	0.4	120	0	0.3	140	20	0.4	160	40	1.1
10	60	0.4	30	80	0.2	50	100	0.2	70	120	0.2	90	140	1.3	120	10	0.4	140	30	-0.3	160	50	1.8
10	70	0.3	30	90	0.9	50	110	-0.2	70	130	1.2	100	0	0.2	120	20	0.2	140	40	0.5	160	60	0.2
10	80	0.4	30	100	0.4	50	120	0.3	70	140	1.4	100	10	0.5	120	30	-0.3	140	50	0.4	160	70	1.8
10	90	1.2	30	110	0.3	50	130	0.3	80	0	0.5	100	20	-0.1	120	40	-0.2	140	60	-0.3	160	80	0.7
10	100	1.4	30	120	1.2	50	140	1.8	80	10	0.2	100	30	-0.5	120	50	-0.1	140	70	0.2	160	90	0.3
10	110	1.3	30	130	0.6	60	0	10	80	20	10	100	40	-1.6	120	60	-1	140	80	0.5	160	100	0.5
10	120	1.1	30	140	1.4	60	10	10	80	30	10	100	50	-1.7	120	70	0.2	140	90	-0.1	160	110	0.4
10	130	0.5	40	0	1.5	60	20	10	80	40	-2.1	100	60	0.2	120	80	0.5	140	100	0.7	160	120	1.3
10	140	3.3	40	10	-1.1	60	30	10	80	50	-2.2	100	70	-2	120	90	0.7	140	110	0.9	160	130	2.1
20	0	1.3	40	20	-0.8	60	40	-2.3	80	60	0.6	100	80	0.4	120	100	0.9	140	120	1.3	160	140	2.1
20	10	1.3	40	30	-0.2	60	50	-3.3	80	70	0.2	100	90	0.7	120	110	0.3	140	130	1.5			

Table A-20: Bed elevations of J-spur at 0.20 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	-0.1	20	20	-0.6	40	40	-0.1	60	60	-0.3	80	80	-0.6	100	100	-0.1	120	120	-0.8	140	140	0
0	10	0.2	20	30	-0.1	40	50	-0.8	60	70	-0.6	80	90	-0.8	100	110	-0.2	120	130	-0.6	150	0	-0.4
0	20	-0.1	20	40	-0.2	40	60	-0.1	60	80	-0.5	80	100	0.1	100	120	-0.1	120	140	0.1	150	10	-0.7
0	30	0.2	20	50	-0.7	40	70	-0.3	60	90	-0.6	80	110	0.3	100	130	0.3	130	0	0	150	20	0.2
0	40	0.3	20	60	-0.4	40	80	-0.4	60	100	-0.8	80	120	-0.3	100	140	0.8	130	10	-0.2	150	30	-0.3
0	50	0.2	20	70	-0.2	40	90	-0.3	60	110	-0.7	80	130	0.3	110	0	-0.3	130	20	0.1	150	40	-0.5
0	60	0.3	20	80	-0.2	40	100	0	60	120	-0.1	80	140	0.2	110	10	-0.3	130	30	-0.5	150	50	-0.6
0	70	0.4	20	90	-0.1	40	110	-0.7	60	130	-0.1	90	0	-0.1	110	20	-0.2	130	40	0.9	150	60	-0.7
0	80	0.8	20	100	-0.3	40	120	0.1	60	140	0.3	90	10	-0.1	110	30	-0.3	130	50	0.5	150	70	-0.1
0	90	0.3	20	110	-0.3	40	130	0.3	70	0	10	90	20	-0.3	110	40	0	130	60	-0.6	150	80	-0.4
0	100	0.2	20	120	0.1	40	140	0.7	70	10	10	90	30	10	110	50	-0.5	130	70	0.1	150	90	-0.4
0	110	0.4	20	130	-0.1	50	0	-0.1	70	20	10	90	40	-0.6	110	60	-0.1	130	80	-0.6	150	100	-0.5
0	120	0.3	20	140	0.4	50	10	-0.4	70	30	10	90	50	-0.1	110	70	-0.2	130	90	-0.6	150	110	-0.4
0	130	0.3	30	0	-0.1	50	20	-0.5	70	40	-1	90	60	-0.1	110	80	-0.4	130	100	-0.6	150	120	-0.7
0	140	0.3	30	10	0.3	50	30	-0.6	70	50	-0.5	90	70	-0.5	110	90	-0.3	130	110	-0.8	150	130	-0.6
10	0	-0.2	30	20	-0.5	50	40	-0.4	70	60	-0.2	90	80	-0.6	110	100	-0.4	130	120	-0.3	150	140	-0.1

10	10	0.3	30	30	-0.3	50	50	-0.3	70	70	-0.1	90	90	-0.3	110	110	-0.1	130	130	-0.3	160	0	-0.5
10	20	-0.3	30	40	-0.1	50	60	-0.2	70	80	-0.6	90	100	-0.1	110	120	2.1	130	140	0.1	160	10	-0.1
10	30	-0.2	30	50	-0.6	50	70	-0.4	70	90	-0.8	90	110	-0.2	110	130	0.5	140	0	-0.3	160	20	-0.2
10	40	-0.1	30	60	-0.3	50	80	-0.1	70	100	-0.6	90	120	-0.1	110	140	0.3	140	10	-0.6	160	30	-0.6
10	50	-0.6	30	70	0.1	50	90	0.3	70	110	-0.7	90	130	0	120	0	-0.1	140	20	-0.1	160	40	-0.7
10	60	0.7	30	80	-0.3	50	100	-0.3	70	120	-0.2	90	140	0.7	120	10	-0.1	140	30	-0.1	160	50	-0.8
10	70	-0.1	30	90	0.1	50	110	-0.4	70	130	0.1	100	0	0	120	20	0.2	140	40	-0.8	160	60	-0.8
10	80	-0.5	30	100	-0.1	50	120	0	70	140	0.3	100	10	0	120	30	-0.4	140	50	-0.3	160	70	-0.6
10	90	-0.6	30	110	-0.5	50	130	0.3	80	0	-0.3	100	20	-0.1	120	40	-0.4	140	60	-0.4	160	80	-0.5
10	100	-0.3	30	120	0.2	50	140	0.3	80	10	-0.2	100	30	-0.8	120	50	0.2	140	70	0.3	160	90	-0.5
10	110	0.6	30	130	-0.3	60	0	10	80	20	-0.6	100	40	-0.6	120	60	-0.4	140	80	-0.3	160	100	-0.3
10	120	-0.7	30	140	0.5	60	10	10	80	30	10	100	50	-0.8	120	70	-0.1	140	90	-0.1	160	110	-0.6
10	130	0.4	40	0	-0.3	60	20	10	80	40	-0.8	100	60	-0.8	120	80	-0.5	140	100	-0.3	160	120	-0.6
10	140	0.3	40	10	0.2	60	30	10	80	50	-0.3	100	70	-0.1	120	90	-0.5	140	110	-0.5	160	130	-0.3
20	0	0.1	40	20	-0.3	60	40	-0.8	80	60	-0.1	100	80	-0.8	120	100	-0.6	140	120	0.6	160	140	-0.2
20	10	0.4	40	30	-0.3	60	50	-0.1	80	70	-0.3	100	90	-0.6	120	110	-0.1	140	130	-0.5			

Table A-21: Bed elevations of J-spur at 0.30 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	0.1	20	20	-0.6	40	40	-0.5	60	60	-0.8	80	80	-0.4	100	100	0.2	120	120	-1.7	140	140	0.9
0	10	0.3	20	30	0.2	40	50	-0.8	60	70	-0.7	80	90	-2	100	110	-1.5	120	130	-0.4	150	0	-0.8
0	20	0.5	20	40	-0.5	40	60	-0.6	60	80	-0.8	80	100	0.4	100	120	-0.9	120	140	0.3	150	10	-0.2
0	30	0.6	20	50	-0.6	40	70	-0.6	60	90	-0.6	80	110	-2.3	100	130	0.9	130	0	-0.1	150	20	-0.1
0	40	0.4	20	60	-0.6	40	80	0.5	60	100	-1.2	80	120	-0.9	100	140	0.5	130	10	-0.3	150	30	-0.8
0	50	0.7	20	70	-0.6	40	90	-1.5	60	110	-0.8	80	130	1.1	110	0	-0.5	130	20	-0.7	150	40	-0.8
0	60	0.9	20	80	0.3	40	100	0.2	60	120	-0.8	80	140	0.9	110	10	-0.5	130	30	-0.5	150	50	-1.3
0	70	0.8	20	90	-1.1	40	110	-2.1	60	130	0.7	90	0	-0.1	110	20	-0.4	130	40	-2	150	60	0.1
0	80	0.9	20	100	-0.9	40	120	-0.5	60	140	0.9	90	10	-0.3	110	30	-0.8	130	50	-0.7	150	70	-0.7
0	90	0.3	20	110	-0.5	40	130	0.3	70	0	10	90	20	-0.2	110	40	-1.1	130	60	-1.2	150	80	-1.5
0	100	0.4	20	120	-0.6	40	140	0.3	70	10	10	90	30	10	110	50	-0.4	130	70	-0.5	150	90	-0.7
0	110	0.2	20	130	0.3	50	0	-0.8	70	20	10	90	40	-1.5	110	60	-2.1	130	80	-2	150	100	-0.3
0	120	0.4	20	140	0.4	50	10	-1	70	30	10	90	50	-1.6	110	70	-0.1	130	90	-0.3	150	110	-2.1
0	130	0.5	30	0	-0.4	50	20	-2	70	40	-3.2	90	60	-0.4	110	80	-0.8	130	100	-1.7	150	120	-0.6
0	140	0.7	30	10	-0.6	50	30	-2.5	70	50	-3.5	90	70	-0.7	110	90	-0.3	130	110	-0.7	150	130	-0.4
10	0	0.1	30	20	-0.7	50	40	-3	70	60	-0.6	90	80	-1.5	110	100	-1.7	130	120	0.1	150	140	0.2

10	10	-0.1	30	30	-0.4	50	50	-1.2	70	70	-0.5	90	90	-0.8	110	110	-0.7	130	130	0.3	160	0	-0.7
10	20	-0.5	30	40	-0.8	50	60	-0.7	70	80	-3	90	100	0.3	110	120	-0.8	130	140	0.7	160	10	0.1
10	30	-0.3	30	50	-0.7	50	70	-0.3	70	90	-0.7	90	110	0.4	110	130	0.3	140	0	-0.7	160	20	-0.7
10	40	-0.4	30	60	-0.5	50	80	-1.3	70	100	2.2	90	120	-0.7	110	140	0.2	140	10	-0.1	160	30	-0.8
10	50	-0.8	30	70	0.5	50	90	-0.1	70	110	-1.1	90	130	0.5	120	0	-0.3	140	20	-0.8	160	40	-0.1
10	60	-0.8	30	80	-0.7	50	100	-0.2	70	120	-0.7	90	140	0.5	120	10	-0.5	140	30	-0.7	160	50	-0.7
10	70	-0.8	30	90	-0.8	50	110	-0.5	70	130	0.9	100	0	-0.3	120	20	-0.1	140	40	-0.2	160	60	-2
10	80	-1.1	30	100	0.3	50	120	-0.6	70	140	1.1	100	10	-0.2	120	30	-0.5	140	50	-2.1	160	70	-0.5
10	90	-1.2	30	110	-1.1	50	130	0.2	80	0	0	100	20	0.1	120	40	-0.3	140	60	-0.7	160	80	-0.8
10	100	-0.8	30	120	-0.3	50	140	0.5	80	10	-0.5	100	30	-0.5	120	50	-0.1	140	70	-1.1	160	90	-1.1
10	110	-0.5	30	130	0.2	60	0	10	80	20	-0.1	100	40	-0.8	120	60	-1.3	140	80	-1.7	160	100	-0.8
10	120	-0.5	30	140	0.4	60	10	10	80	30	10	100	50	-0.8	120	70	-0.1	140	90	-0.5	160	110	-0.1
10	130	0.5	40	0	-0.5	60	20	10	80	40	-3.6	100	60	-0.4	120	80	-2.1	140	100	-0.5	160	120	-1.5
10	140	0.5	40	10	-0.7	60	30	10	80	50	-2.8	100	70	-0.6	120	90	0.1	140	110	-1.7	160	130	-0.1
20	0	0	40	20	-1.1	60	40	-3.1	80	60	-0.3	100	80	-0.6	120	100	-0.7	140	120	-0.8	160	140	0.3
20	10	-0.5	40	30	-1.2	60	50	-3.1	80	70	-0.8	100	90	-0.8	120	110	-0.5	140	130	-0.4			

Table A-22: Bed elevations of hockey spur at 0.15 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	0.5	20	20	-0.3	40	40	-2.5	60	60	-2	80	80	-0.3	100	100	-0.8	120	120	-0.6	140	140	1.4
0	10	0.3	20	30	-0.3	40	50	-0.5	60	70	-0.5	80	90	-0.7	100	110	-0.1	120	130	0.6	150	0	0.1
0	20	0.2	20	40	0.5	40	60	-0.8	60	80	-1.5	80	100	-0.5	100	120	-0.4	120	140	0.9	150	10	0.3
0	30	0.9	20	50	-0.7	40	70	-0.8	60	90	-3	80	110	-0.7	100	130	-1.5	130	0	-0.2	150	20	-0.1
0	40	0.9	20	60	0.1	40	80	-0.1	60	100	-1.5	80	120	-1.3	100	140	0.3	130	10	-0.1	150	30	-2.7
0	50	0.7	20	70	-1.1	40	90	-0.5	60	110	-1.3	80	130	0.1	110	0	-0.4	130	20	-0.9	150	40	-0.9
0	60	0.9	20	80	-0.5	40	100	-0.7	60	120	-0.4	80	140	1.2	110	10	-0.1	130	30	-0.4	150	50	-1.7
0	70	0.5	20	90	-2	40	110	0.5	60	130	0.7	90	0	-0.6	110	20	-0.3	130	40	-1.1	150	60	-2.7
0	80	0.3	20	100	-0.3	40	120	-0.7	60	140	1	90	10	-0.3	110	30	-0.4	130	50	0.2	150	70	-1.1
0	90	0.5	20	110	-0.4	40	130	0.2	70	0	10	90	20	-0.3	110	40	-1.3	130	60	0.1	150	80	-0.9
0	100	0.7	20	120	-0.4	40	140	0.7	70	10	10	90	30	10	110	50	-0.5	130	70	-1.1	150	90	-2.5
0	110	0.9	20	130	0.2	50	0	-0.5	70	20	10	90	40	-4.5	110	60	0.2	130	80	-3	150	100	-0.8
0	120	0.3	20	140	0.1	50	10	-0.9	70	30	10	90	50	-0.5	110	70	-2.7	130	90	-0.9	150	110	-2.1
0	130	0.2	30	0	-0.3	50	20	-0.4	70	40	-3.5	90	60	-0.7	110	80	-0.5	130	100	-0.6	150	120	-0.8
0	140	0.1	30	10	0.1	50	30	-2.1	70	50	-0.5	90	70	-2	110	90	-0.1	130	110	-1.1	150	130	0.2
10	0	-0.1	30	20	-0.4	50	40	-3.5	70	60	-0.8	90	80	-0.8	110	100	-2.7	130	120	-0.5	150	140	0.5
10	10	-0.1	30	30	-0.8	50	50	0.8	70	70	-1.3	90	90	-1	110	110	-0.8	130	130	0.5			
10	20	-0.1	30	40	0.3	50	60	-1.1	70	80	0.2	90	100	-0.8	110	120	-2	130	140	1.1			
10	30	-0.5	30	50	-0.3	50	70	-0.8	70	90	-0.1	90	110	-0.7	110	130	0.1	140	0	0			
10	40	-0.5	30	60	0.1	50	80	-2.1	70	100	-1.5	90	120	-0.5	110	140	0.2	140	10	0.5			
10	50	-0.1	30	70	-0.3	50	90	-0.8	70	110	0.1	90	130	0	120	0	-0.3	140	20	-0.5			
10	60	-0.4	30	80	-0.6	50	100	-0.3	70	120	-1.1	90	140	-0.1	120	10	0.3	140	30	-0.7			

10	70	-0.1	30	90	-0.7	50	110	-0.7	70	130	0.9	100	0	-0.1	120	20	-0.7	140	40	-0.3			
10	80	-0.3	30	100	-0.3	50	120	-1.1	70	140	1.1	100	10	0	120	30	-0.1	140	50	-3.2			
10	90	-0.5	30	110	-0.8	50	130	0.3	80	0	-0.5	100	20	-0.4	120	40	0.1	140	60	-0.5			
10	100	-0.8	30	120	-1.6	50	140	0.9	80	10	-0.1	100	30	-0.8	120	50	-0.4	140	70	-2.1			
10	110	-0.3	30	130	0.9	60	0	10	80	20	-0.5	100	40	-0.7	120	60	-1.2	140	80	-2			
10	120	-0.1	30	140	0.3	60	10	10	80	30	10	100	50	-0.5	120	70	-0.8	140	90	-0.1			
10	130	-0.1	40	0	-0.4	60	20	10	80	40	-3.5	100	60	-1.3	120	80	-3.5	140	100	-0.5			
10	140	0.3	40	10	0	60	30	10	80	50	-2	100	70	-0.4	120	90	-2.1	140	110	-0.5			
20	0	-0.5	40	20	-0.3	60	40	-2.5	80	60	-0.8	100	80	-0.7	120	100	-2.9	140	120	-0.7			
20	10	-0.2	40	30	0.7	60	50	-4.1	80	70	-1.1	100	90	-2.1	120	110	-0.7	140	130	1.1			

Table A-23: Bed elevations of hockey spur at 0.20 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	1.9	20	20	0.4	40	40	-0.1	60	60	-1.7	80	80	0.4	100	100	0.2	120	120	1.1	140	140	1.9
0	10	1.8	20	30	0.5	40	50	-1.5	60	70	-1	80	90	0.1	100	110	0.7	120	130	1.5	150	0	1.1
0	20	1.3	20	40	1.1	40	60	-1.1	60	80	-0.7	80	100	0.1	100	120	0.3	120	140	1.6	150	10	0.7
0	30	1.5	20	50	0.3	40	70	0.4	60	90	0.1	80	110	-1.6	100	130	0.4	130	0	0.7	150	20	0.3
0	40	1.4	20	60	0.3	40	80	0.2	60	100	-0.2	80	120	0	100	140	1.2	130	10	0.2	150	30	1
0	50	1.3	20	70	0.5	40	90	0.8	60	110	0.1	80	130	0.2	110	0	0.5	130	20	0.1	150	40	0.9
0	60	1.8	20	80	1.2	40	100	-0.3	60	120	0.3	80	140	1.5	110	10	0.3	130	30	0.1	150	50	0.2
0	70	1.9	20	90	0.7	40	110	0.4	60	130	-0.1	90	0	0.3	110	20	-0.1	130	40	0.4	150	60	-0.1
0	80	1.7	20	100	0.5	40	120	0.4	60	140	1.3	90	10	0	110	30	-0.2	130	50	0.2	150	70	0.7
0	90	1.3	20	110	0.4	40	130	0.5	70	0	10	90	20	-0.5	110	40	-0.3	130	60	0.3	150	80	0
0	100	1.8	20	120	1	40	140	2.1	70	10	10	90	30	-0.6	110	50	-0.4	130	70	0.4	150	90	-0.5
0	110	1.3	20	130	0.6	50	0	-1.7	70	20	10	90	40	-1.5	110	60	-0.5	130	80	0.4	150	100	1.2
0	120	1	20	140	1.5	50	10	-1.8	70	30	10	90	50	-1.2	110	70	-0.2	130	90	-0.2	150	110	0.9
0	130	0.8	30	0	1.3	50	20	-2	70	40	-2.2	90	60	-0.2	110	80	0.2	130	100	0.6	150	120	1.4
0	140	1.8	30	10	1	50	30	-2.5	70	50	-2.5	90	70	-1.5	110	90	0.4	130	110	-0.1	150	130	1.3

10	0	1.9	30	20	-0.5	50	40	-3	70	60	0.2	90	80	0.4	110	100	0.7	130	120	1.8	150	140	1.6
10	10	1.7	30	30	0.2	50	50	-2.6	70	70	-1	90	90	-1	110	110	0.9	130	130	1.3	160	0	0.3
10	20	1.4	30	40	1	50	60	-0.6	70	80	0.3	90	100	0.2	110	120	1.8	130	140	1.1	160	10	0.2
10	30	1.2	30	50	-0.5	50	70	-0.3	70	90	0.7	90	110	1	110	130	1.3	140	0	0.8	160	20	0.2
10	40	1.3	30	60	0.2	50	80	-0.5	70	100	0.4	90	120	-0.5	110	140	1.2	140	10	0.4	160	30	1.3
10	50	0.4	30	70	0.7	50	90	-0.5	70	110	0.7	90	130	0.4	120	0	0.3	140	20	0.4	160	40	1.1
10	60	0.4	30	80	0.2	50	100	0.2	70	120	0.2	90	140	1.3	120	10	0.4	140	30	-0.3	160	50	1.8
10	70	0.3	30	90	0.9	50	110	-0.2	70	130	1.2	100	0	0.2	120	20	0.2	140	40	0.5	160	60	0.2
10	80	0.4	30	100	0.4	50	120	0.3	70	140	1.4	100	10	0.5	120	30	-0.3	140	50	0.4	160	70	1.8
10	90	1.2	30	110	0.3	50	130	0.3	80	0	0.5	100	20	-0.1	120	40	-0.2	140	60	-0.3	160	80	0.7
10	100	1.4	30	120	1.2	50	140	1.8	80	10	0.2	100	30	-0.5	120	50	-0.1	140	70	0.2	160	90	0.3
10	110	1.3	30	130	0.6	60	0	10	80	20	10	100	40	-1.6	120	60	-1	140	80	0.5	160	100	0.5
10	120	1.1	30	140	1.4	60	10	10	80	30	10	100	50	-1.7	120	70	0.2	140	90	-0.1	160	110	0.4
10	130	0.5	40	0	1.5	60	20	10	80	40	-2.1	100	60	0.2	120	80	0.5	140	100	0.7	160	120	1.3
10	140	3.3	40	10	-1.1	60	30	10	80	50	-2.2	100	70	-2	120	90	0.7	140	110	0.9	160	130	2.1
20	0	1.3	40	20	-0.8	60	40	-2.3	80	60	0.6	100	80	0.4	120	100	0.9	140	120	1.3	160	140	2.1
20	10	1.3	40	30	-0.2	60	50	-3.3	80	70	0.2	100	90	0.7	120	110	0.3	140	130	1.5			

Table A-24: Bed elevations of hockey spur at 0.30 cusec/m

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
0	0	-0.1	20	20	-0.6	40	40	-0.1	60	60	-0.3	80	80	-0.6	100	100	-0.1	120	120	-0.8	140	140	0
0	10	0.2	20	30	-0.1	40	50	-0.8	60	70	-0.6	80	90	-0.8	100	110	-0.2	120	130	-0.6	150	0	-0.4
0	20	-0.1	20	40	-0.2	40	60	-0.1	60	80	-0.5	80	100	0.1	100	120	-0.1	120	140	0.1	150	10	-0.7
0	30	0.2	20	50	-0.7	40	70	-0.3	60	90	-0.6	80	110	0.3	100	130	0.3	130	0	0	150	20	0.2
0	40	0.3	20	60	-0.4	40	80	-0.4	60	100	-0.8	80	120	-0.3	100	140	0.8	130	10	-0.2	150	30	-0.3
0	50	0.2	20	70	-0.2	40	90	-0.3	60	110	-0.7	80	130	0.3	110	0	-0.3	130	20	0.1	150	40	-0.5
0	60	0.3	20	80	-0.2	40	100	0	60	120	-0.1	80	140	0.2	110	10	-0.3	130	30	-0.5	150	50	-0.6
0	70	0.4	20	90	-0.1	40	110	-0.7	60	130	-0.1	90	0	-0.1	110	20	-0.2	130	40	0.9	150	60	-0.7
0	80	0.8	20	100	-0.3	40	120	0.1	60	140	0.3	90	10	-0.1	110	30	-0.3	130	50	0.5	150	70	-0.1
0	90	0.3	20	110	-0.3	40	130	0.3	70	0	10	90	20	-0.3	110	40	0	130	60	-0.6	150	80	-0.4
0	100	0.2	20	120	0.1	40	140	0.7	70	10	10	90	30	10	110	50	-0.5	130	70	0.1	150	90	-0.4
0	110	0.4	20	130	-0.1	50	0	-0.1	70	20	10	90	40	-0.6	110	60	-0.1	130	80	-0.6	150	100	-0.5
0	120	0.3	20	140	0.4	50	10	-0.4	70	30	10	90	50	-0.1	110	70	-0.2	130	90	-0.6	150	110	-0.4
0	130	0.3	30	0	-0.1	50	20	-0.5	70	40	-1	90	60	-0.1	110	80	-0.4	130	100	-0.6	150	120	-0.7
0	140	0.3	30	10	0.3	50	30	-0.6	70	50	-0.5	90	70	-0.5	110	90	-0.3	130	110	-0.8	150	130	-0.6
10	0	-0.2	30	20	-0.5	50	40	-0.4	70	60	-0.2	90	80	-0.6	110	100	-0.4	130	120	-0.3	150	140	-0.1

10	10	0.3	30	30	-0.3	50	50	-0.3	70	70	-0.1	90	90	-0.3	110	110	-0.1	130	130	-0.3	160	0	-0.5
10	20	-0.3	30	40	-0.1	50	60	-0.2	70	80	-0.6	90	100	-0.1	110	120	2.1	130	140	0.1	160	10	-0.1
10	30	-0.2	30	50	-0.6	50	70	-0.4	70	90	-0.8	90	110	-0.2	110	130	0.5	140	0	-0.3	160	20	-0.2
10	40	-0.1	30	60	-0.3	50	80	-0.1	70	100	-0.6	90	120	-0.1	110	140	0.3	140	10	-0.6	160	30	-0.6
10	50	-0.6	30	70	0.1	50	90	0.3	70	110	-0.7	90	130	0	120	0	-0.1	140	20	-0.1	160	40	-0.7
10	60	0.7	30	80	-0.3	50	100	-0.3	70	120	-0.2	90	140	0.7	120	10	-0.1	140	30	-0.1	160	50	-0.8
10	70	-0.1	30	90	0.1	50	110	-0.4	70	130	0.1	100	0	0	120	20	0.2	140	40	-0.8	160	60	-0.8
10	80	-0.5	30	100	-0.1	50	120	0	70	140	0.3	100	10	0	120	30	-0.4	140	50	-0.3	160	70	-0.6
10	90	-0.6	30	110	-0.5	50	130	0.3	80	0	-0.3	100	20	-0.1	120	40	-0.4	140	60	-0.4	160	80	-0.5
10	100	-0.3	30	120	0.2	50	140	0.3	80	10	-0.2	100	30	-0.8	120	50	0.2	140	70	0.3	160	90	-0.5
10	110	0.6	30	130	-0.3	60	0	10	80	20	-0.6	100	40	-0.6	120	60	-0.4	140	80	-0.3	160	100	-0.3
10	120	-0.7	30	140	0.5	60	10	10	80	30	10	100	50	-0.8	120	70	-0.1	140	90	-0.1	160	110	-0.6
10	130	0.4	40	0	-0.3	60	20	10	80	40	-0.8	100	60	-0.8	120	80	-0.5	140	100	-0.3	160	120	-0.6
10	140	0.3	40	10	0.2	60	30	10	80	50	-0.3	100	70	-0.1	120	90	-0.5	140	110	-0.5	160	130	-0.3
20	0	0.1	40	20	-0.3	60	40	-0.8	80	60	-0.1	100	80	-0.8	120	100	-0.6	140	120	0.6	160	140	-0.2
20	10	0.4	40	30	-0.3	60	50	-0.1	80	70	-0.3	100	90	-0.6	120	110	-0.1	140	130	-0.5			