SEDIMENT TRAP DESIGN:
AN INTERIM REPORT FOR JAY MCCORMACK

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**EXECUTIVE SUMMARY**

In order to conduct research on how sediment reacts in turbulent flow, the existing flume, with an already constructed sediment feeder, must have a way to trap the accumulated sediment on the bed load, be able to continuously weigh the sediment, transport the sediment to the dumpster located in the alley and finally separate the sediment from the water for recirculation. Plates will be used as a stop for the bed load holder. These will be inexpensive and easy to use. A funnel located, after the bed load holder attached to the bottom of the funnel, leads to a three pronged drum which will be rotated and attached load cells will be used to take weight recordings. This solution is based off a working well-designed sediment trap already in use at the University of Minnesota. As the sediment falls from the drum it will settle at the bottom of the funnel. The sediment will be mixed with water into slurry and taken up in a controlled matter by an auger attached to a pipe. A slurry pump will be used to pump the slurry through the pipes to the dumpster. In the dumpster the sediment will be allowed to settle once more and the remaining water with only suspended sediment will be pumped and piped back to the beginning of the flume for recirculation.
# Table of Contents

**Executive Summary** ........................................................................................................... 2  
**Background** ............................................................................................................................ 4  
**Problem Definition** ................................................................................................................. 4  
**Project Plan** ............................................................................................................................. 5  
**Concept Consideration and Selection** .................................................................................... 5  
  - Funnel System ......................................................................................................................... 5  
  - Catchment System .................................................................................................................. 7  
  - Drum Rotation System .......................................................................................................... 9  
  - Sediment Weighing System ................................................................................................. 10  
  - Slurry Removal System ....................................................................................................... 13  
  - Slurry Transportation ............................................................................................................ 14  
  - Separator Subsystem ............................................................................................................ 15  

**Future Work** ........................................................................................................................... 17  
**Appendix** ............................................................................................................................... 17  
**Specifications** ......................................................................................................................... 17  
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BACKGROUND
The Center for Ecohydraulics Research (CER) is located in the Idaho Water Center (IWC) in downtown Boise. The Center for Ecohydraulics Research Stream Laboratory (CERSL) is a 2500 square foot lab located on the first floor of the IWC. The CERSL features a high gradient sediment flume designed in close collaboration with state and federal agencies and several of the major research laboratories in academia. The facility has been carefully designed to fill a current void in laboratory facilities to study the interaction of sediment and turbulence. A combination of operational features makes this facility unique. These include: a steep slope (variable up to 11%), large scale (20m long, 2m wide, and 1.2m deep), and a computer controlled flow, sediment system, and instrumentation system. The maximum water discharge is 1.4 m$^3$/s (or 50 cfs).

The St Anthony Falls Lab at the University of Minnesota has developed a sediment trap concept that is in use at a few flumes (that are different in size from the CERSL flume) around the U.S. It involves a rotating drum that is suspended by load cells. This exact design will not work for the flume at the IWC due to several reasons. The most important of these reasons is it does not account for the variable 11% slope or the size variances of the flume in Boise.

Another concept for sediment removal designed by a current staff member at the IWC describes catching sediment falling off the end of the flume by using baskets. These baskets would then be transported to the waste facilities outside the building. This concept has not been implemented due to its very high operating costs.

PROBLEM DEFINITION
The IWC wants to be able to accurately weigh and remove sediment during experiments with the flume. To do this, we have begun to design, fabricate and test a sediment trap system capable of trapping and weighing sediment that is traveling down the bed of the flume.

NEEDS/SPECIFICATIONS
The purpose of our needs and specification analysis (see appendix) is to determine a set of specifications that our final design will meet. After talking to the customer, the specifications analysis was needed to decode all the information we obtained.

Our needs and specifications analysis is broken into five subsystems: Sediment handling, flume/sediment trap interface, sediment waste, input/output and miscellaneous. Within each subsystem, the needs were prioritized (*, **, *** where *** is the highest priority) based on our conversations with the customer, Ralph Budwig. From each need, one to three specifications have been developed. The priority of each spec was examined when we presented the details to Ralph Budwig.

FUNCTIONAL MODEL
The purpose of the functional model is to show the various systems of the flume their inputs and outputs. The flume system has been split into four subsystems: the flume, the sediment feeder, the sediment trap and the sump. Three input/output categories are examined: Energy, material and input/output. Also, the two subsystems of interest, the flume and the sediment trap, have several of the needs added in. This allows us to link each need to the subsystem and ultimately to link the inputs directly to each need. The flume and sediment trap functional model are shown in Appendix 4.
**PROJECT PLAN**

The sediment trap will be attached to the end of the flume, collecting sediment before the water spills out. A stop or plate will be inserted into the flume to hold and collect the bedload for weighing. The bedload sediment will range in size from less than 1mm to 70 mm. The system must then continuously weigh the sediment with only a brief (less than 10 seconds) interruption while the weighing device is being emptied. The recorded weight measurements will be output in a readable and electronic (voltage) form. After it is measured, the sediment must be removed and disposed of. Throughout this process the flow conditions must remain constant and unchanged. The current sediment system has a computer controlled flow and instrumentation system. Adding a trap will make the flume more versatile and allow for additional uses in the future.

The flume is currently used for environmentally driven research. Using the flume creates opportunities to test water flows under various conditions allowing for increases in our understanding of water flows. The flume is also widely used as an educational tool for teachers such that these teachers can return to their respective schools and pass on knowledge gained from studying the flume. Adding a sediment trap creates new educational tools because it creates a way to conduct cheaper, more efficient studies of many different types. All of which can be housed under one roof with the building of a sediment trap.

Many people stand to benefit from the sediment trap’s construction. Researchers will be able to conduct additional experiments and flow conditions using various soils. More natural stream conditions will soon be created allowing environmentalists and other experts to better understand the environment. Teachers and students have a stake in the sediment trap’s construction because of the learning possibilities it creates. New water flow knowledge can also lead to better waterway construction technologies, and, therefore, people that specialize in waterway design will also benefit.

Throughout the construction of the trap a number of experts have been and will continue to be consulted. The IWC, through Dr. Ralph Budwig and Dr. Klaus Jorde, will be providing information on the operation of the flume and the sediment trap requirements. The University of Minnesota has built a similar trap, and their expertise and knowledge of the inner workings of the trap will be helpful. Jay McCormack and Chris Huck will provide advice and guidance as necessary to keep the project from derailing.

**CONCEPT CONSIDERATION AND SELECTION**

**FUNNEL SYSTEM**

The first system that the sediment encounters is the funnel. The sediment is carried over the bedload holder by the water, and falls to the bottom of the flume. Shortly after the bedload holder, a funnel will direct the sediment to the catchment system. Figure 1 shows a general sketch of the funnel, circled in red. Three ideas were considered for the funnel:

- Parallel walls, both at an angle to the flume (when flume is fully inclined, the funnel is vertical) – Figure 2
- One vertical, one negative slope (vertical when flume is fully inclined) - Figure 3
- Hinge system that keeps the funnel vertical at all times
The first idea, with two parallel walls at an angle to the flume, can be seen below in figure 2. The theory for this idea is that when the flume is flat, the sediment will easily fall down to the catchment system. When the flume inclines to a 5% grade, both walls will be slanted slightly. One benefit of this design is the simplicity. Designing and building the two angled-wall funnel would be easy and not very time consuming. However, the wall that is less vertical when the flume is flat could cause some sediment build up. Also, there is a geometry constraint between the bottom of the flume and the wall under the flume, which may cause a problem with this solution.

The second idea consists of one vertical wall and one inclined wall, as seen in Figure 3. When the flume is inclined, the inclined wall would be vertical, and the vertical wall would be slanted more negative.
Similar to design one, this design would be simple to construct, but wouldn’t have the problem of sediment buildup when the flume is flat. However, the geometry constraint between the flume and the wall still exists for this solution.

The third design would use two vertical walls, but the whole sediment trap system would be on a hinge system. When the flume inclined, the hinges would allow the sediment trap (funnel, catchment etc) to remain vertical.

Unlike the previous two designs, this idea is a little more complex. The hinge system would have to be completely sealed and any piping exiting the sediment trap would have to be able to move. One benefit to this design is that the size constraint between the wall and the flume wouldn’t be as big of a factor. However, the added complexity may not add enough value to justify.

After evaluating the pros and cons of these designs, we decided to pursue the funnel with two slanted walls, as seen in figure 2. An Economic analysis of the funnel is shown in Table 1.

Table 1: Cost analysis for slanted funnel

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>Spec</th>
<th>Dimensions (m)</th>
<th>Quantity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width of Flume</td>
<td>Aluminum</td>
<td>t = 1/4”</td>
<td>?</td>
<td>2</td>
<td>~$40</td>
</tr>
<tr>
<td>Length of Flume</td>
<td>Aluminum</td>
<td>t = 1/4”</td>
<td>?</td>
<td>2</td>
<td>~$40</td>
</tr>
</tbody>
</table>

**Total Cost** ~$80

**CATCHMENT SYSTEM**

After the sediment falls through the funnel, it lands in the catchment system. The purpose of the catchment system is to catch the sediment, so that it can be weighed before exiting the flume. The catchment system is a “drum” shaped series of plates that will catch the sediment until the volume is full or a certain time is reached, and then dumps it. Some sort of rotation system dumps the catchment system. The drum idea was used by the St. Anthony Falls lab and was concluded to be the best option. However, several modifications will be made when applied to our design.

Two different drum geometries were considered for this subsystem, as well as several different methods for rotating the drum. The drum geometries were:

- A three “V” drum
- A four “V” drum
The methods for drum rotation were:

- A “binary” air cylinder – drum only uses two of the three V’s and rotates back and forth
- A motor connected to the shaft through the drum-rotates in 120° increments, uses all V’s
- A rack/pinion gear drive – drum uses two of the V’s and rotates back and forth

Figures 4 and 5 show the three and four V drums, respectively.

![Figure 4: Three “V” Drum](image)

The three V drum is similar to the design used in the St. Anthony Falls lab. Some benefits of this idea are that each catchment can hold a fairly large amount of sediment (0.0838 m³), less material is needed for construction and fewer rotations would be needed per test (less likely to disturb flow and less down time). One issue with the three V drum is that it would take longer to rotate (has to move 120°).

![Figure 5: Four “V” Drum](image)

The four V drum would have the four fins placed 90° to each other. Some benefits to this design are that the load cells wouldn’t have to hold as much weight (greater accuracy) and the construction would be easier than the three V drum. One issue with the four V drum is that it would have to be rotated 33% more often than the three V drum.
**DRUM ROTATION SYSTEM**

The drum rotation methods also were considered in detail. The first idea, a binary air cylinder is the system that the St. Anthony Falls lab uses. Some of the benefits of this system are that it is fairly simple, it has been proven successful and it would involve mainly one system. Some issues with it are that it could get complicated when the flume rotates, and it only utilizes two of the three V’s on the catchment system.

Another drum rotation method that was discussed was using a motor connected to the shaft. The motor would turn on when the shaft needed to rotate and would turn the shaft. Some benefits to this design would be simplicity and easily contained (all in one spot). One issue with this design is that it would need a lot of torque to turn the drum when full of sediment.

The third drum rotation method would use a pneumatic rotary actuator to provide motion to the shaft. The actuator is a rack and pinion system that is powered by compressed air. The benefits to this solution is that it is very compact and can generate rather large amounts of torque.

The fin sizes needed for the V drum are approximately 0.165x2x0.0125 meters. Also, a stress calculation for the shaft was done, which resulted in a shaft diameter of about 0.051 m (2 inches), with a safety factor of about two. The shaft length is approximately 2 meters. The fins on the drum are assumed to be aluminum, and the shaft is steel. The estimated cost for the two solutions is shown in Tables 2 and 3.

### Table 2: Cost analysis for 3 V drum

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>Spec</th>
<th>Dimensions (m)</th>
<th>Quantity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>V-Fin</td>
<td>Aluminum</td>
<td>t = 1/2&quot;</td>
<td>0.165x2</td>
<td>3</td>
<td>$101</td>
</tr>
<tr>
<td>Shaft</td>
<td>Steel</td>
<td>d = 2&quot;</td>
<td>L = 2</td>
<td>1</td>
<td>$57.45</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>$361.45</strong></td>
</tr>
</tbody>
</table>

### Table 3: Cost Analysis for 4 V drum

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>Spec</th>
<th>Dimensions (m)</th>
<th>Quantity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>V-Fin</td>
<td>Aluminum</td>
<td>t = 1/2&quot;</td>
<td>0.165x2</td>
<td>4</td>
<td>$101</td>
</tr>
<tr>
<td>Shaft</td>
<td>Steel</td>
<td>d = 2&quot;</td>
<td>L = 2</td>
<td>1</td>
<td>$57.45</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>$462.45</strong></td>
</tr>
</tbody>
</table>

As table 2 and 3 show, the three V design is more cost effective. Also, it appears the three V drum has more benefits then the four V drum. Based on the cost analysis and benefits/consequences of the designs, the three V design was selected.

The following list portrays the cost comparison between the drum rotation options:

1. **Pneumatic Cylinder:** Costs estimated at $250
   a. $150 for the cylinder
   b. $100 for additional materials for the assembly
2. **Air Powered Motor** costs up to $1000
3. **Pneumatic Rotary Actuator** about $500
The pneumatic rotary actuator is the best choice for this design. While it costs more than the pneumatic cylinder system, the pneumatic rotary actuator has the added benefit of being purchased, not built.

WEIGHING THE SEDIMENT

While the sediment is accumulating in the catchment system, the weight must be recorded. After communications with Ralph Budwig, reviewing the St. Anthony Falls sediment trap design and individual research, the team decided to use load cells to measure the sediment weight. Several design ideas were considered. The first idea, which is similar to the St. Anthony Falls load cell system, is seen in Figure 6.

For this idea, a load cell is located above the flume and connected to the ceiling. Two cables are used to hold up a shaft that runs through the drum underneath the flume. As the sediment falls on the drum, the cables increase in tension and the load cell records the weight. The load cell used in this idea would be a hydraulic load cell or a single point load cell. One plus to this design is the simplicity. It would be relatively easy to attach a load cell to the ceiling, as well as two cables. Also, since the St. Anthony Falls lab uses this design, it is proven successful. However, one concern was the safety hazard associated with the cables. If a cable were to break, it could cause catastrophic damage to the flume and personal working with the flume.

The second idea also used a drum with a shaft running through it. However, instead of a load cell above the flume, this concept had a load cell on each side of the shaft, as seen in Figure 7.
Figure 7: Bending Beam load cells on shaft

The load cells used for this idea would be bending beam load cells. These load cells record the moment that is placed on them and output the weight. The two load cells would be used in series, and the outputs would be added together to get the total weight. One benefit of this design is self-containment; everything involved with weighing is contained underneath the flume in a neat fashion. One concern is that when the flume inclines, (between 0-11% grade) the weight measurement could be skewed. A future prototype will help categorize this problem.

The third design concept is similar to the second, because it is self-contained. This idea would simply be one load cell located underneath the drum, as seen in Figure 8.

Figure 8: Load cell underneath sediment trap

This concept seems to be fairly simple, because it is self-contained and only involves one load cell. However, the geometry for this setup is still unknown.
After reviewing the pros and cons of the designs, both as a team and with the stakeholders in Boise, the load cell configuration was narrowed to two options; the shaft-moment idea, or the load cell beneath the flume. In order to move forward with this decision, a geometry mock-up of the drum and funnel were made. In order to size the load cell, the worst-case scenario needed to be investigated. The max weight that the load cell would see would happen if no water was in the flume (drum wasn’t submerged) and the drum was full of sediment. Although this should never happen, it is possible, thus the load cells need to be able to handle enough weight. In order to calculate this maximum weight, several assumptions were made:

- The drum material is aluminum ($\rho = 2702 \text{ kg/m}^3$)
- The sediment has the density of sand ($\rho = 1515 \text{ kg/m}^3$)
- The shaft is steel ($\rho = 8054 \text{ kg/m}^3$, L=2 m, d = 0.051 m (2 in))
- The load cell can withstand 150% max without permanent damage

Calculations were made in EES, and a maximum weight of $W_{\text{max}} = 267 \text{ kg}$ was found. The calculations can be found in Appendix 2.

Another important parameter that was needed was the maximum weight when the fully loaded drum is submerged in water. Archimedes principle was applied to the drum as a function of water depth. When the drum (full of sediment) was fully submerged, the apparent weight of the drum and sediment was 214 kg, or about 53 kg less then out of water. This buoyancy calculation was done assuming an average density (aluminum, steel and sediment). The calculations can be found in Appendix 3.

After finding the maximum weight of the drum and sediment system, as well as the submerged weight, a load cell capacity could be selected and a cost analysis could be performed. From the maximum weight, a load cell capacity of 200 kg was selected. This means that the maximum load the load cell can withstand without permanent damage is 300 kg (150%*maximum weight). Also, the uncertainty of this load cell will be within 0.5 N if the measurement is less then 254 kg (0.02% FSO). Tables 4 and 5 show the cost analysis for a two-load cell setup and a one-load cell setup, respectively.

Table 4: Two-Load Cell Setup Cost Analysis

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 kg LC</td>
<td>2</td>
<td>$210</td>
</tr>
<tr>
<td>Summing Box</td>
<td>1</td>
<td>$225</td>
</tr>
<tr>
<td>Visual Indicator</td>
<td>1</td>
<td>$425</td>
</tr>
<tr>
<td>Cable</td>
<td>20 ft (estimate)</td>
<td>$20</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td><strong>$1,090</strong></td>
</tr>
</tbody>
</table>

Table 5: One-Load Cell Setup Cost Analysis

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 kg LC</td>
<td>1</td>
<td>$210</td>
</tr>
<tr>
<td>Visual Indicator</td>
<td>1</td>
<td>$425</td>
</tr>
<tr>
<td>Cable</td>
<td>20 ft?</td>
<td>$20</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td><strong>$655</strong></td>
</tr>
</tbody>
</table>

From the cost analysis, it is obvious that the one-load cell setup is significantly more cost effective. However, the geometry of this solution may present a problem and is yet to be determined.
Based on the geometry of the system, the two-load cell setup was chosen. One 100 kg single point load cells will be placed at each end of the shaft running through the drum.

**SLURRY REMOVAL**

As sediment piles up at the bottom of the trap after dropping from the drum, it will become necessary to remove it without stopping or altering flume conditions. The method for removal will need to be able to remove sediment as quickly as it is coming in, or no less than two kilograms per second. It also should be cost effective, lightweight and easy to use and maintain.

While several ideas have been considered, only two practical solutions for this system were developed. The first one involves implementing a simple pipe drain at the bottom of the trap. The second one would use an auger to constantly feed sediment into a pipe where it could be pumped away.

The pipe drain solution would use gravity to pull the sediment into a pipe at the bottom of the trap. The trap bottom would have to be built with a funnel design so that the sediment would all tumble down into the pipe where it could be pumped away. Once it reaches the pipe it will be pumped to the separator using a slurry pump. This design would be simple in all aspects. It uses gravity instead of any moving parts making it cheap to build. The lack of additional parts will also make it lighter weight.

The other option comes from a design used on flumes at the University of Minnesota and Berkley. The design would use an auger to pull sediment from the bottom of the flume up into a pipe mounted at the top of the auger. A sloped bottom would have to be designed so that the auger would interface with the sediment at the lowest point in the trap. Just as in the drain design, this pipe would be in line with a pump to transport the slurry over to the separator. Because of the addition of the auger, this design does not have the simplicity that the drain design has. The auger will create more weight as well as increase the cost of the system. Each solution is diagrammed below.

![Figure 9: Drain Pipe](image1)

![Figure 10: Auger](image2)
After discussing the situation with Chris Ellis and Jim Mullin, we determined it is necessary to use the auger method for slurry removal. In a system with no auger each load of sediment dumped down from above would cause a large clump of sediment particles to hit the drainpipe all at once. This would make it much more likely for some to get stuck in the pipe and clog up the system, causing the trap to fill to the point where it could no longer function properly. In order to clear the clogged pipe the flume would have to be shut down, the piping cleared and the flume started back up again creating an amount of down time unacceptable to the researchers. The auger’s purpose is to provide a constant, manageable amount of sediment to the intake pipe. Without all the sediment coming at the pipe at once the chance of the pipe clogging is greatly diminished.

**AUGER**

In a lot of ways the auger is the centerpiece of this subsystem. The auger we select has to fit within the space allowed by the trap. Based on the other designs the auger will need to have a diameter around 4-6 inches and a length about 3-4 feet long. It will also have to be turned by a motor. Assuming that sediment is entering the trap at two kilograms per minute and that it has a density of 1700-2000 kilograms per cubic meter the motor will have to be able to turn the blade fast enough that it can move .0012 cubic meters per second or nearly twenty gallons per minute of sediment. Since the flume is indoors the motor must not create emission problems. The auger bit will cost between $100 and $200 from most vendors. Motors on the other hand cost much more. Depending on the company, motors will range between $600 and $1800. Additional costs will include materials needed to mount the auger onto the trap and then hold it in place. As a whole the auger will most likely cost in the neighborhood of $1000 to $3000.

**PUMP**

A slurry pump will be needed to transport the sediment. It will need to transport up to 300 gallons per minute of slurry. The maximum amount of sediment in the slurry is 3%, which was found from the most pump manufacturer’s websites. A sediment amount above 3% could jam the pump or the pipes, and could increase wear and tear on them. The pump will need to connect to a 3” piping system. It has been shown in the system built by Berkley that particles in the range of 2.7” in diameter will pass through a 3” pipe at a flow rate of 300 gpm.

**SLURRY TRANSPORT**

Many factors must be considered for slurry transport. These factors include the size and concentration of the solid particles, abrasivity of the slurry, pumping pressures, pipe diameter, reactivity between solids and liquid and surfaces, viscosity of the liquid and the critical velocity. The critical velocity is the velocity the slurry needs to be to prevent settling of solids in the pipe, which could lead to clogging. The factors affecting the settling velocity include the particle size, volumetric concentration of solids, pipe diameter, viscosity of fluid, fluid density, solid setting velocity, and solid density. The pipe wall thickness can be calculated using the maximum design pressure in the pipe, the maximum allowable design stress and allowance for corrosion/erosion.

The specs for our design project include the slurry in the pipes must not go over 3% solids. The pipes must be able to handle a solid particle size of less than 1mm to 70mm. The max discharge of water in the flume is 1.4 m^3/sec with a max flow rate of 30 tons/hr of sediment. The pipes and pump together must be able to handle the transport of the slurry to keep up with the max water and sediment flows.
There are many different types of pipes made for slurry transport. Some of the different types are non ferrous pipes made of polybutylene or polyurethane, there are patents for piping abrasive slurry transport of systems where in the internal surface is uniformly plated with a deposit of chromium which resists abrasion, NK-SL80 abrasion resistant pipe, and others. For our project, typical standard PVC pipe is the cheapest and most applicable. PVC schedule 40 pipe will not corrode and should be used for ambient temperature and low pressure. 3” PVC pipe costs around $5.04/ft and is sold in 10 ft lengths. 4” PVC pipe costs around $5.43/ft.

The Berkley design deals with a flow of 300 gal/min. They use a 3-inch PVC pipe, with a settling velocity of 12 ft/sec. Our design deals with very similar specs. Chris, our University of Minnesota contact, suggested using a broad sweep elbow instead of a 90-degree bend elbow to decrease the amount of energy loss in pipes. There is a 0.5 ft loss in every tight elbow; the broad sweep elbow is only half of that loss.

SEPARATOR SUBSYSTEM

CENTRIFUGAL SEPARATORS

Centrifugal Separators are devices that rely on the velocity of a vortex to exert enough force upon particles suspended in a fluid to move those particles to the outside of the vortex to areas of lower velocity where they can fall out of the fluid. Usually the particles are kept in a small container at the bottom of the separator called the purge tank. This container proceeds to discharge the particles on a timed interval basis leaving the water supply clean and free of sediment.

Centrifugal Separators are typically coupled with other centrifugal separators to ensure the particle separation is efficient. This can be costly when purchasing multiple separators along with the hardware to install them. Typically these devices are used for removing particles in the order of magnitude of microns. The largest separator available for purchase separates particles maxing out at .375 inches.

Though these are very effective at separating particles such as silt and ash, they are not capable of removing the particle sizes required by the Idaho Water Research Center. There would be a high risk of clogging and this could create a potential water hazard.

RECEPTACLE SEPARATION

Another plan is to separate the sediment at the dumpster site located on the wall outside of the research center. In this scenario the slurry will be pumped from the drum directly to the dumpster where the sediment particles will settle out to the bottom of the dumpster, and the water will be pumped from the surface. To do this a floating hose will be placed in the dumpster which will travel back into the research center where it will be connected to a self-priming centrifugal pump. A limit switch will be placed on the end of the floating hose in dumpster that will be used to indicate water levels. When the water level drops, the switch will depress from hitting the sediment on the bottom of the dumpster and will relay a signal to the pump to shut off. A rubber liner must be used in the dumpster to help prevent leaking. This setup is shown in Figure 12 and 13.
Since all of the separation occurs at the dumpster site on the outside of the building this system does not pose any serious water hazard threats if it fails. The components are fairly cheap and reliable as well. The self-priming centrifugal pump is the main expense with a cost ranging from $400 to $1000 depending on the make and model. Self-priming pump is needed because they create and maintain a sufficient vacuum level to draw fluid without external assistance. This would be important so the system can be left to operate without supervision. Self-priming pumps are also capable of pumping when subjected to mixture of water and air. Since the conditions in the dumpster will be unpredictable it is essential that the intake of air does not affect the performance of the pump. There is a possibility of the pump clogging from the intake of a large sediment particle but this can be minimized with the proper pump selection.
The rubber liners are mainly used in pond and waterfall applications and range from roughly $0.59 to $0.70 per sq ft in cost. An average sized dumpster is about 4×8×4 ft which gives an inside surface area of about 128 sq. ft. and costs anywhere from $75 to $100 to completely cover. The liners are made tough with tear and puncture resistant qualities that will allow the liner to be used repeatedly. However they can be torn or punctured but repair is easy and cheap by applying a patch.

A mechanical limit switch is a device that can be used to determine the physical position of an object. Many limit switches utilize a push button for activation. When an object comes into contact with the button it depresses to either turn on or off the circuit through it.

**Future Work**

So far, design decisions have been made regarding the drum, the separation method, the piping, the removal of slurry from the trap, and the method for drum rotation. The drum geometry will have three fins with a geometry of about 12”x78”. The receptacle separator will be used, but it must still go through a detailed design process. We will use PVC schedule 40 piping, but the diameter of the pipe has not been chosen. We will have to use an auger/slurry pump setup to remove sediment from the drum area. The auger’s approximate size will be 4-inch diameter bit 3 feet long. The drum will be rotated with a pneumatic rotary actuator.

During this next month, we will be moving forward with our chosen designs and will perform research and calculations regarding undecided subsystems. We will build a scaled down prototype of the sediment trap out of either wood or metal, depending on the availability of the materials. There will be no labor cost for this operation, since one of us will be assembling it. Also throughout this month, we will be performing the calculations necessary to size the sediment trap, the drum, and the funnel to avoid issues with breaking (both component and flume failure).

Beginning next semester we will start by testing the prototype that will be built. The testing goals are to fully understand how the drum, the funnel, and the load cells will work with each other, helping us identify problems with the design early on. Another component that will be further designed at the beginning of the next semester is the auger, its motor, and its relationship with the trap. Also, a pump has not yet been selected to drive the slurry away from the sediment trap. This design decision should be easy, however, since the specifications of the pump will tie in with the rest of the design. Finally, as of now, the method we plan on using for holding the bedload in place is using a simple piece of wood. It has been impressed that we do not need to over design this system, and so its priority level has decreased slightly.