EVALUATING THE EFFECTIVENESS OF THE SKIMMER VERSUS THE PERFORATED RISER IN SEDIMENTATION BASINS

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(ABSTRACT)

Erosion, transportation, and deposition of sediment into receiving waters can have substantial environmental and economic impacts. Sedimentation basins are a remediation technique used to limit sediment transport from earth disturbance activities. Retention efficiency is used as a measure of a sedimentation basin's effectiveness.

Several factors influence retention efficiency including the type of principal spillway used. The most common spillway is the perforated riser which dewaters the basin throughout its entire vertical profile. However, a relatively new outlet device, the skimmer, has been developed, which dewaters the basin from the water surface.

A laboratory study was conducted to compare the skimmer with the perforated riser for three different soil types and determine if there were any significant differences in the trapping efficiencies of the two outlets. The test basin dewatered over a three hour period. The parameters observed were dewatering rate, effluent sediment concentration, sediment loss rate, and retention efficiency.

The skimmer treatments consistently had higher values of sediment retention efficiencies. A statistical analysis performed on the retention efficiency data showed that retention efficiency was not influenced by any combination of outlet and soil type and that outlet was significant at the 5% level. Overall, the skimmer outperformed the perforated riser for all soil types tested.

Additionally, retention efficiencies were predicted for shorter dewatering times. The results indicated shorter dewatering times may have smaller impacts on the retention efficiency of basins where the skimmer is utilized rather than the perforated riser.

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Introduction

Erosion, transportation, and deposition of sediment are natural processes that have occurred throughout the earth's history. It was not until the first European settlers began to clear forests for farming purposes in the east that soil erosion and sedimentation accelerated in the United States (Brady, 1990). Early American settlers found that the muddy waters caused by soil erosion filled millponds and river channels with silt, increased flooding, covered productive fields with mud, destroyed fish spawning beds, and turned clear deep rivers into shallow muddy channels (Trimble, 1974). Today, the loss of soil from both agricultural and nonagricultural lands is a serious problem throughout the world.

On a mass basis, sediment is the most visible and significant pollutant originating from nonpoint sources. In addition to a deterioration of the aesthetic value of the receiving waters, other effects of soil erosion include a loss of storage capacity in reservoirs and a diminished ability of the remaining subsoil to support plant growth. Furthermore, eroded soil contains nitrogen, phosphorous and other pollutants that, when deposited into receiving waters, can trigger algal blooms that reduce water clarity, deplete oxygen, and lead to fish kills. The economic impacts can be quite substantial with one estimate placed at $6.1 billion (1980 dollars) annually (Clark et al., 1985).

General public recognition of the impact of accelerated erosion problems did not occur until 1930 when H.H. Bennett and associates alerted the federal government to the problem and obtained support for erosion control efforts (Brady, 1990). Since then, a great deal of research has been conducted on reducing accelerated erosion. There are two types of erosion: on-site erosion and boundary erosion. On-site erosion is defined as "the detachment and transport of soil particles" (Jarrett, 1996) and includes splash, sheet, interrill, rill, gully and channel erosion. Boundary erosion is defined as "the movement of soil from one's property and eventually into a stream" (Jarrett, 1996) and is addressed by regulatory legislation.

Remediation techniques are those which "limit sediment transport or enhance sediment removal" (Jarrett, 1996) and are required to remove sediment from runoff to keep it from reaching nearby streams. A common remediation technique geared toward controlling boundary erosion is the sedimentation basin. Sedimentation basins are impoundment structures designed to remove sediment from runoff originating from earth disturbance sites. They provide an opportunity for sediment and other pollutants to settle out before the water is discharged from the site.

Since the early 1970's many studies have investigated the performance of sedimentation basins. These studies have encompassed various aspects of the sedimentation basin's design from wind effects (Rodney and Stefan, 1984) to the most effective designs for sediment removal (Warner and Schwab, 1989; EPA, 1980). An Environmental Protection Agency study (EPA, 1976) and the enactment of the Surface

Mining Control and Reclamation Act (SMCRA) in 1977 served as catalysts for sedimentation basin research throughout the 1970's and early 1980's, however, most of this research focused on the mining industry and basins with permanent pools.

Thereafter, states required or recommended the use of sedimentation basins in urban and construction areas where earth disturbances occurred. However, the fact that most of these basins do not contain permanent pools of water was practically ignored (Jarrett, 1996). Additionally, urban and construction areas constitute the highest short term rates of erosion (Ward et al., 1979b) and commonly result in a 5 to 20 fold increase in the average sediment reaching nearby water bodies (Meybeck et al., 1989). Nevertheless, state regulatory agencies developed rules and procedures for boundary erosion control despite the fact that little research was conducted on the typically dry basins employed at construction sites (Jarrett, 1996).

Most sedimentation basins are initially designed as storm water detention structures and are then modified by adding a temporary perforated riser as an outlet control device. This poor design is presumably due to a lack of understanding of perforated riser hydraulics and typically results in low sediment retention efficiency with a high percentage of total suspended solids passing through the basin (Jarrett, 1996).

Skimmers, or floating risers, have recently been introduced as a means of sedimentation basin drawdown. These outlet devices have been shown to produce higher sediment trapping efficiencies (Millen et al., 1996) and finer effluent particle size distributions (Ehrhart, 1996) than the traditional perforated riser. However, due to the fact that this apparatus is new, there is still a need for further research.

Objectives

The overall goal of this research is to evaluate the effectiveness of the skimmer in improving sediment trapping efficiency. Specific objectives include:

1. conduct a laboratory study to compare the effectiveness of the skimmer and the conventional perforated riser for a range of soil types;
2. determine if there is a significant difference in the performance of the two outlets for different soil types.

Literature Review

A wealth of studies has been published regarding sedimentation basin design and methods to improve trapping efficiencies. The following discussion addresses several issues concerning sedimentation ponds including basin settling theory and general regulations. Also included are factors affecting the performance of sedimentation basins.

Sedimentation Basin Settling Theory and Design

Sediment basins temporarily store sediment laden runoff from earth disturbance sites and thereby retain and remove sediment. In addition to acting as sediment control measures, sediment ponds must also meet stability, safety and flood control requirements (Ward et al., 1979a).

Many measures can be used to determine the effectiveness of a sedimentation basin including trapping or retention efficiency, average effluent concentration, peak effluent concentration and peak effluent settleable solids (Barfield et al., 1985). The most common and perhaps the easiest parameter to determine, trapping efficiency, is represented by the following equation:

$$E = \frac{S_{in} - S_{out}}{S_{in}} \qquad (1)$$

where E is the trapping efficiency (%), S_{in} is the influent sediment mass, and S_{out} is the effluent sediment mass. The effluent concentration, whether it be average or peak, considers all particle sizes. It tends to be the most difficult factor to predict because a small error in predicted trapping efficiency can have a large impact on predicted effluent concentration (Haan et al., 1994).

Total suspended solids (TSS) include settleable solids and non-settleable solids. Settleable solids are those which settle out according to the Stokes' equation (Jarrett, 1996) while non-settleable solids include those that remain in suspension due to Brownian motion (Haan et al., 1994). Non-settleable solids are less than 0.1 μm in diameter (Geankoplis, 1983; Peavy et al., 1985).

Sedimentation basin settling theory generally follows Stokes’ law (Eqn. 2) and assumes free or ideal settling where soil particles fall independent of each other, are round in shape and have relatively uniform specific gravities (Goldman et al., 1986).

$$v_s = \frac{g(\rho_s - \rho)d^2}{18\mu} \qquad (2)$$

v_s = settling velocity (m/sec)
g = gravitational acceleration (m/sec^2)

ρ_s = particle density (kg/m^3)
ρ = fluid density (kg/m^3)
d = particle diameter (m)
μ = dynamic viscosity (Pa·sec)

Stokes' law applies to spherical particles moving under laminar flow conditions. According to this theory, a particle will settle in the vertical direction and accelerate to a constant velocity known as the settling velocity.

In designing a sedimentation basin, the settling velocity of the smallest particle that is desired to be removed is first chosen, and in theory, any particle with a greater settling velocity will be removed. Next, a ratio known as the overflow rate must be calculated. This is done by dividing the desired trapping efficiency by the settling velocity of the smallest particle to be removed. Once the overflow rate is known, equation 3 is used to determine the surface area of the basin (JMM, Inc., 1985).

$$v_{of} = \frac{Q}{A_s} \qquad (3)$$

V_{of}= overflow rate (m/day)
Q = basin inflow rate (m^3/day)
A_s = basin surface area (m^2)

Regulations

The two methods of prescribing the effluent water quality of sedimentation basins are performance standards and hydraulic standards. Performance standards involve criterion for effluent concentrations while hydraulic standards concentrate on basin design specifications based on the drainage area (Jarrett, 1996). On the federal level, the Surface Mining Control and Reclamation Act (SMCRA, 1977) was instrumental in the development of sedimentation basin effluent criteria. Although SMCRA applied to mining activities, many states, including Virginia, have since set guidelines of their own to minimize accelerated erosion from non-mining earth disturbance sites. Virginia regulations are based primarily on basin capacity. The design storage capacity must be at least 253 m^3 per hectare (134 yd^3 per acre) of total contributing drainage area with the lower 126.5 m^3 of storage in the form of a permanent pool and the upper 126.5 m^3 of storage serving as drawdown volume. Sediment should be removed from the basin when the volume of the permanent pool is reduced by one half, or 63.75 m^3 (VDCR, 1992). Additionally, Virginia requires erosion and sediment control plans for all urban land disturbance activities (VDCR, 1992). The purpose of the plans is to describe the potential for erosion and sedimentation on the project and to illustrate and explain measures to control such problems.

Factors Affecting Basin Performance

The ideal sedimentation basin is rarely encountered. Trapping efficiency is generally calculated based on certain design requirements which may never occur. When actual flow through the basin is greater than the design value, reduced retention efficiency can result (Goldman et al., 1986). Bonta and Hamon (1980) determined that a low intensity long duration storm decreased the trapping efficiency by 17.5%. Bondurant et al. (1975) found that higher flow rates improved basin trapping efficiency. This was attributed to the fact that at lower flow rates, coarser particles were deposited in approach channels and the resulting influent to the basin was finer particles that moved through the basin without settling. At higher flow rates, coarser particles were transported to the basin where they settled out.

Under ideal conditions, the assumption regarding detention time states that the longer the sediment laden water is detained, the higher the trapping efficiency. McBurnie et al. (1990), using the SEDIMOT II hydrology/sedimentology model, found that for detention times less than six hours there was a rapid increase in the trapping efficiency as time progressed, however, for detention times greater than six hours trapping efficiencies only slightly increased with time. Reinforcing this research, Ehrhart (1996) found that increasing detention time from six hours to seven days only resulted in retention efficiency increases ranging from 5.6% to 13.1% depending on the type of outlet device used. A study by the EPA (1976) recommends a detention time of at least ten hours in surface mine sedimentation basins in order to achieve a suspended solids removal efficiency of approximately ninety percent.

McBurnie et al. (1990) also determined that detention time alone is not necessarily an effective design standard due to the fact that other parameters, such as surface area, can influence the trapping efficiency. The EPA (1976) and Goldman et al. (1986) also noted that surface area plays an important part in determining trapping efficiency. Assuming ideal settling conditions and trapping efficiency to be a function of the particle size distribution of the inflowing sediment, Goldman et al. (1986) reported that the only practical way to increase retention efficiency is to increase the surface area of the basin.

Other physical features, such as reservoir shape, can affect the performance of the basin. Basin effective length to width ratios should be greater than 2:1 to minimize dead storage (Barfield et al., 1985). Dead storage includes areas of the basin where water and suspended sediment occupy but do not effectively mix with other portions of the basin. It can be best visualized as a portion of the pond volume that is bypassed entirely by incoming flow. While estimation of dead storage is difficult, dye tracer studies are typically used in the analyses. Griffin et al. (1985) used tracer tests and reactor models to show that ponds with length to width ratios less than 2:1 had approximately 10% more dead storage than those ponds with length to width ratios of 2:1 or greater. Short circuiting, or the flow of water through the pond from inlet to outlet in a straight line fashion, can also affect basin efficiency. There are several factors that can contribute to short circuiting including poor pond geometry, failure to remove accumulated sediment from the pond, multiple inlets and high inlet velocities (EPA, 1980; Estep-Johnson et al., 1988). Baffles can be used to prevent short circuiting, dissipate inlet velocity and decrease dead storage.

Stokes' law is dependent upon the viscosity of the fluid which is temperature dependent. The EPA (1980) showed that the settling velocity of a particle decreased by 44% with a temperature decrease of 20°C. Furthermore, uneven heating of the basin by sunlight was found to influence short circuiting.

Wind also affects trapping efficiency. Basins with shallow beaches and large, open water surfaces are more susceptible to particle (less than 10 μm) resuspension by wave action. Wind effects should be considered when mean seasonal wind speeds exceed 3 m/s, however, the effects decline as side slopes become steeper (Rodney and Stefan, 1984). Goldman et al. (1986) suggest combating the wind effects by placing several smaller basins with the capacity of one large basin in parallel.

The dewatering method can also affect trapping efficiency. Gravitational dewatering is the cheapest and most preferred method of dewatering a basin (Jarrett, 1996). However, Ward et al. (1980) found that to meet water quality standards, either flocculating agents or increased detention time (greater than 24 hours) were required in basins where more than 20% of the sediment inflow contains particles finer than 20 µm. The EPA (1980) recommended using chemical coagulants to achieve sufficient suspended solids removal when the influent particle size distribution contains high percentages of silt and clay. They add that the removal of colloidal particles from suspension using coagulants is dependent upon certain water characteristics such as pH and temperature. However, since water characteristics are not typically controlled, chemical coagulants do not lend themselves to use in sedimentation basins found at urban development and construction sites.

Several dewatering configurations have been designed including a floating weir which dewaters the pond from the surface (Adler, 1981) and a swirl concentrator which uses centrifugal force to separate sediment from the incoming flow (Warner and Dysart, 1983). Although both methods present several advantages, neither has gained popularity. Conventional principal spillway designs include drop inlets, perforated risers, siphons, multi-stage outlets and trickle tubes.

The most practical spillway for urban development and construction sites is the perforated riser. The primary drawback of the perforated riser, however, is its overdesign. With no standard design criteria, there is often rapid dewatering and therefore inadequate sediment removal. Also, the lack of design standards makes comparing perforated risers from one basin to another difficult. Ward et al. (1979b) showed that trapping efficiency can be affected by spacing, size and location of the perforations on the riser. Jarrett (1993) derived a design and analysis procedure, based on a linear stage-storage relationship in the water storage zone of the basin, to evaluate dewatering of perforated riser controlled sedimentation basins.

Filters at the basin outlet are another tool used to reduce effluent concentrations, however, they have drawbacks. Poe and Betson (1985) noted a case where sediment laden water got inside a filter fabric and sent an initial flush of high suspended sediment out of the basin. Fisher and Jarrett (1984) tested six filter fabrics and found that they all removed sand particles while varying degrees of retention ability were found for each fabric exposed to coarse silt particles. However, most of the fabrics tested could not retain silt clay particles (less than 37 μm or 400 mesh). Another problem associated with filter fabrics is the increased dewatering time due to the soil accumulating on the filter. Engle and Jarrett (1990) investigated four principal spillway riser configurations. Although the best sediment removal was from a perforated riser wrapped with a filter fabric, the extended dewatering time created a need for a larger basin in order to accommodate any subsequent runoff events. Gravel filters and expanded polystyrene chip filters, on the other hand, have been shown to be effective measures for increasing sediment retention without extending dewatering time (Engle and Jarrett, 1991; 1995).

Other sedimentation basin spillways have been researched including the single orifice and siphon tubes. The single orifice was found to have less total sediment loss than the perforated riser (Fennessey and Jarrett, 1993). This was attributed to the differences in outflow hydrographs of each of the spillways. Furthermore, it was concluded that the single orifice was slightly more susceptible to the effects of resuspension. Siphons have also performed well in sedimentation basins. Warner and Schwab (1989) compared a perforated riser, a drop inlet and two types of siphons using the Sediment, Erosion, Discharge by Computer Aided Design (SEDCAD+) model. The perforated riser and siphon tubes consistently performed better than the drop inlet by increasing trapping efficiency and reducing the peak discharge, stage and effluent sediment concentration. Both siphons had slightly higher trapping efficiencies and lower peak sediment concentrations than the perforated riser. On surface mined sedimentation ponds the EPA (1976) recommends using a siphon instead of a perforated riser for two reasons: there are no perforations for sediment to escape through as the pond fills and to aid in sediment removal during basin cleanout.

Skimmers, or floating risers, are a relatively new type of outlet device currently being researched. Skimmers float on the surface of the water and, in theory, discharge the highest quality water from the less turbid top of the basin while allowing the lower portions with higher sediment concentrations to remain still, thereby preventing resuspension. The first test on skimmers, although an informal experiment, proved these devices had potential for improving basin performance (Faircloth, 1995). Changes have since been made to the floating riser and other formal research efforts have been made on the improved design.

Millen et al. (1996) tested skimmers against perforated risers, each with and without baffles, and found that skimmers had higher trapping efficiencies in both cases. The addition of baffles was found to actually decrease the performance of the skimmer with a retention efficiency of 0.3% lower than without baffles. All four treatments retained all particles greater than 75 µm. Millen et al. (1997) expanded this study by redistributing the particle size distributions to include only particles smaller than 75µm. The resulting effluent particle size distributions were strongly related to influent particle size distribution and showed little variability among the four treatments. The skimmer did not remove larger particles towards the end of the dewatering period as well as the perforated riser. The skimmer also showed a tendency to remove slightly larger particles during the influent period.

Ehrhart (1996) found that increasing the detention time from six hours to seven days resulted in a finer effluent particle size distribution when skimmers were used while effluent particle size distribution was not affected in the case of the perforated riser. Regardless of detention time, skimmers had higher trapping efficiencies than perforated risers.

Summary

A review of the literature has revealed that there are several factors affecting sedimentation basin performance. Although a great deal of emphasis has been placed on the principal spillway, there is still a need for continued research in this area. Lack of standard design criteria, coupled with differences in eroded particle size distribution and runoff hydrographs from one basin to the next, make comparative evaluations between spillways at different sites difficult. Much of the design work relies on the judgment and experience of the designer as opposed to experimental evidence.

Methodology

The experiment was conducted as a two-factor factorial, completely randomized design, with three replications, two levels of the outlet factor and three levels of the soil type factor. Each replication consisted of filling a tank with 1390 L of tap water obtained from the Blacksburg, VA Municipal Water System. Thirty-five kilograms (dry weight) of soil was added to the tank and allowed to soak for fourteen hours in an attempt to break up the smaller aggregates. At the start of each run, the sediment and the water were stirred with paddles to mix and suspend as much sediment as possible.

Over a three hour period the upper 695 L, the 'dry storage' volume, was dewatered through one of two 2.54 cm (1 in) diameter holes in the bottom of the tank (one hole remained plugged while the other was in use). The lower 695 L, the 'wet storage' volume, served as a permanent pool. The dewatering process was controlled by either a skimmer or a perforated riser.

Each combination of outlet and soil type was tested for its effect on the dewatering rate, sediment concentration of the effluent, sediment loss rate, overall retention efficiency, particle size distribution of sediment in the influent and effluent, and retention efficiency of individual particle sizes.

Sedimentation Basin

A 1590 L flat bottomed, straight walled, tank was constructed of 1.91 cm (0.75 in) thick plywood and used as a laboratory scale sedimentation basin (Figure 1). The tank sat in an angle iron frame 0.76 m (21 in) off the ground and its shape was rectangular with a length of 2.39 m (94 in), a width of 1.09 m (43 in) and a depth of 0.61 m (24 in). The basin's volume was approximately 1/200th of that required by Virginia standards for a 1.21 ha (3 ac) site.

The basin was constructed to account for changing outlet devices by drilling two holes in the bottom of the tank. The first hole (center drain) was centered 1.17 m (46 in) along the length of the tank and the second hole (end drain) was centered 2.24 m (88 in) along the length of the tank. During each run, one drain remained closed while an outlet device was connected at the other drain.

The skimmer connected at the center drain and extended along the length of the tank such that the orifice of the skimmer was at a point approximately 0.15 m (6 in) from the end of the tank. The perforated riser connected at the end drain. The basin was designed with this configuration to ensure that both outlets would drain the basin from

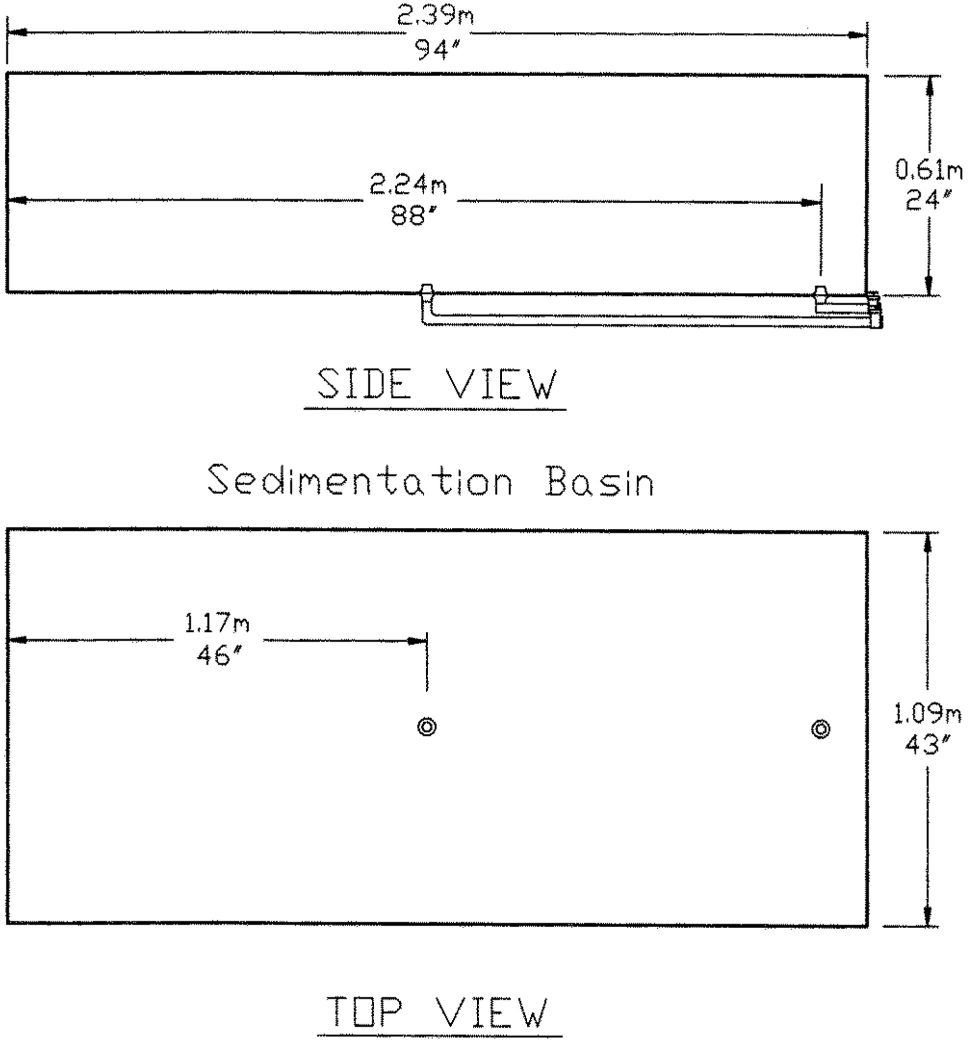

Figure 1: Schematic of sedimentation basin

the same point (0.15 m from the end of the tank) and to maintain the 2:1 length to width ratio necessary for reducing dead storage.

On the underside of the basin, pipes connected into the bottom of each drain. Gate valves at the end of the pipes were fully opened to start the run and closed at the completion of the run. Sitting on the ground under the basin, was a receiving tank. This tank was used to catch the effluent leaving the sedimentation basin (Figure 2).

Outlet Devices

The first outlet device, the perforated riser, is shown in Figure 3. It was designed according to Virginia standards (VDCR, 1992) to dewater the dry storage volume of the tank in three hours and was fixed in the end drain described above. It consisted of a 2.54 cm (1 in) diameter, 0.61 m (24 in) long, schedule 40 PVC pipe with six columns of 8.33 mm (21/64 in) diameter perforations spaced vertically every 88.9 mm (3.5 in). The center of the lowest perforation was placed 0.27 m (10.5 in) above the bottom of the tank to establish the permanent pool. At the end of the pipe (connected into end drain under basin) a 6.75 mm (17/64 in) orifice controlled the dewatering. The perforations in the riser and the orifice at the outlet were sized according to the orifice equation below (Eqn. 4) such that when the water level in the basin was at the top of the lowest row of perforations, the orifice would still control the flow.

$$Q = cA\sqrt{2gh} \tag{4}$$

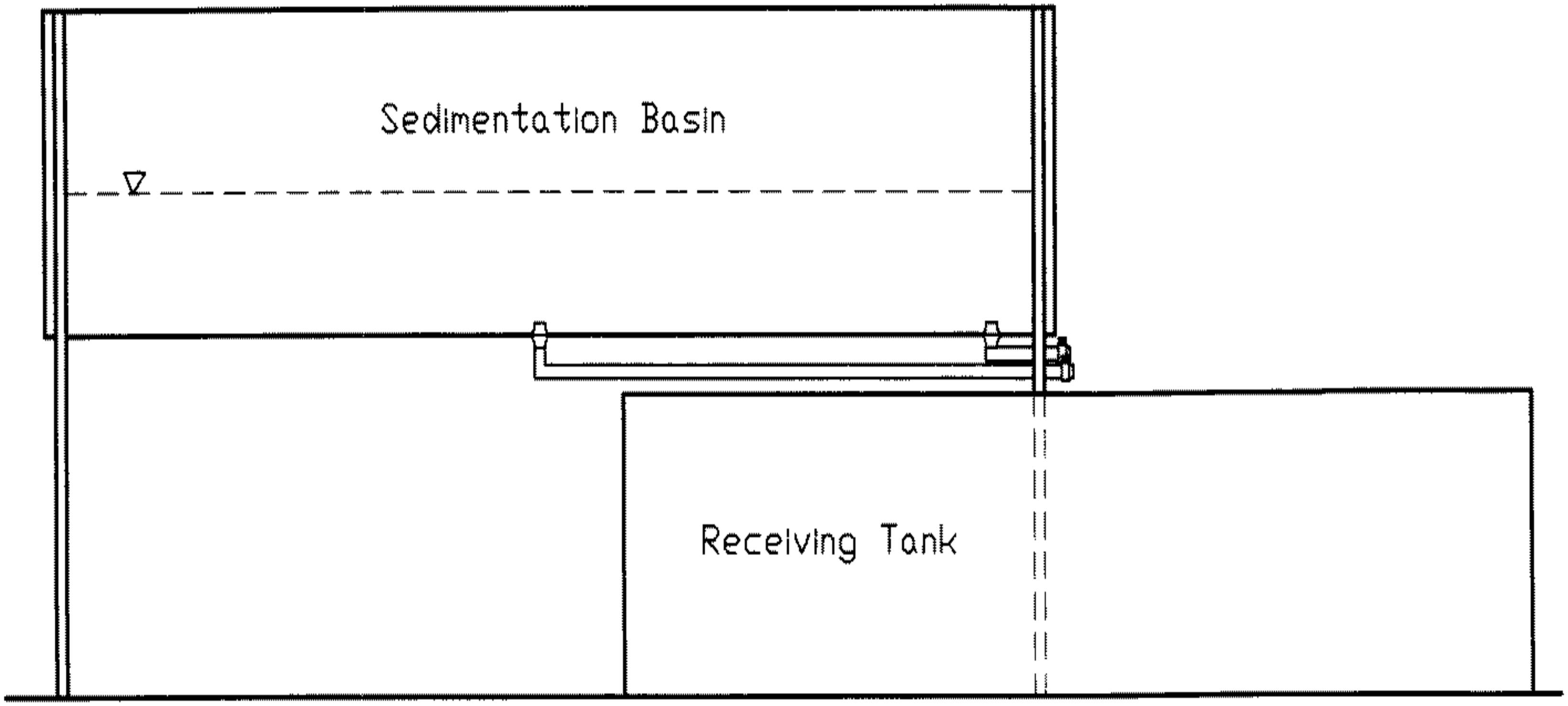

Figure 2: Schematic of sedimentation basin with receiving tank

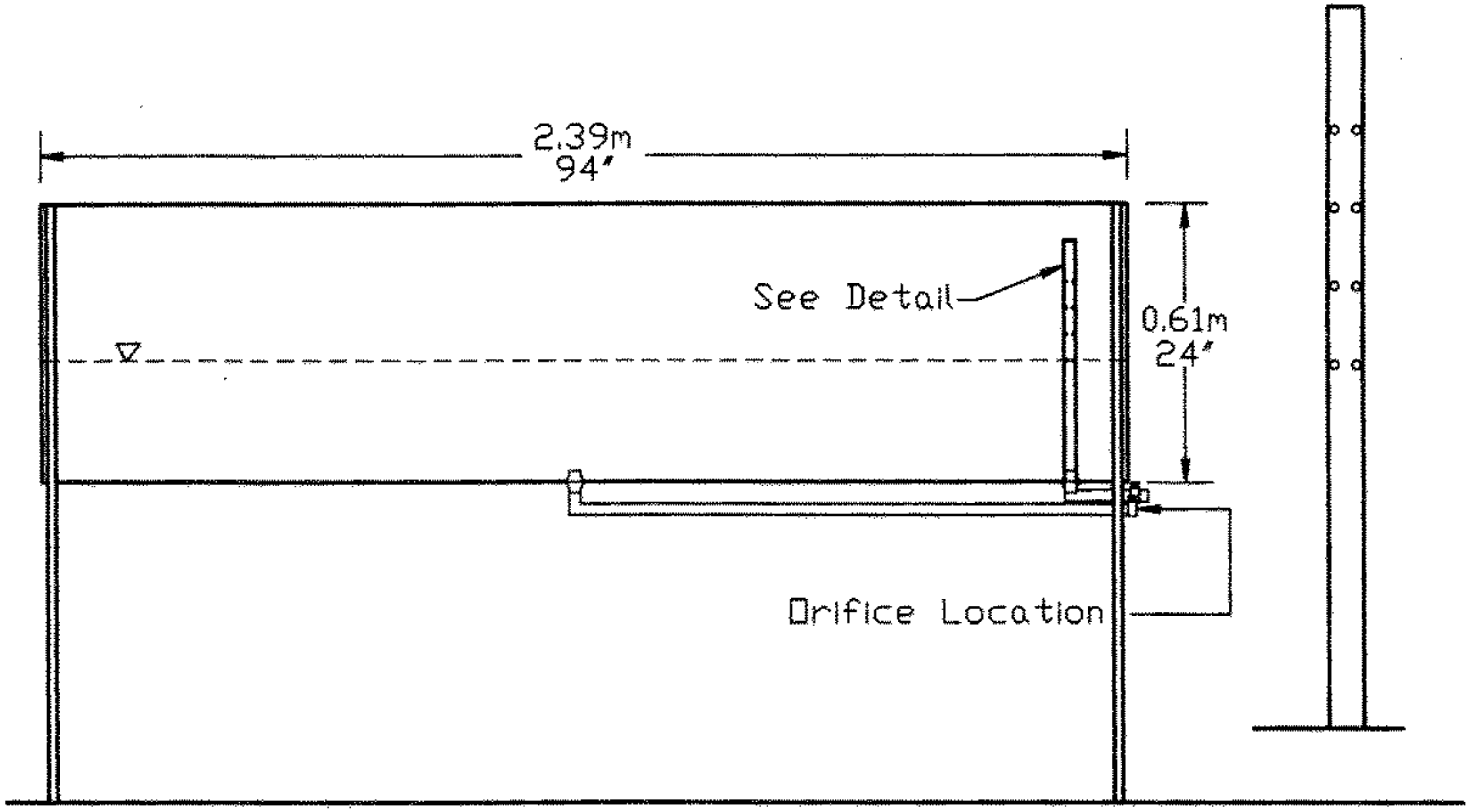

Figure 3: Experimental perforated riser

Q = dewatering rate (m^3/sec)
c = orifice coefficient
g = gravitational acceleration (m/sec^2)
h = head on orifice (m)
d = diameter of orifice (m)

The second outlet device, shown in Figure 4, was the skimmer, or floating riser. The flow of water through the skimmer was controlled by an orifice located at the top of the skimmer arm, therefore the equation for a submerged orifice was used to determine the proper head on the orifice to dewater the dry storage in three hours. An orifice coefficient of 0.84 was determined based on actual tests of the skimmer with a constant head of 5.08 cm (2 in) above a 1.19 cm (15/32 in) skimmer orifice. Once this orifice coefficient had been calculated, the necessary dewatering rate to drain the tank in three hours was determined. Since the head on the skimmer orifice was constant, the dewatering rate was also constant. Therefore, the dewatering volume (695 L) was divided by the dewatering time (3 hours) to obtain the necessary dewatering rate (3.86 L/min). With the dewatering rate and orifice coefficients determined, equation 4 was used to calculate the head on the 1.19 cm orifice. This head was calculated to be 2.54 cm.

The skimmer was constructed of 3.81 cm (1.5 in) schedule 40 PVC pipe. The skimmer arm was attached under the C-enclosure using two conduit clamps. Tightening the bolts through the conduit clamps prevented the skimmer arm and the C-enclosure from moving separately and therefore allowed the orifice to be submerged and achieve the desired head.

With Faircloth's original design (Figure 5), the skimmer arm extended almost all of the way to the outlet and there was a small piece of flexible tubing connecting the skimmer arm to the outlet. The buoyant forces on the skimmer arm necessitated the

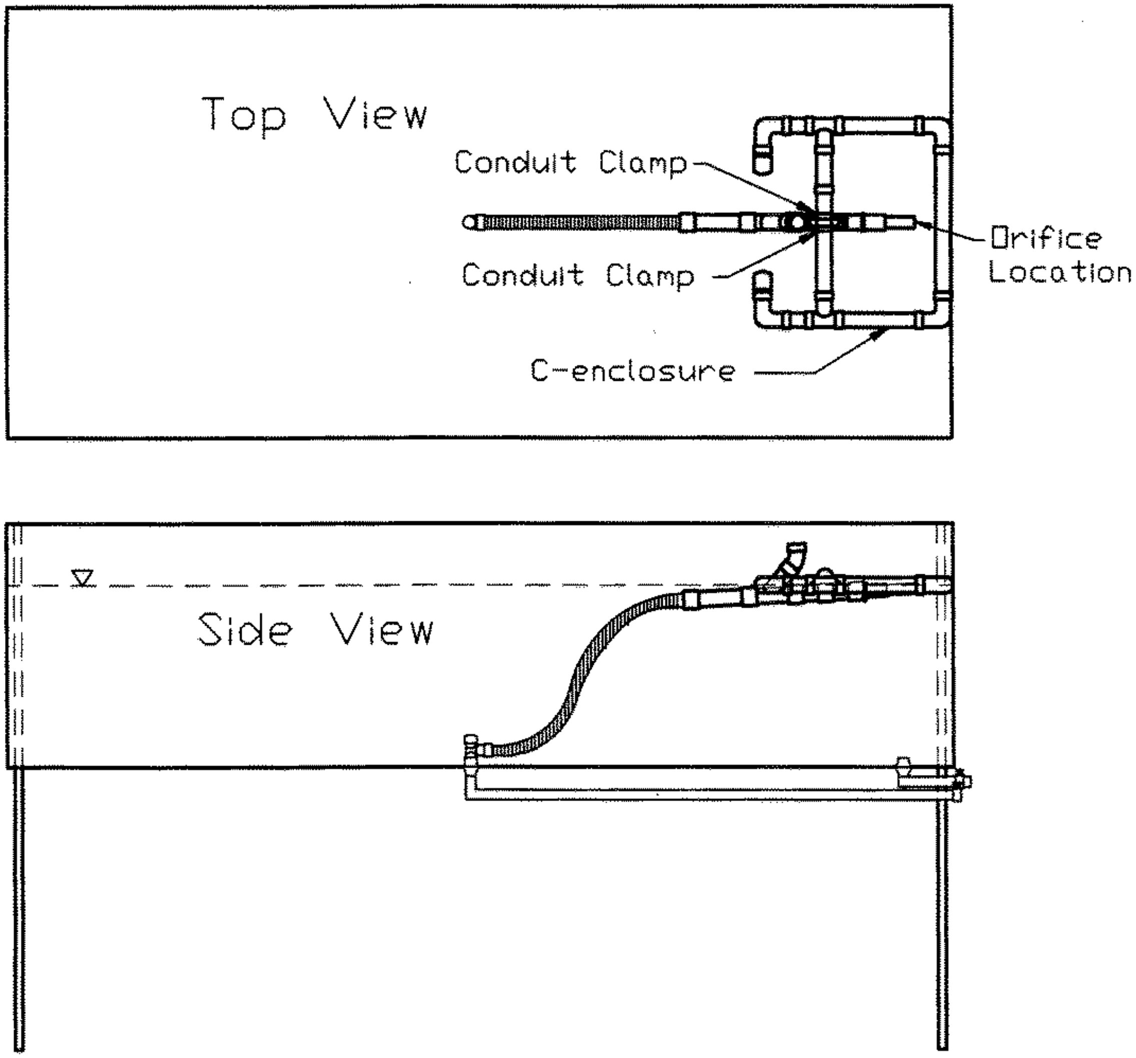

Figure 4: Experimental skimmer

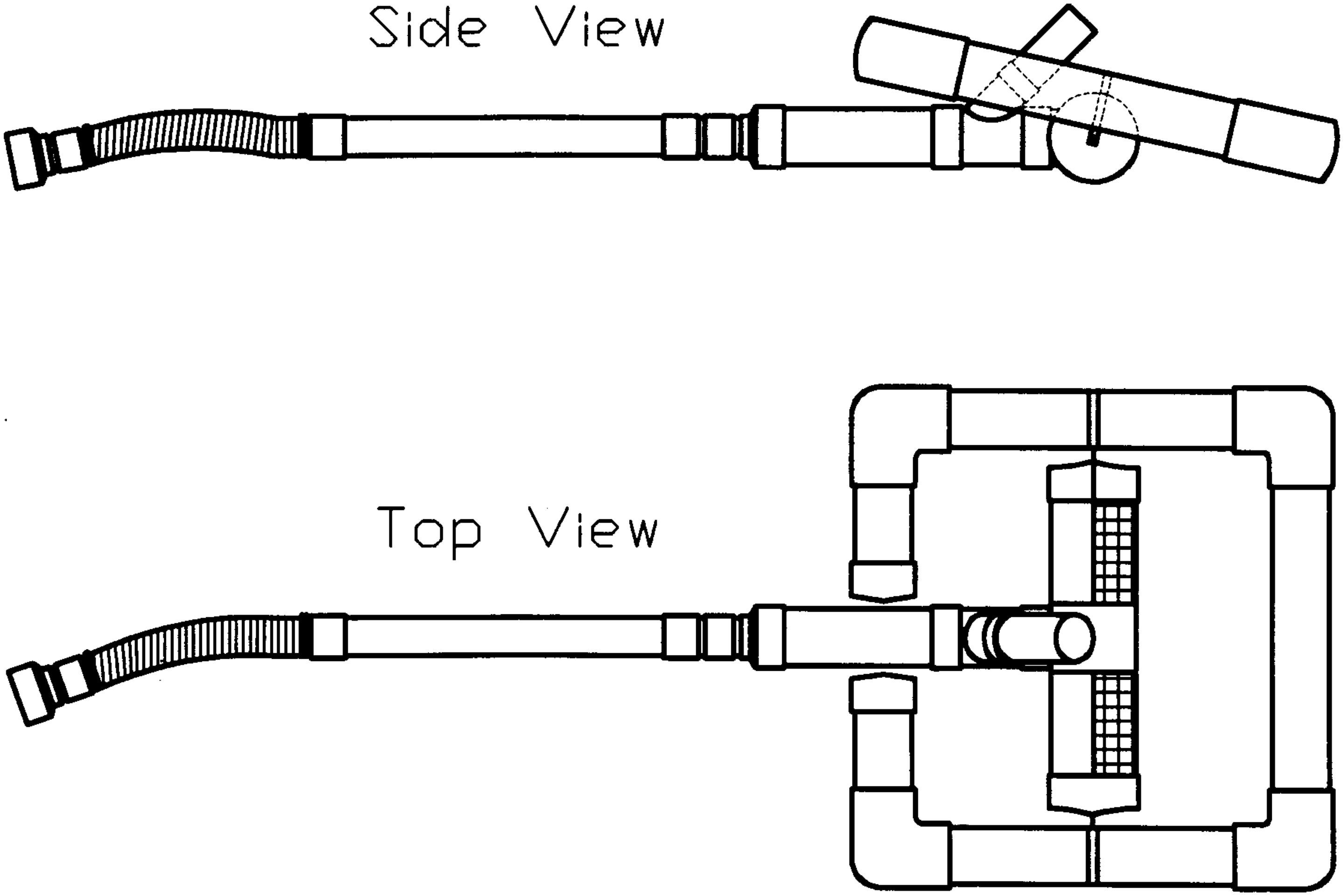

Figure 5: Faircloth's skimmer design

need for the C-enclosure to weigh the skimmer arm down and thereby keep the orifice submerged. However, the modified skimmer used in this study had a very short skimmer arm and a long piece of lightweight flexible tubing, therefore the buoyant forces were not as great on the skimmer arm. Instead of using the C-enclosure to weigh the skimmer down, as with Faircloth's design, the modified skimmer floated on the water surface primarily due to the buoyant forces on the water tight C-enclosure. In addition, the C-enclosure in Faricloth's design also served to keep floating trash from obstructing the screen on the horizontal pipe. This was not as important with the modified design as trash was not present in the experiment.

A 3.81 cm (1.5 in) diameter, schedule 40 PVC wye connected to the skimmer arm and pointed upward. This wye was used to prevent suction in the skimmer arm, ensuring that the orifice would control the flow. The skimmer arm had a 3.81 cm diameter piece of flexible tubing attached to it to allow the floating riser to move up and down as the water level changed. This tubing was attached to a 3.81 cm diameter, schedule 40 PVC tee at a point below the permanent pool level. Water flowed through the tee and out through the center drain in the bottom of the tank. When the water level in the tank reached the permanent pool level, a valve was closed and the flow of water stopped.

Soil Types

Three different soil types, each with a different particle size distribution, were selected to represent soils from three of the physiographic regions in Virginia. The soil selected to be representative of the Coastal Plains region was a Suffolk loam (8.0% clay, 39.7% silt, 52.3% sand). The Piedmont soil was a Davidson silty clay loam (37.5% clay, 45.3% silt, 17.2% sand), and a Groseclose silt loam (11.6% clay, 58.3% silt, 30.1% sand) was chosen to represent the Mountain and Valley region. The particle sizes were categorized according to the USDA particle size classification system as found in Brady (1990). Additional details regarding the three soil types are provided in Appendix A.

The Suffolk and Davidson soils were from fields with a corn/soybean crop rotation. The sites were located on knolls that were more eroded than the surrounding areas. The Groseclose was from a fallow field. This site had had the top 10-15 cm of soil removed in a previous study. After a light raking to remove vegetative matter from the surface, all of the soils were obtained from the top 6-8 cm (B horizon). This was done to represent conditions found at a completely disturbed construction site devoid of vegetation and top soil. Prior to being added to the basin, the soil was sifted through pans with 6.35 mm (0.25 in) circular apertures to break up the large aggregates and screen out vegetation, insects, rocks, and other trash.

A particle size analysis was done on each of the three soils using the pipette method (Day, 1965). The sediment loading was determined based on prior research (Ross and Dillaha, 1990, 1991, 1993; Engle and Jarrett, 1991, 1995). In the research by

Ross and Dillaha, a rainfall simulator was used on forestry runoff plots to evaluate and demonstrate the effectiveness of forestry best management practices (BMPs) for logging roads. The sediment concentrations in the runoff from the plots without BMP implementation (unstabilized logging roads with bare soil) were examined, as they returned values representative of a 'worst case scenario'. The average sediment concentration from these studies was 6500 mg/L. The research by Engle and Jarrett was a sedimentation basin study that evaluated the effectiveness of three outlets over two different dewatering times. In that study 55 kg (dry weight) of soil was put into a 1.32 m^3 sedimentation basin for an initial sediment concentration of 41667 mg/L. Thirty five kilograms of soil was chosen for this study because it produced a sediment concentration of 25180 mg/L, near the average of the sediment concentrations for the other studies.

Sampling and Analysis

As previously mentioned, the sediment was put in suspension at the beginning of the experiment by stirring and mixing the basin's contents with paddles. During the ten to fifteen second period between the time when the mixing stopped and dewatering could begin by fully opening a valve on the downstream end of the principal spillway, a portion of the original sediment had settled out of suspension. Five hundred milliliter grab samples were collected from the center of the sedimentation basin at the time the valve was opened. Subsamples ranging in size from 25 mL to 50 mL were measured in graduated cylinders, filtered, and dried to determine the initial sediment concentration. (The size of the subsample was based on the turbidity of the water.) This resulted in two different values of cumulative sediment in: one based on the total 35 kg of sediment put into the tank at the beginning of the run (35 kg) and one based on the mass of soil in suspension at the time the valve was opened (determined from the above sampling/filtering process).

At the time the valve was opened, 900 mL grab samples were also taken from the same point inside the basin. A particle size analysis was done on the sediment in suspension using a variation of the pipette method as follows. Because the 500 mL initial samples previously mentioned were taken at the same time and location as the 900 mL samples, the mass of sediment in suspension at the start of the run (determined from the filtering of the 25 mL – 50 mL subsamples) was used to determine the initial mass of sediment in the 900 mL sample. The 900 mL sample was then diluted to 1 L, mixed, and pipetted according to the standard procedure (Day, 1965). The particle size distribution calculations were based on the initial mass of soil in the 900 mL sample.

Grab samples of 500 mL were taken at the outlet every five minutes for the first thirty minutes and every fifteen minutes until the completion of the dewatering process. The time to collect these samples was measured with a stopwatch and the dewatering rates calculated. From each outflow sample, subsamples ranging in size from 25mL to 100 mL were measured in a graduated cylinder and filtered. Again, the size of the subsample was based on the turbidity of the water. The filtered samples were dried and the mass of sediment calculated. With the mass of sediment known, the sediment concentrations were determined. Sediment loss rates were also calculated by multiplying the dewatering rates and the sediment concentrations at each time increment.

Upon completion of the dewatering process, the effluent in the outflow tank was mixed with paddles to resuspend all of the sediment. A 500 mL grab sample was taken from within the receiving tank. Subsamples (75-100 mL) were filtered and dried and sediment concentration calculated. This concentration was then used to determine cumulative sediment out.

Samples of 900 mL were also taken from the outflow tank after the dewatering process had stopped. Particle size analyses were done on these samples using the variation of the pipette method described above.

Based on the cumulative sediment in and out, retention efficiencies were calculated. Because there were two values of cumulative sediment in, two values of retention efficiency were determined. Retention efficiencies were also calculated for each particle size. Again, there were two particle size analyses performed on the sediment in: one on the 35 kg of sediment and one on the sediment in suspension at the start of the run. Therefore, two particle size retention efficiencies resulted.

Results and Discussion

The dewatering rate, effluent sediment concentration, sediment loss rate and retention efficiency were plotted and evaluated for each of the six treatments. A statistical analysis was performed on the sediment retention efficiencies that included a two-way analysis of variance with outlet and soil type as the two factors. The analysis used the SAS General Linear Model (GLM) Procedure (SAS/STAT, 1990) to test for treatment differences at the 5% level. Particle size analyses attempts failed due to the lack of sufficient amounts of sediment. Finally, retention efficiencies were predicted for shorter dewatering times.

Dewatering Rate

The basin dewatering rates are plotted in Figure 6. Each point plotted is the average of the three replication responses at each sampling time. The dewatering rates

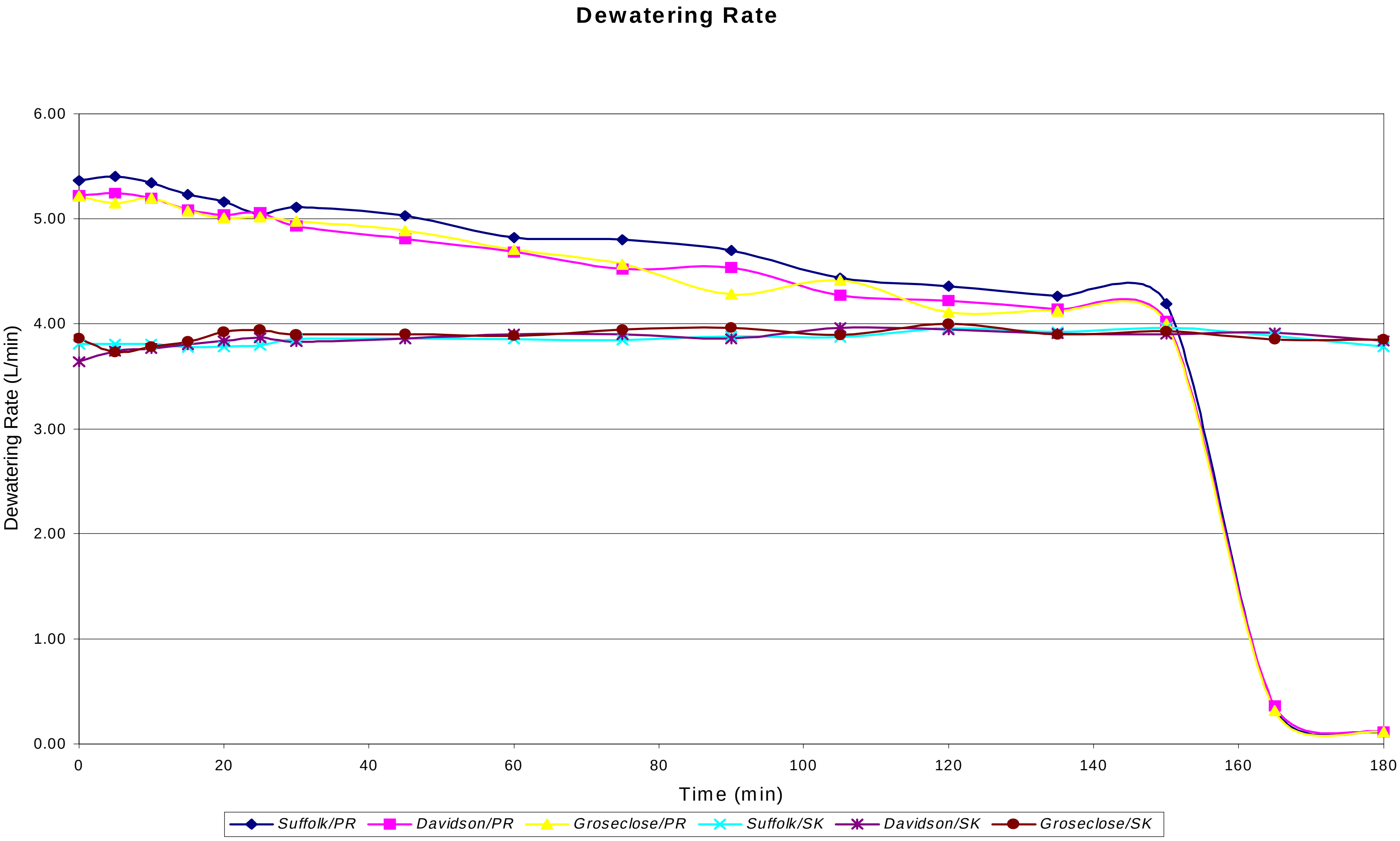

Figure 6: Dewatering rates of perforated riser (PR) and skimmer (SK)

of the perforated riser peak at the start of the run and show a steady decline up to 150 minutes into the run as the head on the orifice decreases. Sometime between 150 minutes and 165 minutes the orifice stops controlling the flow and the bottom row of perforations take over. This accounts for the sudden decline in dewatering rate. After the point at which the perforations begin to control the flow, the dewatering rates continue a steady decline towards zero although at a much slower rate than before. Because the center of the lowest row of perforations (not the invert) is at the top of the permanent pool, the dewatering rates never actually reach zero, as shown in the figure. At approximately 180 minutes, a valve is closed that stops dewatering of the basin.

In the case of the skimmer, the dewatering rates are nearly constant. This is to be expected as the skimmer is designed to have a constant head on its orifice. Similar to the perforated riser, water was still flowing at the end of the 180 minute dewatering period and a valve was closed to end the dewatering process.

The dewatering rate for the skimmer was lower than that of the perforated riser at every sampling time prior to when the perforations began to control the flow through the perforated riser. Because the skimmer released water slower throughout most of the run, there was a greater opportunity for suspended sediment to settle in the basin.

Sediment Concentration of Effluent

The average sediment concentrations are plotted in Figures 7-9. The sediment concentrations were highest at the beginning of each run just after mixing the sediment in the basin. The peak sediment concentrations were similar for the Groseclose and Suffolk soils (around 4.0 g/L) although the concentration was slightly higher for the Groseclose soil. This is probably due to the fact that the Groseclose soil is higher in silt particles which tend to stay in suspension while the Suffolk soil is higher in sand particles which tend to settle out of suspension rapidly. The peak sediment concentration for the Davidson soil, of approximately 2.5 g/L, was quite a bit lower than that of the Groseclose and Suffolk soils. This was probably due to the fact that clay soils are highly aggregated and the larger aggregates settle out of suspension quite rapidly.

Following the peak, the sediment concentrations declined exponentially. Throughout the runs, the sediment concentration at any given sampling time was usually highest for the Groseclose soil and lowest for the Davidson soil, regardless of which outlet was in place. For each soil, the effluent sediment concentration tended to be higher with the perforated riser than the skimmer until about 90 minutes into the run. After this time, there was little difference in the effluent sediment concentration between outlets. Thus, it appears the skimmer proved to be most effective during the first half of the dewatering period.

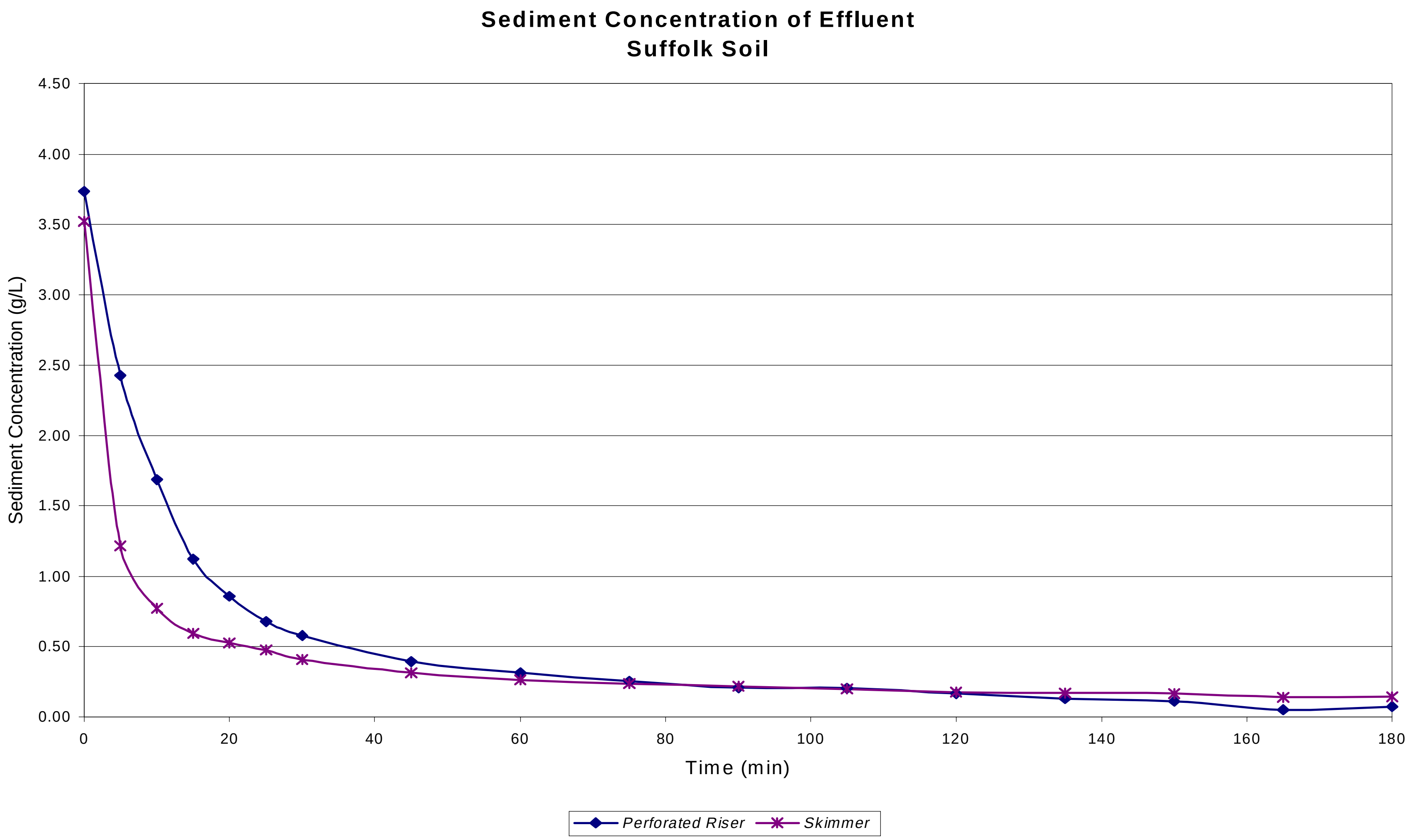

Figure 7: Effluent sediment concentrations - Suffolk soil

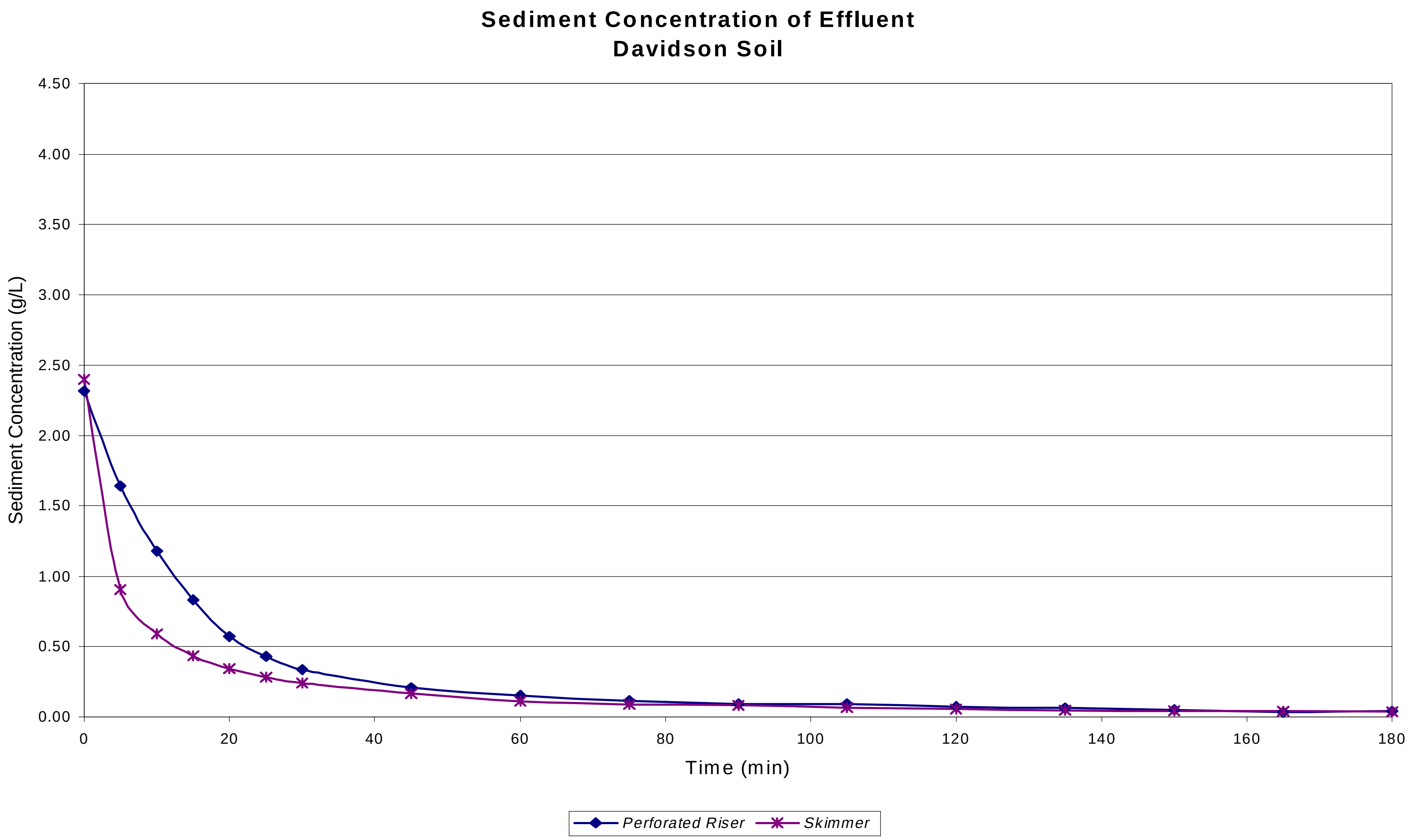

Figure 8: Effluent sediment concentrations - Davidson soil

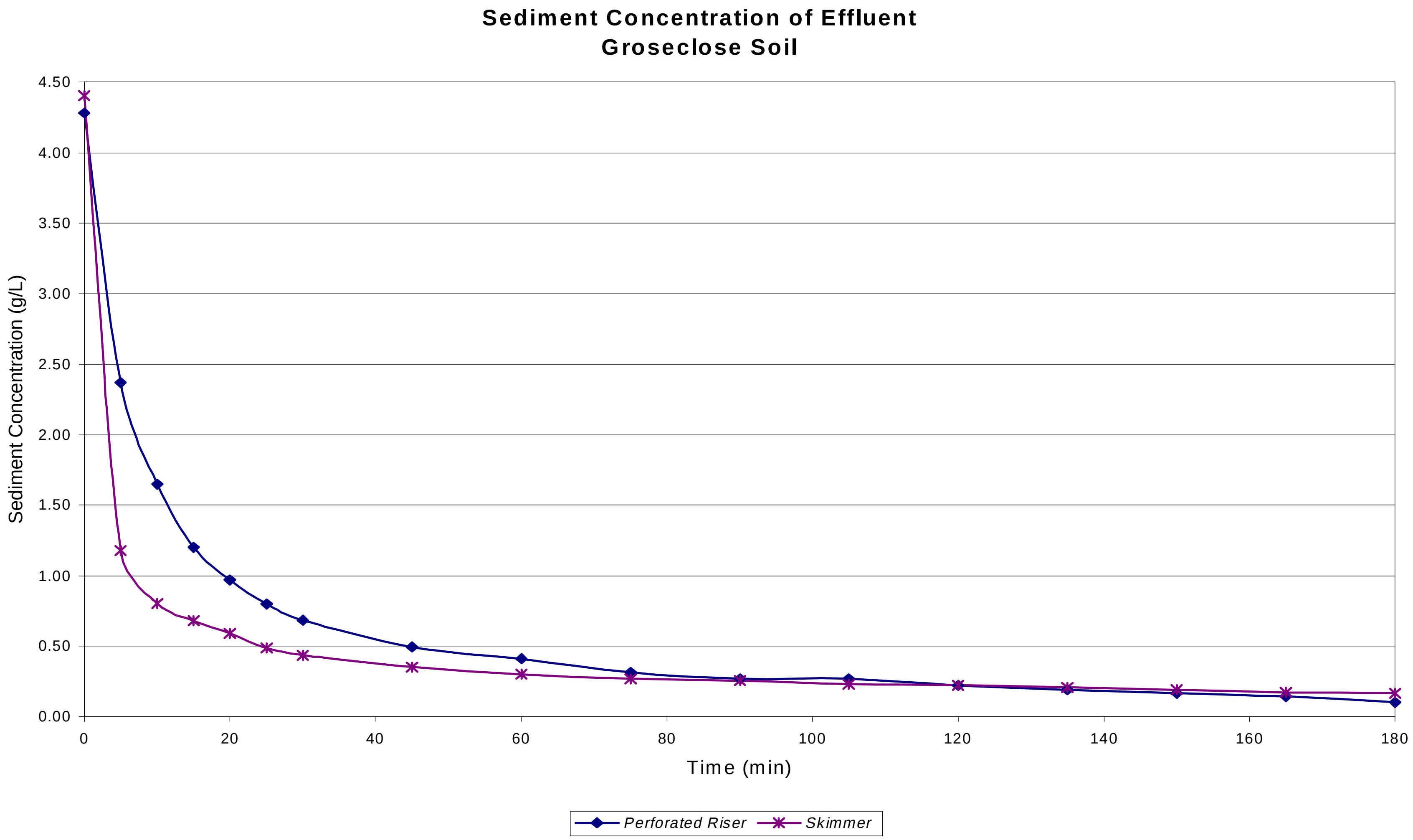

Figure 9: Effluent sediment concentration - Groseclose soil

Sediment Loss Rate

The sediment loss rates were calculated by multiplying the dewatering rates by the sediment concentration of the effluent at each sampling time. The resulting plots are shown in Figures 10-12. As expected, for each soil type, the perforated riser had higher sediment loss rates than the skimmer. Regardless of which treatment was used, most of the sediment loss occurred within the first 90 minutes of the run.

The sediment loss rate curves were integrated to determine a calculated value of cumulative sediment loss. These values were compared to the actual value of cumulative sediment loss obtained by filtration (Table 1) and found to be very similar.

Table 1: Total sediment loss by filtration and by integration of sediment loss rate curves

Soil type	Outlet	Sediment loss by filtration (kg)	Sediment loss by integration (kg)
Suffolk	PR	0.34	0.38
Suffolk	SK	0.21	0.23
Davidson	PR	0.21	0.23
Davidson	SK	0.12	0.12
Groseclose	PR	0.39	0.43
Groseclose	SK	0.23	0.27

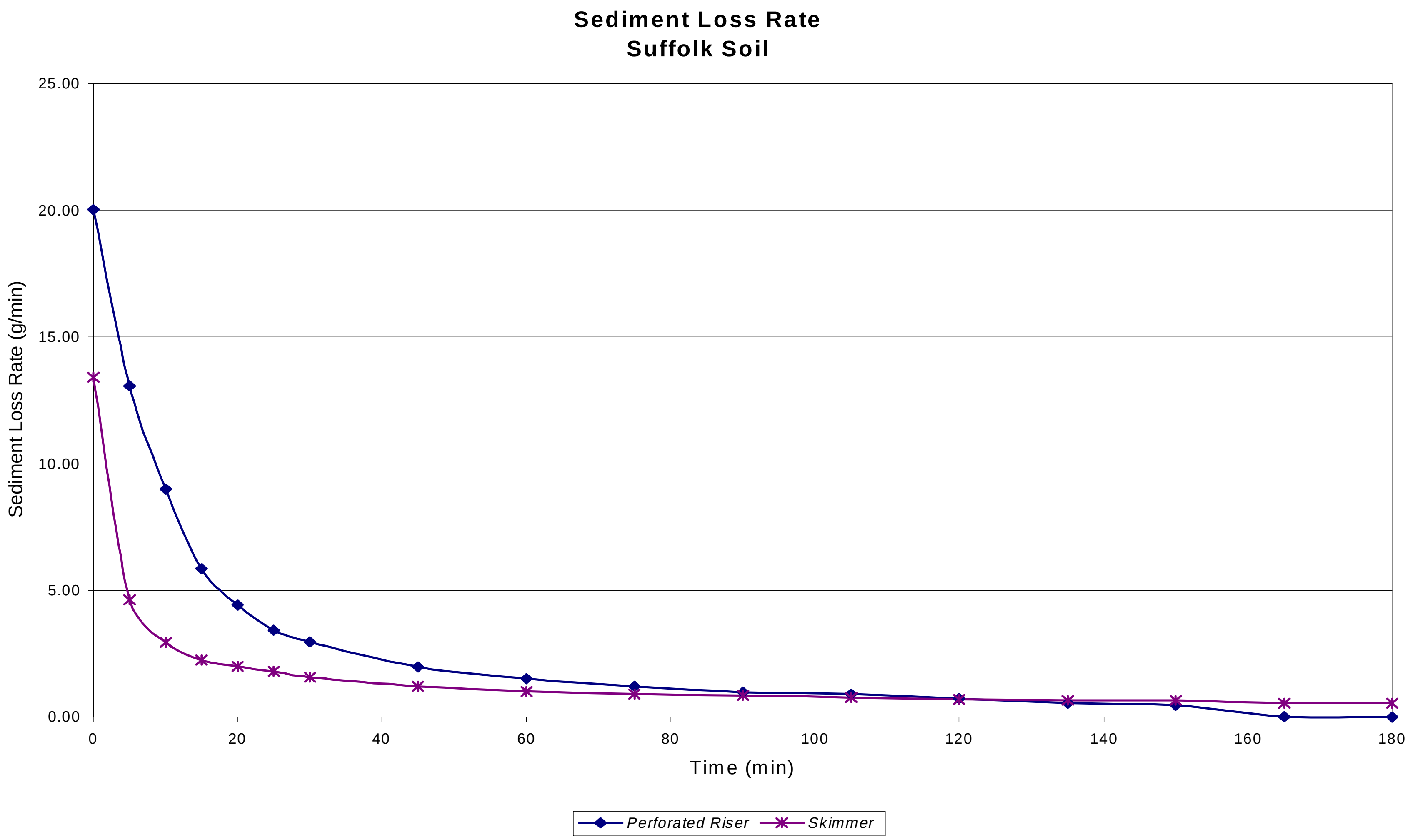

Figure 10: Sediment loss rate - Suffolk soil

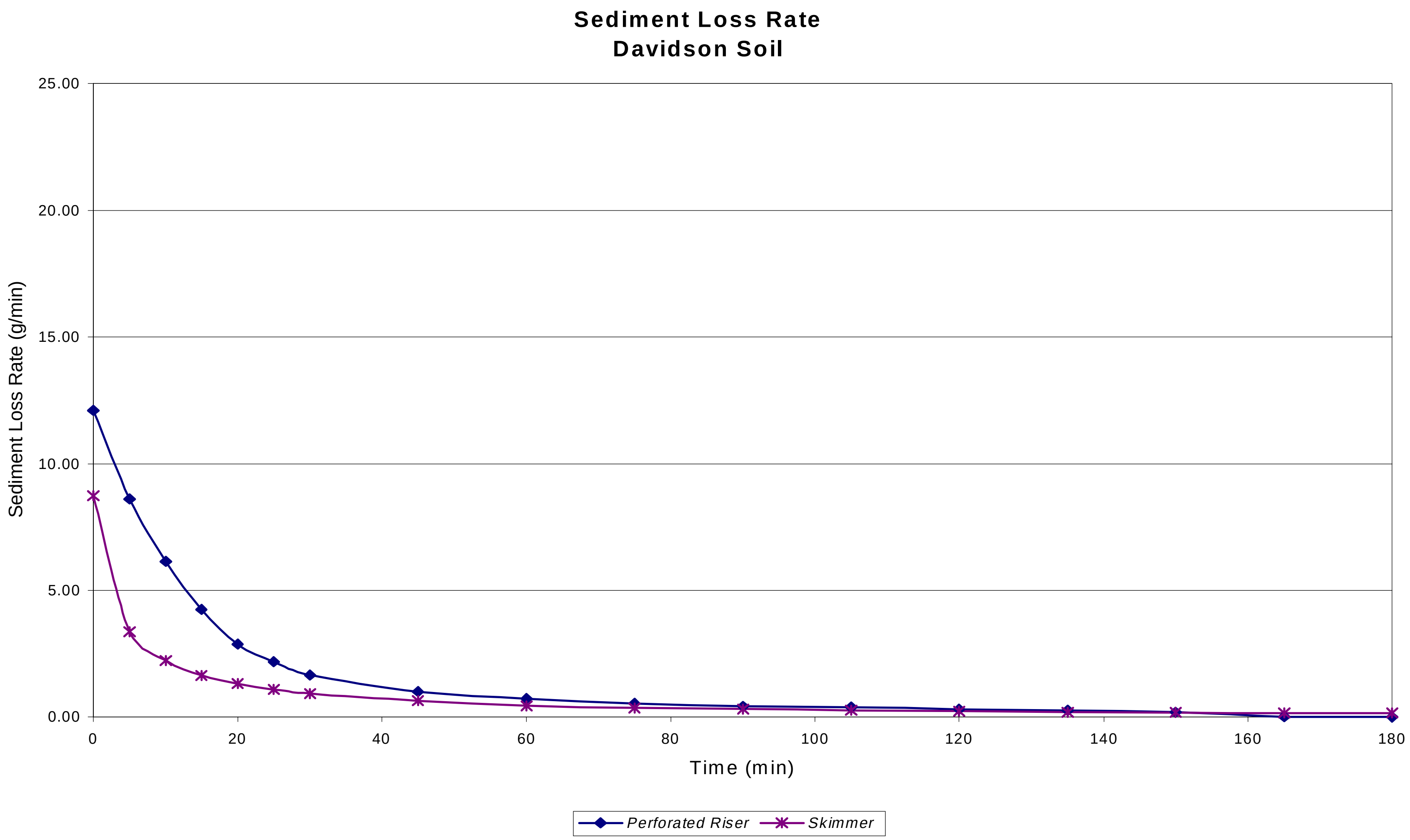

Figure 11: Sediment loss rate - Davidson soil

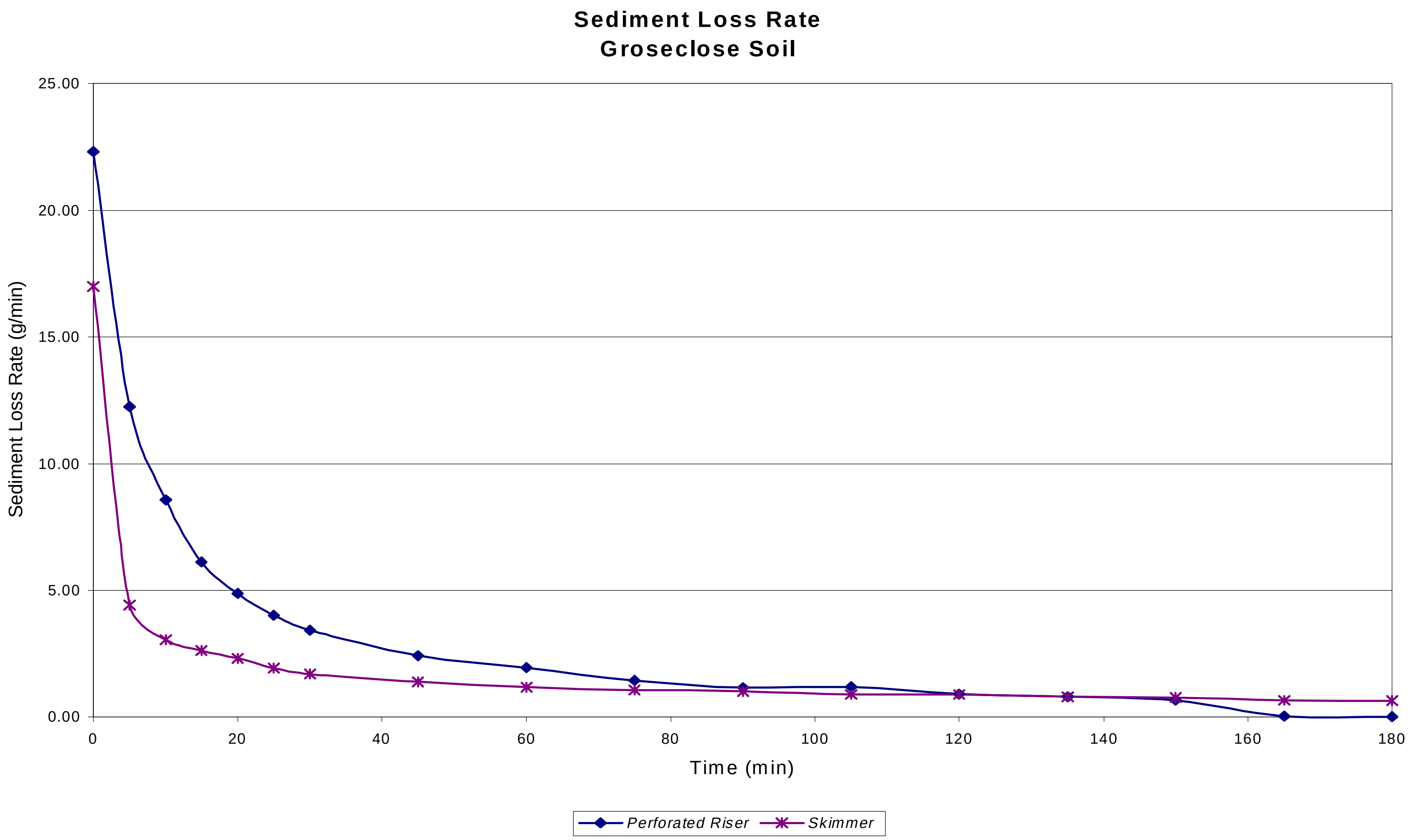

Figure 12: Sediment loss rate - Groseclose soil

Retention Efficiency

Retention efficiency was calculated based on two values of cumulative sediment in: the total 35 kg of sediment in and the mass of sediment in suspension at the start of the run (Table 2). The former represents the type of sediment loading one might encounter if runoff from a high intensity storm reached the sedimentation basin. This type of storm would produce large amounts of runoff with higher flow rates, increased carrying capacity and therefore more suspended material with larger particle sizes in the runoff. When the runoff reached the sedimentation basin, it would most likely contain a mixture of coarse as well as fine particles, similar to the 35 kg sediment loading used in the experiment.

The average retention efficiencies based on the 35 kg sediment loading are plotted in Figure 13. All of the retention efficiencies were very high however, the skimmer consistently had higher retention efficiencies than the perforated riser. A two-way analysis of variance was performed on the sediment retention efficiencies and the results are presented in tabular (Table 3) and graphical (Figure 14) formats.

It is important to note is that there was no interaction between outlet and soil type. This is known because the P value for the outlet*soil factor (P=0.5364) is less than the 0.05 significance level. Not only is this shown by the P value (Table 3), but it is also shown in Figure 14. The plotted lines do not cross, therefore there is no interaction. This means that the basin's retention efficiency was not influenced by any particular combination of outlet and soil type. The analysis of variance also found outlet to be significant (P=0.0001). This means that the skimmer performed better than the perforated riser for each soil type. This is

Table 2: Retention efficiencies for all treatments

Soil type	Outlet	Run	Cumulative sediment in* (kg)	Cumulative sediment in** (kg)	Cumulative sediment out (kg)	Retention efficiency* (%)	Retention efficiency** (%)
Suffolk	PR	1	5.41	35.00	0.32	94.00	99.07
Suffolk	PR	2	4.01	35.00	0.29	92.67	99.16
Suffolk	PR	3	6.16	35.00	0.40	93.56	98.87
Suffolk	SK	1	5.05	35.00	0.24	95.25	99.31
Suffolk	SK	2	4.37	35.00	0.18	95.85	99.48
Suffolk	SK	3	5.27	35.00	0.21	96.03	99.40
Davidson	PR	1	3.56	35.00	0.24	93.22	99.31
Davidson	PR	2	2.79	35.00	0.18	93.72	99.50
Davidson	PR	3	3.31	35.00	0.22	93.48	99.38
Davidson	SK	1	3.75	35.00	0.12	96.70	99.65
Davidson	SK	2	3.04	35.00	0.11	96.32	99.68
Davidson	SK	3	3.21	35.00	0.11	96.43	99.67
Groseclose	PR	1	4.57	35.00	0.34	92.45	99.02
Groseclose	PR	2	6.42	35.00	0.34	94.66	99.02
Groseclose	PR	3	6.86	35.00	0.47	93.18	98.66
Groseclose	SK	1	6.11	35.00	0.20	96.81	99.44
Groseclose	SK	2	6.29	35.00	0.27	95.74	99.24
Groseclose	SK	3	5.97	35.00	0.24	96.00	99.32

** Based on mass of sediment in suspension at start of run*

*** Based on total mass of sediment in*

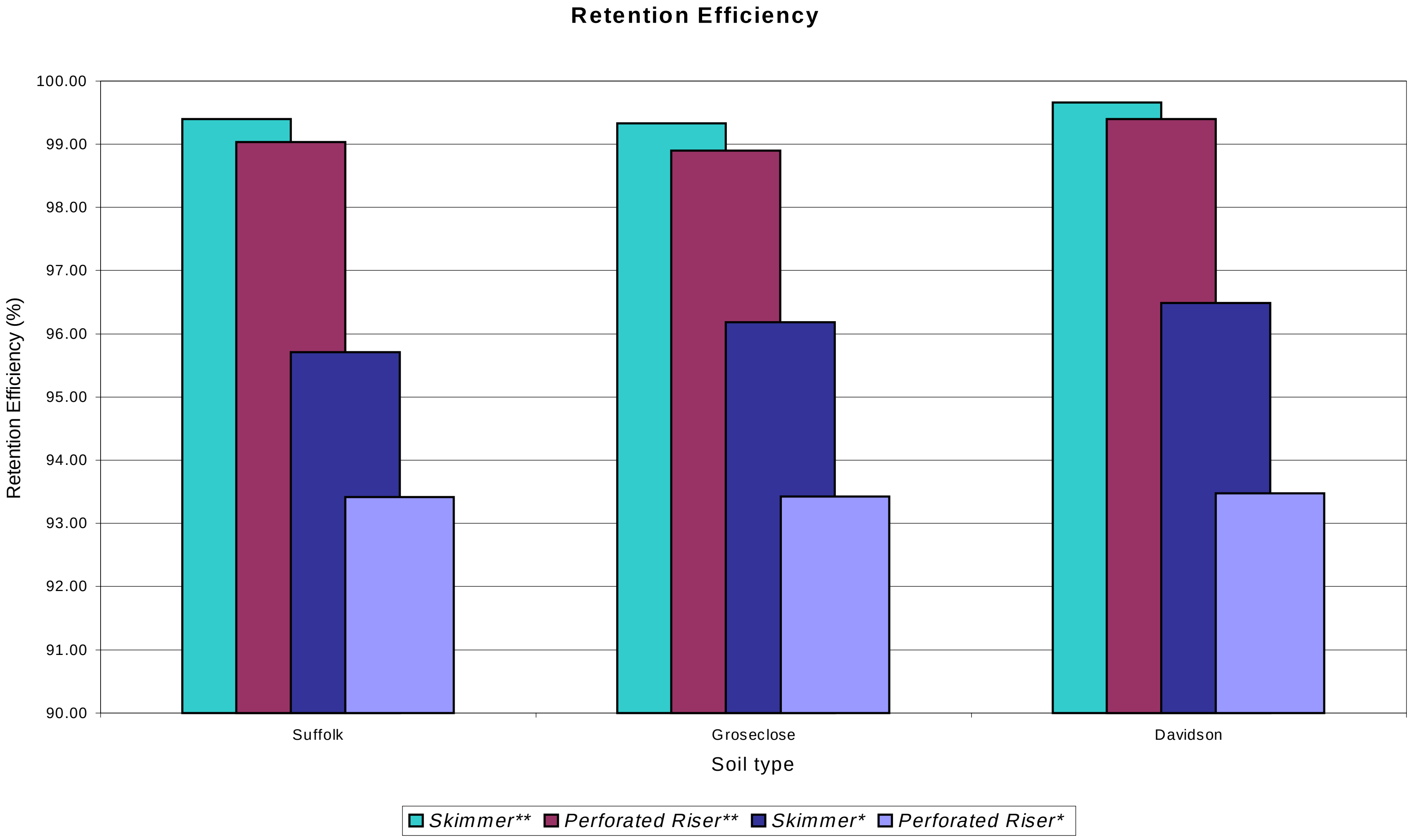

Figure 13: Retention efficiency for all treatments based on: sediment in suspension at the start of the run* and 35 kg sediment load**

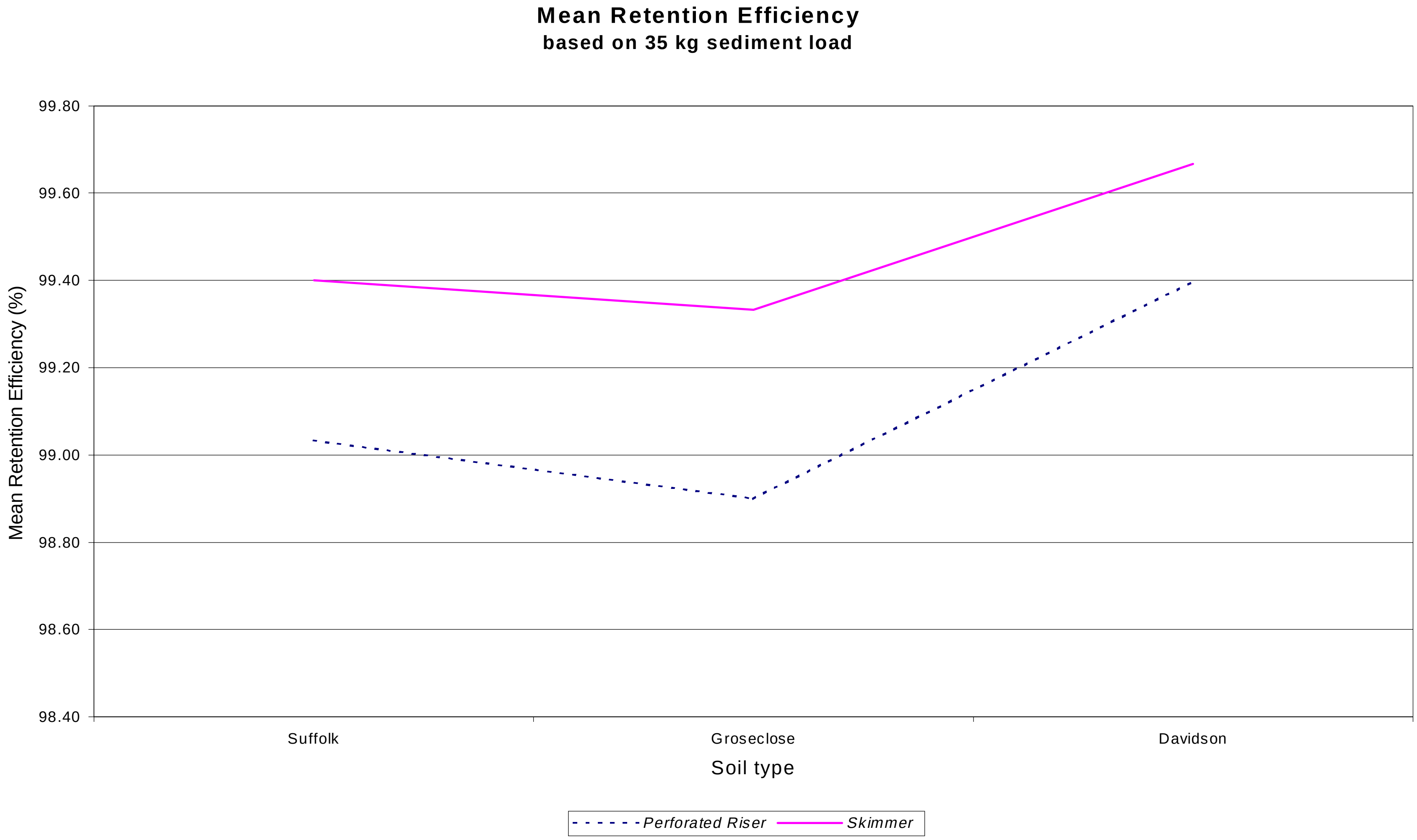

Figure 14: Mean retention efficiency based on 35 kg sediment load

Table 3: Analysis of variance results for retention efficiencies based on total 35 kg sediment load

	Degrees of Freedom	Sums of Squares	Mean Square	F Value	P Value
Outlet	1	0.5689	0.5689	37.07	0.0001
Soil	2	0.5643	0.2822	18.39	0.0002
Outlet * Soil	2	0.0201	0.0101	0.66	0.5364
Error	12	0.1841	0.0153		
Total	17	1.3375			

shown in Figure 14 by the mean skimmer retention efficiencies being higher than the mean perforated riser retention efficiencies for each soil type.

A drawback to using this type of retention efficiency to compare outlets was that the soil type also impacted the retention efficiency and therefore masked the effects of the outlet. Soils with coarser particles showed higher retention efficiencies due in part to the fact that these particles settled out of suspension very rapidly. The two way analysis of variance proved this point. Here, soil type was found to be significant (P=0.0002). A multiple comparison was done to determine which soil type was different and the results are presented in Table 4.

Table 4: Multiple comparison of soil types

	Mean	P value		
	Ret. Eff.	Davidson	Groseclose	Suffolk
Davidson	99.53	----	0.0001	0.0008
Groseclose	99.12	0.0001	----	0.1943
Suffolk	99.22	0.0008	0.1943	----

A significant difference was found between Davidson and Groseclose soils (P=0.0001) and between Davidson and Suffolk soils (P=0.0008). This is better shown in Figure 14. Horizontal, or close to horizontal, lines indicate no significant differences. The slope of both lines between the Suffolk and Groseclose soils is small, indicating no significant difference in soil type between the mean retention efficiencies for these soils for either outlet. However, the upward slopes are dramatic enough to indicate a significant difference between Davidson and the other two soils for both outlets. This means that the use of the Davidson soil influenced retention efficiency. As discussed earlier, the Davidson soils had high amounts of clay aggregates which settled out of suspension rapidly and retention efficiencies were also higher when this soil type was used.

Since it is less likely that the coarsest particles ever make it to the sedimentation basin, retention efficiencies were also calculated based on what was in suspension at the start of the run. This would be more representative of situations in which coarser particles settle in drainageways before reaching the sedimentation basin. Also, because the coarse particles had rapidly settled out of suspension and therefore did not affect retention efficiency, a better measure of outlet performance was obtained.

These average retention efficiencies are also plotted in Figure 13. Again, all of the retention efficiencies were very high, although they were, as expected, lower than the retention efficiencies based on the 35 kg sediment load. The skimmer consistently had higher retention efficiencies than the perforated riser. For both the skimmer and the perforated riser, the Davidson soil had the highest retention efficiencies and the Suffolk soil had the lowest retention efficiencies.

A two-way analysis of variance was also performed on these retention efficiencies. The results of this analysis of variance are presented in Table 5 and in Figure 15.

Table 5: Analysis of variance results for retention efficiencies based on sediment in suspension at the start of the run

	Degrees of Freedom	Sums of Squares	Mean Square	F Value	P Value
Outlet	1	32.5087	32.5087	84.58	0.0001
Soil	2	0.5306	0.2653	0.69	0.5203
Outlet * Soil	2	0.3877	0.1939	0.50	0.6161
Error	12	4.6120	0.3843		
Total	17	38.0391			

Again, no interaction between outlet and soil type was found (P=0.6161). The outlet was found to be significant (P=0.0001) and the soil type was not (P=0.5203). This means that retention efficiency based on sediment in suspension at the start of the run is only affected by outlet and is therefore a better measure of outlet performance. Because outlet was the only factor found to statistically affect retention efficiency and because the retention efficiencies are higher for the skimmer than for the perforated riser for all three soil types, the skimmer outperformed the perforated riser regardless of which soil type was used.

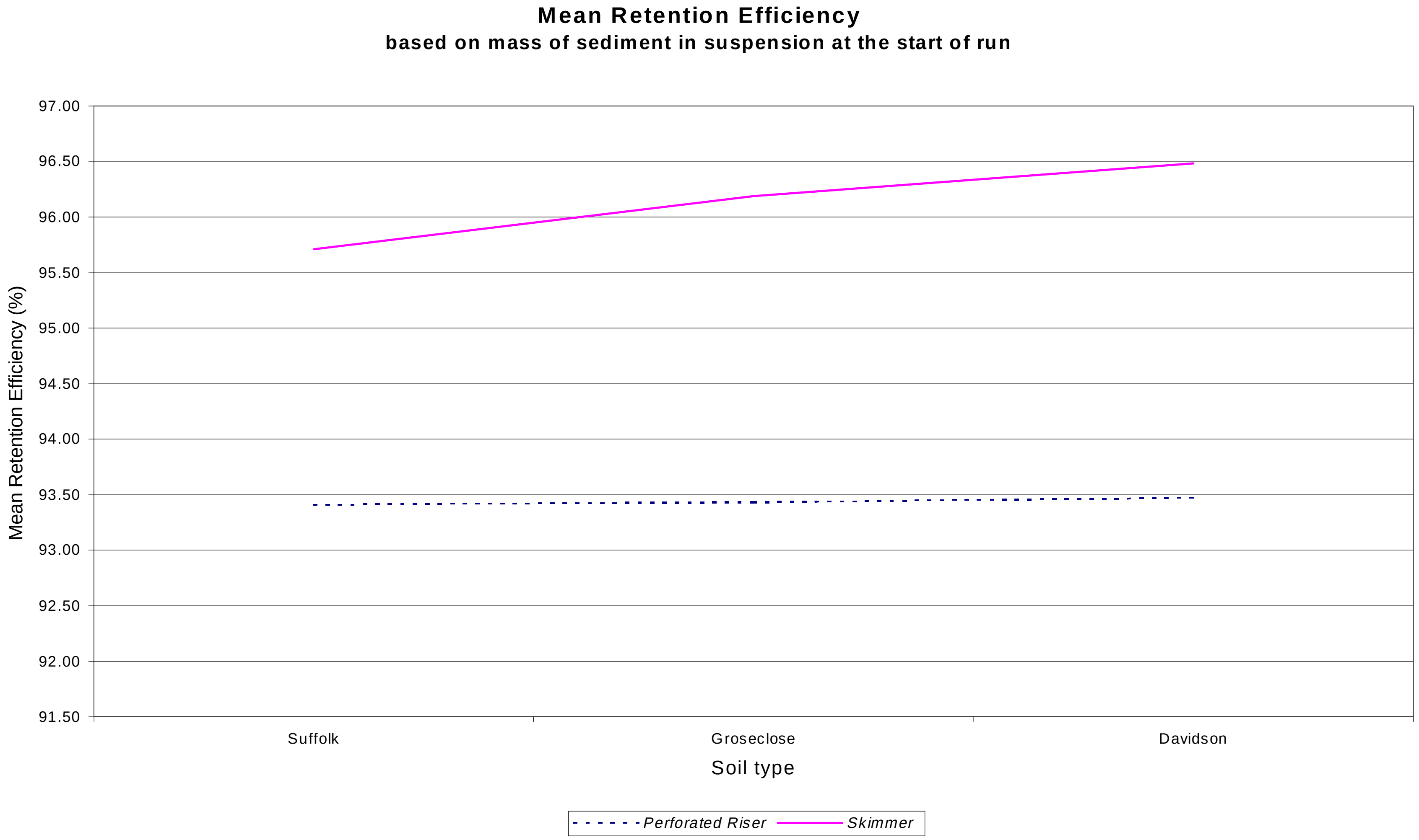

Figure 15: Mean retention efficiency based on sediment in suspension at the start of the run

Particle Size Analysis

Particle size analyses on the sediment in suspension at the start and finish of the runs were attempted, but failed due to low sediment concentrations. The variation of the pipette method previously mentioned was tried however, due to the fact that the samples contained far less soil than the 10 g required to perform the analysis, the accuracy of the results was questionable.

The Horiba model CAPA-300 particle size analyzer could not be used due to the same problem. A minimum of 25 g of soil was needed to utilize this apparatus. The hydrometer method had to be ruled out for similar reasons. The hydrometer method measures changes in suspension density over time. However, the samples contained substantially less than the 40 g required for this procedure and therefore, changes in density would be next to zero. That is, from one time increment to the next, all hydrometer readings would be about equal and therefore all particle sizes would be the same. Clearly, these results would also have been unreliable.

Predicting Outlet Performance

The retention efficiencies were not only very high for both the perforated riser and the skimmer but also very similar, although the analysis of variance results showed that a significant difference existed between the two outlets. Also, the sediment loss rate curves showed that most of the sediment loss occurred during the first 90 minutes of the run. Therefore, shorter dewatering times were used to predict their effects on retention efficiency. Dewatering times of one and two hours were examined.

First, predicted dewatering rates had to be calculated. In the case of the skimmer, where the dewatering rate is constant, this was simply a matter of dividing the volume to be dewatered by the appropriate dewatering time.

The perforated riser's dewatering rate was more complicated. The orifice that controls the dewatering for the perforated riser was sized according to the equation for a submerged orifice (Equation 4). The perforations were then sized according to the same equation such that when the water level in the tank was at the top of the lowest row of perforations, the orifice still controlled the flow. Next, the actual average dewatering rate data obtained from the experimental runs was used to calculate the orifice coefficient at each time increment throughout the runs. These orifice coefficients were averaged and the resulting orifice coefficient was then used in the orifice equation to determine dewatering rates.

Since the head above the orifice was known when the tank was full, a dewatering rate could be calculated at time, t=0. This dewatering rate was assumed to be constant until time, t=1 minute. This dewatering rate was then multiplied by the 1 minute over which it was constant and a dewatered volume determined. Dividing this volume by the surface area of the water and then subtracting this value from the head at time, t=0, yielded a new head at time, t=1 minute. This dewatering rate calculation was repeated over one minute increments until the water level in the tank reached the top of the lowest row of perforations. Constant dewatering rates were assumed over each one minute time increment.

Sometime after the water level dropped below the top of the lowest row of perforations, the flow was no longer controlled by the orifice but instead by the perforations. Therefore, flow was no longer governed by the submerged orifice equation. In attempting to model dewatering rate from this point until the end of the run, it was difficult to determine at exactly what time the perforations began to control the flow rate and a great deal of error was being encountered. However, after observing the data collected in the experimental runs, it was determined that for all possible treatments, less than 2.5% of the total sediment loss occurred in this time frame and therefore, was considered negligible. Thus, for the perforated riser, dewatering rates were not calculated beyond the time when the water level was at the top of the lowest row of perforations. Dewatering rates were then selected that corresponded to the sample collection times in the experimental runs: every five minutes for the first 30 minutes and every 15 minutes thereafter until the end of the dewatering period, including the final dewatering rate (i.e., the dewatering rate at the time when the water level was at the top of the lowest row of perforations).

With dewatering rates calculated, sediment loss rate curves could be determined. It was assumed that, for each soil type, the settling pattern at any point in time was the same. In other words, the sediment was assumed to settle at the same rate within the basin for the predicted cases as it did in the experimental runs. Therefore, the values of effluent sediment concentration (and sediment in suspension at the start of the run) determined in the experimental runs were assumed to be the same when predicting sediment loss rate. An effluent sediment concentration was determined from the laboratory data at the end of the dewatering time by interpolation. Multiplying the predicted values of dewatering rate by the effluent sediment concentration values returned sediment loss rates at each time increment. Integrating the sediment loss rate curves yielded values of cumulative sediment out. From these values, retention efficiencies were predicted.

Other assumptions were made when predicting retention efficiencies. Normally, the orifice coefficient, c, decreases slightly as the head decreases or the orifice diameter increases. However, in this case, when the dewatering rate was predicted, an average value of c was calculated from the actual dewatering data and was assumed to be constant as the head decreased. Also, this coefficient was assumed constant as the orifice size increased (with shorter dewatering times).

The predicted retention efficiencies based on the mass of sediment in suspension at the start of the run are presented in Table 6 along with the actual three hour retention efficiencies.

Table 6: Predicted retention efficiencies for one and two hour dewatering times

Soil type	Outlet	One hour retention efficiency* (%)	Two hour retention efficiency* (%)	Three hour retention efficiency** (%)
Suffolk	PR	85.15	90.33	93.41
Suffolk	SK	91.13	95.57	95.71
Davidson	PR	84.39	90.29	93.47
Davidson	SK	91.47	95.74	96.48
Groseclose	PR	85.95	90.56	93.43
Groseclose	SK	92.01	96.00	96.18

** predicted values*
*** actual values*

As the dewatering time dropped from three hours to two hours, the perforated riser treatments showed an average decline in retention efficiency of 3.04% while the skimmer's retention efficiency dropped by an average of only 0.36%. As the dewatering time decreased further to one hour, the average retention efficiency for the perforated riser treatments decreased an additional 5.23% and the retention efficiencies for the skimmer treatments declined further by an average of 4.23%. Therefore, in reducing the dewatering time from three hours to one hour, the total average decline in retention efficiencies for the perforated riser treatments was 8.27% compared to 4.59% for the skimmer treatments.

Shortening the dewatering time from three hours to two hours appears to have a major impact on retention efficiencies for the perforated riser treatments and only a minimal impact on the retention efficiencies for the skimmer treatments. When the dewatering time was decreased by one more hour, however, the retention efficiencies for both the perforated riser and skimmer treatments are substantially impacted. Therefore, a two hour dewatering time may be nearly as effective as a three hour dewatering time in trapping suspended sediment if a skimmer is used while the same may not be true in the case of the perforated riser. Overall, the predicted results indicate that by using the skimmer, it may be possible to shorten dewatering times and still maintain high retention efficiencies.

Summary and Conclusions

A laboratory study was conducted to evaluate the performance of the skimmer versus the perforated riser as an outlet for a sedimentation basin. Three different soil type inputs were tested: a Suffolk loam, a Davidson silty clay loam and a Groseclose silt loam. Each treatment was replicated three times. Outlet performance was based on the basin's sediment retention efficiency.

Each replication involved filling the basin with a fixed volume of water and mass of sediment, mixing the water and sediment, and dewatering the basin's dry storage volume over a period of three hours. Grab samples were taken from within the basin at the start of the run, from the effluent stream at set time intervals throughout the run, and from a tank containing the effluent volume at the completion of the run. The initial and final samples were used to determine sediment concentrations and cumulative sediment in and out of the tank. Particle size analyses were attempted but the results were unreliable due to low sediment concentrations. Dewatering rates were measured as the intermediate samples were collected. These samples were then used to determine effluent sediment concentration and sediment loss rate at each sampling time.

Skimmer dewatering rates were found to be nearly constant throughout the run and perforated riser dewatering rates showed a steady decline until the point near the completion of the dewatering process when the perforated riser orifice stopped controlling the flow. At this point the lowest row of perforations began controlling the dewatering process and the flow rates declined sharply. The skimmer released water slower throughout most of the run and therefore presented a better opportunity for suspended sediment to settle rather than exit the basin.

The effluent sediment concentrations were highest at the start of each run and then declined exponentially. The Groseclose soil tended to have the highest sediment concentrations followed by the Suffolk soil. The Davidson soil had the lowest sediment concentrations, probably due to the fact that the soil contained aggregates that settled out of suspension more rapidly.

Retention efficiencies were calculated and the skimmer consistently returned higher values than the perforated riser. A two way analysis of variance was performed on the retention efficiencies and it found that a significant difference existed among the outlets at the 5% level.

Retention efficiencies were predicted to examine outlet performance for shorter dewatering times. These results showed little change in retention efficiency for the skimmer and greater retention efficiency changes for the perforated riser as the dewatering time was reduced.

As a result of this study, the following conclusions can be made:

1. The skimmer yielded statistically higher retention efficiencies than the

perforated riser, and therefore outperformed the perforated riser for each of the three soil types used in this experiment.

2. There was no statistical interaction between outlet and soil type therefore the basin retention efficiency was not influenced by any particular combination of outlet and soil type.

3. Shorter dewatering times may have less of an impact on retention efficiency when the skimmer is utilized than when the perforated riser is used thereby possibly requiring smaller sedimentation basin sizes.

Recommendations for Future Study

This study was done as an attempt to further advance sedimentation basin principal spillway design efforts. The skimmer was found to be an effective sedimentation basin outlet however, due to the fact that it has not been thoroughly tested, there is still a need for further research on this device. The following recommendations are made for future study:

1. test the skimmer's performance in basins with and without permanent pools and compare the results to similar studies involving the perforated riser;
2. test the skimmer in basins with permanent pools to determine the effect of an influent hydrograph on retention efficiency;
3. based on the predicted results of retention efficiency for shorter dewatering times, evaluate the potential for skimmers to alter design criteria of sedimentation basins.

Bibliography

Adler, J. 1981. Automatic Device for Emptying a Detention Pond at a Constant Low Flow Rate and Velocity. *Proceedings, International Symposium on Urban Hydrology, Hydraulics and Sediment Control*. Lexington, KY: University of Kentucky.

Barfield, B.J., R.C. Warner and C.T. Haan. 1985. *Applied Hydrology and Sedimentology for Disturbed Areas*. Stillwater, OK: Oklahoma Technical Press.

Bondurant, J.A., C.E. Brockway and M.J. Brown. 1975. Some Aspects of Sedimentation Pond Design. *Proceedings, National Symposium on Urban Hydrology and Sediment Control*. Lexington, KY: University of Kentucky.

Bonta, J.V. and W.R. Hamon. 1980. Preliminary Evaluation of a Sediment Pond Draining a Surface Mined Watershed. *Proceedings, Symposium on Surface Mining Hydrology, Sedimentology and Reclamation*. Lexington, KY: University of Kentucky.

Brady, N.C. 1990. *The Nature and Properties of Soils*. New York, NY: Macmillan Publishing Company.

Clark, E.H., J.A. Haverkamp and W. Chapman. 1985. *Eroding Soils: The Off Farm Impacts*. Washington, DC: The Conservation Foundation.

Day, P.R. 1965. Particle Fractionation and Particle-Size Analysis. In: Black, C.A., D.D. Evans, L.E. Ensminger, J.L. White, F.E. Clark and R.C. Dinauer, eds. *Methods of Soil Analysis, Part I*. Madison, WI: American Society of Agronomy.

Ehrhart, B.J. 1996. *Effects of Detention Time on Sedimentation Basin Performance*. Baccalaureate Thesis, Department of Biological and Agricultural Engineering, The Pennsylvania State University, University Park, PA.

Engle, B.W. and A.R. Jarrett. 1990. Improved Sediment Retention Efficiencies of Sedimentation Basins. ASAE Paper No. 90-2629. St. Joseph, MI: ASAE.

Engle, B.W. and A.R. Jarrett. 1991. Sediment Retention Efficiencies of Sediment Basin Filtered Outlets. ASAE Paper No. 91-2578. St. Joseph, MI: ASAE.

Engle, B.W. and A.R. Jarrett. 1995. Sediment Retention Efficiencies of Sedimentation Basin Filtered Outlets. *Transactions of the ASAE* 38(2): 435-439.

Environmental Protection Agency. 1976. *Effectiveness of Surface Mine Sedimentation Ponds*. Report No. EPA-600/2-76-117. Cincinnati, OH: U.S. Environmental Protection Agency.

Environmental Protection Agency. 1980. *Development of Methods to Improve Performance of Surface Mine Sediment Basins, Phase I*. Report No. EPA-600/7-80-072. Cincinnati, OH: U.S. Environmental Protection Agency.

Estep-Johnson, M.A., K.G. Kirk and R. Warner. 1988. Sediment Pond Design and Performance Analysis. *Proceedings, Symposium on Mining, Hydrology, Sedimentology and Reclamation*. Lexington, KY: University of Kentucky.

Faircloth, W. 1995. Experimental Dewatering Device to Improve Sediment Basin Efficiency. *Proceedings of Conference XXVI: International Erosion Control Association*. Steamboat Springs, CO: International Erosion Control Association.

Fennessey, L.A.J. and A.R. Jarrett. 1993. Sedimentation Basin Analysis for Nonpoint Source Sediment Remediation. ASAE Paper No. 93-2595. St. Joseph, MI: ASAE.

Fisher, L.S. and A.R. Jarrett. 1984. Sediment Retention Efficiency of Synthetic Filter Fabrics. *Transactions of the ASAE* 27(2): 429-436.

Geankoplis, C.J. 1983. *Transport Processes and Unit Operations*. 2nd ed. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Goldman, S.J., K. Jackson and T.A. Bursztynsky. 1986. *Erosion and Sediment Control Handbook*. New York, NY: McGraw-Hill, Inc.

Griffin, M.L., B.J. Barfield and R.C. Warner. 1985. Laboratory Studies of Dead Storage in Sediment Ponds. *Transactions of the ASAE* 28(3): 799-804.

Haan, C.T., B.J. Barfield and J.C. Hayes. 1994. *Design Hydrology and Sedimentology for Small Catchments*. San Diego, CA: Academic Press, Inc.

Jarrett, A.R. 1993. Design of Perforated Risers to Control Dewatering of Sedimentation Basins. *Applied Engineering in Agriculture* 9(1): 37-42.

Jarrett, A.R. 1996. *Sedimentation Basins Evaluation and Design Improvements*. Final Completion Report to the Orange County Board of Commissioners, Orange County Planning Department. Hillsborough, NC.

JMM, Inc. (James M. Montgomery, Consulting Engineers, Inc.), 1985. *Water Treatment Principles and Design*. New York, NY: John Wiley & Sons.

McBurnie, J.C., B.J. Barfield, M.L. Clar and E. Shaver. 1990. Maryland Sediment Detention Pond Design Criteria and Performance. *Transactions of the ASAE* 6(2): 167-173.

Meybeck, M., D. Chapman and R. Helmer, eds. 1989. *Global Freshwater Quality, A first Assessment*. Cambridge, MA: Basil Blackwell, Inc.

Millen, J., A.R. Jarrett and J.W. Faircloth. 1996. Reducing Sediment Discharge From Sedimentation Basins with Barriers and a Skimmer. ASAE Paper No. 96-2056. St. Joseph, MI: ASAE.

Millen, J., A.R. Jarrett and J.W. Faircloth. 1997. Improved Sedimentation Basin Performance with Barriers and a Skimmer. *Transactions of the ASAE*, in press.

Peavy, H.S., D.R. Rowe and G. Tchobanoglous. 1985. *Environmental Engineering*. New York, NY: McGraw-Hill, Inc.

Poe M.L. and R.P. Betson. 1985. Are Surface Coal Mine Sediment Ponds Working? *Proceedings, Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation*. Lexington, KY: University of Kentucky.

Rodney, M.W. and H.G. Stefan. 1984. How Wind Can Affect a Sedimentation Basin. *Journal Water Pollution Control Federation* 56(11): 1204-1208.

Ross, B.B. and T.A. Dillaha. 1990. *Rainfall Simulation for Forestry Best Management Practice Evaluation*. Final Report to the Virginia Department of Forestry. Charlottesville, VA.

Ross, B.B. and T.A. Dillaha. 1991. *Rainfall Simulation for Forestry Best Management Practice Evaluation*. Final Report to the Virginia Department of Forestry. Charlottesville, VA.

Ross, B.B. and T.A. Dillaha. 1993. *Rainfall Simulation for Forestry Best Management Practice Evaluation*. Final Report to the Virginia Department of Forestry. Charlottesville, VA.

SAS/STAT. 1990. *SAS/STAT User's Guide*. 4th ed. Vol. 2, Ver. 6. Cary, NC: SAS Institute, Inc.

Surface Mining Control and Reclamation Act of 1977. 91 STAT. 445 Public Law 95-87- August 3, 1977 (30 USCA sec. 1201 et seq.).

Trimble, S.W. 1974. *Man Induced Soil Erosion on the Southern Piedmont, 1700-1970*. USA: Soil Conservation Society of America.

United States Department of Agriculture. 1971. *Soil Survey Orange County, Virginia*. Washington, DC: USDA.

United States Department of Agriculture. 1982. *Soil Survey of Richmond County Virginia*. Washington, DC: USDA.

United States Department of Agriculture. 1985. *Soil Survey of Montgomery County Virginia*. Washington, DC: USDA.

Virginia Department of Conservation and Recreation. 1992. *Virginia Erosion and Sediment Control Handbook*. 3rd ed. Richmond VA: VDCR.

Ward, A., T. Haan and J. Tapp. 1979a. *The DEPOSITS Sedimentation Pond Design Manual*. Lexington, KY: University of Kentucky.

Ward, A.D., C.T. Haan and B.J. Barfield. 1979b. Prediction of Sediment Basin Performance. *Transactions of the ASAE* 22(1): 126-136.

Ward, A.D., C.T. Haan and B.J. Barfield. 1980. The Design of Sediment Basins. *Transactions of the ASAE* 23(2): 351-356.

Warner, R.C. and B.C. Dysart. 1983. Potential Use of the Swirl Concentrator for Sediment Control on Surface Mined Lands. *Proceedings, Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation*. Lexington, KY: University of Kentucky.

Warner, R.C. and P. Schwab. 1989. Alternative Designs of Sedimentation Basins: Environmental and Economic Considerations ASAE Paper No. 89-2020. St. Joseph, MI: ASAE.

Appendix A: Description of Soils

Suffolk loam – 2 to 6 percent slopes (USDA, 1982)

This is a deep, gently sloping, and well drained soil found on ridgetops on the Coastal Plain upland. The surface layer is brown and yellowish brown sandy loam about 8 inches thick. The permeability of this soil is moderate and surface runoff is slow to medium. The surface layer is low in organic matter content and in natural fertility.

Davidson silty clay loam – 2 to 7 percent (USDA, 1971)

This is a deep, well drained soil found in the Piedmont uplands. The surface layer is a dark reddish brown clay loam about 7 inches thick. Infiltration is rapid in the surface layer and permeability is moderately rapid in the subsoil. The Davidson soil is medium in organic matter content and in natural fertility.

Groseclose silt loam – 2 to 7 percent slopes (USDA, 1985)

This is a gently sloping, well drained soil found on ridgetops. The surface layer is brown loam about 10 inches thick. Permeability is slow in the Groseclose soil and surface runoff is medium. The organic matter is low to moderate and natural fertility is low.

Appendix B: Data and Calculations

B1: Dewatering Rate

B2: Filtering Data

B3: Effluent Sediment Concentration

B4: Sediment Loss Rate

B5: Cumulative Sediment In

B6: Cumulative Sediment Out

B1: Dewatering Rate

All dewatering rates were calculated by dividing the volume of the sample (0.5 L) by the time in minutes that it took to collect the sample.

Suffolk, Perforated Riser, Run 1

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	5.48	0.09	5.47
10	500	0.50	5.65	0.09	5.31
15	500	0.50	5.81	0.10	5.16
20	500	0.50	5.84	0.10	5.14
25	500	0.50	6.03	0.10	4.98
30	500	0.50	5.88	0.10	5.10
45	500	0.50	6.09	0.10	4.93
60	500	0.50	6.19	0.10	4.85
75	500	0.50	6.18	0.10	4.85
90	500	0.50	6.42	0.11	4.67
105	500	0.50	6.81	0.11	4.41
120	500	0.50	6.78	0.11	4.42
135	500	0.50	6.96	0.12	4.31
150	500	0.50	7.38	0.12	4.07
165	500	0.50	96.05	1.60	0.31
180	500	0.50	280.44	4.67	0.11

Suffolk, Perforated Riser, Run 2

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	5.49	0.09	5.46
10	500	0.50	5.61	0.09	5.35
15	500	0.50	5.59	0.09	5.37
20	500	0.50	5.81	0.10	5.16
25	500	0.50	6.03	0.10	4.98
30	500	0.50	5.83	0.10	5.15
45	500	0.50	5.97	0.10	5.03
60	500	0.50	6.26	0.10	4.79
75	500	0.50	6.24	0.10	4.81
90	500	0.50	6.40	0.11	4.69
105	500	0.50	6.74	0.11	4.45
120	500	0.50	7.00	0.12	4.29
135	500	0.50	7.21	0.12	4.16
150	500	0.50	7.11	0.12	4.22
165	500	0.50	81.13	1.35	0.37
180	500	0.50	283.21	4.72	0.11

Suffolk, Perforated Riser, Run 3

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	5.70	0.10	5.26
10	500	0.50	5.59	0.09	5.37
15	500	0.50	5.81	0.10	5.16
20	500	0.50	5.79	0.10	5.18
25	500	0.50	5.80	0.10	5.17
30	500	0.50	5.90	0.10	5.08
45	500	0.50	5.84	0.10	5.14
60	500	0.50	6.21	0.10	4.83
75	500	0.50	6.34	0.11	4.73
90	500	0.50	6.34	0.11	4.73
105	500	0.50	6.74	0.11	4.45
120	500	0.50	6.88	0.11	4.36
135	500	0.50	6.96	0.12	4.31
150	500	0.50	7.01	0.12	4.28
165	500	0.50	94.31	1.57	0.32
180	500	0.50	259.74	4.33	0.12

Suffolk, Skimmer, Run 1

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	7.84	0.13	3.83
10	500	0.50	7.94	0.13	3.78
15	500	0.50	8.14	0.14	3.69
20	500	0.50	8.01	0.13	3.75
25	500	0.50	7.93	0.13	3.78
30	500	0.50	7.73	0.13	3.88
45	500	0.50	7.91	0.13	3.79
60	500	0.50	7.93	0.13	3.78
75	500	0.50	7.91	0.13	3.79
90	500	0.50	7.56	0.13	3.97
105	500	0.50	7.71	0.13	3.89
120	500	0.50	7.65	0.13	3.92
135	500	0.50	7.60	0.13	3.95
150	500	0.50	7.69	0.13	3.90
165	500	0.50	7.67	0.13	3.91
180	500	0.50	7.95	0.13	3.77

Suffolk, Skimmer, Run 2

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	8.07	0.13	3.72
10	500	0.50	7.72	0.13	3.89
15	500	0.50	7.84	0.13	3.83
20	500	0.50	7.97	0.13	3.76
25	500	0.50	7.86	0.13	3.82
30	500	0.50	7.74	0.13	3.88
45	500	0.50	7.92	0.13	3.79
60	500	0.50	7.78	0.13	3.86
75	500	0.50	7.77	0.13	3.86
90	500	0.50	7.86	0.13	3.82
105	500	0.50	7.65	0.13	3.92
120	500	0.50	7.31	0.12	4.10
135	500	0.50	7.64	0.13	3.93
150	500	0.50	7.65	0.13	3.92
165	500	0.50	7.77	0.13	3.86
180	500	0.50	7.92	0.13	3.79

Suffolk, Skimmer, Run 3

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	7.74	0.13	3.88
10	500	0.50	7.99	0.13	3.75
15	500	0.50	7.85	0.13	3.82
20	500	0.50	7.83	0.13	3.83
25	500	0.50	7.93	0.13	3.78
30	500	0.50	7.88	0.13	3.81
45	500	0.50	7.52	0.13	3.99
60	500	0.50	7.64	0.13	3.93
75	500	0.50	7.72	0.13	3.89
90	500	0.50	7.79	0.13	3.85
105	500	0.50	7.89	0.13	3.80
120	500	0.50	7.80	0.13	3.85
135	500	0.50	7.71	0.13	3.89
150	500	0.50	7.38	0.12	4.07
165	500	0.50	7.74	0.13	3.88
180	500	0.50	7.94	0.13	3.78

Davidson, Perforated Riser, Run 1

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	5.80	0.10	5.17
10	500	0.50	5.77	0.10	5.20
15	500	0.50	5.85	0.10	5.13
20	500	0.50	6.14	0.10	4.89
25	500	0.50	5.95	0.10	5.04
30	500	0.50	6.24	0.10	4.81
45	500	0.50	6.51	0.11	4.61
60	500	0.50	6.74	0.11	4.45
75	500	0.50	7.04	0.12	4.26
90	500	0.50	6.94	0.12	4.32
105	500	0.50	7.17	0.12	4.18
120	500	0.50	7.38	0.12	4.07
135	500	0.50	7.61	0.13	3.94
150	500	0.50	7.90	0.13	3.80
165	500	0.50	85.34	1.42	0.35
180	500	0.50	268.08	4.47	0.11

Davidson, Perforated Riser, Run 2

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	5.89	0.10	5.09
10	500	0.50	5.87	0.10	5.11
15	500	0.50	6.01	0.10	4.99
20	500	0.50	5.95	0.10	5.04
25	500	0.50	5.92	0.10	5.07
30	500	0.50	5.98	0.10	5.02
45	500	0.50	6.37	0.11	4.71
60	500	0.50	6.44	0.11	4.66
75	500	0.50	6.74	0.11	4.45
90	500	0.50	6.53	0.11	4.59
105	500	0.50	7.03	0.12	4.27
120	500	0.50	6.90	0.12	4.35
135	500	0.50	7.05	0.12	4.26
150	500	0.50	7.24	0.12	4.14
165	500	0.50	79.69	1.33	0.38
180	500	0.50	270.04	4.50	0.11

Davidson, Perforated Riser, Run 3

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	5.49	0.09	5.46
10	500	0.50	5.69	0.09	5.27
15	500	0.50	5.84	0.10	5.14
20	500	0.50	5.79	0.10	5.18
25	500	0.50	5.92	0.10	5.07
30	500	0.50	6.05	0.10	4.96
45	500	0.50	5.87	0.10	5.11
60	500	0.50	6.07	0.10	4.94
75	500	0.50	6.18	0.10	4.85
90	500	0.50	6.40	0.11	4.69
105	500	0.50	6.88	0.11	4.36
120	500	0.50	7.06	0.12	4.25
135	500	0.50	7.11	0.12	4.22
150	500	0.50	7.27	0.12	4.13
165	500	0.50	85.45	1.42	0.35
180	500	0.50	272.16	4.54	0.11

Davidson, Skimmer, Run 1

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	8.38	0.14	3.58
10	500	0.50	7.81	0.13	3.84
15	500	0.50	7.99	0.13	3.75
20	500	0.50	7.84	0.13	3.83
25	500	0.50	7.69	0.13	3.90
30	500	0.50	7.63	0.13	3.93
45	500	0.50	7.55	0.13	3.97
60	500	0.50	7.53	0.13	3.98
75	500	0.50	7.74	0.13	3.88
90	500	0.50	7.63	0.13	3.93
105	500	0.50	7.62	0.13	3.94
120	500	0.50	7.66	0.13	3.92
135	500	0.50	7.55	0.13	3.97
150	500	0.50	7.62	0.13	3.94
165	500	0.50	7.45	0.12	4.03
180	500	0.50	7.69	0.13	3.90

Davidson, Skimmer, Run 2

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	7.85	0.13	3.82
10	500	0.50	8.01	0.13	3.75
15	500	0.50	7.79	0.13	3.85
20	500	0.50	7.86	0.13	3.82
25	500	0.50	7.66	0.13	3.92
30	500	0.50	7.99	0.13	3.75
45	500	0.50	7.88	0.13	3.81
60	500	0.50	7.90	0.13	3.80
75	500	0.50	7.82	0.13	3.84
90	500	0.50	7.73	0.13	3.88
105	500	0.50	7.54	0.13	3.98
120	500	0.50	7.56	0.13	3.97
135	500	0.50	7.76	0.13	3.87
150	500	0.50	7.68	0.13	3.91
165	500	0.50	7.76	0.13	3.87
180	500	0.50	7.91	0.13	3.79

Davidson, Skimmer, Run 3

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	7.86	0.13	3.82
10	500	0.50	8.11	0.14	3.70
15	500	0.50	7.89	0.13	3.80
20	500	0.50	7.75	0.13	3.87
25	500	0.50	7.92	0.13	3.79
30	500	0.50	7.89	0.13	3.80
45	500	0.50	7.91	0.13	3.79
60	500	0.50	7.66	0.13	3.92
75	500	0.50	7.54	0.13	3.98
90	500	0.50	7.98	0.13	3.76
105	500	0.50	7.56	0.13	3.97
120	500	0.50	7.59	0.13	3.95
135	500	0.50	7.73	0.13	3.88
150	500	0.50	7.77	0.13	3.86
165	500	0.50	7.79	0.13	3.85
180	500	0.50	7.85	0.13	3.82

Groseclose, Perforated Riser, Run 1

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	5.97	0.10	5.03
10	500	0.50	5.69	0.09	5.27
15	500	0.50	6.17	0.10	4.86
20	500	0.50	6.18	0.10	4.85
25	500	0.50	6.13	0.10	4.89
30	500	0.50	6.31	0.11	4.75
45	500	0.50	6.54	0.11	4.59
60	500	0.50	6.74	0.11	4.45
75	500	0.50	6.87	0.11	4.37
90	500	0.50	7.15	0.12	4.20
105	500	0.50	7.34	0.12	4.09
120	500	0.50	7.61	0.13	3.94
135	500	0.50	7.82	0.13	3.84
150	500	0.50	8.01	0.13	3.75
165	500	0.50	107.41	1.79	0.28
180	500	0.50	291.68	4.86	0.10

Groseclose, Perforated Riser, Run 2

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	5.79	0.10	5.18
10	500	0.50	6.02	0.10	4.98
15	500	0.50	5.81	0.10	5.16
20	500	0.50	5.93	0.10	5.06
25	500	0.50	5.88	0.10	5.10
30	500	0.50	5.82	0.10	5.15
45	500	0.50	6.00	0.10	5.00
60	500	0.50	6.57	0.11	4.57
75	500	0.50	6.52	0.11	4.60
90	500	0.50	7.28	0.12	4.12
105	500	0.50	6.70	0.11	4.48
120	500	0.50	7.38	0.12	4.07
135	500	0.50	7.37	0.12	4.07
150	500	0.50	7.78	0.13	3.86
165	500	0.50	88.65	1.48	0.34
180	500	0.50	274.85	4.58	0.11

Groseclose, Perforated Riser, Run 3

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	5.72	0.10	5.24
10	500	0.50	5.63	0.09	5.33
15	500	0.50	5.77	0.10	5.20
20	500	0.50	5.88	0.10	5.10
25	500	0.50	5.94	0.10	5.05
30	500	0.50	5.97	0.10	5.03
45	500	0.50	5.92	0.10	5.07
60	500	0.50	5.89	0.10	5.09
75	500	0.50	6.33	0.11	4.74
90	500	0.50	6.63	0.11	4.52
105	500	0.50	6.41	0.11	4.68
120	500	0.50	6.96	0.12	4.31
135	500	0.50	6.74	0.11	4.45
150	500	0.50	6.84	0.11	4.39
165	500	0.50	94.09	1.57	0.32
180	500	0.50	253.38	4.22	0.12

Groseclose, Skimmer, Run 1

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	8.08	0.13	3.71
10	500	0.50	8.11	0.14	3.70
15	500	0.50	8.00	0.13	3.75
20	500	0.50	7.84	0.13	3.83
25	500	0.50	7.98	0.13	3.76
30	500	0.50	7.81	0.13	3.84
45	500	0.50	7.75	0.13	3.87
60	500	0.50	7.79	0.13	3.85
75	500	0.50	7.72	0.13	3.89
90	500	0.50	7.69	0.13	3.90
105	500	0.50	8.02	0.13	3.74
120	500	0.50	7.41	0.12	4.05
135	500	0.50	7.74	0.13	3.88
150	500	0.50	7.73	0.13	3.88
165	500	0.50	7.77	0.13	3.86
180	500	0.50	7.77	0.13	3.86

Groseclose, Skimmer, Run 2

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	7.77	0.13	3.86
10	500	0.50	7.88	0.13	3.81
15	500	0.50	7.39	0.12	4.06
20	500	0.50	7.67	0.13	3.91
25	500	0.50	7.37	0.12	4.07
30	500	0.50	7.81	0.13	3.84
45	500	0.50	7.63	0.13	3.93
60	500	0.50	7.75	0.13	3.87
75	500	0.50	7.51	0.13	3.99
90	500	0.50	7.36	0.12	4.08
105	500	0.50	7.66	0.13	3.92
120	500	0.50	7.52	0.13	3.99
135	500	0.50	7.60	0.13	3.95
150	500	0.50	7.59	0.13	3.95
165	500	0.50	7.98	0.13	3.76
180	500	0.50	7.64	0.13	3.93

Groseclose, Skimmer, Run 3

Time (min)	Volume of sample (mL)	Volume of sample (L)	Time to collect (sec)	Time to collect (min)	Dewatering rate (L/min)
5	500	0.50	8.29	0.14	3.62
10	500	0.50	7.82	0.13	3.84
15	500	0.50	8.16	0.14	3.68
20	500	0.50	7.44	0.12	4.03
25	500	0.50	7.52	0.13	3.99
30	500	0.50	7.49	0.12	4.01
45	500	0.50	7.68	0.13	3.91
60	500	0.50	7.64	0.13	3.93
75	500	0.50	7.59	0.13	3.95
90	500	0.50	7.68	0.13	3.91
105	500	0.50	7.46	0.12	4.02
120	500	0.50	7.56	0.13	3.97
135	500	0.50	7.77	0.13	3.86
150	500	0.50	7.60	0.13	3.95
165	500	0.50	7.65	0.13	3.92
180	500	0.50	7.99	0.13	3.75

B2: Filtration Data

Following are the filtration results in the random order in which the samples were collected. A duplicate filtration was done on every tenth samples as a quality control method. With each duplicate, a blank sample was run. This involved filtering deionized water. A blank was also filtered when there was a break of 24 hours or more between filtering samples. Each blank was subtracted from its preceding initial values of total suspended solids (TSS) to obtain the true value of TSS.

Samples L1-L18: Suffolk, Skimmer, Run 1
Samples L21-L38: Groseclose, Perforated Riser, Run 1
Samples L41-L58: Davidson, Perforated Riser, Run 1
Samples L61-L78: Groseclose, Perforated Riser, Run 2
Samples L81-L98: Davidson, Perforated Riser, Run 2
Samples L101-L118: Davidson, Skimmer, Run 1
Samples L121-L138: Suffolk, Skimmer, Run 2
Samples L141-L158: Suffolk, Perforated Riser, Run 1
Samples L161-L178: Davidson, Skimmer, Run 2
Samples L181-L198: Suffolk, Skimmer, Run 3
Samples L201-L218: Davidson, Skimmer, Run 3
Samples L221-L238: Groseclose, Skimmer, Run 1
Samples L241-L258: Suffolk, Perforated Riser, Run 2
Samples L261-L278: Groseclose, Skimmer, Run 2
Samples L281-L298: Groseclose, Skimmer, Run 3
Samples L301-L320: Davidson, Perforated Riser, Run 3
Samples L321-L338: Groseclose, Perforated Riser, Run 3
Samples L341-L358: Suffolk, Perforated Riser, Run 3

Of each of the above sample sets:

sample 1 (e.g. sample 261 from the sample set 261-278) was at time t=0 from inside the sedimentation basin; this value was used in Appendix B5 to compute cumulative sediment in suspension at the start of the run

sample 2 was at t=5 minutes

sample 3 was at t=10 minutes

sample 4 was at t=15 minutes

sample 5 was at t=20 minutes

sample 6 was at t=25 minutes

sample 7 was at t=30 minutes

sample 8 was at t=45 minutes

sample 9 was at t=60 minutes

sample 10 was at t=75 minutes

sample 11 was at t=90 minutes

sample 12 was at t=105 minutes

sample 13 was at t=120 minutes

sample 14 was at t=135 minutes

sample 15 was at t=150 minutes

sample 16 was at t=165 minutes

sample 17 was at t=180 minutes

sample 18 was at t=180 minutes from inside the receiving tank; this value was used in Appendix B6 to compute cumulative sediment out

samples 19-20 are not shown because they were the 1 L samples taken at the start and finish of each run to be used for particle size analyses

All samples followed by a ‘d’ are the duplicate samples. Samples beginning with ‘B’ are the blanks corresponding to every tenth sample. Samples beginning with a ‘Blk’ are blanks corresponding to a break of 24 hours or more between filtration.

Tare weight is the mass of the dry filter prior to filtering. Volume is the volume of the subsample that was filtered. Dry Wt. is the mass of the filter and sediment after filtering and drying. TSS/Corr. Blk. was calculated by subtracting the tare from the dry weight and dividing by the volume of the subsample. The true total suspended solids (True TSS) were calculated by subtracting from the total suspended solids the first corrected blank that followed the sample.

As an example:

Sample L114 was the sample taken at 135 minutes into the first run of the Davidson/Skimmer treatment. Its true TSS was calculated by subtracting the corrected blank (LB11; -1.00 mg/L) from the TSS for the sample (50.00 mg/L).

Sample	Tare	Volume	Dry Wt.	TSS/Corr. Blk.	True TSS
	(g)	(mL)	(g)	(mg/L)	(mg/L)
L1	1.1071	35	1.2339	3622.86	3631.86
L2	1.1085	52	1.1822	1417.31	1426.31
L3	1.1244	53	1.1732	920.75	929.75
L4	1.1162	52	1.1519	686.54	695.54
L5	1.1134	58	1.1498	627.59	636.59
L6	1.1259	64	1.1631	581.25	590.25
L7	1.1175	100	1.1669	494.00	503.00
L8	1.1225	100	1.1600	375.00	384.00
L9	1.1264	99	1.1573	312.12	321.12
L10	1.1263	100	1.1532	269.00	278.00
L10d	1.1099	99	1.1367	270.71	279.71
LB1	1.1154	100	1.1145	-9.00	-----
L11	1.1289	100	1.1535	246.00	252.00
L12	1.0980	100	1.1218	238.00	244.00
L13	1.0989	100	1.1202	213.00	219.00
L14	1.0974	100	1.1168	194.00	200.00
L15	1.1069	100	1.1255	186.00	192.00
L16	1.1063	100	1.1227	164.00	170.00
L17	1.1060	100	1.1228	168.00	174.00
L18	1.1194	100	1.1533	339.00	345.00
L21	1.1092	40	1.2404	3280.00	3286.00
L22	1.1098	60	1.2215	1861.67	1867.67
L22d	1.1194	62	1.2382	1916.13	1922.13
LB2	1.1226	100	1.1220	-6.00	-----
L23	1.1078	70	1.1989	1301.43	1308.43
L24	1.1164	71	1.1950	1107.04	1114.04
L25	1.1147	100	1.2001	854.00	861.00
L26	1.1222	100	1.1916	694.00	701.00
L27	1.1127	100	1.1733	606.00	613.00
L28	1.1102	100	1.1534	432.00	439.00
L29	1.1260	100	1.1624	364.00	371.00
L30	1.1192	100	1.1469	277.00	284.00
L31	1.1055	100	1.1305	250.00	257.00
L32	1.1196	100	1.1434	238.00	245.00
L32d	1.0750	100	1.0999	249.00	256.00
LB3	1.0751	100	1.0744	-7.00	-----
L33	1.1109	100	1.1319	210.00	216.00
L34	1.1113	100	1.1317	204.00	210.00
L35	1.1198	100	1.1412	214.00	220.00
L36	1.1171	100	1.1356	185.00	191.00
L37	1.1219	100	1.1361	142.00	148.00
L38	1.1134	100	1.1624	490.00	496.00
L41	1.0789	25	1.1427	2552.00	2558.00
L42	1.1041	26	1.1554	1973.08	1979.08
L43	1.0995	26	1.1374	1457.69	1463.69
L44	1.0904	31	1.1213	996.77	1002.77
L44d	1.0793	30	1.1116	1076.67	1082.67

Sample	Tare	Volume	Dry Wt.	TSS/Corr. Blk.	True TSS
	(g)	(mL)	(g)	(mg/L)	(mg/L)
LB4	1.0784	100	1.0778	-6.00	-----
L45	1.0790	30	1.0970	600.00	609.00
L46	1.0845	31	1.0974	416.13	425.13
L47	1.0959	40	1.1098	347.50	356.50
L48	1.0976	50	1.1072	192.00	201.00
L49	1.1103	61	1.1185	134.43	143.43
L50	1.1039	65	1.1102	96.92	105.92
L51	1.1041	100	1.1126	85.00	94.00
L52	1.0979	100	1.1085	106.00	115.00
L53	1.1098	100	1.1172	74.00	83.00
L54	1.1077	100	1.1129	52.00	61.00
L54d	1.1036	100	1.1077	41.00	50.00
LB5	1.1147	100	1.1138	-9.00	-----
L55	1.1139	100	1.1172	33.00	40.00
L56	1.1029	100	1.1053	24.00	31.00
L57	1.1108	100	1.1143	35.00	42.00
L58	1.1084	75	1.1339	340.00	347.00
LBlk	1.1090	100	1.1083	-7.00	-----
L61	1.1127	40	1.2972	4612.50	4618.50
L62	1.1133	60	1.2455	2203.33	2209.33
L63	1.1116	60	1.2125	1681.67	1687.67
L64	1.0969	75	1.1883	1218.67	1224.67
L65	1.1038	75	1.1750	949.33	955.33
L66	1.1003	100	1.1755	752.00	758.00
L66d	1.1048	100	1.1802	754.00	760.00
LB6	1.0976	100	1.0970	-6.00	-----
L67	1.1102	100	1.1741	639.00	645.00
L68	1.1070	100	1.1513	443.00	449.00
L69	1.1080	100	1.1461	381.00	387.00
L70	1.1085	100	1.1381	296.00	302.00
L71	1.1100	100	1.1334	234.00	240.00
L72	1.0907	100	1.1152	245.00	251.00
L73	1.0921	100	1.1107	186.00	192.00
L74	1.1050	100	1.1191	141.00	147.00
L75	1.1003	100	1.1112	109.00	115.00
L76	1.0911	100	1.0965	54.00	60.00
L76d	1.1061	100	1.1116	55.00	61.00
LB7	1.1045	100	1.1039	-6.00	-----
L77	1.1141	100	1.1185	44.00	49.00
L78	1.1122	100	1.1610	488.00	493.00
L81	1.0909	25	1.1410	2004.00	2009.00
L82	1.0941	25	1.1275	1336.00	1341.00
L83	1.0916	30	1.1149	776.67	781.67
L84	1.0917	30	1.1092	583.33	588.33
L85	1.0930	35	1.1084	440.00	445.00
L86	1.0816	40	1.0957	352.50	357.50
L87	1.0905	40	1.1012	267.50	272.50

Sample	Tare	Volume	Dry Wt.	TSS/Corr. Blk.	True TSS
	(g)	(mL)	(g)	(mg/L)	(mg/L)
L88	1.0836	50	1.0927	182.00	187.00
L88d	1.0922	50	1.1005	166.00	171.00
LB8	1.0875	100	1.0870	-5.00	-----
L89	1.0825	60	1.0911	143.33	150.33
L90	1.0886	75	1.0967	108.00	115.00
L91	1.1145	100	1.1235	90.00	97.00
L92	1.1065	100	1.1145	80.00	87.00
L93	1.0853	100	1.0918	65.00	72.00
L94	1.1042	100	1.1099	57.00	64.00
L95	1.0988	100	1.1042	54.00	61.00
L96	1.0942	100	1.0970	28.00	35.00
L97	1.1071	100	1.1129	58.00	65.00
L98	1.0987	75	1.1171	245.33	252.33
L98d	1.1125	75	1.1298	230.67	237.67
LB9	1.1012	100	1.1005	-7.00	-----
L101	1.0791	25	1.1465	2696.00	2696.00
L102	1.1163	25	1.1444	1124.00	1124.00
L103	1.1033	35	1.1260	648.57	648.57
L104	1.1048	35	1.1227	511.43	511.43
L105	1.1044	40	1.1197	382.50	382.50
L106	1.0965	50	1.1123	316.00	316.00
L107	1.0963	50	1.1083	240.00	240.00
L108	1.0972	60	1.1060	146.67	146.67
L109	1.1272	70	1.1339	95.71	95.71
L110	1.1129	85	1.1193	75.29	75.29
L110d	1.1103	85	1.1158	64.71	64.71
LB10	1.1226	100	1.1226	0.00	-----
L111	1.1210	100	1.1291	81.00	82.00
L112	1.1162	100	1.1237	75.00	76.00
L113	1.1239	100	1.1300	61.00	62.00
L114	1.1098	100	1.1148	50.00	51.00
L115	1.1177	100	1.1222	45.00	46.00
L116	1.1230	100	1.1272	42.00	43.00
L117	1.1083	100	1.1118	35.00	36.00
L118	1.1085	100	1.1262	177.00	178.00
L121	1.0823	40	1.2080	3142.50	3143.50
L122	1.1127	50	1.1726	1198.00	1199.00
L122d	1.1196	50	1.1804	1216.00	1217.00
LB11	1.1252	100	1.1251	-1.00	-----
L123	1.1188	80	1.1772	730.00	723.00
L124	1.1164	100	1.1709	545.00	538.00
L125	1.1099	100	1.1557	458.00	451.00
L126	1.1109	100	1.1542	433.00	426.00
L127	1.0735	100	1.1091	356.00	349.00
L128	1.0734	100	1.1005	271.00	264.00
L129	1.1168	100	1.1395	227.00	220.00
L130	1.1029	100	1.1233	204.00	197.00

Sample	Tare	Volume	Dry Wt.	TSS/Corr. Blk.	True TSS
	(g)	(mL)	(g)	(mg/L)	(mg/L)
L131	1.1251	100	1.1436	185.00	178.00
L132	1.1198	100	1.1348	150.00	143.00
L132d	1.1101	100	1.1248	147.00	140.00
LB12	1.1239	100	1.1246	7.00	-----
L133	1.1107	100	1.1226	119.00	116.00
L134	1.1131	100	1.1253	122.00	119.00
L135	1.1153	100	1.1297	144.00	141.00
L136	1.1090	100	1.1202	112.00	109.00
L137	1.1242	100	1.1364	122.00	119.00
L138	1.1197	100	1.1461	264.00	261.00
LBlk	1.1104	100	1.1107	3.00	-----
L141	1.1255	40	1.2812	3892.50	3894.50
L142	1.1350	50	1.2544	2388.00	2390.00
L143	1.0852	50	1.1668	1632.00	1634.00
L144	1.1247	80	1.2078	1038.75	1040.75
L144d	1.0829	80	1.1657	1035.00	1037.00
LB13	1.1015	100	1.1013	-2.00	-----
L145	1.1018	100	1.1849	831.00	833.00
L146	1.1232	100	1.1900	668.00	670.00
L147	1.1166	100	1.1726	560.00	562.00
L148	1.1065	100	1.1432	367.00	369.00
L149	1.1140	100	1.1445	305.00	307.00
L150	1.1231	100	1.1462	231.00	233.00
L151	1.1197	100	1.1389	192.00	194.00
L152	1.1249	100	1.1424	175.00	177.00
L153	1.1323	100	1.1458	135.00	137.00
L154	1.0937	100	1.1052	115.00	117.00
L154d	1.0912	100	1.1019	107.00	109.00
LB14	1.0914	100	1.0912	-2.00	-----
L155	1.0939	100	1.1034	95.00	95.00
L156	1.0971	100	1.1028	57.00	57.00
L157	1.0943	100	1.1027	84.00	84.00
L158	1.0946	100	1.1413	467.00	467.00
LBlk	1.0913	100	1.0913	0.00	-----
L161	1.1080	30	1.1736	2186.67	2189.67
L162	1.1000	40	1.1313	782.50	785.50
L163	1.0957	40	1.1185	570.00	573.00
L164	1.1011	45	1.1182	380.00	383.00
L165	1.0944	55	1.1120	320.00	323.00
L166	1.0950	55	1.1084	243.64	246.64
L166d	1.1035	55	1.1163	232.73	235.73
LB15	1.1106	100	1.1103	-3.00	-----
L167	1.1168	65	1.1327	244.62	244.62
L168	1.1043	70	1.1158	164.29	164.29
L169	1.0856	70	1.0933	110.00	110.00
L170	1.1093	80	1.1166	91.25	91.25
L171	1.1020	100	1.1107	87.00	87.00

Sample	Tare	Volume	Dry Wt.	TSS/Corr. Blk.	True TSS
	(g)	(mL)	(g)	(mg/L)	(mg/L)
L172	1.0977	100	1.1045	68.00	68.00
L173	1.1187	100	1.1240	53.00	53.00
L174	1.0914	100	1.0961	47.00	47.00
L175	1.0900	100	1.0941	41.00	41.00
L176	1.0988	100	1.1025	37.00	37.00
L176d	1.0944	100	1.0984	40.00	40.00
LB16	1.0866	100	1.0866	0.00	-----
L177	1.0891	100	1.0926	35.00	38.00
L178	1.0876	100	1.1034	158.00	161.00
LBlk	1.1239	100	1.1236	-3.00	-----
L181	1.1146	40	1.2661	3787.50	3791.50
L182	1.0881	60	1.1493	1020.00	1024.00
L183	1.0977	70	1.1440	661.43	665.43
L184	1.0921	90	1.1413	546.67	550.67
L185	1.0798	100	1.1290	492.00	496.00
L186	1.0967	100	1.1377	410.00	414.00
L187	1.0965	100	1.1329	364.00	368.00
L188	1.0898	100	1.1187	289.00	293.00
L188d	1.0914	100	1.1208	294.00	298.00
LB17	1.0856	100	1.0852	-4.00	-----
L189	1.0876	100	1.1118	242.00	246.00
L190	1.0951	100	1.1184	233.00	237.00
L191	1.0926	100	1.1150	224.00	228.00
L192	1.0915	100	1.1126	211.00	215.00
L193	1.0962	100	1.1155	193.00	197.00
L194	1.1191	100	1.1376	185.00	189.00
L195	1.1221	100	1.1390	169.00	173.00
L196	1.1240	100	1.1384	144.00	148.00
L197	1.1072	100	1.1209	137.00	141.00
L198	1.1274	100	1.1571	297.00	301.00
L198d	1.1142	100	1.1438	296.00	300.00
LB18	1.1081	100	1.1077	-4.00	-----
L201	1.1197	30	1.1889	2306.67	2308.67
L202	1.1222	40	1.1545	807.50	809.50
L203	1.1174	40	1.1393	547.50	549.50
L204	1.1126	45	1.1308	404.44	406.44
L205	1.1143	55	1.1324	329.09	331.09
L206	1.1116	55	1.1272	283.64	285.64
L207	1.1254	55	1.1384	236.36	238.36
L208	1.1258	75	1.1398	186.67	188.67
L209	1.1198	100	1.1329	131.00	133.00
L210	1.1030	100	1.1131	101.00	103.00
L210d	1.1075	100	1.1168	93.00	95.00
LB19	1.0958	100	1.0956	-2.00	-----
L211	1.1190	100	1.1267	77.00	80.00
L212	1.1179	100	1.1239	60.00	63.00
L213	1.1110	100	1.1164	54.00	57.00

Sample	Tare	Volume	Dry Wt.	TSS/Corr. Blk.	True TSS
	(g)	(mL)	(g)	(mg/L)	(mg/L)
L214	1.1090	100	1.1137	47.00	50.00
L215	1.0946	100	1.0989	43.00	46.00
L216	1.1179	100	1.1220	41.00	44.00
L217	1.1021	100	1.1064	43.00	46.00
L218	1.1090	100	1.1252	162.00	165.00
L221	1.0855	50	1.3053	4396.00	4399.00
L222	1.0791	100	1.1626	835.00	838.00
L222d	1.0809	100	1.1657	848.00	851.00
LB20	1.1039	100	1.1036	-3.00	-----
L223	1.1011	100	1.1683	672.00	671.00
L224	1.0834	100	1.1424	590.00	589.00
L225	1.1026	100	1.1501	475.00	474.00
L226	1.0994	100	1.1398	404.00	403.00
L227	1.0877	100	1.1259	382.00	381.00
L228	1.1024	100	1.1342	318.00	317.00
L229	1.1021	100	1.1287	266.00	265.00
L230	1.1039	100	1.1271	232.00	231.00
L231	1.0963	100	1.1193	230.00	229.00
L232	1.1144	100	1.1335	191.00	190.00
L232d	1.1096	100	1.1278	182.00	181.00
LB21	1.1133	100	1.1134	1.00	-----
L233	1.1065	100	1.1237	172.00	172.00
L234	1.1147	100	1.1316	169.00	169.00
L235	1.1051	100	1.1212	161.00	161.00
L236	1.1176	100	1.1320	144.00	144.00
L237	1.1136	100	1.1288	152.00	152.00
L238	1.1173	100	1.1454	281.00	281.00
LBlk	1.1174	100	1.1174	0.00	-----
L241	1.1067	40	1.2218	2877.50	2885.50
L242	1.1139	55	1.2200	1929.09	1937.09
L243	1.1071	60	1.1940	1448.33	1456.33
L244	1.1060	80	1.1849	986.25	994.25
L244d	1.0943	80	1.1746	1003.75	1011.75
LB22	1.1106	100	1.1098	-8.00	-----
L245	1.1077	100	1.1838	761.00	770.00
L246	1.1053	100	1.1651	598.00	607.00
L247	1.1055	100	1.1567	512.00	521.00
L248	1.1117	100	1.1448	331.00	340.00
L249	1.1056	100	1.1295	239.00	248.00
L250	1.1102	100	1.1318	216.00	225.00
L251	1.1095	100	1.1275	180.00	189.00
L252	1.1160	100	1.1348	188.00	197.00
L253	1.1207	100	1.1361	154.00	163.00
L254	1.1160	100	1.1272	112.00	121.00
L254d	1.1146	100	1.1259	113.00	122.00
LB23	1.1035	100	1.1026	-9.00	-----
L255	1.0998	100	1.1099	101.00	107.00

Sample	Tare	Volume	Dry Wt.	TSS/Corr. Blk.	True TSS
	(g)	(mL)	(g)	(mg/L)	(mg/L)
L256	1.1029	100	1.1065	36.00	42.00
L257	1.1049	100	1.1139	90.00	96.00
L258	1.1019	100	1.1436	417.00	423.00
L261	1.1071	50	1.3329	4516.00	4522.00
L262	1.1056	100	1.2649	1593.00	1599.00
L263	1.1078	100	1.2042	964.00	970.00
L264	1.1071	100	1.1870	799.00	805.00
L265	1.1235	100	1.1910	675.00	681.00
L266	1.1066	100	1.1642	576.00	582.00
L266d	1.1139	100	1.1716	577.00	583.00
LB24	1.1122	100	1.1116	-6.00	-----
L267	1.1100	100	1.1634	534.00	539.00
L268	1.1127	100	1.1524	397.00	402.00
L269	1.1092	100	1.1435	343.00	348.00
L270	1.1104	100	1.1412	308.00	313.00
L271	1.1067	100	1.1355	288.00	293.00
L272	1.1217	100	1.1462	245.00	250.00
L273	1.1116	100	1.1359	243.00	248.00
L274	1.1216	100	1.1444	228.00	233.00
L275	1.1081	100	1.1298	217.00	222.00
L276	1.0946	100	1.1141	195.00	200.00
L276d	1.1024	100	1.1221	197.00	202.00
LB25	1.0920	100	1.0915	-5.00	-----
L277	1.0907	100	1.1086	179.00	184.00
L278	1.0962	100	1.1342	380.00	385.00
L281	1.0992	40	1.2707	4287.50	4292.50
L282	1.0986	80	1.1864	1097.50	1102.50
L283	1.1012	100	1.1779	767.00	772.00
L284	1.1036	100	1.1678	642.00	647.00
L285	1.1134	100	1.1748	614.00	619.00
L286	1.1130	100	1.1601	471.00	476.00
L287	1.1049	100	1.1438	389.00	394.00
L288	1.1098	100	1.1439	341.00	346.00
L288d	1.1102	100	1.1446	344.00	349.00
LB26	1.1152	100	1.1147	-5.00	-----
L289	1.1185	100	1.1473	288.00	295.00
L290	1.1221	100	1.1477	256.00	263.00
L291	1.1154	100	1.1401	247.00	254.00
L292	1.1193	100	1.1437	244.00	251.00
L293	1.1137	100	1.1385	248.00	255.00
L294	1.1247	100	1.1463	216.00	223.00
L295	1.1299	100	1.1491	192.00	199.00
L296	1.1198	100	1.1364	166.00	173.00
L297	1.1147	100	1.1310	163.00	170.00
L298	1.1234	100	1.1570	336.00	343.00
L298d	1.1169	100	1.1499	330.00	337.00
LB27	1.1242	100	1.1235	-7.00	-----

Sample	Tare	Volume	Dry Wt.	TSS/Corr. Blk.	True TSS
	(g)	(mL)	(g)	(mg/L)	(mg/L)
L301	1.1223	25	1.1817	2376.00	2384.00
L302	1.1335	30	1.1814	1596.67	1604.67
L303	1.1324	40	1.1837	1282.50	1290.50
L304	1.1304	40	1.1663	897.50	905.50
L305	1.1457	45	1.1750	651.11	659.11
L306	1.1332	45	1.1557	500.00	508.00
L307	1.1399	50	1.1585	372.00	380.00
L308	1.1337	60	1.1474	228.33	236.33
L309	1.1457	60	1.1555	163.33	171.33
L310	1.1459	75	1.1549	120.00	128.00
L310d	1.1359	75	1.1457	130.67	138.67
LB28	1.1385	100	1.1377	-8.00	-----
L311	1.1379	100	1.1465	86.00	91.00
L312	1.1501	100	1.1573	72.00	77.00
L313	1.1376	100	1.1438	62.00	67.00
L314	1.1425	100	1.1490	65.00	70.00
L315	1.1223	100	1.1267	44.00	49.00
L316	1.1321	100	1.1359	38.00	43.00
L317	1.1332	100	1.1350	18.00	23.00
L318	1.1307	85	1.1567	305.88	310.88
LBlk	1.1263	100	1.1258	-5.00	-----
L321	1.1125	40	1.3097	4930.00	4935.00
L322	1.1091	50	1.2605	3028.00	3033.00
L322d	1.1188	50	1.2641	2906.00	2911.00
LB29	1.1056	100	1.1051	-5.00	-----
L323	1.1107	70	1.2472	1950.00	1953.00
L324	1.1091	100	1.2360	1269.00	1272.00
L325	1.1086	100	1.2179	1093.00	1096.00
L326	1.1123	100	1.2060	937.00	940.00
L327	1.1086	100	1.1883	797.00	800.00
L328	1.1149	100	1.1742	593.00	596.00
L329	1.1174	100	1.1650	476.00	479.00
L330	1.0957	100	1.1317	360.00	363.00
L331	1.1096	100	1.1405	309.00	312.00
L332	1.0905	100	1.1219	314.00	317.00
L332d	1.0875	100	1.1188	313.00	316.00
LB30	1.1236	100	1.1233	-3.00	-----
L333	1.1137	100	1.1395	258.00	259.00
L334	1.1108	100	1.1332	224.00	225.00
L335	1.0969	100	1.1132	163.00	164.00
L336	1.1175	100	1.1354	179.00	180.00
L337	1.0974	100	1.1084	110.00	111.00
L338	1.1111	100	1.1783	672.00	673.00
L341	1.1050	40	1.2821	4427.50	4428.50
L342	1.1145	55	1.2771	2956.36	2957.36
L343	1.1108	60	1.2288	1966.67	1967.67
L344	1.1004	80	1.2067	1328.75	1329.75

Sample	Tare	Volume	Dry Wt.	TSS/Corr. Blk.	True TSS
	(g)	(mL)	(g)	(mg/L)	(mg/L)
L344d	1.0997	80	1.1918	1151.25	1152.25
LB31	1.1103	100	1.1102	-1.00	-----
L345	1.1106	100	1.2081	975.00	975.00
L346	1.1002	100	1.1762	760.00	760.00
L347	1.1068	100	1.1722	654.00	654.00
L348	1.1118	100	1.1593	475.00	475.00
L349	1.0996	100	1.1382	386.00	386.00
L350	1.1082	100	1.1382	300.00	300.00
L351	1.1059	100	1.1305	246.00	246.00
L352	1.1188	100	1.1434	246.00	246.00
L353	1.1132	100	1.1332	200.00	200.00
L354	1.1143	100	1.1299	156.00	156.00
L354d	1.1156	100	1.1309	153.00	153.00
LB32	1.1051	100	1.1051	0.00	-----
L355	1.1056	100	1.1185	129.00	132.00
L356	1.0998	100	1.1047	49.00	52.00
L357	1.1028	100	1.1064	36.00	39.00
L358	1.0976	100	1.1543	567.00	570.00
LBlk	1.1258	100	1.1255	-3.00	-----

B3: Effluent Sediment Concentration

Following are the effluent sediment concentrations as reported in Appendix B2. They were converted into g/L for purposes of calculating sediment loss rates.

Suffolk, Perforated Riser, Run 1

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	2390.0000	2.39
10	1634.0000	1.63
15	1040.7500	1.04
20	833.0000	0.83
25	670.0000	0.67
30	562.0000	0.56
45	369.0000	0.37
60	307.0000	0.31
75	233.0000	0.23
90	194.0000	0.19
105	177.0000	0.18
120	137.0000	0.14
135	117.0000	0.12
150	95.0000	0.09
165	57.0000	0.06
180	84.0000	0.08

Suffolk, Perforated Riser, Run 2

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	1937.0909	1.94
10	1456.3333	1.46
15	994.2500	0.99
20	770.0000	0.77
25	607.0000	0.61
30	521.0000	0.52
45	340.0000	0.34
60	248.0000	0.25
75	225.0000	0.22
90	189.0000	0.19
105	197.0000	0.20
120	163.0000	0.16
135	121.0000	0.12
150	107.0000	0.11
165	42.0000	0.04
180	96.0000	0.10

Suffolk, Perforated Riser, Run 3

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	2957.3636	2.96
10	1967.6667	1.97
15	1329.7500	1.33
20	975.0000	0.97
25	760.0000	0.76
30	654.0000	0.65
45	475.0000	0.48
60	386.0000	0.39
75	300.0000	0.30
90	246.0000	0.25
105	246.0000	0.25
120	200.0000	0.20
135	156.0000	0.16
150	132.0000	0.13
165	52.0000	0.05
180	39.0000	0.04

Suffolk, Skimmer, Run 1

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	1426.3077	1.43
10	929.7547	0.93
15	695.5385	0.70
20	636.5862	0.64
25	590.2500	0.59
30	503.0000	0.50
45	384.0000	0.38
60	321.1212	0.32
75	278.0000	0.28
90	252.0000	0.25
105	244.0000	0.24
120	219.0000	0.22
135	200.0000	0.20
150	192.0000	0.19
165	170.0000	0.17
180	174.0000	0.17

Suffolk, Skimmer, Run 2

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	1199.0000	1.20
10	723.0000	0.72
15	538.0000	0.54
20	451.0000	0.45
25	426.0000	0.43
30	349.0000	0.35
45	264.0000	0.26
60	220.0000	0.22
75	197.0000	0.20
90	178.0000	0.18
105	143.0000	0.14
120	116.0000	0.12
135	119.0000	0.12
150	141.0000	0.14
165	109.0000	0.11
180	119.0000	0.12

Suffolk, Skimmer, Run 3

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	1024.0000	1.02
10	665.4286	0.67
15	550.6667	0.55
20	496.0000	0.50
25	414.0000	0.41
30	368.0000	0.37
45	293.0000	0.29
60	246.0000	0.25
75	237.0000	0.24
90	228.0000	0.23
105	215.0000	0.22
120	197.0000	0.20
135	189.0000	0.19
150	173.0000	0.17
165	148.0000	0.15
180	141.0000	0.14

Davidson, Perforated Riser, Run 1

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	1979.0769	1.98
10	1463.6923	1.46
15	1002.7742	1.00
20	609.0000	0.61
25	425.1290	0.43
30	356.5000	0.36
45	201.0000	0.20
60	143.4262	0.14
75	105.9231	0.11
90	94.0000	0.09
105	115.0000	0.12
120	83.0000	0.08
135	61.0000	0.06
150	40.0000	0.04
165	31.0000	0.03
180	42.0000	0.04

Davidson, Perforated Riser, Run 2

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	1341.0000	1.34
10	781.6667	0.78
15	588.3333	0.59
20	445.0000	0.45
25	357.5000	0.36
30	272.5000	0.27
45	187.0000	0.19
60	150.3333	0.15
75	115.0000	0.11
90	97.0000	0.10
105	87.0000	0.09
120	72.0000	0.07
135	64.0000	0.06
150	61.0000	0.06
165	35.0000	0.03
180	65.0000	0.06

Davidson, Perforated Riser, Run 3

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	1604.6667	1.60
10	1290.5000	1.29
15	905.5000	0.91
20	659.1111	0.66
25	508.0000	0.51
30	380.0000	0.38
45	236.3333	0.24
60	171.3333	0.17
75	128.0000	0.13
90	91.0000	0.09
105	77.0000	0.08
120	67.0000	0.07
135	70.0000	0.07
150	49.0000	0.05
165	43.0000	0.04
180	23.0000	0.02

Davidson, Skimmer, Run 1

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	1124.0000	1.12
10	648.5714	0.65
15	511.4286	0.51
20	382.5000	0.38
25	316.0000	0.32
30	240.0000	0.24
45	146.6667	0.15
60	95.7143	0.10
75	75.2941	0.08
90	82.0000	0.08
105	76.0000	0.08
120	62.0000	0.06
135	51.0000	0.05
150	46.0000	0.05
165	43.0000	0.04
180	36.0000	0.04

Davidson, Skimmer, Run 2

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	785.5000	0.79
10	573.0000	0.57
15	383.0000	0.38
20	323.0000	0.32
25	246.6364	0.25
30	244.6154	0.24
45	164.2857	0.16
60	110.0000	0.11
75	91.2500	0.09
90	87.0000	0.09
105	68.0000	0.07
120	53.0000	0.05
135	47.0000	0.05
150	41.0000	0.04
165	37.0000	0.04
180	38.0000	0.04

Davidson, Skimmer, Run 3

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	809.5000	0.81
10	549.5000	0.55
15	406.4444	0.41
20	331.0909	0.33
25	285.6364	0.29
30	238.3636	0.24
45	188.6667	0.19
60	133.0000	0.13
75	103.0000	0.10
90	80.0000	0.08
105	63.0000	0.06
120	57.0000	0.06
135	50.0000	0.05
150	46.0000	0.05
165	44.0000	0.04
180	46.0000	0.05

Groseclose, Perforated Riser, Run 1

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	1867.6667	1.87
10	1308.4286	1.31
15	1114.0423	1.11
20	861.0000	0.86
25	701.0000	0.70
30	613.0000	0.61
45	439.0000	0.44
60	371.0000	0.37
75	284.0000	0.28
90	257.0000	0.26
105	245.0000	0.25
120	216.0000	0.22
135	210.0000	0.21
150	220.0000	0.22
165	191.0000	0.19
180	148.0000	0.15

Groseclose, Perforated Riser, Run 2

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	2209.3333	2.21
10	1687.6667	1.69
15	1224.6667	1.22
20	955.3333	0.96
25	758.0000	0.76
30	645.0000	0.64
45	449.0000	0.45
60	387.0000	0.39
75	302.0000	0.30
90	240.0000	0.24
105	251.0000	0.25
120	192.0000	0.19
135	147.0000	0.15
150	115.0000	0.11
165	60.0000	0.06
180	49.0000	0.05

Groseclose, Perforated Riser, Run 3

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	3033.0000	3.03
10	1953.0000	1.95
15	1272.0000	1.27
20	1096.0000	1.10
25	940.0000	0.94
30	800.0000	0.80
45	596.0000	0.60
60	479.0000	0.48
75	363.0000	0.36
90	312.0000	0.31
105	317.0000	0.32
120	259.0000	0.26
135	225.0000	0.23
150	164.0000	0.16
165	180.0000	0.18
180	111.0000	0.11

Groseclose, Skimmer, Run 1

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	838.0000	0.84
10	671.0000	0.67
15	589.0000	0.59
20	474.0000	0.47
25	403.0000	0.40
30	381.0000	0.38
45	317.0000	0.32
60	265.0000	0.27
75	231.0000	0.23
90	229.0000	0.23
105	190.0000	0.19
120	172.0000	0.17
135	169.0000	0.17
150	161.0000	0.16
165	144.0000	0.14
180	152.0000	0.15

Groseclose, Skimmer, Run 2

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	1599.0000	1.60
10	970.0000	0.97
15	805.0000	0.81
20	681.0000	0.68
25	582.0000	0.58
30	539.0000	0.54
45	402.0000	0.40
60	348.0000	0.35
75	313.0000	0.31
90	293.0000	0.29
105	250.0000	0.25
120	248.0000	0.25
135	233.0000	0.23
150	222.0000	0.22
165	200.0000	0.20
180	184.0000	0.18

Groseclose, Skimmer, Run 3

Time (min)	Sediment concentration-effluent (mg/L)	Sediment concentration-effluent (g/L)
5	1102.5000	1.10
10	772.0000	0.77
15	647.0000	0.65
20	619.0000	0.62
25	476.0000	0.48
30	394.0000	0.39
45	346.0000	0.35
60	295.0000	0.30
75	263.0000	0.26
90	254.0000	0.25
105	251.0000	0.25
120	255.0000	0.26
135	223.0000	0.22
150	199.0000	0.20
165	173.0000	0.17
180	170.0000	0.17

B4: Sediment Loss Rate

All sediment loss rates were determined by multiplying the dewatering rates (L/min) from Appendix B1 by the effluent sediment concentrations (g/L) from Appendix B3 for each sampling time.

Suffolk, Perforated Riser, Run 1

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	5.47	2.39	13.08
10	5.31	1.63	8.68
15	5.16	1.04	5.37
20	5.14	0.83	4.28
25	4.98	0.67	3.33
30	5.10	0.56	2.87
45	4.93	0.37	1.82
60	4.85	0.31	1.49
75	4.85	0.23	1.13
90	4.67	0.19	0.91
105	4.41	0.18	0.78
120	4.42	0.14	0.61
135	4.31	0.12	0.50
150	4.07	0.09	0.39
165	0.31	0.06	0.02
180	0.11	0.08	0.01

Suffolk, Perforated Riser, Run 2

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	5.46	1.94	10.59
10	5.35	1.46	7.79
15	5.37	0.99	5.34
20	5.16	0.77	3.98
25	4.98	0.61	3.02
30	5.15	0.52	2.68
45	5.03	0.34	1.71
60	4.79	0.25	1.19
75	4.81	0.22	1.08
90	4.69	0.19	0.89
105	4.45	0.20	0.88
120	4.29	0.16	0.70
135	4.16	0.12	0.50
150	4.22	0.11	0.45
165	0.37	0.04	0.02
180	0.11	0.10	0.01

Suffolk, Perforated Riser, Run 3

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	5.26	2.96	15.57
10	5.37	1.97	10.56
15	5.16	1.33	6.87
20	5.18	0.97	5.05
25	5.17	0.76	3.93
30	5.08	0.65	3.33
45	5.14	0.48	2.44
60	4.83	0.39	1.86
75	4.73	0.30	1.42
90	4.73	0.25	1.16
105	4.45	0.25	1.09
120	4.36	0.20	0.87
135	4.31	0.16	0.67
150	4.28	0.13	0.56
165	0.32	0.05	0.02
180	0.12	0.04	0.00

Suffolk, Skimmer, Run 1

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	3.83	1.43	5.46
10	3.78	0.93	3.51
15	3.69	0.70	2.56
20	3.75	0.64	2.38
25	3.78	0.59	2.23
30	3.88	0.50	1.95
45	3.79	0.38	1.46
60	3.78	0.32	1.21
75	3.79	0.28	1.05
90	3.97	0.25	1.00
105	3.89	0.24	0.95
120	3.92	0.22	0.86
135	3.95	0.20	0.79
150	3.90	0.19	0.75
165	3.91	0.17	0.66
180	3.77	0.17	0.66

Suffolk, Skimmer, Run 2

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	3.72	1.20	4.46
10	3.89	0.72	2.81
15	3.83	0.54	2.06
20	3.76	0.45	1.70
25	3.82	0.43	1.63
30	3.88	0.35	1.35
45	3.79	0.26	1.00
60	3.86	0.22	0.85
75	3.86	0.20	0.76
90	3.82	0.18	0.68
105	3.92	0.14	0.56
120	4.10	0.12	0.48
135	3.93	0.12	0.47
150	3.92	0.14	0.55
165	3.86	0.11	0.42
180	3.79	0.12	0.45

Suffolk, Skimmer, Run 3

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	3.88	1.02	3.97
10	3.75	0.67	2.50
15	3.82	0.55	2.10
20	3.83	0.50	1.90
25	3.78	0.41	1.57
30	3.81	0.37	1.40
45	3.99	0.29	1.17
60	3.93	0.25	0.97
75	3.89	0.24	0.92
90	3.85	0.23	0.88
105	3.80	0.22	0.82
120	3.85	0.20	0.76
135	3.89	0.19	0.74
150	4.07	0.17	0.70
165	3.88	0.15	0.57
180	3.78	0.14	0.53

Davidson, Perforated Riser, Run 1

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	5.17	1.98	10.24
10	5.20	1.46	7.61
15	5.13	1.00	5.14
20	4.89	0.61	2.98
25	5.04	0.43	2.14
30	4.81	0.36	1.71
45	4.61	0.20	0.93
60	4.45	0.14	0.64
75	4.26	0.11	0.45
90	4.32	0.09	0.41
105	4.18	0.12	0.48
120	4.07	0.08	0.34
135	3.94	0.06	0.24
150	3.80	0.04	0.15
165	0.35	0.03	0.01
180	0.11	0.04	0.00

Davidson, Perforated Riser, Run 2

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	5.09	1.34	6.83
10	5.11	0.78	3.99
15	4.99	0.59	2.94
20	5.04	0.45	2.24
25	5.07	0.36	1.81
30	5.02	0.27	1.37
45	4.71	0.19	0.88
60	4.66	0.15	0.70
75	4.45	0.11	0.51
90	4.59	0.10	0.45
105	4.27	0.09	0.37
120	4.35	0.07	0.31
135	4.26	0.06	0.27
150	4.14	0.06	0.25
165	0.38	0.03	0.01
180	0.11	0.06	0.01

Davidson, Perforated Riser, Run 3

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	5.46	1.60	8.77
10	5.27	1.29	6.80
15	5.14	0.91	4.65
20	5.18	0.66	3.42
25	5.07	0.51	2.57
30	4.96	0.38	1.88
45	5.11	0.24	1.21
60	4.94	0.17	0.85
75	4.85	0.13	0.62
90	4.69	0.09	0.43
105	4.36	0.08	0.34
120	4.25	0.07	0.28
135	4.22	0.07	0.30
150	4.13	0.05	0.20
165	0.35	0.04	0.02
180	0.11	0.02	0.00

Davidson, Skimmer, Run 1

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	3.58	1.12	4.02
10	3.84	0.65	2.49
15	3.75	0.51	1.92
20	3.83	0.38	1.46
25	3.90	0.32	1.23
30	3.93	0.24	0.94
45	3.97	0.15	0.58
60	3.98	0.10	0.38
75	3.88	0.08	0.29
90	3.93	0.08	0.32
105	3.94	0.08	0.30
120	3.92	0.06	0.24
135	3.97	0.05	0.20
150	3.94	0.05	0.18
165	4.03	0.04	0.17
180	3.90	0.04	0.14

Davidson, Skimmer, Run 2

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	3.82	0.79	3.00
10	3.75	0.57	2.15
15	3.85	0.38	1.47
20	3.82	0.32	1.23
25	3.92	0.25	0.97
30	3.75	0.24	0.92
45	3.81	0.16	0.63
60	3.80	0.11	0.42
75	3.84	0.09	0.35
90	3.88	0.09	0.34
105	3.98	0.07	0.27
120	3.97	0.05	0.21
135	3.87	0.05	0.18
150	3.91	0.04	0.16
165	3.87	0.04	0.14
180	3.79	0.04	0.14

Davidson, Skimmer, Run 3

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	3.82	0.81	3.09
10	3.70	0.55	2.03
15	3.80	0.41	1.55
20	3.87	0.33	1.28
25	3.79	0.29	1.08
30	3.80	0.24	0.91
45	3.79	0.19	0.72
60	3.92	0.13	0.52
75	3.98	0.10	0.41
90	3.76	0.08	0.30
105	3.97	0.06	0.25
120	3.95	0.06	0.23
135	3.88	0.05	0.19
150	3.86	0.05	0.18
165	3.85	0.04	0.17
180	3.82	0.05	0.18

Groseclose, Perforated Riser, Run 1

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	5.03	1.87	9.39
10	5.27	1.31	6.90
15	4.86	1.11	5.42
20	4.85	0.86	4.18
25	4.89	0.70	3.43
30	4.75	0.61	2.91
45	4.59	0.44	2.01
60	4.45	0.37	1.65
75	4.37	0.28	1.24
90	4.20	0.26	1.08
105	4.09	0.25	1.00
120	3.94	0.22	0.85
135	3.84	0.21	0.81
150	3.75	0.22	0.82
165	0.28	0.19	0.05
180	0.10	0.15	0.02

Groseclose, Perforated Riser, Run 2

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	5.18	2.21	11.45
10	4.98	1.69	8.41
15	5.16	1.22	6.32
20	5.06	0.96	4.83
25	5.10	0.76	3.87
30	5.15	0.64	3.32
45	5.00	0.45	2.25
60	4.57	0.39	1.77
75	4.60	0.30	1.39
90	4.12	0.24	0.99
105	4.48	0.25	1.12
120	4.07	0.19	0.78
135	4.07	0.15	0.60
150	3.86	0.11	0.44
165	0.34	0.06	0.02
180	0.11	0.05	0.01

Groseclose, Perforated Riser, Run 3

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	5.24	3.03	15.91
10	5.33	1.95	10.41
15	5.20	1.27	6.61
20	5.10	1.10	5.59
25	5.05	0.94	4.75
30	5.03	0.80	4.02
45	5.07	0.60	3.02
60	5.09	0.48	2.44
75	4.74	0.36	1.72
90	4.52	0.31	1.41
105	4.68	0.32	1.48
120	4.31	0.26	1.12
135	4.45	0.23	1.00
150	4.39	0.16	0.72
165	0.32	0.18	0.06
180	0.12	0.11	0.01

Groseclose, Skimmer, Run 1

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	3.71	0.84	3.11
10	3.70	0.67	2.48
15	3.75	0.59	2.21
20	3.83	0.47	1.81
25	3.76	0.40	1.52
30	3.84	0.38	1.46
45	3.87	0.32	1.23
60	3.85	0.27	1.02
75	3.89	0.23	0.90
90	3.90	0.23	0.89
105	3.74	0.19	0.71
120	4.05	0.17	0.70
135	3.88	0.17	0.66
150	3.88	0.16	0.62
165	3.86	0.14	0.56
180	3.86	0.15	0.59

Groseclose, Skimmer, Run 2

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	3.86	1.60	6.17
10	3.81	0.97	3.69
15	4.06	0.81	3.27
20	3.91	0.68	2.66
25	4.07	0.58	2.37
30	3.84	0.54	2.07
45	3.93	0.40	1.58
60	3.87	0.35	1.35
75	3.99	0.31	1.25
90	4.08	0.29	1.19
105	3.92	0.25	0.98
120	3.99	0.25	0.99
135	3.95	0.23	0.92
150	3.95	0.22	0.88
165	3.76	0.20	0.75
180	3.93	0.18	0.72

Groseclose, Skimmer, Run 3

Time (min)	Dewatering rate (L/min)	Sediment concentration-effluent (g/L)	Sediment loss rate (g/min)
5	3.62	1.10	3.99
10	3.84	0.77	2.96
15	3.68	0.65	2.38
20	4.03	0.62	2.50
25	3.99	0.48	1.90
30	4.01	0.39	1.58
45	3.91	0.35	1.35
60	3.93	0.30	1.16
75	3.95	0.26	1.04
90	3.91	0.25	0.99
105	4.02	0.25	1.01
120	3.97	0.26	1.01
135	3.86	0.22	0.86
150	3.95	0.20	0.79
165	3.92	0.17	0.68
180	3.75	0.17	0.64

B5: Cumulative Sediment In

Cumulative sediment in was determined by multiplying the filtration samples from Appendix B2 by 1390 L, the initial volume of water in the tank.

Soil type	Outlet	Run	Sediment concentration (mg/L)	Cumulative sediment in* (kg)	Cumulative sediment in** (kg)
Suffolk	PR	1	3894.5000	5.41	35.00
Suffolk	PR	2	2885.5000	4.01	35.00
Suffolk	PR	3	4428.5000	6.16	35.00
Suffolk	SK	1	3631.8571	5.05	35.00
Suffolk	SK	2	3143.5000	4.37	35.00
Suffolk	SK	3	3791.5000	5.27	35.00
Davidson	PR	1	2558.0000	3.56	35.00
Davidson	PR	2	2009.0000	2.79	35.00
Davidson	PR	3	2384.0000	3.31	35.00
Davidson	SK	1	2696.0000	3.75	35.00
Davidson	SK	2	2189.6667	3.04	35.00
Davidson	SK	3	2308.6667	3.21	35.00
Groseclose	PR	1	3286.0000	4.57	35.00
Groseclose	PR	2	4618.5000	6.42	35.00
Groseclose	PR	3	4935.0000	6.86	35.00
Groseclose	SK	1	4399.0000	6.11	35.00
Groseclose	SK	2	4522.0000	6.29	35.00
Groseclose	SK	3	4292.5000	5.97	35.00

** Based on mass of sediment in suspension at start of run*

*** Based on total mass of sediment in*

B6: Cumulative Sediment Out

Cumulative sediment out was determined by multiplying the filtration samples from Appendix B2 by 695 L, the volume of water that drained into the receiving tank.

Soil type	Outlet	Run	Sediment concentration (mg/L)	Cumulative sediment out (kg)
Suffolk	PR	1	467.00	0.32
Suffolk	PR	2	423.00	0.29
Suffolk	PR	3	570.00	0.40
Suffolk	SK	1	345.00	0.24
Suffolk	SK	2	261.00	0.18
Suffolk	SK	3	301.00	0.21
Davidson	PR	1	347.00	0.24
Davidson	PR	2	252.33	0.18
Davidson	PR	3	310.88	0.22
Davidson	SK	1	178.00	0.12
Davidson	SK	2	161.00	0.11
Davidson	SK	3	165.00	0.11
Groseclose	PR	1	496.00	0.34
Groseclose	PR	2	493.00	0.34
Groseclose	PR	3	673.00	0.47
Groseclose	SK	1	281.00	0.20
Groseclose	SK	2	385.00	0.27
Groseclose	SK	3	343.00	0.24

Vita

Lisa M. Hoechst was born to William and Jean Hoechst on September 21, 1972 in Orlando, Florida. She graduated from Apopka High School in Apopka, Florida in 1990 and entered Virginia Tech where she received the Bachelor of Science in Agricultural Engineering degree in 1994. Upon graduation, she passed her EIT exam and worked for Carter & Burgess, Inc. until the fall of 1995. She then resumed her education in the department of Biological Systems Engineering at Virginia Tech. She expects to complete the requirements for the Master of Science degree in December, 1997.