A Scrolling Geotextile Fabric Filter Device for Primary Clarification

Craig Stuart Riddle

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Dr. John T. Novak, Chair
Dr. J.M. Hughes
Dr. Nancy G. Love

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By

Craig S. Riddle

Committee Chair: Dr. John T. Novak

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(ABSTRACT)

This study investigated the feasibility of using a portable geotextile fabric based filtering device to remove suspended solids from raw sewage. This device was considered to replace a conventional primary clarifier. The proposed filtration process directs wastewater influent through a geotextile fabric filter. As filtering progresses, and solids accumulate on the fabric, the loaded fabric is scrolled to present a fresh surface.

Only non-woven polypropylene geotextile fabrics were investigated. These products are constructed by spunbonding or needle-punch technique. Needle-punched fabrics proved superior in terms of Total Suspended Solids (TSS) filtering performance and fabric usage rates. Spunbonded products absorbed less moisture, reducing loaded fabric weight. Fabric thickness did not affect filtration efficiencies for either type of geotextile.

Process variables affecting unit performance were investigated. Flow rate, head level, and fabric tension did not affect TSS removal. Fabric tension, however, is limited by tensile strength of the geotextile material.

Two wastewater receving basin configurations for the device were investigated. An influent basin with two 45^0 angled walls forming a V-shape performed better in terms of fabric feed rates. It is recommended for full-scale applications.

Finally, several methods were used in an effort to improve treatment performance. Polymer use, and polymer use in conjunction with pre-screening of wastewater, were both used. Polymer use alone did not increase the operating efficiency. Polymer use, along with pre-screening, was promising enough to consider this as a stand-alone treatment system.

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Chapter 1. Introduction

This study addresses several design considerations pertaining to the construction of a portable wastewater filtration unit (WFU) for the US Army. The proposed WFU makes up the first stage of a mobile two-stage wastewater treatment system capable of being deployed with Army units in the field. Development of a portable treatment unit eliminates the expense of paying local contractors to haul and dispose of stored wastewater in foreign and domestic deployments.

Wastewater treated by this unit is expected to have an average Total Suspended Solids (TSS) of 447 mg/L and a Biochemical Oxygen Demand (BOD) of 616 mg/L (UTD, 2000). These values are stronger than typical domestic wastewater due to low flushing water volumes used in Army field operations. Treatment goals for the first stage WFU are 70% TSS removal and 50% BOD removal. This treated flow from the first stage proceeds to second stage treatment where it is treated to achieve a BOD of 30 mg/L. This second stage utilizes a Biological Activated Filter (BAF) to achieve this treatment standard (Asiedu, 2001). The effluent from the BAF then passes once more through the WFU to remove biological solids in order to meet final discharge requirements of 30 mg/L TSS and 30 mg/L BOD. Figure 1 shows a preliminary design configuration of the WFU.

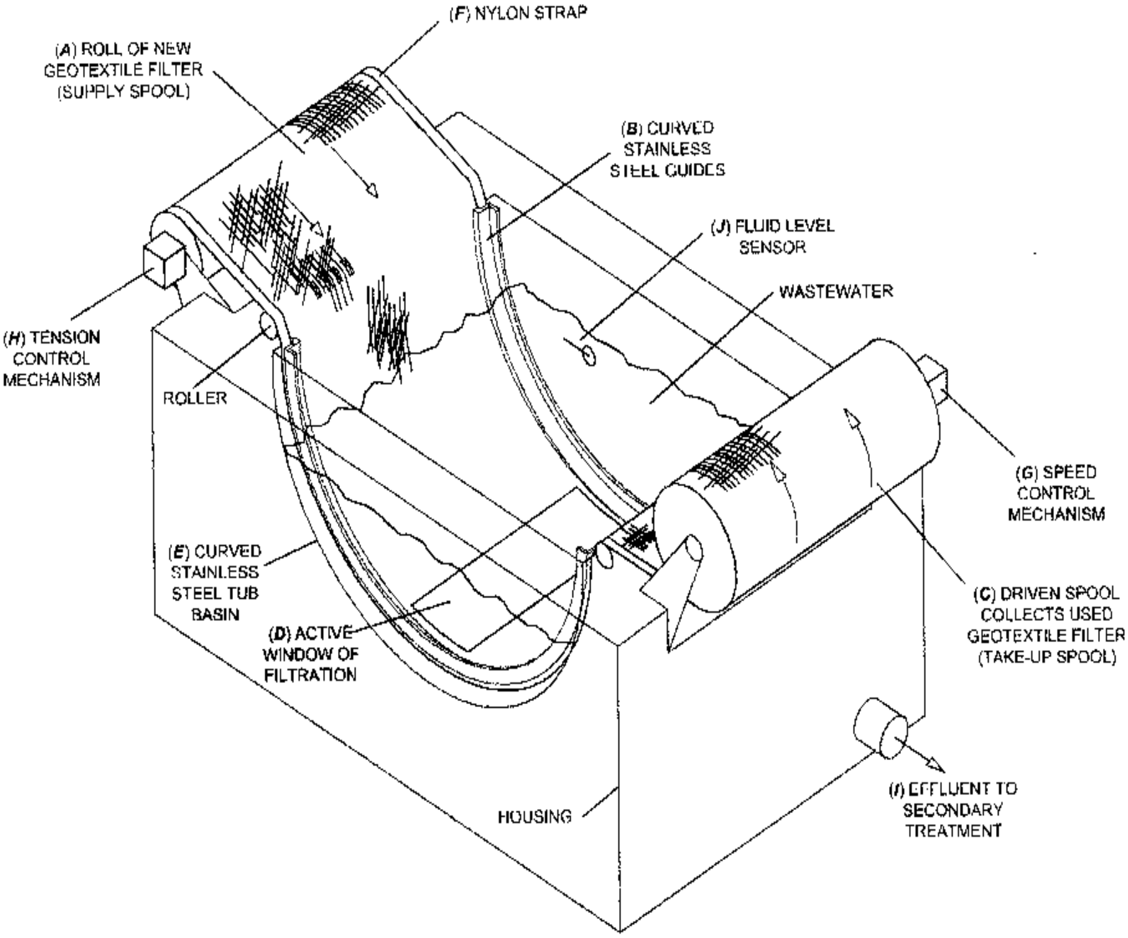


Figure 1: Preliminary WFU Design

* Courtesy UTD Corporation, 2000.

This basin arrangement for the WFU utilizes a scrolling geotextile fabric attached to a spool at both ends to filter the wastewater influent. As the fabric becomes loaded with solids and begins to restrict throughput, the spool is advanced to maintain a constant volume of filtered effluent, and prevent excessive head build-up. One of the principal concerns in designing the WFU is “wrap-around flow”. This phenomenon occurs when wastewater creates hydraulic short circuits by flowing around the edges of the fabric without being adequately filtered. The preliminary design addresses this problem by routing nylon straps, sewn into the geotextile, through stainless steel guides to seal the fabric to the basin surface.

Upon completion of filtering, the loaded geotextile spools may be disposed of using an incinerator. The specific design of the fabric incinerators remains to be completed.

Objectives

Selection of the best geotextile fabric was a major objective of this study. Non-woven geotextiles were selected as the filtering media due to their availability, and favorable performance in waste disposal applications for filtering site run-off (Rowe, 1993). Additionally, geotextiles tested in this study are chemically inactive, and therefore pose little environmental risk (Santvoort, 1995). Only geotextiles constructed of polypropylene were analyzed. Polypropylene's temperature operating range of 5^0 C to 60^0 C (41^0 F to 140^0 F), and non-toxic combustion characteristics that produce clean air emissions, suggested it would meet performance requirements in full-scale use (UTD, 2000).

Spunbonding and needle-punching are the two prevalent manufacturing processes used to manufacture geotextiles. Spunbonded fabrics have several unique properties that differ from needle-punched fabrics. The spunbonded products have a smoother surface texture, lower permittivity values (the ability to allow flow normal to fabric surface), and absorb much less moisture than needle-punched fabrics. The smoother surface texture was an important consideration during testing, because filtered sewage solids might not be trapped within the fabric sufficiently to be removed by scrolling. Rather, the material deposited on the fabric surface might be pushed back into the reactor as the loaded fabric passed through the pressure rollers. Additionally, the lower permittivity of these fabrics might lead to quicker head build-up, and that could pose unacceptable limitations in full-scale operation.

Evaluations were made for each fabric to determine if the fabric could support the specified flow necessary to fully treat the required volume of wastewater each filtering cycle. Moisture absorption comparisons between the two fabric types were important since manual transfer of spent rolls to incinerators is desired for simplicity. Army specifications call for each WFU to be easily serviced by two individuals, which dictates a weight limitation to perform this material transfer.

Comparison testing between spunbonded and needle-punched geotextiles focused on TSS removal efficiencies, moisture absorption, head build-up times, and feed rate. Feed rate is the speed at which the solids loaded uptake spool moves the fabric through the influent basin to prevent excessive head build-up. This factor determines the amount of fabric necessary for filtering.

Experimental analyses were also performed with fabrics of different thickness. It was expected that thicker fabrics, while weighing more and being more expensive, would have higher filtering efficiencies and lower rates of head build-up that might offset the weight and cost disadvantages. These tests, taken as a whole, were used to evaluate and compare the performance of various geotextiles.

Several other factors that influence fabric selection for the full-scale unit were not within the scope of this study, but might warrant further inspection. If suspended solids in the wastewater flow contain particles slightly larger than the apparent opening size of a fabric (the smallest diameter of particle where no more than 5% of the particles filter through the fabric), this could cause clogging and inhibited filtering performance (UTD, 2000). Carroll (1983) also notes that apparent opening size and permeability alone do not indicate the clogging potential of geotextiles. Testing of wastewaters having particles within specified size ranges could assist in refining fabric selection beyond recommendations in this study. Precise tensioning force analysis for the full-scale unit would also need to be performed to determine if selected geotextiles would have the required tensile strength. Finally, an analysis of BOD filtering properties for particular fabrics might prove useful. BOD reductions by the fabric filter would assist the second stage BAF in meeting the design effluent BOD standard of 30 mg/L.

Efficient operation of the WFU became the most significant design consideration. Several factors that could influence unit performance were investigated. These included flow rate, head level, fabric tension, polymer addition, and polymer addition with pre-screening. Experiments were then conducted to determine optimal operating conditions.

Initial testing focused on determining the effects of flow rate, head level, and fabric tension on operation of the unit. The flow rate is an important process variable since high flows are needed to keep the size of the unit small enough to fit the container size designated by the Army. The head build-up was investigated to determine if larger flow gradients under high head loadings would alter filter performance. Considerable deformation of the fabric from tension applied by the spool drive mechanism can potentially alter moisture absorption properties and filtering performance.

Two influent basin configurations were compared. The original configuration consisted of an influent basin with a flat bottom and two 45^0 angled walls. Four pressure rollers were utilized to route the fabric through the basin. An alternate design used an influent basin with two 45^0

angled walls joining together at the bottom forming a V-shape. Two pressure rollers guided fabric in this configuration.

Finally, pretreatment of wastewaters to enhance the WFU efficiency was also explored. Polymers are currently used to assist in the coagulation of raw sewage during clarification. It was hoped that the use of polymers in this application would similarly assist in improving TSS removal efficiencies. Additionally, polymer dosing in conjunction with pre-screening of wastewater using a fine wire mesh was tested. The sum of all the data and observations collected allowed the researcher to suggest several possible configurations for a final design.

Chapter 2. Materials and Methods

2.1 Fabric Specifications

Table 1 lists fabric specifications for the geotextiles used in this study. With the exception of the Amoco 4510, which is made by Amoco Fabrics and Fibers Company, all of the fabrics were manufactured by Linq Industrial Fabrics, Incorporated. Apparent opening size dimension in this table refers to the smallest diameter particle where no more than 5% of the particles pass through the fabric. Permittivity indicates the relative ease with which a fabric will pass flow normal to its surface. Higher values reflect a geotextiles' ability to pass a greater flow volume over a given period of time.

Table 1: Geotextile Fabric Specifications

Fabric Type	Unit Wt. (g/m^2)	Thickness (mm)	AOS (mm)	Permittivity (sec^-1)	Grab Tensile/Elongation (kN/%)	Construction Technique
Typar 3401	135	0.4	0.21	0.7	579/60	Spunbonded
Typar 3631	214	0.56	0.1	0.1	1113/60	Spunbonded
130 EX	136	1.4	0.21	2	467/50	Needle-Punched
180 EX	272	2.03	0.18	1.2	890/50	Needle-Punched
225 EX	306	2.16	0.18	1	957/50	Needle-Punched
350 EX	543	3.81	0.15	0.5	1891/50	Needle-Punched
Amoco 4510	339	2.15	0.15	1.2	1001/50	Needle-Punched

* AOS: Apparent Opening Size
(Source: GFR Specifier's Guide, 1997)

2.2 Peristaltic Pump/Controller

A Cole-Parmer Model No. 7553-70 peristaltic pump rated to pump a maximum of 4 L/Min at 600 RPM was used to transfer wastewater volumes from mixing reservoirs to the various experimental devices tested. Flow rate was regulated using a Cole-Parmer Model No. 7553-71 Controller.

2.3 Column Apparatus

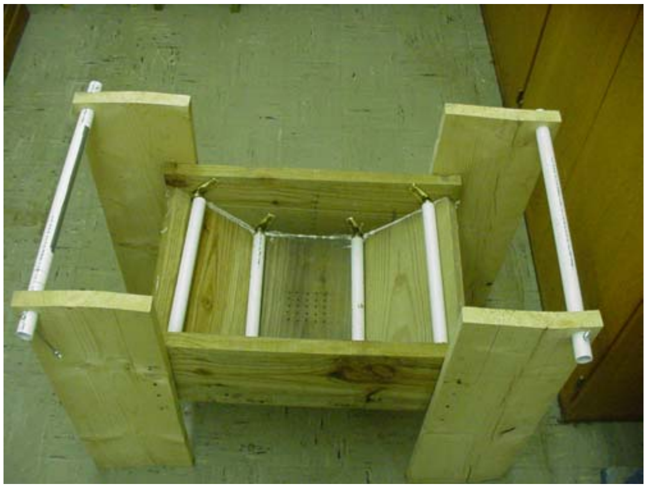
To obtain preliminary data on head build-up characteristics, a small diameter column study was conducted. Using this device, fabrics could be compared. The 3-½ foot tall column was assembled using 3-inch PVC conduit. The column had ½-inch outflow valves installed at 1, 2, and 3 feet from the base. A mounting bracket to position fabric samples was installed at the base of the apparatus. Fabric samples were sandwiched between two 1/16-inch rubber gaskets within the mounting assembly during testing. A ½-inch clear vinyl manometer tube fastened to the exterior of the column was used to monitor head level. Figure 2 shows this apparatus.

Figure 2: Column Apparatus

2.4 First-Generation Primary Treatment Apparatus

An experimental-scale apparatus was constructed to model fabrics during operational conditions. This apparatus was designed to be similar to the expected full-scale unit. Specific items of interest to be evaluated using this unit were passage of solids around the fabric edges, behavior of deposited material as it passed under the pressure rollers used to seal the fabric to the filter bed, and filtering efficiency of the unit. A picture of this device is shown in Figure 3.

Figure 3: First-Generation Primary Treatment Apparatus



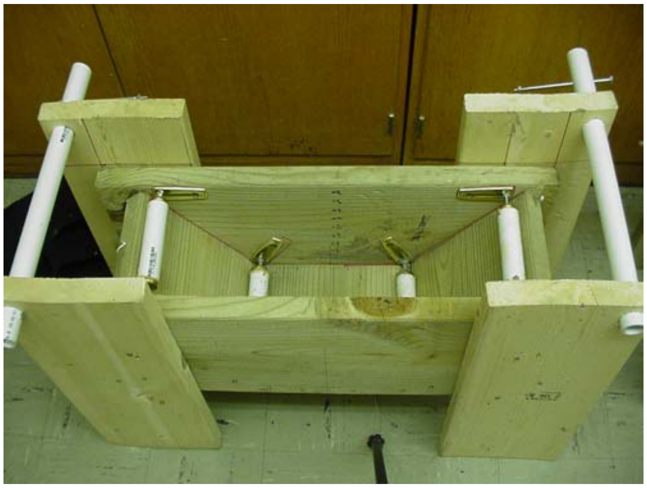
All basin structure and support features were constructed of 2 X 12-inch thick pressure treated lumber. Wood was used for ease of construction and cost reasons. The amount of time required to develop a metal or plastic device, as well as the cost to produce it were deemed prohibitive and not needed. The basin consisted of a flat bottom with two 30^0 angled walls. The maximum depth was nine inches. The top of the basin measured 27 X 17-½ inches. Wood screws were used to fasten elements to one another. Waterproof sealing caulk was applied to all necessary areas to minimize leakage. Four 1-inch PVC tubes with bearings cemented to the ends were utilized to seal the fabric to the basin surface. Bolts on adjustable slide brackets were centered within the bearing housings of the rollers. Adjustment of the brackets allowed pressure to be applied to the fabric. Scrolling was performed by manually rotating a 1-inch PVC uptake spool.

Influent was drawn from 12- gallon plastic tubs pumped using the peristaltic pump/controller described in Section 2.2. The effluent drained through a 3 ½ X 4-inch square of evenly spaced 13/64-inch holes centered at the bottom of the basin. The effluent window was arbitrarily sized to allow sufficient flow to conduct experiments.

2.5 Second-Generation Primary Treatment Apparatus (Smaller)

Because of the large volume of wastewater required by the first generation unit, a smaller unit of similar configuration was built. Wastewater volumes used in this device were a third of the volumes used by the larger apparatus. All experiments involving fabric usage rates, tensioning, and configuration comparisons were conducted using this device in conjunction with the device described in Section 2.6. This smaller, experimental-scale apparatus, was constructed in the same manner as the device presented in 2.4 with several dimensions altered.

Figure 4: Second-Generation Primary Treatment Apparatus (Smaller)



The influent basin consisted of a flat bottom and two 45^0 angled walls. Maximum depth was nine inches. The top of the basin measured 24 X 8 inches. Four pressure rollers were used to route the fabric through the basin. Rollers were adjusted to provide sealing pressure similarly to the device in Figure 3. Manual scrolling of the uptake spool was again utilized. Influent was drawn from 12- gallon plastic tubs pumped using the peristaltic pump/controller described in Section 2.2. Effluent was drained through a 3 X 3-inch square of evenly spaced 13/64-inch holes centered at the bottom of the basin.

2.6 Alternative Configuration Primary Treatment Apparatus

A third experimental apparatus was constructed in a similar manner to the units described in Sections 2.4 and 2.5. All experiments involving fabric usage rates, tensioning, and configuration comparisons were conducted using this device in conjunction with the device described in Section 2.5. This unit used an altered basin configuration, in addition to several dimension adjustments, as compared to the devices shown in Figures 3 and 4. As seen in Figure 5, two 45^0 angled walls joined together to form the basin structure. The maximum depth was nine inches. The top of the basin measured 15 X 8 inches. Two pressure rollers provided sealing pressure similarly to the devices described in Sections 2.4 and 2.5. Fabric was transitioned from right to left with the device oriented as in Figure 5. The uptake spool was positioned beneath the basin lip to create tension on the fabric during manual scrolling.

Figure 5: Alternative Configuration Primary Treatment Apparatus

Influent was drawn from 12- gallon plastic tubs pumped using the peristaltic pump/controller described in 2.2. Effluent was drained through a 3 X 3-inch square of evenly spaced 13/64-inch holes. The lower edge of the drain box was spaced two inches from the bottom of the bed wall on the uptake spool side of the basin.

2.7 TSS Removal Efficiency Testing

The primary goal of the filtration unit is the removal of suspended solids, which makes removal efficiency testing an important part of this study. Fabric samples were positioned in the mounting bracket of the column apparatus during testing. Primary sludge from Peppers Ferry Regional Wastewater Treatment Facility (PFRWWTF) in Radford, VA was diluted with tap water to 400-600 mg/L TSS in 12-gallon plastic tubs to constitute the wastewater influent (henceforth known as “study standard diluted sludge”). The contents in the tubs were thoroughly mixed for 30 seconds before experiments were conducted. A grab sample of the influent was taken immediately after mixing. The wastewater was then pumped into the top of the column apparatus. A 100-mL grab sample of the effluent was taken when four inches of head had built up in the column. This sample was then thoroughly mixed, and split into two 50-mL samples to test for TSS using Method 2450D (APHA, 1998). Each fabric was tested at a flow rate of 1.42 L/min and 3.75 L/min. These flow rates corresponded to 38% and 100% respectively of the peristaltic pump's capacity.

2.8 Moisture Absorption

Since loaded fabric rolls might be incinerated as a disposal method, moisture absorption experiments were conducted to provide a comparison basis in regards to incineration fuel costs among the various fabrics. Testing was performed using the second-generation primary treatment apparatus (see Figure 4). Study standard diluted sludge was used for the wastewater influent. The sludge was thoroughly mixed for 30 seconds before experiments were conducted. A grab sample of the influent was taken immediately after mixing. Average influent TSS values were determined using Method 2450D (APHA, 1998). The basin was filled, and a 6-inch head level was maintained for 10 minutes while advancing the fabric through the bed at a rate to maintain the 6-inch head.

Random samples of fabric from the loaded uptake spool were cut, promptly weighed, and then placed in a Fisher Scientific Model 665F Isotemp oven set to 105^0. After a drying time of 12 hours, the samples were then re-weighed, and moisture content determined.

2.9 Column Study

A column study (using column seen in Figure 2) determined the relative head build-up characteristics of the various fabrics at various flow rates. Fabric samples were positioned in the mounting bracket of the column apparatus during testing. Study standard diluted sludge was used for the wastewater influent. The sludge was thoroughly mixed for 30 seconds before experiments were conducted. The wastewater was then pumped into the top of the column apparatus. Head build-up with respect to time was monitored and recorded using a stopwatch. The experiment concluded when a head level of 12-inches was reached. Head loss for each geotextile was determined at a flow rate of .603 L/min, 1.42 L/min, 2.56 L/min, and 3.75 L/min. These flow rates corresponded to clearly marked levels on the pump controller power dial.

2.10 Feed Rate Comparisons

Feed rate tests enabled a comparison of the relative amount of fabric required to perform filtering. Two fabrics were tested using the small-scale prototype bed configurations described in Sections 2.5 and 2.6. Study standard diluted sludge was used for the wastewater influent. The sludge was thoroughly mixed for 30 seconds before experiments were conducted. The basin was filled to a 6-inch head level, and that head was maintained for 10 minutes by advancing the fabric through the bed as necessary. Feed rates were determined by measuring the length of fabric transitioned through the basin during this 10-minute period.

2.11 TSS Removal Efficiency Testing with respect to Filtered Volume

This testing assessed whether the fabric, or the sludge build-up on the fabric surface, was performing the filtering. Two fabrics of different thickness were tested using the column apparatus. Study standard diluted sludge was used for the wastewater influent. The sludge was thoroughly mixed for 30 seconds before experiments were conducted. A grab sample of the influent was taken immediately after mixing. The wastewater was then pumped into the top of the column apparatus. 100-mL grab samples were taken at filtered volumes of 0, 1, 2, 3, and 4 liters. Testing proceeded until the fabric became plugged and no appreciable fluid could pass. All TSS analyses were performed using Method 2450D (APHA, 1998).

2.12 Screening Apparatus

Figure 6 shows the screening apparatus used to pre-screen wastewater test samples to determine if pre-screening would augment the filtering capabilities of the WFU.

Figure 6: Screening Apparatus

At the beginning of each experiment, a wire mesh screen was fastened to a 45^0-angled mounting device using a staple gun. Two 9-½ X 14 inch catch basins were positioned beneath the mounted sample screen. One basin received the screened effluent, while the other basin was utilized to capture sludge and solids sloughing off the screen. A 35 X 35 grid per inch mesh screen (.010-inch wire diameter), a 30 X 30 grid per inch mesh screen (.012-inch wire diameter), and a 30 X 30 grid per inch mesh screen (.0095-inch wire diameter) were used to test pre-screening of wastewater. All screens were stainless steel woven wire cloth manufactured by McMaster-Carr Supply Company of Atlanta, GA.

2.13 Flow Rate Tests

Flow rate tests indicated how flow rate influenced filtering performance. Fabric samples were positioned in the mounting bracket of the column apparatus during testing. Study standard diluted sludge was used for the wastewater influent. The sludge was thoroughly mixed for 30 seconds before experiments were conducted. A grab sample of the influent was taken immediately after mixing. The wastewater was then pumped into the top of the column apparatus. A grab sample of the effluent was taken when four inches of head had built up in the column. Each fabric was tested at a flow rate of 1.42 L/min and 3.75 L/min. All TSS analyses were performed using Method 2450D (APHA, 1998).

2.14 Head Level Effects

The affect of head level on filtering performance was determined with these tests. Linq 3401 Typar fabric samples were positioned in the mounting bracket of the column apparatus during testing. Study standard diluted sludge was used for the wastewater influent. The sludge was thoroughly mixed for 30 seconds before experiments were conducted. A grab sample of the influent was taken immediately after mixing. The wastewater was then pumped into the top of the column apparatus. TSS Removal was evaluated at head levels of 1 ft., 2 ft., and 3 ft. Head level was maintained by opening an effluent port on the column at the desired head level. Additionally, influent flow was reduced if these measures proved inadequate due to severe plugging of the fabric. Grab samples were taken after three minutes at each head level. All TSS analyses were performed using Method 2450D (APHA, 1998).

2.15 Fabric Tensioning

These tests were used to determine whether fabric tension would affect moisture absorption properties. Testing was conducted using the second-generation primary treatment apparatus (see Figure 4). Study standard diluted sludge was used for the wastewater influent. The sludge was thoroughly mixed for 30 seconds before experiments were conducted. A grab sample of the influent was taken immediately after mixing. Average influent TSS values were determined using Method 2450D (APHA, 1998). The basin was filled to a 6-inch head level, and that head was maintained for 10 minutes by advancing the fabric through the bed as necessary. Random samples of fabric from the loaded uptake spool were cut, promptly weighed, and then placed in a Fisher Scientific Model 665F Isotemp oven set to 105^0. After a drying time of 12 hours, the samples were then re-weighed to determine moisture content. Low-tension experiments were conducted with no resistive force being applied to the supply spool. The fabric was transitioned through the influent basin by rotation of the uptake spool. Medium tensioning represents a moderate applied resistive force to the supply spool. High tension was the result of large resistive forces being applied. Tensioning force was established on a relative basis. Precise instrument measurement of forces was not made.

2.16 Configuration Comparisons

2.16.1 Feed Rate

Fabric feed rate served as one of two parameters used to compare configurations. Two fabrics were tested using the two small-scale prototype bed configurations described in Sections 2.5 and 2.6. Study standard diluted sludge was used for the wastewater influent. The sludge was thoroughly mixed for 30 seconds before experiments were conducted. The basin was filled to a 6-inch head level, and that head was maintained for 10 minutes by advancing the fabric through the bed as necessary. Feed rates were determined by measuring the length of fabric transitioned through the basin during this 10-minute period.

2.16.2 Filtering Efficiency

The relative filtering efficiency performance of the two configurations was also used to compare the configurations. Amoco 4510 fabric was tested using the two small-scale bed configurations described in Sections 2.5 and 2.6. Study standard diluted sludge was used for the wastewater influent. The sludge was thoroughly mixed for 30 seconds before experiments were conducted. A grab sample of the influent was taken immediately after mixing. The basin was filled to a 6-inch head level, and that head was maintained for 10 minutes by advancing the fabric through the bed as necessary. Grab samples of effluent were then taken. TSS values were determined using Method 2450D (APHA, 1998).

2.17 Polymer Addition

2.17.1 Filtering Efficiency

These experiments determined if polymer addition enhanced filter performance. Jar testing was utilized to determine the proper dosing concentrations of Stockhausen 650 BC polymer (.255 % wt./wt.). Backwash from the proposed second stage BAF (Asiedu, 2001) was used during this phase of testing. Samples were mixed at 300 RPM for one minute, and then at 30 RPM for 5 minutes. After 30 minutes of settling, the NTU (N Turbidity Units) of the sample was ascertained using an Orbeco-Hellige Model 965 turbidimeter. An optimal polymer dose of .0125 mL/mL BAF backwash was used during TSS removal testing. The Linq 130 EX and 225 EX fabrics were selected to perform comparative removal efficiency tests.

Fabric samples were positioned in the mounting bracket of the column apparatus during testing. BAF backwash was drawn from a five-gallon bucket that was being mixed using a Thermolyne Cimarec stirrer and large stir bar. Influent grab samples were taken at the beginning of each test. Effluent grab samples were taken after one liter of backwash had been filtered. Plugging of the column usually occurred at this point or shortly thereafter. All TSS analyses were performed using Method 2450D (APHA, 1998).

2.17.2 Head Build-Up Effects

These experiments determined how polymer addition modified head build-up characteristics. Amoco 4510 fabric samples were positioned in the mounting bracket of the column apparatus during testing. Study standard diluted sludge was used for the wastewater influent. A dosage of 1 mL Stockhausen 650 BC polymer (.255% wt./wt.) per liter wastewater was used for amended influent. Raw mixed liquor solids from the Blacksburg and Virginia Polytechnic Institute Wastewater Treatment Plant (BVPIWWTP) in Montgomery County, VA was diluted with tap water to 400-600 mg/L TSS in 12-gallon plastic tubs for raw sewage testing. Again, a dosage of 1mL polymer per liter wastewater was used to amend wastewater for comparison experiments. The contents in the tubs were thoroughly mixed for 30 seconds before experiments were conducted. The wastewater was then pumped into the top of the column apparatus. Head build-up with respect to time was monitored and recorded using a stopwatch. The experiment concluded when a head level of 12-inches was reached. Each sample was tested at a flow rate of 1.42 L/min.

2.18 Polymer Addition w/Pre-Screening

Experiments utilizing polymer addition, in conjunction with pre-screening, were conducted to determine the effect on filtering performance. The different mesh sizes were tested using the screening apparatus described in Section 2.12. One liter of raw mixed liquor solids from the Blacksburg and Virginia Polytechnic Institute Wastewater Treatment Plant (BVPIWWTP) in Montgomery County, VA was polymer dosed and thoroughly mixed at the beginning of each test. After five minutes of coagulation and settling, the dosed wastewater was poured vertically through the mesh surface. Each mesh type was tested at polymer doses of .5 mL, .75 mL, 1 mL, and 2 mL per liter of wastewater. Polymer was again a Stockhausen 650 BC prepared on a .255% wt./wt. basis. Filtered samples were analyzed for TSS using Method 2450D (APHA, 1998).

Chapter 3. Results

3.1 Fabric Comparisons

One pivotal evaluation was the selection of the geotextile fabric best suited for full-scale application. This study considered only non-woven geotextile fabrics constructed of polypropylene. These fabrics, however, come in many different commercially available products due to different manufacturing techniques and thickness.

Testing to determine which manufacturing method produced the best fabric for use in the WFU directly compared spunbonded and needle-punched constructed fabrics. TSS removal efficiency, moisture absorption, head build-up times, and feed rate were utilized to make this assessment. Testing was also undertaken to determine if fabric thickness would affect filtering performance.

3.1.1 Filtering Efficiency

Since the primary function of the WFU is TSS removal, this performance parameter would have to weigh heavily in comparative analysis. Results of TSS removal efficiency tests are presented in Table 2.

Table 2: TSS Removal Efficiencies

Fabric Type	Thickness (mm)	Construction Technique	Flow Rate (L/Min)	TSS in (mg/L)	TSS out (mg/L)	TSS Removal Efficiency %
Linq 130 EX	1.4	Needle-Punched	1.42	600	52	91.3
			3.75	604	62	89.7
Linq 180 EX	2.03	Needle-Punched	1.42	628	72	88.5
			3.75	576	94	83.7
Linq 225 EX	2.16	Needle-Punched	1.42	624	84	86.5
			3.75	440	76	82.7
Linq 350 EX	3.81	Needle-Punched	1.42	576	66	88.5
			3.75	672	80	88.1
Amoco 4510	2.15	Needle-Punched	1.42	612	56	90.8
			3.75	696	80	88.5
Linq Typar 3401	0.4	Spunbonded	1.42	576	130	77.4
			3.75	636	154	75.8
Linq Typar 3631	0.56	Spunbonded	1.42	580	124	78.6
			3.75	608	184	69.7

These results indicate that needle-punched fabrics exhibit superior filtering properties to their spunbonded counterparts, independent of flow rate. Removal efficiencies were as much as 20 % better in some cases. This performance superiority would allow the designer to use smaller biological units since the secondary units would receive a reduced organic loading. Further investigation would be necessary to precisely access this benefit to make a final product evaluation.

3.1.2 Moisture Absorption

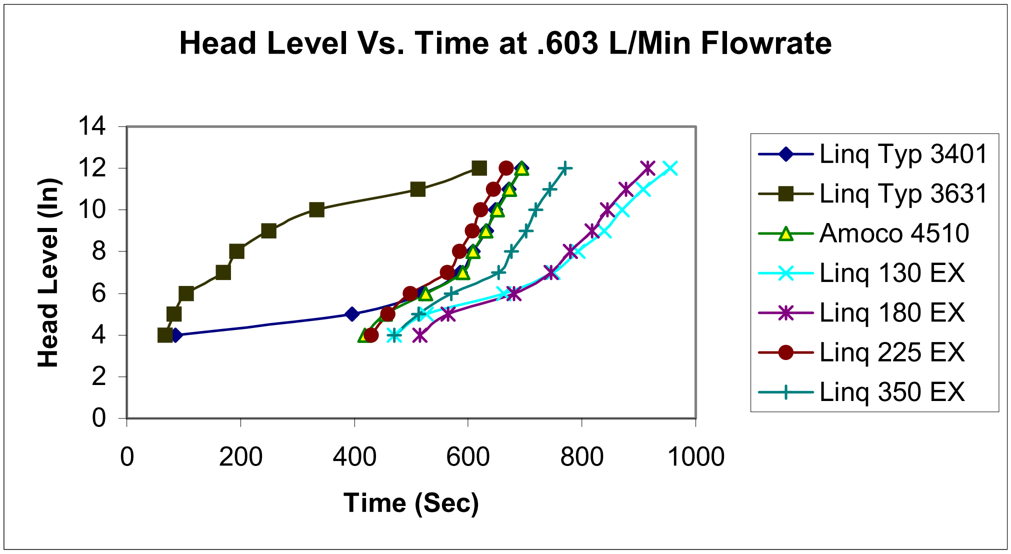
Moisture absorption properties of the fabric directly impact incineration fuel costs. Excess moisture present at the conclusion of filtering must be evaporated during incineration, resulting in increased fuel costs. Material with additional moisture will also be heavier and more difficult to transport to the incinerator unit. Testing was conducted to compare fabric moistures using the small-scale filter bed configurations to accurately simulate actual operating conditions. Due to cost and availability constraints, only one representative fabric from each manufacturing method was selected to perform these tests. The moisture content of the needle-punched Amoco 4510 fabric after loading was 91.5 % for an average influent TSS of 501 mg/L, while the spunbonded Linq Typar 3401 had an average moisture content of 54.5 % with an average influent TSS of 459 mg/L. This shows a very significant advantage in using the spunbonded products with regards to moisture holding capacity. Incineration costs would decrease with moisture content reduction.

3.1.3 Head Build-Up

Head build-up is an important parameter in designing influent basin sizes. Rapid build-up times would require larger structures and use more fabric to contain the draining wastewater without overflow. Comparison tests among different fabrics are shown in Figures 7 and 8. In these tests, head build-up was timed using the column apparatus with the particular fabric being tested secured in the mounting bracket.

Several observations can be made from the data presented in these figures. With the exception of the Linq Typar 3401 and 3631 fabrics, all the geotextiles became plugged and flow slowed dramatically at approximately the same time at each test flow rate. Plugging was found to occur uniformly at a head level of approximately 7 inches for all fabrics at all flow rates. This can be seen on the plots where the curves representing the fabrics change slope abruptly, and head level begins increasing at a markedly greater rate than previously. A clear plot of this break point can be seen in Figure 9 for the Amoco 4510 fabric at a flowrate of 3.75 L/Min.

Figure 7: Head Build-Up Times at .603 L/Min and 1.42 L/Min Flow Rates



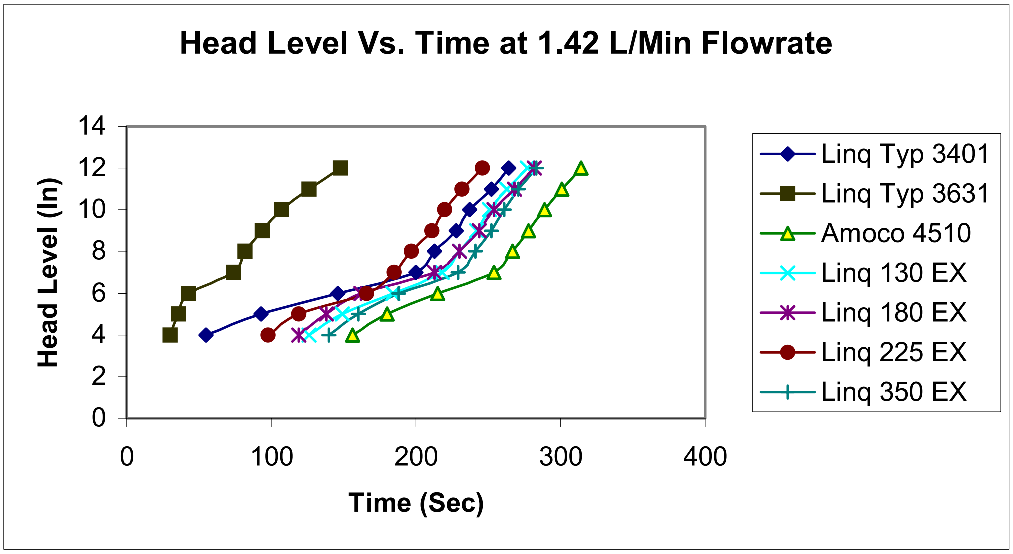
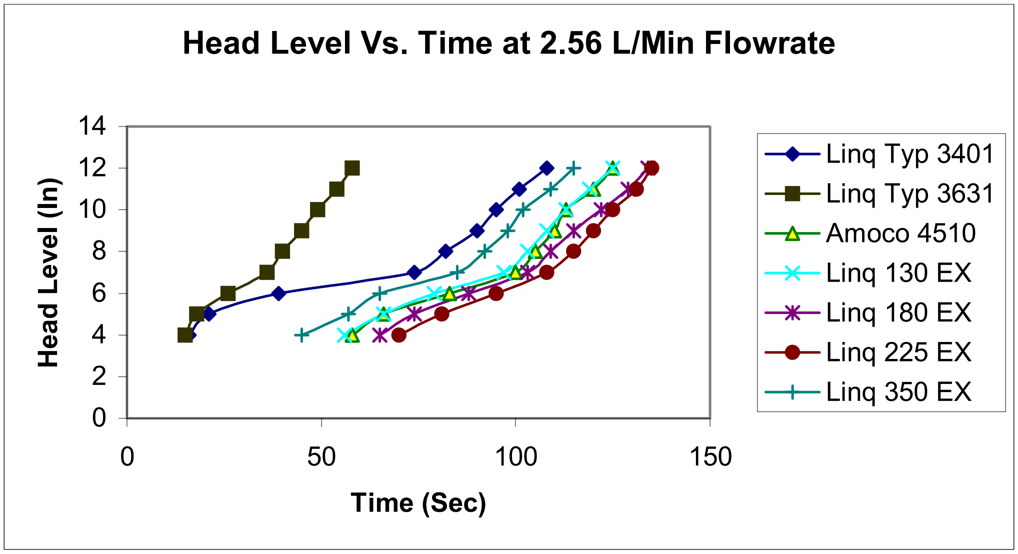


Figure 8: Head Build-Up Times at 2.56 L/Min and 3.75 L/Min Flow Rates



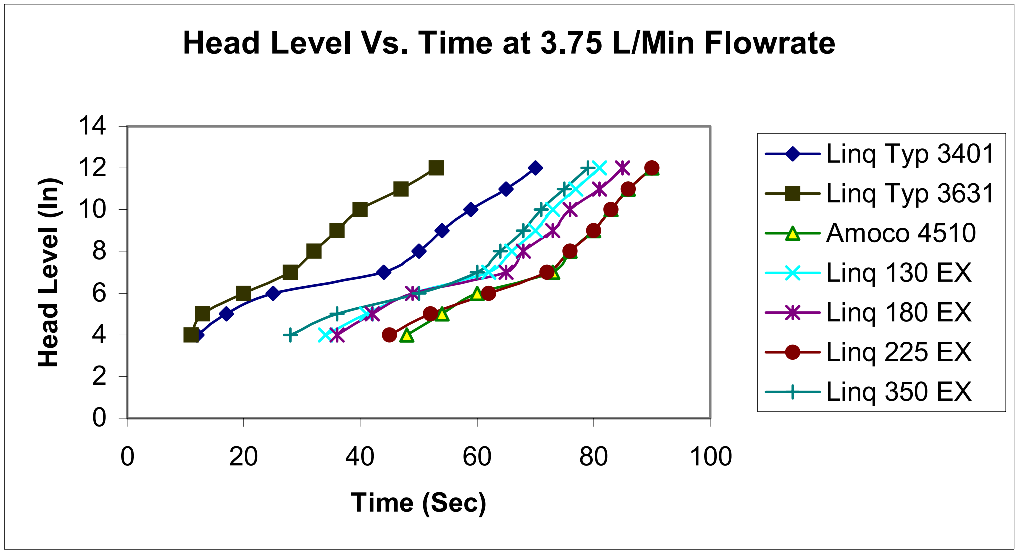
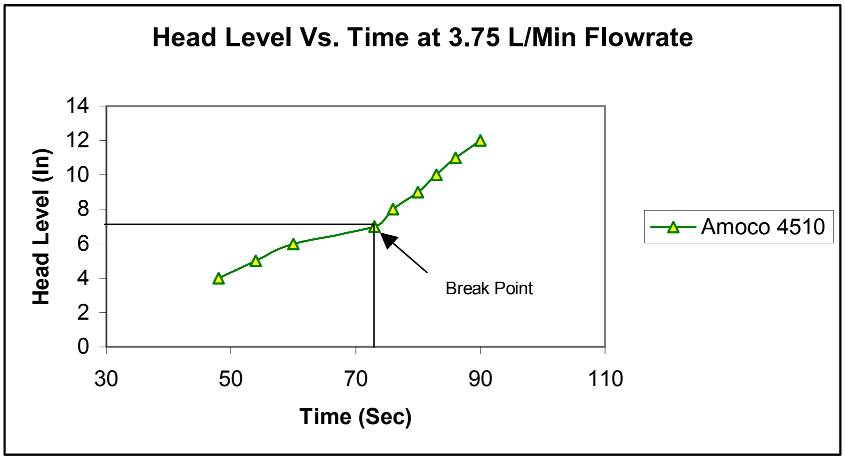


Figure 9: Break Point Detail



The difference in the time required to plug a fabric could be utilized to determine a geotextile's performance capabilities, since this break point would establish a relative limit on the amount of time the fabric could be loaded before scrolling would be necessary to maintain containment of wastewater volume within the influent basin.

It is clearly evident that the spunbonded Typars were the poorest performers with regards to head build-up. At the lower flow rates of .603 and 1.42 L/Min, the Linq Typar 3631 is clearly inferior to the other fabrics, while the Typar 3401 performs amongst the poorer needle-punched products. It is at the higher flows of 2.56 and 3.75 L/Min, however, where the superiority of the needle-punched fabrics is clearly shown. Both Typar fabrics at each of these flow rates are distinctly separated from the other fabrics. The best performing needle-punched fabrics took almost twice as long as the Typar 3401 to reach the plugging point, and almost three times as long as the Typar 3631 fabric at a flow rate of 3.75 L/Min. Needle-punched geotextiles, therefore, would allow for smaller influent basin sizing since overflow concerns would not be as great.

Another observation made from these figures relates to the difference in time required to cause plugging at the various flow rates used. At a flow rate of .603 L/Min, the average time for the needle-punched fabric to plug was approximately 11 minutes. At a 3.75 L/Min flow rate, this time dropped to 65 seconds. A simple integrating flow rate over time calculation indicates that 6.6 liters of wastewater could be treated before plugging at a flow rate of .603 L/Min, while only 4 liters of wastewater could be treated at the higher 3.75 L/Min flow rate. This result shows that lower flow rates, with the concurrent smaller pumps and energy requirements, could be utilized to produce a more cost effective design. The increase in treated flow before plugging at the lower flow rates would also result in reduced fabric usage rates. Subsequent testing using experimental influent basin configurations, however, seemed to indicate an opposite trend in the relationship between head stabilization/fabric usage and flow rate.

3.1.4 Feed Rate Comparisons

As discussed in the previous section, solids loading over a period of time greatly reduces flow through for a geotextile, causing excessive head build-up. The fabric must be transitioned through the influent basin to prevent this build-up, and corresponding overflow. Transition feed rates necessary to stabilize head levels determine the amount of fabric required to filter a given wastewater flow over a specified time. Comparative testing of fabric feed rates was conducted using the small-scale filter bed configurations. Again, due to cost and availability constraints, only one representative fabric from each manufacturing method was selected to perform these tests. Table 3 presents the results of these experiments.

Table 3: Feed Rate Comparisons

Bed Configuration	Flow Rate (L/Min)	Fabric Feed Rates (Ft.^{2}/Min)	
		Amoco 4510	Linq Typar 3401
Traditional	0.6	0.022	0.178
	1.42	0.032	0.261
	3	0.044	N/A*
V-Bed	0.6	0.014	0.144
	1.42	0.021	0.211
	3	0.034	N/A*
* N/A represents a head level that could not be maintained			

This testing clearly shows the advantage of the needle-punched fabric. Feed rates were on the order of ten times less using the needle-punched fabric (Amoco 4510) versus using the spunbonded product (Linq Typar 3401). In addition, at a flow rate of 3 L/min, the Typar was unable to maintain the head level at six inches. For the Typar, the head level continually increased, and confirmed that the low permittivity of the spunbonded geotextiles would establish flow limitations that might be prohibitive in field use. The relatively low feed rates for the needle-punched Amoco fabric, on the other hand, would allow the designer much more flexibility in treatment capacity per day. Reduced fabric usage would also result in lower costs and decreased material handling.

3.1.5 Fabric Thickness

Removal efficiency comparisons were necessary to determine whether the higher costs of thicker fabrics produces a corresponding benefit in TSS reduction. Since the thickness of a geotextile changes under compressive loading, thickness is measured as the distance between the upper and lower surface of the fabric under a constant pressure of 2 kPa (Koerner, 1984).

Results of removal efficiency testing between fabrics of different thickness are tabulated in Table 4.

Table 4: Fabric Thickness and Removal Efficiencies

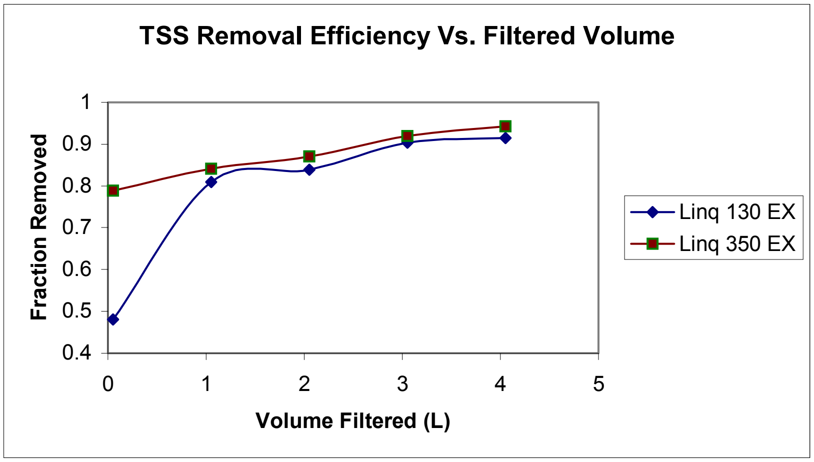
Fabric Type	Construction Technique	Thickness (mm)	TSS in (mg/L)	TSS Removal Efficiency %
Linq Typar 3401	Spunbonded	0.4	606	76.6
Linq Typar 3631	Spunbonded	0.56	594	74.2
Linq 130 EX	Needle-Punched	1.4	602	90.5
Linq 180 EX	Needle-Punched	2.03	602	86.1
Amoco 4510	Needle-Punched	2.15	654	89.7
Linq 225 EX	Needle-Punched	2.16	532	84.6
Linq 350 EX	Needle-Punched	3.81	624	88.3

* Table represents averages of tests run at 1.42 L/min and 3.75 L/min flow rates

Efficiencies were found to be relatively independent of thickness. The difference in filtering efficiency with the Typars appears to be due to the spunbonded construction, and not thickness. The deposited layer does the filtering.

Analysis of these results suggested that solids accumulation on the fabric surface over time was performing the majority of the filtering, as opposed to the fabric. An experiment was conducted comparing removal efficiencies at intervals of filtered volume to test this theory. The two needle-punched fabrics with the greatest difference in thickness were selected for this experiment. An initial grab sample was taken during tests for both fabrics, and then a sample was taken after every liter of filtered wastewater, until the fabrics became plugged. Figure 10 shows the results.

Figure 10: TSS Removal Efficiency at Intervals of Filtered Volume



The filtering performance of the thinner 130 EX is initially very poor, with only 48% solids removal, as compared to a 79% removal rate with the 350 EX fabric. However, the efficiency of the two fabrics becomes essentially the same as the volume applied increases, and solids form a cake on the surface of the geotextile. This convergence of performance occurs rapidly (after the first liter of wastewater is filtered), and proves that cake development and filtering capacity is achieved soon after filter exposure to waste flows. The advantage of using the thicker geotextiles would only be realized if fabrics were exposed to flows for short periods of time. Field operations, however, would involve long exposure times to fully utilize fabric resources. Use of the thinnest fabric available would be recommended due to lower weight and costs.

3.2 Process Variables

Several process variables were identified that could affect unit performance. These included flow rate of influent, applied head level, and fabric tensioning level. Experiments were then conducted to determine the conditions necessary to achieve optimal performance.

3.2.1 Flow Rate

Flow rate is one of the key operational process variables investigated. A wide range of flows during field operations could affect filtering efficiency, as well as fabric usage. Table 5 shows that removal efficiency did not vary significantly between flow rates of 1.42 L/Min and 3.75 L/Min.

Table 5: Flow Rate Effects on Filtering Efficiency

Fabric	Removal Efficiency %	
	1.42 L/min Flowrate	3.75 L/min Flowrate
Linq 130 EX	91.3	89.7
Linq 180 EX	88.5	83.7
Linq 225 EX	86.5	82.7
Linq 350 EX	88.5	88.1
Amoco 4510	90.8	88.5
Linq Typar 3401	77.4	75.8
Linq Typar 3631	78.6	69.7

Since filtering efficiency is relatively independent of flow rate, maximum daily treatability levels can be determined by the maximum flow rate that each fabric can maintain for a specified operating head. This could exclude some fabrics in full-scale operations if head build-up limitations restrict the maximum flow rate below that required for treating peak waste flow rates. Alternatively, if peak treatment levels did not impose significant flow rate demands, this efficiency independence could allow for smaller pump sizing, which would reduce cost and energy requirements.

Experiments were also conducted to determine the effect of flow rate on fabric usage. These results are shown in Table 6.

Table 6: Fabric Used per Liter Filtered Wastewater

Fabric Type	Flow Rate (L/Min)	Fabric Used (Ft.^{2} / L)	
		Traditional Config.	V-Bed Configuration
Amoco 4510	0.6	0.037	0.023
	1.42	0.023	0.014
	3	0.015	0.012
Linq Typar 3401	0.6	0.294	0.239
	1.42	0.183	0.150
	3	N/A*	N/A*
* N/A represents a head level that could not be maintained			

In all cases, higher flows proved more efficient in terms of fabric usage. Therefore, choosing the optimal flow rate would require balancing the advantages of lower flows and concurring smaller pump requirements mentioned above, and reduced geotextile fabric usage at higher flows.

3.2.2 Head Level Effects

Head level was investigated to determine if larger flow gradients under high head loadings would alter filter performance. Table 7 shows that this gradient did not exert a major influence on solids removal efficiency. The change in filtration efficiency with head level was seen as insignificant for head levels of 1, 2, and 3 feet.

Table 7: Removal Efficiency at Various Head Levels

Head Level (ft.)	TSS in (mg/L)	Removal Efficiency %
1	366	77.3
2	430	78.4
3	458	80.4

This relative independence of efficiency with head level enables the designer to reduce influent basin size since there would be no need for a large head gradient to improve filter performance.

3.2.3 Fabric Tensioning

An investigation was undertaken to determine whether fabric tensioning affected moisture absorption. Using the Amoco 4510 fabric, the experimental results presented in Table 8 were obtained.

Table 8: Tensioning Effects on Moisture Absorption

Tension	Avg. TSS (mg/L)	Moisture Content %
Low	422	82.1
Medium	354	82.5
High	380	80.5

The moisture content of the sludge loaded fabric proved independent of tension levels. Since high loading tension does not produce beneficial moisture squeezing, low tension might be desired to avoid fabric structural integrity problems.

3.3 Configuration Comparisons

Sections 2.5and 2.6 describe the two alternatives. These two configuration designs competed on the basis of fabric feed rates and filtering efficiency. The initial configuration was designed with an influent basin to roughly simulate the preliminary WFU design proposed by UTD Corporation. An alternate influent basin was designed to address the concern of sludge trapping encountered with the initial configuration. This trapping occurred when filtered solids accumulated on the bottom of the influent basin. The fabric was unable to remove these accumulations during scrolling due to squeezing caused by the pressure roller closest to the uptake spool on the basin floor. Instead of entraining the solids into the geotextile as hoped, the roller acted to scrape the wastes from the fabric, creating the accumulation problem in the bottom of the unit. The altered design utilized a reconfigured basin and roller layout to address this concern. The flat bottom surface of the initial configuration basin where solids accumulated was removed, leaving two angled walls in the shape of a "V" forming the basin structure (as illustrated in Figure 5). The effluent drain window was located on the wall closest to the uptake spool. One pressure roller was positioned on the lip of the wall nearest the supply spool, while another roller was located at the bottom of the basin. The uptake spool was positioned beneath the basin lip, providing fabric tension through force exerted by the bottom roller and lip surface. This allowed effluent to drain through the fabric without subsequent squeezing by a roller. It should be noted that the use of pressure rollers in each of these designs to seal the fabric to the influent basin surface differed from the UTD Corporation proposal, which recommended the use of stainless steel guides. However, this configuration required fabric rolls with sewn nylon straps that were routed through the guides. The cost to procure geotextile rolls specially manufactured with these straps proved prohibitive, and was not investigated in this study.

Actual comparison testing showed similar filtering efficiency with each design. The V-bed configuration performed significantly better in terms of fabric feed rates however. Tables 9 and 10 summarize these results.

Table 9: Configuration Design Effects on Fabric Feed Rates

Fabric Type	Flow Rate (L/Min)	Fabric Feed Rates (Ft.^{2}/Min)	
		Traditional Config.	V-Bed Configuration
Amoco 4510	0.6	0.022	0.014
	1.42	0.032	0.021
	3	0.044	0.034
Linq Typar 3401	0.6	0.178	0.144
	1.42	0.261	0.211
	3	N/A*	N/A*
* N/A represents a head level that could not be maintained			

Table 10: Configuration Design Effects on Filtering Efficiency

Configuration	TSS in (mg/L)	TSS out (mg/L)
Traditional	475	79
V-Bed	334	80

The V-bed design would be recommended since, in addition to reduced fabric usage, sludge accumulation was minimal. Configuration analysis would have to be re-evaluated, however, if other fabric sealing methods such as stainless steel guides were desired.

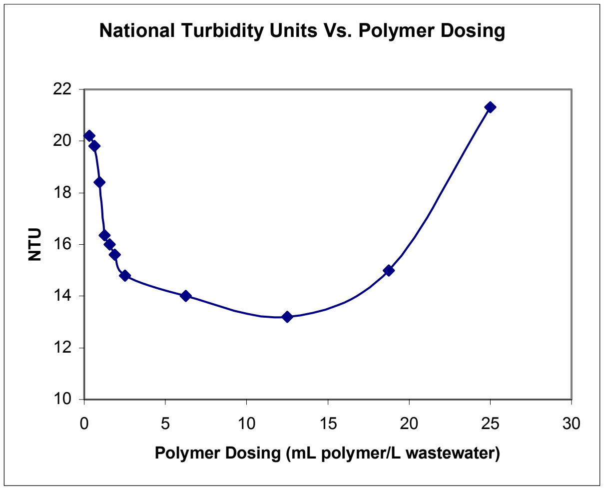
Chapter 4. Treatment Process Design

Several treatment process amendments were explored to determine the viability of the proposed WFU concept. Polymer addition and polymer addition in conjunction with pre-screening were both seen as possible alternatives to the treatment cycle that could potentially lower operating costs and increase filtration efficiencies. The results of these experiments, and the evaluations from the previous chapter, allowed an assessment to be made on the most effective treatment process design.

4.1 Polymer Addition

Polymer addition for coagulating wastewater solids suggests a possible beneficial influence for this application. Jar testing results identified the most effective polymer dose. Optimal polymer dosing corresponded to 12.5 mL polymer/L wastewater, where solids settling produced the most transparent jar sample water. The results of this testing are presented in Figure 11.

Figure 11: Polymer Dosing Selection



Once an appropriate polymer dose was found, removal efficiency testing was conducted on wastewater samples to determine whether using polymer would increase the effectiveness of the geotextile at reducing solids. Two needle-punched fabrics of different thickness were selected to conduct these experiments.

Table 11: Polymer Effects on TSS Removal

Fabric	Removal Efficiency %	
	wo/polymer	w/polymer
Linq 130 EX	90.7	87.7
Linq 225 EX	90.4	90.5

Table 11 points out that removal rates were only slightly affected by polymer addition for either fabric. This could possibly suggest that polymer use would be ineffective. More extensive experimentation, however, would be necessary to establish this conclusion definitively.

4.2 Polymer Addition w/ Pre-Screening

The use of polymers in conjunction with pre-screening was investigated to determine its effectiveness in reducing solids loadings introduced to the WFU. Results of these tests are shown in Table 12.

Table 12: Polymer Addition w/ Pre-Screening

Mesh Type	Polymer Conc. (mL/L)	Filtered TSS (mg/L)	% TSS Removal
30x30x.012	None	1370	5.3
	0.5	528	63.5
	0.75	348	75.9
	1	241	83.3
	2	82	94.3
30x30x.0095	None	1387	4.1
	0.5	869	39.9
	0.75	459	68.3
	1	440	69.6
	2	217	85.0
35x35x.010	None	1383	4.4
	0.5	799	44.7
	0.75	239	83.5
	1	260	82.0
	2	99	93.2

These performance levels are very promising. Solids reductions using this process may prove adequate as a stand-alone treatment option. Using the WFU to further reduce the TSS of the pre-screened effluent might actually become unnecessary. Since sludge cake build-up on the geotextile fabric surface removes the majority of TSS, lack of solids present from this pre-treatment process might eliminate the need for the WFU. Additionally, with an expected wastewater TSS of 447 mg/L during operations, it seems reasonable that this treatment system can meet 70 % removal efficiency requirements for discharge to the secondary unit.

4.3 Design Suggestions

Polymer addition coupled with pre-screening suggests that the UTD configuration should be reconsidered. While the fabric filter unit was determined to be effective in terms of solids removal, several problems presented themselves that limit this design as the most effective means of addressing Army treatment goals. UTD developed and identified several alternatives using the information gathered in this research.

The primary focus of future experimental research will involve the development of a screening unit incorporating polymer addition. This unit has many advantages over the design used for the experiments presented in this paper. Principal amongst these is that this process would not require geotextile fabric. Additionally, without any moving parts, maintenance requirements would be minimal. This would be extremely beneficial given that expected field-operating conditions could vary widely.

UTD will consider the use of a belt press running a spunbonded Typar fabric. As solids accumulate, a scraper blade would clean the surface of the fabric to allow it to continue filtration.

Spunbonded Typars would be used since, during testing, they proved particularly resistant to entrainment of solids. This recycle-based process design would, therefore, use relatively little fabric as compared with the scrolled fabric approach.

The scope of future research, incorporating more operational and full-scale testing, will allow UTD, Inc. to more fully understand and compare these treatment process designs. The final design will balance cost, maintenance, and size considerations in its assessment criterion. The data collected and experiments performed in this research project have served as the first step in this iterative process to determine the best possible design for the Army.

Chapter 5. Summary and Conclusions

The experiments and testing described in the previous sections of this paper led to several significant conclusions for final design recommendations. When testing corresponded to research conducted by UTD Corporation's investigation involving geotextiles for this application, results were similar and consistent. Budgeting demands, however, prevented the use of all fabrics during the various experiments. Constraints imposed by time, scale, and scope, could also limit the accuracy of these observations as applied to field performance expectations. In this context, these conclusions serve as guidelines that allow future research to more specifically focus the direction of full-scale experiments that can truly examine the potential of various fabrics and unit configurations to perform the required filtering.

Eleven conclusions follow:

1. Needle-Punch manufactured geotextiles filter solids more efficiently than spunbond manufactured fabrics, independent of flow rate. Each fabric type meets the US Army requirement of 70 % solids removal. However, the more efficient needle-punch fabrics would allow the designer to use smaller biological units.
2. Spunbonded products absorbed significantly less moisture. This decreases fuel requirements during subsequent incineration.
3. Needle-Punched fabrics permitted higher flow rates, increasing head build-up times. Smaller influent basin design would be possible due to ease of head stabilization with these geotextiles compared to spunbonded products.

4. Needle-Punched geotextiles had slower feed rates resulting in reduced fabric usage. This translates into lower costs and decreased disposal logistics.
5. Fabric thickness had a minor effect on filtering performance. A thinner fabric would be preferable due to lower weight and costs.
6. Filtering efficiency is independent of flow rate. Fabric usage requirements, however, are less at higher flows. Optimal flow rate would have to be determined by balancing fabric usage/disposal costs and cost/energy benefits of smaller pumps.
7. Head level did not affect filtering efficiencies. Therefore, influent basin sizing would not have to account for head gradient to drive filtering performance.
8. Fabric tensioning does not affect fabric moisture absorption. Low tension would be desired to avoid fabric tearing.
9. The V-bed influent basin was superior to the flat bottom configuration. This conclusion only applies to designs using pressure rollers to seal fabric to the basin surface. Additional testing and experimentation would be necessary for evaluating alternative sealing mechanisms.
10. Polymer addition with pre-screening proved effective at reducing the solids loading to the filter. The effectiveness of polymers with pre-screening was significant enough to consider this as a stand-alone treatment system.
11. Other process designs should be considered to determine the best possible system with regards to cost, maintenance, and size.

Chapter 6. Discussion

The primary purpose of this study was to assess the feasibility of a mobile wastewater filtration unit for the treatment of primary effluent. The US Army is interested in this technology to reduce security concerns associated with outside contracted waste disposal in foreign deployments. Current world events will likely increase these deployments, and the corresponding need for such a device. Although there has been research into small on-site wastewater treatment systems such as intermittent filters (Roy et. al., 1998), there is currently no portable technology available that can filter efficiently at the expected flows in this application.

A thorough analysis to determine the final design configuration for the device to be used will have to take into account several key factors. These parameters include operational costs, maintenance requirements, filtration efficiency, and portability. Other factors may also require consideration. Using a matrix approach, with factors weighted according to importance, an assessment can then be made to select the device most suitable for full-scale operational use.

The potential also exists for this technology to be applied to other design situations where a portable, short-term wastewater treatment facility might be desirable. Specifically, many areas in the developing world could greatly improve water quality by reducing solids loading to receiving streams and rivers. Alternatively, a portable facility could serve as an effective stopgap for growing communities during transition periods, while larger facilities are constructed. Another possible application could be to provide treatment in the event a terrorist attack disables local facilities. This eventuality is of particular significance given the new proposed legislation regarding threat assessment studies and contingency plans for municipalities. With each of these applications, different design envelopes would have to be established to properly characterize and define the scope of the eventual design.

UTD Corporation has identified several possible configurations for a full-scale unit. The first design option involves the scrolling geotextile fabric filter device that was the principal focus of the study presented. This unit proved very effective at removing solids from the waste stream. Further, due to the low cost of geotextiles, operational costs would not be significant for the actual filtering process. However, there are several disadvantages to this device configuration. The most significant of these disadvantages is the high potential expense to dispose of loaded fabric rolls, especially if incineration were utilized to perform this task. Additionally, clogging and maintenance problems could prove prohibitive.

Another possible configuration, identified through testing in this study, would be a small containment basin with a fine mesh screen to filter an incoming waste stream. Polymer would be added prior to screening to coagulate the solids for more effective removal. This configuration would have several advantages, including low operational costs, low maintenance due to the lack of moving parts, efficient solids removal (as evidenced by testing), and ease of set-up and operation. A significant problem, though, could arise if polymer coagulation were ineffective due to environmental factors such as temperature and wastewater characteristics. This could dramatically affect the ability to filter incoming solids using the screen. In addition, this device could experience problems with clogging under high solids loading conditions, and would most likely require a larger settling basin than the previous design configuration. Also, collected solids would still require treatment and disposal.

The final design configuration proposed by UTD would utilize a belt press and scraper mechanism using a Linq Typar fabric. A Typar fabric would be used due to its surface texture, and ability to resist entrainment of solids. The fabric would be routed continuously in a circular manner receiving an incoming waste stream. The scraper would remove solids from the surface of the geotextile and direct them to a collection system. This design configuration would hopefully address the potential problem with varying environmental conditions cited for the previous configuration, and be effective at removing solids under a wide range of operational situations. Further, geotextile fabric usage would be greatly reduced in comparison to the first proposed configuration. Testing, however, would be required to assess whether the geotextiles would have sufficient durability to operate effectively and efficiently under actual operating conditions. There is indication that polypropylene materials under constant loading do have a tendency to collapse at very short notice (Pilarczyk, 2000). If testing revealed the fabric belt would require frequent replacement, this configuration could prove infeasible unless a belt material with more durability was identified. Additionally, this configuration would require high maintenance to ensure the rollers and mechanisms of the press were operating properly. And, as with the previous design configuration, collected solids would still require treatment and disposal.

In the final assessment, this study has shown that a mobile wastewater treatment unit is a viable technology. Actual design of the full-scale unit will require further testing, and will have to specifically focus on defining the desired application. It may even prove useful to modularly design a unit so that it can have the flexibility to expand to treat larger flows if necessary. Also, the designer may choose to use different configurations given different operating conditions and applications. As with the device in this study, operational factors, as well as materials used in the filtering process will have to be researched and tested to determine the most viable end product for full-scale use. The ultimate goal, and one that seems very achievable judging from the results of this study, is to produce a low-cost device requiring little maintenance that will efficiently filter solids from a waste stream under all expected design conditions.

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Vita

Mr. Riddle was born in Newport News, VA on September 7, 1971 to Mr. And Mrs. Edwin Parker Riddle. He received an undergraduate degree in Aerospace Engineering from Virginia Polytechnic Institute and State University in December of 1994. He worked at various locations before returning to VPI & SU in the Fall of 2000 to work on the requirements necessary to receive a Master of Science in Environmental Engineering. He is currently employed in Roanoke, VA at Hayes, Seay, Mattern, and Mattern, Incorporated. His work focuses on Water Treatment and Wastewater Treatment Plant design, as well as various other aspects of the Environmental Engineering field.