Use of Non-woven Geotextiles for

the sealing of Earthen Manure Storage Facilities

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ABSTRACT

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The mechanisms by which manures seal soils indicate the need for an interface of fine porosity between the waste's liquid and the porous medium. The objective of this study was to determine if fine porosity geotextiles offer such a possibility as an interface media.

Non-woven geotextiles of 20, 30 and 40 μ m equivalent pore sizes were subjected to heads of 0.9 , 1.8 and 2.7 m of 5% total solids (TS) swine slurry for 1800 hours. Infiltration rates decreased from 5 X 10⁻⁵ m/s to less than 1 X 10⁻⁷ m/s and 2 X 10⁻⁸ m/s within 150 and 1000 hours, respectively and all demonstrated minimum seepage rates of 1.3 to 1.8 X 10⁻⁸ m/s after 1000 to 1400 hours ; these rates are slighly greater than the 10⁻⁸ m/s guideline established by the Quebec government.

Field sealing of geotextiles liners was confirmed using a 20 μ m fabric subjected to swine slurries of various total solids (TS) concentrations ranging from 1% to 10%. Infiltration rates indicate that satisfactory sealing requires slurries with a minimum TS content of 4%. As well, higher TS levels favour a longer lasting manure seal at the fabric surface.

Sterilized manure of 5% total solids (TS) used to simulate cool field conditions or poor biological sealing mechanisms showed that the sterilized manure retained a constant infiltration rate after 1000 hours. The equivalent natural manure, on the other hand, demonstrated an increase in infiltration rates after 1000 hours, indicating that microbial degradation of the manure solids mat had occured.

Seepage for all experiments conducted showed high degrees of contamination, with the highest Chemical Oxygen Demand (COD) concentrations observed for the 2.7 m heads as well as for the 20 μ m fabric which also gave significantly higher infiltration rates.

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NOMENCLATURE

- A cross sectional area of non-woven geotextiles exposed to swine slurry, m^2
- I infiltration rate average over time T, m/s
- T time span during which volume V was collected, s
- V volume of seepage collected over time T, m^3
- W constant
- x constant
- t infiltration time, s
- d95 fabric equivalent pore size , value equal to or smaller than the diameter of 95% of the fabric pores (openings)
- ^d85 particle diameters at which 85% of the total particles are smaller on a weight basis
- PVC polyvinylchloride
- TS total solids concentration, mg/L
- SS suspended solids concentration, mg/L
- COD chemical oxygen demand, mg/L
- FOS Filtration opening size
- Q total flow , m^3/s
- K hydraulic conductivity, m/s
- H hydraulic head of water column, m
- H_0 initial hydraulic head at t = 0, m
- A_c cross sectional area of cylinder containing fabric,m²
- L thickness of fabric (geotextile), m

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- a cross sectional area of supply tube, m^2
- T_{c} temperature correction factor
- A_d weight of dried solids, g

B - weight of wet solids, g

WA - water added , L

SA - initial moisture content of swine manure slurry, %

FM - final moisture content of swine manure slurry , %

APHA - American Public Health Association

- R² Coefficient of determination
- R Correlation coefficient

ANOVA - analysis of variance

A.U. - animal unit

I. Introduction

Within the past twenty years, Quebec and Ontario have experienced rapid growth in high intensity, small land base livestock production (animal confinement) operations. The most dramatic increase being within the Canadian hog industry, which in 1961 contained 5.3 million head nation wide and by 1981 this number had risen to 9.9 million head. The most significant increase was in Quebec which doubled its percentages of the national total from 17% in 1961 to 35% in 1981 (Statistics Canada, 1981).

Accompanied with this growth is the fact that many operations have converted to liquid manure handling systems because they are the most cost-effective method for handling large quantities of manure generated by such operations. As a result, the pollution potential of such a handling system is high. This is due to the increased likelihood of such waste reaching ground water and/or surface water sources, and hence contributing to their deterioration if not properly contained.

Sources of water pollution from animal production systems result from direct discharge, runoff and seepage or percolation of pollutants to surface or groundwater. Pollutants consist of sediment , nutrients, pesticides, organic materials, salinity and microorganisms. One of the larger sources of pollutants on most livestock farms is manure. Therefore , the management and handling of manure and animals is an important part of water quality improvement. Since liquid manure systems are extensively used at present, most storage facilities consist of either concrete storage tanks, or earthen manure storage tanks (reservoirs). The size of these storage facilities varies with the size of the operation. In Ontario, the Agricultural Code of practice requires that 26 weeks of storage capacity be provided before an operation can be certified, and in Quebec legislation requires a 200-day storage capacity at present but is examining the possibility of extending this period.

These storage requirements are necessary for two reasons. Firstly to eliminate land application on frozen soils during winter months in order to avoid pollution hazards

through surface runoff, and secondly to avoid disposal upon actively growing crops which can result in reduced yields.

Because of the high construction costs of concrete storage tanks $($20/m^3)$, producers have constantly looked for alternative storage facilities which are environmentally sound and will still satisfy government requirements (Barrington, 1987, personal communication). Many producers already use earthen storage reservoirs as a viable alternative because they are considered environmentally safe providing they are constructed in soils meeting specific requirements, as to particle size distribution, porosity and infiltration rate. According to Environment Quebec, an infiltration rate of 10^{-8} m/s is considered acceptable (Bernard and Bussières , 1984). This has also been supported by DeTar (1979) who concluded that some soils may be considered acceptable (ie."sealed") when the infiltration rate drops below 10^{-8} m/s. As well, Barrington (1985) has concluded that the environmental impact of these earthen reservoirs can be minimized if constructed in soils of 5% and 15% minimum clay content for dairy and swine manures, respectively. Since coarse sands and gravels do not satisfy these conditions they must be lined with some type of artificial seal. Clay liners, geomembranes and cement residues all act as impermeable layers but their cost of installation approaches that of concrete structure while their life span is relatively shorter.

Research by Barrington (1985) and Rowsell (1980) have shown that clogging mechanisms for manure and wastewater do not require sealing liners to be impermeable, but rather to be of fine-porosity. This has led to the belief that fine-porosity geotextiles could provide and adequate sealing liner over coarse soils (sands and gravels). Fine-porosity geotextiles (non-woven) offer these characteristics and are a fraction of the cost of geomembranes, while being stress resistant and durable.

This study examines the sealing capability of such geotextiles and the degree to which they meet Environment Quebec guidelines; seepage rates of less than 10^{-8} m/s, when exposed to swine manure slurry (swine manure slurry being more difficult to seal

than cattle manure). This was examined in relation to several parameters which included the porosity and pore size of the material, the concentration of the solids of the stored material, as well as the relationship between the sealing mechanisms and hydraulic head.

II. Literature Review

2.1 Introduction

Research on the actual use of (non-woven) fine-porosity geotextiles as liners for earthen storage reservoirs used to store liquid swine manure is limited. Most research conducted on manure storage to-date has been focused on the mechanisms involved in sealing unlined earthen reservoirs and the pollution resulting from seepages under such systems. There have been essentially two approaches taken by researchers studying the potential pollution threat of seepages from unlined earthen lagoons. One is direct measurement of infiltration of pond or lagoon contents into soils. The other is the measurement of levels of contaminants from lagoons or ponds in underlying and adjacent groundwater and extrapolation of this information to the rate of seepage which occurs from lagoon and ponds.

One should note that references made to waste lagoon, waste storage ponds and earthen waste reservoirs in the literature refer to the same structure designed for storage. An earthen lagoon is a structure designed for the treatment of wastes by aerobic, anaerobic or facultative microorganisms. Anaerobic microbial respiration may occur in a storage pond but the primary purpose of the pond or reservoir is to hold waste.

With regards to geotextile applications the emphasis thus far has been mainly geotechnical in nature, with applications to such items as erosion control, earth reinforcement and dam construction. Research has been performed on geotextile fabrics which are used in the drainage industry as well. These fabrics are used to prevent drainage conduit from clogging. Hence, research on soil/geotextile systems has been examined with regards to its filtering capacity and ability to hold back fine particles to prevent clogging of the drainage conduit itself. Inadvertently, research conducted on hydraulic and filtration characteristics has lead to an understanding of how clogging in such fabrics occurs. Ultimately this is the desired goal of such a fabric when its intended

use is as a liner for earthen manure reservoirs used to reduce or prevent seepage and groundwater contamination.

The literature review for this study has been divided into three main sections. The first of these is a brief history outlining what developments have occurred in the agricultural industry in Quebec over the past twenty years, and the problems and policies which have resulted over this period. Secondly, sealing mechanisms under earthen structures will be reviewed to show how this has lead to examining geotextiles as a possible solution in alleviating surface and groundwater deterioration problems. Finally a review will be given as to what has been studied with geotextiles in terms of their properties, and why they appear to be a promising solution to some of the environmental problems faced by some areas in Quebec.

2.2 Historical Background

For well over twenty years the Canadian hog industry has been developing and expanding. In 1961, the Census of Agriculture estimated that there were 5.3 million hogs on Canadian farms. By 1981, after five distinct cycles, farm inventories had climbed to 9.9 million hogs. Not only did the absolute number of hogs increase, but the distribution throughout Canada changed. The most dramatic changes in the provincial number of hogs on farms occurred in Quebec which went from a portion of 17% of total Canadian inventories with just under one million head in 1961 to one of dominance in 1981 with 35% of total inventories of 3.4 million hogs. The reasons for such growth are varied which in part was influenced by government programs such as income stabilization, farm credit, interest rate subsidies and grants. All of this contributed to a shifting of production away from areas of comparative advantage to locations defined by political boundaries. (Clements and Carter, 1984).

Geographically, hog production in Quebec occurs mainly south of the St. Lawrence River, although it is found all across the province except in the northwest region. The three regions which provide the largest number of hogs for slaughter are the

areas of L'Assomption, the Beauce, and St. Hyacinthe. The majority of hog production occurs within close proximity to major cities. In some of these regions, the concentration of these operations geographically has created large volumes of manure that cannot be accommodated by the land area immediately at hand, keeping in mind that, traditionally, manure has been spread on lands surrounding such operations and is used as a fertilizer source. As a result, in some regions the ratio of animal units (A.U.) per hectare of tillable land surpasses the permissible rate by as much as 200%. (Gangbazo and Buteau,1985).

During the period 1971-1981, hog production in these three areas developed rapidly. However, the region with the greatest increase in growth was the Nicolet region where from 1971 to 1981 the number of hogs has quadrupled according to Statistics Canada (1981) figures. Of interest also was that Nicolet was the region with the greatest concentration of the dairy industry. This rapid expansion in the hog industry reflects, in part, the effect supply management of the dairy industry had on the swine industry.

Accompanied with the concentration in hog production was the fact that farms became larger and more specialized. Statistics Canada (1981) has shown that the average farm in Quebec doubled the number of hogs every five years, leading all other provinces. In 1961, the average hog farm in Quebec had 19 hogs, which fell below the national average of twenty four hogs per farm. In 1981, this average had risen dramatically to 430 hogs per farm in Quebec which was well above the national average of 17.7 hogs per farm.

If we were to consider farms with twenty hogs or more as commercial farms, then the above trend is even more dramatic. In 1971, the average commercial farm size in Canada was 114 hogs per farm and by 1981 it had increased to 303. In Quebec, the average commercial hog farm increased from 147 hogs per farm in 1971 to 586 hogs per farm in 1981, partly reflecting the impact of the new dairy policy in the early seventies as well as the relatively strong hog prices during most of that period, with the greatest amount of growth occurring between 1971 to 1976. On the other hand the greatest

amount of growth in Ontario occurred from 1976-1981 with growth in western Canada remaining relatively steady over this ten year period. These regional variations are not due to the larger number of hogs on commercial farms in Quebec than in other major regions, but rather the actual number of hog farms in Quebec.

A factor contributing to the fewer and larger commercial hog farms in Quebec compared to other producing regions is the fact that hog producers in Quebec operated on small land bases and tended to be single enterprises. In 1981, the average hog farm in Canada operated on 230 acres (93 hec). The Quebec average was 80 acres (32 hec) with Ontario and the prairie provinces being 100 (40 hec) and 375 acres (151 hec), respectively.

One of the great contradictions in Quebec hog industry is that hog production thrived although there was very little feed grain production (Clements and Carter,1984). This emphasizes the role of the commercial feed supply network in the development of the hog industry. In 1983, commercial mills produced 293 million tones of feed. This compares to on-farm mills producing only 67.5 thousand tonnes. Although on farms grain production is increasing it is still far from being a major feed source. Hog production in most regions, tends to occur in areas of greatest feed supplies. In Quebec, this holds true since the three major hog producing regions also account for 61% of the commercial mills and 40% of on-farm milling (Statistics Canada,1981).

Although there are numerous factors influencing the growth of the hog industry in Quebec, the single most important factor has been limited opportunities in other agricultural industries. Historically, hog production has been a vital component of the total provincial farm economy, second only to the dairy industry. With political incentives stemming from both provincial and federal programs, such as income stabilization, farm credit, and feed freight assistance, the hog industry became an industry which had room for expansion. It is still, in fact, supporting limited growth which is maintaining Quebec as the leading hog producer in Canada. Accompanied with

such growth is an increased environmental burden and a need to resolve or limit the environmental impact of such rapid expansion.

2.3 Environmental Concerns and Policy Development

Associated with the factors which contributed to the rapid expansion of the hog industry in Quebec, are environmental concerns which have evolved as a result. The repercussions of this increase in livestock intensity is highlighted by the fact that Quebec produces more hogs per farm than any other province in Canada. As well, Quebec hog farmers accomplish this on the smallest average land base 80 ha, (32 acres) per farm in Canada, about one third the national average (Statistics Canada, 1981).

Clements and Carter (1984) have indicated that hog producers in Quebec rely heavily on commercial feed mills. These three factors in combination with the substantial increase in quantity and intensity have lead to major environmental problems within several regions in Quebec. Gangbazo and Buteau (1985) suggest that the inability of pollution abatement technology to keep pace with such growth along with improper management of manure, such as high land application rates, has eventually resulted in severe water pollution problems when excess manure enters waterways and the groundwater by runoff or percolation.

The preferred method for handling these wastes is as a liquid in order to decrease labour costs (Barrington et al., 1987; Rowsell,1980). Unlined earthen reservoirs have gained popularity for storage of large volumes of manures because of their low construction costs, about one tenth the cost of concrete (Barrington et al.,1987). However since the soils with which these structures are constructed are not totally impermeable, there is always an associated risk with the possibility of migration of contaminants from these storage lagoons into underlying or adjacent ground or surface waters. This migration of contaminants in some instances has been demonstrated to cause a substantial decrease in both groundwater and surface water quality (Rowsell,1980; Coote and Hore,1979).

As a result of this deterioration the Quebec Government in 1972 drafted "The Environmental Quality Act" and identified poorly managed animal wastes (manures) as being the principle source of agricultural pollution in Quebec (Bernard and Bussières,1984). The Minister of Environment of Quebec (MENVIQ), therefore, imposed strict guidelines and conditions on all new or expanding livestock producers with regards to how these wastes were to be handled and stored.

The initial guidelines outlined in 1972 required storage facilities to be capable of storing the amount of waste produced by a given size herd for a 200 day period. Under the resulting bylaws, storage facilities were to be constructed of an impermeable membrane or any other material with a permeability not exceeding 10^{-7} cm/s (10^{-9} m/s). This bylaw was officially regulated by the MENVIQ on June 3,1972. In practice, the only materials meeting this criteria were concrete structures or earthen structures lined with a geomembrane. Due to the cost of such facilities and the inability of the government to properly monitor such criteria, many of these guidelines were often not met (Gangbazo and Buteau,1985).

When farmers did build such facilities they were often not built to facilitate any additional storage if the operation was to expand. This resulted in a high incidence of manure spreading on frozen ground and in some instances directly dumping into waterways as a way of keeping reservoirs from overflowing (Gangbazo and Buteau, 1985).

The Union de Producteur Agricole, protested these requirements on the basis that they were too expensive for the majority of farmers and that in other provinces earthen storage structures were found to be sufficient.

The MENVIQ made changes to its bylaws which were officially enacted in 1981. The result was a re-definition of the term "impermeable" to include any structures which would allow nitrogen seepage rates no greater than those allowed for municipal waste water ponds. More precisely, it would allow a maximum seepage rate of 10 to 20 liters

per square meter per day with an average nitrogen concentration of 30 mg/l. If a sealing factor of 50 is assumed, the MENVIQ accepted any earthen storage structure of hydraulic conductivity not exceeding 10^{-6} cm/s (10^{-8} m/s), based on a normal average nitrogen concentration of 3000 mg/l for liquid hog manure with a hydraulic head of 3.0 m within the storage structure and an effective soil sealing of 1.0m of thickness (Barrington, 1985).

This amendment allowed earthen storage structures to be constructed in heavy clays of low permeability. However under these guidelines most farmers were still required legally to construct concrete structures (Barrington, 1985). Still further modifications were made to the government guidelines in 1984, which made earthen storage structures acceptable with the exception of soils with extremely low clay contents of less than 5% and 15% for dairy and hog producers, respectively (Barrington et al., 1987).

The result showed that the situation had improved, but only marginally. Furthermore, "impermeable" concrete structures have been shown to be susceptible to cracking due to Quebec climate conditions. This indicated that alternative solutions were needed.

With regards to unlined earthen reservoirs, the infiltration of the entire substance of the manure does not necessarily pose a threat to groundwater quality. Undoubtedly considerable filtration and sorption of manure constituents could occur. Thus the material penetrating into the soil beneath a storage pond may bear only a slight resemblance to the material contained in the pond (Rowsell, 1980).

In the majority of cases described in the literature, researchers have found that the flux of material from unlined earthen storage ponds into underlying soils decreases with time after the pond or reservoir is loaded. This decrease is attributed to the formation of a partial or total seal at or near the manure soil interface (Rowsell,1980; Coote and Hore,1979; DeTar,1979). Quebec hog producers who were unable to meet

government legislations for unlined earthen reservoirs began installing impermeable geomembranes as a liner for their earthen manure reservoirs. However, gas formation or a high water table often caused these liners to lift. As well, their cost and delicate nature (ease with which they tore) made them unsuitable.

Research conducted by Barrington (1985) has shown that the use of geotextiles as liners used to simulate fine soils would allow gas to escape and would decrease the rate at which contaminants would reach the groundwater. The principle sealing mechanism was similar to that found in unlined earthen lagoons.

2.4 Sealing Mechanisms of Earth Structures

Earthen structures, as previously mentioned, offer an economical alternative for farmers who do not wish to construct concrete storage tanks. DeTar (1979) suggest that earth structures could be considered "sealed" if the infiltration rate drops below 10^{-8} m/s. Since these seals are not totally impermeable, there always exists the risk for a certain degree of groundwater contamination. The need to identify what factors influence the sealing of such structures has been examined closely by DeTar (1979), Miller et al. (1985), Rowsell (1980), Rowsell et al. (1985) and Barrington (1985). From such research, it has been determined that the sealing of soil under manures (dairy and swine) can be attributed to three distinct mechanisms: physical, biological and chemical.

2.4.1 Physical Sealing

Physical sealing according to Rowsell (1980) and Barrington (1985) appears to be the most dominant factor influencing the sealing of manures over soils. Sealing takes place due to particles in the manure being larger in size than pore openings. As a result pores become clogged. Changes in friction coefficients or the reduced size or volume of pore spaces therefore causes the hydraulic conductivity of the soil to decrease.

Barrington (1985) found that this seal formed chiefly through the deposition of organic particles (manure solids) at the entry of, or within pores of the medium being infiltrated by the liquid waste. Thus, deposition processes were demonstrated for soils

infiltrated by wastewaters containing C^{14} -DDT labeled suspended solids. The largest organic particles are screened at the soil surface while the medium size particles are strained within the first 10 mm of silty soil (Vinten et al.,1983). Very fine particles according to Barrington (1985) and Rowsell et al. (1985) are removed by a convectiondiffusion processes respecting a first order model. This deposition process has also been visualized under microscope with soils infiltrated with manures.

Barrington (1985) demonstrated that the processes occurred quickly and efficiently as long as the soil can hold most of the manure particles at its surface. From these studies, it was concluded that the only physical property of interest for the soil was its effective inter-particle void diameter.

When extensive, this deposition process leads to the formation of an impermeable manure solids mat over, as well as within the surface of the porous medium. But, extensive organic solid deposition requires a medium of pore size selected in consideration of the particle size distribution of the waste (Barrington and Broughton, 1988).

Rowsell et al. (1985) conducted column studies with sterilized manure, and glass beads in place of soils which drew them also to conclude that physical processes are the major factor in sealing unlined earthen type structures. The significance of using sterilized manure, and glass beads being that biological and chemical mechanisms of sealing were neutralized. In these studies no significant difference was found in sealing between columns treated in this manner and those with non-sterilized manures and soils. Due to the brevity (31 days) of his experiments, they did not conclude, however, that these processes were entirely without effect over an extended period of time. The effect of hydraulic head of the slurry was shown to be significant. Greater head resulted in a greater initial infiltration rate, but a better seal in the longer term.

Miller et al. (1985) were also able to conclude that for a coarse textured soil material, initial infiltration and the time for a seal to develop will be greater. This would

tend to support the theory put forth by Barrington (1985) which states that the effective void is the most critical soil parameter in reference to forming a seal under manures.

In conjunction with the actual sealing process, DeTar (1979) found that there was also a relationship between the total solids content of the manure and the sealing of soils. For more concentrated total solids, the soil sealed quicker, and for lower concentrations, he was able to conclude that liquid manure was more sensitive to hydraulic conductivity than at higher concentrations.

From the literature several conclusions can be made about physical sealing mechanisms. The most significant of these being that the equivalent pore size opening in the soil is the most critical factor in determining how quickly, and to what extent the soil seals. The seal forms basically at the interface between the soil and the organic matter and is the result of soil pores becoming clogged with organic particles from the manure slurry. The rate of initial infiltration and sealing rate has also been correlated with total solids content of the manures. It has also been shown that at lower total solids, the liquid manures are more sensitive to hydraulic conductivity of the soil than at higher concentrations.

2.4.2 Biological Sealing

Biological sealing like physical sealing has been shown to be a surface as well as an interface phenomenon (Barrington et al.,1987; and Rowsell et al.,1985). This sealing mechanism results from essentially two processes. The first of these being clogging effects presumed to originate from bacterial "slimes" and polysaccharides, rather than from the growth of a large number of microorganisms as once thought to be the case (Gupta and Swartzwendruber,1965). These biological "gums" or "slimes" which form at the interface are composed of hexan uronide carbohydrates, uronides being present in manures, and originating from the urine in these wastes. Biological sealing is supported by the fact that work done by Thomas et al. (1966) showed that soils which were sealed

by septic sewage effluents were characterized by a heavy overgrowth of black "slime" consisting of partially degraded organic matter and settled particulate matter.

Since manures are recognized as offering quite a range of microflora, no inoculation is required but some degree of heat is required (Tollner et al., 1983). Below temperature of 15 °C very little biological sealing is found to occur. (Barrington et al., 1987).

The second process is the destruction of soil structures by the reduction of iron oxides during microbial respiration under saturated conditions. This causes macropores to be eliminated which, in turn, leads to a reduction in the soils hydraulic conductivity. This process is referred to as gliezation (Barrington, 1985). Whereas Barrington (1985) found that biological mechanisms were secondary to physical processes but still significant, Rowsell (1980) in his research was unable to draw such a conclusion in regards to its significance but believed it to be secondary nonetheless.

Although Rowsell (1980) and Barrington (1985) concluded that biological sealing is secondary next to physical sealing, research conducted by Davis et al. (1973) concluded that in the sealing of a dairy waste pond, biological sealing mechanisms were believed to be the most significant contributing factor. Manure water, according to Davis et al. (1973) gives rise to a bottom "slime" and a rapid deterioration of biological sludge. The cells of living and dead bacteria adjacent to the soil surface are forced into the soil pores by hydrostatic pressure, effectively reducing or blocking further infiltration. One should note that the blocking of pores by the cells of living and dead bacterial cells is in fact a physical process and as previously mentioned has been demonstrated by Gupta and Swartzwendruber (1965) to be an incorrect conclusion when trying to characterize it as a biological sealing process. Rather, Gupta and Swartzwendruber (1965) demonstrated that it is bacterial "slimes" which are the significant contributor in the biological sealing process not the physical nature of the bacterial cells themselves. Davis et al.(1973) conclusion may have been based solely on the findings at the end of their eight month

study and the presence of a large amount of "slime" would surely suggest this. However, most literature suggests that initially, physical sealing mechanisms are dominant until biological "gums" and "slimes" have time to develop. This may suggest that over an extended period of time, initially, the physical mechanisms of sealing are primarily responsible for sealing but may assume a less important role as time progresses. Biological sealing by "slimes" and "gums" may, in time, take over and assume the dominant role in maintaining the seal.

As well, Barrington (1985) concluded that biological processes intervened within the physical seal to further reduce the infiltration rate, but required temperatures of at least 5 °C to be effective. From experiments conducted by Barrington (1985) using sterilized and non-sterilized manure over fine sands it was also shown that biological sealing is responsible for stabilization against fluid movement within the physical seal. This leads to the conclusion, that even though biological sealing within the manure material may be of secondary importance in itself, it may be of primary importance in terms of the stability of the physical seal over time, and is beneficial in the case of coarse soils, where gleization may not be realized.

2.4.3 Chemical Sealing

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The third and final form of sealing is that related to chemical mechanisms. This results from modifications to the soil pore geometry due to chemical reactions or ionic exchanges within the soil that leads to a breakdown in the structure and consequently the permeability of the soil (Barrington, 1985). The chief contributor to this being the interaction of salts containing ions such as sodium (Na^+) and calcium (Ca^{++}) with the negative charges on the surfaces of clay particles which creates around themselves a diffuse double layer. As a result, this tends to deflocculate and therefore disperse the soil particles resulting in a breakdown of the soil structure. This causes a decrease in the hydraulic conductive of the soil.

Given the fact that the problem for which a solution is being sought is brought about by a lack of these fine soil/clay particles it is not necessary to elaborate further on this topic.

One should not however, overlook the chemical complexity of the chemical reactions/inter-relations which occur in the manure matter itself. This is complex in nature and is not examined in detail in this report. Geotextiles are inert in nature and one would not expect pore size to structurally change within the material itself.

2.5 Geotextiles

Geotextiles are non-woven or woven synthetic fabrics which have been utilized to solve a wide variety of geotechnical problems ranging from soil stability, erosion control, earth reinforcement, dam construction and other civil engineering type projects. As well, recent applications in the agricultural industry have been focused on the use of such fabrics as a way of extending the life span of subsurface drainage systems by preventing the clogging of these systems by silty soils.

In terms of applying geotextiles as liners for earthen manure structures, there is no evidence of any research done on such an application. Of primary interest to the application are the hydraulic properties of these materials, their interplay with the soils in which they are utilized, and their clogging mechanisms when placed under manures (in this particular case, swine manure).

Within the past ten years there has been an ever increasing attention focused on the hydraulic and filtration characteristics of these materials. Research conducted by Maisonauve et al. (1980), Rollin (1983), Rollin et al. (1985), Rollin and Denis (1987),Heertwen and Wittmann (1985) and Wei et al. (1985) are among some of the more recent and concise studies and shall be the main focus of this review.

2.5.1 Soil/Geotextile Systems

Masounave et al. (1980) conducted research into predicting the hydraulic properties of geotextiles in various situations. They found that the permeability of a

soil/geotextile system was quite different from that of the virgin textile. They also showed that the permeability of the system decreased with time. It was also found that initially smaller particles were carried through the system by fluid flow, while larger particles became trapped in the fiber structure. As time passed, particle migration was shown to eventually decrease to virtually nothing, and an equilibrium state then existed. Smaller particles may still enter the media but only become trapped themselves, and result in an even greater decrease in permeability. The probability of these particles not becoming entrapped, and percolating through the membrane decreases as its pore diameter increases. Furthermore, confidence was shown in assuming that a slight increase in head did not have an effect on particles already trapped since it was assumed that once trapped, these particles are difficult to dislodge. These results were verified by actually observing the physical seal in the geotextile by use of a Quantimet image analysis system.

Research concluded by Wei et al. (1985) using a specially constructed permeameter to evaluate the performance of soil geotextile systems allowed them to draw several conclusions from this study. Firstly they found that the permeability of a soil geotextile system was less than that of either the geotextile or the soil by itself, and was actually controlled by the filter cake (mat) that developed. As soon as this cake began to develop, permeability decreased rapidly with the increase in its thickness. Their research has interestingly showed that beyond what seemed to be a critical cake thickness, the flow rate seemed to be fixed for a given cake thickness for three distinctly different fabrics. This would seem to suggest that the permeability of the cake seemed to dominate the permeability of the system.

Heertwen and Wittmann (1985) studied geotextiles and mineral filters, and as a result were able to come to several conclusions about geotextiles and their similarity to soils. With regards to the filter properties of the geotextiles themselves it was found that with increasing filter thickness, measured pore-size distributions became more controlled

by the smaller pore sizes. This followed from the fact that larger pores become progressively more isolated by smaller pores during the passage of a fine soil particle along a pore channel.

In comparing geotextiles to mineral filters, several contrasts and comparisons could be made. It was noted that within geotextiles, pore diameters are generally much larger than fibre diameters whereas with mineral or soil filters soil particles tend to have a larger diameter than pores. As a result the porosity of a geotextile is much greater than that of most soils. For example, for a needle punched non-woven geotextile, porosity may be as high as 90%, whereas with a loose mineral filter it is only 50%, and with a dense soil filter it may only be as high as 25%.

Their work also goes on to state that needle punched non-woven fabrics demonstrated the same deep filtration as with mineral filters. It was concluded that the interaction of fibre and grain particle is responsible for long term filtering efficiency. Lastly, they determined that an increase in geotextile thickness caused a considerable reduction in particle passage.

2.5.2 Pore Size and Porosity

As has previously been shown, most researchers agree that physical sealing of earthen structures has proven itself to be the predominant mechanism in soil sealing under manures, and that with time biological mechanisms may also contribute to better sealing, and greater stability of these seals. Therefore, the most logical approach in selecting a suitable geotextile would be to use a fabric which favoured the formation of a physical seal. Thus the geotextiles pore size must be selected as a function of the waste (Barrington et al.,1987).

Optimum medium pore size investigated by Yao et al. (1971) for sand filters used to treat water and wastewater indicate that sand beds of particle sizes ranging from 400 to 600μ m have provided satisfactory filtration without immediate clogging. Solid particles as small as 8 μ m and 1 μ m can be removed by sedimentation and interception

, respectively. Solid particles smaller than $1\mu m$ are often removed by diffusion towards sand grains where an adhesion process takes place. A similar phenomenon was observed by Vinten et al. (1983) using silty soils to treat waste waters.

Barrington (1985) postulates that if the pores in a soil with a diameter greater than 50 μ m were to be eliminated, it would loose a high percentage of initial permeability, and that long term infiltration rates may therefore, not be significantly different between coarse soils such as sands and fine clays, even though initial infiltration rates may be significantly lower for clays. Furthermore with the resultant clogging of smaller pores (5 to 50 μ m in diameter), flow would probably be reduced to as low as 0.5% of its original value, and therefore, is comparable to finer soils such as clays.

Therefore, from the above discussion it would seem that a suitable lining material should have an effective pore opening size of 50 μ m or smaller in which a physical seal could develop through the accumulation of organic matter.

Research by Barrington (1985) has shown that swine and dairy manures have sealed soils of equivalent pore size of 40 μ m under temperatures exceeding 15 °C, temperatures favorable to the strengthening of physical seals through biological processes. Note that equivalent pore size is calculated from the soils' particle size distribution and porosity.

Pore size of fabric/soil filters has been related to the particle size distribution of the material to be retained (Faure et al.,1986). When the fabric is more permeable than the soil, the fabric equivalent pore size must not exceed 1.2 times the d_{85} of the soil. Fabric equivalent pore size refers to that value equal to or greater than the diameter of 85% of the filter pores.

Porosity, usually defined as the void fraction of a material or the ratio of the non solid volume to total volume, was evaluated by Wei et al. (1985) to examine its effect on the flow behavior of water through the geotextile. Testing three different porosity nonwoven fabrics they found that the magnitude of water head to maintain a constant flow rate decreased as fabric porosity increased. This was probably due to the free volume of he geotextile. Since free volume in a high porosity geotextile is greater than that in a low porosity textile, the water head (pressure) would understandably decrease with increasing porosity of the fabric at a constant flow rate.

Of other interest, Wei et al. (1985) and his co-workers found that thin and low weight fabrics allowed for the fastest flow. As flow rates increased, the differences between fabric type due to fabric weight and thickness became more prominent.

2.5.3 Clogging Mechanisms of Geotextiles

Research into the clogging mechanisms of geotextiles themselves is limited and somewhat speculative. The most comprehensive research in this area has been performed by Rollin (1983). In his research he was able to examine clogged geotextiles by encapsulating samples (taken from drain tube envelopes and fabric used in a dam installation) using a transparent resin and then analyzing them using a high powered microscope, specifically a Quantimet 720 image analyzer. His results, based on a soil/geotextile system indicate that clogging of geotextiles results from several factors. In the case of soil/geotextile systems it was shown that particles infiltrating into the geotextile itself contribute to the clogging of the pores within the fabric makeup. As well, the degree to which those particles penetrate into the fabric is related to the characteristics of the fabric itself. In general, the greater the distances between fibres making up the geotextiles, the higher the degree of clogging and the larger the particles entering into the fabric itself. Also related to this is the fact that a large portion of the particles entering into the fabric become trapped within the first 2 mm of the geotextile itself. Once the initial blockage has occurred, it allows for the formation of a cake (mat) to accumulate on top of the fabric. This leads to the formation of arches at the soil geotextile interface and subsequent "funnels" being formed within the cake itself. It is the combination of these factors which results in the clogging of the geotextile within a

soil/geotextile system, and one may speculate that similar mechanisms will be involved in a geotextile/manure type system.

Based on this information, it would appear that geotextiles may clog in a manner similar to soils. Therefore, they are a likely candidate for lining earthen structures in coarse soils, which are used for storing animal wastes. This is providing that the geotextile has a minimum pore size distribution. This would seem to be about $50\mu m$ or less for the majority of soils as previously indicated.

2.5.4 Sealing of Geotextiles by Manures

Although equally a filtration process, the sealing of geotextiles by manure represents conditions differing from those of sand beds and soil filters. Sand bed grain size translated into equivalent pore size corresponds to a value of 100 to 150 μ m according Yao et al. (1971). This by far exceeds the 40 μ m, previously cited. This is due to the fact that sand beds in such an application are required to restrain from immediate clogging (Yao et al., 1971). Sand bed grains also offer absorption characteristics over a depth of 60 cm more or less, while geotextiles are inert and, in our case, 1.5-2.0 mm thick.

Soil filters, on the other hand, rely on the formation of stable bridges over their pores, and as shown by Rollin (1983), geotextiles may also rely on this fact to aid in sealing. As well, the actual penetration of fine particles into the geotextile itself is a contributor to the fabric sealing whether in a soil/geotextile system or a manure/geotextile system. However, one difference which does exist between soil filters and manure mats (formed on top of geotextiles) is the fact that such mats are constantly being disturbed by microbial activity (Barrington,1985). Furthermore, their design criteria applied to manures of d_{85} values ranging from 800 to 2000 µm suggests unrealistic equivalent geotextile pore sizes of 960 to 2400 µm.

2.5.5 The Economics of Geotextile Liners

In analyzing how economical non-woven geotextile liners would be, it is necessary to compare their costs to those of concrete storage structures or the use of geomembranes as liners.

According to Barrington (1987, personal communication), current costs for construction of a concrete structure are approximately $20/m^3$, as opposed to earthen structures which are approximately 5 to $6/m^3$. If a geotextile has to be installed to bring the structure within acceptability of MENVIQ norms it would only augment the cost of the earthen facility by approximately another $2/m^3$, including installation costs. If we examine the cost of geotextiles, we find them to be of the order of $2-4/m^2$ (for 20-40µm) whereas geomembranes can be as much as 10 times the cost of a similar geotextile. Therefore, a farmer faced with the prospect, at present, of having to build a concrete manure storage facility on a coarse soil, may economize significantly with a geotextile lined earthen structure.

III. Objectives and Scope

The purpose of this study was to conduct research into an alternative liner material for earthen storage reservoirs which would be more economical than geomembranes and concrete, as well as being able to overcome some of their inherent faults, such as the delicate nature of geomembranes and the suceptability of concrete structures to cracking. The proposed alternative being a non-woven, synthetic-fibre liner or geotextile.

In this project, column studies were undertaken to determine the effectiveness of fine-porosity geotextiles when used as liners for coarse soils (soils unacceptable for constructing earthen reservoirs). The main criterion for suitability is that the liner seal to an acceptable infiltration rate to satisfy the Environment Quebec guidelines of 10^{-8} m/s or less.

In the study, the sealing of these materials is examined in relation to several parameters. These include properties of the material itself such as the equivalent pore size, the relationship between sealing and the hydraulic head of the stored material (in this case swine slurry) and the concentration of solids in the stored material.

The specific objectives of this study were as follows :

- To determine the infiltration rates of three non-woven fine-porosity geotextiles (20,30,40 µm equivalent pore sizes), each subjected to three different hydraulic heads (0.9,1.8, 2.7 m) of 5% total solids (TS) swine slurry.
- 2. To determine the critical (TS) level, defined as the minimum swine slurry TS level, above which no significant difference in geotextile infiltration rates can be measured.

- 3. To determine the differences in geotextile infiltration rates between sterilized and natural manure used to simulate field conditions of low temperature, or the absence of biological sealing.
- 4. To examine the quality of the exfiltrate of all of the above combinations.

The study was limited in scope to :

- 1. Laboratory studies using 150 mm PVC columns.
- Geotextiles of a minimum nominal pore size of 20 μm due to manufacturing limitations.
- 3. Manure type ; swine manure being more difficult to seal than cattle manure.

IV. Material and Methods

<u>4.1 Introduction</u>

This research was conducted at Macdonald College Farm Mechanical Shop over the period of July 1987 to February 1988, and consisted of three separate experiments. Each experiment was subdivided into two parts. The first involved investigations into infiltration rates under different treatments, and the second being the chemical and physical analysis of all exfiltrates collected for each experimental set up. All experiments were conducted in ambient temperature ranging from 15 to 25 °C.

4.1.1 Experiment No.1

Experiment No.1 was designed to measure the infiltration rates of three fineporosity non-woven geotextiles, each exposed to three different heads of nominal 5% total solids (TS). The selected geotextiles had a nominal equivalent pore size of 20,30, and 40 μ m. Each fabric was subjected to triplicate swine slurry manure hydraulic heads of 0.9, 1.8 and 2.7 m, for 1800 hours using PVC columns.

4.1.2 Experiment No.2

Experiment No.2 was designed to determine the critical TS level required for sufficient sealing to occur. This level was defined as the minimum swine slurry TS concentration above which no significant difference in infiltration rates could be measured. A 20 μ m non-woven geotextile (the same as that used in Experiment No.1) was subjected to TS levels of 1,2,4,6,8 and 10% in triplicate setups of 1.8m swine slurry heads. The duration of the experiment was 1800 hours.

4.1.3 Experiment No.3

Experiment No.3 was designed to determine the difference in geotextile infiltration rates between sterilized and natural swine manure slurries. This was performed in order to simulate conditions of low temperature, or an absence of biological sealing. Sterilized and natural swine slurries of 0.9 m heads and 5% nominal TS

concentration were tested in quintuplet columns using a 20 μ m equivalent porosity nonwoven geotextile (same as that used in Experiments No.1 and No.2).

4.2 Experimental Apparatus (Setup)

A schematic representation of the experimental apparatus is presented in Fig.4.1. All experiments were conducted using such columns. Each column was constructed of two pieces of 150 mm PVC sewer pipe. Each piece of pipe had a PVC flange attached to it by chemical welding. The geotextile was mounted between the two flanges, and leaking was prevented by applying a commercially available silicon caulking around the edges of the geotextiles. The flanges were attached to each other using eight 6 mm bolts and body washers. The geotextile was supported from beneath by sieved and washed gravel with a median particle size of approximately 15 mm diameter. The gravel, in turn was supported by a wire mesh made from cage wire which contained 10 mm square openings.

The bottom of the columns were mounted with 150 mm to 100 mm PVC reducers in which polyethylene funnels were thermally glued on using a Bostich model 3000 glue gun. 18 mm tygon plastic tubing was then used to connect the funnel to sealed 1.5 L mason jars which were used to collect and measure exfiltrates.

All columns were assembled using silicon caulking which was placed around the geotextile between the two flanges, and left to stand for a period of 24 hours to allow the silicon caulking to cure properly. All columns were hydraulically tested for leakage prior to being filled with the appropriate swine slurry concentration.

The columns were constructed in three different heights to test the hypothesis that greater hydraulic head led to a better seal in the long-term at the expense of a greater infiltration rate in the short term. The chosen heads were 0.9 m,1.8 m and 2.7 m. This was considered a good range over which to test the hypothesis since most earthen structures seldom exceed 3 m in depth. As well, the selected hydraulic heads would give a good indication as to how these structures would perform throughout the year as they
were filled. Ten centimeters were left at the top of each column as freeboard. Therefore, the upper section of each column size was 1.0 m, 1.9 m, and 2.8 m in height for each of the required heads.



FIGURE 4.1 - THE EXPERIMENTAL SETUP

4.3 Geotextile Selection

Non-woven geotextiles were used in this study as they provide finer porosities than woven geotextiles and can be easily manufactured. As well, non woven geotextiles are more stress resistant than woven geotextiles which is important as the application of such fabrics will be in the field.

4.3.1 Fabric Composition

The fabrics used were composed of needled, short-staple fibres of 100% polyester, with a density of 1.38 g/cm³. The only variation was the 20 μ m fabric which contained some polypropylene fibers as well. Porosity and pore size are a function of the calendering time and temperature. In general, the finer the pore size the higher the calendering temperature and the longer the calendering time.

The fabrics were supplied by Texel Inc. of St. Elzear de Beauce, Quebec, Canada. The nominal pore sizes were 20, 30 and 40 μ m. These pore sizes were chosen in conjunction with previous work using 75 μ m and 50 μ m fabrics as well as the fact that results by Barrington and Jutras (1987) suggested that soils with equivalent pore sizes of 40 μ m were capable of sealing both dairy and swine manures and hence fabrics of 40 μ m or less would seem to be a reasonable choice to examine. As well, such fabrics could be manufactured economically using existing technology.

Samples of these fabrics are included in appendix A. On the following page their pertinent characteristics are described. It should be noted that Texel Inc. was not willing to release technical information pertaining to the specifics of calendering time and temperature values as they did not wish to reveal any trade or manufacturing "secrets". Hence, relevant technical information in regards to the manufacturing process cannot be discussed in any detail in this report.

4.3.1.1 20 µm Fabric

The 20 μ m (nominal) fabric was constructed of polyester and polypropylene fibers in the proportion of 85% polyester and 15% polypropylene. The polypropylene

accounts for the fabric having a glossy surface on one side. The mass per unit area was $344.14 + 18.6 \text{ g/m}^2$ with a fabric thickness of 1.5 mm. Refer to the sample in appendix A.

4.3.1.2 30 µm Fabric

The 30 μ m (nominal) fabric was composed of 100% polyester fibres only. The material mass per unit area was 420.6 +\- 9.6 g/m² with a fabric thickness of 2.0 mm. Refer to the sample in appendix A.

4.3.1.3 40 µm Fabric

The 40 μ m (nominal) fabric was also composed of 100% polyester fibers. The mass per unit area was 341.52 +/- 7.2 g/m² with a fabric thickness of 2.0 mm. Refer to the sample in appendix A.

4.3.2 Pore Size Distribution

The pore size distribution of each fabric was determined at Ecole Polytechnique of the Universite de Montreal,Quebec,Canada. The procedure for determining the pore size distribution was "The Hydrodynamic Sieving Method". This is a method that was developed at the University and incorporates some procedures adapted from a "Proposed standard test method for determining the apparent opening size of a geotextile". This proposed test at the time of testing was not yet an ASTM Standard.

4.3.2.1 Hydrodynamic Sieving

The theory of this operation is such that four horizontal bars were attached to a steel bar to create an arrangement where baskets could be placed at four separate sections. The steel bar was attached to a piston which moved within a cylindrical chamber. The basket in which the fabric was supported had two sections. The detachable lower section contained a grove in which a wire mesh support was placed and its circumference was ringed with twelve equally spaced plastic bolts. The upper section included an extension at the bottom with twelve holes through which the bolts in the lower section penetrated. A pneumatic system supplied the pressure for the set up and

was linked to a timer through a control box which also acted as a cycle counter . An illustration of the sieving system is shown in Fig. 4.2.



FIGURE 4.2 - HYDRODYNAMIC SIEVING APPARATUS

<u>4.3.3.2 Procedure for a Typical Run</u>

A fabric sample with a diameter (40 cm), equal to the diameter of the lower section of the basket was, cut and twelve small holes, correspondent to the positions of the twelve bolts were drilled. The fabric was then placed on the lower section and the upper section installed on the fabric. The two sections were then screwed tightly together and the gap filled by the fabric was tapped to prevent seepage of particles. Another wire mesh support was then placed on the fabric and 300 g of a mixture of glass beads of known particle size distribution was evenly spread out on top of the fabric. The basket, which had two hanging plates at opposite sides, was placed on one of the four sections of the horizontal bars and firmly screwed down, a numbered container, with an opening diameter of 50 cm, was filled with 20 L of water and placed directly below the basket with the corresponding number. The procedure was repeated for the three other baskets and containers. The number of cycles and the pressure drop for the run were then set at 2000 and 414 kPa, respectively. After a visual inspection to ensure that nothing was amiss, the system was started. The apparatus was designed such that at a pressure drop of 414 kPa, the duration of one cycle was 28 seconds including a seven second immersion in the basket of water.

After termination of the run, the glass beads which penetrated the fabric were allowed to settle. The water in the containers was then removed and the glass beads collected separately in plastic jars. Fresh water was then added to each jar and small samples of the thoroughly mixed suspensions collected for analysis. The suspensions were next dried and the mass of glass beads determined. The size distribution of the glass beads was determined with a microscopic computerized particle analyzer which was composed of a set of microscopes (Leitz, Model #210,) a camera (Hitachi, Model H1A), an IBM PC with appropriate software and a printer.

The filtration opening size (FOS) of the fabric was taken to be the particle size corresponding to the 95th percentile (d_{95}) on a cumulative size distribution plot of the

particles which penetrated the fabric. The respective d_{95} of each fabric is shown in figures 5.1 to 5.3 (Results and Discussion section).

4.3.3 Permeability

of the fabrics used were determined using the "Falling Head Method". This was Performed at Macdonald College Farm Shop, Ste Anne de Bellevue, Quebec, Canada.

This Method was modified from the Soil Conservation Service (SCS) method to suit our purpose. The testing apparatus consisted of a 1m high 150 mm PVC pipe identical to our experimental setup (see figure 4.1).

4.3.3.1 Procedure For Falling Head Method

The fabric to be tested was installed between the two flanges and completely sealed and hydraulically tested for water tightness. The column was then filled with water to a set head above the fabric. A section of rubber tubing was connected to a funnel portion and a clamp was applied to the tubbing to facilitate opening and closing. The tubing was then directed into a bucket below, where water passing through the fabric could be collected and its volume measured. over a known period of time and Water was then allowed to travel through the fabric being tested. By treating the fabric as a soil, equations for the falling head permeameter can be developed by considering two expressions for the total flow through a porous medium.

If Q is equal to the total flow then dQ/dt is the rate of flow per unit time and by Darcy's Law :

$$dQ/dt = K AH/L$$
(1)

where : K is the hydraulic conductivity (cm/s)

H is the hydraulic head (cm) in the water column measured with respect to the upper fabric surface

A is the cross sectional area of the cylinder containing the fabric (cm^2)

L is the thickness of fabric (cm)

The water in the supply column, in this case directly above the fabric being tested , drops from H_0 to H in time t, where H_0 is the initial hydraulic head (cm). The outflow pressure head on the surface remains constant, hence the total flow Q may also be shown as :

$$Q = aH_0 - aH \text{ or } dQ/dH = -a \quad (2)$$

where "a" is the cross sectional area of the supply tube or column, in this case it is equivalent to A. We now have two expressions for dQ that we can equate. Setting equation (1) equal to equation (2) we have :

$$-adH = (kA H/L) dt$$
(3)

or -dH/H = (kA aL) dt (4)

in our case a'' = A, therefore :

-dH/H = (kL) dt(5)

The limits of integration are $H = H_0$ at $t = t_0$ and H = H at t = t. Therefore on integration we have :

 $\ln H_0/H = (k/L) (t-t_0)$ (6) $k = L \ln H_0/H \quad \text{or } k = (L/t) \ln H_0/H$ (7) $(t-t_0)$

and

where L is the thickness of the material (cm).

A temperature correction factor T_c is then used to bring the measured value to a standard 60 °F (15.5 °C). For our purposes five replications per fabric were performed.

<u>4.4 Swine Slurry Characteristics</u>

The swine manure used for the duration of all experiments was collected fresh from the Macdonald College Farm Finishing Unit. Manure was collected in the gutters over a two day period and then removed using a chain scraper system. Adequate amounts of the manure were then transported to the lab in garbage pails where batch dilution were carried out to meet the required total solids (TS) concentration for each experiment combination.

4.4.1 Total Solids (TS) Concentration

Total solids (TS) concentrations were determined according to standard methods (APHA,1981). Triplicate samples were placed on tared aluminum foil plates and were then placed in an oven where they were allowed to dry at 103 °C for a period of 24 hours or until a constant weight was achieved. Using the following equation the TS concentration can be determined.

Total Solids (TS) =
$$A_d X 100$$

 A_d = weight of dried solids

B = weight of wet samples

The average TS concentration of the fresh manure collected was in the range of 11% to 16% on a dry matter basis. Once the fresh manure TS concentration was determined, water was added to obtain the required TS concentration for each

experimental combination. The amount of water required to be added was determined using the following equation:

WA = [(1-SM)/(1-FM)]-1

WA = wt. of water added

SM = starting moisture content per unit wt. (decimal)

FM = final moisture content per unit wt.(decimal)

Once the dilutions were made samples were taken and tested once more and TS concentrations were determined. If the TS concentrations were lower than required, manure was added; if further dilution was required, water was added. Before filling the columns with the required manure concentration the TS concentration was once more determined and recorded as the TS used. Each triplicate or quintuplet column of equal head or the same TS concentration was filled from the same batch of manure in order to reduce error when comparing the various geotextile combinations.

In experiment No.1, the required TS concentration was 5% for the three different heads of 0.9 m, 1.8 m and 2.7 m. In this case three batches of manure with nominal TS concentration of 5% were made. Each batch was then used to fill a specific column head, for example, for 0.9 m head for all the geotextiles being tested. We should note that batches were required as limitation existed on the size of the mixing tank available. In experiment No.2, six batches of manure were prepared for the nominal TS concentration of 1%,2%,4%,6%, 8% and 10% and each triplicate 1.8 m column was filled with the required concentration.

In Experiment No.3 only one batch of nominal 5% TS concentration was used to fill the quintuplet columns of 0.9 m heads natural manure and a second batch was prepared for the 5% TS sterilized manure.

4.4.2 Particle Size Analysis

Particle size analysis was not performed directly in this study. Instead, data were obtained from work conducted by Fernandes et al. (1988) who performed a particle size analysis using the same swine manure source as was used in all experiments of this study.

The method employed is known as the "wet sieve analysis" which has been adopted from Kemper (1965). Since this was not directly performed as part of this experiment, a short summary of the method will be described.

The method utilizes a representative sample of manure which is placed on the uppermost of a set of graduated sieves. The sieves are then stacked on top of one another, and immersed in water. The sieves are then oscillated vertically and rhythmically, so that water is made to flow up and down through the screens and the manure. At the end of a specific period of sieving, usually 30 minutes, the nest of sieves is removed and separated. The oven dried weight of the material left on each sieve is determined and is subsequently calculated as a percent of the total mass; thus giving a breakdown of the manure particle size distribution.

4.4.3 Preparation of Sterilized Manure

In preparing the sterilized manure used in Experiment No.3, a 37.5% strength commercial grade formaldehyde solution was used. In previous work done by Rowsell (1981), a Warburg Respirometer was utilized to measure the level of microbial activity through respiration. Once respiration (CO_2 levels) rates were undetectable the manure was said to be sterilized. In his work this was found to occur when a 40% formaldehyde solution was added to manure in a 2% by volume ratio.

It should be noted that the results of Rowsell (1981) were not strictly transferable, as there was some uncertainty as to the similarity of the manure characteristics used for each respective study. Hence, a verification was performed.

Since a Warburg Respirometer was not available, an alternative microbial approach was taken with the assistance of the Macdonald College Microbiology Department.

The required formaldehyde-to-manure ratio to ensure complete sterilization of the manure slurry was determined using two methods. The first method involved plating (a technique used in microbiology for inoculation purposes) onto general purpose agar and the second method involved the use of a tryptone dextrose broth test tubes and inverted gas collecting vials. Both methods required two-day old samples (to allow for microbial arrest to occur) containing 5% TS manure slurry and formaldehyde mixed at ratios of 0.5%,1.0%,2%,3.0% and 4.0%, by volume.

Duplicate general purpose agar plates were inoculated with the five mixture ratios. The plates were incubated at 25 °C for a 48 hour period under both aerobic and anaerobic conditions. At the end of two days, all plates were visually examined with the aid of a lab technician to determine if any microbial growth had occurred. At the 2% and above mixture there was no evidence of microbial growth and activity was assumed to have been arrested.

In the case of the tryptone dextrose broth tubes, the same mixture ratios were used. In this method, a change in the color of the solution indicates a change in the pH and subsequent microbial respirator as a result of $C0_2$ being released. As well, inverted gas collecting vials placed in the tubes can indicate anaerobic activity if they are found to contain any trapped $C0_2$ gas in them as a result of $C0_2$ being respired.

Duplicate test tubes of the tryptone dextrose broth were inoculated with all five ratio mixtures. All tubes were incubated at 25 °C for 48 hours in both aerobic and anaerobic conditions (identical to the general agar plates). Results from observations showed no bacterial activity at the 2% level thus confirming the results of the general agar plating method. Based on these findings a 25% contingency was incorporated as an

added precaution. A formaldehyde concentration of 2.5% by volume was used to sterilize the manure used in Experiment No.3.

For Experiment No.3 all columns were filled two days after the mixing of formaldehyde and manure to allow adequate time for complete arrest of biological/microbial activity.

4.5 Infiltration Rates

Infiltration rates were measured from the volume of seepage or exfiltrate collected as follows:

I = V / AT

I = infiltration rate average over time (m/s)

V = volume of exfiltrate collected over time (m^3)

A = cross sectional area of geotextile (m^2)

T = Time(s)

All experiments were conducted at ambient air temperature ranging from 15 to 25 °C. Infiltration rates were then corrected for a constant temperature of 15 °C (refer to appendix H for correction factors). Collected exfiltrates were sampled such that the slurry head did not fluctuate more than 2%. In most cases frequent sampling at the beginning decreased to weekly sampling as the infiltration rate had decreased to an reasonable limit, (about 10^{-6} m/s).

4.6 Effluent Sampling and Analysis

Individual column exfiltrates were sampled weekly for experiment No.1, and bimonthly for Experiment No.2 and No.3. Physical and chemical analysis were performed on each sample collected. Sampling for experiments No.2 and No.3 was conducted on a bi-monthly basis as results from experiment No.1 showed little variation in parameters being measured over the duration of the experiment. Therefore, it was felt that bimonthly sampling would be suitable for analysis purposes. The parameters which were measured includes pH, NH₃ (ammonia), K (potassium), Cl (chloride), NO₃-N (nitratenitrogen), COD (chemical oxygen demand) and SS (suspended solids).

4.6.1 Sampling and Storage

The volume of exfiltrate sample collected was 60-70 ml. pH and ammonia were analyzed immediately on the same day when collected where as samples for potassium, chloride, and NO₃-N were stored in a refrigerator at 4 °C and were analyzed within the

week after sampling. In the case of COD and SS, the samples were acidified with concentrated sulfuric acid , H_2SO_4 (CON) ,until a pH of less than 2 was obtained, and

frozen until a further date when testing could be performed.

4.6.2 Chemical Analysis

Six chemical parameters were measured on all exfiltrates collected. This was performed to give an indication of the degree of pollution potential to ground water. The parameters monitored were : chemical oxygen demand (COD), pH, ammonia (NH₃), nitrate-nitrogen (NO₃-N), potassium (K⁺) and chloride (Cl⁻).

4.6.2.1 Chemical Oxygen Decimal (COD)

The COD test was performed according to Standard Methods (APHA, 1981). It measures the oxygen equivalent to the organic matter present in the sample and which is susceptible to oxidation by a strong chemical oxidant, in this case potassium dichromate $(K_2 Cr_2 0_7)$. The COD was measured using an EPA (Environmental Protection Agency) approved Hach model 16500 COD reactor (16 tube capacity) employing the closed reflux dichromate method. A colorimetric evaluation was used to measure the amount of potassium dichromate $(K_2Cr_20_7)$ reduced by the sample when refluxed for two hours at $150 + 2 \circ C$ in a strong acid solution and in the presence of silver sulfate (Ag_2S0_4) which acts as a catalyst. Halide interference was prevented by adding mercuric sulfate $(HgSO_4)$. Colorimetric response was measured using a Bausch and Lomb Spectronic 20 spectrophotometer, set at 620nm.

Potassium hydrogen phthalale (KHP) was used as the material to calibrate the colorimetric measurement of COD, due to the availability of high purity material, its stability and its lack of moisture pickup. Each mg of KHP requires 1.175 mg of oxygen for complete oxidation. Thus 0.85105 g of KHP dissolved in deionized water was used to prepare a stock solution of 1000 mg/l 0_2 . A standard calibration curve was prepared for 1000,800,500,300,and 100 mg/l 0_2 and a best fit standardization curve was generated to which tested samples were compared.

Sample dilutions ranged from 4 times by volume for 1% TS concentration exfiltrate, to 100 times by volume for raw swine slurry. Once dilutions were complete, one ml samples were then used in the procedure.

The accuracy and precision for this methodology varies and is of the order of 5-10% standard deviation.

<u>4.6.2.2 pH</u>

The pH value, which measures the hydrogen ion activity of a solution at a given temperature, was determined with a combined (glass and reference) Orion model No. 120 electrode. A Corning portable digital pH/ion meter, Model 155 from Corning Science Products USA, was employed. The pH meter compensated for temperature effects and it was calibrated for each measurement with buffer solution of pH 7.0 and pH 4.0. Sodium interference was not considered since all samples had a pH below 10, (APHA, 1981). **4.6.2.3** Ammonia (NH₃)

As outlined in Standard Methods (APHA, 1981), the concentration of ammonia was determined in each sample using an Orion model No. 951201 ion-selective electrode from Orion Research Inc., USA. The electrode uses a hydrophobic gas permeable membrane to separate the sample from the electrode internal solution. Dissolved ammonia in the sample is released when a 10M NaOH solution is added to the sample which raises the pH and increases the percentage of ammonia to 100%. The dissolved ammonia diffuses through the membrane until the partial pressure of the ammonia is the

same on both sides of the membranes. In any given sample the partial pressure of ammonia will be proportional to its concentration. Ammonia diffusing through the membrane dissolves in the internal filling solution, and, to a small extent, reacts reversibly with water in the filling solution. The internal filling solution contains ammonium chloride (NH_4CI) at a sufficiently high level so that the ammonium ion concentration can be considered fixed. Thus, essentially, the electrode functions by measuring the potential difference in millivolts (mV's) between the ion activity in the filler solution and the ion activity in the sample. In this case a Corning Model 155 digital pH/ion meter manufactured by Corning Science Products, USA was used to measure the potential in millivolts.

The electrode itself was calibrated by creating a standard curve with a series of standard solutions of known concentrations and within the range of values of samples being tested (after dilutions). Standards solutions were prepared by dissolving ammonium chloride (NH_4Cl) in deionized water to create a stock solution of 1000 ppm. This, in turn, was diluted to standards of 100,10,1 and 0.1 ppm. A best fit approach was then utilized to obtain the calibration curve and the samples were tested. The samples to be tested were diluted 20-25% of their original concentration so that their ammonia concentration would fall within the measurable range of the electrode and standard solutions. A standard curves along with a sample of the measurements, and results for

4.6.2.4 Nitrate Nitrogen (N03-N)

each sample can be found in appendix E.

The concentration of nitrate-nitrogen was determined with the assistance of The Department of Microbiology at Macdonald College. This was done using a Chemlab Autoanalyzer II and a Clemlab multi-channel Colorimeter Mark III both manufactured by Chemlab Instruments Ltd, England. The method employed is based on the formation of an azo-dye which is estimated colorimetrically as a result of nitrate-nitrite reduction (Anonymous, 1978). A filtered sample is used in the determination of nitrite and nitrate,

both of which may be present in solution. The principle of operation involves determining nitrite concentration alone with deionized water passing through a hydrogencopper line. When no reduction of nitrate occurs it is unable to take part in the formation of the diazo compound. The determination is then repeated with a hydrazine-copper reagent present to reduce nitrate to nitrite enabling it to form a diazo compound and so be estimated. This second determination estimates total oxidized nitrogen (nitrate plus nitrite-nitrogen). The nitrite-nitrogen value from the first determination is then subtracted to give the nitrate-nitrogen concentration in solution. In simplified form :

TOTAL OXIDIZED NITROGEN - NITRITE NITROGEN = NITRATE NITROGEN

The azo-dye is measured colorimetrically by setting the colorimeter to a wavelength of 520mm. The qualitative analysis of concentration is then recorded on a chart recorder and $(N0_3-N)$ nitrate concentrations are obtained by comparing sample peaks to a series of standard or reference peaks. It should be noted that these references or standard peaks were generated from stock solutions prepared from potassium nitrate and sodium nitrite. Through a series of serial dilutions reference concentrations were diluted to the approximate range of nitrate concentrations found in the samples (initially a trial and error process), in this case < 10 PPM.

4.6.2.5 Potassium (K⁺)

As with ammonia, an ion-selective electrode was used to determine the concentration of potassium as outlined in Standard Methods (APHA, 1981). In this case, an Orion model 93-13 potassium electrode was employed from Orion Research Inc., USA. This electrode consists of an electrode body and a replaceable pre-tested sensing module. The sensing module contains a liquid internal filling solution in contact with a gelled organophyllic membrane containing a potassium selective ion exchanger. When the membrane is in contact with a potassium solution an electrode potential develops across the membrane. This potential, which depends on the level of free potassium ion in solution is measured against a constant reference potential which in this case is an Orion

model 90-02 double junction reference electrode. This reference electrode contains an inner chamber solution which matches the characteristics of a standard KCl calomel electrode and an outer chamber which for potassium concentration determination contained a 2% by volume 5M NaCl solution.

The potential was measured in millivolts (mV's) using the Corning model 155 digital pH/ion meter, manufactured by Corning Science Products, USA. The mV potential of the sample was then compared to a series of standard solutions of known concentrations of 100,10,1,0.1 ppm which were prepared from a stock solution (1000 ppm) of KCl dissolved in deionized water. A best fit approach was used for determining the calibration curve. Hence, the standard curve and sample reading can be related and the concentration of potassium in the sample can be obtained. A sample of results can be found in appendix E.

It should be noted that in the case of potassium concentration determinations, an Ionic Strength Adjustor (ISA) was added to all potassium standards and samples so that the background ionic strength is high and maintained constant relative to the variable concentrations of potassium ion. In this case, a 5M electrode NaCl solution is the recommended ISA. This concentration of 5M NaCl was added at the rate of 2 ml ISA for every 100ml of sample.

<u>4.6.2.6 Chloride</u> (Cl⁻)

As with potassium an ion-selective electrode was used to determine the concentration of chloride as outline in Standards Methods (APHA, 1981). In this case an Orion model 93-17 chloride electrode was employed from Orion Research Inc.,USA. This electrode consists of an electrode body and a replaceable pre-tested sensing module. This sensing module contains a liquid internal filling solution in contact with a gelled organophyllic membrane containing a chloride selective ion exchanger. When the membrane is in contact with a chloride solution an electrode potential develops across the membrane. This potential, which depends on the level of free chloride ion in solution, is

measured against a constant reference potential, which in this case is an Orion model 90-02 double junction electrode. This reference electrode contains an inner chamber solution which matches the characteristic of a saturated KCl (potassium chloride) calomel electrode and an outer chamber which for chloride concentration determinations contains a 10M KCl solution.

The potential was measured in millivolts (mV's) using the Corning Model 155 digital pH/ion meter manufactured by Corning Science Products, USA. The mV potential of the samples is then compared to a series of standard solutions of known concentrations of 100,10,0.1 ppm. which were prepared from stock solution (1000 ppm) of dissolved NaCl (sodium chloride) in deionized water. A best fit approach was then used for determining the calibration curve. Hence the standard curve and sample readings can be correlated and the concentration of chlorides in the samples can be obtained. A sample of results and calibration curve can be found in appendix E.

<u>4.6.3 Physical Parameters</u>

Only one physical parameter was monitored for pollution potential, that being suspended solids (SS).

4.6.3.1 Suspended Solids (SS)

As outlined in Standard Methods (APHA, 1981), suspended solids refers to the nonfilterable residue which is retained on a standard glass fiber filter after filtration of a well mixed sample and dried at 103 to 105 °C for at least 24 hours or until a constant weight is obtained. For the tests, a Millipore membrane filter apparatus from Millipore Filter Corporation, USA, and 0.45 μ m glass fibre filter supported in aluminum dishes were used. Prior to weighing, all samples were collected and stored in a glass desiccator. A Sartorious Analytical balance capable of weighing down to 0.1 mg was used.

4.7 Experimental Design

4.7.1 Experiment No.1

The experiment design for Experiment No.1 was that of a 3 X 3 factorial with three replications. Three geotextiles (20,30, and 40 μ m) and three hydraulic heads (0.9,1.8 and 2.7 m) formed nine treatments (27 columns in total).

4.7.2 Experiment No.2

The design for Experiment No.2 was that of a 1 X 6 factorial with three replications. One geotextile fabric (20 μ m) was subjected to six (6) different swine slurry concentrations (1,2,4,6,8, and 10% TS) under a constant head to form six treatments (18 columns in total).

4.7.3 Experiment No.3

Experiment No.3 was that of a 1 X 2 factorial experiment with five replications. One geotextile (20 μ m) was subjected to two manure slurries sterilized and natural, of equal TS concentration and constant head. This gave us two treatments and ten columns in total.

4.8 Statistical Analysis

Infiltration rates and effluent concentrations were compared for significant differences using the analysis of variance method. Each sampling period was grouped as a block to limit experimental error among treatments. The least-square method was used to identify significant treatment differences.

Regression models were developed for all experimental conditions to establish a relationship between infiltration rate and time. The best fit was obtained using the logarithmic form of the exponential equation:

 $I = Wt^X$

where : I = infiltration rate average over time (m/s)

W, x = constants

t = infiltration time(s)

This exponential equation was found to give the best fit as it gave the highest correlation coefficients. Because infiltration rates evidently increased after 1000 to 1400 hours of experimentation (for natural manures), two such models were obtained for each combination. The most probable point in time constituting the initial increase in infiltration represented the time separating the two models giving the best fit. The best fitting pair of models were selected from that giving the highest correlation coefficient.

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V. Results and Discussion

5.1 General Material Characteristics

In each of the experiments conducted the characteristics of the geotextiles and manure utilized were consistent, and are shown below.

5.1.1 Pore Size

Using the Hydrodynamic Sieving method, the respective d_{95} of each fabric used in the study is shown in figures 5.1 to 5.3 for the 20, 30 and 40 μ m fabrics, respectively.



FIGURE 5.1 - PARTICLE SIZE DISTRIBUTION OF SAMPLE

THROUGH MACDONALD FABRIC (20 MICRONS)



PARTICLE SIZE (µm)

FIGURE 5.2 - PARTICLE SIZE DISTRIBUTION OF SAMPLE

THROUGH MACDONALD FABRIC (30 MICRONS)



PARTICLE SIZE (µm)

FIGURE 5.3 - PARTICLE SIZE DISTRIBUTION OF SAMPLE

THROUGH MACDONALD FABRIC (40 MICRON)

5.1.2 Permeability

Through the use of the Falling Head method, the respective hydraulic conductivity values based on five (5) replications per fabric sample are summarized in table 5.1 below.

TABLE 5.1

Geotextil	e Pore Size	Hydrai (4	ulic conductivity saturated), <10 ⁻⁵ m/s	
nominal, µm	measured, µm	mean	standard dev.	– Geolexille inickne ss, mm
20	21.8	4.56	0.406	1.5
30	29.6	6-30	1.100	2.0
40	40-9	5.47	0.526	2.0

GEOTEXTILE CHARACTERISTIC SUMMARY

5.1.3 Manure Particle Size Analysis

The results for the manure used in this study are shown in table 5.2 below. It should be noted that these results were taken from Fernandes et al. (1988).

TABLE 5.2

PARTICLE SIZE DISTRIBUTION AS A PERCENTAGE OF TOTAL SOLIDS

PARTICLE SIZE	FRESH RAW MANURE
< 53	52.8
53 - 75	2.7
75 - 105	2.5
105 - 150	18
150 - 250	13
250 - 500	31
500 - 1180	84
> 1180	27.4
TOTAL	100

5.2 Experiment No. 1

Experiment No.1 was used to compare three different geotextiles, each of which was subjected to three different heads and a constant TS concentration of swine manure slurry. The characteristics of the manure with regards to their original chemical and physical parameters is represented in Table 5.3 below.

TABLE 5.3

EXPERIMENT NO.1 - SWINE SLURRY CHARACTERISTICS

Shum.		Slurry analysis						
head,	TS,	pH [·]	COD,	NH3	NO ₃ -N	Cl,	k,	SS,
m	%		g/l	ppm	ppm	g/l	ppm	g/l
2·7	4-64	7·1	53·5	4871	1.7	2.46	1180	43·3
1·8	4-59	7-0	53·6	4260	1.5	2.36	1241	33·6
0·9	4-71	7·1	52·9	4311	1.6	2.26	1191	33·8

SS = suspended solids

5.2.1 Infiltration Rates

Infiltration rates for all experimental combinations are shown in Figs. 5.4 to 5.7. In general, seepage rates dropped below 1×10^{-7} m/s and 2×10^{-8} m/s within 150 and 1000 hours, respectively. When dismantling the various columns a typical manure mat was found to have accumulated at the geotextile surface. This mat was composed of the solids which had been originally present in the manure slurry. The mat formation consisted of large-sized particles directly in contact with the geotextile material itself with a gradient of smaller sized particles progressively as the height of the manure mat increased and extended away from the geotextile. On top of the "mat" a black sludge like "scum" had also formed. The odor and color were characteristic of partially decomposed organic matter formed by predominantly anaerobic microbial decomposition.



FIGURE 5.4 - INFILTRATION RATE FOR THE 20µm FABRIC



FIGURE 5.5 - INFILTRATION RATE FOR THE 30µm FABRIC



FIGURE 5.6 - INFILTRATION RATE FOR THE 40µm FABRIC



FIGURE 5.7 -INFILTRATION RATE FOR THE AVERAGE OF ALL FABRICS

In performing the analysis of variance it was shown that there exist some significant differences among experimental combinations (see appendix D). When considering individual fabrics only the 40 μ m fabric showed significant differences among heads. The 2.7 m slurry head pressure produced higher infiltration rates at the 95% confidence level. This pressure head influence is associated as well with a higher infiltration rate. This may be related to the fact that high pressure head can influence the degree to which particles are held within the geotextile fabric itself. The fabric's ability to hold and trap smaller sized particles may be reduced due to the porosity of the fabric. Thus the ability to trap these smaller particles may not be fully realized.

When considering individual manure heads, the 30 μ m fabric gave significantly higher infiltration rates for the 2.7 m slurry (95% confidence level). As well, for individual manure heads there were significantly higher seepage rates for the 0.9 m and 1.8 m slurry pressures for the 20 μ m fabric (95% confidence level) When the three geotextiles were compared, respective of manure pressure, (fig. 5.7) the 20 µm fabric gave significantly higher seepage rates (95% confidence level). The higher infiltration rates, associated with the smallest equivalent pore size fabric may be the result of the lowest geotextile permeability as described by Faure et al. (1986). Fabrics of higher hydraulic conductivity are known to develop a more compact, and therefore, more impermeable manure mat at their surface. This is related to the ability of smaller size particle in the manure slurry to become trapped in the fabric layer itself and may partially be related to results suggested by Faure et al. (1986) that the lack of ability to form stable arches above pore openings in the geotextile leads to a reduction in its ability to seal or become blocked. Another factor which may contribute to the higher infiltration rates for the 20 µm fabric may be due to its smaller thickness, 1.5 mm, compared to 2.0 mm for the other fabrics. These factors are useful in filter fabrics used in preventing drainage piping from being" blocked off" but is less useful in the application as a sealing medium as is intended in this particular use.

Regression models were determined for all nine experimental combinations, Table 5.4, as well as for all three geotextiles irrespective of slurry head (Fig. 5.7). Infiltration rates decreased from 5 X 10⁻² m/s to less than 1 X 10⁻⁷ and 2 X 10⁻⁸ m/s within 150 and 1000 hr, respectively. Minimum infiltration rates ranged from 1.3 to 1.8 x 10^{-8} m/s and occurred between 1000 and 1400 hr.of experimentation. These rates are slightly above the 10^{-8} m/s set by most environmental authorities. Among all nine

TABLE 5.4

INFILTRATION RATE REGRESSION MODELS FOR ALL

Expe	riment			
Pore Size µm	head (m)	Regression model I, 10 ⁻⁸ m/s	Period, h	Determination, R ²
20	0.9	$\frac{131 \cdot 8t^{-0-63}}{6 \cdot 46 \times 10^{-5} t^{1-46}}$	0-1150 1150-1800	0.63 0.53
20	1-8	$409.9t^{-0.82}$ $1.22 \times 10^{-7}t^{2.29}$	0-1150 1150-1800	0·70 0·90
20	2.7	$317 \cdot 1t^{-0.79}$ 3 \cdot 2 × 10 ⁻¹⁰ t ^{3 \cdot 107}	0-1250 1250-1825	0-82 0-50
30	0.9	$\frac{110t^{-0.64}}{4.8t^{-0.13}}$	0-815 815-1800	0-77 0.01
30	1-8	6291 ⁻⁰⁻⁹⁴ 0-261 ⁰⁻²⁵	0-985 985-1800	0-88 0-04
30	2.7	13-281 ⁻⁰⁻¹⁷ 28061 ⁻⁰⁻⁷⁹	01330 13301800	0-04 0-20
40	0- 9	70-431 ⁻⁰⁻⁵⁷ 1-2 × 10 ⁻⁶ 1 ¹¹⁻⁹⁵	0-1150 1150-1800	0-62 0-59
40	1-8	$324t^{-0.81}$ $4.2 \times 10^{-4}t^{1.13}$	0-1150 1150-1800	0-83 0-55
40	2.7	$206 \cdot 7t^{-0.69}$ $1 \cdot 82 \times 10^{-7}t^{2 \cdot 20}$	0-1350 1350-1830	0-79 0-34

EXPERIMENT NO. 1 COMBINATIONS

combinations, minimum infiltration rates varied by only 2.0 x 10^{-9} m/s despite significant differences indicated by the analysis of variance. All columns exhibited an increase in infiltration rates after 1000 to 1400 hr. A probable cause for this is leaching or microbial degradation or disintegration of the impermeable manure solids mat accumulated over the geotextile. This leaching phenomenon was previously observed by Barrington (1985) with fine sand columns. In actual field conditions an increase in infiltration rates after 1000 hr. to 1400 hr. may be offset by the fact that fresh manure solid will be added on a continual basis which would replace the mat with new organic material. One should note that in the field this accumulation of manure solids is usually removed from its storage area and spread on the land to make way for the following season's accumulation. During this experimentation, fresh manure was not added to the columns once experimentation began so that total solids concentrations would remain constant in all columns.

When examining the regressions model established (Table 5.4) none of the \mathbb{R}^2 values exceeded 0.90. This suggests that a poor correlation exists between infiltration rates and time. Closer examination of some of the data reinforces these statistical results as it is obvious that infiltration rates decrease rapidly for the first 400 hr but thereafter can fluctuate by as much as 100% of their value. Thus, the general trends of most infiltration rates after 400 hr becomes less related to time but more related to other mechanisms such as microbial degradation and the movement of manure solids through/from the mat above the geotextile. Hence, the infiltration rate may, in fact, be initially related to time as affected by physical sealing mechanisms but over the longer duration the infiltration rate may become more closely related to factors other than physical sealing.

5.2.2. Filtrate Analysis

Filtrate seepage analysis have been summarized in Tables 5.5 to 5.9 . pH levels remained constant within the range of 6.5 to 7.5 for all experimental combinations while nitrate (NO₃-N) concentrations increased from 1.5 to 2.5 ppm.

Ammonia (NH₃) concentrations were the highest among all 2.7 m head combinations and among geotextiles for the 20 μ m fabric at both the 1.8 and 2.7 m heads (99% confidence level).

Chloride (Cl) concentrations were not significantly different among treatments while potassium (K) levels were significantly higher only for the 0.9 m 30 μ m experimental combination (95% confidence level).

Poor correlation ($\mathbb{R}^2 = 0.2 - 0.3$) was found to exist between SS and infiltration rates, although SS levels were the lowest after 1000 to 1200 h of experimentation. A possible explanation for the poor correlation may be due to the fact that particle sizes which cannot be trapped on the standard filter material may be a result of advanced microbial degradation and hence may not be captured after the 1000 to 1200 h duration at which point infiltration rates begin to increase.

TABLE 5.5

Nominal Pore Size	slurry head, m						
μ m	0.9	1.8	2.7	All			
20	18 500	17 700	21 300	19 200			
	(9520)	(6050)	(7730)	(7760)			
30	16 500	18 400	21 000	18 600			
	(4710)	(7290)	(6610)	(6200)			
40	21 200	21 400	21 900	21 500			
	(11 540)	(11 200)	(8740)	(13 830)			

Chloride Concentration of Seepages, mg/L

The values in parentheses are the standard deviations based on ten samples, taken at regular intervals throughout the experiment. No significant difference was observed among all combinations

Nominal Pore Size		Slurry l	head, m	
of Geotextile	0.9	1.8	2.7	All
20	669	681	777	709
	(321)	(265)	(361)	(311)
30	836*	711	840	796
	(254)	(295)	(293)ւ	(278)
40	732	701	815	749
	(335)	(320)	(349)	(327)

TABLE 5.6

Potassium Concentration of Seepages, mg/L

The values in parentheses are the standard deviations based on ten samples, taken at regular intervals throughout the experiment.

* significantly higher value among geotextiles (95% confidence level)

TABLE 5.7

Nominal Pore Size	ze Slurry head, m					
of Geotextile µm	0.9	1.8	2.7	All		
20	3360	3400**	‡4060*	3610		
	(353)	(382)	(458)	(504)		
30	3200	3090.	‡3800	3360		
	(341)	(266)	(360)	(447)		
40	3170	3270	‡3830	3420		
	(359)	(390)	(340)	(457)		

Ammonia Concentration of Seepages, mg/L

The values in parentheses are the standard deviations based on nine samples, taken at regular intervals throughout the experiment.

** significantly higher value among geotextiles (99% confidence level)

* significantly higher value among geotextiles (95% confidence level)

‡ significantly higher value among heads (99% confidence level)

Ľ	A	B	L	E	5.	8	

Nominal Pore Size	Slurry head, m					
of Geotextile • µm	0.9	1.8	2.7	All		
20	32 810**	33 690**	‡41 020**	35 840**		
	(4600)	(4450)	(5930)	(6020)		
30	29 010	28 780	‡34 320*	30 700		
	(4320)	(3580)	(4470)	(4660)		
40	28 490	†31010	†31 770	30 420		
	(2920)	(3600)	(4860)	(3870)		

COD Concentration of Seepages, mg/L

The values in parentheses are the standard deviations based on five samples, taken at regular intervals throughout the experiment.

** significantly higher value among geotextiles (99% confidence level)
* significantly higher value among geotextiles (95% confidence level)
‡ significantly higher value among heads (99% confidence level)

† significantly higher value among heads (95% confidence level)

TABLE 5.9

Nominal Pore Size	Slurry head, m					
μm	0.9	1.8	2.7	All		
20	3897	3358	3827	3694		
	(1183)	(1217)	(1238)	(1199)		
30	3630	3550	3653	3611		
	(1025)	(1133)	(1144)	(1068)		
40	†4253	2985	3632	3623		
	(1769)	(1056)	(1317)	(1465)		

SS Concentration of Seepages, mg/L

The values in parentheses are the standard deviations based on five samples, taken at regular intervals throughout the experiment.

† significantly higher value among heads (95% confidence level)

All exfiltrates were shown to be highly contaminated, indicating that geotextiles act solely as a screening media.

COD levels were found to be the highest among all heads of 2.7 m (99% confidence level) and among the 20 μ m geotextile fabric (99% confidence level). However, the 2.7 m heads for both the 30 μ m and 40 μ m fabrics combinations did not show significantly higher infiltration rates. These results suggest that despite higher COD levels as a result of manure solids leaching, the 2.7 m heads produce higher pressures on the manure mat thus reducing its porosity as well as permeability.

In regards to suspended solids (SS), they were shown to be significantly higher among heads and geotextiles for the 0.9 m and 40 μ m.

All seepages were contaminated, suggesting that the installation of such materials would require seepage collection systems to ensure protection of groundwater from possible contamination.

5.3 Experiment No.2

Experiment No.2 was designed to determine the critical TS level or the minimum swine slurry TS level above which no significant difference in geotextile infiltration rate can be measured. Tables 5.10 and 5.11 below show experimental data. Note that swine slurry characteristic for experiment No.3 are included in Table 5.10 as well.

5.3.1 Infiltration rates

Infiltration rates for this experiment were monitored for 1800h for all TS levels (1%,2%,4%,6%,8%,10%) with the exception of the 1% TS concentration which was terminated after 1000 hours because of its excessively high seepage rates.

Results from this experiment are illustrated in Fig. 5.8 using their respective regression models. The analysis of variance indicates significantly higher infiltration rates for the 1% and 2% TS swine slurries (99% confidence level). Minimum seepage rates of 95×10^{-8} m/s and 15×10^{-8} m/s were reached with these two slurries,
TABLE 5.10

75	pH	COD, mg/l	SS, g/l	NH3 ppm	NO ₃ -N <i>ppm</i>	Cl, ppm	K, ppm
1	7.05	8 7 3 4	9.8	810	0-3	4 210	210
2	7-01	38 440	4-6	1825	0-5	7 150	470
. 4	6-96	50 220	23.7	2710	0.9	19 430	1080
6	6-88	51 400	41-1	3050	1-6	23 490	1320
8	6-93	65 050	58-2	4300	2.1	31 640	1860
10	6-79	104 060	77.9	4800	2-6	34 860	2240
5 (natural)	6 ·86	50 790	39-4	2940	1-5	21 640	1095
5 (+formaldehyde)	6-21	59 500°	39-4	640	1.5	21 640	1095

CHEMICAL ANALYSES OF EXPERIMENTAL SWINE SLURRIES

* Value not corrected for the formaldehyde content

TABLE 5.11

EXPERIMENTAL DATA FOR EXPT. No. 2

Con	lo-tilo			Swine sli	итту
Geor equivalent nominal, µm	Pore Size measured, µm	k°, 10 ⁻⁵ m/s	Total nominal, %	solids measured, %	Hydraulic head above geotextile, m
20	21.8	4.56	1	1-02	1.8
20	21.8	4-56	2	2.10	1-8
20	21-8	4-56	4	4-26	1.8
20	21.8	4-56	6	6-14	1.8
20 ·	21-8	4-56	8	8-17	1.8
20	21-8	4-56	10	10-30	1-8

.

* refers to the k saturated hydraulic conductivity using water

respectively, while the 4,6,8 and 10% TS manures all reached minimum rates of 1.2 to 1.0×10^{-8} m/s. Although the regression lines showed a decreasing trend in infiltration rates with TS levels of 4% and more, the analysis of variance performed on the data show no significant difference in infiltration rates for all slurries with more than 4% TS. This may be explained by the fact that initial infiltration rates for the 4,6,8 and 10% slurries differ. However, after 400 hours infiltration rates are similar. This would tend to indicate that the critical swine slurry TS level can therefor be considered at 4% at the very least. Since experiment No.1 has shown that the 20 µm fabric produced the highest infiltration rates then it would be safe to assume that this 4% critical TS level would be acceptable for the 30 µm and 40 µm fabric as well.

Regression analysis was performed on all experimental data to relate the infiltration rates as a function of time. The 1,2, and 4% TS swine slurries demonstrated increasing seepage rates after 250,400, and 1000 hours of monitoring, (Table 5.12), while the 6,8 and 10% TS showed no increasing infiltration rates. This would seem to indicate that although the critical TS level was found to be 4% it would appear that higher manure solids levels would help in maintaining a longer lasting seal (consistent with literature findings) most likely as a result of the larger portion of material which would need to be degraded hence producing a more stable mat over extended periods.

TABLE 5.12

INFILTRATION RATE REGRESSION MODELS FOR ALL

EXPERIMENT No. 2 COMBINATIONS

Manure,	Monitoring interval,	Regression model	COEFFICIENT OF
70	<u> </u>	/, 10 ^{-•} m/s	DETERMINATION, R ²
1	0-400	6634 20-77	0.90
	4001000	0-03 (1-27	0.49
2	0-400	2591 (-0-84	0.74
	400-1500	0.66 (-0-67	0.49
4	0-1000	4365 (~1-14	0.96
	1000-1500	0.02 (0.54	0.99
6	0-1000	$6087 t^{-1-13}$	0.95
	1000-1500	4543 1-1-48	0.78
. 8	0-400	$1 \times 10^{6} t^{-2.23}$	0.99
	400-1500	12.17 1-0-34	0.91
10	0750	613 / -0.96	0.98
•	750-1500	8.56 1-0-28	0.58

.



1% TS, —.— O; 2% TS, —.— △; 4% TS, —.— ●;

6% TS, —.— ▲; 8% TS, —.— □; 10% TS, —.— ₩

FIGURE 5.8 - INFILTRATION RATES FOR EXPT. No. 2

5.3.2 Filtrate Analysis

Chemical analysis of all filtrates, (Table 5.13), indicates highly contaminated seepages resulting from the mere screening action of the geotextile. All soluble contaminants such as NH_3 , NO_3 -N and Cl were of nearly the same concentrations to that

of the original swine slurries. COD concentrations as well as SS concentration appears to decrease with increasing TS swine slurry concentration. This appears to reflect the ability of the deeper manure mat to retain its solids above the geotextile. Swine slurry COD concentrations vary in relation to TS concentrations up to the 4% TS, probably as a result of dilution effects on manure solids concentration. Thus, no conclusions can be drawn with respect to significant differences in COD concentrations among various TS seepages.

TABLE 5.13

Manure TS,	SS,	COD,	NH3	NO ₃ -N	K,	Cl,
%	mg/l	mg/l	ppm	ppm	ppm	ppm
1	1156	5166	772	0·3	192	424·9
	(302-1)	(862·7)	(35·3)	(0·072)	(11·4)	(116·6)
2	(12)	(59)	(95)	(100)	(91)	(101)
	1241	10 040	1418	0·4	453	6536
	(226·4)	(1337)	(179-3)	(0·033)	(12·2)	(415·4)
	(8·5)	(26)	(78)	(80)	(96)	(91)
4	171 6	25 080	2914	0-8	969	21 760
	(571·1)	(7311)	(211·6)	(0-043)	(39·8)	(1798)
6	(7·2)	(50)	(93)	(89)	(90)	(112)
	2097	21 040	2934	1·6	1297	25 450
_	(1244) (5·1)	(8039) (41)	(106-3) (96)	(100)	(49·3) (98)	(2020) (108)
8	1779	26 190	3830	2·1	1734	35 180
	(1053)	(4581)	(276-3)	(0·098)	(75·1)	(2285)
10	(3·1)	(40)	(89)	(100)	(93)	(111)
	1493	22 950	4043	2·6	1974	36 930
	(896-6)	(5185)	(369·6)	(0-061)	(96·1)	(2715)
	(1-9)	(22)	(84)	(100)	(88)	(106)

FILTRATE ANALYSIS FOR THE TOTAL SOLIDS (TS) EXPERIMENT

The first value in parenthesis is the standard deviation from 11 values.

The second value in parenthesis represents the percentage value over that of the original swine slurry

¢

5.4 Experiment No.3

Experiment No.3 was designed to determine the difference in geotextile infiltration rates between sterilized manure and natural manure slurries. This was performed to simulate conditions of low temperature and/or conditions of poor biological sealing mechanisms. Experimental data are shown in Table 5.14. (note: manure characteristics are included in Table 5.10)

TABLE 5.14

Geote equivalent nominal, µm	xtile Pore size measured, µm	k*, 10 ⁻⁵ m/s	TS, %	Swine slurry treatment	h**, m
20	21·8	4·56	5·21	sterilized natural	0-9
20	21·8	4·56	5·24		0-9

EXPERIMENTAL DATA FOR STERILIZED AND NATURAL MANURE

* k refers to the saturated hydraulic conductivity using water. ** h refers to the pressure head of swine slurry above the geotextile

5.4.1 Infiltration Rates

Infiltration rates between sterilized and natural 5% TS swine slurries in contact with a geotextile of 20 μ m in equivalent pore size were found to have no significant difference in infiltration rates between the two types of manure up to 1000 hours, refer to Fig. 5.9. The regression analysis relating their infiltration rates to time indicates an increasing infiltration rate for the natural manure after 1000 hours. This suggests that biological sealing mechanisms did not reduce infiltration rates in this case. Rather, it appears as if microbial activity demonstrated a tendency to deteriorate the impermeable mat lodged at the geotextile surface, thus producing increasing infiltration rates after a given period.



FIGURE 5.9 - INFILTRATION RATES FOR THE NATURAL AND

STERILIZED MANURES

Based on these results it would appear as if geotextile sealing liners should therefore perform better under winter conditions where manure temperatures may reach 5 to 10 °C typical of many large manure reservoirs in Canada during a major part of the year. Although it appears as if biological action, particularly degradation, may increase infiltration rates, the opposite may in fact occur if systems (reservoirs) are replenished with fresh manure on a regular basis. One may speculate that new swine slurry will subsequently be degraded through microbial action. This action over time could result in a mix of various sized particles which may eventually form a more secure seal.

Therefore, on a continuous usage basis biological activity may in fact lead to a strengthening of the seal over the long run. However, lagoons used as "one time" storage or "batch storage" reservoirs will most likely show signs of increased infiltration rates over time and perhaps any design criteria should take into consideration the "manure renewal rate" to ensure optimal sealing is obtained.

5.4.2. Filtrate Analysis

As in experiment No.2 chemical analysis of all filtrates , (Table 5.15) indicated highly contaminated effluents. pH for the sterilized manure was found to be significantly higher (99% confidence level) as were NH₃, NO₃-N, and COD concentrations. Of particular interest was the fact that COD levels were found to be significantly higher in the natural manure slurry whereas SS concentration were found to be not significantly different. This may indicate an increase in dissolved solids for the natural slurry, (capable of passing the 0.45 μ m filter of the SS test), probably as a result of microbial degradation of the impermeable mat lodged over the geotextile. It is the degradation which is most likely responsible for the gain in manure mat permeability after 1000 hours of experimentation.

TABLE 5.15

FILTRATE ANALYSIS FOR NATURAL AND STERILIZED SLURRY

EXPERIMENT

Swine slurry	pH	COD, g/l	SS, g/l	NH3 ppm	NO3-N ppm	Cl, ppm	K, ppm
5% (natural)	6-9**	20.6**	1-81	2580**	1·2*	24 516*	916
	(0-12)	(5·5)	(1-008)	(272-5)	(0-0087)	(3171)	(194-2)
5% (sterilized)	`6-4	`9-8	`1•79	526	1-3	23 202	910
	(0-19)	(2-88)	(0•933)	(39-6)	(0-110)	(1659)	(105-8)

First value in parenthesis is the standard deviation. ** significantly higher at a 99% confidence level * significantly higher at a 95% confidence level

VI. Conclusions and Suggestions for Future Work

6.1 Conclusion

Of the three (3) non-woven geotextiles subjected to 5% TS concentration, the smallest equivalent pore size fabric, 20 μ m, gave the highest infiltration rates. This may be attributed to the fact that it also had the lowest hydraulic conductivity and physically had the smallest thickness, 1.5 mm, compared to 2.0 mm for the other fabrics. Despite significant differences minimum infiltration rates for all experimental combinations ranged from 1.3 to 1.8 x 10⁻⁸ m/s, sightly higher than the acceptable government limit set at 10⁻⁸ m/s.

Hydraulic head did not have a significant effect upon the rate of decrease of infiltration rates suggesting that a self equalizing process governed by the manure mat controlled the rate of decrease.

All combinations of slurry pressure head and geotextiles demonstrated an initially decreasing infiltration rate followed, after 1000 h to 1400 h, by an increasing infiltration rate. Poor correlation existed between infiltration rates and time suggesting that infiltration rates may be less related to time and more related to other mechanisms such as microbial degradation. It is this microbial degradation or leaching of the impermeable mat accumulated over the geotextile which is suspected as the factor giving rise to increasing infiltration rates over time. In actual field conditions this increase may not be realized as the manure mat is expected to be constantly replenished by fresh manure.

In regards to minimum TS concentrations required for sealing, results demonstrated that for proper (or adequate) geotextile sealing, swine manure slurry should have a TS concentration level of at least 4%. Furthermore, slurries of 6% TS and above demonstrated no trend increasing of infiltration rates over the duration of the experiment ,as was observed with the 4% TS concentration and the 5% TS concentration used in experiment No.1. This suggests that field conditions may produce lower

infiltration rates compared to the present laboratory conditions where columns were refilled with exfiltrate collected rather than with fresh manure.

Sterilized manure demonstrated no loss in manure mat impermeability as observed with natural swine slurry trials. These sterilized conditions were used to simulate cool reservoir conditions (5-10 °C) and to examine the role of biological sealing mechanisms in the overall sealing process.

Results allow us to conclude that the lack, or loss, of biological activity will not lead to an increase in infiltration rates. On the contrary, biological activity in natural swine slurries leads to microbial degradation and subsequent leaching. This appears to be the primary reason for gains in permeability of the manure mat and subsequent higher infiltration rates and seepage SS and COD concentrations of experiment No.3. This suggests that design criteria of such reservoirs should include manure renewal rates to compensate for rates of biological degradation.

Chemical analysis of all effluents from the experiments were highly contaminated. This appears to indicate that the geotextetile merely acts as a screen, and provides a physical structure to which a manure mat (composed of particulates contained within the slurry) can accumulate to form a seal.

If geotextiles are to be used as earthen reservoir liners over coarse soils and or gravel, a seepage collection system would have to be included as part of its design criterion.

<u>6.2 Suggestions for Future Work</u>

Three main areas deserve attention for future work. The first is in regards to life expectancy of geotextile materials. Accelerated aging tests, that is, cold/warm or freeze/thaw cycles could lend itself to help define the expected lifespan of such products, and hence give an indication of its economic advantage over that of concrete structures or the same basis.

The second area is in regards to the examination of other types of manure and the relationships between manure particle size and geotextile composition and geotextile porosity and equivalent pore size. This would lead to more specific fabric recommendations for other wastes as well.

The third area which deserves attention deals with how seepage rates may be affected by manure renewal rates (not accounted for in this experimental set). This may be reflected by the fact that correlation factors between time and infiltration rates were poor, suggesting that further work may be required to examine other factors such as microbial degradation rates and their relationship to infiltration rates.

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APPENDIX

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APPENDIX B

INFILTRATION DATA

EXPERIMENT	r No	. 1		- TABLES	5 B1	TO	B9
EXPERIMENT	No.	2	-	TABLES	B10	TO	B15
EXPERIMENT	No.	3	-	TABLES	B16	TO	B17

TABLE B.1 KXP. No. 1 O.9m HEAD 20µm FABRIC

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head 0.9m 20 micron Fabric Exp. No. 1

•		1			+		!	!			!				-1
		: Time	Change		ACCUMUL.	TEMP	VISC.	VOLUME	of	Effluent	Infiltration	Rate	ce/s	E Average E Infil	1
i DATE	i nc 	Hours	Minutes	SECONDS	HOURS		 	. REP1	: REP2	REP3	R EP1	REP2	REP3	ce/s	; -
june 19	10.30	0.00	0.00	. 0.00	U.00	24.50	. 0.00		1	:			ł	i	ł
i june 23	11.00	96.00	30.00	347400.00	1 96.50	24.00	: 0.820	750.00	460.00	640.00	9.98E-06	6.12E-06	8.52E-06	B.21E-06	ł
l june 30	15.30	: 172.00	30.00	621000.00	269.00	22.00	0.855	740.00	320.00	1 485.00	5.74E-06	4.26E-06	6.45E-06	1 5.40E-06	1
i july 5	16.45	121.00	: 15.00	436500.00	: 390.25	22.50	0.845	315.00	145.00	200.00	: 3.44E-06	1.93E-06	2.66E-06	1 2.68E-06	ł
i july 9	10.30	89.00	45.00	323100.00	: 480.00	24.00	0.820	175.00	; 70.00	: 130.00	2.50E-06	9.31E-07	1.73E-06	1.728-06	ł
july 14	9.25	130.00	55.00	471300.00	610.92	29.00	0.730	: 350.00	190.00	; 320.00	3.06E-06	2.53E-06	4.26E-06	: 3.28E-06	1
l july 16	11.00	37.00	35.00	135300.00	648.50	23.00	: 0.835	80.00	40.00	80.00	2.78E-06	5.32E-07	1.06E-06	1.46E-06	ł
i july 20	9.35	94.00	35.00	340500.00	743.08	24.50	0.810	220.00	1 95.00	145.00	2.95E-06	1.26E-06	1.93E-06	: 2.05E-06	ł
i july 23	8.50	71.00	25.00	257100.00	: B14.50	25.00	0.800	: 135.00	20.00	: 110.00	2.37E-06	2.66E-07	1.46E-06	1.37E-06	ł
july 27	10.50	98.00	0.00	352800.00	912.50	24.00	0.820	260.00	110.00	215.00	3.41E-06	1.46E-06	2.86E-06	: 2.58E-06	1
iuly 30	10.55	72.00	: 5.00	259500.00	984.58	23.00	0.835	170.00	; 55.00	195.00	: 3.08E-06	7.32E-07	2.59E-06	1 2.14E-06	ł
l Aug 3	10.50	95.00	55.00	345300.00	1080.50	23.00	0.835	205.00	; 75.00	: 180.00	2.79E-06	9.98E-07	2.39E-06	1 2.06E-06	1
l Aun 6	10.55	72.00	1 5.00	259500.00	1152.58	22.00	: 0.B55	: 135.00	: 55.00	1 130.00	: 2.51E-06	7.32E-07	1.73E-06	1 1.66E-06	1
: Aug 10	10.25	95.00	30.00	343800.00	1248.08	22.00	0.855	: 210.00	B0.00	235.00	2.94E-06	1.06E-06	3.13E-06	: 2.38E-06	ł
l Aug 13	10.20	71.00	55.00	258900.00	: 1320.00	22.00	0.855	200.00	: 70.00	205.00	: 3.72E-06	9.31E-07	2.73E-06	: 2.46E-06	ł
l Aug 17	9.30	95.00	10.00	342600.00	1415.17	24.00	0.820	225.00	: 115.00	160.00	1 3.04E-06	1.53E-06	2.13E-06	: 2.23E-06	1
l Aug 20	10.20	72.00	50.00	262200.00	1488.00	22.00	: 0.855	165.00	1 215.00	160.00	: 3.03E-06	2.86E-06	2.13E-06	: 2.67E-0a	1
1 Aug 27	10.20	168.00	0.00	604800.00	1 1656.00	18.00	: 0.915	: 290.00	: 390.00	1 320.00	: 2.47E-06	5.19E-06	4.26E-06	1 3.97E-06	•
Sent 2	10.20	1 144.00	0.00	518400.00	1800.00	20.00	0.885	290.00	250.00	230.00	: 2.79E-06	3.336-06	3.06E-06	1 3.06E-06	1
t oche w	1	1	!	1	1		1	1	1			t i i i i i i i i i i i i i i i i i i i	ł	;	;
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TABLE B.2 EXP. No. 1 1.8m HEAD 20µm FABRIC

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head 1.8m 20 micron Fabric Exp. No. 1

DATE	; ; ; ; ;	TIME	Time Hours	Change Ninutes	ELAPSED SECONDS	ACCUNUL . Time Hours	TEMP DEG-C	VISC. Corrected	VOLUME	ot 1 REP2	Effluent : REP3	Infiltration	Rate : REP2	ca/s 1 REP3	Average I Infil I co/s
1 june 19	:	10.00	0.00	. 0.00	0.00	. 0.00	24.50	: 0.00		:	:	{			
i june 23	Ì	10.45	96.00	45.00	348300.00	96.75	24.00	0.820	590.00	1440.00	700.00	7.83E-06	: 1.91E-05	9.29E-06	1.21E-05 1
i june 30	1	15.30 :	173.00	45.00	625500.00	270.50	22.00	0.855	310.00	: 630.00	520.00	2.39E-06	8.36E-06	6.90E-06	1 5.88E-06 1
july 5	1	16.45 :	121.00	15.00	436500.00	391.75	22.50	0.845	185.00	: 155.00	180.00	2.02E-06	1 2.06E-06	2.39E-06	: 2.15E-06 ;
i july 9	1	10.30 :	89.00	45.00	323100.00	481.50	24.00	0.820	: 135.00	145.00	130.00	1.93E-06	1.92E-06	1.73E-06	1.86E-06 ;
july 14	1	9.20 ;	130.00	50.00	471000.00	612.33	29.00	0.730	280.00	: 190.00	200.00	2.45E-06	1 2.52E-06	2.65E-06	1 2.54E-06 1
i july 16	:	11.00 :	37.00	40.00	135600.00	650.00	23.00	0.835	60.00	: 50.00	60.00	2.08E-06	1 6.64E-07	7.96E-07	: 1.18E-06 :
t july 20 t	1	9.30 :	94.00 :	30.00	340200.00	744.50	24.50	0.810	150.00	: 100.00	130.00	2.01E-06	1.33E-06	1.73E-06	1.69E-06 :
july 23	ł	8.40 1	71.00 ;	50.00	258600.00	816.33	25.00	0.800	70.00	70.00	100.00	1.22E-06	: 9.29E-07	1.33E-06	1.16E-06
july 27	}	10.45	98.00 ¦	5.00 1	353100.00 :	914.42	24.00	0.820	225.00	: 310.00	190.00	2.95E-06	1 4.11E-06	2.52E-06	: 3.19E-06 i
t july 30 f	1	10.45 ;	72.00 :	0.00	259200.00	986.42	23.00	0.835	105.00	140.00	100.00	1.91E-06	1.86E-06	1.33E-06	1.70E-06 :
l Aug 3 l		10.45	96.00 1	0.00 1	345600.00 :	1082.42	23.00 1	0.835	170.00	120.00	125.00	2.32E-06	1 1.59E-06	1.66E-06	1.86E-06 ;
l Aug 6 l	1	10.45	72.00 :	35.00	261300.00	1155.00	22.00	0.855	105.00	80.00	85.00	1.94E-06	1.06E-06	1.13E-06	1.38E-06 ;
Aug 10		10.20	95.00 i	35.00 1	344100.00 :	1250.58	22.00	0.855	135.00	90.00	125.00	1.89E-06	1.19E-06	1.66E-06	1.58E-06 ;
: Aug 13 :		10.10 ;	71.00	50.00 :	258600.00	1322.42	22.00	0.855	155.00	60.00	105.00	2.89E-06	1 7.96E-07	1.39E-06	1.69E-06 ;
Aug 17	}	9.25 :	95.00	15.00 ;	342900.00	1417.67	24.00 ;	0.820	200.00	90.00	115.00	2.70E-06	1.19E-06	1.53E-06	1.81E-06 ;
1 Aug 20 1	Ì	10.10 ;	72.00	45.00 :	261900.00 :	1490.42	22.00	0.855	195.00	95.00	205.00	3.59E-06	: 1.26E-06	2.72E-06	2.52E-06 1
1 Aug 27	1	10.10 1	168.00 :	0.00	604800.00 1	1658.42	18.00	0.915	365.00	270.00	250.00	3.11E-06	3.58E-06	3.32E-06	1 3.34E-06 1
Sept 2		15.00 :	148.00	50.00 :	535800.00 :	1807.25	20.00	0.885	300.00	280.00	240.00	2.79E-06	3.72E-06	3.19E-06	3.23E-06 :
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TABLE B.3 EXP. No. 1 2.7m HEAD 20µm FABRIC

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head 2.7m 20 micron Fabric Exp. No. 1

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DATE	TINE	Time Hours	Change Minutes	ELAPSED Seconds	ACCUMUL. TIME HOURS	TEMP DEG-C	VISC. CORRECTED	VOLUME	of 1 REP2	Effluent I REP3	Infiltration	Rate REP2 t	ca/s 	Average Intil ca/s
<pre>i june 18 june 22 june 29 july 5 july 9 july 14 july 14 july 16 july 20 july 23 july 27 july 30 Aug 3 Aug 6 Aug 10 Aug 13 Aug 17 Aug 20 Aug 27 Sept 2 i </pre>	14.00 10.30 14.00 10.30 10.30 9.15 11.00 9.25 8.30 10.35 10.35 10.35 10.35 10.35 10.35 10.35 10.00 9.20 10.00 10.00 10.00 10.00 10.00	0.00 92.00 171.00 146.00 90.00 130.00 37.00 94.00 71.00 98.00 71.00 95.00 71.00 95.00 71.00 95.00 71.00 168.00	$\begin{array}{c} 0.00\\ 30.00\\ 30.00\\ 30.00\\ 0.00\\ 45.00\\ 45.00\\ 25.00\\ 5.00\\ 5.00\\ 5.00\\ 5.00\\ 5.00\\ 5.00\\ 0.00\\ 5.00\\ 0.00\\ 10.00\\ 10.00\\ 0.00\\ 10.00\\ 0.$	0.00 333000.00 617400.00 527400.00 324000.00 470700.00 135900.00 339900.00 255900.00 345900.00 345900.00 345900.00 344400.00 258300.00 343200.00 343200.00 537000.00	0.00 92.50 264.00 410.50 500.50 631.25 669.00 763.42 834.50 932.58 1004.58 1100.67 1172.58 1268.25 1340.00 1435.33 1508.00 1676.00 1825.17	24.50 23.00 21.00 22.50 24.00 29.00 23.00 24.50 25.00 24.50 23.00 23.00 23.00 23.00 23.00 22.00 22.00 22.00 22.00 22.00 18.00 20.00	 0.00 0.835 0.870 0.845 0.820 0.730 0.835 0.810 0.800 0.820 0.835 0.835 0.855 0.895 0.895 	540.00 540.00 190.00 190.00 110.00 190.00 40.00 100.00 140.00 90.00 105.00 80.00 100.00 120.00 100.00 120.00 1140.00 540.00 1140.00	<pre> 1015.00 335.00 190.00 120.00 250.00 120.00 120.00 120.00 120.00 160.00 160.00 15.00 100.00 85.00 100.00 85.00 110.00 85.00 110.00 170.00 150.00</pre>	<pre> 915.00 310.00 200.00 110.00 200.00 110.00 200.00 120.00 120.00 120.00 140.00 B0.00 115.00 B0.00 115.00 B0.00 105.00 105.00 140.</pre>	7.63E-06 : 2.38E-06 : 1.72E-06 : 1.57E-06 : 1.66E-06 : 1.48E-06 : 1.48E-06 : 1.48E-06 : 1.43E-06 : 1.43E-06 : 1.43E-06 : 1.43E-06 : 1.49E-06 : 1.49E-06 : 1.49E-06 : 1.35E-06 : 2.24E-06 : 1.35E-06 : 3.29E-06 : 5.02E-06 :	1.43E-05 4.74E-06 2.69E-06 1.70E-06 3.53E-06 9.89E-07 1.70E-06 1.27E-06 1.27E-06 1.20E-06 1.43E-06 1.41E-06 1.20E-06 1.27E-06 2.40E-06 2.12E-06 1.2E-06	1.29E-05 : 4.38E-06 : 2.83E-06 : 1.55E-06 : 2.83E-06 : 2.83E-06 : 1.70E-06 : 1.70E-06 : 1.98E-06 : 1.13E-06 : 1.13E-06 : 1.13E-06 : 1.48E-06 : 1.48E-06 : 1.98E-06 : 1.98E-06 :	1.16E-03 3.83E-06 2.41E-06 1.61E-06 1.62E-06 1.32E-06 1.32E-06 1.32E-06 1.32E-06 1.32E-06 1.36E-06 1.46E-06 1.46E-06 3.66E-06 3.04E-06

TABLE B.4 EXP. No. 1 0.9m HEAD 30µm FABRIC

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nead 0.9m 30 micron Fabric Exp. No. 1

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: ! DATE	 ! Tinf	1	Time	Change	 ! ELAPSEN	ACCUMUL.	TEMP	· · VISC.	Volume	of	Effluent	Infiltration	Rate	ce/s	Average
1 DATE	: : !	י 	Hours	Minutes	SECONDS	HOURS			REP1	REP2	REP3	REP1	REP2	REP3	
! iune 19	1 10	10 I	۰۰۰۰۰	0 00		· · · · · · · · · · · · · · · · · · ·		i	i	· ; -	i	;			ii
1 June 17	1 10.	10 I	01.00	1 0.00	1 U.VU	· 0.00	i 24.30	i 0.09	i 1 460 00	i 1 440 00	i 1 470 00				
i june 10	1 10. L 14	10 1 10 1	172 00	1 20.00	1 110000.00	1 70.JJ	1 24.00		i 400.00	i 440.00	i 430.00	i 6.00E-06	1 J.865-06	3./3E-06	i 3.86E-06 i
i june so	r 17. 1 12	40 I	172.00			i 200.JV		i V.833	1 200.00	: 220.00	1 210.00	i 2.33E-06	1 4.40E-06	4.13E-06	1 3.62E-06 1
i july J	1 10.	93 i 78 i	122.00	i J.VV	i 437300.00	i 390.38	i 22.30	i U.843	160.00	1 265.00	i 140.00	1.73E-06	3.53E-06	1.87E-06	2.38E-06 I
i july Y	· 7.	30 i	00.00	i 43.00	1 214200.00	4/9.33	24.00	0.820	; 110.00	1 150.00	1 100.00	1.59E-06	2.00E-06	1.33E-06	1.64E-06 ;
i july 14	i 20.	43 i	131.00	15.00	i 4/2500.00	610.58	29.00	0.730	220.00	240.00	180.00	1.92E-06	3.20E-06	2.40E-06	1 2.50E-06 I
i july 16	10.	00 :	37.00	15.00	134100.00	647.83	23.00	0.835	1 60.00	80.00	1 60.00	2.11E-06	1.07E-06	8.00E-07	1.32E-06 :
i july 20	: 9.	20 1	95.00	20.00	343200.00	743.17	24.50	0.B10	100.00	300.00	: 100.00	1.33E-06	4.00E-06	1.33E-06	: 2.22E-06 :
l july 23	; 9.	30 1	72.00	10.00	259800.00	015.33	25.00	0.800	70.00	: 130.00	80.00	1.22E-06	1.73E-06	1.07E-06	1 1.34E-06 ;
l july 27	10.	20 1	96.00	50.00	348600.00	912.17	26.00	0.780	120.00	: 290.00	115.00	1.51E-06	3.87E-06	1.53E-06	2.30E-06 ;
l july 30	: 9.	45 I	71.00	25.00	257100.00	983.58	23.00	0.835	115.00	165.00	65.00	2.11E-06	2.208-06	8.66E-07	1.72E-06 1
l Aug 3	: 10.	15	96.00	30.00	347400.00	1080.08	23.00	0.835	155.00	: 340.00	85.00	2.10E-06	4.53E-06	1.13E-06	2.59E-06 ;
l Aug 6	19.	50 l	71.00	35.00	257700.00	1151.67	22.00	Ú.855	70.00	: 240.00	65.00	1.31E-06	3.20E-06	8.66E-07	1.79E-06 :
t Aug 10	: 10.	45 ;	96.00	55.00	348900.00	1248.58	22.00	0.855	85.00	300.00	80.00	1.17E-06	4.00E-06	1.07E-06	2.08E-06 :
l Aug 13	; 9.	20 ł	70.00	35.00	254100.00	1319.17	22.00	0.855	65.00	130.00	1 60.00	1.23E-04	1.736-04	8 00E-07	1 24E-04 1
: Aug 17	: 9.	00 :	95.00	40.00	344400.00	1414.43	24 Aŭ	0 820	100 00	190.00	20.00	1 145-04	2 515-04	8 116-07	· 1 LOE_AL ·
l Aug 20	. 9.	70 !	72.00	20.00	240400 00	1487 17	27.00	0.020 0.055	4 45 00	1 100.00	1 70.00	1.JAC 00		1.33E-V7	1 1.075-VG 1 1 1.75 A/ 1
! Aug 27	. ,. ! q	20 1	149 00 9			1 1455 17	16 AA	· · · · · · · · · · · · · · · · · · ·	1 0J.VV	1 TAE AA	+ 30.00		1 2.9VE-VG 1	4.00E-07	i 1.33E-06 i
1 Goot 7	· · ·	1 0 1	144 00 0		530000 00 I	1033.17	10.00			1 343.00			1 4.8VE-VO 1	1.0/2-06	i 2.20E-VD i
i aehr X	1 IV.	1 90	111.00	0 10.00	1 JZV8VV.00	1/77.03	29.00	CBB.V	i 110.00	i 210.00	i 130.00	i 1.03E-06	4.13E-06	2.00E-06	1 2.39E-06 1
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TABLE B.5 KXP. No. 1 1.8m HEAD 30µm FABRIC

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head 1.8m 30 micron Fabric Exp. No. 1

Image: Time Change: ACCUMUL. TEMP VISC. VOLUME of Effluent Infiltration Rate Ca/s DATE TIME Hours Hinutes SECONDS HOURS REP1 REP2 REP1 REP1 REP1 REP2 REP3 june 19 9.45 0.00 0.00 0.00 96.25 24.50 0.00 1130.00 570.00 8.746-06 1.51E-05 7.60E june 23 10.00 96.00 15.00 346500.00 96.25 22.50 0.845 160.00 195.00 130.00 1.74E-06 1.51E-05 7.60E july 5 16.30 122.00 0.00 370.75 22.50 0.845 160.00 190.00 1.55E-06 2.40E-64 1.51E-06 2.40E-64 1.41E-66 1.41EE 1.41E<	1						!	!	!	!	!			!				- 1
i Hours Hou	1	NATE		TIME	Time	Change		ACCUMUL.	TENP ! DEG-C	VISC.	I VOLUME	of	Effluent	' Infiltration	Rate	ce/s	· Average ! Intil	:
i june 19 9.45 0.00 0.00 0.00 0.00 24.50 0.00 24.50 0.00 1130.00 570.00 8.94E-06 1.51E-05 7.60E june 30 14.30 172.00 30.00 621000.00 268.75 22.00 0.855 340.00 195.00 330.00 2.64E-06 2.64E-06 2.60E-06 4.40E july 5 16.30 122.00 0.00 439200.00 390.75 22.50 0.855 340.00 195.00 130.00 1.74E-06 2.40E- july 7 9, 50 89.00 0.00 320400.00 479.75 24.00 0.825 120.00 130.00 1.74E-06 2.40E- july 14 8.45 131.00 15.00 134100.00 648.25 23.00 0.835 190.00 150.00 190.00 1.65E-06 2.00E-06 2.53E- i july 20 9.15 95.00 45.00 34700.00 744.00 24.50 0.810 100.00 100.00 100.00 1.52E-06 3.34E-07 6.47E- i july 21 9.15 95.00 45.00 347400.00 744.00 24.50 0.810 100.00 100.00 100.00 1.52E-06 3.34E-07 6.47E- i july 23 9.40 72.00 25.00 257100.00 816.42 25.00 0.805 175.00 45.00 150.00 1.52E-06 1.13E-06 1.40E- i july 30 9.35 71.00 25.00 257100.00 912.92 26.00 0.780 120.00 85.00 135.00 1.52E-06 1.13E-06 1.40E- i july 30 9.35 71.00 25.00 257100.00 984.33 23.00 0.835 70.00 85.00 135.00 1.52E-06 1.13E-06 1.40E- i guly 31 10.10 96.00 35.00 347400.00 912.92 26.00 0.780 120.00 85.00 135.00 1.52E-06 1.13E-06 1.40E- i guly 31 0.10 96.00 35.00 347400.00 912.92 20.00 0.855 175.00 150.00 135.00 1.52E-06 1.13E-06 1.40E- i guly 31 0.10 96.00 35.00 347400.00 1129.12 22 20.00 0.855 155.00 55.00 75.00 1.28E-06 1.33E-06 1.43E- i guly 31 0.10 96.00 35.00 34700.00 1129.42 22.00 0.855 155.00 55.00 75.00 1.50E-66 7.34E-07 1.00E- i Aug 31 0.10 97.00 20.00 257400.00 1129.42 22.00 0.855 90.00 100.00 3.03E-66 1.33E-66 1.33E- i Aug 13 9.10 70.00 20.00 253200.00 1319.92 22.00 0.855 90.00 45.00 80.00 1.71E-66 1.60E-06 7.34E-07 1.00E- i Aug 20 9.10 7.00	1	VMIC	, ; ,_,_		Hours	Minutes	SECONDS	HOURS	 	 	REP1 !	I REP2	I REP3	REP1 !	REP2	REP3	: ca/s	 -1
i june 23 : 10.00 : 96.00 : 15.00 : 346500.00 : 96.25 : 24.00 : 0.820 : 670.00 : 1130.00 : 570.00 : 8.94E-06 : 1.51E-05 : 7.60E j june 30 : 14.30 : 172.00 : 30.00 : 621000.00 : 268.75 : 22.00 : 0.855 : 340.00 : 195.00 : 330.00 : 2.64E-06 : 2.60E-06 : 4.40E j july 5 : 16.30 : 122.00 : 0.00 : 439200.00 : 390.75 : 22.50 : 0.845 : 160.00 : 110.00 : 180.90 : 1.74E-06 : 1.47E-06 : 2.40E-06 : 4.40E j july 7 : 9.30 : 89.00 : 0.00 : 439200.00 : 390.75 : 22.50 : 0.845 : 160.00 : 190.00 : 130.00 : 1.74E-06 : 1.47E-06 : 2.40E-06 : 2.53E j july 14 : 8.45 : 131.00 : 15.00 : 472500.00 : 611.00 : 29.00 : 0.730 : 190.00 : 150.00 : 190.00 : 1.55E-06 : 2.00E-06 : 2.53E j july 16 : 10.00 : 37.00 : 15.00 : 134100.00 : 648.25 : 23.00 : 0.813 : 50.00 : 40.00 : 50.00 : 1.73E-06 : 5.34E-07 : 6.57E j july 23 : 9.40 : 72.00 : 25.00 : 344700.00 : 744.00 : 24.50 : 0.810 : 100.00 : 120.00 : 1.32E-06 : 1.33E-06 :	¦ ¦j	une 19		9.45	0.00	. 0.00	I 0.00	. 0.00	24.50	. 0.00	1	1	!	1	:	1	1	ł
i jung 30 : 14.30 : 172.00 : 30.00 : 621000.00 : 268.75 : 22.00 : 0.855 : 340.00 : 195.00 : 330.00 : 2.64E-06 : 2.64E-06 : 2.64E-06 : 2.40E-06 : jung 5 : 16.30 : 122.00 : 0.00 : 437200.00 : 370.75 : 22.50 : 0.845 : 160.00 : 110.00 : 180.00 : 1.74E-06 : 1.47E-06 : 2.40E-07 : 1.37E-16 : jung 7 : 9.30 : 89.00 : 0.00 : 320400.00 : 479.75 : 24.00 : 0.820 : 120.00 : 70.00 : 130.00 : 1.5E-06 : 2.00E-06 : 2.33E-07 : 1.73E-06 : jung 7 : 9.30 : 15.00 : 15.00 : 130.00 : 15.00 : 15.00 : 641.100 : 29.00 : 0.730 : 150.00 : 150.00 : 1.5E-06 : 2.00E-06 : 2.33E-07 : 1.73E-06 : jung 70 : 9.15 : 95.00 : 15.00 : 134100.00 : 648.25 : 23.00 : 0.835 : 50.00 : 40.00 : 50.00 : 1.5E-06 : 5.34E-07 : 6.67E-1 jung 20 : 9.15 : 95.00 : 45.00 : 344700.00 : 744.00 : 24.50 : 0.810 : 100.00 : 100.00 : 120.00 : 1.5E-06 : 1.33E-06 : 1.33E-06 : 1.42E-07 : 1.33E-10 : 1.33E-06 : 1.33E-	ij	une 23	1	10.00	96.00	15.00	346500.00	96.25	24.00	0.820	670.00	1130.00	570.00	B.94E-06	1.51E-05	1 7.60E-06	1 1.05E-05	1
i july 5 16.30 122.00 0.00 43920.00 390.75 22.50 0.845 160.00 110.00 180.90 1.74E-06 1.47E-06 2.47E july 14 8.45 131.00 150.01 47250.00 611.00 29.00 0.730 190.00 150.00 1.75E-06 3.4E-07 1.73E july 14 8.45 131.00 150.01 47250.00 611.00 24.50 0.835 50.00 40.00 50.00 1.75E-06 3.34E-07 1.73E july 20 9.15 95.00 45.00 344700.00 744.00 24.50 0.815 50.00 400.00 50.00 1.75E-06 3.34E-07 1.33E july 21 9.15 95.00 45.00 344700.00 744.00 24.50 0.815 50.00 400.00 50.00 1.55E-06 8.67E-07 1.33E july 21 9.40 72.00 25.00 26070.00 816.42 25.00 0.800 90.00 65.00 85.00 1.55E-06 8.67E-07 1.33E july 21 9.35 71.00 25.00 257100.00 912.92 26.00 0.780 120.00 85.00 1.55E-06 1.56E-06 8.67E-07 1.33E i july 30 9.35 71.00 25.00 347400.00 912.92 26.00 0.780 120.00 85.00 1.52E-06 1.33E-06 1.33E-06 1.33E i july 30 9.35 71.00 25.00 257100.00 984.33 23.00 0.835 70.00 55.00 75.00 1.52E-06 1.78E-06 1.33E- i Aug 3 10.10 96.00 30.00 347400.00 1132.42 22.00 0.835 70.00 55.00 75.00 3.09E-06 7.34E-07 1.00E Aug 3 0.10 70.00 20.00 253200.00 1319.92 22.00 0.835 70.00 85.00 100.00 3.03E-06 1.33E-06 1.33E- Aug 13 9.10 70.00 20.00 253200.00 1319.92 22.00 0.855 20.00 85.00 100.00 3.03E-06 1.33E- Aug 13 9.10 70.00 20.00 253200.00 1319.92 22.00 0.855 90.00 45.00 80.00 1.71E-06 4.00E- Aug 20 9.10 7.200 15.00 26010.00 1487.92 22.00 0.855 90.00 100.00 2.82E-06 1.20E-06 1.33E- Aug 27 9.10 72.00 15.00 26010.00 1487.92 22.00 0.855 90.00 100.00 2.82E-06 1.20E-06 1.33E- Aug 27 9.10 72.00 15.00 26010.00 1487.92 22.00 0.855 90.00 100.00 1.00.00 2.82E-06 1.20E-06 1.33E- Aug 27 9.10 168.00 0.00 604880.00 1455.92 18.00 0.915 675.00 140.00 80.7	ij	une 30	1	14.30	172.00	30.00	621000.00	268.75	1 22.00	0.855	1 340.00	: 195.00	330.00	: 2.64E-06	2.60E-06	: 4.40E-06	3.21E-06	ł
i july 9 ; 9.30 ; 89.00 ; 0.00 ; 320400.00 ; 479.75 ; 24.00 ; 0.820 ; 120.00 ; 70.00 ; 130.00 ; 1.73E-06 ; 9.34E-07 ; 1.73E july 14 ; 8.45 ; 131.00 ; 15.00 ; 472500.00 ; 611.00 ; 29.00 ; 0.730 ; 190.00 ; 150.00 ; 190.00 ; 1.65E-06 ; 2.00E-06 ; 2.53E july 20 ; 9.15 ; 95.00 ; 45.00 ; 334700.00 ; 744.00 ; 24.50 ; 0.810 ; 100.00 ; 100.00 ; 120.00 ; 1.75E-06 ; 5.34E-07 ; 1.33E- july 21 ; 9.40 ; 72.00 ; 25.00 ; 260700.00 ; 816.42 ; 25.00 ; 0.805 ; 0.810 ; 100.00 ; 120.00 ; 1.55E-06 ; 0.34E-07 ; 1.33E- i july 23 ; 9.40 ; 72.00 ; 25.00 ; 260700.00 ; 816.42 ; 25.00 ; 0.800 ; 0.700 ; 90.00 ; 85.00 ; 1.55E-06 ; 0.45E-07 ; 1.33E- i july 23 ; 9.40 ; 72.00 ; 25.00 ; 260700.00 ; 816.42 ; 25.00 ; 0.800 ; 0.700 ; 90.00 ; 85.00 ; 1.55E-06 ; 0.45E-07 ; 1.33E- i july 30 ; 9.35 ; 71.00 ; 25.00 ; 257100.00 ; 984.33 ; 23.00 ; 0.805 ; 70.00 ; 55.00 ; 75.00 ; 1.52E-06 ; 1.32E-06 ; 1.33E-06 ; 1.38E- i july 30 ; 9.35 ; 71.00 ; 25.00 ; 257100.00 ; 984.33 ; 23.00 ; 0.835 ; 70.00 ; 55.00 ; 75.00 ; 1.52E-06 ; 1.32E-06 ; 1.33E-06 ; 1.400 ; 0.00 ; 1487.92 ; 22.00 ;	lj	uly 5	1	16.30	122.00	0.00	439200.00	: 390.75	22.50	0.845	160.00	110.00	180.00	1.74E-06	1.47E-06	2.40E-06	1.87E-06	:
i july 14 : 8.45 : 131.00 : 15.00 : 472500.00 : 611.00 : 29.00 : 0.730 : 190.00 : 150.00 : 1.65E-06 : 2.00E-06 : 2.33E- i july 16 : 10.00 : 37.00 : 15.00 : 134100.00 : 648.25 : 23.00 : 0.835 : 50.00 : 40.00 : 50.00 : 1.75E-06 : 5.34E-07 : 6.7E july 20 : 9.15 : 95.00 : 45.00 : 344700.00 : 744.00 : 24.50 : 0.810 : 100.00 : 120.00 : 1.32E-06 : 1.33E-06 : 1.60E july 23 : 9.40 : 72.00 : 25.00 : 260700.00 : 816.42 : 25.00 : 0.800 ! 90.00 : 65.00 ! 135.00 ! 1.52E-06 ! 1.13E-06 ! 1.60E july 30 : 9.35 : 71.00 : 25.00 ! 257100.00 ! 984.33 ! 23.00 ! 0.835 ! 70.00 ! 135.00 ! 1.28E-06 ! 1.32E-06 ! 1.32E-07 ! 1.00E july 30 : 9.35 : 71.00 ! 25.00 !	1 j	uly 9	ł	9.30	89.00	0.00	320400.00	479.75	24.00	0.820	120.00	70.00	130.00	1.73E-06	9.34E-07	1.73E-06	1.47E-06	ł
<pre>: july 16 : 10.00 : 37.00 : 15.00 : 134100.00 : 648.25 : 23.00 : 0.835 : 50.00 : 40.00 : 50.00 : 1.75E-06 : 5.34E-07 : 6.67E : july 20 : 9.15 : 95.00 : 45.00 : 344700.00 : 744.00 : 24.50 : 0.810 : 100.00 : 100.00 : 120.00 : 1.32E-06 : 1.33E-06 : 1.60E : july 23 : 9.40 : 72.00 : 25.00 : 260700.00 : 816.42 : 25.00 : 0.800 : 970.00 : 65.00 : 85.00 : 1.56E-06 : 8.67E-07 : 1.13E : july 30 : 9.35 : 71.00 : 25.00 : 257100.00 : 994.33 : 23.00 : 0.835 : 70.00 : 55.00 : 75.00 : 1.52E-06 : 1.32E-06 : 1.32E-</pre>	lj	uly 14	1	8.45 1	131.00	15.00	472500.00	611.00	29.00	: 0.730	: 190.00	150.00	: 190.00	1.65E-06	2.00E-06	: 2.53E-06	2.06E-06	1
i july 20: 9.15: 95.00: 45.00: 344700.00: 744.00: 24.50: 0.810: 100.00: 120.00: 1.32E-06: 1.32E-06:<	¦ j	uly 16	1	10.00	37.00	15.00	134100.00	648.25	23.00	: 0.835	1 50.00	40.00	1 50.00	1.75E-06	1 5.34E-07	6.67E-07	1 9.85E-07	1
i july 23 : 9.40 : 72.00 : 25.00 : 260700.00 : 816.42 : 25.00 : 0.800 : 90.00 : 65.00 : 85.00 : 1.56E-06 : 8.67E-07 : 1.13E i july 27 : 10.10 : 96.00 : 30.00 : 347400.00 : 912.92 : 26.00 : 0.780 : 120.00 : 85.00 : 1.52E-06 : 1.13E-06 : 1.80E j july 30 : 9.35 : 71.00 : 25.00 : 257100.00 : 984.33 : 23.00 : 0.835 : 70.00 : 55.00 : 1.52E-06 : 1.13E-06 : 1.80E Aug 3 : 10.10 : 96.00 : 35.00 : 347700.00 : 1080.92 : 23.00 : 0.835 : 175.00 : 95.00 : 15.00 : 2.37E-06 : 1.32E-06 : 1.33E Aug 4 : 9.40 : 71.00 : 30.00 : 257400.00 : 1152.42 : 22.00 : 0.855 : 165.00 : 55.00 : 75.00 : 3.09E-06 : 7.34E-07 : 1.00E Aug 10 : 10.50 : 97.00 : 10.00 : 349800.00 : 1249.58 : 22.00 : 0.855 : 90.00 : 45.00 : 80.00 : 1.71E-06 : 1.33E-06 :<	ij	uly 20	:	9.15 ;	95.00	45.00	1 344700.00	744.00	24.50	0.810	100.00	: 100.00	120.00	1.32E-06	: 1.33E-06	1.60E-06	1.42E-06	ł
i july 27 : 10.10 : 96.00 : 30.00 : 347400.00 : 912.92 : 26.00 : 0.780 : 120.00 : 85.00 : 135.00 : 1.52E-06 : 1.13E-06 : 1.80E i july 30 : 9.35 : 71.00 : 25.00 : 257100.00 : 984.33 : 23.00 : 0.835 : 70.00 : 55.00 : 75.00 : 1.28E-06 : 7.34E-07 : 1.00E i Aug 3 : 10.10 : 96.00 : 35.00 : 347700.00 : 1080.92 : 23.00 : 0.835 : 175.00 : 95.00 : 115.00 : 2.37E-06 : 1.27E-06 : 1.53E i Aug 6 : 9.40 : 71.00 : 30.00 : 257400.00 : 1152.42 : 22.00 : 0.855 : 165.00 : 55.00 : 75.00 : 3.09E-06 : 7.34E-07 : 1.00E i Aug 10 : 10.50 : 97.00 : 10.00 : 349800.00 : 1249.58 : 22.00 : 0.855 : 165.00 : 55.00 : 75.00 : 3.03E-06 : 1.13E-06 : 1.33E i Aug 13 : 9.10 : 70.00 : 20.00 : 253200.00 : 1319.92 : 22.00 : 0.855 : 90.00 : 45.00 : 80.00 : 1.71E-06 : 6.00E-07 : 1.07E i Aug 17 : 8.55 : 95.00 : 45.00 : 344700.00 : 1415.67 : 24.00 : 0.855 : 90.00 : 45.00 : 80.00 : 1.71E-06 : 6.00E-07 : 1.07E i Aug 20 : 9.10 : 72.00 : 15.00 : 260100.00 : 1487.92 : 22.00 : 0.855 : 405.00 : 75.00 : 70.00 : 2.82E-06 : 1.20E-06 : 1.33E i Aug 27 : 9.10 : 168.00 : 0.00 : 604800.00 : 1655.92 : 18.00 : 0.915 : 675.00 : 160.00 : 5.76E-06 : 1.00E-06 : 9.34E i Aug 27 : 9.10 : 168.00 : 0.00 : 534000.00 : 1655.92 : 18.00 : 0.915 : 675.00 : 140.00 : 165.00 : 5.76E-06 : 1.60E-06 : 9.34E i i i i i i i i i i i i i i i i i i i	1 j	uly 23	1	9.40	72.00	25.00	: 260700.00	816.42	25.00	0.800	90.00	65.00	85.00	1.56E-06	8.67E-07	1.13E-06	1.19E-06	1
i july 30 : 9.35 : 71.00 : 25.00 : 257100.00 : 984.33 : 23.00 : 0.835 : 70.00 : 55.00 : 75.00 : 1.28E-06 : 7.34E-07 : 1.00E Aug 3 : 10.10 : 96.00 : 35.00 : 347700.00 : 1080.92 : 23.00 : 0.835 : 175.00 : 95.00 : 115.00 : 2.37E-06 : 1.27E-06 : 1.53E Aug 6 : 9.40 : 71.00 : 30.00 : 257400.00 : 1152.42 : 22.00 : 0.855 : 165.00 : 55.00 : 75.00 : 3.09E-06 : 7.34E-07 : 1.00E Aug 10 : 10.50 : 97.00 : 10.00 : 349800.00 : 1249.58 : 22.00 : 0.855 : 220.00 : 85.00 : 100.00 : 3.03E-06 : 1.13E-06 : 1.33E Aug 13 : 9.10 : 70.00 : 20.00 : 253200.00 : 1319.92 : 22.00 : 0.855 : 90.00 : 45.00 : 80.00 : 1.71E-06 : 6.00E-07 : 1.07E Aug 17 : 8.55 : 95.00 : 45.00 : 344700.00 : 1415.67 : 24.00 : 0.820 : 210.00 : 90.00 : 100.00 : 2.82E-06 : 1.20E-06 : 1.33E Aug 20 : 9.10 : 72.00 : 15.00 : 260100.00 : 1487.92 : 22.00 : 0.855 : 405.00 : 75.00 : 70.00 : 7.50E-06 : 1.00E-06 : 9.34E Aug 27 : 9.10 : 168.00 : 0.00 : 604800.00 : 1655.92 : 18.00 : 0.915 : 675.00 : 140.00 : 165.00 : 5.76E-06 : 1.87E-06 : 2.20E Sept 2 : 13.30 : 148.00 : 20.00 : 534000.00 : 1655.92 : 18.00 : 0.915 : 675.00 : 140.00 : 165.00 : 5.76E-06 : 1.87E-06 : 2.20E Sept 2 : 13.30 : 148.00 : 20.00 : 534000.00 : 1655.92 : 20.00 : 0.855 : 875.00 : 120.00 : 140.00 : 8.17E-06 : 1.60E-06 : 1.87E-06	łj	ulý 27	:	10.10	96.00	30.00	: 347400.00	912.92	26.00	0.780	120.00	85.00	135.00	1.52E-06	1.13E-06	1.80E-06	1.48E-06	1
i Aug 3 i 10.10 96.00 i 35.00 i 347700.00 i 1080.92 i 23.00 i 0.835 i 175.00 i 95.00 i 115.00 i 2.37E-06 i 1.27E-06 i 1.53E i Aug 6 9.40 71.00 30.00 i 257400.00 i 1152.42 i 22.00 i 0.855 i 165.00 i 55.00 i 75.00 i 3.09E-06 i 7.34E-07 i 1.00E i Aug 10 i 10.50 97.00 i 10.00 i 349800.00 i 1249.58 i 22.00 i 0.855 i 220.00 i 85.00 i 100.00 i 3.03E-06 i 1.13E-06 i 1.33E i Aug 13 9.10 70.00 i 20.00 i 253200.00 i 1319.92 i 22.00 i 0.855 i 90.00 i 45.00 i 80.00 i 1.71E-06 i 6.00E-07 i 1.33E i Aug 17 8.55 95.00 i 45.00 i 344700.00 i 1415.67 i 24.00 i 0.820 i 210.00 i 90.00 i 100.00 i 2.82E-06 i 1.30E-06 i 1.33E i Aug 20 9.10 72.00 i 15.00 i 260100.00 i 1487.92 i 22.00 i 0.855 i 405.00 i 70.00 i 7.50E-06 i	ij	uly 30		9.35 ;	71.00	25.00	: 257100.00	: 984.33	23.00	0.835	70.00	: 55.00	75.00	1.28E-06	: 7.34E-07	1.00E-06	1.01E-06	:
I Aug 6 9.40 71.00 30.00 257400.00 1152.42 22.00 0.855 165.00 55.00 75.00 3.09E-06 7.34E-07 1.00E I Aug 10 10.50 97.00 10.00 349800.00 1249.58 22.00 0.855 220.00 85.00 100.00 3.03E-06 1.13E-06 1.33E I Aug 13 9.10 70.00 20.00 253200.00 1319.92 22.00 0.855 90.00 45.00 80.00 1.71E-06 6.00E-07 1.07E I Aug 17 8.55 95.00 45.00 344700.00 1415.67 24.00 0.820 210.00 90.00 100.00 2.82E-06 1.20E-06 1.33E I Aug 20 9.10 72.00 15.00 260100.00 1487.92 22.00 0.855 405.00 70.00 7.50E-06 1.00E-06 9.34E I Aug 27 9.10 72.00 15.00 260100.00 1655.92 18.00 0.915 675.00 140.00 165.00 5.76E-06 1.87E-06 2.20E Sept 2 13.30 148.00	1	Aug 3	1	10.10 ;	96.00	35.00	1 347700.00	1080.92	23.00	0.835	175.00	95.00	115.00	2.37E-06	1.27E-06	1 1.53E-06	1.72E-06	ł
Aug 10 10.50 97.00 10.00 349800.00 1249.58 22.00 0.855 220.00 85.00 100.00 3.03E-06 1.13E-06 1.33E Aug 13 9.10 70.00 20.00 253200.00 1319.92 22.00 0.855 90.00 45.00 80.00 1.71E-06 6.00E-07 1.07E Aug 17 8.55 95.00 45.00 344700.00 1415.67 24.00 0.820 210.00 90.00 100.00 2.82E-06 1.20E-06 1.33E Aug 20 9.10 72.00 15.00 260100.00 1487.92 22.00 0.855 405.00 75.00 70.00 7.50E-06 1.00E-06 9.34E Aug 27 9.10 168.00 0.00 604800.00 1655.92 18.00 0.915 675.00 140.00 5.76E-06 1.87E-06 2.20E Sept 2 13.30 148.00 20.00 1804.25 20.00 9.885 875.00 140.00 8.17E-06 1.60E-06 1.87E-06 2.20E Sept 2 13.30 148.00 20.00 1804.25 <td>1</td> <td>Aug 6</td> <td>:</td> <td>9.40</td> <td>71.00</td> <td>30.00</td> <td>257400.00</td> <td>1152.42</td> <td>22.00</td> <td>0.855</td> <td>165.00</td> <td>: 55.00</td> <td>75.00</td> <td>3.09E-06</td> <td>7.34E-07</td> <td>1.00E-06</td> <td>1.61E-06</td> <td>ł</td>	1	Aug 6	:	9.40	71.00	30.00	257400.00	1152.42	22.00	0.855	165.00	: 55.00	75.00	3.09E-06	7.34E-07	1.00E-06	1.61E-06	ł
I Aug 13 9.10 70.00 20.00 253200.00 1319.92 22.00 0.855 90.00 45.00 1.71E-06 6.00E-07 1.07E I Aug 17 8.55 95.00 45.00 344700.00 1415.67 24.00 0.820 210.00 90.00 100.00 2.82E-06 1.20E-06 1.33E I Aug 20 9.10 72.00 15.00 260100.00 1487.92 22.00 0.855 405.00 75.00 70.00 7.50E-06 1.00E-06 9.34E I Aug 27 9.10 168.00 0.00 604800.00 1655.92 18.00 0.915 675.00 140.00 5.76E-06 1.87E-06 2.20E I Sept 2 13.30 148.00 20.00 534000.00 1804.25 20.00 9.885 875.00 120.00 140.00 8.17E-06 1.60E-06 1.87E- I </td <td>Å</td> <td>ua 10</td> <td>Ì</td> <td>10.50</td> <td>97.00</td> <td>10.00</td> <td>349800.00</td> <td>1249.58</td> <td>22.00</td> <td>0.855</td> <td>220.00</td> <td>85.00</td> <td>100.00</td> <td>3.03E-06</td> <td>1.13E-06</td> <td>1.33E-06</td> <td>1.83E-06</td> <td>ł</td>	Å	ua 10	Ì	10.50	97.00	10.00	349800.00	1249.58	22.00	0.855	220.00	85.00	100.00	3.03E-06	1.13E-06	1.33E-06	1.83E-06	ł
Aug 17 B.55 95.00 45.00 344700.00 1415.67 24.00 0.820 210.00 90.00 100.00 2.82E-06 1.20E-06 1.33E Aug 20 9.10 72.00 15.00 260100.00 1487.92 22.00 0.855 405.00 75.00 70.00 7.50E-06 1.00E-06 9.34E Aug 27 9.10 168.00 0.00 604800.00 1655.92 18.00 0.915 675.00 140.00 165.00 5.76E-06 1.87E-06 2.20E Sept 2 13.30 148.00 20.00 534000.00 1804.25 20.00 0.885 875.00 120.00 8.17E-06 1.60E-06 1.87E- I	1 A	un 13	1	9.10	70.00	20.00	: 253200.00	1319.92	22.00	Ú.855	90.00	1 45.00	80.00	1.718-06	6.00E-07	1.07E-06	1.13E-06	:
Aug 20 9.10 72.00 15.00 260100.00 1487.92 22.00 0.855 405.00 75.00 70.00 7.50E-06 1.00E-06 9.34E Aug 27 9.10 168.00 0.00 604800.00 1655.92 18.00 0.915 675.00 140.00 165.00 5.76E-06 1.87E-06 2.20E Sept 2 13.30 148.00 20.00 534000.00 1804.25 20.00 9.885 875.00 120.00 140.00 8.17E-06 1.60E-06 1.87E I	I A	ua 17	i	8.55	95.00	45.00	344700.00	1415.67	24.00	0.820	210.00	1 90.00	100.00	2.82E-06	1.20E-06	1.33E-04	1.785-06	1
Aug 27 : 9.10 : 168.00 : 0.00 : 604800.00 : 1655.92 : 18.00 : 0.915 : 675.00 : 140.00 : 165.00 : 5.76E-06 : 1.87E-06 : 2.20E Sept 2 : 13.30 : 148.00 : 20.00 : 534000.00 : 1804.25 : 20.00 : 9.885 : 875.00 : 120.00 : 140.00 : 8.17E-06 : 1.60E-06 : 1.87E I I I I I I I I I I I I I I I I I I I	1 4	ua 20		9.10	72.00	15.00	260100.00	1487.92	22.00	: 0.855	1 405.00	1 75.00	70.00	7.50E-06	1.00E-06	9.34E-07	3.158-06	i
Sept 2 13.30 148.00 20.00 534000.00 1804.25 20.00 0.885 875.00 120.00 140.00 8.17E-06 1.60E-06 1.87E	: A	ua 27	ì	9.10	168.00	1 0.00	1 604800.00	1655.92	18.00	0.915	1 675.00	140.00	165.00	5.76E-06	1.87E-06	2.70E-04	3.28E-06	1
	1 9	ent 2	1	13.30	148.00	20.00	1 534000.00	1804.25	20.00	. 0.895	1 875.00	120.00	140.00	8.17F-04	1.40E-04	1.87E-04	1 3.88E-04	i
	1		i	10100	110100					;	1	!	!					i
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TABLE B.6 EXP. No. 1 2.7m HEAD 30µm FABRIC

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head 2.7m 30 micron Fabric Exp. No. 1

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		Time	Change		ACCUHUL.	TEMP		VOLUME	of	Effluent	Infiltration	Rate	ce/s	: Average : Intil	1
I DAIL	1186	Hours	Minutes	SECONDS	HOURS		 	REP1	REP2	REP3	REP1	REP2	REP3	ce/s	 -!
! june 19 !	11.15	. 0.00	0.00	0.00	: 0.00	24.50	, , 0.00	• •	1	•				1	1
i june 22 :	14.30	99.00	15.00	357300.00	99.25	23.00	0.835	930.00	1010.00	0.00	1.23E-05	1.33E-05	0.00E+00	1.28E-05	1
l june 29 1	14.30	168.00	0.00	604800.00	267.25	21.00	0.870	615.00	\$20.00	1070.00	4.99E-06	6.85E-06	1.34E-05	1 5.92E-06	ł
july 5	16.30	146.00	0.00	525600.00	413.25	22.50	0.845	220.00	220.00	490.00	1.99E-06	2.90E-06	6.45E-06	2.45E-06	1
ijuly 9	9.30	89.00	0.00	320400.00	502.25	24.00	0.820	: 130.00	120.00	200.00	1.88E-06	1.58E-06	2.63E-06	1.73E-06	:
july 14	8.45	119.00	45.00	431100.00	622.00	29.00	0.730	440.00	200,00	650.00	4.20E-06	2.63E-06	8.56E-06	: 3.42E-06	1
; july 16 ;	10.00	37.00	15.00	134100.00	659.25	23.00	: 0.835	: 160.00	50.00	170.00	5.62E-06	6.59E-07	2.24E-06	: 3.14E-06	;
1 july 20 1	9.00	95.00	0.00	342000.00	754.25	24.50	0.810	400.00	: 120.00	275.00	5.34E-06	1.58E-06	3.62E-06	1 3.46E-06	1
; july 23 ;	9.50	71.00	50.00	258600.00	826.08	25.00	0.800	: 150.00	95.00	130.00	2.62E-06	1.25E-06	1.71E-06	1.93E-06	;
july 27	10.00	96.00	10.00	346200.00	922.25	26.00	0.780	1000.00	: 160.00	165.00	1.27E-05	: 2.11E-06	2.17E-06	: 7.40E-06	;
july 30	9.25	71.00	25.00	257100.00	993.67	23.00	0.835	780.00	90.00	155.00	1.43E-05	1.19E-06	2.04E-06	1 7.73E-06	1
Aug 3	10.00	96.00	35.00	347700.00	1090.25	23.00	0.835	685.00	: 110.00	175.00	9.27E-06	: 1.45E-06 1	2.31E-06	1 5.36E-06	ł
1 Aug 6 1	9.30	71.00	30.00	257400.00	1161.75	22.00	0.855	340.00	: 85.00	110.00	6.37E-06	1.12E-06	1.45E-06	: 3.74E-06	1
: Aug 10 :	10.55	97.00	: 25.00	350700.00	1259.17	22.00	0.855	890.00	: 105.00	150.00	1.22E-05	1.382-06	1.98E-06	: 6.B1E-06	ł
Aug 13	9.00	70.00	5.00	252300.00	1329.25	22.00	0.855	520.00	: 80.00	50.00	9.93E-06	1 1.05E-06	6.59E-07	: 5.49E-06	:
Aug 17	8.50	95.00	50.00	345000.00	1425.08	24.00	0.810	1050.00	: 100.00	150.00	1.39E-05	1.32E-06	1.93E-06	1 7.61E-06	ł
: Aug 20	9.00	72.00	10.00	259800.00	1497.25	22.00	0.855	945.00	: 85.00	55.00	1.75E-05	1.12E-06	· 7.25E-07	1 9.33E-06	ł
Aug 27	11.00	170.00	0.00	612000.00	1667.25	18.00	0.915	1950.00	170.00	435.00	1.64E-05	2.24E-06	5.73E-06	: 9.34E-06	:
: Sept 2	14.20	147.00	: 20.00 I	530400.00	1014.58	20.00	0.885	1130.00	: 150.00	325.00	1.06E-05	1.98E-06	4.28E-06	1 6.30E-06	1
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TABLE B.7 KXP. No. 1 0.9m HEAD 40µm FABRIC

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nead 0.9m 40 micron Fabric Exp. No.1

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I DATE	TIME	Time	Change	L L FLAPSED	ACCUMUL.	I TEMP ! DEG-C	VISC.	VOLUME	of	Effluent	' Infiltration !	Rate	ca/s	Average 1
 	 	Hours	Minutes	SECONDS	HOURS			REP1	REP2	REP3	REP1	REP2	I REP3	ce/s
, i june 19	10.20	0.00	0.00	0.00	0.00	24.50	0.00	:	:	:	; 	;	:	
l june 23	10.30	96.00	10.00	: 346200.00	96.17	24.00	0.820	415.00	: 440.00	465.00	5.54E-06	5.87E-06	6.21E-06	5.B7E-06 ;
1 june 30	14.40	172.00	10.00	619800.00	268.33	22.00	0.855	240.00	240.00	460.00	1.87E-06	3.20E-06	6.14E-06	1 3.74E-06 1
l july 5	16.45	122.00	5.00	439500.00	390.42	22.50	0.845	130.00	140.00	195.00	1.41E-06	1.87E-06	2.60E-06	1 1.96E-06 1
t july 9	10.00	89.00	15.00	321300.00	479.67	24.00	0.820	100.00	100.00	120.00	1.44E-06	1.34E-06	1.60E-06	1.46E-06 ;
i july 14	21.10	131.00	10.00	472200.00	610.83	29.00	0.730	150.00	150.00	390.00	1.31E-06	2.00E-06	5.21E-06	1 2.84E-06 1
july 16	10.30	37.00	20.00	134400.00	648.17	23.00	0.835	40.00	40.00	90.00	1.40E-06	5.34E-07	1.20E-06	: 1.05E-06 ;
july 20	9.30	95.00	0.00	342000.00	743.17	24.50	0.810	95.00	100.00	175.00	1.27E-06	1.34E-06	2.34E-06	: 1.65E-06 ;
july 23	9.20	71.00	50.00	258600.00	815.00	25.00	0.800	75.00	1 70.00	135.00	1.3IE-06	9.35E-07	1.80E-06	1.358-06 1
i july 27 i	10.25	97.00	5.00	: 349500.00	912.08	26.00	0.780	100.00	100.00	365.00	1.26E-06	1.34E-06	4.87E-06	: 2.49E-06 ;
i july 30	10.00	71.00	35.00	257700.00	983.67	23.00	0.835	60.00	70.00	165.00	1.10E-06	9.35E-07	2.20E-06	: 1.41E-06 ;
l Aug 3 l	10.30	96.00	30.00	347400.00	1080.17	23.00	0.835	85.00	75.00	200.00	1.15E-06	1.00E-06	2.67E-06	: 1.61E-06 ;
i Aug 6	10.05	71.00	35.00	257700.00	1151.75	22.00	0.855	60.00	65.00	130.00	1.12E-06	8.68E-07	1.74E-06	: 1.24E-06 ;
: Aug 10 :	10.40	96.00	35.00	347700.00	1248.33	22.00	0.855	70.00	85.00	195.00	9.70E-07	1.13E-06	2.60E-06	: 1.57E-06 ;
: Aug 13	9.30	70.00	50.00	255000.00	1319.17	22.00	0.855	70.00	55.00	105.00	1.32E-06	7.34E-07	1.40E-06	1 1.15E-06 1
: Aug 17	9.05	95.00	35.00	344100.00	1414.75	24.00	0.820	80.00	85.00	170.00	1.07E-06	1.13E-06	2.27E-06	1 1.49E-06 1
L Aug 20	9.30	73.00	25.00	264300.00	1488.17	22.00	0.855	60.00	65.00	260.00	1.09E-06	8.48E-07	3.47E-06	1.81E-06 1
: Aug 27	9.30	168.00	0.00	604800.00	1656.17	18.00	0.915	200.00	130.00	450.00	1.715-06	1.74E-04	: A.01E-0A	1 3.15F-0A 1
Sept 2	10.10	144.00	40.00	520800.00	1800.83	20.00	0.885	145.00	110.00	280.00	1.39F-04	1.47F-04	3.74F-04	1 7.20F-0A 1
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TABLE B.8 EXP. No. 1 1.8m HEAD 40µm FABRIC

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head 1.8m 40 micron Fabric Exp. No. 1

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1		, - ; , т 11	 	Tine	Change		ACCUMUL.	TEMP	VISC.	, ; volune	of	Effluent	Infiltration	Rate	ca/s	Average Infil	1
i 	DHIF	i 110 		Hours	Minutes	SECONDS	HOURS	UEU-L !	1 GUNNEGIEV 1 1 1	REP1	: REP2	REP3	REP1	REP2	REP3	ca/s	 -
i	iune 10	· ! ! ! 1	45 ?	0.00	: 0.00	1 1 0_00	. 0.00	24.50	. 0.00	1	:	1	•				1
	june 17 june 23	· · · · ·	.30 :	94.00	45.00	341100.00	94.75	24.00	0.820	770.00	640.00	600.00	1.04E-05	B.67E-06	8.13E-06	9.08E-06	ł
•	june 30	. IV ! 15	00 !	173 00	1 10100	. 624600.00	268.25	27.00	0.855	410.00	: 380.00	315.00	3.16E-06	5.15E-06	4.27E-06	: 4.19E-06	1
1	june sv	1 IJ ! 16	45 1	121 00	1 45 00	438300.00	: 390.00	22.50	: 0.845	: 170.00	: 175.00	140.00	1.85E-06	2.37E-06	1.90E-06	2.04E-06	1
;	july J	· 10	 	00 00	1 15 00	122300.00	479.25	24.00	0.820	130.00	: 145.00	120.00	1.87E-06	1.96E-06	1.63E-06	: 1.82E-06	:
1	july 7 inly 14	i IV ! 21	00 1 05 !	111 00	5.00	471900.00	! 610.33	29.00	: 0.730	1 200.00	200.00	175.00	1.74E-06	2.71E-06	2.37E-06	: 2.28E-06	1
;	july 14 july 16	1 <u>1</u> 1 10	.05 Ι το Ι	37 00	25 00	134700 00	447.75	: 23.00	0.835	1 50.00	; 70.00	45.00	1.75E-06	9.49E-07	6.10E-07	: 1.10E-06	:
	july 10 july 20	i 9	. 30 1	94.00	50.00	341400.00	1 742.58	24.50	0.810	115.00	: 120.00	110.00	1.54E-06	1.63E-06	1.49E-06	1.55E-06	1
-	july 2V	. , . 0	10 1	71 00	50.00	258400.00	814.42	25.00	: 0.800	90.00	80.00	1 75.00	1.57E-06	1.08E-06	1.02E-06	: 1.22E-06	1
1	july 23	1 1 1 10	10 1 30 !	97 00	20.00	350400.00	911.75	24.50	0.810	1 150.00	: 130.00	190.00	1.95E-06	1.76E-06	2.57E-06	: 2.10E-06	1
	jury 27 july 30	· · ·	16 !	71 00	1 A0 00	258000 00	983.42	23.00	: 0.835	1 65.00	: 80.00	1 70.00	: 1.19E-06	1.08E-06	9.49E-07	: 1.07E-06	. 1
	Aug 3	1 10	75 !	96.00	25.00	347100.00	1079.83	23.00	0.835	1 110.00	105.00	1 95.00	1.49E-06	1.42E-06	1.29E-06	: 1.40E-06	. :
	Aug 5	10	. 15 !	71.00	1 30.00	257400.00	1151.33	22.00	0.855	; 75.00	75.00	1 75.00	1.40E-06	1.02E-06	1.02E-06	: 1.15E-06	
	Aun 10	10	.35	96.00	20.00	346800.00	1247.67	22.00	0.855	100.00	105.00	80.00	1.39E-06	1.42E-06	1.08E-06	1.30E-06	:
	Aug 13	: 9	.40	71.00	5.00	255900.00	1318.75	22.00	1 0.855	1 75.00	: 135.00	: 70.00	1.41E-06	1.83E-06	9.49E-07	1 1.40E-06	. 1
	Aug 17	; 9	.10	95.00	30.00	343800.00	1414.25	24.00	0.820	95.00	: 100.00	90.00	1.20E-06	1.36E-06	1.22E-06	1 1.286-06	1
1	Aug 20	1 9	.40	72.00	30.00	261000.00	1486.75	22.00	: 0.855	: 105.00	150.00	70.00	: 1.94E-06	1 2.03E-06	9.49E-07	1.64E-06	1
1	Aug 27	: 9	.40 :	168.00	: 0.00	604800.00	: 1654.75	18.00	0.915	: 260.00	: 190.00	140.00	2.22E-06	2.57E-06	: 1.90E-06	1 2.23E-06	. 1
1	Sept 2	1 15	.10	149.00	; 30.00	538200.00	1804.25	20.00	0.985	180.00	: 130.00	120.00	1.67E-06	1.76E-06	1.63E-06	i 1.69E-06	, 1
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TABLE B.9 KXP. No. 1 2.7m HEAD 40µm FABRIC

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nead 2.7m 40 micron Fabric Exp. No. 1

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: DATE	: : : 11	NF	Time	Change	! ! FLAPSED	ACCUNUL.	TEMP DEG-C	VISC. ! CORRECTED	I VOLUME	of	Effluent	Infiltration	Rate	cø/s	· Average ! Intil	:
 	 !		Hours	Minutes 	SECONDS	HOURS			REPI	: REP2	REF3	REP1	REP2	REP3	i cs/s	
i june 18	1 1	1.40	0.00	0.00	0.00	0.00	24.50	0.00	:	1			 	;	;	1
l june 22	1 1	4.30	98.00	50.00	355800.00	98.83	23.00	0.835	870.00	650.00	630.00	1.15E-05	8.60E-06	8.33E-06	9.48E-06	1
l june 29	: 1	4.20	167.00	50.00	604200.00	266.67	21.00	0.8 70	: 590.00	: 340.00	320.00	4.79E-06	4.50E-06	4.23E-06	4.51E-06	ł
july 5	: 1	6.30	146.00	10.00	526200.00	412.83	22.50	0.B45	330.00	205.00	200.00	2.99E-06	2.71E-06	2.65E-06	2.78E-06	ł
1 july 9	1	0.00	90.00	30.00	325800.00	503.33	24.00	0.820	140.00	: 125.00	110.00	1.99E-06	: 1.65E-06	1.46E-06	1.70E-06	ł
l july 14	!	9.00	131.00	0.00	471600.00	634.33	29.00	0.730	570.00	190.00	270.00	4.97E-06	2.51E-06	3.57E-06	1 3.69E-06	:
july 16	: 1	0.30	37.00	30.00	135000.00	671.83	23.00	0.835	155.00	50.00	70.00	5.40E-06	6.61E-07	9.26E-07	2.33E-06	;
i july 20	1	9.30	95.00	0.00	342000.00	766.83	24.50	0.B10	205.00	: 115.00	115.00	2.74E-06	1.52E-06	1.52E-06	1.93E-06	ł
; july 23	:	9.00	71.00	i 30.00	257400.00	830.33	25.00	0.B00	145.00	80.00	85.00	2.54E-06	1.06E-06	1.12E-06	1.57E-06	ł
l july 27	1	0.35 #	97.00	35.00	: 351300.00	935.92	24.50	0.81 0	340.00	: 130.00	130.00	4.42E-06	1.72E-06	1.72E-06	2.62E-06	ł
l july 30	1	0.25	71.00	50.00	258600.00	1007.75	23.00	0.835	170.00	80.00	195.00	1 3.09E-06	1.06E-06	2.58E-06	2.24E-05	;
t Aug 3	: 1	0.40	96.00	10.00	346200.00	1103.92	23.00	0.835	130.00	: 110.00	: 110.00	1.77E-06	1.46E-06	1.46E-06	1.56E-06	1
: Aug 6	1 1	0.25	71.00	45.00	258300.00	1175.67	22.00	0.855	B0.00	80.00	80.00	1.49E-06	1.06E-06	1.06E-06	1.20E-06	ł
l Aug 10	: 1	0.30	96.00	5.00	345900.00	1271.75	22.00	0.855	140.00	100.00	110.00	1.95E-06	1.32E-06	1.46E-06	1.58E-06	ł
: Aug 13	1	9.50	71.00	20.00	256800.00	1343.08	22.00	0.855	120.00	1 75.00	70.00	2.25E-06	9.92E-07	9.26E-07	1.39E-06	:
1 Aug 17	:	9.15	95.00	25.00	343500.00	1438.50	24.00	0.820	150.00	: 105.00	100.00	2.02E-06	1.39E-06	1.32E-06	1.58E-06	:
l Aug 20	:	9.50	72.00	35.00	261300.00	1511.08	22.00	0.855	260.00	: 80.00	80.00	4.80E-06	1.06E-06	1.06E-06	2.30E-06	:
1 Aug 27	1	9.50	168.00	0.00	604800.00	1679.08	18.00	0.915	800.00	: 170.00	2030.00	6.82E-06	2.25E-06	2.69E-05	: 1.20E-05	1
: Sept 2	:	3.10	149.00	20.00	537600.00	1828.42	20.00	0.885	240.00	: 140.00	560.00	2.23E-06	1.85E-06	7.41E-06	: 3.83E-06	ł
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TABLE B.10 EXP. No. 2 1.8m HEAD - 20µm FABRIC - 1% TS

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Head 1.8m 20 micron Fabric 1X Total Solids Exp. No. 2

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	:	י דזאכ ו	Time	Change	EL ARGEN	ACCUMUL.	TENP DEG_C	VISC.	I VOLUME	of	Effluent	Infiltration	Rate	ca/s	Average Infil
	• 		Hours	Minutes	SECONDS	HOURS			: REP1	: REP2	REP3	REP1	REP2	REP3	C#/5
Oct 30	1	12.00	0.00	0.00		0.00	24.00	. 0.00	:	:	:	: 1			i i
L Oct 30	i	23.30	11.00	30.00	41400.00	11.50	24.00	0.820	8860.00	; 7610.00	6050.00	9.89E-04	8.50E-04	6.75E-04	8.38E-04
: Oct 31	:	11.15 :	11.00	45.00	42300.00	23.25	24.00	0.820	1 5620.00	5650.00	5570.00	: 6.14E-04 1	6.17E-04	6.09E-04	1 6.13E-04 l
I Nov 1	1	12.00 :	24.00	15.00	87300.00	47.50	24.00	0.820	7500.00	6750.00	6980.00	3.97E-04	3.57E-04	3.70E-04	1 3.75E-04 I
: Nov 1	:	19.30 :	19.00	30.00	70200.00	67.00	24.00	0.820	3050.00	3400.00	3700.00	1 2.01E-04 1	2.24E-04	2.44E-04	2.23E-04 I
l Nov 2	1	11.00 ;	27.00	30.00	99000.00	94.50	24.00	0.820	3400.00	3750.00	3700.00	1.59E-04 H	1.75E-04	1.73E-04	1.59E-04 I
Nov 2	:	21.15	10.00	15.00	36900.00	104.75	24.00	0.820	1150.00	1880.00	1590.00	: 1.44E-04 I	2.36E-04	1.99E-04	1.93È-04 I
I Nov 3	Ì	8.00 :	10.00	45.00	38700.00	115.50	21.00	0.870	1440.00	2100.00	2420.00	: 1.82E-04	2.66E-04	3.07E-04	2.52E-04 1
: Nov 3	:	23.00	15.00	0.00	54000.00	130.50	21.00	0.870	1 1470.00	2200.00	2430.00	1.34E-04 1	2.00E-04	2.21E-04	1 1.85E-04 i
Nov 4	i	15.50	16.00	50.00	60600.00	147.33	22.00	0.855	1490.00	2570.00	2870.00	: 1.19E-04	2.04E-04	2.28E-04	1.84E-04 I
1 Nov 5	1	12.30	20.00	40.00	74400.00	149.00	22.00	0.855	: 1450.00	2010.00	2740.00	: 9.39E-05 #	1.30E-04	1.77E-04	1 1.34E-04 l
1 Nov 7	÷	10.00	45.00	30.00	163800.00	213.50	24.00	0.820	2170.00	: 2015.00	4930.00	6.12E-05	5.69E-05	1.39E-04	8.57E-05 1
t Nov B		18 15 3	32.00	15.00	116100.00	245.75	23.00	0.835	1 670.00	1 680.00	1 3160.00	: 2.72E-05	2.76E-05	1.28E-04	1 6.09E-05 1
1 Nov 14	i	17.45	143.00	30.00	516600.00	389.25	21.00	0.870	840.00	: 1810.00	4700.00	1 7.97E-06	1.72E-05	4.46E-05	: 2.33E-05 ;
Nov 18		12.00	89.00	45.00	323100.00	479.00	21.00	: 0.870	1 400.00	3280.00	6330.00	: 6.07E-06	4.98E-05	9.61E-05	: 5.06E-05 ;
: Nov 20	i	15.30	51.00	30.00	185400.00	530.50	19.00	0.920	240.00	: 2920.00	: 5850.00	: 6.71E-06	8.17E-05	1.64E-04	8.40E-05 :
1 Nov 22	:	13.45	46.00	15.00	166500.00	576.75	10.00	1.160	210.00	: 5080.00	: 3750.00	8.25E-06	2.00E-04	1.47E-04	: 1.18E-04 :
1 Nov 24	÷	11.30	45.00	45.00	: 164700.00	622.50	20.00	0.890	320.00	; 7100.00	: 3940.00	1 9.75E-06	2.16E-04	1.20E-04	: 1.15E-04 :
1 Nov 25	1	11.15	24.00	15.00	87300.00	646.75	22.00	0.855	450.00	: 6380.00	: 3100.00	: 2.48E-05	3.52E-04	1.71E-04	1 1.83E-04 ;
1 Nov 27	i	13.45	50.00	30.00	181800.00	697.25	22.00	0.855	490.00	8600.00	10120.00	: 1.30E-05	2.28E-04	1 2.68E-04	1.70E-04
! Nov 27	:	19 00 9	52 00	! 15 00		749 50	22.00	: 0.855	2470.00	115850.00	:15000.00	1 6.33E-05	4.06E-04	3.84E-04	: 2.85E-04 ;
		10.00	112 00	15.00		941.50 941.75	27.00	: 0.835	1 5330.00	124000.00	124000.00	1 6.21E-05	2.80E-04	2.80E-04	2.07E-04 1
I Den /	1	14 00 1	51 AA	1 46 VV	101100.00		· 23.00	· ^ 955	! A060 A0	1	!	1 1.03E-04	1	!	I ERR 1
i Dec 6	i I	14.00		1 4J.VV	1 100300.00	1 713.39 1 014 AA	1 22.00 27 AA	· ^ 0.0JJ	1 4000.00	i i	1	1 105E 04			ERR !
i vec 8	i	10.30	30.00	1 30.00	. 101000.00	1 704.UV	· 23.00	1 V.03J	1 4400 00	1	1	· · · · · · · · · · · · · · · · · · ·		•	
i Dec 9	i i	10.00	17.00	i 30.00	. 22000.00	1 ART*30	1 23.00	i V.d3J		1	1 1	1 2.776-01			
					i	i			1	1	1	1			

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TABLE B.11 EXP. No. 2 1.8m HEAD - 20µm FABRIC - 2% TS

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Head 1.8m 20 micron Fabric 2% Total Solids Exp. No. 2

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	1		Time	Change		ACCUMUL.	TEMP		VOLUME	of	Effluent	Infiltration	Rate	ca/s	Average I
DAIE	i 		Hours	Hinutes	SECONDS	HOURS		I LUNNELIED I	REP1	: REP2	REP3	REP1	REP2	REP3	ca/s
Oct 30	1	12.00	0.00	0.00	0.00	0.00	24.GU	0.00	1		1	• •			
Oct 31	:	11.20 ;	23.00	20.00	B4000.00	23.33	24.00	1 0.820	4580.00	1 4510.00	4410.00	2.52E-04	2.48E-04 ¦	2.43E-04	2.48E-04 1
Nov 4	:	16.00 :	100.00	40.00	362400.00	124.00	22.00	: 0.855	1740.00	: 1190.00	1220.00	2.31E-05	1.58E-05	1.62E-05	1.84E-05 i
Nov 8	:	18.00 :	98.00	0.00	352800.00	222.00	23.00	0.835	1 3660.00	: 1050.00	2940.00	4.888-05	1.40E-05 !	3.92E-05	3.40E-05 t
Nov 14	:	18.00 ;	144.00	0.00	518400.00	366.00	21.00	0.870	2100.00	1 4380.00	1630.00	: 1.99E-05	4.14E-05	1.54E-05	2.56E-05 ;
Nav 20	:	15.45	141.00	45.00	510300.00	507.75	19.00	0.920	: 1910.00	: 5890.00	850.00	1.94E-05	5.99E-05	8.64E-06	2.93E-05 ;
Nov 22	:	13.45	46.00	0.00	165600.00	553.75	10.00	: 1.160	1 790.00	1 3850.00	1 700.00	3.12E-05	1.52E-04 ;	2.76E-05	7.03E-05 ;
Nov 25	:	11.45	70.00	0.00	252000.00	623.75	22.00	0.855	: 1210.00	1 4450.00	1070.00	2.31E-05	8.51E-05 l	2.05E-05	4.29E-05 ;
Nov 27	1	14.00	50.00	15.00	180900.00	674.00	22.00	0.855	: 1800.00	1 4560.00	200.00	4.80E-05	1.21E-04 ¦	5.33E-06	5.83E-05 1
Dec 4	:	10.50 :	164.00	50.00	593400.00	838.83	23.00	0.835	10200.00	:11900.00	1 580.00	8.09E-05	9.44E-05	4.60E-06	6.00E-05 1
Dec 6	:	14.30	51.00	40.00	186000.00	890.50	22.00	0.855	: 4120.00	: 1540.00	200.00	1.07E-04	3.99E-05 :	5.18E-06	5.06E-05 i
Dec 8	:	11.30	45.00	0.00	162000.00	935.50	23.00	0.835	: 5020.00	1340.00	180.00	1.46E-04	3.89E-05 :	5.23E-06	6.33E-05 ;
Dec 19	1	16.50	269.00	20.00	969600.00	1204.83	21.00	0.870	120000.00	115800.00	: 1070.00	1.01E-04	7.99E-05 ;	5.41E-06	6.22E-05 i
Dec 23	1	9.20	B8.00	30.00	318600.00	1293.33	22.00	0.855	13730.00	1 5520.00	: 390.00	2.08E-04	8.35E-05	5.90E-06	9.90E-05 1
Dec 30	Ì	10.00	168.00	40.00	607200.00	1462.00	22.00	0.855	122000.00	1 6620.00	1 740.00	1.758-04	5.25E-05 H	5.87E-06	7.77E-05
Jan 4	i	10.30	120.00	30.00	433800.00	1582.50	22.00	0.855	125000.00	1 3330.00	1 530.00	1 2.78E-04	3.70E-05 I	5.89E-06	1.07E-04 :
	;														
	DATE Oct 30 Oct 31 Nov 4 Nov 8 Nov 14 Nov 20 Nov 22 Nov 25 Nov 27 Dec 4 Dec 6 Dec 9 Dec 19 Dec 23 Dec 30 Jan 4	DATE DATE Oct 30 Oct 31 Nov 4 Nov 8 Nov 14 Nov 20 Nov 20 Nov 25 Nov 25 Nov 27 Dec 4 Dec 6 Dec 8 Dec 19 Dec 23 Dec 30 Jan 4	DATE TIME DATE TIME Oct 30 12.00 Oct 31 11.20 Nov 4 16.00 Nov 8 18.00 Nov 14 18.00 Nov 20 15.45 Nov 20 15.45 Nov 22 13.45 Nov 25 11.45 Nov 25 11.45 Nov 27 14.00 Dec 4 10.50 Dec 6 14.30 Dec 8 11.30 Dec 19 16.50 Dec 23 9.20 Dec 30 10.00 Jan 4 10.30	Image: Constraint of the second se	DATE TIME Time Change DATE TIME	Image: Second	DATE Time Change ACCUNUL. DATE TIME	DATE Time Change ACCUMUL. TEMP DATE TIME	DATE Time Change ACCUMUL. TEMP VISC. DATE TIME	Image Image <thimage< th=""> <thimage< th=""> <thim< td=""><td>Image Change ACCUMUL. TEMP VISC. VOLUME of DATE TIME </td><td>Image: Time Change: ACCUMUL. TEMP VISC. VOLUME of Effluent DATE TIME </td><td>Image Change ACCUMUL TEMP VISC VOLUME of Effluent Infiltration DATE TIME </td><td>DATE Time Change ACCUMUL. TEMP VISC. VOLUME of Effluent Infiltration Rate DATE ITME ELAPSED TIME DEGC CORRECTED REP1 REP3 REP1 REP3 REP1 REP2 REP3 REP1 REP2 REP3 REP1 REP3 REP1 REP3 REP1 REP3 REP1 REP3 REP1 REP3 REP1 REP3 REP3 REP1 REP3 RE93 RE93 RE93</td><td>Image Change ACCUMUL. TEMP VISC. VOLUME of Effluent Infiltration Rate ca/s DATE ITIME ELAPSED ITIME DEG-C CORRECTED REP1 REP2 REP3 REP1 REP1 REP1 REP2 REP3 REP1 REP1 2.402 2.402 2.402 0.00 2.4.00 2.4.00 0.00 2.4.00</td></thim<></thimage<></thimage<>	Image Change ACCUMUL. TEMP VISC. VOLUME of DATE TIME	Image: Time Change: ACCUMUL. TEMP VISC. VOLUME of Effluent DATE TIME	Image Change ACCUMUL TEMP VISC VOLUME of Effluent Infiltration DATE TIME	DATE Time Change ACCUMUL. TEMP VISC. VOLUME of Effluent Infiltration Rate DATE ITME ELAPSED TIME DEGC CORRECTED REP1 REP3 REP1 REP3 REP1 REP2 REP3 REP1 REP2 REP3 REP1 REP3 REP1 REP3 REP1 REP3 REP1 REP3 REP1 REP3 REP1 REP3 REP3 REP1 REP3 RE93 RE93 RE93	Image Change ACCUMUL. TEMP VISC. VOLUME of Effluent Infiltration Rate ca/s DATE ITIME ELAPSED ITIME DEG-C CORRECTED REP1 REP2 REP3 REP1 REP1 REP1 REP2 REP3 REP1 REP1 2.402 2.402 2.402 0.00 2.4.00 2.4.00 0.00 2.4.00

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TABLE B.12 EXP. No. 2 1.8m HEAD - 20µm FABRIC - 4% TS

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Head 1.8m 20 micron Fabric 4% Total Solids Exp. No. 2

!	!-		!												
	1		Time	Change		ACCUMUL.	TEMP	VISC.	VOLUNE	ot	Effluent	Infiltration	Rate	ca/s	Average i
i DATE i	i ¦	1 TUF	l Hours	l Minutes	SECONDS	HOURS	UE0-L		REP1	REP2	REP3	REP1	REP2	REP3	cn/s
			[!					¦		;			
Oct 30) 1	12.00	0.00	0.00	0.00	0.00	24.00	: 0.00	1	:	:		1		1 1
1 Oct 30	1	23.30	: 11.00	: 30.00	1 41400.00	11.50	24.00	0.820	2300.00	1920.00	2040.00	1 2.57E-04 1	2.14E-04	2.28E-04	2.33E-04 I
1 Oct 31		12.45	25.00	15.00	90900.00	36.75	24.00	0.820	580.00	: 2600.00	: 740.00	: 2.95E-05 :	1.32E-04	3.76E-05	6.64E-05 1
1 Nov 4		16.15	99.00	: 30.00	: 358200.00	136.25	22.00	: 0.855	; 1100.00	2680.00	1060.00	1.4BE-05 :	3.61E-05	1.43E-05	2.17E-05 1
		18 15	1 242 00	1 0.00	971200.00	378.25	21.00	0.970	1180.00	1600.00	1300.00	: 6.64E-06 ;	9.01E-06	7.32E-06	7.66E-06 ;
- 1 May 20		14.00	1 141 00	1 45 00	510300 00	520.00	19 00	. 0.920	1 300 00	1 290 00	340.00	1 3.05E-06 1	2.85E-06	3.46F-06	3.12E-06 1
1 10 20		10.00	1 141.00	1 13.00	· 500400.00				1 500.00	1 500.00	1 400 00		A LIE-01	4 975-04	A 545-04 1
I NOV 2/		14.30	: 166.00	1 20.00	1 399400.00	686.JV	22.00	i V.833	i 320.00	1 280.00	1 000.00	1 4.10C-V0 1	4.002-00	1.02E-V0	
l Dec 4	1	11.00	164.00	: 30.00	: 592200.00	851.00	23.00	0.835	220.00	220.00	: 180.00	: 1.75E-06 i	1./32-06	1.43E-06	i 1.646-06 i
l Dec 11	. 1	11.15	168.00	1 15.00	: 605700.00	1019.25	22.00	: 0.855	140.00	110.00	: 100.00	1.11E-06	8.75E-07	7.968-07	: 9.28E-07 ;
l Dec 18	1 1	11.30	: 168.00	15.00	: 605700.00	1187.50	22.00	: 0.855	150.00	: 110.00	: 120.00	: 1.19E-06	8.75E-07	9.55E-07	: 1.01E-06 ;
1 Dec 23		9.30	118.00	1 0.00	424800.00	1305.50	22.00	0.855	: 110.00	80.00	90.00	: 1.25E-06 :	9.08E-07	1.02E-06	1.06E-06 ;
! . Jan /		10 00	1 288 00	! 30.00	1 1038600 00	1594.00	22.00	0.855	: 300.00	1 220.00	240.00	: 1.39E-06 ;	1.02E-06	1.11E-06	: 1.18E-06 ;
		10.00	1 200.00	1 30100						!	!	!!			
1	;-			1	1			1	1	1			•		

TABLE B.13 KXP. No. 2 1.8m HEAD - 20µm FABRIC - 6% TS

Head 1.8m 20 Micron Fabric 6% Total Solids Exp. No. 2

:	: ; ; TD	¦ 	Time	Change	; [! = E1 APSEN	ACCUMUL.	TEMP	 VISC. CORRECTED	I VOLUME	of	Effluent	Infiltration	ƙate	ca/s	 Average ! Infil
	: : :	ند ، ا	Hours	Ninutes	SECONDS	HOURS	 		REP1 	REP2	REP3	REP1 :	REP2 :	REP3	cn/s
1 Oct 30	1 12	.00 :	0.00	. 0.00	. 0.00	0.00	24.00	0.00	1	:	:		:		· · ·
1 Oct 30	1 23	.40 1	11.00	40.00	42000.00	11.67	24.00	0.820	2050.00	2110.00	; 3150.00	1 2.26E-04 1	2.32E-04 ¦	3.47E-04	1 2.68E-04 I
l Nov 1	1 12	.30 ;	25.00	0.00	90000.00	36.67	24.00	0.820	1 3490.00	: 4220.00	1 2520.00	: 1.79E-04 :	2.17E-04 ¦	1.29E-04	1 1.75E-04 1
l Nov 4	: 16	.30 :	100.00	0.00	360000.00	136.67	22.00	0.855	1220.00	: 1930.00	1730.00	: 1.63E-05 :	2.58E-05 ¦	2.32E-05	1 2.18E-05 1
l Nov 14	1 16	.15 ;	241.00	45.00	870300.00	378.42	21.00	0.870	2110.00	1340.00	: 1960.00	1 1.19E-05 1	7.55E-06 ¦	1.10E-05	1.02E-05 1
l Nov 20	1 16	.15 ;	142.00	0.00	511200.00	520.42	19.00	0.920	330.00	380.00	360.00	: 3.35E-06 :	3.86E-06 ;	3.65E-06	1 3.62E-06 1
: Nov 27	1 14	.45 :	166.00	30.00	599400.00	686.92	22.00	0.855	450.00	: 500.00	640.00	: 3.62E-06 1	4.02E-06 :	5.15E-06	1 4.26E-06 1
l Dec 4	: 11	.15 1	164.00	45.00	593100.00	851.67	23.00	0.835	200.00	210.00	1 300.00	: 1.59E-06 !	1.67E-06	2.38E-06	1 1.88E-06 1
Dec 11	1 11	.30 1	168.00	15.00	605700.00	1019.92	1 22.0Ú	0.855	140.00	: 120.00	: 140.00	: 1.11E-06 ;	9.55E-07 l	1.11E-06	1.06E-06 :
Dec 18	1 11	.45 1	168.00	15.00	605700.00	1188.17	22.00	0.855	: 150.00	: 130.00	: 160.00	: 1.19E-06 ;	1.03E-06 :	1.27E-06	: 1.17E-06 :
l Dec 23	1 9	.45 1	118.00	0.00	424800.00	1306.17	22.00	0.855	80.00	; 70.00	90.00	: 9.08E-07 :	7.94E-07 ¦	1.02E-06	: 9.08E-07 :
l Jan 4	1 10	.30	288.00	45.00	1039500.00	1594.92	22.00	0.855	230.00	230.00	: 240.00	: 1.07E-06 ;	1.07E-06 ¦	1.11E-06	1.08E-06 1
;		}		 					·						· ·

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TABLE B.14 KXP. No. 2 1.8m HEAD - 20µm FABRIC - 8% TS

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Head 1.8m 20 micron Fabric 8% Total Solids Exp. No. 2

!		.!		!			!	!	!	!			!			!
	10	•	TINC	Time	Change	I FLADGED	ACCUMUL.	TEMP	VISC.	I VOLUME	of	Effluent	Infiltration	Rate	C4/S	Average
1 UH	112	•	1100	Hours	Minutes	I SECONDS	HOURS			REP1	I REP2	F KEP3	REP1	REP2	REF 3	ce/s
i No	ov 1		11.00	0.00	0.00	6.00	0.00	24.00		1	1	:	:	;; ;		
i No	iv 4	1	16.30	41.00	30.00	149400.00	41.50	22.00	0.855	1130.00	1 780.00	: 500.00	: 3.65E-05	2.52E-05	1.61E-05	2.59E-05 :
1 Nov	14	ł	18.45	242.00	15.00	872100.00	283.75	21.00	: 0.870	: 560.00	680.00	320.00	3.15E-06	3.82E-06	1.802-06	2.92E-06 1
: Nov	20	1	16.15	141.00	30.00	: 509400.00	425.25	19.00	0.920	170.00	: 150.00	160.00	1.73E-06	1.53E-06	1.63E-06	1.63E-06 I
: Nov	27	:	15.00	166.00	45.00	1 900200.00	592.00	22.00	0.855	: 160.00	170.00	150.00	1.288-06	1.36E-06 ;	1.20E-06	1.28E-06
; De	c 4	1	11.20	164.00	20.00	: 591600.00	756.33	23.00	0.835	150.00	1 160.00	160.00	1.19E-06	1.27E-06 ;	1.27E-06	1.25E-06 ;
: Dec	11	:	11.45	158.00	25.00	606300.00	924.75	22.00	0.855	1 110.00	160.00	150.00	8.74E-07	1.27E-06	1.19E-06	1.11E-06 f
: Dec	18	ł	12.00	: 168.00	15.00	: 605700.00	1093.00	22.00	0.855	130.00	140.00	: 150.00	1.03E-06	1.11E-06 ;	1.19E-06	1.11E-06 1
: Dec	23	1	9.50	117.00	50.00	424200.00	1210.83	22.00	0.855	90.00	: 100.00	90.00	: 1.02E-06	1.14E-06	1.02E-06	1.06E-06 1
i Ja	n 4	:	10.30	288.00	40.00	1039200.00	1499.50	22.00	0.855	220.00	250.00	200.00	1.02E-06	1.16E-06 ;	9.28E-07 (1.04E-06 I
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TABLE B.15 KXP. No. 2 1.8m HEAD - 20µm FABRIC - 10% TS

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nead 1.8m 20 micron Fabric 10% Toal Solids Exo. No. 2

	DATE		TIME	: Time Hours 	Change Minutes 	I ELAPSED SECONDS	ACCUMUL. Time Hours	TEMP DE6-C	VISC. Corrected	VOLUME REP1	of : REP2 :	Effluent REP3	Infiltration	Rate REP2	ca/s REP3	Average Infil co/s
ł	Nov 1	ł	11.00	: 0.00	1 0.00	0.00	0.0Ú	24.00	0.00	1	:	:	: :	1		l :
1	Nov 4	ł	16.40	41.00	1 40.00	150000.00	41.67	22.00	0.855	1 580.00	730.00	430.00	: 1.86E-05	2.35E-05 !	1.38E-05	1.86E-05 ;
ł	Nov 14	1	19.00	242.00	30.00	873000.00	284.17	21.00	0.870	1 320.00	610.00	300.00	1.80E-06 :	3.43E-06 1	1.69E-06	2.30E-06 i
1	Nov 20	1	16.30	: 141.00	45.00	510300.00	425.92	19.00	0.920	140.00	220.00	130.00	: 1.42E-06 !	2.245-06	1.32E-06	1.66E-06 1
1	Nov 27	ł	15.10	166.00	: 55.00	600900.00	592.83	22.00	0.855	140.00	200.00	140.00	1.12E-06 ;	1.60E-06 ;	1.12E-06	1.20E-06 t
1	Dec 4	ł	11.30	164.00	30.00	592200.00	757.33	23.00	0.835	1 160.00	200.00	150.00	1.27E-06 1	1.59E-06 1	1.19E-06	1.356-06 :
1	Dec 11	ł	12.00	168.00	30.00	606600.00	925.83	22.00	0.855	150.00	160.00	160.00	: 1.19E-06 ;	1.27E-06 ;	1.27E-06	1.24E-06
1	Dec 18	ł	12.15	: 168.00	: 15.00	605700.00	1094.08	22.00	0.855	130.00	140.00	130.00	: 1.03E-06 ;	1.11E-06 ¦	1.03E-06	1.05E-06 1
1	Dec 23	ł	10.00	: 117.00	1 45.00	423900.00	1211.83	22.00	0.855	100.00	110.00	110.00	: 1.14E-06 ;	1.25E-06	1.25E-06	1.21E-06 I
ł	Jan 4	:	10.30	288.00	: 30.00	1038600.00	1500.33	22.00	0.855	230.00	230.00	250.00	: 1.07E-06	1.07E-06 ¦	1.16E-06	1.10E-06 ;
1		;			·							· · · · ·	¦			

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TABLE B.16EXP. No. 30.9m HEAD - 20µm FABRIC
NON-STERILIZED MANURE 5% To

head 0.9s f20

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Non-Sterilized 5% T.S.

 ! NATE	 !	; ; ;	Time	Change	;- -		•;• 	ACCUMUL.	•;• 	TERP	VISC.	•;• 	VOLUME		of	E	fflu
: :		י 	Hours	Minutes	-1	SECONDS	1	HOURS	1	9E0-0	• GORREGIEN	1 1 1	REPL	;	REP2	;	RE
Nov 17	11.3	0	0.00	0.00	1	0.00	1	0.00	1	21.00	0.00	1		1		'i "	
: Nov 18	12.4	5 ;	25.00	: 15.00	!	90900.00	ł	25.25	ł	21.00	: 0.870	ł	3150.00	ł	1460.00	I	1560.
1 Nov 20	16.4	5 :	52.00	: 0.00	ł	187200.00	ł	77.25	ł	19.00	: 0.905	ł	1330.00	ł	2450.00	ł	2180.
Nov 24	11.5	0 :	91.00	: 5.00	1	327900.00	ł	168.33	:	20.00	: 0.885	ł	700.00	ł	1360.00	1	1150.
Nov 27	15.1	0 ;	75.00	: 20.00	1	271200.00	1	243.67	ł	22.00	: 0.855	ł	960.00	ł	1840.00	;	1750.
Dec 9	8.1	5 ;	281.00	: 5.00	ł	1011900.00	;	524.75	ł	23.00	0.835	ł	1480.00	ł	1450.00	1	1940.
Dec 23	9.1	0 :	336.00	: 55.00	:	1212900.00	ł	861.67	ł	22.00	0.855	1	470.00	1	430.00	ł	530.
Jan 5	12.1	5 ;	315.00	: 5.00	ł	1134300.00	ł	1176.75	1	22.00	: 0.855	ł	540.00	;	350.00	1	980.
Jan 11	8.3	0 1	140.00	15.00	1	504900.00	:	1317.00	1	24.00	0.820	ł	1950.00	ł	1130.00	1	1780.

	•-		:1	nfiltration	Rate		ca/s			:	Ave	rage
REP4	: 	REP5	; ; ;	REP1 ;	REP2	 ¦ '	REP3		REP4	REP5	In C	fil Ø/S
	l			:		, 		1	;; ;	; ;	*****	
2660.00	1 :	2050.00	1	1.70E-04 ;	7.88E-05	:	8.42E-05	1	1.44E-04 ;	1.11E-04 ;	1.	17E-04
1580.00	1	1980.00	1	3.62E-05 ;	6.68E-05	1	5.94E-05	1	4.31E-05 ;	5.40E-05 :	5.	41E-05
790.00	1	990.00	l	1.06E-05 ;	2.07E-05	:	1.75E-05	Ì	1.20E-05 !	1.515-05 :	1.	635-05
1210.00	1	1650.00	ł	1.718-05 ;	3.27E-05	1	3.11E-05	1	2.15E-05 ;	2.935-05 :	2	705-04
1730.00	1	1780.00	!	6.888-06 ;	6.74E-06	:	9.028-06	Ì	8.05E-06 !	8.28E-06 !	7	
480.00	: :	3700.00	1	1.87E-06	1.71E-06		2.11E-06	i	1.915-06 !	1.475-05 !	1	995_AC
2780.00	: :	3100.00	1	2.298-06	1.495-06		4.16E-06	i	1.18E-05 !	1 325-05 1	2	UJL -VQ (92_AC
880.00	1 2	2080.00	1	1.79E-05 ;	1.03E-05		1.63E-05		8.06E-06 ;	1.902-05 :	1.	48E-05

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TABLE B.17 KXP. No. 3 0.9m HEAD - 20µm FABRIC

STERILIZED MANURE 5% TS

3.65E-06 ;

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1.65E-06 | 1.70E-06 | 1.53E-06 |

head 0.9s f20 Sterilized 57 T.S.

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	!		1				1	I		. –
DATE	I I TINE	i Tine C	hange i		ACCUMUL. Time Hours	TENP	VISC.	VOLUME	of	Ef
		Hours I N	inutes :	SECONDS		926-U		REP1	: REP2	1
Nov 17	11.30	0.00	0.00 ;	0.00	0,00	21.00	0.00	; ======= {	•; ••••••••••	
Nov 18	: 12.30	25.00 :	0.00 :	90000.00	25.00	21.00	0.870	: 1640.00	1880.00	: 2
Nov 20	: 16.30	: 52.00 ;	0.00 :	187200.00	77.00	19.00	: 0.905	630.00	: 1050.00	11
Nov 24	1 16.45	: 96.00 :	15.00 :	346500.00	173.25	20.00	: 0.885	770.00	: 540.00	11
Nov 27	1 15.15	70.00 :	30.00 ;	253800.00	243.75	22.00	0.855	670.00	920.00	11
Dec 4	1 11.35	164.00 1	20.00 :	591600.00	408.08	23.00	0.835	1790.00	: 1370.00	11
Dec 23	9.00	453.00	25.00 1 1	632300.00	861.50	22.00	0.855	: 1470.00	: 890.00	11
Jan 5	: 12.30	; 315.00 ;	30.00 ; 1	135800.00	1177.00	22.00	0.855	350.00	: 350.00	:
Jan 11	8.30	: 140.00 :	0.00 ;	504000.00	1317.00	24.00	0.820	135.00	: 140.00	1
		Infiltration	Rate	c s /9	5		Avera	; ge :		
REP4	REP5	REP1 ;	REP2	i REP:	3 : REP	4 : REP	Infi 5 cm/	1 : 5 :		
1770 00	2990 00		1 005 0					;		
1230.00	450 00	0.742-VJ ! 1.722_AK		Fri 1.201 ⊈ i ⊃.611	L-V4 i 9.6 4 E-05 i 9.05	E-VJ i 1.3/	E-V4 ; 1.14	1-04 5 45 1		
1890.00	1720.00	·	2.00C-V	G (2.01) C (2.17)	C-VJ i 3.33 C-AK I 2.79	E-VJ i 1.23 E-AE / 2.40	2-103 i 2.46	2-03 ;		
790.00	1030.00	· ····································	1 755_6	≂ti 4.1/1 ≤ti 4.6%		E-VJ i 2.98 E-AF I 1.06	E-VJ i 1.39	1-VJ i		
	TARATAA	• 1•2/5-VJ i	1.736-0	JI 1.74	1.3V	Σ−VĴ i I.3D	6-VJ i 1.63	1-V3 i		

2180.00 : 1680.00 : 1.42E-05 : 1.09E-05 : 1.22E-05 : 1.73E-05 : 1.34E-05 : 1.24E-05 :

140.00 : 140.00 : 1.24E-06 : 1.28E-06 : 1.42E-06 : 1.28E-06 : 1.28E-06 : 1.31E-06 :

1850.00 : 1370.00 : 4.34E-06 : 2.63E-06 : 3.99E-06 : 5.46E-06 : 4.05E-06 :

390.00 : 400.00 ; 1.49E-06 : 1.49E-06 : 1.61E-06 :

APPENDIX C

 $\omega = 1 - \omega_{\rm c}$

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EFFLUENT ANALYSIS DATA SUMMARY

EXPERIMENT NO.1 - TABLES C1 TO C7 EXPERIMENT NO.2 - TABLES C8 TO C13 EXPERIMENT NO.3 - TABLES C14 TO C15

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TABLE C.1 EXP. No. 1 pH DATA SUMMARY

; sai	NPLE ;	JUNE 18-23;	JUNE 30;	JULY 9 ;	JULY 16:	JULY 23;	JULY 3C;	AUG. 6 :	AUS. 13;	AUE. 20;	AUE. 27 ;	SEPT. 2
4	20.1 ;	6.41 :	6.41 ;	6.43 ;	6.39 ;	6.57 ;	7.20 :	7.53 ;	7.08 ;	6.34 ;	6.23/6.25!	6.6
ł	20.2 :	6.42 :	7.47	7.08	7.43	7.36 :	7.49 :	7.52 ;	7.72 ;	7.48 :	7.70 :	7.7
:	20.3	6.35 ;	7.31 ;	6.87 :	7.60	7.42 ;	7.52	7.56	7.72 ;	7.22 ;	7.80 ;	7.8
:	20.9 :	6.92 ;	7.46	7.40 ;	6.44 ;	7.61 :	7.61	7.54	7.80 ;	7.53 1	7.71	7.4
	20.5 :	6.55 (6.27 :	6.29 ;	7.62 :	6.48	6.21	6.61 :	6.84	6.55 ;	6.30 :	7.8
:	20.6 :	6.61 :	7.67 ;	6.97	7.58 🕻	7.72	7.66	7.87 ;	7.60 ;	7.00 ;	7.74	8.0
•	20.7 ;	6.58 :	6.97	6.90 1	7.62 ;	7.22 :	6.78	7.38	6.63	7.43	7.49 1	7.5
:	20.8 :	6.94 ;	7.47	7.18 ;	7.80 :	7.54 :	7.77	7.89 :	7.74	7.22 :	6.77 :	7.3
!	20.9 ;	6.80 ;	7.48 :	6.92 ;	6.80 ;	7.40 1	7.35	7.51 (7.45 1	7.54 :	7.51 ;	7.4
1 1	30.1 ;	6.14 :	6.18 ;	6.98 ;	6.31	6.52	6.27	6.33 :	7.16 :	6.62 :	6.20/5.31;	6.2
	30.2	6.14 :	6.33 ;	6.85 ;	6.95 ;	7.16 ;	7.18	7.48 (7.44 1	7.36	7.58 ;	7.3
	30.3	6.15 :	6.53 ;	7.02 ;	7.54	7.61	7.69	7.76	7.84 (6.22 ;	7.02 ;	7.0
	30.4 ;	6.84 :	7.33 ;	7.07 ;	6.98 !	7.72 :	7.86	7.41 1	7.79 :	5.95	6.34 (6.8
	30.5 ;	6.78 ;	6.30 ;	6.14 ;	6.28	6.42 ;	6.54	6.79 ;	6.77	7.76 :	7.94 !	7.8
	30.6 :	6.47	6.99	7.09	7.64 :	7.68 :	7.43 ;	7.59	7.51	7.51 :	7.57 :	7.8
1	30.7 ;	6.84	7.43	7.12	6.51 ;	7.97	7.89	7.90 ;	9.00 :	8.07 ;	7.97 :	3.0
	30.8 :	6.51 ;	6.80	6.95	7.05	7.54	7.41 :	7.22 :	7.38	7.39	7.39 [7.7
	30.9	6.79	6.38	5.86 :	7.36	7.69	7.81	7.86 :	8.00	8.04 ;	8.05 :	7.5
	40.1	6.24	5.46	7.11	6.36	7.18 ;	6.94 1	7.68 :	7.25	6.83 (£.37 ;	7.1
	40.2	6.28	7.59	7.35	6.91	7.55	7.58	7.84 1	7.62	7.39 :	7.85	7.6
	40.3 :	6.74	7.37	7.41	6.90 1	:	8.07 ;	7.80 ;	7.95 ;	7.76 ;	6.66/6.18	6.7
	40.4 ;	6.13	6.23 :	6.37 :	7.82	6.66 ;	6.67	6.87 :	6.87 :	5.65 1	5.41 1	6.7
	40.5	6.48	7.51	7.30	6.30 :	6.88	7.29 :	7.14 ;	6.72 1	6.67	6.82 ;	7.9
	40.5	6.52	7.31 1	6.37	7.64	7.79	7.91	8.15	8.15	7.99	8.03 :	7.8
	40.7	6.71	7.37 :	7.35	7.70	7.65	7.88	7.97	8.08	7.81	6.68	7.7
	40.8	6.83	7.70	7.34	7.50	7.69	7.77	8.09	8.16	7.91	7.71 :	8.0
	40.9	6.51	7.23	7.26	7.51	7.37	6.99	7.26 1	7.47	7.32 :	7.25 1	7.4

PH RESULTS FOR EXP. NO. 1 - JUNE - SEPT.

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CODING : EXAMPLE 20.1 INDICATES 20 NICRON FABRIC

.1,.2,.3 INDICATES THE 0.9m HEAD .4,.5,.6 INDICATES THE 1.90 HEAD .7,.8,.9 INDICATES THE 2.70 HEAD
TABLE C.2 EXP. No. 1 NITRATE DATA SUMMARY

.

SAMPLE ;	JUNE 18-23; PPN	JUNE 9 PPN	JULY 231 PPH 1	AUG. 6 1 PPM 1	AUG. 20: PPN :	SEPT. 2
20.1 ;	1.8 ;	1.7 !	2.0 ;	2.1 ;	2.2 :	2.3
20.2 ;	1.6 [1.7 1	1.8 :	1.8	2.0	2.2 ;
20.3	1.8 !	1.6	1.5 :	1.7 ;	1.8 1	2.1
20.4	2.1 ¦	2.0	2.1	2.2 [2.2	2.4
20.5 ;	1.8 ;	1.8 ;	1.9	2.0 ;	2.0 :	2.1
20.6	1.7	2.0 (2.0	2.0 ;	2.1	2.2
20.7 :	2.3	2.2 :	2.3 (2.3 (2.2 !	2.3
20.8 ;	1.6	1.7 1	1.8 ;	1.9 ;	2.0	2.1 !
20.9 ;	1.8 ;	1.8	1.9	1.9 [1.9 :	2.1
30.1	1.8 1	1.8 :	1.8 1	1.9 1	2.0	2.1 !
30.2 1	1.8 ;	1.8 (1.9 ;	2.1 :	2.1 :	2.3
30.3 ;	1.7 1	1.9	2.0 ;	2.1	2.2 ;	2.3
30.4	2.0 (2.0 ;	2.2 ;	2.2 ;	2.2 [2.3 (
30.5	1.9	2.0	2.1	2.2	2.3	2.4
30.6	2.0 (2.1 ;	2.2 :	2.3 (2.3	2.4
30.7	2.1	2.1 !	2.3	2.4	2.8 1	2.8
30.8	2.9	2.2 :	2.3 (2.3	2.4	2.5
20.9	1.7	1.3	1.9	2.1 ;	2.3 ;	2.5
40,1	1.8	1.9	2.0 (2.1 :	2.1	2.7
40.2	1.6	1.8	9	2.2	2.3 (2.4
40.3	1.7	1.9	1.7 1	2.2	2.3 ;	2.5
40,4	2.0	2.0 :	2.2	2.2	2.3	2.5
40.5	2,1	2.1	2.2	2.3	2.3	2.4
40.6	1.8	1.9	2.0	2.1	2.4	2.4
40.7	1.9	1.9 !	2.0	2.1	2.4	2.5
40.8	2.0	2.1	2.1	2.3	2.4	2.6
40.9	1.8	2.0	2.1	2.2	2.3	2.5

EXP. NG. 1 NITRATE 5% T.S.

		ËX	PERIMEN	IT No. 1	COD (mg/l) DATA SUMMARY (AVERAGES)						
						DATE					
SAMPLE	Jun-18	Jun-29	Jul-09	Jul-16	Jul-23	<u>Jul-30</u>	Aug-06	Aug-13	Aug-20	Aug-27	Sep-02
20 MICRON	30973	39982	43522	40021	44268	44552	40560	45587	45786	40639	42567
0.9 m HEAD											
20 MICRON	26208	34696	33018	34872	36398	32893	35844	39096	36974	33553	36431
1.8 m HEAD											
20 MICRON	25172	35916	34048	31988	32245	36450	36702	39413	35873	36108	36481
2.7 m HEAD											
30 MICROM	28694	42828	34295	36108	37929	41193	31257	42422	39398	33636	38278
0.9m HEAD											
30 MICRON	24550	33069	28281	28898	27654	33091	33401	38965	31247	31412	30578
1.8 m HEAD											
30 MICRON	21649	32052	30464	23956	24593	32696	30743	38762	29264	31988	32673
2.7 m HEAD	-						.				
											07700
40 MICHON	26172	39675	28281	27869	28310	39019	34987	43845	36764	39403	37008
0.9 m HEAD					<u> </u>	ļ	<u> </u>		<u> </u>		
									00770		0.077
40 MICHON	25793	31849	30423	29311	28965	30845	33068	39779	30764	33430	34875
1.8 m HEAD	<u> </u>							ļ	<u> </u>	 	ļ
					-						
40 MICRON	24550	25180	29617	26221	27654	35660	32643	36626	28383	30136	29643
2.7 m HEAD		I					L			· .	

TABLE C.3 EXP. No. 1 EFFLUENT DATA SUMMARY (COD mg/l)

		EXPERIMENT No. 1 AMMONIA			MONIA	(PPM) DATA SUMMARY			(AVERAGES)		
						DATE					
SAMPLE	Jun-18	Jun-29	Jul-09	Jul-16	Jul-23	Jul-30	Aug-06	Aug-13	Aug-20	Aug-27	Sep-02
20 MICRON	2292.3	2503.3	4042.6	3894.4	4257.5	4681.4	3243.6	4367.2	3991.4	3642.3	4498.9
0.9 m HEAD											
20 MICRON	1627.2	2043.9	3219.9	2938	3386.3	3582.3	2797.5	3440.2	4061.7	3658.4	3633.1
1.8 m HEAD											
						0.047	00000	0440.4		0404	2770 4
20 MICRON	1588.6	2035.3	3168	3131.8	3292.2	3447	2080.A	3419.1	3802	3404	3//8.4
2.7 m HEAD							}				
20 1000014	00147	0710 5	2704 4	2008 6	2504.0	4207	2170	4008 7	2795	2400 6	4192.9
30 MICHOM	2314.7	2/19.0	3784.4	3880.0	3004.9	420/	31/8	4008.7	3/65	3488.0	4102.5
U.SIM HEAD					· · · · ·						
20 MICRON	1808 7	10210	2026 1	2178 2	2002.2	2094 6	2690.0	2200 6	3479 A	2788.8	3364 7
1.0 michon	1000.7	1031.0	2920.1	31/0.2	3003.2	3084.0	2000.0	5200.0	34/0.4	2700.0	
1.0 M HEAD		<u> </u>			}						
	1007.0	1700 1	0170 0	0108.0	0050 1	0178.0	2550 8	2245.2	2800 4	01041	2800.0
30 MICHON	1037.3	1780.1	31/3.2	3130.0	2906.1	31/0.2	2000.0	3340.3	3008.4	3134.1	3088.8
A.T MINEAD					ł		t			<u> </u>	
40 MICRON	2170 7	2044 8	3254 2	3727 9	3619.2	4279 7	3971 7	39324	4190 6	3503.9	A147 8
0.9 m HEAD		2044.0	0207.2	0/2/.0			0071.7	0002.4		0000.0	
<u></u>							+			<u> </u>	
40 MICRON	1632.3	1890	2730.5	2974.4	3048	3586.2	3030.9	3474.5	3921.6	3041.9	3609.6
1.8 m HEAD			<u>-</u>		<u></u>		<u></u>				
	1			I	Î	l .		[····	.	1	
40 MICRON	1628.9	178.3	2586.8	3089.2	2996.6	3441.5	2948.3	3240	3625.2	2926.1	3677.9
2.7 m HEAD											

TABLE C.4 EXP. No. 1 EFFLUENT DATA SUMMARY (AMMONIA PPM)

		EXPE	EXPERIMENT No. 1 POTASSIUM (PPM) DATA SUMMARY		MMARY	(AVERAGES)				
						DATE				
SAMPLE	Jun-18	Jun-29	Jul-09	Jul-16	Jul-23	Jul-30	Aug-06	Aug-13	Aug-20	Aug-27
<u> </u>										
20 MICRON	801.5	1030.8	766.4	385.8	536.8	1115.4	1516.2	738.3	396.7	478.8
0.9 m HEAD									· · · · ·	
20 MICBON	767 3	849 3	674 A	545.4	410.3	941.8	1218.8	499.3	660.3	358
1.8 m HEAD							1			
20 MICRON	725.1	856.1	617.6	694.7	267.5	986	1276.4	635.8	337.3	290.4
2.7 m HEAD										
30 MICROM	835.6	939.2	1091.9	663.1	591.1	1144.5	1381	653.2	644.5	456.7
0.9m HEAD										
30 MICRON	765.1	820.5	794.6	392.3	454.3	1064.1	1239.5	769.2	373.8	440.9
1.8 M HEAD				<u> </u>		<u> </u>		<u> </u>		
30 MICRON	726.4	788.4	960.3	527.4	600.4	1154.5	1267.6	868.2	947.7	518.9
2.7 m HEAD										
40 MICHON	872.5	857.6	935.3	921.9	445.9	1294	1367.8	640.2	289.6	5 20.7
0.9 m HEAD			_ <u></u>	ļ						
40 14100001	700 1	1004.0	e 00 e			1080 4	11507	807.0	004.0	
1.9 m HEAD	728.1	1034.2	029.0	604.4	308.8	1009.4	1102.7	607.3	224.0	440
1.5 III HEAD				<u> </u>			-{	<u> </u>		<u> </u>
40 MICRON	754.6	944.6	595.4	572.6	406.8	968.7	1342.7	972	178.6	583.2
2.7 m HEAD										
				1		1		1		<u> </u>
								1		

TABLE C.5 EXP. No.1 EFFLUENT DATA SUMMARY (POTASSIUM PPM)

EXPERIMENT NO. 1 CHLORIDES (PPM) DATA SUMMARY (AVERAGES)										AGES)
		EAFE				DATE				
		1	1.1.00	Inda 18	Jul-23	Jul-30	Aug-06	Aug-13	Aug-20	Aug-27
SAMPLE	Jun-18	Jun-24	JUI-08							
			- 7000	20617	22205	12436	10548	16858	31511	27410
20 MICRON	16198	27533	1/309	30017	23200	12122	1			
0.9 m HEAD							+			
				00010	24284	11536	10726	20242	22539	27477
20 MICRON	12462	13083	13803	20818	29209	11000				
1.8 m HEAD							+			
			44494	10005	16474	12892	10512	17596	36312	36101
20 MICRON	11668	10890	14404		10414					
2.7 m HEAD		<u> </u>								
		05022	15720	21682	21180	13895	10003	20915	26314	34189
30 MICHOM	18188	20032	10/20		- = ::==-			1		
0.9m HEAD				·	+					
	10070	10222	17242	27389	21719	11718	12135	14946	29254	27012
30 MICRON	120/3	10333	1/242	2.000		h		1		
1.8 m HEAD		 	ļ					1		
		<u> </u>		00778	17820	12245	12398	15633	17214	26966
30 MICRON	14291	11060	18/00	20770	17020			1		
2.7 m HEAD	<u> </u>	ļ	ļ		+	 				1
						1	14160	21405	41229	26603
40 MICRON	14341	22921	17376	17543	29749	13371	14143	1 21700		-
0.9 m HEAD		1								
						l		+		08005
40 MICRON	14711	8670	20017	16607	34587	13364	14738	19196	40400	TOAAD
1.8 m HEAD										
						·			+	
40 MICRON	14813	12059	21183	21172	26289	12326	14171	13250	49940	20790
2.7 m HEAD	•					<u></u>		<u> </u>		1

TABLE C.6 EXP No.1 EFFLUENT DATA SUMMARY (CHLORIDES PPM)

	EXPERIMENT No. 1 81				SUSPENDED SOLIDS (mg/l) DATA SUMMARY (AVERAGES)						<u>>)</u>
						DATE					
											0.00
SAMPLE	Jun-18	Jun-29	Jul-09	Jul-16	Jul-23	Jul-30	Aug-06	Aug-13	Aug-20	Aug-2/	30p-02
20 MICRON	4647	3557	5473	4423	6083	2847	1647	6000	4077	2977	3240
0.9 m HEAD											
20 MICRON	4893	3050	4700	5130	3730	2527	1398	3833	3190	2143	2347
1.8 m HEAD											
20 MICRON	4716	4457	3680	5983	3983	2673	1200	4507	4197	3077	3620
2.7 m HEAD	1]			
	[1							
30 MICROM	4800	4397	2773	6130	4173	2933	1780	3927	4110	3203	2707
0.9m HEAD	[1	1								
										ļ	
30 MICRON	5167	3297	3847	4003	4957	1993	1980	4627	3863	2930	2387
1.8 m HEAD			<u> </u>			ļ	ļ	ļ			
					·						0107
30 MICRON	5060	4303	3020	4897	5140	2307	1447	4227	3290	3030	310/
2.7 m HEAD					<u> </u>					<u> </u>	
	1	ļ								2492	2280
40 MICRON	6193	6563	3940	8223	4847	3080	1887	4980	3303	2403	3260
0.9 m HEAD			L	1				Į		<u> </u>	
		<u> </u>	ļ							0070	0780
40 MICRON	2673	3270	3280	6730	2567	2493	1460	3020	3317	2370	2/60
1.8 m HEAD	I			L	ļ	<u></u>	<u> </u>	·	 	<u> </u>	<u> </u>
						l		l			<u> </u>
40 MICRON	4973	2250	4133	5670	5140	2613	1373	3993	3077	3017	3713
2.7 m HEAD			<u> </u>	1			1	1	L	<u> </u>	<u> </u>

TABLE C.7 EXP. No.1 EFFLUENT DATA SUMMARY (SS mg/l)

	<u> </u>	EXPERIME	NT No. 2	1%TS (DA	TA SUMMAR	Y SHEET)			
			DATE						
DADAMETED	REP No	OCT 31/87	NOV 14/87	NOV 18/87	NOV 20/87	NOV 24/87	DEC 4 87	DEC 8/87	
<u>ranameten</u>	1	7 02	6.94	6.99	-	6.89	6.85	6.96	
	2	7 12	7.01	7.03	-	6.96	6.88	•	
<u>pu</u>	2	7 22	7.02	6.97	7.01	6.84	6.76	•	
		757	745	710	•	726	693	650	
	2	685	840	725	•	729	760	· · ·	
	3	918	874	885	821	720	810	· · ·	
	<u>† 1</u>	0.3	0.3	0.4	•	0.4	0.5	0.5	
NITRATE	2	0.2	0.2	0.3	-	0.3	0.4	·	
(PPM)	3	0.3	0.3	0.4	0.4	0.4	0.4		
	1	4110	4860	4750	-	4950	4320	4210	
CHI ORIDES	2	3980	3880	4020	-	4160	4080	·	
(DDM)	3	4315	4050	4216	4325	4060	3980	·	
	+	163	172	180	•	165	190	183	
POTACCILIM	2	185	190	240	-	220	200	•	ļ
		190	210	200	178	165	210	· · ·	<u> </u>
	+	1620	1320	1480	•	680	1160	1060	
CHEDENDED		1560	980	1060	•	840	1540	•	
		1200	720	880	620	700	1600	•	
<u>20102 (22)</u>		5459	4730	4605		7399	7399	10327	
		5945	5847	3674	-	4667	4667	•	
(ma/l)	3	5823	6468	2743	4508	4605	4484		
<u></u>		* 0	N DEC 4 RI	EPS 2&3 W	ERE TERMIN				
		-	ON DEC 8	REP 1 WAS	TERMINATE	D			
								<u></u>	<u> </u>

TABLE C.8 EXP. No. 2 EFFLUENT DATA SUMMARY (1% TS)

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		EXPERIME	ENT No. 2	2%TS (DA	TA SUMMAF	RY SHEET)	
			DATE				
PARAMETER	REP No.	OCT 31/87	NOV 14/87	NOV 25/87	DEC 8/87	DEC 23/87	JAN 4/88
	1	7.06	7.01	6.96	6.84	6.93	6.97
pH	2	7.01	7.01	6.9	6.99	6.84	6.79
	3	7	6.89	6.98	7.01	6.72	6.79
	1	1776	1414	1328	1365	1280	1240
AMMONIA	2	1929	1358	1462	1390	1360	1380
(PPM)	3	1463	1472	1285	1310	1265	1225
<u></u>	1	0.4	0.4	0.5	0.5	0.5	0.6
NITRATE	2	0.03	0.3	0.3	0.4	0.4	0.4
(PPM)	3	0.03	0.3	0.3	0.3	0.3	0.4
B	1	6340	5420	6880	7210	7560	6840
CHLORIDES	2	6110	5320	6210	6850	6725	6950
(PPM)	3	7101	6890	6560	6940	5920	6260
······	1	440	395	415	450	430	405
POTASSIUM	2	560	510	520	490	480	510
(PPM)	3	400	460	420	430	390	395
	1	1060	1760	1720	1020	1120	1340
SUSPENDED	2	860	860	1220	1280	1160	1220
SOLIDS (SS)	3	760	1080	1640	1520	1560	1780
	1	8299	10247	8040	8940	10900	7020
COD	2	8786	10052	9750	10200	10560	7020
(mg/l)	3	7081	9516	11620	13100	13480	11260
		1	1				

TABLE C.9 EXP. No. 2 EFFLUENT DATA SUMMARY (2% TS)

	EXPERIMENT No. 2 4%TS (DATA SUMMARY SHEET)						
			DATE				
PARAMETER	REP No.	OCT 31/87	NOV 14/87	NOV 27/87	DEC 23/87	JAN 4/88	
	1	6.96	6.84	6.79	6.83	6.74	
pH	2	7.06	6.95	6.85	6.78	6.75	
	3	7.01	6.89	6.76	6.73	6.91	
	1	2662	2849	2670	2540	2410	
AMMONIA	2	2662	3213	3310	2980	3100	
(PPM)	3	2561	3425	3250	3120	2960	
	1	0.8	0.8	0.8	0.9	0.9	
NITRATE	2	0.7	0.7	0.8	0.8	0.8	
(PPM)	3	0.9	0.7	0.9	0.9	1	
	1	16310	18360	22460	23410	20590	
CHLORIDES	2	19560	22330	24630	34960	21490	
(PPM)	3	20490	24480	23740	21360	24760	
	1	990	1010	1060	980	1100	
POTASSIUM	2	1040	940	960	890	1005	
(PPM)	3	870	910	930	880	970	
	1	2200	1920	1060	1760	1600	
SUSPENDED	2	3500	1380	840	1680	1820	
SOLIDS (SS)	3	2160	1480	1200	1480	1660	
	1	21575	27431	26455	1 7671	15719	
COD	2	22063	31823	30846	22551	22747	
(mg/l)	3	21575	36995	44022	18940	15719	

	EXPERIMENT No. 2 6%TS (DATA SUMMARY SHEET)					
			DATE		<u> </u>	
PARAMETER	REP No.	OCT 31/87	NOV 24/87	NOV 27/87	DEC 23/87	JAN 4/88
	1	6.95	6.84	6.92	6.83	6.77
pH	2	6.76	6.72	6.66	6.72	6.75
	3	6.88	6.93	6.87	6.83	6.72
	1	2876	2919	2870	2640	2720
AMMONIA	2	3157	2884	2910	2960	2640
(PPM)	3	3037	3252	3160	3005	2980
	1	1.4	1.4	1.4	1.4	1.5
NITRATE	2	1.5	1.5	1.6	1.6	1.6
(PPM)	3	1.8	1.7	1.7	1.8	1.8
	1	22410	23100	26410	26840	30400
CHLORIDES	2	20460	23400	26010	27800	24310
(PPM)	3	24560	27980	25410	29400	23210
	1	1260	1110	1180	1205	1240
POTASSIUM	2	1420	1360	1340	1400	1380
(PPM)	3	1310	1260	1210	1420	1360
	1	3800	2840	1550	990	1110
SUSPENDED	2	3740	1800	1810	1650	930
SOLIDS (SS)	3	4770	2840	930	1570	1130
	1	24311	33095	12014	11136	16230
COD	2	25044	33827	17724	12600	16230
(mg/l)	3	26508	29728	29435	10260	17400

	EXPERIME	ENT No. 2	8%TS (D4	TA SUMMAP	RY SHEET)	
	İ		DATE			
PARAMETER	REP No.	NOV 4/87	NOV 14/87	NOV 27/87	DEC 23/87	JAN 4/88
	1	6.99	6.88	6.67	6.74	6.82
рН	2	6.92	6.86	6.72	6.78	6.74
	3	6.94	6.95	6.87	6.71	6.7
	1	5143	3894	3650	3740	3610
AMMONIA	2	3921	4168	4210	3940	3800
(PPM)	3	3772	3425	3570	3390	3210
	1	1.8	1.9	1.9	2.1	2.1
NITRATE	2	2	2.1	2.2	2.2	2.2
(PPM)	3	2.1	2.2	2.2	2.3	2.3
	1	29310	31640	33740	38200	36500
CHLORIDES	2	33720	36700	39260	36430	35410
(PPM)	3	32410	36900	32690	40120	34620
	1	1610	1810	1740	1790	1730
POTASSIUM	2	1580	1710	1670	1810	1705
(PPM)	3	1640	1740	1860	1840	1 780
	1	4820	2630	750	2850	830
SUSPENDED	2	2620	1590	490	1470	1330
SOLIDS (SS)	3	2580	1410	570	1770	970
	1	32181	25458	18257	28049	36691
COD	2	23058	20658	16526	26128	29777
(mg/l)	3	35061	25459	28049	18447	29009

	EXPERIME	NT No. 2	10%TS (D	ATA SUMMA	RY SHEET)	
			DATE			
PARAMETER	REP No.	NOV 4/87	NOV 14/87	NOV 27/87	DEC 23/87	JAN 4/88
	1	6.8	6.75	6.72	6.81	6.69
pH	2	6.77	6.83	6.76	6.81	6.59
	3	6.76	6.81	6.77	6.71	6.61
	1	4405	3973	3820	3760	3680
AMMONIA	2	3972	4321	4120	3840	3710
(PPM)	3	5557	4020	3980	3650	3840
	i 1	2.4	2.4	2.5	2.6	2.6
NITRATE	2	2.7	2.7	2.7	2.8	2.7
(PPM)	3	2.6	2.6	2.6	2.6	2.8
	1	30210	36470	36280	42640	39480
CHLORIDES	2	35420	39420	33480	38420	39000
(PPM)	3	36780	43410	32460	36570	33910
	1	1910	2010	2140	2100	2120
POTASSIUM	2	1740	1830	1860	1910	1980
(PPM)	3	1810	1980	2140	2060	2020
	1	3030	1810	870	1270	970
SUSPENDED	2	1870	1050	1010	1930	850
SOLIDS (SS)	3	3130	1010	510	1290	790
	1	25403	12410	14816	16019	26606
COD	2	32862	17944	25643	30696	31658
(mg/l)	3	19869	12410	31418	22034	24440

TABLE C.14 EXP.No.3 EFFLUENT DATA SUMMARY (NATURAL)

E	KPERIMENT	No. 3 5%TS	NATURAL	(DATA SUM	MARY SHEET	Γ)
			DATE			
PARAMETER	REP No.	NOV18/87	NOV 24/87	DEC 4/87	JAN 5/88	JAN 11/88
	1	6.91	6.89	6.88	6.79	6.8
pH	2	7.01	7.03	6.96	6.84	6.87
	3	6. 95	6.85	6.76	6. 79	6.75
	4	7.23	7.06	7.01	6.89	6.79
	5	7.05	7	7.05	6.91	6.91
	AVG	7.03	6.966	6.932	6.844	6.824
	1	2740	2610	2730	2640	2550
AMMONIA	2	2840	2640	2710	2540	2510
(PPM)	3	2930	3010	3110	2870	2760
	4	2540	2480	2560	2390	2410
	5	2310	2290	2250	1940	2160
	AVG	2672	2606	2672	2476	2478
	1	1.2	1.2	1.2	1.2	1.3
NITRATE	2	1.3	1.3	1.4	1.4	1.4
(PPM)	3	1.3	1.3	1	1.4	1.4
	4	1.1	1.1	1.2	1.4	1.4
	5	1	1.2	1.2	1.3	1.3
	AVG	1.18	1.22	1.2	1.34	1.36
	1	18640	22740	23410	28410	25610
	2	20610	26470	22320	24560	22100
CHLORIDES	3	23410	21100	26310	23670	28400
(PPM)	4	26490	25420	31620	28400	26310
	5	19470	22460	21410	27600	25970
	AVG	21724	23638	25014	26528	25678
	1	960	1020	1200	1120	1180
······································	2	1100	1120	1080	1160	1070
POTASSIUM	3	880	910	960	980	1060
(PPM)	4	740	690	740	500	790
	5	680	720	800	640	820
	AVG	872	892	956	880	984
	1	4240	1920	1040	2440	780
	2	2860	2560	1340	1980	880
SUSPENDED	3	4560	2100	2240	1880	840
SOLIDS (SS)	4	2400	1860	1020	1200	940
(ma/l)	5	1980	1620	580	980	1120
	AVG	3208	2012	1244	1696	912
	1	21777	26935	16431	20240	24626
COD	2	20939	21161	15224	24626	37484
(ma/l)	3	16108	18273	21604	17032	25454
· · · · · · · · · · · · · · · · · · ·	4	14664	17552	18236	28101	25829
	5	13942	14626	14626	18236	22446
	AVG	17486	19709.4	17224.2	21647	27167.8

TABLE C.15 EXP. No.3 EFFLUENT DATA SUMMARY (STERILIZED)

EXI	PERIMENT	No. 3 5%TS	STERILIZED	(DATA SUN	MARY SHEE	T)
]	I	DATE		l	
PARAMETER	REP No.	NOV18/87	NOV 24/87	DEC 4/87	JAN 5/88	JAN 11/88
	1	6.51	6.52	6.51	6.41	6.36
pН	2	6.42	6.36	6.29	6.28	6.28
	3	6. 6	6.51	6.42	6.36	6.28
	4	6.7	6.81	6.26	6.15	6.12
	5	6.68	6.76	6.45	6.2	6.22
	AVG	6.582	6.592	6.386	6.28	6.252
	1	530	480	505	<u>510</u>	485
AMMONIA	2	540	500	510	525	490
(PPM)	3	580	550	540	500	505
	4	610	580	500	550	460
	5	480	490	565	585	570
	AVG	548	520	524	534	502
	1	1.3	1.3	1.3	1.3	1.3
NITRATE	2	1.2	1.1	1,1	1.1	1.1
(PPM)	3	1.2	1.2	1.2	1.2	1.2
	4	1.1	1.1	1.1	1.1	1.1
	5	1	1.1	1.1	1.1	1.1
<u> </u>	AVG	1.16	1.16	1.16	1.16	1.16
	1	22410	23640	21888	24360	24690
CHLORIDES	2	21460	24690	25430	26430	22480
(PPM)	3	22100	20680	23410	21460	23480
	4	23640	21690	26430	24470	24310
	5	20680	22430	24300	21670	21840
	AVG	22058	22626	24291.6	23678	23360
	1	840	910	950	940	960
POTASSIUM	2	1100	1140	1090	1020	980
(PPM)	3	910	910	960	940	960
	4	900	860	790	810	840
	5	740	790	840	800	760
	AVG	898	922	926	902	900
	1	3840	1560	1110	1020	1200
SUSPENDED	2	3260	2320	1360	1280	1400
SOLIDS (SS)	3	3940	2480	1200	1360	1640
(mg/l)	4	2860	2160	840	940	1060
	5	2940	1840	960	1070	1040
	AVG	3368	2072	1094	1134	1268
	1	14563	18420	14472	13115	13460
COD	2	15270	18340	14690	15240	14125
(mg/l)	3	16425	17275	13525	13535	13470
	4	12735	13395	11430	12670	12755
	5	13630	15864	11825	12830	12805
	AVG	14524.6	16658.8	13188.4	13478	13323

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APPENDIX D

STATISTICAL ANALYSES OF INFILTRATION RATES AND EFFLUENT DATA

EXPERIMENT No.1 - TABLES D1 TO D12 EXPERIMENT No.2 - TABLES D13 TO D16 EXPERIMENT No.3 - TABLES D17 TO D18

EXPERIMENT No. 1 (20 MICRON FABRIC) TREATMENT COMPARISON AMONG HEADS (0.9 m vs 1.8 m HEAD)

1	0.00				
	df	SS	MS	F cal	
 TOTAL	35	159.02			
TREAT	1	0.01	0.01	0.018	
BLOCKS	17	149.55	8.8	15.81 **	
 ERROR	17	9.46	0.556		

** Significant at 1% level

EXPERIMENT No. 1 (20 MICRON FABRIC) TREATMENT COMPARISON AMONG HEADS (0.9 m vs 2.7 m HEAD)

df	SS	MS	F cal	
35	150.42			
1	0.27	0.27	0.45	
17	140.13	8.24	13.98 **	
17	10.02	0.59		
	(0.5 m 05 2.7 df 35 1 17 17	df SS 35 150.42 1 0.27 17 140.13 17 10.02	df SS MS 35 150.42 1 0.27 0.27 17 140.13 8.24 17 10.02 0.59	df SS MS F cal 35 150.42 1 0.27 0.45 17 140.13 8.24 13.98 ** 17 10.02 0.59

** Significant at 1% level

EXPERIMENT No. 1 (20 MICRON FABRIC) TREATMENT COMPARISON AMONG HEADS (1.8 m vs 2.7 m HEAD)

		,			
	df	SS	MS	F cai	
TOTA	NL 35	216.12			
TREA	AT 1	0.17	0.17	0.6	
BLOC	CKS 17	211.01	12.41	42.73 **	
ERRC	DR <u>17</u>	4.94	0.29		

EXPERIMENT No. 1 (30 MICRON FABRIC) TREATMENT COMPARISON AMONG HEADS (0.9 m vs 1.8 m HEAD)

	(0.5 11 \$5 1.0				
	df	SS	MS	F cal	
TOTAL	35	101.95			
TREAT	1	0.32	0.315	0.346	
BLOCKS	17	86.14	5.067	5.561 **	
ERROR	17	15.49	0.911		

** Significant at 1% level

EXPERIMENT No. 1 (30 MICRON FABRIC) TREATMENT COMPARISON AMONG HEADS (0.9 m vs 2.7 m HEAD)

	(0.0 111 10 2.7				
	df	SS	MS	F cal	
TOTAL	35	283.22			
TREAT	1	112.93	112.93	33.95 **	
BLOCKS	17	113.77	6.69	2.01	
ERROR	17	56.53	3.32		

** Significant at 1% level

EXPERIMENT No. 1 (30 MICRON FABRIC) TREATMENT COMPARISON AMONG HEADS (1.8 m vs 2.7 m HEAD)

	(
	df	SS	MS	F cal	
TOTAL	35	333.32			
TREAT	1	101.3	101.3	44.04 **	
BLOCKS	5 17	192.91	11.35	4.93 **	
ERROR	17	39.11	2.3		

EXPERIMENT No. 1 (40 MICRON FABRIC) TREATMENT COMPARISON AMONG HEADS (0.9 m vs 1.8 m HEAD)

.

	(0.911 491.0				
	df	SS	MS	F cal	
TOTAL	35	84.01			
TREAT	1	0.007	0.006	0.019	
BLOCKS	17	77.7	4.57	12.32 **	
ERROR	17	6.3	0.037	<u></u>	

** Significant at 1% level

EXPERIMENT No. 1 (40 MICRON FABRIC) TREATMENT COMPARISON AMONG HEADS (0.9 m vs 2.7 m HEAD)

	(0.5 m v3 2.3				
	df	SS	MS	F cal	
TOTAL	35	91.43			
TREAT	1	2.48	2.48	4.36	
BLOCKS	17	79.27	4.66	8.19 **	
ERROR	17	9.67	0.57		

** Significant at 1% level

EXPERIMENT No. 1 (40 MICRON FABRIC) TREATMENT COMPARISON AMONG HEADS (1.8 m vs 2.7 m HEAD)

,	df	SS	MS	F cal	
 TOTAL	35	126.97			
TREAT	1	2.22	2.22	9.39 **	
BLOCKS	17	120.72	7.1	29.98 **	
ERROR	17	4.03	0.24		

EXPERIMENT No. 1 (0.9 m HEAD) TREATMENT COMPARISON AMONG FABRICS (20 vs 30 micron fabric)

	120 43 00 11				
	df	SS	MS	F cal	
TOTAL	35	70.08			
TREAT	1	3.52	3. 5 2	11.58 **	
BLOCK	S 17	61.39	3. 61	11.87 **	
ERROR	17	5.17	0.304		

** Significant at 1% level

_

EXPERIMENT No. 1 (0.9 m HEAD) TREATMENT COMPARISON AMONG FABRICS (20 vs 40 micron fabric)

	(20 V3 40 1110				
	df	SS	MS	F cal	
TOTAL	35	75.71			
TREAT	1	5	5	30.39 **	
BLOCKS	5 17	67.91	3.99	24.26 **	
ERROR	17	2.8	0.165		

** Significant at 1% level

EXPERIMENT No. 1 (0.9 m HEAD) TREATMENT COMPARISON AMONG FABRICS (30 vs 40 micron fabric)

df	SS	MS	F cal						
35	44.19								
1	0.13	0.13	1.37						
17	42.45	2.5	26.4 **						
17	1.61	0.094							
	df 35 1 17 17	df SS 35 44.19 1 0.13 17 42.45 17 1.61	df SS MS 35 44.19 1 0.13 0.13 17 42.45 2.5 17 1.61 0.094	df SS MS F cal 35 44.19 1 0.13 1.37 17 42.45 2.5 26.4 ** 17 1.61 0.094					

EXPERIMENT No. 1 (1.8 m HEAD) TREATMENT COMPARISON AMONG FABRICS (20 vs 30 micron fabric)

	(,		
		df	SS	MS	F cal
•	TOTAL	35	195.55		
-	TREAT	1	1.47	1.47	4.19
[BLOCKS	17	188.08	11.06	31.39 **
I	ERROR	17	5.99	0.352	

** Significant at 1% level

EXPERIMENT No. 1 (1.8 m HEAD) TREATMENT COMPARISON AMONG FABRICS (20 vs 40 micron fabric)

		df	SS	MS	F cal			
	TOTAL	35	176.52					
	TREAT	1	4.22	4.22	13.88 **			
	BLOCKS	17	167.14	9.83	32.37 **			
	ERROR	17	5.16	0.304				

** Significant at 1% level

EXPERIMENT No. 1 (1.8 m HEAD) TREATMENT COMPARISON AMONG FABRICS (30 vs 40 micron fabric)

	df	SS	MS	F cal	
TOTAL	35	142.28			
TREAT	1	0.703	0.703	2.11	
BLOCKS	17	135.93	8	24.08 **	
ERROR	17	5.64	0.332		

** Significant at 1% level

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EXPERIMENT No. 1 (2.7 m HEAD) TREATMENT COMPARISON AMONG FABRICS (20 vs 30 micron fabric)

		df	SS	MS	F cal		
	TOTAL	35	339.76				
	TREAT	1	85.87	85.87	37.51 **		
	BLOCKS	17	214.96	12.64	5.52 **		
	ERROR	17	38.92	2.29	<u></u>		

** Significant at 1% level

EXPERIMENT No. 1 (2.7 m HEAD) TREATMENT COMPARISON AMONG FABRICS (20 vs 40 micron fabric)

	df	SS	MS	F_cal				
TO	TAL 35	168.41						
TR	EAT 1	0.021	0.021	0.028				
BL	OCKS 17	155.76	9.16	12.33 **				
ER	IROR 17	12.63	0.74					

** Significant at 1% level

EXPERIMENT No. 1 (2.7 m HEAD) TREATMENT COMPARISON AMONG FABRICS (30 vs 40 micron fabric)

	100 49 40 1110			
	df	SS	MS	F cal
TOTAL	35	303.77		
TREAT	1	88.58	88.58	26.11 **
BLOCKS	17	157.52	9.27	2.73
ERROR	17	57.67	3.39	

EXPERIMENT No. 1 OVERALL FABRIC TREATMENT COMPARISON (20 vs 30 MICRON FABRIC)

	` df	SS	MS	F cal	
ΤΟΤΑ	L 35	145.62			
TREA	Т 1	4.24	4.24	11.3 **	
BLOC	KS 17	135.01	7.94	21.17 **	
ERRC	DR <u>17</u>	6.38	0.37		

** Significant at 1% level

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EXPERIMENT No. 1 OVERALL FABRIC TREATMENT COMPARISON (20 vs 40 MICRON FABRIC)

(•			· · · • • •		
	df	SS	MS	F cal	<u>_</u>
TOTAL	35	129.45			
TREAT	1	2.18	2.18	8.76 **	
BLOCKS	17	123.02	7.24	29.01 **	
ERROR	17	4.24	0.25		

** Significant at 1% level

EXPERIMENT No. 1 OVERALL FABRIC TREATMENT COMPARISON (30 vs 40 MICRON FABRIC)

	df	SS	MS	F cal	
TOTAL	35	116.97			
TREAT	1	12.51	12.51	26.11 **	
BLOCKS	17	96.32	5.67	11.83 **	
ERROR	17	8. <u>14</u>	0.48		

AMONG TREATMENT COMBINATIONS

	df	SS	MS	Fcal	
 TOTAL	89	3.11E+09			
TREAT.	8	1.14E+09	1.43E+08	13.82245 **	
BLOCK	9	1.22E+09	1.36E+08	13.15363 **	
ERROR	72	7.44E+08	10327474		

** Significant at 1% level

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Least significant Difference (Isd) @72 df and 0.005 =2169

OVERALL (RESPECTIVE OF MANURE PRESSURES)

di		SS	MS	F cal
TOTAL	29	5.99E+08		
TREAT.	2	1.4E+08	70065230	18.23385 **
BLOCK	9	3.89E+08	43256310	11.25707 **
ERROR	18	69166634	3842591	

** Significant at 1% level

Least significant Difference (Isd) @18 df and 0.005 =4136

AMONG TREATMENT COMBINATIONS

	df	SS	MS	F cal
TOTAL	80	18078967		
TREAT	8	8529875	1066234	21.4932 **
BLOCK	8	6374180	796772.5	16.06137 **
ERROR	64	3174912	49608	

** Significant at 1% Level

.

Least Significant Difference (Isd) @ 64 df and 0.005 = 278

OVERALL (RESPECTIVE OF MANURE PRESSURES)

	df	SS	MS	Fcal
TOTAL	26	2916458		
TREAT	2	291698.6	145849.3	4.666876 *
BLOCK	8	2124727	265590.8	8.498356 **
ERROR	16	500032.4	31252.02	

** Significant ait 1% Level

* Significant at 5% Level

Least Significant Difference (Isd) @ 16 df and 0.025 = 177

Least Significant Difference (Isd) @ 16 df and 0.005 = 243

TABLE D.10 STATISTICAL ANALYSIS FOR EXP. No. 1 (CHEMICAL ANALYSIS - POTASSIUM mg/l)

AMONG TREATMENT COMBINATIONS

	df	SS	MS	F cal	
TOTAL	89	8253107			
TREAT.	8	359060.5	44882.56	2.510341 *	
BLOCK	9	6606753	734083.7	41.05827 **	
ERROR	72	1287293	17879.07		

** Significant at 1 % level
*Significant at 5% level
Least Significant Difference @ 72 df and 0.005 = 158
Least Significant Difference @ 72 df and 0.025 = 119

OVERALL (RESPECTIVE OF MANURE PRESSURES)

	df	SS	MS	F cal
TOTAL	29	2427152		
TREAT.	2	37812.69	18906.34	1.819007 **
BLOCK	9	2202251	244694.6	23.54242
ERROR	18	187087.9	10393.77	

** Significant at 1 % level

Least Significant Difference @ 18 df and 0.005 = 133

AMONG TREATMENT COMBINATIONS

	df	SS	MS	F cal	
TOTAL	89	3.83E+10			
TREAT.	8	3. 8E+09	4.75E+08	1.21 5018	
BLOCK	9	6.31E+09	7.01E+08	1.792141	
ERROR	72	2.82E+10	3.91E+08		

No significant difference

OVERALL (RESPECTIVE OF MANURE PRESSURES)

df		SS	MS	F cal
TOTAL	26	3.6E+09		
TREAT.	2	5.52E+08	2.76E+08	1.771715
BLOCK	8	5.53E+08	69182207	0.444494
ERROR	16	2.49E+09	1.56E+08	

No significant difference

AMONG TREATMENT COMBINATIONS

	lf	SS	MS	F cal
TOTAL	89	1.45E+08		
TREAT.	8	10572740	1321593	2.867119 **
BLOCK	9	1.02E+08	11303751	24.52284 **
ERROR	72	33188247	460947.9	

**Significant at 1% Level

Least Significant Difference (Isd) @ 72 df and 0.005 = 805

OVERALL (RESECTIVE OF MANURE PRESSURES)

	df	SS	MS	F cal
TOTAL	29	37899023		
TREAT.	2	46971.92	23485.96	0.107275
BLOCK	9	33911253	3767917	17.21035 **
ERROR	18	3940798	218933.2	

**Significant at 1% Level

Least Significant difference (Isd) @ 18 df and 0.005 = 602

EXPERIMENT No. 2 TREATMENT COMPARISON (4%TS vs 1% TS)

	df	SS	MS	F cal
TOTAL	17	480616.2		
TREAT	1	250374.8	250374.8	30.63 **
BLOCKS	8	164861.8	20607.72	2.52
ERROR	8	65379.6	8172.45	

** Significant at 1% level

EXPERIMENT No. 2 TREATMENT COMPARISON (4%TS vs 2% TS)

	df	SS	MS	F cal	
TOTAL	17	72453.23			
TREAT	1	17215.02	17215.02	33.93 **	
BLOCKS	8	51179.68	6397.46	12.61 **	
ERROR	8	4058.52	507.32		

** Significant at 1% level

EXPERIMENT No. 2 TREATMENT COMPARISON (2%TS vs 1% TS)

	df	SS	MS	F cal
TOTAL	17	383703.9		
TREAT	1	136285.5	136285.5	25.23 **
BLOCKS	8	204205.7	25525.72	4.73
ERROR	8	43212.69	5401.59	

EXPERIMENT No. 2 TREATMENT COMPARISON (6%TS vs 1% TS)

	df	SS	MS	F cal	
TOTAL	17	483239.2			
TREAT	1	237514.4	237514.4	34.98 **	
BLOCK	S 8	191403.1	23925.38	3.52	
ERROF	8	54321.75	6790.22		

** Significant at 1% level

EXPERIMENT No. 2 TREATMENT COMPARISON (6%TS vs 2% TS)

	df	SS	MS	F cal
TOTAL	17	85829.34		
TREAT	1	13801.25	13801.25	31.41 **
BLOCKS	8	68513.27	8564.16	19.49 **
ERROR	8	3514.81	<u>439.35</u>	

** Significant at 1% level

EXPERIMENT No. 2 TREATMENT COMPARISON (6%TS vs 4% TS)

	df	SS	MS	F_cal
TOTAL	17	55039.49		
TREAT	1	188.43	188.44	1.14
BLOCKS	8	53530.38	6691.29	40.5 **
ERROR	8	1320.67	165.08	

EXPERIMENT No. 2 TREATMENT COMPARISON (8%TS vs 1% TS)

	df	SS	MS	F cal
TOTAL	17	496699.2		
TREAT	1	286259.6	286259.6	23.66 **
BLOCKS	8	113639	14204.97	1.17
ERROR	8	96799.8	12099.98	

** Significant at 1% level

EXPERIMENT No. 2 TREATMENT COMPARISON (8%TS vs 2% TS)

	df	SS	MS	F cal
TOTAL	17	64019.59		
TREAT	1	27276.69	27276.69	15.16 **
BLOCKS	8	22347.69	2793.46	1.55
ERROR	8	14395.21	1799.4	· · · · · ·

** Significant at 1% level

EXPERIMENT No. 2 TREATMENT COMPARISON (8%TS vs 4% TS)

	df	SS	MS	F cal	
TOTAL	17	20718.5			
TREAT	1	1152.64	1152.64	1.4	
BLOCKS	8	12974.05	1621.76	1.96	
ERROR	8	6591.81	823.97	<u> </u>	

No Significant Difference

EXPERIMENT No. 2 TREATMENT COMPARISON (8%TS vs 6% TS)

	df	SS	MS	F cal	
TOTAL	17	38628.92			
TREAT	1	2273.18	2273.18	1.32	
BLOCKS	8	22556.49	2819.56	1.63	
ERROR	8	13799.25	1724.91		

No Significant Difference

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EXPERIMENT No. 2 TREATMENT COMPARISON (10%TS vs 1% TS)

	df	SS	MS	F cal
 TOTAL	17	498870.6		
TREAT	1	287395.7	287395.7	23.031 **
BLOCKS	8	111645.6	13955.7	1.118
 ERROR	8	99829.4	12478.7	

** Significant at 1% level

EXPERIMENT No. 2 TREATMENT COMPARISON (10%TS vs 2% TS)

	df	SS	MS	F cal	
TOTAL	17	19706.66			
TREAT	1	13144.95	13144.95	27.13 **	
BLOCKS	8	2686.24	335.78	0.69	
ERROR	8	3875.47	484.43		

** Significant at 1% level

EXPERIMENT No. 2 TREATMENT COMPARISON (10%TS vs 4% TS)

	df	SS	MS	F cal	
TOTAL	17	20570.5			
TREAT	1	1275.8	1275.8	1. 38	
BLOCKS	8	11888.51	1486.06	1. 61	
ERROR	8	7406.21	925.78		

No Significant Difference

EXPERIMENT No. 2 TREATMENT COMPARISON (10%TS vs 6% TS)

	df	SS	MS	F cal
TOTAL	17	38529.47		
TREAT	1	2444.87	2444.87	1. 31
BLOCKS	8	21117.96	2639.74	1.41
ERROR	8	14966.64	1870.83	

No Significant Difference

TABLE D.16 (CONT) EXP. No. 2 - 10% TS COMBINATIONS

EXPERIMENT No. 2 TREATMENT COMPARISON (10%TS vs 8% TS)

	df	SS	MS	F cal
TOTAL	17	802.53		
TREAT	1	3.125	3.125	1.05
BLOCKS	8	775.67	96.95	32.67 **
ERROR	8	23.74	2.97	

EXPERIMENT No. 3 - NATURAL vs STERILIZED MANURE INFILTRATION RATES (20 MICRON FABRIC - 0.9m HEAD 5 %TS)

	df	SS	MS	F cal	
 TOTAL	15	21119.15			
TREAT	1	102.41	102.41	1.75	
BLOCKS	7	20606.53	2943.79	50.23 **	
 ERROR	7	410.21	58.6		

** Significant at 1% level

EXPERIMENT No. 3 - NATURAL vs STERILIZED SEEPAGE CONCENTRATIONS (AMMONIA) (20 MICRON FABRIC - 0.9m HEAD 5 %TS)

df	SS	MS	F cal	
9	10599602			
1	10559618	10559618	1813 **	
4	23293.6	5823.4	1.39	
4	16690.4	4172.6		<u></u>
	df 9 1 4 4	df SS 9 10599602 1 10559618 4 23293.6 4 16690.4	df SS MS 9 10599602 1 1 10559618 10559618 4 23293.6 5823.4 4 16690.4 4172.6	df SS MS F cal 9 10599602 1 10559618 10559618 1813 ** 4 23293.6 5823.4 1.39 4 16690.4 4172.6 1.39

** Significant at 1% level

EXPERIMENT No. 3 - NATURAL vs STERILIZED SEEPAGE CONCENTRATIONS (CHLORIDES) (20 MICRON FABRIC - 0.9m HEAD 5 %TS)

	` df	SS	MS	F cal	
TOTAL	9	21606550			
TREAT	1	4313862	4313862	1.23	
BLOCKS	4	14030246	3507562	4.3	
ERROR	4	3262442	815610.4		

No Significant Difference

EXPERIMENT No. 3 - NATURAL vs STERILIZED SEEPAGE CONCENTRATIONS (POTASSIUM) (20 MICRON FABRIC - 0.9m HEAD 5 %TS)

	df	SS	MS	F_cal	
TOTAL	9	10865.6			
TREAT	1	129.6	129.6	0.09	
BLOCKS	4	5857.6	1464.4	1.2	
ERROR	4	4878.4	1219.6		

No Significant Difference

EXPERIMENT No. 3 - NATURAL vs STERILIZED SEEPAGE CONCENTRATIONS (pH) (20 MICRON FABRIC - 0.9m HEAD 5 %TS)

	df	SS	MS	F cal	
TOTAL	9	0.75996			
TREAT	1	0.625	0.625	20.58 **	
BLOCKS	4	0.1215	0.03	9	
ERROR	4	0.0135	0.003		

** Significant at 1% level

EXPERIMENT No. 3 - NATURAL vs STERILIZED SEEPAGE CONCENTRATIONS (NITRATES (20 MICRON FABRIC - 0.9m HEAD 5 %TS)

	df		SS	MS	F cal	
тс	OTAL	9	0.053			
TF	REAT	1	0.025	0.025	7.14 *	
BL	LOCKS	4	0.014	0.0035	1	
Ef	RROR	4	0.014	0.0035		

* Significant at 5% level

EXPERIMENT No. 3 - NATURAL vs STERILIZED SEEPAGE CONCENTRATIONS (SS) (20 MICRON FABRIC - 0.9m HEAD 5 %TS)

·	df	SS	MS	F cal
TOTAL	9	6893522		
TREAT	1	1849.6	1849.6	0.001
BLOCKS	4	6646382	1661595	27.09 **
ERROR	4	245290.4	245290.4	

** Significant at 1% level

EXPERIMENT No. 3 - NATURAL vs STERILIZED SEEPAGE CONCENTRATIONS (COD) (20 MICRON FABRIC - 0.9m HEAD 5 %TS)

			0.0111112112	• /• · • /	
	df	SS	MS	F cai	
TOTAL	9	1.77E+08			
TREAT	1	1.03E+08	1.03E+08	13.27 *	
BLOCKS	4	30974412	7743603	0.71	
ERROR	4	43593873	10898468		

APPENDIX E

CHEMICAL ANALYSES OF EFFLUENT (SAMPLE SETS)

COD SAMPLE SET - TABLE E.1 AMMONIA SAMPLE SET - TABLE E.2 POTASSIUM SAMPLE SET - TABLE E.3 CHLORIDE SAMPLE SET - TABLE E.4 SUSPENDED SOLIDS (SS) SAMPLE SET - TABLE E.5

TABLE E.1 CHEMICAL OXYGEN DEMAND (COD) SAMPLE SET

	C 0 1	D	ANALYSIS	FOR	EIPERIMENT #	IJ	INE TO SEPTE	IBE	R
Standard :	Stock	;	4:1	;	2:1	;	3.33:1	;	10:1
Z Abs (x):	0.425	;	0.355	:	0.225		0.15	;	0.057
Conc.(y)	1000	:	800	1	500	:	300	:	100

The first five dilutions were used to give a straight line

The equation used is as follows:

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	Sue y #(Sue x)^2 - sue x #(sue x#y)		n # (sum x#y)- (sum x # sum y)
b =		. =	
	n # Sum (x^2) - (sum x)^2		n ± (sum x^2) - (sum x)^2

Sample Size (n)	= 5.0
Sum x =	1.2120
Sue y =	2700.00
Sum(x^2) =	0.3830
(Sum x)^2 =	1.4689
(Sua x+y) =	872.20
b =	-51.4182
. =	2439.84

,

y = 2439.8 x-51.41

;	COD Test Date =March 20							: Average :			
:	Dat	e 	- !	SAMPLE	DI	UTION	;	I Abs	1	ppe	: ppe :
1	June	29	;	20.1	ì	50.0	• †	0.340) ;	44048.3	1
ł	June	29	ł	20.2	:	50.0	:	0.310) :	40388.5	: :
;	June	29	ł	20.3	:	50.0	;	0.270)	35508.8	: 39981.9 :
;	June	30	;	20.4	;	50.0	-	0.250) ;	33069.0	1 1
ł	June	30	;	20.5	1	50.0	;	0.330	1	42828.3	: :
ţ	June	30	ł	20.6	1	50.0	;	0.210	1	28189.3	: 34695.5 :
;	June	30	;	20.7	1	50.0	ł	0.410	1	52587.7	1 1
;	June	30	1	20.8	1	50.0	1	0.230	:	30629.1	1 1
ł	June	30	;	20.9	:	50.0	:	0.180	1	24529.5	: 35915.5 :
ł	June	29	:	30.1	1	50.0	5	0.355	1	45878.2	
;	June	29	ł	30.2	;	50.0	;	0.345	:	44658.2	
ł	June	29	ł	30.3	:	50.0	1	0.290	;	37948.7	: 42828.3 :
;	June	30	ł	30.4	:	50.0	;	0.170	ł	23309.6	
ł	June	30	;	30.5	1	50.0	ł	0.310	ł	40388.5	: :
ł	June	30	1	30.6	1	50.0	ł	0.270	1	35508.8	; 33069.0 ;
1	June	30	1	30.7	1	50.0	ł	0.170	1	23309.6	: :
1	June	30	;	30.B	1	50.0	ł	0.275	ł	36118.8	: :
1	June	30	1	30.9	:	50.0	;	0.280	ł	36728.7	32052.4 :
1	June	29	ł	40.1	1	50.0	;	0.410	ł	52587.7	: :
	June	29	!	40.2	:	50.0	ł	0.240	ţ	31849.0	
	June	29	1	40.3	1	50.0	ł	0.260	ł	34288.9	: 39575.2 ;
	June	30	1	40.4	;	50.0	:	0.320	ł	41608.4	; ;
	June	30	;	40.5	;	50.0	;	0.200	:	26969.4	i 1
	June	30	1	40.6	1	50.0	ł	0.200	ł	26969.4	: 31849.0 ;
	June	30	1	40.7	1	50.0	ł.	0.168	1	23065.6	I I
	June	30	ł	40.8	1	50.0	1	0.150	1	20869.7	: :
	June	30	1	40.9	ł	50.0	;	0.238	÷	31605.1	25180.1 :
			ł		ł		:		;		!
TABLE E.2 AMMONIA SAMPLE SET

	AMA	DNIA	ANALYSIS	FO	EIPERIMENT #	1	JUNE TO SEP	TEN	BER
Standard	Stock	1	10:1	:	100:1	 ¦	1000:1		10000:1
Reading	-237	7	-180	 	-120		-61	;	-21
Conc. :	1000) ;	100	;	10	;	1	 	0.1
l log (y) ;		} ;	2	!	1	:	0	;	 -

The first four dilutions were used to give a straight line on semi-logarithmic paper.

The equation used is as follows:

b =	Sue x log y - 1/n Sue log y Sue x		Sum log y	Sue x
	Sum (x^2) - 1/n (Sum x)^2	4 -		

Sample Size (n) = 4.0 Sum x log y = -1191.0 Sum log y Sum x = -3588.0 Sum(x^2) = 106690.0 (Sum x)^2 = 357604.0 b = - 0.0170 a = - 1.0423

log y = 0.0170x-1.0423 y (ppa-N) = 10^(-0.0170x - 1.0423)

Assonia		Test Date =	July 8		Average
Date	SAMPLE :	DILUTION :	eV i	pps	ppe
June 18	20.1 ;	10.0 ;	-197	2031.1	*******
June 18	20.2 :	10.0 ;	-201	2375.5	
June 18	20.3 :	10.0 ;	-202	2470.4	2292.3
June 23	20.4 1	10.0 :	-191 :	1605.9	
June 23	20.5 :	10.0 ;	-192 ;	1670.0	
June 23	20.6 1	10.0 ;	-191 :	1605.9	1627.2
June 23	20.7 ;	10.0 ;	-193 ;	1736.7	
June 23	20.8 :	10.0 ;	-190 :	1544.2	
June 23	20.9 ;	10.0 ;	-189 :	1484.9	1588.6
June 18	30.1 :	10.0 :	-200 :	2284.3	
June 18	30.2 :	10.0	-201 :	2375.5	
June 18	30.3 :	10.0 :	-200 ;	2284.3	2314.7
June 23	30.4 1	10.0 ;	-192 ;	1670.0 ;	
June 23	30.5 :	10.0 :	-191	1605.9 :	
June 23	30.6 1	10.0 ;	-190 ;	1544.2 ;	1606.7
June 23	30.7 ;	10.0 ;	-188 :	1427.9 ;	
June 23	30.8 ;	10.0 :	-195 ;	1878.1 ;	
June 23 1	30.9 :	10.0 ;	-191 ;	1605.9 ;	1637.3
June 18	40.1 :	10.0 ;	-200 ;	2284.3 :	
June 18 ;	40.2	10.0 :	-199 ;	2195.6 ;	
June 18 ;	40.3 :	10.0 ;	-197	2031.1 :	2170.7
June 23	40.4 ;	10.0 :	-194 ;	1806.0 ;	
June 23	40.5 ;	10.0 :	-191 :	1605.9 ;	
June 23	40.6 ;	10.0 :	-189	1484.9 ;	1632.3
June 23	40.7 ;	10.0 ;	-191 1	1605.9 :	
June 23	40.8 :	10.0	-193 :	1736.7 1	
June 23	40.9 ;	10.0 :	-190	1544.2 ;	1628.9
1	:	1	;	:	

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	POTASSIU	m	ANALYSIS	FOI	EXPERIMENT &	1	JUNE	TO SEPTE	IBEI	R
Standard :	Stock	:	10:1	;	100:1	;		1000:1	;	10000:1
Reading	-44.5	;	-101.2	:	-157.4			-209.2	 !	-21
Conc. :	1000		100	:	10				 	0.1
log (y)	3		2	;		 		0	;	

The first four dilutions were used to give a straight line

on semi-logarithmic paper.

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The equation used is as follows:

Sum log y Sum x a = -----

n

n

Sample Size (n) =4.0Sum x log y =-493.3Sum log y Sum x =-3073.8Sum(x^2) =80761.1(Sum x)^2 =262451.3b =-0.0182a =-3.8263

log y = -0.01816 x-3.826 y (ppm-N) 10^(-0.01816x-3.8263)

		Test Date	= July 22		Average
Date	SAMPLE	DILUTION :	•¥ :	ppe	, ppe
July 9	20.1	2.0 ;	-76.30 ;	551.4	; **********
July 9	20.2	2.0 ;	-58.50 ;	1160.8	
July 9	20.3	2.0 :	-74.80 ;	587.1	755.4
July 9	20.4	2.0 ;	-78.00 :	513.5	
July 9	20.5	2.0 :	-81.40 ;	445.5	
July 9	20.5	2.0 :	-68.50 :	754.1	574.4
July 9	20.7	2.0 :	-74.70 :	589.6	
July 9	: 20.8	2.0 ;	-66.20 :	841.2	
July 9	20.9	2.0	-82.70 ;	421.9	617.6
July 9	30.1	2.0 :	-60.00 ;	1090.3	
July 9	30.2	2.0 ;	-63.70 ;	934.0 ;	
July 9	30.3 :	2.0 ;	-56.70 ;	1251.6 ;	1091.9
July 9	30.4	2.0 :	-61.40 :	1028.3 :	
July 9	30.5 :	2.0 :	-78.80 :	496.7	
July 9	30.6 1	2.0 ;	-65.70 ;	859.0 ;	794.6
July 9	: 30.7 ;	2.0 ;	-57.60 ;	1205.4 ;	
July 9	30.8 ;	2.0 :	-66.00 ;	848.3 ;	
July 9	: 30.9 ;	2.0 ;	-66.60 ;	827.3 ;	960.3
July 9	40.1 ;	2.0 ;	-70.90 ;	691.1 ;	
July 9	40.2	2.0 :	-57.80 :	1195.3 ;	
July 9	40.3 ;	2.0 ;	-64.10 ;	918.5 :	935.0
July 9	40.4 ;	2.0 :	-74.00 ;	607.1	
July 9	40.5 ;	2.0 ;	-74.20 :	602.0 :	
July 9	40.6 ;	2.0 :	-71.30 :	679.6	629.6
July 9 🛛	40.7 :	2.0 :	-72.80 :	638.3 ;	
July 9	40.8 ;	2.0 :	-72.60 :	643.7 ;	
July 9	40.9 1	2.0 ;	-78.50 ;	502.9 :	595.0
1	;	1	1		

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TABLE E.4 CHLORIDE SAMPLE SET

CHLORIDES ANALYSIS FOR EXPERIMENT # 1 JUNE TO SEPTEMBER

Standard	Stoct :	10:1		100:1	;	1000:1	;	10000:1
Reading	67.8 ;	122.0	:	175.3	:	229.4	;	-21
Conc. :	1000 ;	100	 ;	10	!	!	;	•:
log (y) :	3 ;	2	 	1	 	•••••••		: -1 :

The first four dilutions were used to give a straight line

on semi-logarithmic paper.

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The equation used is as follows:

 Sue x log y - 1/n Sue log y Sue x
 Sue log y Sue x

 b =
 ______b

 Sue (x^2) - 1/n (Sue x)^2
 n

 Sample Size (n) =
 4.0

 Sum x log y =
 622.7

 Sum log y Sum x =
 3567.0

 Sum(x^2) =
 102835.3

 (Sum x)^2 =
 353430.3

 b =
 0.0186

 a =
 -4.2620

log y = 0.018583 x-4.262 y (ppm-N) 10^(-0.01858x-4.262)

;	Chlorides		Test Date =	July 6		Average (
:	Date	SAMPLE	DILUTION :	eV ;	ppe	i ppe i
;	June 18	20.1 :	20.0 ;	75.90 1	14207.9	;; ;
:	June 18	20.2 :	20.0 :	75.50 :	14453.2	
ł	June 18	20.3 :	20.0 :	71.80 ;	16932.6	15197.9 ;
;	June 23	20.4 ;	20.0 :	81.20 ;	11325.0	
ł	June 23	20.5 :	20.0 ;	77.60 :	13211.1	
ł	June 23	20.6 :	20.0 :	78.30 ¦	12821.2	12452.4 ;
;	June 23 l	20.7 :	20.0 :	77.40 ;	13324.5	
;	June 23 1	20.8 :	20.0 ;	82.60 ;	10666.5	
ł	June 23 :	20.9 ;	20.0 ;	82.50 :	10712.2	11567.8 :
1	June 18 1	30.1 :	20.0 :	72.90 :	16154.1	:
1	June 18 1	30.2 :	20.0 :	67.50 :	20353.3	1
ł	June 18 1	30.3 1	20.0 1	70.30 :	18055.1	18187.5 :
1	June 23 1	30.4 1	20.0 ;	78.10 ;	12931.4 :	1
1	June 23	30.5 :	20.0 1	76.40 :	13907.2 :	:
i	June 23 1	30.6 1	20.0	81.50 ;	11180.5 :	12673.0
i	June 23	30.7 1	20.0 1	77.30 ;	13381.8 :	:
;	June 23 1	30.8 1	20.0 1	72.80	16223.3 :	!
i	June 23	30.9	20.0 1	77.50	13267.7 :	14291.0 :
i	June 18 1	40.1	20.0 :	74.60 1	15020.7	1
i	JUNE 18 :	40.2	20.0	75.70	14330.0 :	1
i	June 18 i	40.3 1	20.0	76.80	13671.2 :	14340.6
i I	June 23 ; Tune 20 h	40.4	20.0	73.40 1	15812.1	;
i I	June 23 i	40.5 ;	20.0	75.00 1	14765.8 :	1
: ;	JUNE 23 i	4V.6 i	20.0	77.00	13554.7	14710.9 1
	JUNE 23 i	40.7	20.0	73.60	15677.4	ł
) [June 22 i	40.0 1	20.0	/5.90	13612.8	
1	i 63 SILPE	7V.J i I	20.0 1	/4.40 1	15149.8	14813.3
' 		i 	i	-	1	1

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TABLE E.5 SUSPENDED SOLIDS SAMPLE SET

Suspended	Solids	Test	Date	=	Harch16			suspended: Solids	Average SS
Date	SAMPLE	IDILU	TION	; !	1		2	i #9/1 !	: B y/l !
fuly 8	: : 20.1	.; !	1.0	1	1.6089	;	1.6386	5720	
July C	20.2	i	1.0	•	1.6048	1	1.6370	: 6220	;
July 6	: 20.3	1	1.0	;	1.6155	ł	1.6390	4480	; 5473
July 9	20.4	1	1.0	:	1.6306	:	1.6508	: 3820	1
July 9	20.5	1	1.0	1	1.6235	1	1.6401	; 3100	:
July 9	20.6	1	1.0	;	1.4554	1	1.4924	: 7180	4700
July 9	20.7	:	1.0	ł	1.4631	ł	1.4882	4800	1
July 9	: 20.8	1	1.0	1	1.4614	ł	1.4795	3400	1
July 9	20.9	1	1.0	;	1.4604	ł	1.4757	2840	3680
July 8	: 30.1	1	1.0	1	1,4775	ł	1.4920	: 2680	1
July 8	: 30.2	Ì	1.0	:	1.6366	:	1.6537	3200	1
July 8	: 30.3	1	1.0	1	1.6136	:	1.6269	1 2440	; 2773
July 9	: 30.4	i	1.0	1	1.6274	1	1.6508	4460	ļ
July 9	: 30.5	1	1.0	1	1.6077	ł	1.6211	2460	1
July 9	: 30.6	1	1.0	ł	1.6275	:	1.6517	4620	: 3847
July 9	: 30.7		1.0	ł	1.4642	:	1.4712	1180	:
July 9	: 30.8	1	1.0	;	1.4635	ł	1.4844	3960	:
July 9	: 30.9	1	2.0	1	1.4727	ł	1.4934	; 3920	; 3020
July 8	40.1	i	1.0	1	1.6301	ł	1.6512	4000	1
July 8	: 40.2		1.0	Ì	1.6277	ł	1.6430	2840	1
July 8	40.3	l	1.0	1	1.4683	ł	1.4943	: 4980	1 394
July 9	: 40.4		1.0	1	1.6372	1	1.6517	2680	!
July 9	40.5		1.0	;	1.6345	1	1.6594	4760	:
July 9	40.6	. :	1.0	;	1.6348	;	1.6479	: 2400	328
July 9	40.7	' ;	1.0	ł	1.6061	;	1.6264	: 3840	+
July 9	40.8		1.0	ł	1.6297	' '	1.6526	; 4360	:
July 9	40.9		1.0	;	1.6474	1	1.6695	4200	413
July 8	blank		1.0	ł	1.4731	. 1	1.4741	: 160	1
July 8	blank		1.0	1	1.4645	i 1	1.4661	; 280	: 22

Suspended Solids

1 = Mass of filter and cup 2 = Mass of filter and cup and residue

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APPENDIX F

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PERMEABILITY OF VIRGIN GEOTEXTILES

20	MICRON	FABRIC	-	TABLE	F.1
30	MICRON	FABRIC		TABLE	F.2
40	MICRON	FABRIC		TABLE	F.3

TABLE F.1 PERMEABILITY OF 20 MICRON FABRIC

Perseability of Virgin Geotextile By falling Head Method

20 um Geotextile

Thickness (d) = 0.15 cm

; (; ; } ;	lriginal Height Io, (cs)	 	Time , t (sec)	 -	Volume , V (ml)		Final Height Hi , (cm)	l Peri	eability - (cm/s)	
•	75.000	', 	18.000	• ; • 	5845.000	-;-	42.048	; ;	4.82E-03	-; ;
i 1	/0.000	:	24.000	1	5945.000	1	36.484	1	4.07E-03	1
i	81.000	i i	19.000	ł	6230.000	1	45.878	!	4.49E-03	1
;	80.000	;	15.000	1	4980.000	;	51.925	1	4.32E-03	1
} 	70.000	: :	20.000	: !	6125.000	; .!	35.470	1	5.10E-03	;
-		•		•	verage Perneab	nil.	ity =	1	4.56E-03	· i

Crossectional Area of the Geotextile (A) = 177.38 sq. cm.

Thickness of the Geotextile d = 0.15 cm

Hi = Ho - (V/A)

 $K = \ln (Ho/Hi) + d/t$

TABLE F.2 PERMEABILITY OF 30 MICRON FABRIC

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Original : Height :	Ti se , t (sec)	Volume,V ((ml) (Final Height	Permeability
Ho, (ca) ;		l	Hi , (cm)	K , (ce/s)
80.000 ;	22.000	6395.000	43.947	5. 45E-03
76.000	28.000	6390.000 ;	39,976	4.595-03
81.000 :	23.000	6840.000 ;	42.439	5.62E-03
75.000 :	15.000 ;	4680.000 ;	48.616	5.78E-03
70.000 ;	19.000 :	5350.000 ;	39.839	5.93E-03

Perseability of Virgin Geotextile By falling Head Method

Crossectional Area of the Geotextile (A) = 177.38 sq. cm.

Thickness of the Geotextile d = 0...20 cm

Hi = Ho - (V/A)

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 $K = \ln (Ho/Hi) + d/t$

30 um Geotextile

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TABLE F.3 PERMEABILITY OF 40 MICRON FABRIC

Permeability of Virgin Geotextile By falling Head Method

40 um Geotextile

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Thickness (d) = 0.20 cm

Origin Heigh Ho. (c	al ; t ; e) ;	Time , t (sec)	 !	Volume , V (el)	1	Final Height Hi(ce)	: Pe : : r	reeability
			¦		•¦••		,	
7	1.000 :	15.000	1	5575.000	1	39.570	1	7.79E-03
8	0.000 ;	19.000	!	5515.000	ł	48.909	1	5.18E-03
7	5.000 1	15.000		5480.000	:	44.106	ł	7.08E-03
8	0.000 :	20.000	:	6340.000	:	44.258	1	5.92E-03
7	5.000 :	23.000	:	6250.000	:	39.765	1	5.52E-03

Average Permeability =

6.30E-03

Crossectional Area of the Geotextile (A) = 177.38 sq. cm.

Thickness of the Geotextile d = 0..20 cm

Hi = Ho - (V/A)

 $K = \ln (Ho/Hi) + d/t$

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APPENDIX G

TOTAL SOLIDS (TS) DATA FOR ALL EXPERIMENTS

EXPERIMENT NO.1 - TABLE G.1 EXPERIMENT NO.2 - TABLE G.2 EXPERIMENT NO.3 - TABLE G.3

EXPERIMENT	No.	1 TS	(DATA	SUMMARY)
------------	-----	------	-------	----------

	Sample	Nass of Tin	Mass of Tin and Wet Slurry	Mass of Tin and Dry Slurry	Nass of Wet Slurry	Mass of Dry Slurry	% Total Solids	Average T.S.
i	1.00	3.61	91.51	7.57	87.90	3.96	4.51	1 e 1
	2.00 3.00	3.58 3.64	85.34 96.09	7.40	81.76 92.45	3.8Z	4.67	4.59
:	4.00	3.64 3.67	94.91 84.33	7.83	91.27	: 4.19 : 3.74	4.59	4.59
	6.00	3.67	73.60	7.01	67.93	3.34	4.78	4.71
) 	8.00	3.67	86.35	7.60	82.68	3.93	4.75	4.56
4	9.00 10.00	: 3.61 ; 3.64	74.82	6.96 6.96	71.21 72.71	3. 35 3.32	4.70 4.57	4.64
						:	i	

TABLE G.2 EXP. No. 2 TOTAL SOLIDS DATA SUMMARY

EXPERIMENT No. 2 TS (DATA SUMMARY)

Sample	Mass of Tin	Mass of Tin and Wet Slurry	Mass of Tin and: Dry Slurry 1	Mass of 1 Wet Slurry 1	Mass of 1 Dry Slurry 1	Z Total Solids	Average
1.00	1.35	22.79	1.55	21.44	0.20	0.93	1 7 1
2.00	1.35	31.57	1.69	30.22	0.34	1.13	1
3.00	1.34	41.20	1.74 ;	39.86	0.40	1.00	1.02
4.00	1.34	27.43	1.88	26.09	G.54 ;	2.07	1
5.00	1.35	36.04	2.05 ;	34.69 :	0.70	2.02	1 1
6.00	1.35	29.28	1.97	27.93	0.62	2.22	: 2.10
7.00	1.36	28.28	2.50	26.92	1.14 ;	4.23	1
8.00	1.36	33.95	2.70	32.59 ;	i.34 ;	4.11	:
9.00	1.37	26.90	2,50 ;	25.53	1.13	4.43	; 4.2
10.00	1.35	21.87	2.62	20.52	1.27	6.19	
11.00	1.35	29.66	3.10 !	28.31	1.75 !	6.13	
12.00	1.37	! 37.17 !	3.23 !	30.75	1.86	6.05	6.1
13.00	1.35	33-16	3.97 !	31.81	2.62	8.24	1
14.00	1.35	29.67	3.69 :	28.32	2.34 :	8.26	•
15.00	1.37	: 38.41	4.34	37.04 :	2.97	8,02	: 8.1)
16.00	1.37	1 34.98	4,80 1	33.61	3.43 !	10.21	
17.00	1.34	1 33.21	4.73 !	31.87	3.39	10.64	
18.00	1.35	- 36.18 ·	4.85	34.83 !	3.50	10.05	10.3

Mass of wet slurry = mass of tin and wet slurry -mass of tin Mass of dry slurry = mass of tin and dry slurry -mass of tin

Total Solids (T.S.) = (Mass of dry slurry / Mass of wet slurry)\$100

TABLE G.3 EXP. NO. 3 TOTAL SOLIDS DATA SUMMARY

Sample	Nass f of Tin	Mass of Tin and Wet Slurry	Mass of Tin and: Dry Slurry	Mass of Wet Slurry	Hass of Dry Slurry	% Total Solids	Average T.S.
1.00	1.37	32.23	2.96		1.59	5.15	
2.00	1.36	35.45	3.17 (34.09 !	1.81	5.31	: :
3.00	1.36	34.56	; 3.08 ;	33.20	1.72 :	5.13	:
4.00	1.34	29.16	2.78	27.82	1.44	5.18	STERILE ;
5.00	1.35	28.45	2.77 ;	27.10	1.42 :	5.24	5.21 :
6.00	1.35	33.67	3.05	32.32	1.70 ;	5.26	: 1
7.00	1.35	37.81	3.28	36.46	1.93 !	5.29	
5.00	: 1.36	26.57	2.68	25.21	1.32 :	5.24	
9.00	1.36	36.24	3.22 ;	34.88	1.86 :	5.33	NATURAL ;
10.00	; 1.37	35.32	3.10	33.95	1.73 ;	5.10	5.24 ;
- 	- ¦			!			!

EIPERIMENT No. 3 TS (DATA SUMMARY)

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Mass of wet slurry = mass of tin and wet slurry -mass of tin Mass of dry slurry = mass of tin and dry slurry -mass of tin

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Total Solids (T.S.) = (Mass of dry slurry / Mass of wet slurry)\$100

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VISCOSITY CORRECTION FAC					
ADJUSTED TO BASE OF 15 °C					
(FOR PURE WATE	ER)				
TEMPERATURE	CORRECTION				
	FACTOR				
30	0.720				
29	0.730				
28	0.755				
27	0.770				
26	0.785				
25	0.800				
24	0.820				
23	0.835				
22	0.855				
21	0.870				
20	0.885				
19	0.905				
18	0.915				
17	0.935				
16	0.960				
15	1.000				
14	1.020				
13	1.035				
10	1.055				
9	1.075				
8	1.090				
7	1.105				
6	1.125				
5	1.145				
	Luthin (1966)				