RESEARCH REPORT

Assessment of the Takla Landing Contour Trench Wastewater Disposal System

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Assessment of the Takla Landing Contour Trench Wastewater Disposal System

A Report to:
Canada Mortgage and Housing Corporation
Environment Canada
Health & Welfare Canada
Indian & Northern Affairs Canada
Takla Lake Band

May, 1989

NovaTec Consultants Inc.
Environmental Engineers & Scientists

SUMMARY

A two year monitoring study of a community contour trench wastewater disposal system was carried out at Takla Landing B.C. The principal objective of the study was evaluate the effect of the following three trench bottom surface infiltrative media with regard to their ability of enhancing the formation of a biomat, or biological/organic material layer. The three media were: synthetic geotextile; the insitu material (a moderate to highly permeable sand/gravel); and a specified sand. Wastewater samples were collected using sampling devices located directly underneath the trench bottom and analyzed for BOD/COD, nutrients and bacterial quality. In addition, groundwater samples were collected from monitoring wells positioned downslope of the test section of the contour trench and the analytical data compared with the background groundwater quality with respect to nutrient and bacterial concentrations. Biomat samples were collected and analyzed for microbial activity and subjected to scanning electron microscopy (SEM).

In general, the contour trench functioned satisfactorily from a wastewater renovation standpoint, with little or no deterioration of the surrounding groundwater quality. However, problems were encountered with regard to uneven flow distribution along the length of the trench, presumably as a result of some degree of post-installation settlement. In the early stages of the study, the geotextile appeared to have good biomat formation characteristics. However, after approximately 18 months of operation the fabric appeared to be plugging up with organic material. Concern was expressed that the rate of organic material accumulation exceeded the rate of bacterial degradation so that the long term hydraulic permeability of the fabric was jeopardized. The results also indicated that there was no statistically significant difference between the three surface infiltrative media on the wastewater renovation characteristics of the trench, i.e. that there was no advantage to lining with trench bottom with either a specified sand or the geotextile.

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ACKNOWLEDGEMENTS

Canada Mortgage and Housing Corporation, Environment Canada, Health and Welfare Canada, the Takla Lake Band, and Indian and Northern Affairs Canada were supporting parties for this project and contributed funding for various portions over its duration. Health and Welfare Canada and Indian and Northern Affairs Canada provided further assistance with respect to transportation, analytical and related costs of the site visits. The financial and technical support of all of the above parties is gratefully acknowledged.

In addition to the above financial contributors, appreciation is extended to the parties who were involved during the initiation and implementation of this demonstration and assessment project. Their co-operation and valuable input is greatly appreciated. The parties are:

The Takla Lake Band - Owner
Urban Systems Ltd. - Design Engineers
T.R. Underwood Engineering - Design Technical Advisors
Mr. R.F. Crowe P.Eng, President, Associated Geotextile Systems, - Geotextile Manufacturers
Duncan and Associates - Construction Resident Engineers
Chilako Construction - Construction Supervision Contractor
B.C. Science Council - Funding Agency for Effluent Samplers

The members of the study Team are follows:

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Mr. Rick Guiton, Golder Associates, Project Hydrogeologist
Mr. Terry Underwood, Technical Resource Person
Dr. Jon Smit, University of B.C., Project Microbiologist
Mr. Peter Nix., EVS Consultants, Project Microbiologist

1. INTRODUCTION

1.1 The Site

The community of Takla Landing is located on Takla Lake Band Reserves No. 7 and 7A on the east shore of Takla Lake, approximately 120 km north of the Village of Fort St. James. Takla Landing can be accessed by a 300 km road from Fort St. James through Manson Creek, east of Takla Landing, only during the summer months. Alternatively, access to the community is by chartered aircraft from Fort St. James or Prince George. Figure 1 illustrates the location of the community in relation to Fort St. James and Prince George.

Figure 2 illustrates the overall layout of the Takla Lake community and shows the general topography and other physical features. Present developed area suitable for housing is somewhat limited, being confined by Takla Lake to the west and the B.C. Railway right-of-way to the east. The railway has not been used or maintained for a period of over 10 years.

The present population of the community is estimated to be approximately 350. As illustrated in Figure 2, the community includes about 60 houses, a school, two teacher's residences, a church, a medical clinic, and the Band Office. The majority of houses on the reserve are located south-east of Hudson's Bay Creek. Proposed development north-east of the railway includes 28 lots within the reserve boundary and additional lots and playing fields between the boundary and Hudson's Bay Creek.

The village is served by a community water system with the water supply being derived from an intake in Takla Lake. Electrical power to the community is supplied by B.C. Hydro.

During the predesign study for upgrading the community's wastewater management servicing, a comprehensive geotechnical and hydrogeological study of the reserve concluded that roughly half

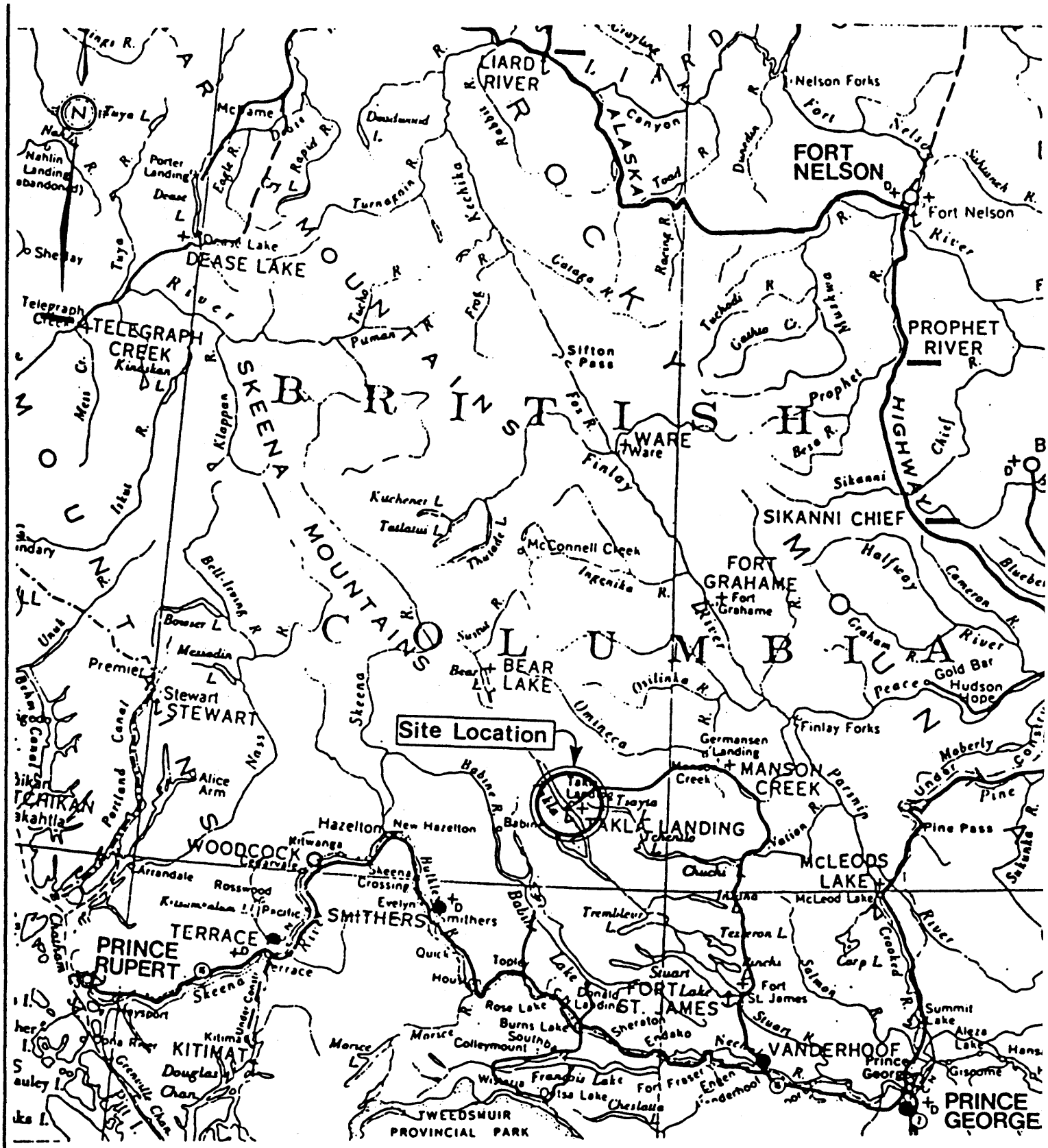
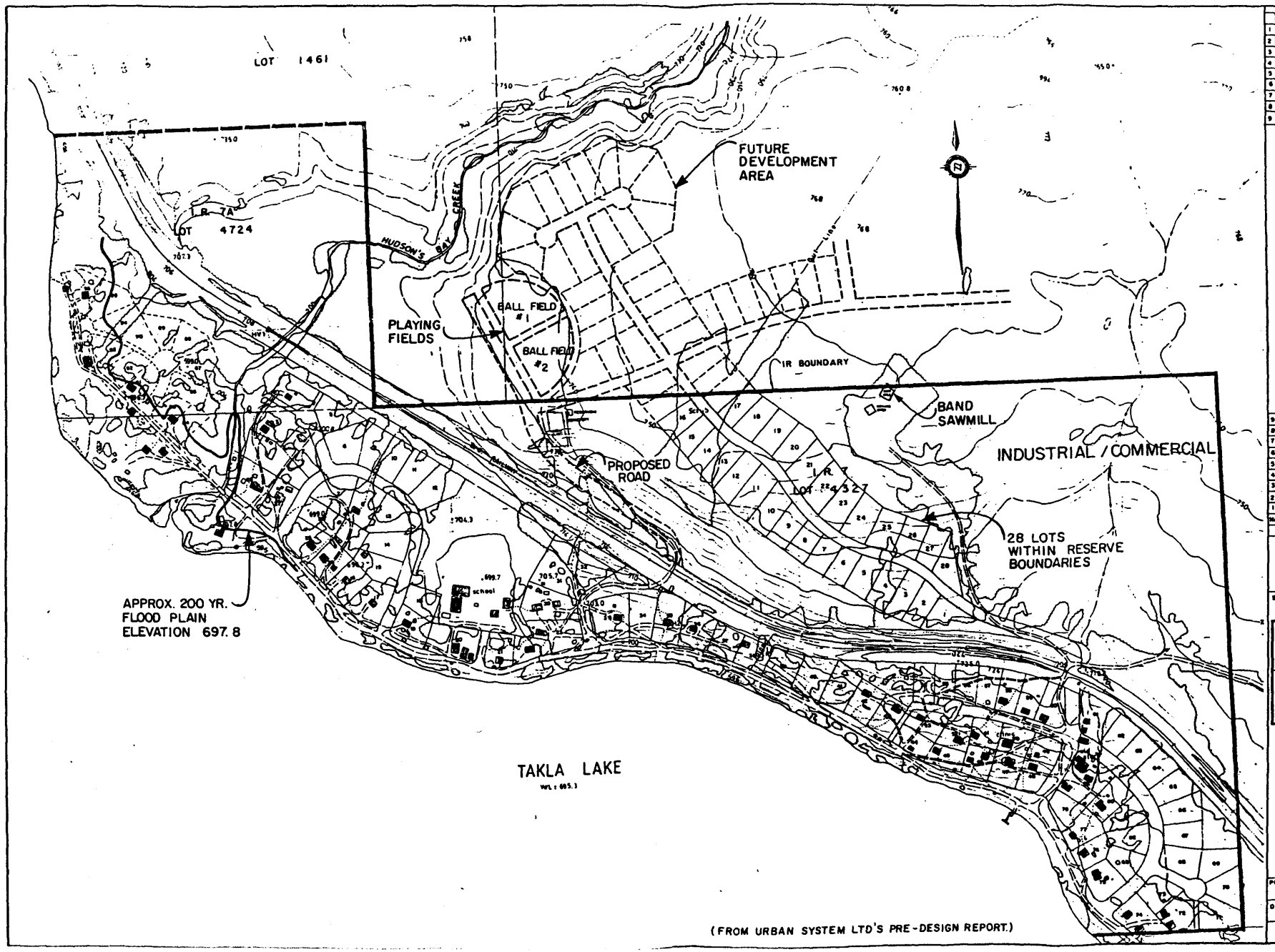


FIGURE 1

LOCATION PLAN

SCALE

0 50 100 150 km



(FROM URBAN SYSTEM LTD'S PRE-DESIGN REPORT.)

	DESCRIPTION	DATE
1	FOR APPROVAL	
2	FOR TENDER	
3	FOR CONSTRUCTION	
4		
5		
6		
7		
8		
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No.	
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REVISIONS

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TAKLA LAKE INDIAN BAND

COMMUNITY EXPANSION AREAS

FIGURE 2

PROJECT NO. PG-83-A827-01

DWG. NO. R

of the building sites on the Reserve are located on outwash materials suitable for individual on-site disposal systems. The remainder of the community, lots 34 to 83 inclusive in the southern part of the Reserve (see Figure 2), is sited on glacial till materials that are unsuitable for individual on-site systems. The proposed areas for future community expansion, located above the railway right-of-way, are also in the glacial soil materials. On the basis of the soils investigation program, the southern half of the existing community and future development areas had to be serviced by a community sewerage system.

1.2 The Contour Trench System

The contour trench wastewater disposal system is a relatively new alternative ground disposal technology developed in Nova Scotia for application in soils having moderate to poor permeability characteristics. The Port Maitland, Nova Scotia system was designed by Mr. Dave Pask of the Nova Scotia Department of Health and Mr. James Vaughan (formerly of Porter Dillon Ltd). Subsequent monitoring and demonstration projects were carried out sponsored by the Canada Mortgage and Housing Corporation, Nova Scotia Department of Health and Environment Canada.

The contour trench system consists of distribution pipes in trenches placed along a constant elevation (or contour) for distances of 200 to 300 metres, and perpendicular to slopes of 5 to 15° (CMHC 1985). A major design objective of the Nova Scotia system is to discharge the effluent to the soil medium along a broad front, thereby minimizing the hydraulic load per unit length of field. The system is fed from a dosing chamber which periodically discharges enough effluent to fill one of the distribution pipes approximately four times a day. The other pipe rests for approximately a six month period. The original intent of the system is that the effluent moves principally in a horizontal direction from the trench side wall, as opposed to a

conventional system in which the effluent moves principally in a downward direction.

In general, the contour trench system offers the following advantages over conventional ground disposal:

1. The system is highly efficient in site area requirements. Because of its linearity, it can readily be used in existing communities using space unsuitable to other facilities, and without conflicting with other facilities.

2. The linear design of the system enables maximizing the separation to adjacent water bodies such as creeks, rivers, or lakes. The increased separation should, theoretically, result in a higher degree of wastewater renovation through the soil when compared with conventional ground disposal systems.

3. The linear design of the contour trench, which is perpendicular to the groundwater flow, results in effluent discharge over a broad front, thereby minimizing the hydraulic load per unit length of the trench. This too should result in a higher degree of renovation when compared with conventional disposal systems.

4. Cost data developed for the system indicates that it is less expensive than an equivalent conventional tile field system.

The contour trench system has potential application in areas where nutrient removal, particularly phosphorus, is a design objective for on-site and community ground disposal systems. The linear concept of the system placed perpendicular to the direction of effluent flow maximizes the soil volume through which the effluent flows. Phosphorus adsorption capacity of the soil is thereby used to the greatest extent possible. The system has potentially widespread application in areas where phosphorus transmission to water courses is a major concern.

Recognizing the advantages of the contour trench system over conventional ground disposal, the system has the potential for widespread application in remote areas throughout Canada. The system is particularly well suited for small communities where the impact on receiving water courses is a major concern, or where topographic or other physical constraints make construction of a conventional disposal system impractical. These applications include communities in which housing is constructed along a narrow strip parallel to a lake or river. Demonstrating that the contour trench system can operate successfully under the severe northern climate and the isolation from regular maintenance by trained personnel could provide a technology to be used in many housing developments and small communities across Canada.

1.3 Application of the Contour Trench System at Takla Landing

Contour trench technology was first applied in British Columbia as a result of enquiries by Mr. Lorne Pierlot, P.Eng., and Mr. Terry Underwood, P.Eng. (formerly of Urban Systems Ltd.) regarding the Port Maitland, Nova Scotia Project.

The principal difference between the contour trench system at Takla Landing and the Nova Scotia installations is the higher permeability of the receiving soils at Takla Landing. The Nova Scotia systems were specifically developed for application in soils having moderate to poor permeability characteristics, with the primary direction of flow being in the downslope lateral direction. At Takla Landing, the native soil materials are moderately to highly permeable sands and gravels. Therefore, the effluent movement from the Takla system was expected to be rapid, and primarily in a vertical direction from the trench bottom to the ground water table. Other differences between the Takla and the Nova Scotia systems are the colder climate conditions and the lack of access to trained maintenance personnel at Takla Landing.

A two-year monitoring/demonstration project was set up at the Takla Landing contour trench system. During the study program the project team evaluated the operating aspects of the system and addressed effluent renovation both in the trench and receiving soils at Takla Landing. There are two fundamental design differences between Takla Landing and the Port Maitland, N.S. demonstration projects. These are the soil matrix and the use of various infiltrative surface materials lining the trench bottom.

The soil matrix is responsible for a number of physical and chemical treatment phenomena such as filtration, sorption, ion exchange and precipitation. Fine grain soils, such as those at the Port Maitland site, are characterized by low permeabilities and percolation rates and usually exhibit a high level of the treatment phenomena. Coarse grain soils such as those at Takla Landing, on the other hand, are characterized by high permeabilities and percolation rates and tend to exhibit much lower levels of wastewater renovation.

A biological and organic solids mat (biomat) usually forms on the infiltrative surfaces of the trench bottom and sidewalls. The filtration efficiency of the surface is directly related to the physical pore size across which the biomat particles must bridge. The biomat improves the filtration and attenuation of contaminants. Therefore, rapid formation of the biomat is particularly important in coarse soils where it improves the treatment efficiency of the system. To promote a rapid formation of the biomat, a medium (usually a specified sand) on which the biomass can grow and on which organic solids can be filtered, is often installed in disposal trenches constructed in granular soils.

The same sand medium is used in fine grain soils, but for different reasons. In fine grain soils, the filter medium protects the native material from clogging by the biological and organic solids, by promoting the biomat formation on the installed medium rather than on the insitu fine grain soil

interface. The medium also reduces masking of the infiltration surface of the trench by the trench drain rock.

The Takla Landing contour trench assessment project was designed to demonstrate the relative filtering and fecal organism attenuation efficiencies of various trench liner media. The three media used were: (i) a non-woven filter fabric (a synthetic geotextile); (ii) a specified mixture of sand with a specific grain size range; and (iii) the coarse insitu sands and gravels.

Establishing whether or not a synthetic geotextile material is an acceptable biomat formation medium is important from an economic perspective. In many cases, sand with acceptable characteristics as a biomat formation and filter medium is not readily available for subsurface ground disposal systems. Consequently, the cost of importing this material to the site often becomes exorbitant. The quality control testing also presents added complexities and costs when using a specified sand media on the trench bottom. On the other hand, the geotextile can be economically transported long distances and into remote areas and is very easily and expediently handled and installed.

1.4 Study Objectives

The overall objective of the Takla Landing contour trench assessment project was to provide guidelines for application of contour trench technology in areas with coarse grain soils. In doing so, it would promote the application of the technology nationally for individual household and small community systems in both fine grain and coarse grain soils. The development and acceptance of contour trench technology will permit the development of housing in areas presently considered unsuitable for ground disposal of sewage, provide lower cost disposal systems, and result in a general improvement of environmental and health conditions.

The specific objectives of this assessment of the contour trench system operation in coarse grain soils at Takla Landing were:

1) to determine the applicability of contour trench technology for attenuating fecal organisms;
2) to determine the effectiveness in mitigation of nutrient loading on surface waters;
3) to demonstrate the potential for use of appropriate trench bottom biomat formation media;
4) to determine the soil temperature profiles alongside the contour trench and upgradient of the trenches, and to evaluate the effects the ground disposal system on frost penetration in coarse granular soils.

2. MATERIALS AND METHODOLOGY

2.1 Takla Landing Contour Trench Design Criteria

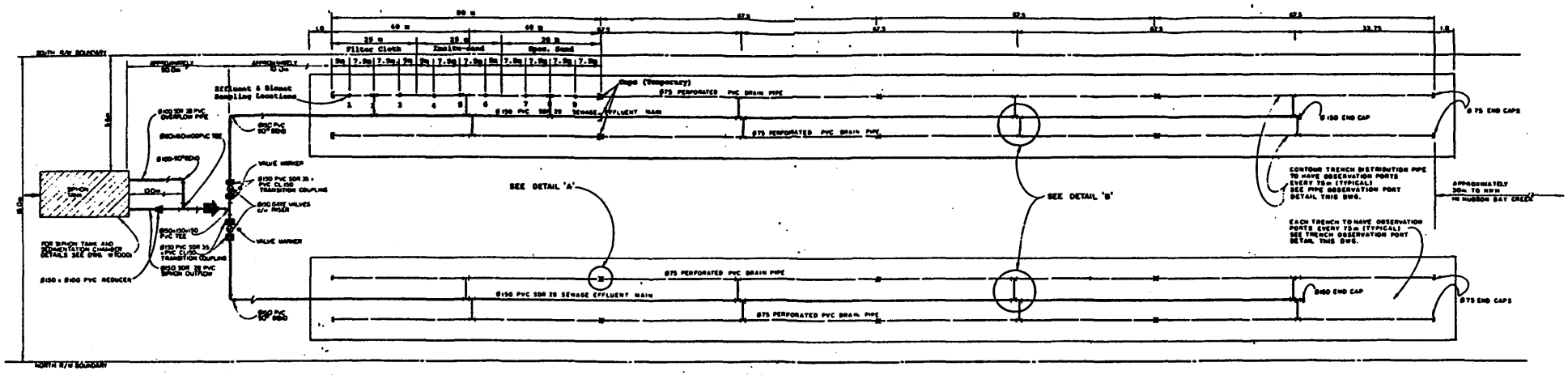
The Takla Landing system consists of two parallel trenches, 260 m long, which are located directly adjacent to, and 7 m below the railway bed of the non-operative B.C. Railway Dease Lake Extension. The design capacity is for 76 homes or 380 people. A summary of the original design criteria is outlined in Appendix I. The engineering predesign study (Urban Systems Ltd., 1985) notes that the ultimate requirements for community ground disposal servicing are for 107 homes or a population of 540 and that the additional capacity would not have to be built for five to ten years. Furthermore, the design engineers believed that due to the conservative nature of the design, it was possible that the actual capacity of the disposal system could be significantly greater than the theoretical design capacity.

Households feeding into the contour trench system have individual septic tanks. The majority of tank effluent is collected by a gravity collection system and delivered to a pump station, from where it is pumped to a grit/detritus sedimentation chamber (having two compartments in series, each with a volume of 2.7 m^3) and a first generation Pask Dosing Syphon. Septic tank effluent from six of the houses drains by gravity directly into the sedimentation chamber.

The contour trench is dosed with septic tank effluent from the dosing syphon with a dosing volume of 12 m^3. The design dosing frequency for present population is three per day and at the design population is seven per day.

2.2 Test Site Layout

The test area consisted of an 80 m long section of one of the trenches of the Takla Landing contour trench effluent disposal



PLAN VIEW OF CONTOUR TRENCH
SHOWING TEST SECTION

NOT TO SCALE

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(PLAN FROM URBAN SYSTEM LTD'S DESIGN DRWG.)

FIGURE 3

field (see Figure 3). The area was subdivided into three sections of approximately equal length, each having three effluent and three biomat samplers, set out in pairs. Each of the three sections had one of the following infiltrative surface materials at the trench bottom:

1) Sampler Nos. 1, 2 & 3 - Synthetic geotextile
2) Sampler Nos. 4, 5 & 6 - Coarse insitu sand/gravel mixture
3) Sampler Nos. 7, 8 & 9 - Specified sand mixture

Detailed drawings of the effluent sample collectors, the biomat samplers, and the pipe and trench and observation port details are presented in Appendix II. The principal function of the biomat samplers was to compare the biomat forming characteristics of the three media investigated. Each biomat sampler was equipped with a collector located directly underneath the contour trench drain pipe. The collectors were designed to redirect wastewater from the trench drain pipe onto self-draining biomat media buckets located at the base of the biomat samplers. Foam insulating plugs, 600 mm in length, were installed in the biomat sampler access pipe to protect the sample against freezing and limit exposure to surface air. During sampling, the insulating plugs and buckets were removed via the access pipe so that the biomat could be inspected and sampled.

The effluent samplers were to provide the capability of comparing the effect of the three biomat formation media on micro-organism and nutrient concentrations in the effluent. Three effluent samplers were installed directly underneath each of the three infiltrative surface media. A length of 38 mm PVC flexible tubing, containing a 6 mm PVC sampling tube, connected the sample chamber to the ground surface. By connecting the sampling tube to a vacuum flask and pump, the sample chamber was drained during visits by the project team. Each sample chamber was fitted with an overflow pipe that limited the storage capacity of the chamber to approximately 2 L. This modification of the original sampler design ensured that a sample taken at any time during the

monitoring program was relatively fresh, in spite of the infrequent sampling. A length of heat tracing tape was attached to the sampling tube to thaw it out in the event of freezing.

The trench observation ports were installed to determine whether ponding was occurring in the trench. Pipe observation ports were installed to facilitate visual checks of flow along the trench length.

A thermistor rod having sensors at ground level and depths of 0.5, 0.65, 1.2 and 1.5 m was installed at the edge of the trench to monitor the temperature profile of the soil. These depths represent top of the trench, the invert level of the perforated drain pipe, the trench bottom, and 300 mm below the trench bottom, respectively. A similar thermistor rod was installed approximately 20 m up-gradient from the trench as a control. The locations of the two thermistor rods are shown on the site plan in Appendix II.

Seven groundwater monitoring wells were installed in the vicinity of the disposal field to determine the effect of the disposal field on the quality of the groundwater migrating towards the lake. Three of the wells (Wells 1, 2 and 3) were installed approximately 50 m apart and 50 m downstream of the test section of the trench. A second set of three monitoring wells (Wells 4, 5 and 6) was placed 5 m down stream of the test section, with each well at the approximate midpoint of each of the three test sections. The seventh monitoring well was installed approximately 30 m south of the southern end of the field to monitor the background water quality. The locations of the monitoring wells are shown on the site plan in Appendix II.

2.3 Sampling and Monitoring

During each site visit, samples were drawn from the dosing chamber and each of the effluent samplers, sub-divided and

preserved in accordance with the analytical requirements and the procedures outlined in "Standard Methods for the Examination of Water and Wastewater" (16th Ed., 1985). A one litre sample was taken from each of the nine samplers for BOD, TOC, TKN, NH_4 and Total-P analyses. Samples for nutrient analysis were preserved by acidification to pH<2 by the addition of concentrated H_2SO_4. A 125 mL sample for nitrate analysis was preserved using a mercuric acetate/acetone solution. Samples for total and fecal coliform analysis were taken using 125 mL sterile glass sample bottles.

Biomat samplers were removed, inspected and photographed. Whenever a slime layer had formed on the media surface, a small area of it was scraped off and suspended in approximately 3 mL of distilled water in a glass vial for transport to the laboratory for biological activity determination. When intact samples of the geotextile biomat were required for microscopic examination, these were obtained by cutting out a section of the geotextile and replacing it with a new section of the fabric.

The flow rate to the disposal field was determined by monitoring the running time of the pump station upstream of the dosing chamber. The pump flow rates were checked against design specifications.

Control and experimental ground temperature profiles were measured using an ohm meter and the thermistor calibration graph.

2.4 Sample Analysis

Sample BOD and nutrient values were measured in accordance with the procedures described in "Standard Methods for the Examination of Water and Wastewater" (16th Ed., 1985) and TOC values were measured using a Dohrman Carbon Analyser, Model DC-80. Total and fecal coliform analyses were done using the membrane filter technique also described in Standard Methods.

2.5 Microbiological Examination of Biomat

During the course of the study program, the following four microbiological examinations were carried out on the biomat samples:

1) Field assessment to determine extent of biomat formation, and other visual characteristics.

2) Microscopic microbial quantification and identification of the organisms present. This was done by dilution and direct plating using platinum-paladium calibrated loops (0.01 mL). Specific and non-specific isolation media plates were incubated at 22, 35 and 44.5 °C for up to 72 hours. Organisms were examined for biochemical, morphological and colony characteristics in accordance with "Bergey's Manual of Determinative Bacteriology" (8th & 9th Editions).

3) Comparison of the microbial activity of the biomats formed. This was done using the resazurin reduction method developed by Lui and Strachan (1978). Biomat scraping were diluted by placing 1-3 grams of "sludge" into 99 mL of distilled water. Total activity was determined by transferring 10 mL of the dilution to a darkened test tube containing dextrose to a final concentration of 0.1%. Incubation time was noted after addition of 3 mL of resazurin solution (3 tablets in 150 mL distilled water) to the test tubes. The tubes were incubated at 25°C in a water bath until a noticeable colour change occurred. The sludge dry weight content was determined by filtration, oven drying and weighing of the solution. Chemical activity was determined in the same manner as above except that one drop of m-cresol (bactericide) was added prior to the addition of the resazurin solution. Microbial activity is defined as the difference between total and chemical activity.

4) Examination and photographing the geotextile biomat using phase microscopy and scanning electron microscopy (SEM).

2.6 Site Visits

2.6.1 Site Visit No. 1 - October 27, 1987

The first site visit was made by plane by members of the project team and some of the sponsoring parties, including Mr. Al Townshend, P.Eng., of Environment Canada, Mr. Iain Baird, Senior Environmental Health Officer of Health and Welfare Canada, and Mr. Dale Sinclair of Chilako Construction. A meeting with the Takla Lake Band representatives was held to complete the briefing of the Band on the project and to introduce the parties involved. The sampling equipment was inspected and tested and some of the biomat sampler well insulating plugs were installed. In the testing of the monitoring equipment, the first set of wastewater samples were taken from under the bottom of the trench. Due to limitations of time on site and the number of samplers which had not yet accumulated sufficient liquid, only one sampler was sampled from each of two filter media areas. These samples were analyzed for coliform and nutrient concentrations. The analytical data is presented in Section 4.

2.6.2 Site Visit No. 2 - March 20 & 21, 1988

The second site visit was made by plane by members of the project team and Mr. Iain Baird of Health and Welfare Canada. A second set of wastewater samples was taken from under the bottom of the trench. Each of the nine samplers had retained approximately 2 L of sample volume. A grab sample of the dosing chamber was also taken. The samples were subdivided, preserved and sent to the laboratories for coliform, nutrient and BOD analysis. The biomat samplers were removed for visual inspection. A significant biomat had formed only in Sampler Nos. 1, 2 and 3 (geotextile test section). Samples of these biomats were scraped off and suspended in approximately 3 mL of distilled water in a sealed glass vial. Biomat samples were sent to the laboratory for microscopic examination. Flooding of the biomat samplers in the geotextile test section was also noted. Evidence of some biomat growth in

Sampler No. 4 (insitu sand test section) was also observed but was not sufficient to capture a biomat sample. This sampler was repacked with the insitu sand/gravel media as there had been some vandalism of the sampler. Media replacement material had been stored on-site for use throughout the project.

Two sets of thermistor readings were taken to determine the ground temperature profiles in the trench and nearby. A visual inspection of the grit and dosing chambers was made and these appeared to be functioning satisfactorily. A visual inspection of the pump station was made, the pump hours recorded and the flowrate of Pump No. 1 determined.

2.6.3 Site Visit No. 3 - August 30 - September 4, 1988

The third site visit was made by road by members of the project team and Mr. Iain Baird of Health and Welfare Canada. Two sets of wastewater samples were to be drawn from the samplers located under the bottom of the trench. The samplers were to be first drained and then allowed to refill so that a second sample could be drawn and the uniformity of the flow distribution along test section of the trench could be determined.

Upon the initial draining each of the Samplers 1-8 produced approximately 2 L of sample volume, indicating that the sampler overflow was functioning correctly. However, Sampler No. 9 was clearly flooded as it produced more than 10 times the sampler volume. This indicated that there was a serious problem regarding the flow distribution along the length of the test section, with the likelihood of ponding and/or settlement of the trench in the vicinity of Sampler No. 9.

The dosing chamber was checked for a possible malfunction which may have contributing factor to the uneven flow distribution. After observing the dosing chamber for 24 hours, it was apparent that it had not functioned correctly in that the water level remained at its minimum, and the chamber appeared to be

discharging into the field at a constant "trickle" rate rather than on a "batch" basis. Two holes were drilled near the base of the syphon pipe to help break the syphon when the liquid level in the dosing chamber reached its minimum. Portable level recording equipment was installed in the dosing chamber to measure the number and timing of the discharges during the project team's time on site. It was hoped to be able to relate this information to the volumes of sample recovered. The chamber malfunction and the overall low usage of the system (most of the residents were away for the holiday weekend) resulted in no flow records being determined with the portable flow measuring equipment.

Immediately prior to leaving the site, a second set of effluent samples was taken from the samplers located at the bottom of the trench. This time sample volumes ranging from 50-1650 mL were pumped out of Sampler Nos. 1-8. However, Sampler No. 9 once again produced more than ten times the volume of the sampler, confirming the presence of uneven flow distribution and/or localized ponding in the trench system.

One background and six downstream monitoring wells were drilled during the course of this site visit. However, time constraints did not permit the required purging and sampling of the groundwater monitoring wells during this site visit.

2.6.4 Site Visit No. 4 - March 22 & 23, 1989

The fourth site visit was made by plane by a member of the project team and Mr. Iain Baird of Health and Welfare Canada. Samplers 1-9 were drained and samples collected for analysis. As in the case of the previous site visit, there was evidence of uneven flow distribution and/or ponding along the test section of the trench, with Sampler No. 9 receiving an inordinately large fraction of the wastewater flow. This observation was confirmed by the fact that the sample pumped out of Sampler No. 9 had a distinct sewage-like smell, whereas the samples pumped out of Sampler Nos. 1-8 were essentially odourless.

The water table was found to be approximately 7-9 m below the ground level at the time of the site visit. Six of the seven monitoring wells were "purged" by pumping out 8-10 L of groundwater and then sampled using a sterile field sampling procedure. Prior to sampling each well, the sampling equipment was thoroughly rinsed with methanol and distilled water as a means of disinfection. It appears that Well No. 5 did not reach the water table at the time of the visit.

At the time of the site visit, the frost penetration at Takla Landing was estimated to be 1.5 m and it was not possible to retrieve the biomat samplers as the PVC pipe monitoring ports had contracted tight around the insulating plugs with the cold temperature, and the plugs could not be removed. Background and trench ground temperature profiles were taken.

A quick inspection of the dosing chamber indicated that it appeared to functioning properly although time constraints on the site did allow comprehensive monitoring of the dosing chamber and pump station to confirm this.

3. RESULTS

3.1 Wastewater Flows

Wastewater flows to the system were estimated by monitoring the pump times of the pump station which pumped raw wastewater to the grit removal and dosing chambers. At the time of writing, the exact number of houses feeding into the system was not known. However, there were six houses with a total of 22 residents which drain by gravity directly into the grit removal chamber. The pump station flow characteristics are as follows:

Pump Design Specification:

Capacity: 454.5 L/min. at 18.3 m TDH (100 Igpm at 60 ft. TDH)

During the March, 1988 site visit the flow rate of Pump #1 was measured by members of the project team. The pump flow rate was found to be 500 L/min under actual conditions.

The pump station monitoring data is presented in Table 1.

TABLE 1

PUMP STATION MONITORING DATA

Date	Pump Meter Reading (hrs) Pump #1	Pump #2	Reported By	Total Hours	No. of days Between Readings	Average Daily Flow (L/d)
Oct 8/87	68.3	23.0	(a)			
Nov 5/87	72.3	26.6	(b)	7.6	28	7,402
Nov 16/87	74.8	28.9	(b)	4.7	11	11,751
Mar 21/88	91.1	44.5	(c)	31.9	157	5,546
May 16/89	192.7	80.4	(d)	137.5	425	8,801

(a) DIAND Technical Services (R. Radloff)
(b) Chilako Construction Ltd. (D. Sinclair)
(c) NovaTec Consultants Inc. (G. Bull; B. Rabinowitz)
(d) Carrier Sekani Tribal Council (E. Wiens)

Notes:

1) Pumping hours of the two pumps are approximately the same, indicating that the pump rates are approximately equal.
2) Allowing an additional 20% for the six houses that drain directly into the dosage chamber, the total flow to the system is approximately 9,600 L/d or 29.9 $L/m^2/d$ of trench area. This is 71.2% of the design value of 42 $L/m^2/d$.
3) Pump station was inoperative for approximately 2 months between the March, 1988 and March 1989 site visits.

3.2 Coliform Data

The analytical results for wastewater total and fecal coliforms concentrations in samples collected during the October 1987, March 1988, September 1988 and March 1989 site visits are presented in Tables 2, 3, 4 and 5, respectively. Total and fecal coliform concentrations in the groundwater samples drawn from the monitoring wells during the March 1989 site visit are presented in Table 6.

TABLE 2

SYSTEM TOTAL AND FECAL COLIFORM DATA - OCTOBER 1987 SITE VISIT

		Geotextile			Insitu Material			Specified Sand		
Sampler No.:	DC	#1	#2	#3	#4	#5	#6	#7	#8	#9
Parameter:										
TC/100 mL	NS	SE	SE	SE	1,290,000 900,000	NS	NS	42,500 31,500	NS	SE
FC/100 mL	NS	SE	SE	SE	7,350 5,900	NS	NS	FTI FTI	NS	SE

TABLE 3

SYSTEM TOTAL AND FECAL COLIFORM DATA - MARCH 1988 SITE VISIT

		Geotextile			Insitu Material			Specified Sand		
Sampler No.:	DC	#1	#2	#3	#4	#5	#6	#7	#8	#9
Parameter:										
TC/100 mL	OG OG	44,000 25,000	400 400	10,000 11,000	FTI FTI	100 100	950 800	FTI FTI	150,000 160,000	469,000 160,000
FC/100 mL	100,000 310,000	FTI FTI	FTI FTI	FTI FTI	FTI FTI	FTI FTI	FTI FTI	FTI FTI	FTI FTI	100 100

DC = Dosing Chamber
SE = Sampler Empty
NS = Not Sampled
OG = Overgrown
FTI = Failed To Incubate

TABLE 4

SYSTEM TOTAL AND FECAL COLIFORM DATA - SEPTEMBER 1988 SITE VISIT

		Geotextile			Insitu Material			Specified Sand		
Sampler No.:	DC	#1	#2	#3	#4	#5	#6	#7	#8	#9
Parameter:										
TC/100 mL	1,440,000	11,800	28,000	SE	54,000	FTI	700	1,000	1,300	6,320,000
FC/100 mL	362,000	2,500	900	SE	FTI	FTI	400	FTI	270	2,960,000

TABLE 5

SYSTEM TOTAL AND FECAL COLIFORM DATA - MARCH 1989 SITE VISIT

		Geotextile			Insitu Material			Specified Sand		
Sampler No.:	DC	#1	#2	#3	#4	#5	#6	#7	#8	#9
Parameter:										
TC/100 mL	OG	FTI	90	NC	FTI	FTI	FTI	FTI	720	>46,500
FC/100 mL	27,450	FTI	FTI	FTI	FTI	FTI	FTI	FTI	FTI	9,540

DC = Dosing Chamber
SE = Sampler Empty
OG = Overgrown
FTI = Failed To Incubate
NC = Non-Coliform Growth

TABLE 6

GROUNDWATER TOTAL AND FECAL COLIFORM DATA - MARCH 1989 SITE VISIT

Well No.:	#1	#2	#3	#4	#5	#6	#7
Parameter:							
TC/100 mL	NC	FTI	360	NC	SE	21,700	450
FC/100 mL	FTI	FTI	FTI	FTI	SE	FTI	FTI

SE = Sampler Empty
FTI = Failed To Incubate
NC = Non-Coliform Growth

3.3 Nutrient Data

Extensive surveys of the nutrient concentrations in the dosing chamber and the wastewater samplers was carried out during the March 1988, September 1988 and the March 1989 site visits. The results of these surveys are presented in Table 7, 8 and 9, respectively. In the case of NO_3 and NO_2, the March 1988 data indicates, with only one exception, that the nitrogen was predominantly in the NO_3 form. In the September 1988 and March 1989 data, the analytical laboratory reported the sum of the NO_3 + NO_2 simply as NO_x. Nutrient concentrations in the groundwater samples drawn from the monitoring wells during the March 1989 site visit are presented in Table 10.

3.4 Carbon Data

During the March 1988, September 1988 and March 1989 site visits, samples were taken from the dosing chamber and the nine effluent samplers for TOC and BOD analysis. The data generated from these site visits are presented in Tables 11, 12 and 13, respectively.

3.5 Biomat Inspection Data

During the March, 1988 site visit, it was noticed that a significant biomat had developed only on the biomat samplers having the geotextile lining (Samplers 1, 2 and 3), and that minor biomat development had occurred on one of the samplers in the insitu material test section (Sampler 4). Photographs of these four biomats are presented in Appendix III. There was no noticeable biological growth on any of the remaining biomat samplers. At the time of inspection, Biomat Samplers 2, 3 and 4 were submerged with wastewater effluent. The three geotextile biomats were dark green/brown to black in colour and were 1-3 mm thick. Scrapings of the three biomats were resuspended in distilled water and sent off to the laboratory for microbial identification and activity analysis.

TABLE 7

SYSTEM NUTRIENT DATA - MARCH 1988 SITE VISIT

		Geotextile			Insitu Material			Specified Sand		
Sampler No.:	DC	#1	#2	#3	#4	#5	#6	#7	#8	#9
Total P (mg/L)	3.68	0.18	0.23	<0.1	0.40	<0.1	0.14	<0.1	0.16	0.36
PO_4-P (mg/L)	2.75	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
TKN (mg/L)	30.9	13.8	23.4	17.5	12.3	0.66	16.2	14.7	13.8	14.1
NH_4-N (mg/L)	26.1	12.3	19.6	17.2	10.9	0.11	22.0	12.2	10.8	7.0
NO_3-N (mg/L)	<0.05	<0.05	14.0	0.16	4.05	62.5	<0.05	10.8	16.6	<0.05
NO_2-N (mg/L)	<0.05	<0.05	2.80	<0.05	7.59	2.22	<0.05	2.24	3.73	<0.05

TABLE 8

SYSTEM NUTRIENT DATA - SEPTEMBER 1988 SITE VISIT

		Geotextile			Insitu Material			Specified Sand		
Sampler No.:	DC	#1	#2	#3	#4	#5	#6	#7	#8	#9
Total P (mg/L)	8.63	0.09	<0.02	SE	<0.02	<0.02	0.04	0.04	SE	2.21
TKN-N (mg/L)	71.8	-	0.12	SE	<0.01	0.12	5.88	5.05	SE	58.9
NH_4-N (mg/L)	59.7	0.32	0.03	SE	<0.01	0.05	4.01	3.96	SE	43.0
NO_x-N (mg/L)	14.8	0.98	1.02	SE	0.56	0.75	2.27	3.81	SE	11.3

TABLE 9

SYSTEM NUTRIENT DATA - MARCH 1989 SITE VISIT

		Geotextile			Insitu Material			Specified Sand		
Sampler No.:	DC	#1	#2	#3	#4	#5	#6	#7	#8	#9
Total P (mg/L)	10.6	0.24	0.24	0.71	0.37	0.43	0.80	0.35	1.09	0.57
PO_4-P (mg/L)	9.25	<0.02	<0.02	<0.02	<0.02	<0.02	0.49	<0.02	0.12	0.39
TKN-N (mg/L)	81.6	0.20	1.13	0.83	1.00	0.54	6.02	0.31	0.59	49.1
NH_4-N (mg/L)	68.9	0.68	0.17	<0.01	0.08	0.02	5.70	0.06	0.03	46.2
NO_x-N (mg/L)	1.75	60.0	35.3	28.8	23.0	2.5	76.0	67.7	33.8	3.8

TABLE 10

GROUNDWATER NUTRIENT DATA - MARCH 1989 SITE VISIT

Monitoring Well No.:	#1	#2	#3	#4	#5	#6	#7
Total P (mg/L)	0.58	0.66	0.54	1.32	-	0.20	0.86
PO_4-P (mg/L)	0.04	0.04	0.04	0.19	-	0.12	0.09
TKN (mg/L)	0.13	0.09	0.15	0.21	-	0.74	0.23
NH_4-N (mg/L)	<0.01	<0.01	<0.01	<0.01	-	0.03	<0.01
NO_x-N (mg/L)	0.16	0.03	0.27	1.75	-	4.0	<0.01

TABLE 11

SYSTEM CARBON DATA - MARCH 1988 SITE VISIT

		Geotextile			Insitu Material			Specified Sand		
Sampler No.:	DC	#1	#2	#3	#4	#5	#6	#7	#8	#9
Parameter:										
TOC (mg/L)	39	41	33	42	34	35	16	31	32	28
BOD (mg/L)	48	17 (Comp.)			16 (Comp.)			15 (Comp.)		

DC = Dosing Chamber
Comp.= Composite Sample

TABLE 12

SYSTEM CARBON DATA - SEPTEMBER 1988 SITE VISIT

		Geotextile			Insitu Material			Specified Sand		
Sampler No.:	DC	#1	#2	#3	#4	#5	#6	#7	#8	#9
Parameter:										
TOC (mg/L)	-	12	14	SE	8.1	7.1	6.5	5.7	SE	15.0
BOD (mg/L)	-	<10	<10	SE	<10	<10	<10	-	-	20

DC = Dosing Chamber
Comp.= Composite Sample

TABLE 13

SYSTEM CARBON DATA - MARCH 1989 SITE VISIT

		Geotextile			Insitu Material			Specified Sand		
Sampler No.:	DC	#1	#2	#3	#4	#5	#6	#7	#8	#9
Parameter:										
TOC (mg/L)	51	29	15	14	11	25	14	12	14	35
BOD (mg/L)	155	<10	<10	<10	<10	<10	<10	<10	<10	53

DC = Dosing Chamber

On inspection of the biomats during the September 1988 site visit, it was noticed that there had been the continued development of the geotextile biomats (Samplers 1, 2 and 3). Each of the three biomats was submerged and had two distinct layers - a dense black layer approximately 0.5 mm thick on the geotextile cloth which was overlain by a gray/green well formed layer with a thickness of 1-2 mm. Sampler 4 (insitu material) had a well developed uniform gray/black biomat with a thickness of approximately 0.5 mm. Scrapings of the biomat or surface material were taken and sent to the laboratory for microbial activity analysis. There was no visible biomat development on any of the remaining biomat samplers.

3.6 Microbial Identification Data

The results from the microbial identification carried out on scrapings from the geotextile biomats taken during the March 1988 site visit are presented in Table 14. It is important to note that the organism count data (expressed as CFU/100cc) are only useful in expressing the relative number of organisms within each sample and do not provide a meaningful comparison between the number of organisms in different samples. A graphical representation of the relative numbers and types of organisms found in each sample is presented in Figures 4-6. Two scrapings were taken from Biomat Sampler No. 3 in an attempt to sample the two distinct layers. These are reported as 3 (A) and 3(B).

3.7 Microbial Activity Data

The results of the microbial activity analysis carried out on the biomat samples taken during March 1988 are presented in Table 15. Microbial activity is expressed in units of micromoles resazurin reduced/hour/gram of sludge. The values indicate the relative activity of the biomat samples only, as there are no absolute values available for comparison. Results of the microbial activity analysis carried out on the biomat and media samples taken on the September 1988 site visit are presented in Table 16.

TABLE 14

BIOMAT MICROBIAL IDENTIFICATION - MARCH 1988 SITE VISIT

CFU/100 mL	Regular Organisms Found	Comments
Biomat Sampler #1 - Geotextile:		
100,000	Bacillus coagulans	soil
780,000	Kingella sp	sewage, human/respiratory
410,000	Enterobacter agglomerans	vegetation/soil/water
30,000	Kluyvera cryocrescens	soil/water/sewage
410,000	Rahnella aquatilis	freshwater
60,000	Brevibacterium acetylicum	unknown habitat
360,000	Klebsiella oxytoca	fecal, aquatic
10,000	Cardiobacterium sp	human
Fungi/Yeast:		
30,000	Rhizopus sp	
160,000	Penicillium glabrum	
50,000	Penicillium sp	
200	Fusarium sp	
60,000	Gliocladium sp	
180,000	Candida parapsilopsis	
Wet Mount/Gram Stain:		
	3° Sporocytophaga	high organic habitat/aquatic
	4° Nitrococcus sp	ammonia oxidized
Biomat Sampler #2 - Geotextile:		
10,000	Staphylococcus epidermis	skin
20,000	Kingella sp	sewage, human 1° respiratory
3,300,000	Enterobacter agglomerans	vegetation/soil/water
10,000	Kluyvera cryoscrescens	soil/water/sewage
60,000	Rahnella aquatilis	freshwater
70,000	Xanthobacter sp	soil
640,000	Klebsiella oxytoca	fecal, aquatic
Fungi/Yeast:		
30,000	Penicillium glabrum	
70,000	Rhizopus sp	
90,000	Penicillium sp	
60,000	Hansenula sp	
200,000	Candida parapsilosis	
3,000	Mucor sp	
Wet Mount/Gram Stain:		
	2° Cytophaga sp	decaying vegetation/ high organic habitat

TABLE 14 (cont.)

BIOMAT MICROBIAL IDENTIFICATION - MARCH 1988 SITE VISIT

CFU/100 mL	Regular Organisms Found	Comments
Biomat Sampler #3 (A) - Geotextile:		
840,000	Staphylococcus hyicus	skin 1° animal
10,000	Rhodococcus sp	soil
310,000	Kingella sp	sewage, human respiratory
20,000	Enterobacter agglomerans	veg./animal/soil/water
110,000	Kluyvera cryocrescens	soil/water/sewage
40,000	Rahnella aquatilis	freshwater
160,000	Xanthobacter sp	soil
1,400,000	Klebsiella oxytoca	fecal, aquatic
10,000	Sphaerotilus natans	slow running FW, oxidises S
10,000	Bacillus mycoides	soil/water
2,000	Streptococcus sp	oral
2,000	Streptococcus agalactiae	animal pathogen
2,000	Propionibacterium acidi-propionici	skin
Fungi/Yeast:		
20,000	Rhizopus sp	
30,000	Penicillium glabrum	
50,000	Penicillium sp	
60,000	Gliocladium sp	
2,000	Mucor sp	
30,000	Sporobolomyces roseus	
Biomat Sampler #3 (B) - Geotextile:		
10,000	Staphylococcus epidermis	skin
900,000	Kingella sp	sewage, human/respiratory
3,300,000	Enterobacter agglomerans	vegetation/soil/water
1,000,000	Rahnella aquatilis	freshwater
1,000,000	Brevibacterium acetylicum	unknown habitat
3,400,000	Klebsiella oxytoca	fecal, aquatic
200,000	Streptococcus mutans	oral
10,000	Bacillus sp	background
200,000	Streptococcus faecium	fecal
Fungi/Yeast:		**Wet Mount/Gram Stain:**
60,000	Penicillium glabrum	2° Cytophaga
30,000	Gliocladium	
80,000	Mucor sp	
200	Gliomastix	
3,000	Rhizopus sp	
30,000	Sporobolomyses roseus	
90,000	Penicillium sp	

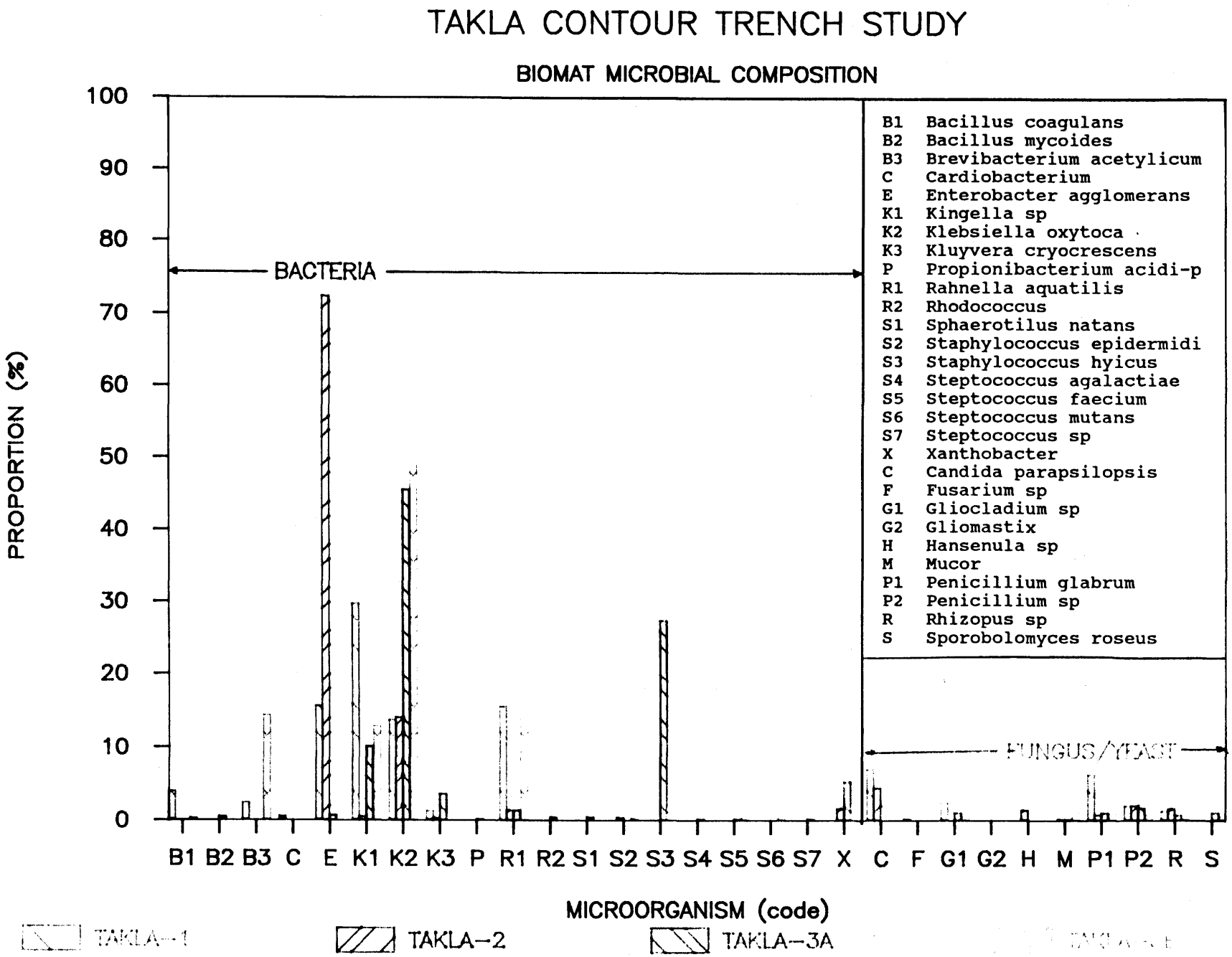

TAKLA CONTOUR TRENCH STUDY
BIOMAT MICROBIAL COMPOSITION
PROPORTION (%)
100
90
80
70
60
50
40
30
20
10
0
BACTERIA
FUNGUS/YEAST
B1 B2 B3 C E K1 K2 K3 P R1 R2 S1 S2 S3 S4 S5 S6 S7 X C F G1 G2 H M P1 P2 R S
MICROORGANISM (code)
B1 Bacillus coagulans
B2 Bacillus mycoides
B3 Brevibacterium acetylicum
C Cardiobacterium
E Enterobacter agglomerans
K1 Kingella sp
K2 Klebsiella oxytoca
K3 Kluyvera cryocrescens
P Propionibacterium acidi-p
R1 Rahnella aquatilis
R2 Rhodococcus
S1 Sphaerotilus natans
S2 Staphylococcus epidermidi
S3 Staphylococcus hyicus
S4 Steptococcus agalactiae
S5 Steptococcus faecium
S6 Steptococcus mutans
S7 Steptococcus sp
X Xanthobacter
C Candida parapsilopsis
F Fusarium sp
G1 Gliocladium sp
G2 Gliomastix
H Hansenula sp
M Mucor
P1 Penicillium glabrum
P2 Penicillium sp
R Rhizopus sp
S Sporobolomyces roseus
TAKLA-1
TAKLA-2
TAKLA-3A

FIGURE 4

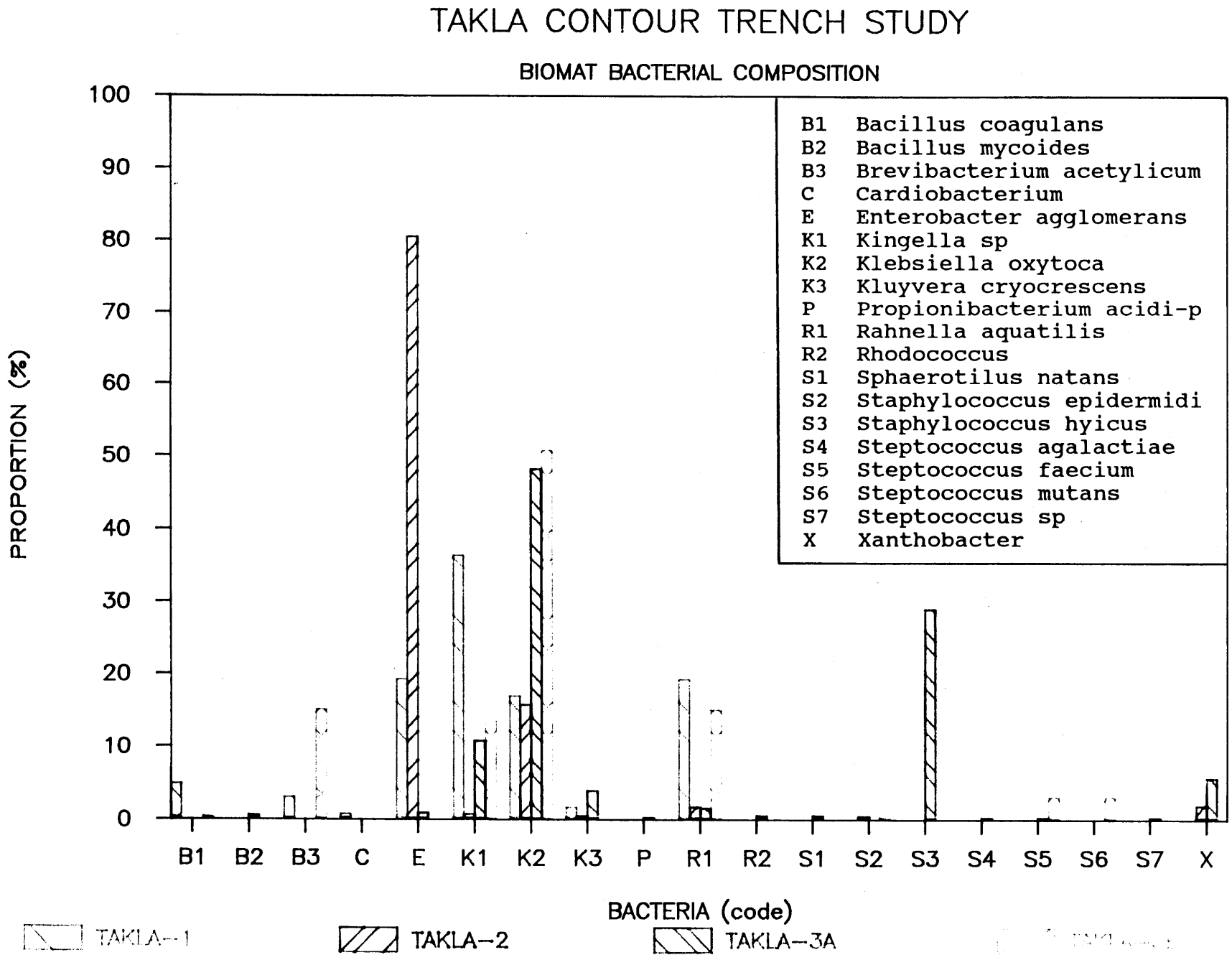

TAKLA CONTOUR TRENCH STUDY
BIOMAT BACTERIAL COMPOSITION
PROPORTION (%)
100
90
80
70
60
50
40
30
20
10
0
B1 Bacillus coagulans
B2 Bacillus mycoides
B3 Brevibacterium acetylicum
C Cardiobacterium
E Enterobacter agglomerans
K1 Kingella sp
K2 Klebsiella oxytoca
K3 Kluyvera cryocrescens
P Propionibacterium acidi-p
R1 Rahnella aquatilis
R2 Rhodococcus
S1 Sphaerotilus natans
S2 Staphylococcus epidermidi
S3 Staphylococcus hyicus
S4 Steptococcus agalactiae
S5 Steptococcus faecium
S6 Steptococcus mutans
S7 Steptococcus sp
X Xanthobacter
B1 B2 B3 C E K1 K2 K3 P R1 R2 S1 S2 S3 S4 S5 S6 S7 X
BACTERIA (code)
TAKLA-1
TAKLA-2
TAKLA-3A

FIGURE 5

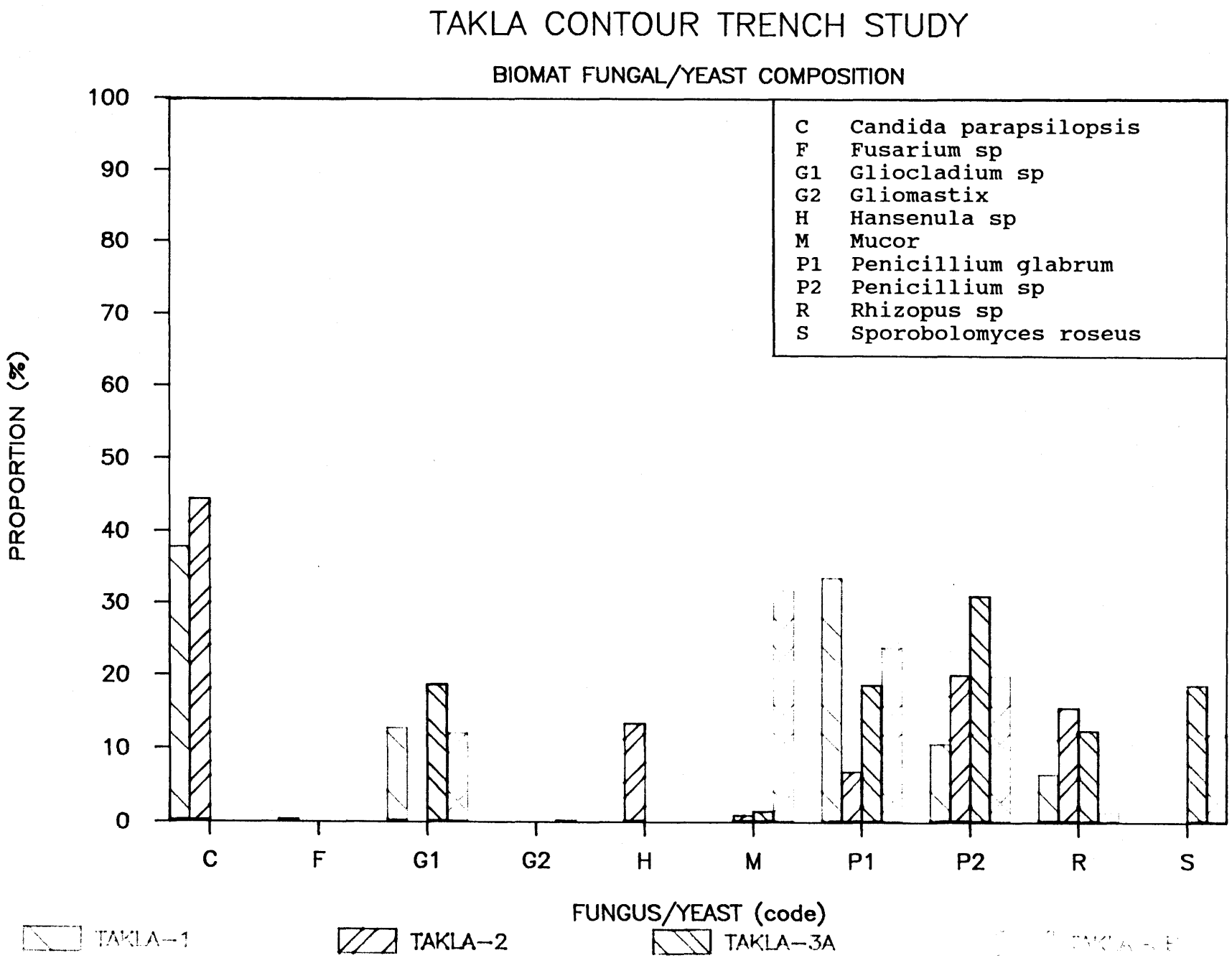

TAKLA CONTOUR TRENCH STUDY
BIOMAT FUNGAL/YEAST COMPOSITION
PROPORTION (%)
100
90
80
70
60
50
40
30
20
10
0
C Candida parapsilopsis
F Fusarium sp
G1 Gliocladium sp
G2 Gliomastix
H Hansenula sp
M Mucor
P1 Penicillium glabrum
P2 Penicillium sp
R Rhizopus sp
S Sporobolomyces roseus
C
F
G1
G2
H
M
P1
P2
R
S
FUNGUS/YEAST (code)
TAKLA-1
TAKLA-2
TAKLA-3A

FIGURE 6

TABLE 15

BIOMAT MICROBIAL ACTIVITY - MARCH 1988 SITE VISIT

Sampler No.	1	2	3(A)	3(B)
Microbial Activity (umol/h/g)	4.2	62.3	30.7	95.0

Two biomat scrapings were taken from Sampler 3.

TABLE 16

BIOMAT MICROBIAL ACTIVITY - SEPTEMBER 1988 SITE VISIT

Sampler No.	1	2	3	4	5	6	7	8	9
Microbial Activity (umol/h/g)	16.6	8.9	9.4	2.2	1.2	NS	0	0	0

Microbial activity of sample = umol resazurin reduced/g sediment/h incubation
There was no detectable activity in Samples 7, 8 and 9.
NS = not sampled

3.8 Microscopic Examination

A microscopic examination of the biomat samples taken during the March 1988 site visit was carried out by Dr. John Smit of the Department of Microbiology, University of British Columbia, to assess the potential for a more detailed microbiological investigation, possibly including scanning electron microscopy (SEM). It was found that, in addition to the organisms noted in the above microbial identification, caulobacter were abundant in the biomat samples examined. It was concluded that it would be of value to examine an undisturbed section of the geotextile biomat using SEM to visually determine the extent of microbial growth at the geotextile/biomat interface.

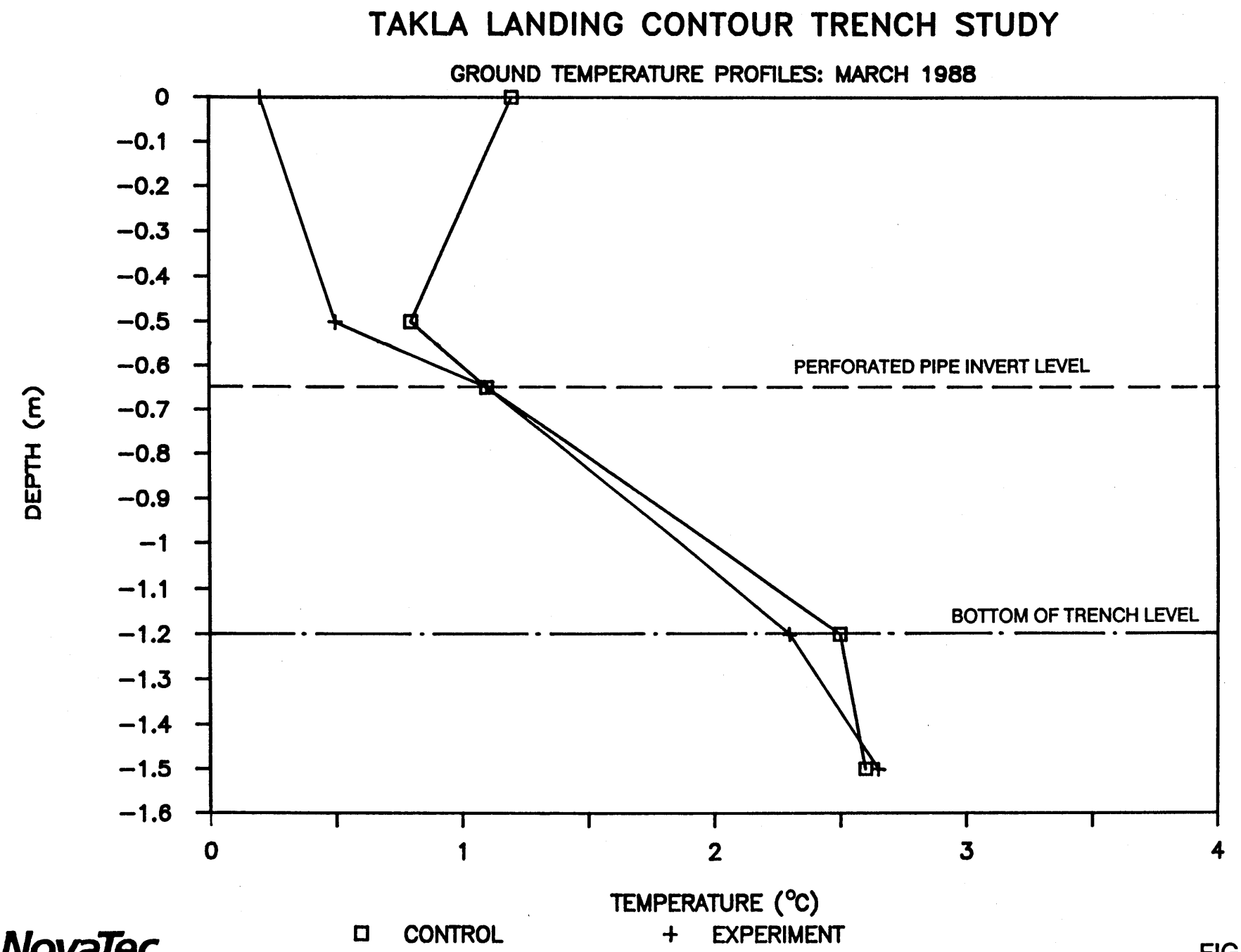
Undisturbed geotextile biomat samples were collected during the September 1988 site visit and subjected to phase microscopy and SEM examination. The text of Dr. Smit's report and SEM photographs produced are presented in Appendix IV. From this microscopic examination it was concluded that the number of bacteria present in the biomat samples was very small on a per gram of sludge basis, when compared to other biological wastewater treatment systems. The biomat and attached organic layer did not appear to be the active biofilm that was originally anticipated. The original intent of using the geotextile was as a means of promoting the growth of a large microbial population to provide a filtering medium and to mineralize most of the wastewater organic carbon. It was believed that the organic layer may readily continue to increase in thickness, possibly to the point where a significant impairment of the water infiltration might occur.

3.9 Ground Temperature Profiles

Ground temperature readings were measured twice during the March, 1988 site visit and control and experimental profiles based on the average reading are presented in Figure 7. Ground temperature profiles were also determined during the March 1989 site visit

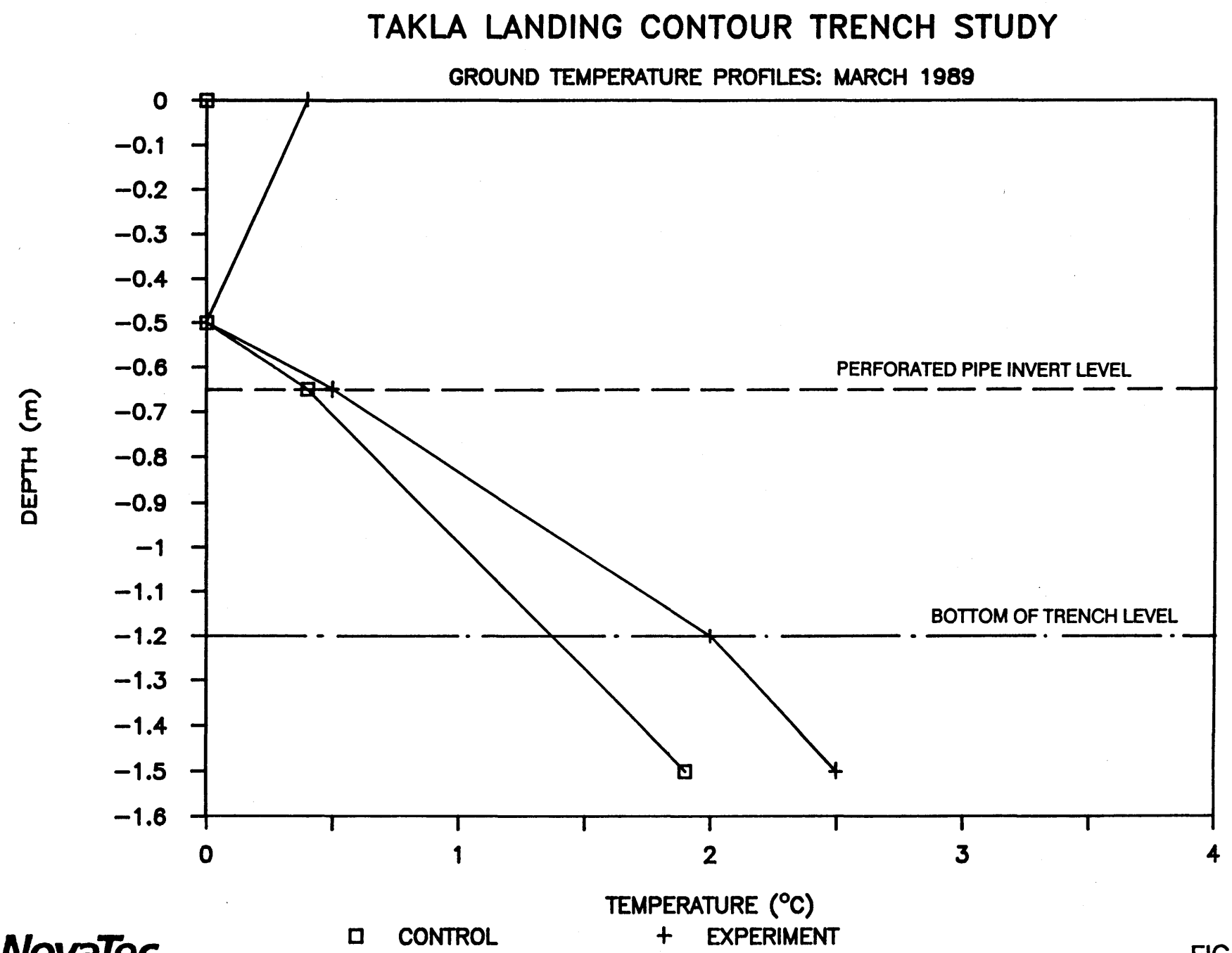
and these are presented in Figure 8. The profiles are not substantially different at the greater depths, with some variation occurring at the ground level and 0.5 m depth. The ground level temperature variation is not considered to be of any significance as the thermistor arrays were placed inside protective boxes and the recorded temperature was largely a function of instantaneous site conditions at the time of measurement.

The winter conditions in 1988/89 were more severe than in 1987/88. As a result of prolonged temperatures below -20°C, the site visit was postponed until late March. The 0°C ground temperature at 0.5 m depth at both locations was probably a result of the prolonged intense cold.



NovaTec Consultants Inc.

FIGURE 7



NovaTec Consultants Inc.

FIGURE 8

4. DISCUSSION

4.1 Wastewater Treatment

In spite of some specific operational difficulties experienced with the dosing chamber and the contour trench, which are further discussed below, it is possible to draw some conclusions regarding the overall performance of the contour trench system in this application.

Average total and fecal coliform reductions of approximately 99% were observed between the dosing chamber and the samplers located underneath the trench. The average total phosphorus removal was approximately 95%, and approximately 80% of the wastewater TKN was either removed or nitrified to NO_x. Although much of the BOD and COD removal data appears to be inconsistent, data from the final site visit indicate that the system is operating satisfactorily.

The background and downstream monitoring well data generated from the final site visit appear to confirm the above observations regarding the coliform and nutrient removal characteristics of the system. However, the long-term effect of the contour trench on the downstream groundwater quality can only be determined through a continued comprehensive groundwater monitoring program.

The major malfunction of the contour trench was the localized ponding observed in the vicinity of Sampler No. 9 during the September 1988 and March 1989 site visits. This ponding is thought to be associated with a uneven flow distribution in the field and resulted in an inordinately large sample volume being drawn from the sampler and a relatively low level of wastewater renovation at this end of the field. There are a number of observations made during the course of the site visits that may explain this problem.

1) The surface of the field appears to have sunk in the vicinity of Samplers 8 and 9 at some point in time between the March 1988 and the September 1988 site visits. If the settlement occurred below the level of the distribution pipe, wastewater may have flowed along the trench bottom, and Sampler No. 9 would have received an inordinately large volume of the flow. (It was reported that during construction, a portion of the trench had to be over-excavated and backfilled).

2) For some of the time at least, the dosing chamber appeared to be malfunctioning in that the wastewater was released at a constant rate rather than in regular doses. This phenomenon, coupled with (1) above, would result in an inordinately large fraction of the flow being discharged at the lowest end of the distribution pipe.

As a result of the contour trench malfunction outlined above, the degree of wastewater renovation occurring in the vicinity of Sampler No. 9 was considerably less than in the remainder of the trench from the time of the September 1988 site visit onwards, for all of the parameters measured. Further evidence of the malfunction can be deduced from the minimal conversion of the ammonia nitrogen to nitrate and/or nitrite (NO_x) in the vicinity of Sampler No. 9. Nonetheless, there is still considerable data through which meaningful comparison of the treatment efficiencies can be made for the system as a hole. The arithmetic mean and 95% confidence interval ranges of all the total coliform, total phosphorus, TKN and NO_x concentrations observed during the course of this study are presented in Table 17 for the three infiltrative surface media.

The statistical data presented in Table 17 indicates that, as a result of the wide variation in the data over the course of the study, there was no statistically significant difference in the treatment efficiencies of the three surface infiltrative media. The means and range in data for the parameters illustrated in

TABLE 17

STATISTICAL ANALYSIS OF DATA

Media:	Geotextile		Insitu Material		Specified Sand	
	Mean	95% Confidence Interval	Mean	95% Confidence Interval	Mean	95% Confidence Interval
Parameter:						
Total Coliform	4,400	540 - 35,400	4,900	156- 153,000	42,000	6,400-277,300
Total P	0.23	0.05 - 0.40	0.26	0.06 - 0.46	0.61	0 - 1.22
TKN	8.13	0 - 17.95	4.75	0 - 9.05	19.57	1.01 - 38.13
NO_x	17.90	0 - 36.96	20.17	0 - 42.87	19.23	0.51 - 37.95

Table 17 for the geotextile and insitu material sections of the trench are very similar. This suggests that there is no additional benefit derived from the use of a geotextile liner with regard to the treatment efficiency of the contour trench system. The higher coliform, TP and TKN for the specified sand are, in all likelihood, attributable to the inordinately large flows being delivered to Sampler No. 9 during the latter half of the study.

The preliminary results of the groundwater monitoring data support the above findings. Although the phosphorus and nitrate concentrations immediately downstream of the specified sand and geotextile test sections appear to be slightly higher than those downstream of the insitu material test section, there is no statistically significant difference between the three infiltrative surface media on the groundwater quality.

4.2 Biomat Characteristics

Based on observations made during the March 1988 site visit, only the geotextile fabric had a detectable build-up of organic material which was assumed to be biomat. However, at the time of the September, 1988 site visit, when the geotextile biomats were examined using scanning electron microscopy, it was observed that there were very few bacteria present on the geotextile to mineralize the organic deposition. As a consequence, concern was expressed that the rate of organic accumulation on the fabric exceeded the rate of microbial degradation and that fabric may have begun to clog up with an organic layer that was increasing in thickness. The absence of a large bacterial population in the biomass suggested that the organic material present may be enriched with inorganics refractory to microbial degradation such as humic compounds, which are the products of the decay of plant materials. Alternatively, the geotextile material may have bactericidal characteristics. Rather than encouraging the growth of a large microbial population that would mineralize the organic material passing by and merely slow the infiltration rate into

the native soil, it appears as if the biomat formed on the geotextile could cause a significant impairment of the water infiltration and cause ponding in the trench.

The results of the microbial identification carried out at the time of the March, 1988 site visit show a typical range of organisms likely to be found in a soil/wastewater environment. Unfortunately, no data could be generated regarding the absolute number of organisms present in the biomat samples for comparative purposes.

The results of the microbial activity assays carried out on the geotextile biomats at the time of the March, 1988 site visit indicate a wide variation in the degree of activity between the four samples examined. This might be at least partly explained by the inordinately long length of time (3 days) between sample collection and analysis. However, data from samples taken during the September, 1988 site visit, which were analyzed within 24 hours, indicated a sharp drop in the microbial activity of the geotextile biomats. Very low levels of microbial activity were found for the insitu sand biomats, and no detectable activity was found for the specified sand in the samples taken in September 1988.

In the early stages of the project the geotextile liner (Samplers 1, 2 and 3) showed good biomat development characteristics. However, in the microscopic examination conducted in September 1988 it was reported that the fabric appeared to be clogged with organic material to the point that hydraulic conductivity may be seriously impaired (See Section 4.2, below). The effects of biomat submergence and/or temperature cannot be determined from the limited data available in this study. However, long term equilibrium conditions could be evaluated at some future date.

The microbial examination carried out at the UBC Department of Microbiology found that organisms of the <u>caulobacter</u> genus were present in significant quantities in the geotextile biomat

samples examined. Unfortunately the samples were not suitable for detailed microscopic examination due to the long storage time prior to examination. Although these organisms are known to have good biomat formation characteristics due to their adhesive properties, they are not commonly reported in the literature as being present in secondary wastewater treatment facilities. This is primarily because Caulobacter are not normally accounted for using conventional API microbial identification techniques.

4.3 Groundwater Monitoring

Results from the single groundwater monitoring survey carried out during the March, 1989 site visit indicate that the presence of the contour trench has only a minimal effect on the downstream groundwater quality. There were no detectable fecal coliform concentrations present in any of the monitoring wells and a small number of total coliforms in the background well and one of the downstream wells. One large total coliform reading (21,700 TC/100mL) observed in Well No. 6 is believed to be the result of an experimental error as there were no detectable fecal coliforms present in the sample.

The Total P and TKN concentrations in the groundwater downstream of the trench were not statistically significantly greater than those present in the background. The small increase groundwater nitrate concentration observed is not thought to present a health risk to the community.

4.4 Temperature Profiles

Based on the late winter ground temperature profiles presented in Figures 7 and 8, the trench bottom and perforated disposal pipe depths of 1.2 m and 0.65 m, respectively, are satisfactory depths to prevent severe freezing under prolonged periods of extremely cold temperatures.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

1) While the initial indications of the study were that the geotextile successfully promoted the growth of a biomat in a ground disposal system, there are serious doubts regarding the long-term use of the material in this application. After approximately one year of use, the geotextile biomat had very few wastewater degradation organisms present, and appeared to have clogged up with organic material to the point that its hydraulic conductivity was in doubt.

2) There was no statistically significant improvement in the degree of wastewater renovation achieved in the contour trench ground disposal system through the use of the geotextile as a trench bottom infiltration media. The coliform, nutrient and carbon removal characteristics of the geotextile and insitu sand sections of the trench were not significantly different.

3) Serious localized ponding and uneven flow distribution in the trench made it impossible to compare the wastewater renovation characteristics of the specified sand with the insitu sand and geotextile sections of the trench.

4) Based on the results of this study the contour trench system does not contaminate the surrounding groundwater when placed in moderately permeable sands and gravels. However, a monitoring program to determine the long term effects of the system on the local groundwater is required.

5) Successful operation of the contour trench system depends upon an even flow distribution along the length of the trench. In this study, the uneven flow distribution could be attributed to one or more of the following:

   a) post-construction settlement of the trench;
   b) post-construction settlement of the distribution pipes;
   c) malfunctioning of the dosing chamber

6) The depths of the perforated disposal pipe and the trench bottom (0.65 m and 1.2 m, respectively) were sufficient to prevent severe freezing under prolonged extreme cold temperature conditions.

7) Specific benefits derived from this study by each of the supporting parties are as follows:

   a) Takla Lake Band: Sampling ports and permanent wells to monitor the operation of the system; identification of probable differential settlement along the length of the system; identification of problems with the system's dosing syphon.

   b) Health and Welfare Canada: Groundwater monitoring wells to gauge the potential of the system for contaminating the groundwater and lake; data of operation of contour trench system in a remote northern community.

   c) Environment Canada: Field testing data regarding the use of geotextile as a surface infiltrative medium in ground disposal systems; permanent monitoring wells adjacent to system; data regarding the importance of operational components of the system.

   d) Canada Mortgage and Housing Corporation: Field testing data on the use of contour trench technology in moderately permeable granular soils; field testing data on the use of geotextile fabric as surface infiltrative media in ground disposal systems.

   e) Indian and Northern Affairs Canada/DIAND Technical Services of Public Works Canada: Field testing data on the use of contour trench technology in a remote native community; field testing data on the use of geotextile fabric as surface infiltrative media in ground disposal systems; permanent monitoring wells adjacent to system; data regarding the importance of operational components of the system.

In addition to the overall conclusions derived from this study, each of the participants gained specific benefits related to their own particular interests.

5.2 Recommendations

1) Geotextile not be used as a surface infiltrative medium in ground disposal systems until the issue of long term clogging with organic material be fully addressed. This will be best done at the bench or pilot scale under carefully controlled conditions.

2) The dosing chamber design should be modified to ensure that syphon breaking occurs every time the chamber is emptied, and under all flow regimes.

3) A thorough investigation of the existing system be conducted to review problems of uneven flow distribution, differential settlement and malfunctioning of the dosing chamber.

4) A thorough groundwater monitoring program be continued to determine the long term effect of the contour trench disposal system on the local groundwater quality.

5) In areas subject to prolonged cold weather (i.e. -20°C for 2 to 3 weeks), the disposal pipes should be installed at depths greater than 0.5 m in coarse granular soils.

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APPENDIX I

Takla Landing Contour Trench

Original Design Criteria

TAKLA LANDING CONTOUR TRENCH

Original Design Criteria

The design criteria for the contour trench system presently installed is as follows (Urban Systems Ltd., Feb/86, Apr/86).

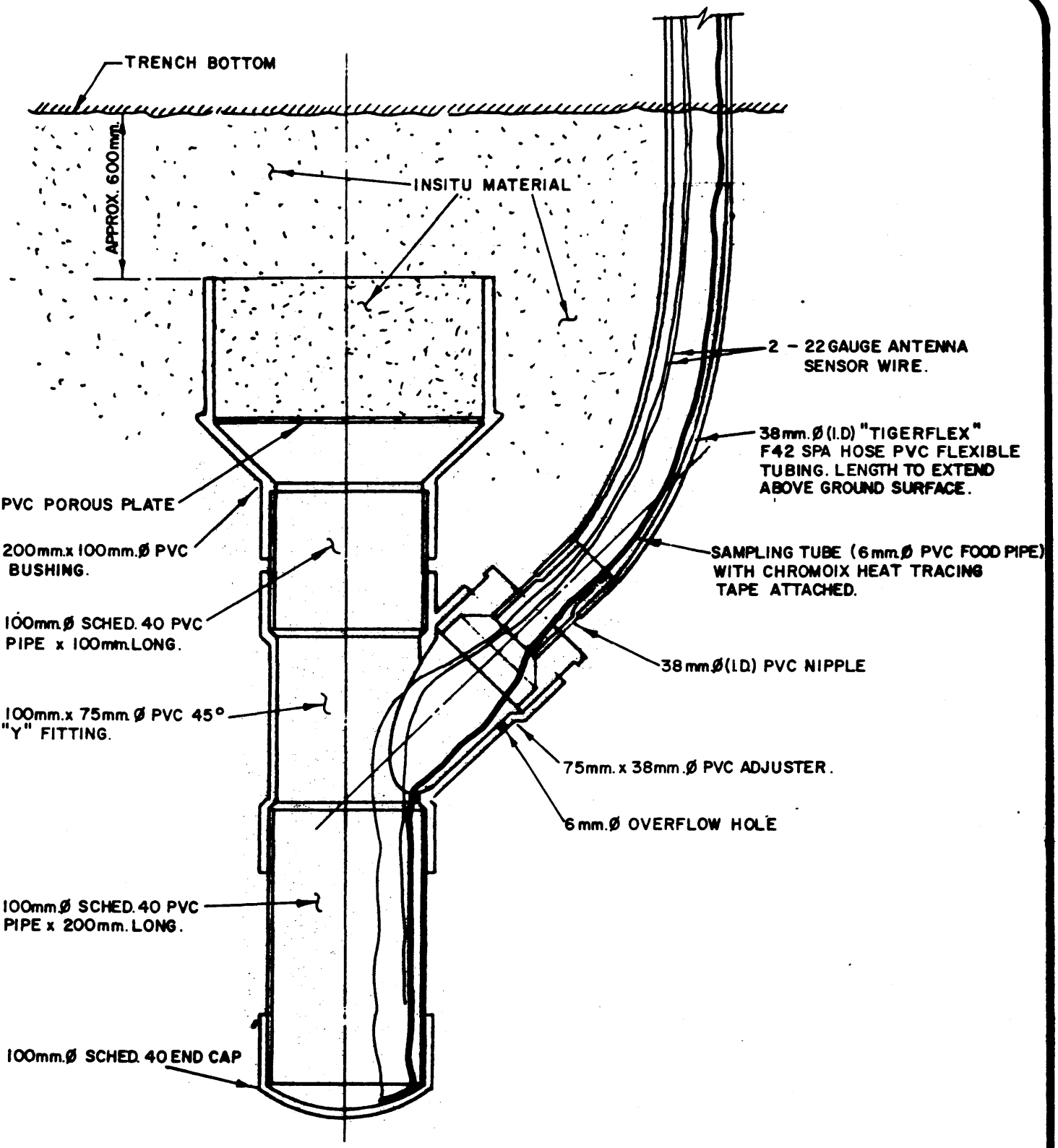
Design Population		380
Number of Homes		76
Per Capita Daily Flow (incl. infiltration)		230 L/d
Design Flow		87,400 L/d
Length of Contour		260 m
Number of Trenches		2
Total Length of Contour Trenches		520 m
Width of Trenches		4 m
Trench Bottom Loading Rate		
-for total length of trench		42.0 $L/m^2/d$
(2 trenches)	or	0.42 mm/d
-for one trench		84.0 $L/m^2/d$
	or	0.84 mm/d

The ultimate requirements for community ground disposal are (Urban Systems Ltd., 1985):

Population	540
Number of Homes	107

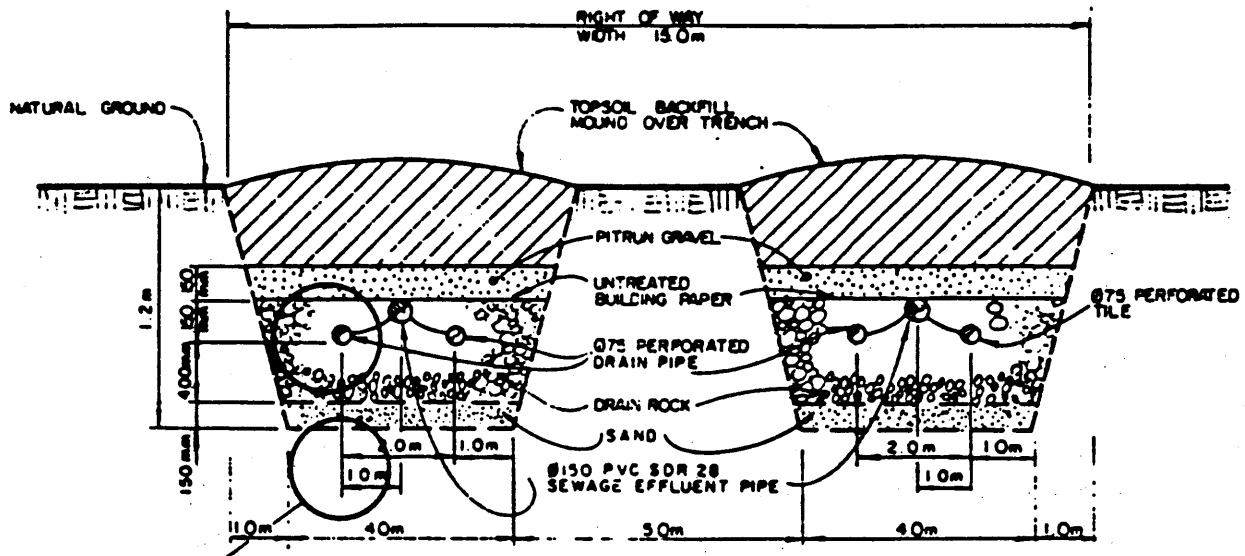
APPENDIX II

Detailed Drawings of Liquid and Biomat Samplers and Observation Ports, and Monitoring Well Locations



NovaTec Consultants Inc.
Environmental Engineers & Scientists

FULLY EQUIPPED EFFLUENT SAMPLER

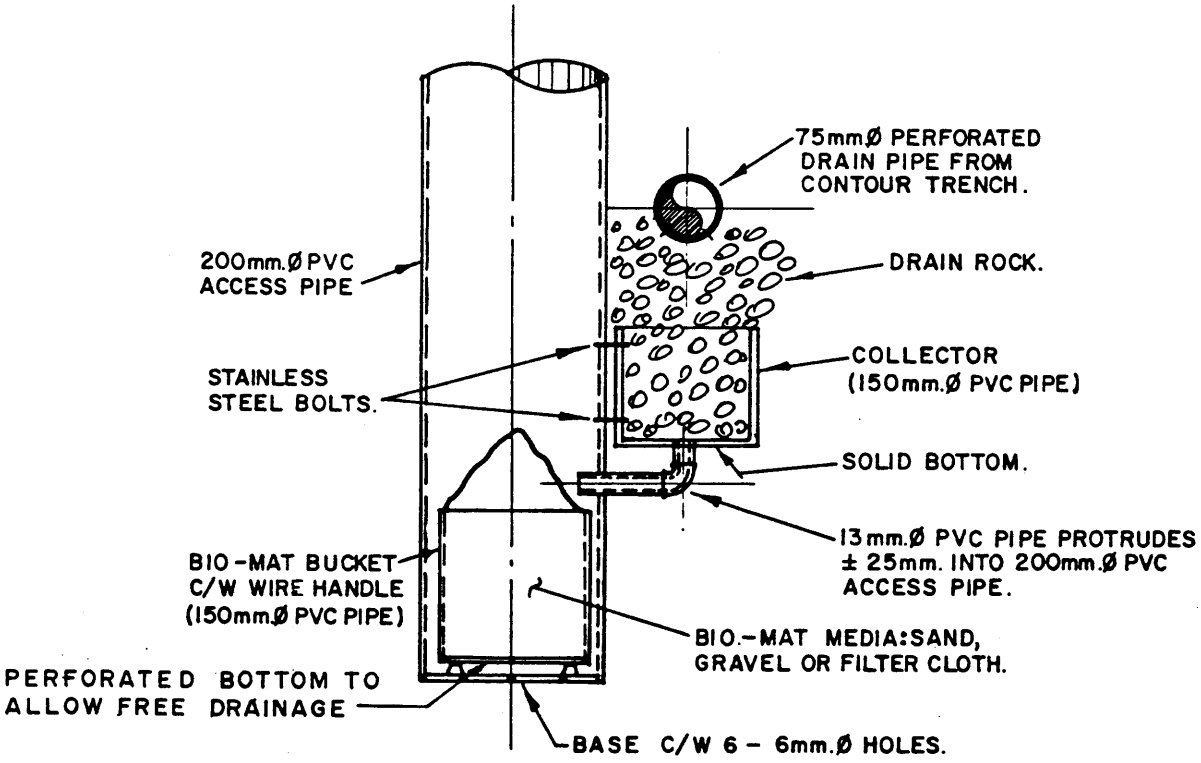


SEE EFFLUENT
SAMPLE COLLECTOR
DETAIL

CROSS SECTION OF CONTOUR TRENCH

NOT TO SCALE

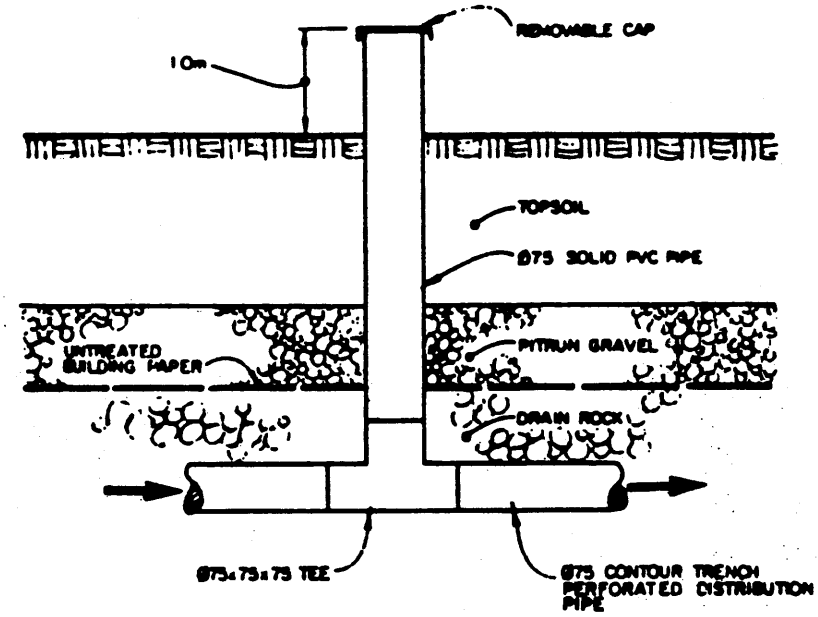
(AS DESIGNED BY URBAN SYSTEMS LTD.)



DETAIL

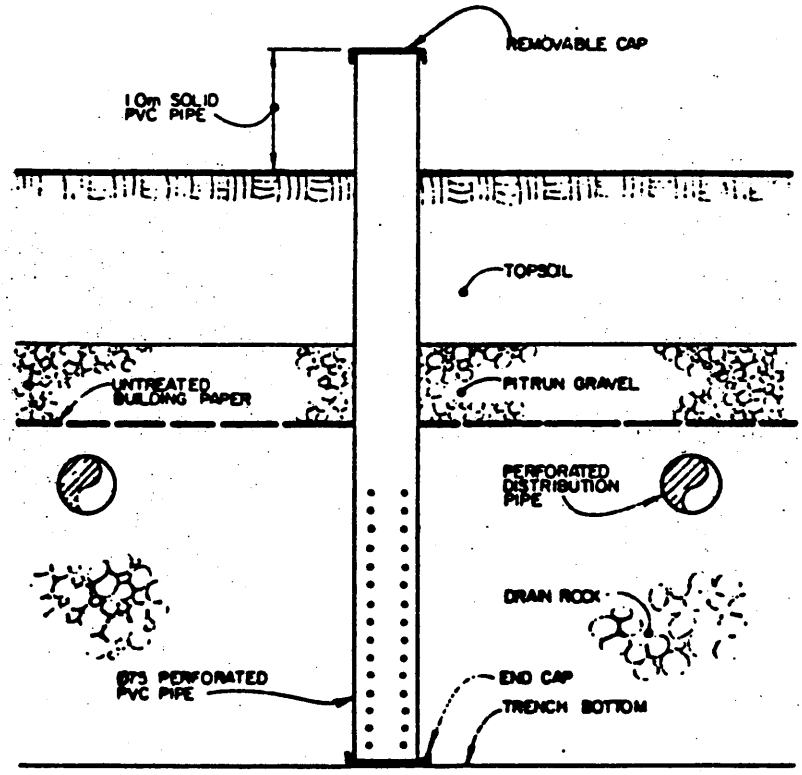
NovaTec Consultants Inc.
Environmental Engineers & Scientists

BIO - MAT SAMPLER



PIPE OBSERVATION PORT DETAIL

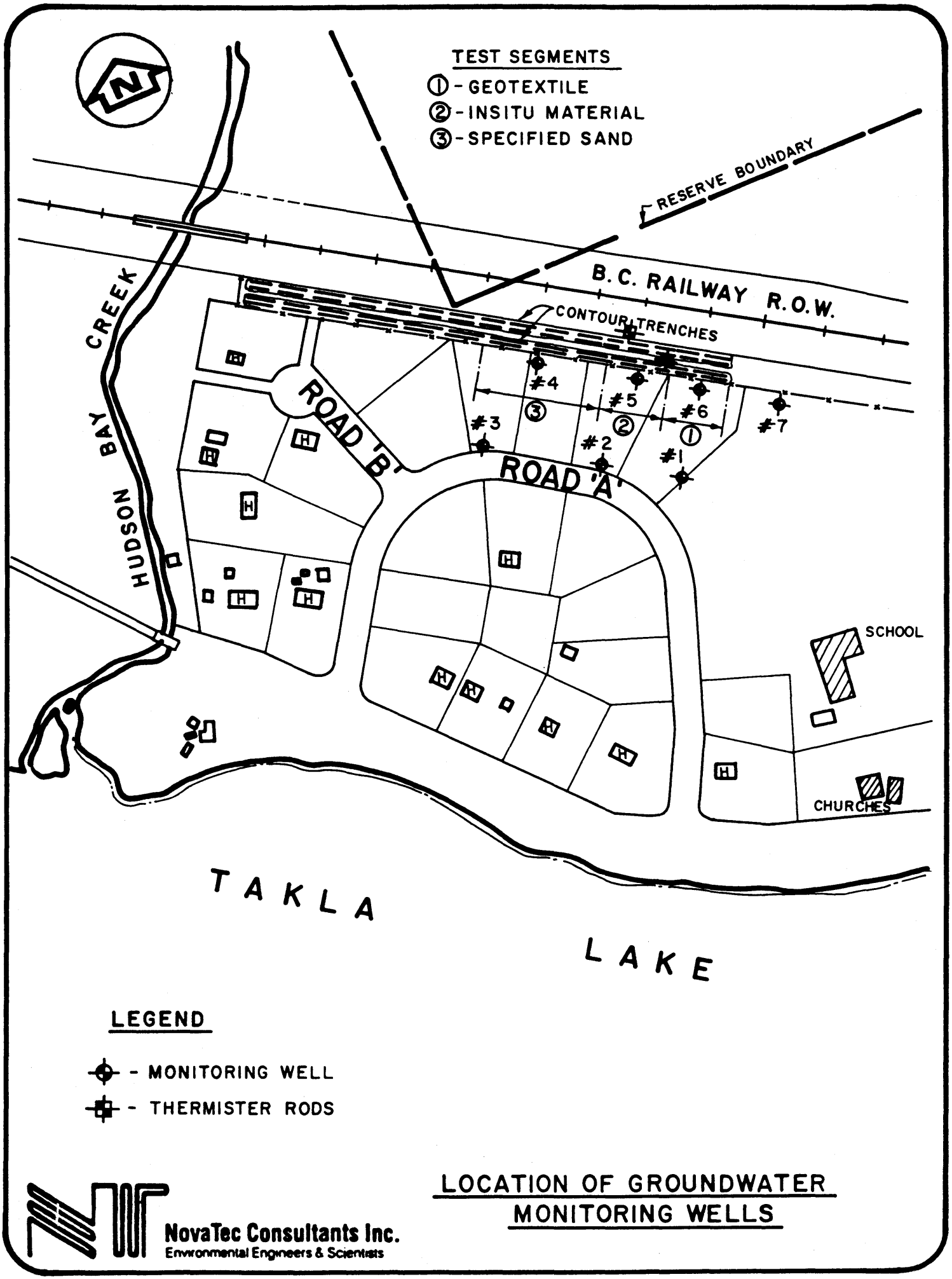
NOT TO SCALE (AS DESIGNED BY URBAN SYSTEMS LTD.)



TRENCH OBSERVATION PORT DETAIL

NOT TO SCALE (AS DESIGNED BY URBAN SYSTEMS LTD.)

NovaTec Consultants Inc.
Environmental Engineers & Scientists



LOCATION OF GROUNDWATER MONITORING WELLS

APPENDIX III

Biomat Photographs - March 1988 Site Visit

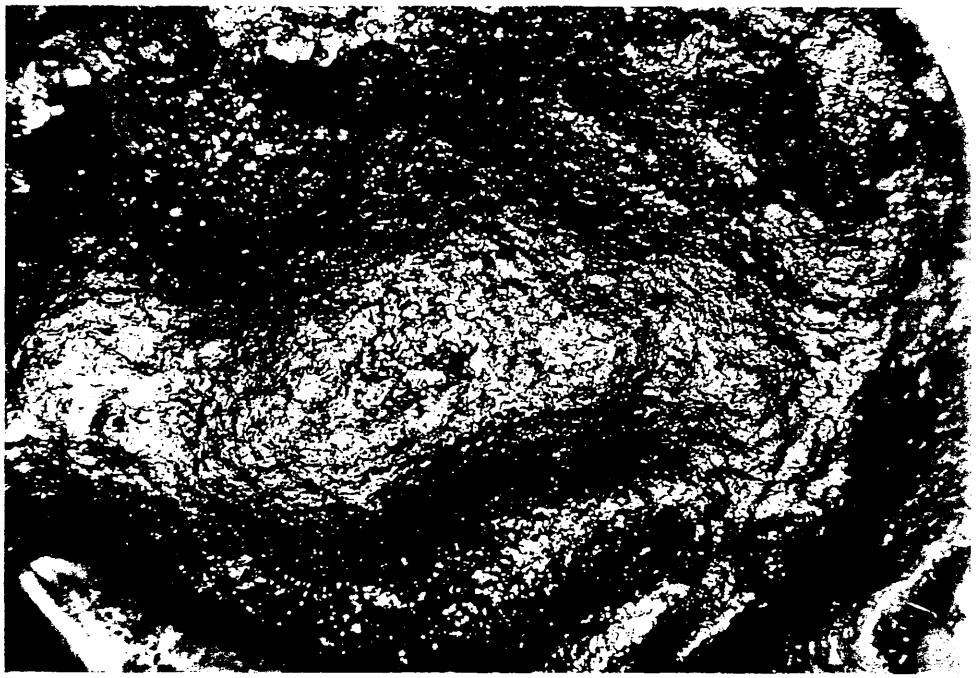


Photo 1: Well-developed biomat on geotextile fabric in Biomat Sampler No. 1 - March 1988.

Photo 2: Well-developed biomat on geotextile fabric in Biomat Sampler No. 3 - March 1988.

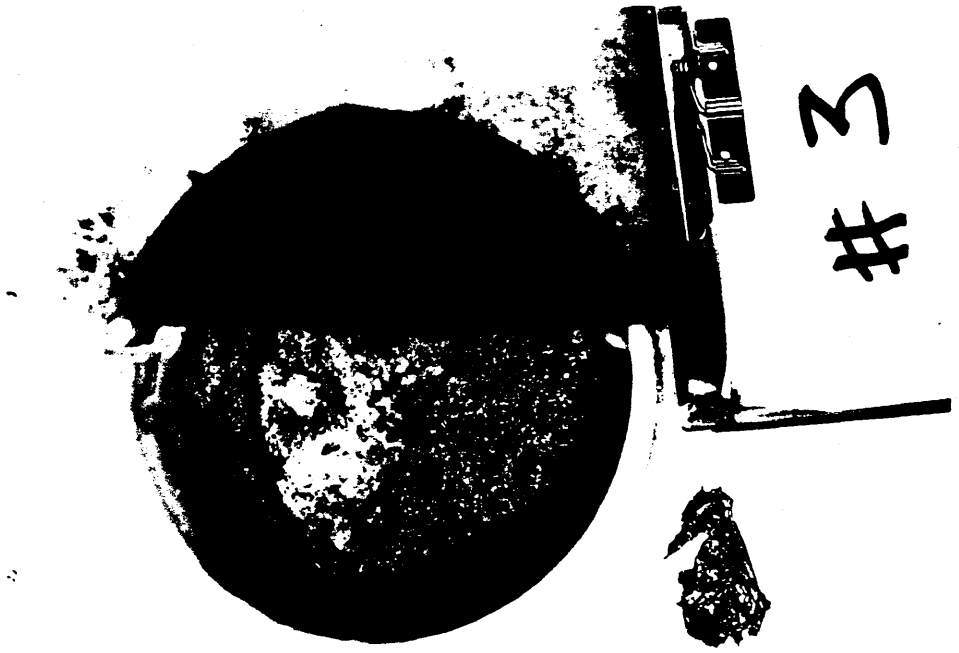


Photo 3: Underside of geotextile fabric in Biomat Sampler No. 3 - March 1988.

Photo 4: Insitu material from Biomat Sampler No. 4 showing early biomat formation - March 1988.

APPENDIX IV

Report by Project Microbiologist

THE UNIVERSITY OF BRITISH COLUMBIA

Department of Microbiology
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Telephone (604) 228-4417
FAX 228-6905 or 6041

Dr. Barry Rabinowitz
Novatech Consultants Inc.
Suite 300, 40 Powell St.
Vancouver, BC V6A 1E7

Thu, Feb 23, 1989

Dear Barry;

Following is my report of the microscopic analysis of the three samples of Biomat with attached organic material, which were collected on 5 September 1988:

1) Phase microscopy examination:
A small amount of the organic material from each sample was suspended in water and a slide mount was prepared. I concluded that there were few bacteria in the sample, on a per gram of sludge basis. This is to be compared to scrapings of surfaces in an aeration tank of a secondary sewage treatment system, where a large number of bacteria with a variety of morphologies are typically noted.

2) Scanning electron microscopy analysis
Small squares (3X3 mm) of sample were excised and prepared for microscope analysis. This involved the use of a relatively unusual fixation procedure. Normal fixation procedures involve the sequential treatment of samples with liquid solutions of glutaraldehyde and osmium tetroxide. If this were done with the Takla samples, the organic material would simply have disintegrated long before the fixation process was completed. Instead I used a rapid freezing method and transfer to a fixation "cocktail" which is kept at -70°C. Chemical crosslinking and substitution of organic solvents for water occurs at low temperature over the course of several days. When the sample is warmed, the organic material holds together due to the chemical crosslinks. Thus we have a reasonably good representation of what is really in the organic material. The subsequent critical point drying and gold coating procedures were done in standard fashion.

My observations in the scanning electron microscope corroborated the phase microscopy observations. There was relatively little indication of a large bacterial population, either in the Biomat or the organic layer overlying. It was difficult to obtain high quality photographs because these samples were prone to severe "charging" which results in heavily distorted photographic images. Nevertheless several micrographs will be sent (by regular mail) for your

evaluation.

3-Tentative Conclusions

a-The Biomat and attached organic layer is not the active, biofilm that was originally anticipated, simply because there is not a large bacterial population present. As a possible consequence, the organic layer may readily continue to increase in thickness. There may not be adequate biological degradation to mineralize the organic material at a rate equal to the rate of deposition. These visual observations should be corroborated with the total microbial counts and speciation per gram of soil performed by Peter Nix and his associates.

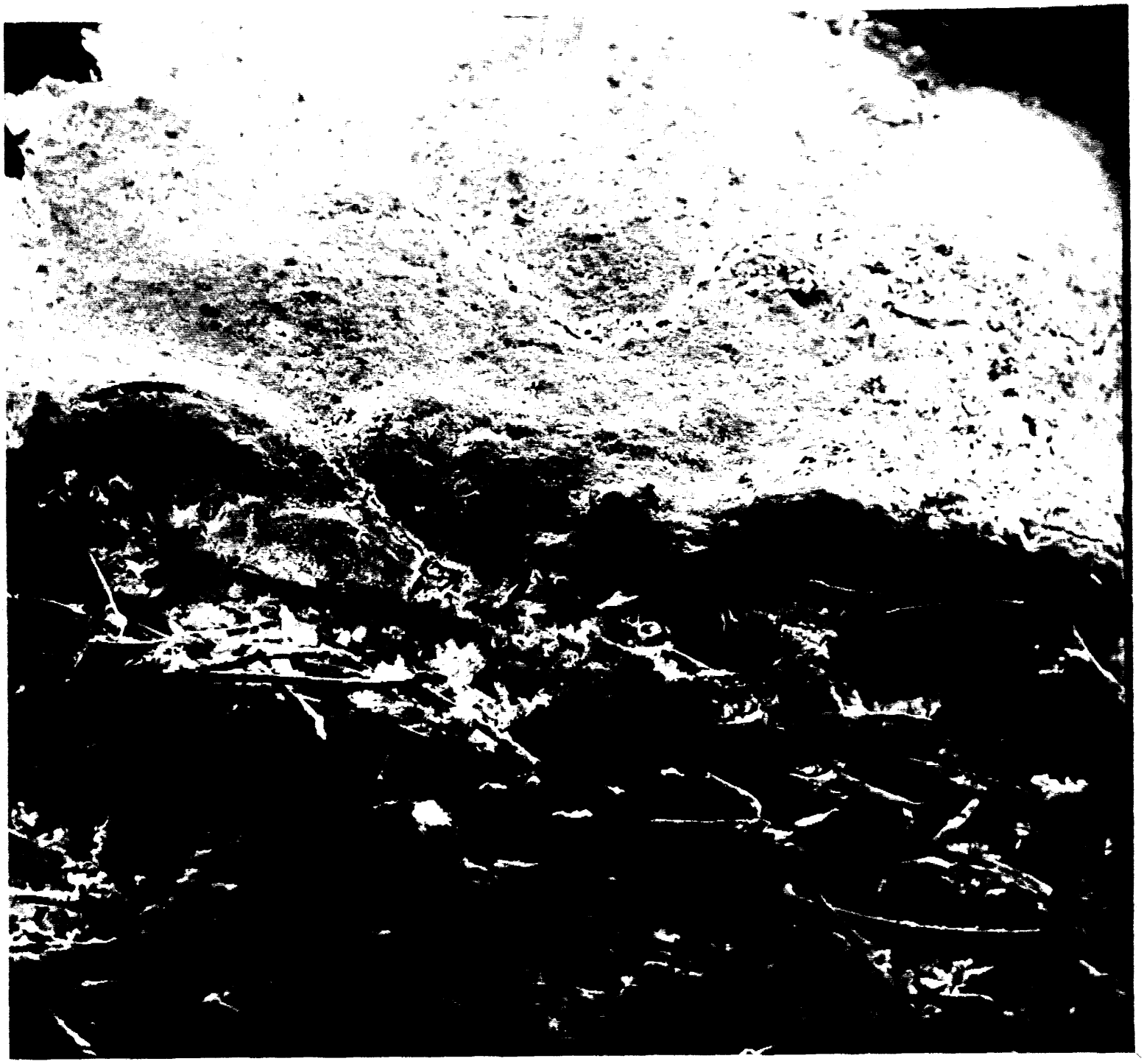
b-The absence of a large bacterial population suggests that the organic material present may be enriched in organics refractory to microbial degradation, particularly humic compounds, the products of the decay of plant materials. This could be corroborated with direct chemical analysis. There are a variety of methods available to measure humic carbon (based on the presence of phenolic ring compounds),the results of which could be compared to the TOC or COD.

c-These observations would seem to run counter to the original estimation that the Biomat would develop a large microbial population that would mineralize most of the organic carbon that came by, and also would somewhat slow the percolation of water into the native porous soil. Instead, a significant impairment in water penetration might be inferred from my observations. This of course can be corroborated with direct hydraulic measurements.

Let me know if you need further information.

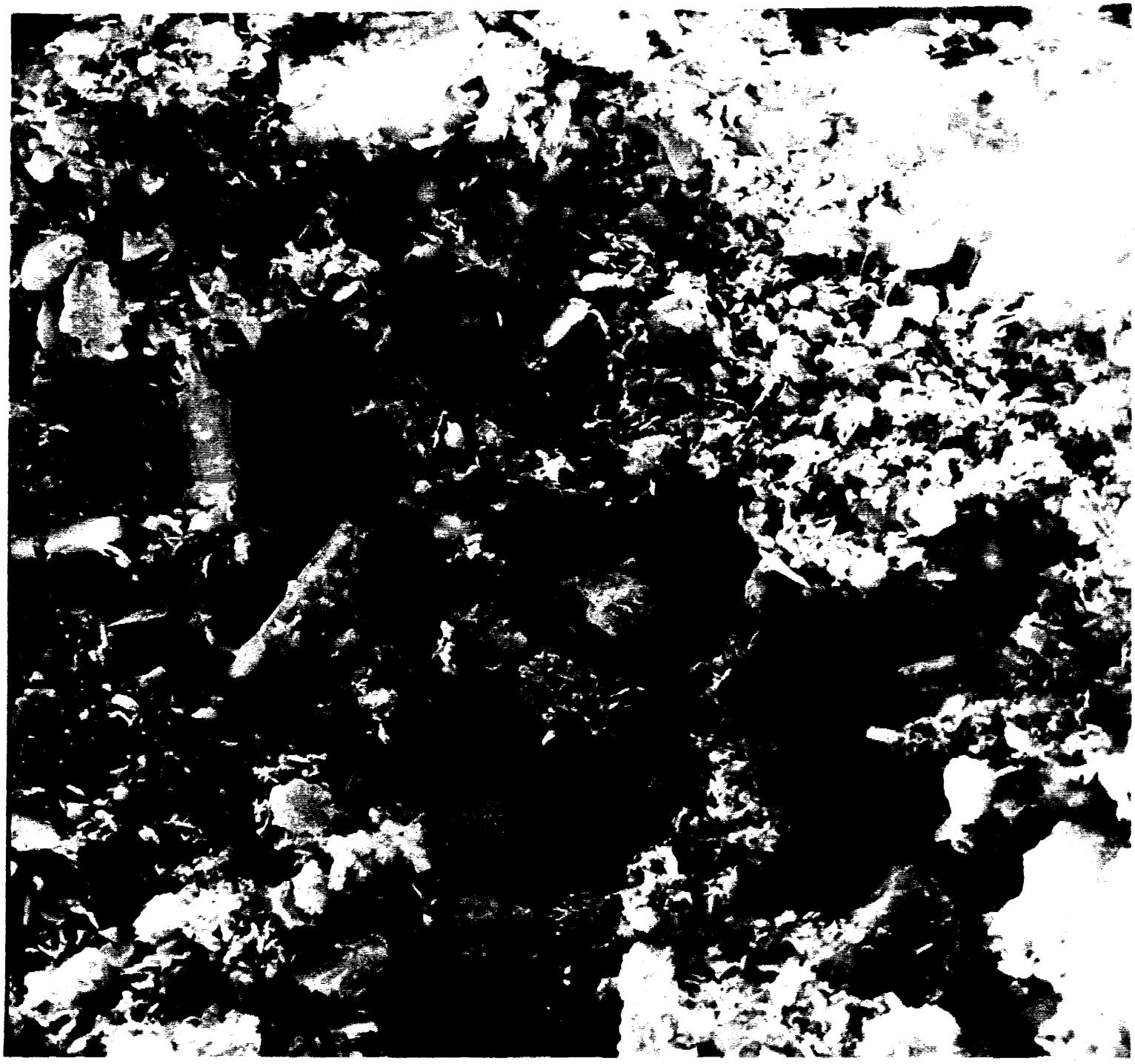
Very truly yours,

John Smit, Ph.D.
Assistant Professor of Microbiology
Assistant Professor of Oceanography
(associate member)



SEM Photo 1: Low magnification view of geotextile with overlying organic layer. (Magnification = 75).

SEM Photo 2: Organic Layer. (Magnification = 3,200).



SEM Photo 3: Organic Layer. (Magnification = 4,000).

SEM Photo 4: Geotextile cloth close to biomat-organic layer interface. Note that the cloth is blocking up with organics. (Magnification = 6,300).

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