An investigation into the performance of subsoils and stratified sand filters for the treatment of wastewater from on-site systems

Final Report

for project 2000-MS-15-M1
(The Hydraulic Performance and Efficiencies of Different Subsoils and the Effectiveness of Stratified Sand Filters)

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1 INTRODUCTION

In Ireland, wastewater from over one third of the population is treated by small-scale independent systems where connection to a sewer is deemed to be unfeasible, usually in rural areas (DoELG *et al*., 1999). The most prevalent treatment application is the conventional septic tank system with over 350 000 systems currently installed in Ireland (EPA, 2000). Due to the ever-increasing pressure on the planning authorities to develop more rural sites, a rigorous site assessment procedure has been introduced according to guidelines from the Environmental Protection Agency (EPA, 2000). This is based upon a desk study followed by an on-site assessment comprised of a visual trial hole inspection and percolation test which aims to determine the vulnerability of local groundwater resources. In situations where a septic tank installation is not suitable, some form of secondary treatment system such as mechanically-aerated systems or filter systems may be installed to improve the quality of the effluent before discharge to the subsoil if ground conditions allow.

1.1 Background

Groundwater is an important resource in Ireland which is under increasing risk from human activities with contamination arising from both ‘diffuse’ (generally agricultural) and ‘point sources’, the latter being exemplified by farmyards (manure and silage storage) and septic tank systems (Daly, 1993). The main aquifers occur in fissured bedrock formations, overlain by superficial deposits (referred to as subsoils in Ireland) of variable thickness and permeability. In areas where the subsoil permeability is too low to allow sufficient soakage there is a risk to watercourses from effluent ponding. Groundwater, on the other hand, is especially at risk in areas where bedrock is close to the surface, where subsoils of high permeability underlie the site and where the water table is close to the surface. With an estimated 200,000 wells and springs in use in Ireland (Wright, 1999) the prevention of groundwater contamination from on-site domestic sewage effluent is of critical importance as, once contaminated, the consequences are usually longer lasting than for surface water owing to longer residence times; moreover, groundwater remediation is usually expensive and often impossible.

The national groundwater protection scheme is based on the concepts of risk and risk management. A hazard-pathway-target model is used for the scheme, in which the hazard is the potentially polluting activity, the pathway is the groundwater vulnerability and the target is the groundwater resource, generally assumed to be the aquifer, or source such as a water supply well or spring (Misstear *et al*., 1998). For protection scheme purposes, the groundwater vulnerability is subdivided into extreme, high, moderate or low vulnerability categories. The division of groundwater into these vulnerability categories is dependent on various factors, the principal ones being the permeability and thickness of the subsoil. The permeability governs the transmission rate of a fluid through the subsoil, and hence the period in which attenuation of contaminants can take place by physical, chemical and/or biological processes. Therefore the permeability of a given subsoil thickness provides a measure of the amount of amelioration that can occur.

A recommended septic tank treatment process involves domestic wastewater (excluding roof / road drainage) flowing into a two chambered tank in which primary sedimentation occurs and also some anaerobic digestion. The effluent then overflows into a suitable soil percolation area where further physical, chemical and biological treatment processes occur. The subsoil percolation area performs a straining and filtration function, in conjunction with sorption and ion exchange and acts as an attached growth medium for aerobic biodegradation due to the unsaturated nature of the soil. Hence, the hydraulic and attenuation properties of the natural ground downstream of the treatment system are important for the further removal of pollutants and the protection of water resources and are viewed as an inherent part of the treatment system.

The publication of the guidance manual for Treatment Systems for Single Houses (EPA, 2000) is aimed at protecting groundwater resources from contamination by domestic wastewater effluent by defining acceptable site suitability criteria. Key to this approach is an intensive site assessment procedure. This assessment, comprised of a desk study followed by an on-site visual trial hole inspection and percolation test, determines the vulnerability of local groundwater resources and identifies receptors potentially at risk. The percolation test is also required to determine the assimilation capacity of the subsoil.

It is recommended that the percolation rate obtained from the standard percolation test (the so-called T-value) for subsoils receiving septic tank wastewater effluent must fall within the specified range of 1min per 25mm to 50min per 25mm of water level fall (i.e. 1 to 50). In addition, a minimum unsaturated subsoil depth of 1.2m below septic tank percolation fields should exist before the site may be deemed suitable for on-site treatment of domestic wastewater effluent from a conventional septic tank design. Where subsoil T-values fall outside the range 1 to 50, or the minimum unsaturated subsoil depth of 1.2m does not exist, a second percolation test (the P-test) should be carried out from ground level. If the resulting P value is in the range 1 to 50 then the guidance manual suggests installing some form of secondary treatment process, providing that there is 0.6m of unsaturated subsoil for percolation of the secondary effluent. These small-scale treatment systems (RBC, SBR etc) provide secondary treatment aerobic degradation either by fixed film or suspended growth microbial processes. Another option promoted in the guidelines is the use of an intermittent stratified sand filter either as a secondary treatment unit or as a polishing filter in place of the percolation area. A stratified sand filter normally comprises of three layers of sand which decrease in coarseness with depth. Effluent is dosed uniformly onto the filter surface at regular intervals by a pump from a collection chamber.

Few field studies have been carried out directly into the fate of the pollutants within the subsoil beneath percolation areas apart from the few trials concentrating on the fate of pathogens (Nicosia *et al.*, 2001, Schijven and Šimůnek, 2002). The results, however, are difficult to extrapolate into an Irish context due to indeterminate percolation rates and different climatic conditions. Equally, in Ireland little research has been carried out on the treatment effectiveness of the subsoils in relation to the percolation test, T-values. For example, the hydraulic effect of the biomat on the distribution of effluent across the percolation area has been incorporated in the guidelines based on theory and laboratory experiments, but has never been verified by trials in the field. There has also been little experience in the use of stratified sand filters in Ireland, although such systems have been used for similar on-site applications within the USA and Scandinavia.

Hence, this document represents the results of a three year research study funded by the Environmental Protection Agency (under the Environmental Research Technological Development and Innovation (ERTDI) Programme as part of the National Development Plan 2000-2006) into the effectiveness of both septic tank and secondary treatment on-site wastewater systems on four sites in Ireland designed according to the Treatment Systems for Single Houses guidelines (EPA, 2000). The results of this study should enable the existing EPA policy, as set out in the guidelines, to be evaluated and more confident engineering design parameters to be developed for the overall enhancement of groundwater protection in Ireland.

1.2 Project Aims and Objectives

The aim of the research project was to carry out a series of rigorous on-site trials in order to enhance the understanding of the processes involved and performance of different subsoils in the wastewater treatment of typical domestic effluent from septic tanks and other small-scale secondary treatment applications. The project also studied the potential application of the stratified sand filter process for the treatment of such effluents.

Specifically, the trials were designed to assess the following parameters:

- the hydraulic and wastewater treatment performance of subsoils receiving septic tank effluent : one trial on a subsoil with a T value 5-20 and one trial on a subsoil with a T value 30-50.

- the hydraulic and wastewater treatment performance of subsoils receiving secondary treated effluent : one trial on a subsoil with a T value of less than 50 and one trial on a subsoil with a T value greater than 50.

- the hydraulic and wastewater treatment performance of two stratified sand filters : one receiving effluent from a septic tank, the other receiving effluent from a typical secondary treatment process.

The project was divided into three distinct phases, consisting of an initial desk study which was then followed by two phases of on-site field trials on a total of four sites. The sites were fundamentally chosen according to the site assessment procedure as set out in Treatment Systems for Single Houses (EPA, 2000) and the trials were designed to be of 12 months duration to capture seasonal variations.

A summary of the project is presented as follows,

Phase 1 An initial review of relevant international work was carried out before the trials were undertaken for comparative purposes and in order to optimise the experimental design of the trials.

Phase 2 Two parallel on-site trials at sites in County Kildare of 12 months duration where effluent was discharged into a standard percolation.

- Site 1 : septic tank effluent into subsoil with T-value of 15
- Site 2 : secondary treated effluent into subsoil with T-value of 29

Phase 3 Two parallel on-site trials at sites in County Wicklow of 8 months duration where effluent was evenly split between a standard percolation area and a stratified sand filter.

- Site 3 : septic tank effluent into subsoil with T-value of 33
- Site 4 : secondary treated effluent into subsoil with T-value of 52

It should be noted that the Phase 3 trials were shorter than their intended 12 month duration due to unforeseen delays in finding suitable sites for the Phase 2, carrying over throughout the project programme which had a fixed end date.

2 SITE SELECTION

2.1 Introduction

A number of essential criteria had to be satisfied during the site selection process in order for the four sites eventually selected to be deemed suitable. T-values of between 1 and 25, 25 and 50, and greater than 50 had to be identified, site location and trial hole inspections had to satisfy EPA (2000) guidelines and there had to be a sufficient number of residents in each dwelling to ensure that at least four, 20m long percolation trenches could be used. It was decided that, due to time constraints, the potential research sites would have to be fully occupied and that dwellings which were only at the planning stage or being built could not be considered.

2.2 Site Selection Criteria

2.2.1 Desk Study

The main aims of the desk study were to obtain hydrogeological data relevant to assessing site suitability and to identify potential water resource targets at risk from the proposed installation of an on-site treatment system. While it is possible to obtain data on bedrock and aquifer type, soil and subsoil type on a small scale (i.e. on a regional or countywide basis) from relevant publications, the GSI, as part of the Groundwater Protection Scheme (GWPS) framework (see Literature Review, Section 1.2.2), has produced individual Groundwater Protection Schemes for 14 counties/regions (Clare, Kildare, Kilkenny, Laois, Limerick, Meath, Monaghan, North Tipperary, Offaly, Roscommon, South Cork, South Tipperary, Waterford and Wicklow) from which it is possible to obtain detailed information (1:50 000 scale maps) on the subsoil type, bedrock type, aquifer category and vulnerability class within these counties. This information, used in conjunction with the Groundwater Protection Response Matrix for Single House Systems (Table 2.1), an integral part of the GWPS, was an essential part of the assessment of site suitability for the installation of a treatment system and also of the type of system to be installed.

VULNERABILITY RATING	RESOURCE PROTECTION AREA Aquifer Category					
	Regionally Imp		*Locally Imp*		*Poor Aquifers*	
	Rk	Rf/Rg	Lm/Lg	Ll	Pl	Pu
Extreme (E)	R2[2]	R2[2]	R2[1]	R2[1]	R2[1]	R2[1]
High (H)	R2[1]	R1	R1	R1	R1	R1
Moderate(M)	R1	R1	R1	R1	R1	R1
Low (L)	R1	R1	R1	R1	R1	R1

R1 Acceptable subject to normal good practice (i.e. system selection, construction, operation and maintenance in accordance with EPA (2000).

R2[1] Acceptable subject to normal good practice. Where domestic water supplies are located nearby, particular attention should be given to the depth of subsoil over bedrock such that the minimum depths required (EPA, 2000) are met and that the likelihood of microbial pollution is minimised.

R2[2] Acceptable subject to normal good practice and the following additional condition:

- There is a minimum thickness of 2m unsaturated soil/subsoil beneath the invert of the percolation trench of a conventional septic tank system;

OR

- A treatment system other than a conventional septic tank system as described in EPA (2000) is installed, with a minimum of 0.6m unsaturated soil/subsoil with P/T values from 1 to 50 (in addition to the polishing filter which should be a minimum depth of 0.6m), beneath the invert of the polishing filter (i.e. 1.2m in total for a soil polishing filter).

Table 2.1 Response Matrix for on-site treatment systems (adapted from DoELG *et al.*, 1999).

While the methodology outlined in *Wastewater Treatment Manual: Treatment Systems for Single Houses* (EPA, 2000) states that a desk study should precede any on-site assessment, this was not a practical option in the identification of suitable sites for the project. Hence, the on-site evaluation procedure was used to eliminate unsuitable sites and a subsequent desk study confirmed potential site suitability.

2.2.2 On-Site Assessment

There are three stages to the on-site assessment process: visual assessment, trial hole inspection and percolation P/T-tests. The visual inspection was a very valuable tool in the selection process and enabled a prompt decision to be made on the suitability of a site for further investigation or its elimination from the selection process prior to any disruptive excavation. Tables 2.2 and 2.3 outline the main factors considered during the visual inspection.

FACTOR	SIGNIFICANCE
Water level in ditches and wells	Indicates depth of unsaturated subsoil
Shape, slope and form of site	May indicate whether water will collect at a site or flow away from the site
Presence of watercourses	May indicate low permeability or a high water table
Presence and types of rock outcrops	Insufficient depth of subsoil to treat wastewater allowing it to enter the groundwater too fast
Proximity to adjacent percolation areas and/or houses	May indicate too high a loading rate for the locality and/or potential nuisance problems
Land use and type of grassland surface (if applicable)	Indicator of rate of percolation or groundwater levels
Vegetation type	Indicator of the rate of percolation or groundwater levels
Proximity to wells on-site and off-site, water supply sources, groundwater, streams, ditches, lakes, surface water ponding, beaches, shellfish areas and wetlands	Indicates targets at risk

Table 2.2 Factors to be considered during a visual assessment (EPA, 2000)

Type of System	Watercourse/ Stream	Wells/ Springs	Lake	Any Dwelling	Site Boundary	Road	Slope Breaks/ Cuts
Septic tank; Prefabricated intermittent filters; mechanical aeration systems	10	10	50	7	3	4	4
In situ intermittent filters; percolation area; polishing filters	10	30	50	10	3	4	4

Table 2.3 Minimum separation distances in metres (EPA, 2000).

Trial Hole

On completion of a successful visual assessment, a trial hole was excavated to ensure that there was a sufficient depth of unsaturated subsoil below the invert of the percolation trench (which should be at a depth of 0.8m from the surface) along its full length. According to the guidelines, the requisite depth should be 1.2m for subsoil receiving septic tank effluent and 0.6m for subsoil receiving secondary effluent. However, it was decided to establish all four sites on 1.2m unsaturated subsoil in order to make direct comparisons between effluent types and subsoil characteristics for the purposes of this research project. It was essential that the trial hole was not excavated within the boundaries of the proposed percolation area as any subsequent consolidation of the backfilled soil could lead to the buckling of the perforated pipe in the percolation trench, thus inhibiting effluent dispersion along the base of the entire trench. The excavation and replacement of the subsoil can also create preferential flowpaths within the subsoil matrix which increases the risk to groundwater contamination from percolating wastewater effluent (see Literature Review, Section 4.2.1).

The soil and subsoil characteristics were also examined in the trial hole as part of this integrated approach of on-site assessment and were described primarily on the basis of their material characteristics according to BS5930, the British Standard Code of Practice for Site Investigations (BSI, 1981) outlined in Table 2.4. They provide a better understanding and description of the subsoil matrix and an insight into future behaviour of the soil on receipt of wastewater effluent.

CHARACTERISTIC	IMPORTANCE
Soil texture	Affects physical and chemical processes within the soil
Structure	Influences pore space, aeration and flow conditions
Preferential flowpaths	Influence the percolation rate of effluent, level of treatment and subsequently the risk to groundwater
Soil density	Influences percolation rate
Colour	Indicative of state of aeration of soil
Layering	Effects percolation rate

Table 2.4 Subsoil characteristics considered during trial hole inspection

T-Test

The T-test is used to ascertain the suitability of a subsoil to receive on-site wastewater effluent. It calculates an average time for water to drop 100mm in two pre-soaked, 300mm square holes, 400mm deep below the invert level of the percolation pipe, therefore giving an indication of the hydraulic assimilation capacity of the subsoil surrounding the base of the percolation trench under saturated conditions. As with the trial hole, it was essential that the T-test holes were excavated outside the boundaries of the proposed percolation area. While the proposed construction of a percolation area for the treatment of effluent from secondary treatment systems allows for a similar test to be carried out from ground level (known as a P-test), it was decided that the percolation trenches on both sites should be constructed to the same specifications, for continuity, and therefore T-tests would be required at both sites.

T-test procedure

Two T-test holes were excavated adjacent to the proposed percolation area. The bottom and sides of the holes were rubbed with a wire brush to remove any smearing or compaction caused during their excavation. Both holes were filled with clear water at 10:00 and again at 17:00. The following day the silt was cleaned out of both holes and a bar with rubber rings was inserted into each hole. The rubber rings were then placed at 100mm intervals up to 400mm from the base of the hole. The holes were refilled with clear water up to the 400mm mark and the time noted. The water was allowed to drop to 300mm and the subsequent time required for the water to drop to 200mm was recorded. The hole was then refilled to the 300mm mark and the time required for it to drop to 200mm recorded again. This procedure was then carried out a second time. The average time of the three recordings, i.e. the time required for the water to drop from 300mm to 200mm, was divided by four to give the time required for a fall of 25mm or the *t-value* for each hole. The average of the t-values is then calculated to give the overall T-value. A proposed percolation area with a T-value less than 1 minute/25mm, or greater than 50minutes/25mm (more commonly described as T-values in the range 1 to 50), is deemed to have failed the test according to the EPA guidelines. However, one of the aims of this project was to examine the assimilation capacity of a subsoil with a T-value greater than 50minutes/25mm for secondary treated effluent.

On completion of a satisfactory desk study and site assessment, a site was then considered as to its suitability for the installation and construction of an on-site treatment system based on the specific requirements for the project, as set out in Chapter 1. It should be appreciated that the results from the trial hole inspection and the T-test are location-specific: the subsoil is not an isotropic homogeneous medium and therefore results from both methods of suitability assessment will vary across the site. There can also be a large difference in the two t-values. It is possible for one, or both, t-value(s) to fall outside the 1-50 range and yet for the T-value to be acceptable (for example t_1=0.5 and t_2=52). This occurrence should necessitate a more comprehensive site assessment. It is also worth considering the size of the range into which a successful T-value must fall (Box 2.1).

Box 2.1

For example a T-test that results in T-value of 1 could be completed in 0.5 hours while a T-test resulting in a T-value of 50 could take18 hours, yet both sites are deemed suitable for the same treatment systems. Saturated conditions in a trench of high T-value subsoil would promote anaerobic conditions which impede the aerobic chemical and biological processes (outlined in Literature Review) that are essential in the attenuation of the wastewater effluent. Similarly, a highly permeable subsoil would mean a short residence time thereby reducing effluent attenuation.

In extreme situations a high T-value could forewarn of surface ponding due to the inability of the subsoil to assimilate the wastewater. While a design loading rate attempts to account for this impedance (EPA, 2000) it fails to distinguish between subsoils of different permeability receiving septic tank effluent. A figure of 20l/m^2.d is recommended for all subsoils with an acceptable T-value receiving septic tank effluent while loading rates of 25l/m^2.d and 50l/m^2.d are recommended for subsoils of T-values between 21and 50, and 1 and 20, respectively, receiving secondary effluent. While the increased hydraulic loading rate acceptable for secondary effluent is justified by the decrease in organic and microbiological loading brought about by the additional treatment step, the size of this increase and the definition of two broad ranges is questionable, particularly because it fails to take into account the hydraulic resistance of the biomat.

2.2.3 Occupancy

The EPA manual calculates the typical daily hydraulic loading to an on-site system for single houses as 180 litres per capita per day (lcd). While no reference for this figure is cited in the manual it appears to be based on research in the USA where water consumption is typically much higher than in Ireland. Research by WS Atkins (2000) calculated the average per capita water consumption for Ireland to be 133 lcd with this figure rising to between 146 and 158 lcd by 2018. Equally, a more recent study in Dublin found water consumption to be surprisingly similar across several different socio-economic housing areas with an average value of 151 lcd (Barry, 2003). A wastewater loading rate of 20 l/m^2d for septic tank effluent and 25 l/m^2 for secondary effluent on subsoils with a T-value between 21 and 50 are recommended (EPA, 2000). With a maximum permissible trench length of 20m and the standard distribution box containing 4 outlets, it was therefore decided that the desired occupancy of the test sites should be 4 people on the sites receiving septic tank effluent and 5 people on the site with a T-value between 21 and 50 receiving secondary effluent. With respect to the site with a T-value greater than 50 receiving secondary effluent it was decided that a minimum occupancy 4 was required.

2.3 Site Selection

The initial site identification process for Sites 1 and 2 took the form of a networking exercise and involved the canvassing of personal contacts such as family, friends, colleagues, students, local builders and members of the GAA in Wicklow. Professional contacts such as the GSI, Teagasc, EPA and various independent consultants were also approached. This method was productive, resulting in 23 site investigations – but only yielded one site which fulfilled the specified criteria. Contact was then made with the relevant department of numerous local authorities in the Leinster region (Carlow, Fingal, Meath, Louth, Kildare, Laois, Wexford and Wicklow). While contact was also initiated with Limerick County Council, the main focus of attention was concentrated on the other local authority areas, especially those bordering Dublin as proximity to laboratory facilities in Trinity College was of utmost importance for sample analysis. It was also desirable from the point of technical support that, if possible, the research sites were within commuting distance of college.

Contact was also made with manufacturers of, and agents for, various secondary treatment systems (Envirocare, Bord na Móna, Bio-clear, Biocycle, Biocrete and Molloy Engineering). It was envisaged that, as the installation process of such systems should involve a comprehensive site assessment, such companies would have a database of potential sites. While this was true, most of the information related to green-field sites or work in progress, save for two sites, and was therefore of little relevance to the project.

The most successful site identification strategy adopted was a media campaign which involved newspaper advertisements, radio interviews and advertisements, a poster campaign and presentations. This yielded 37 potential sites for investigation from over 100 responses. Over 70 sites were rejected due to distance from Dublin and it is worth noting that information gleaned from conversations with these house owners revealed that 15 of these sites experienced a high water table and another 5 experienced drainage problems. Figure 2.1 gives a county by county breakdown of the sites investigated.

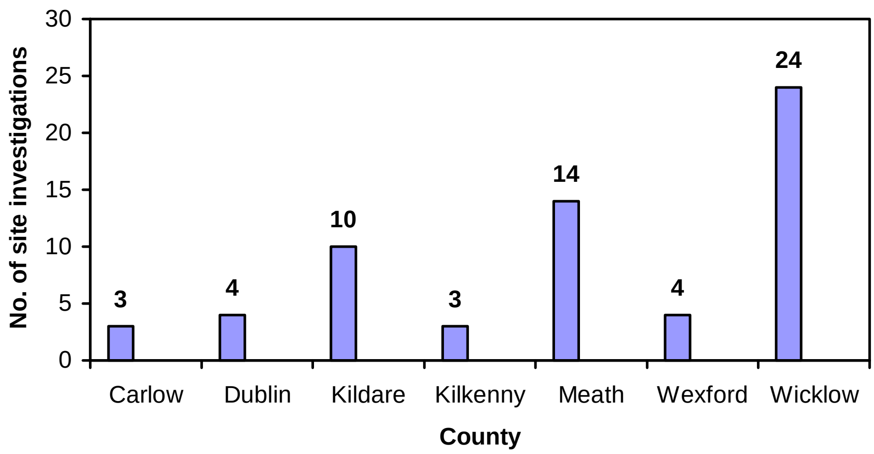


Figure 2.1 Location of site investigations.

Of the total of 60 sites with the desired occupancy rate investigated over a 7 month period only 2 (3.33%) satisfied the site selection criteria, i.e. 2m unsaturated subsoil with a T-value of 1-50. Of a further 14 sites investigated for Sites 3 and 4 only 2 (14.29%) satisfied the site selection criteria. When these data are combined it shows that while all sites had some form of on-site treatment system only 5.41% would have been deemed suitable for the standard septic tank system with percolation trenches set at 0.8m depths. It is clear from Table 2.5 that the most common reason for site rejection was the presence of a high water table. In some of these cases it may have been possible, according to the EPA guidelines, to raise the level of the percolation pipe to provide 1.2m unsaturated subsoil beneath the base of the trench. However, these sites were not considered for the project since they would have involved raised mounds over the trenches which it was considered would not have been acceptable to the house owners.

REASON FOR UNSUITABILITY		**QUANTITY**	**PERCENTAGE**
T-value	*too high*	12	16.4
	too low	9	12.3
Water table		36	49.3
Shallow bedrock		4	5.5
Confined site		9	12.3

Table 2.5 Reasons for site unsuitability.

While proximity to Dublin determined the catchment area for potential research sites, the location of the selected sites within this area was based solely on completion of the dwelling and suitable occupancy levels. Should the results of this assessment of a random sample of sites be indicative of the regional unsuitability for on-site treatment of domestic wastewater, the pressure being exerted on water resources, especially groundwater given the high percentage of sites deemed unsuitable due to the presence of a high water table, could be a cause for concern.

2.4 Test Sites

As a result of the successful networking and advertising campaigns and the subsequent site investigations four suitable sites were identified : two in County Kildare, one in the Curragh (27890E, 21290N) and the other in Rochestown (28890E, 20860N), and two in

County Wicklow, one in Three Wells (31430E, 18160N) and one in Killaveny (30680E, 17390N). The location of these sites is highlighted in Figures 2.2 to 2.5.

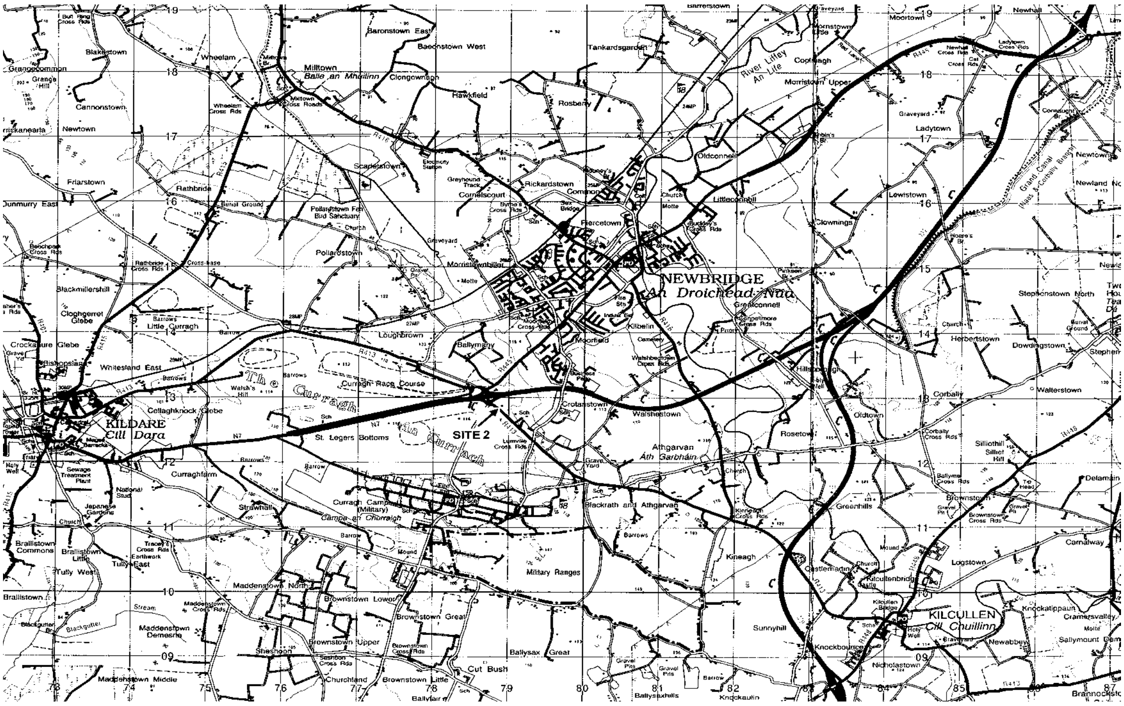


Figure 2.2 Location of Site 1 at the Curragh (County Kildare).

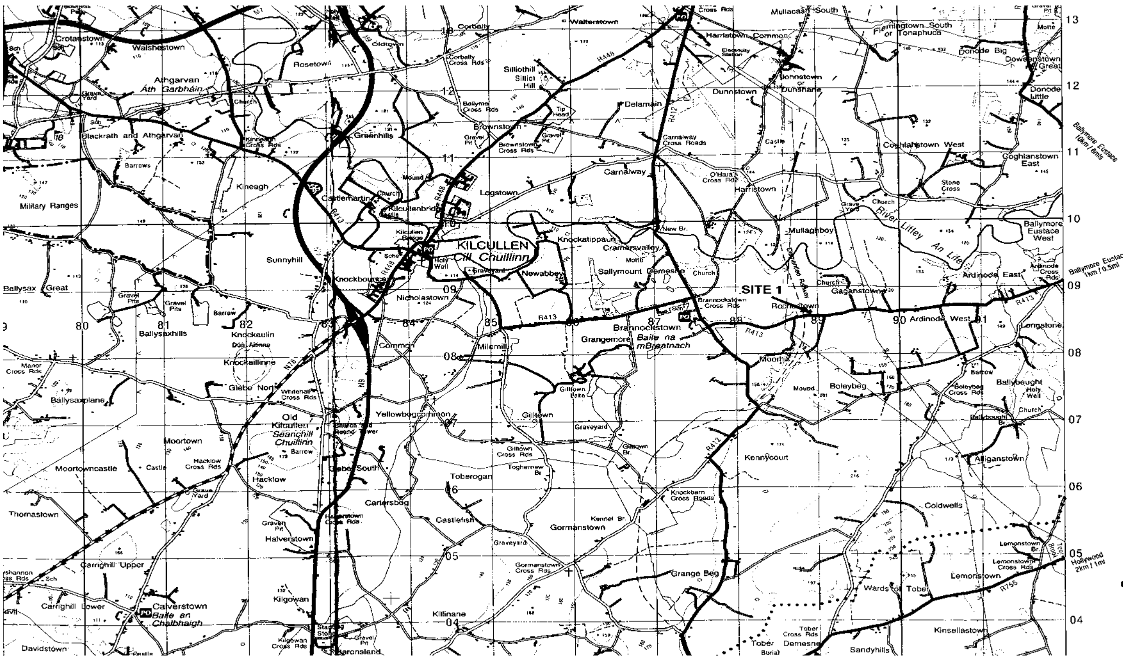


Figure 2.3 Location of Site 2 at Rochestown (County Kildare).

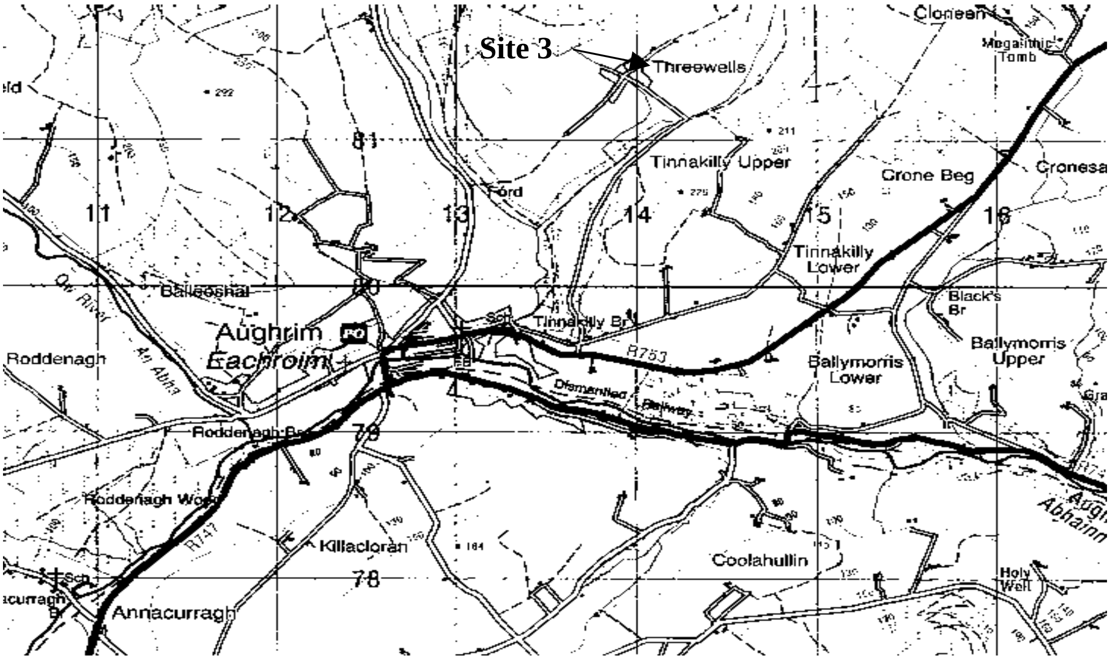


Figure 2.4 Location of Site 3 at Three Wells (County Wicklow).

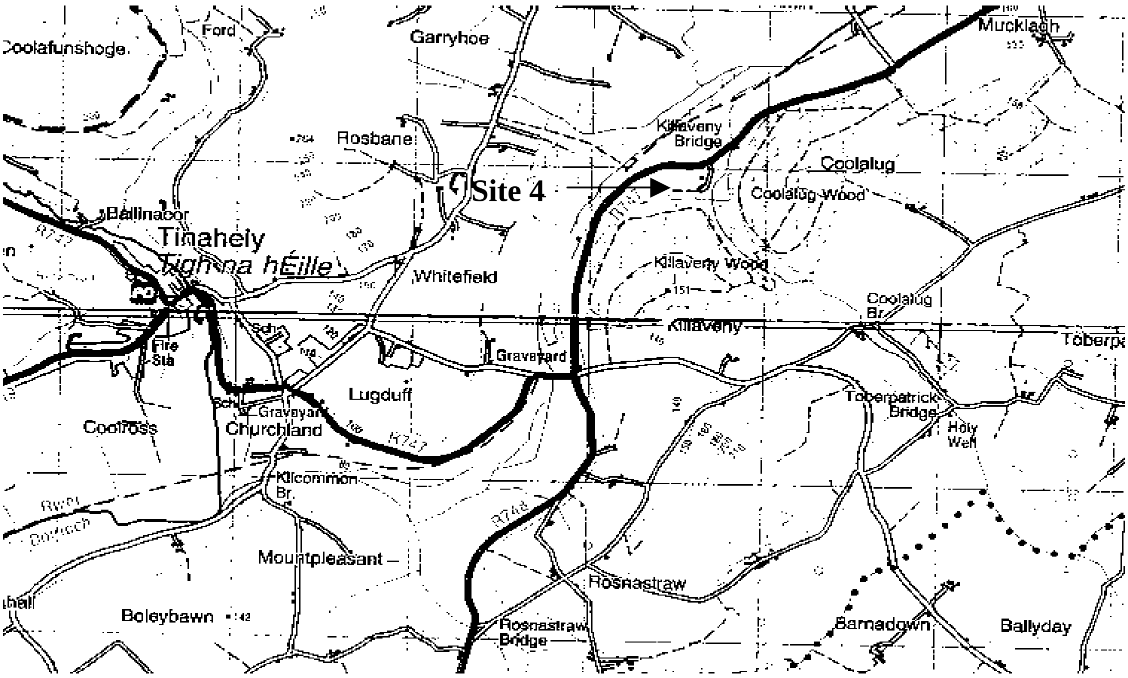


Figure 2.5 Location of Site 4 at Killaveny(County Wicklow).

The Rochestown site was a recently renovated cottage which had no form of on-site treatment system installed. Both surface run-off and domestic effluent were discharged into an open pit of 1.5m depth. As a planning condition relating to the construction work on the Curragh site, Kildare County Council had specified that the present septic tank and percolation area had to be upgraded. Similarly, a planning condition in relation to an extension on the Killaveny site required the upgrading of the existing domestic wastewater treatment system. The site at Three Wells was a recently constructed bungalow on which the septic tank treatment system had yet to be installed. As Figures 2.2 to 2.5 show all sites were located in undeveloped areas, so it was possible to construct four new on-site treatment systems in undisturbed subsoil.

2.4.1 Site 1: The Curragh

Site 1 lies within a region of soil described as the Athy Complex (Conroy *et al.*, 1970). Soils of this type, which generally occur between elevations of 46m and 275m, are found scattered throughout the county but predominantly occur in the southern part. The topography of the regions where soils of this complex are found varies between flattish and undulating, with many areas described as hummocky with sharp slope changes ranging from 0° to 20°. The parent material of these soils consists of calcareous, fluvioglacial coarse gravels and sands of Weichsel Age composed mainly of limestone with a small proportion of sandstone, schist, shale and conglomerate (Conroy, *et al.*, 1970).

The excavation of the trial hole to ensure sufficient depth of unsaturated subsoil also facilitates the examination of the subsoil profile and characteristics and the completion of the required site characterisation form (Appendix A). Soil/subsoil texture classification was carried out in accordance with BS5930 (BSI, 1999) with the aid of a flowchart produced by the Groundwater Section of the GSI (Appendix A). On inspection of the trial hole (Figure 2.6) four distinct layers were observed and classified (Table 2.6). Grain size distribution curves were also produced for samples taken at depths of 1.0m, 1.5m and 2.0m below ground level (Appendix A) which serves to highlights the difficulty in identifying textural differences in an apparently homogenous layer as can be seen in

Table 2.7. As the soil at this site has a higher clay content than the soil at Site 2, it was expected that Site 1 would show a lower percolation rate but this was not borne out by the results of the T-test (Table 2.8).

Figure 2.6 Trial hole on Site 1.

Under high potential levels the hydraulic conductivity of sands is higher than clays while the opposite is true at low potential levels. It is possible, therefore, that on Site 1 the pre-soaking step of the T-test failed to create saturated conditions in the subsoil surrounding the test holes and that unsaturated conditions prevailed. It must also be considered that the presence of preferential flowpaths in the form of macropores, cracks and voids around cobbles were observed across the soil profile (Table 2.6) and that this could explain the higher than expected percolation rate.

	Soil / subsoil Texture & Classification	Soil Structure	Density	Colour	Preferential Flowpaths
0.1m	A Horizon	Crumb	Medium	Dark brown	Roots
0.2m					
0.3m					
0.4m	SILT/CLAY	Structureless-massive	Low	Brown	Some root ends and macropores present
0.5m					
0.6m					
0.7m					
0.8m	sandy CLAY (w/silt) interspersed with rounded cobbles	Structureless-massive	Medium	Reddish Brown	Macropores, cracks & voids around some cobbles
0.9m					
1.0m					
1.1m					
1.2m	sandy CLAY (w/silt) interspersed with rounded cobbles	Structureless-massive	Medium	Brown	Macropores, cracks & voids around some cobble
1.3m					
1.4m					
1.5m					
1.6m					
1.7m					
1.8m					
1.9m					
2.0m					
2.1m					
2.2m					
2.3m	Base of hole				

Table 2.6 Characterisation of subsoil profile at Site 1.

Depth of sample below ground level	% Gravel	% Sand	% Silt	% Clay
1.0m	3.3	23.3	50.1	23.3
1.5m	8.8	18.9	51.1	21.2
2.0m	24.9	23.8	36.8	14.4

Table 2.7 Particle size analysis of soil samples from Site 1.

Research carried out in Galway (Mulqueen and Rogers, 2001) has produced an adapted T-test which derives an equivalent T-value from time factors obtained through laboratory experiments. The main difference between the two tests is that while with the standard T-test the time is recorded at 100mm intervals, it is recorded at 50mm intervals in the adapted T-test. With the adapted T-test the time is initially recorded when the test hole is filled to 400mm and the test is completed when the water level in the hole reaches 100mm above the base. Unlike the standard T-test the adapted T-test only requires the test hole to be filled once. During the T-test on both Sites 1 and 2 the time taken per 50mm fall in water level between the top of the test hole and 200mm above its base was recorded to enable a T-value to be calculated by the adapted T-test method (Table 2.9). While this value gives a good approximation of the standard T-test value, as was found to be the case at Site 2, it gave a slight underestimation of the T-value. However, as has been proved under laboratory conditions (Mulqueen and Rogers, 2001), a completed adapted T-test, due to the reduced head experienced between 100mm and 50mm, may give a better approximation of the standard T-test value and thus greatly reduce the time required in assessing the percolation rate of the subsoil.

SITE OCCUPANCY

On initiation of the project there were four adults resident at Site 1; however, this number fluctuated throughout the year. In November one female resident left although she continued to use the laundry facilities in the house. Over the rest of the project duration the number and profile of residents continued to fluctuate with two females, an elderly lady and her carer, leaving in February to be replaced by two males. A housekeeper also called on Mondays to Fridays throughout the year. There is also a livery stable attached to the house in which three people were employed. The employees started work at approximately 07:00 and left for lunch at between 12:30 and 13:00.They sometimes returned for a few hours in the evening. While the employees did not partake in the daily routine of the house they did have access to an external toilet that was connected to the wastewater system of the main house.

	Test Hole No. 1			Test Hole No. 2		
Fill No.	**Start Time** (at 300mm)	Finish Time (at 200mm)	Δt (minutes)	**Start Time** (at 300mm)	Finish Time (at 200mm)	Δt (minutes)
1	12:04	13:11	67	11:38	12:15	37
2	13:11	14:30	79	12:15	13:00	45
3	14:30	15:46	76	13:00	13:47	47
AverageΔt (minutes)			74	AverageΔt (minutes)		43
AverageΔt/4 = t_1(minutes)			**18.5**	AverageΔt/4 = t_2(minutes)		**10.8**
T-value = $(t_1+t_2)/2$ = 14.6 (minutes/25mm)						

Table 2.8 T-test results from Site 1.

Fall of water in hole (mm)	**Time Factor (T_f)**	**Time (min) of fall (T_m)**		**Field-Saturated hydraulic conductivity $K_{fs} = (T_f/T_m)$**		**Equivalent percolation T-value in minutes/25mm $T = 4.45/K_{fs}$**	
		Hole1	Hole 2	Hole1	Hole 2	Hole1	Hole 2
400-350	5.3	18	5	0.29	1.06	15.3	4.2
350-300	6.9	27	12	0.25	0.58	17.8	7.7
300-250	8.1	32	12	0.25	0.58	17.8	7.7
250-200	9.7	35	25	0.28	0.39	15.9	11.4
					Average T	**12.2**	

Table 2.9 Adapted T-test results from Site 1 (see Mulqueen and Rogers, 2001).

2.4.2 Site 2: Rochestown

Rochestown lies within a region of grey-brown podzolic soil described as the Elton Series, a series that occurs most extensively in the northern and eastern portions of County Kildare (Conroy *et al.*, 1970). These soils normally occur at elevations less than 150m, on undulating relief with slopes of 2 to 6°. They are derived from predominantly limestone drift with a small admixture of shale and sandstone. The soils of this series are deep, well-drained, of loam texture and high base status.

As was the case with Site 1, a trial hole (Figure 2.7) was used to examine the subsoil profile and characteristics, and the results obtained used to complete the required site characterisation form (Appendix A). While the installation of a secondary treatment system only requires the presence of 0.6m of unsaturated subsoil below the invert of the percolation trench, 1.2m of unsaturated subsoil was desired for the project, in order to allow direct comparison between sites with septic tank treatment systems and those with secondary treatment systems.

Figure 2. 7 Trial hole on Site 2.

It was found that the soil profile consisted of three distinctive layers as outlined in Table 2.10. While no particle size distribution analysis was carried out on the B horizon (the layer between 0.3m and 0.9m), it showed the characteristics of a subsoil with a higher clay content than the C horizon, the layer below it. This is consistent with the regional description of the soil as a grey-brown podsol.

In general, the selection of sampling points within a trial hole for BS5930 classification is dependent on the visual assessment of the exposed material, as it is not feasible to examine the subsoil texture at small intervals over the entire hole depth. Therefore, difference in subsoil colour is often used to distinguish between different layers, i.e. layers that appear on visual inspection to be of uniform colour and texture. The flaw in this method is highlighted, as was also the case in Site 1, by comparing the particle size distribution curves of samples taken from a layer that has been described as homogeneous in Table 2.10. Soil samples taken at 1.0m, 1.5m and 2.0m below ground level were analysed for particle size distribution (Appendix A). These were the depths to which it was proposed to install the suction lysimeters and tensiometers. Table 2.11 summarises the graphs produced in Appendix A.

	Soil / subsoil Texture & Classification	**Soil Structure**	**Density**	**Colour**	**Preferential Flowpaths**
0.1m	A Horizon	Crumb	Medium	Dark brown	Roots
0.2m					
0.3m					
0.4m	B Horizon sandy CLAY (w/silt)	Structureless – massive	Medium	Reddish brown	Some roots and macropores
0.5m					
0.6m					
0.7m					
0.8m					
0.9m					
1.0m	C Horizon sandy SILT (w/clay)	Structureless – massive	Medium	Brown	None evident
1.1m					
1.2m					
1.3m					
1.4m					
1.5m					
1.6m					
1.7m					
1.8m					
1.9m					
2.0m					
2.1m					
2.2m	Base of hole				

Table 2.10 Characterisation of subsoil profile at Site 2.

Depth of sample below groundlevel	% Gravel	% Sand	% Silt	% Clay
1.0m	10.6	50.3	32.8	6.3
1.5m	27.5	61.1	11.4	0
2.0m	10.1	59.3	26.8	3.8

Table 2.11 Particle size analysis of soil samples from Site 2.

While Table 2.11 shows that the samples taken at 1.0m and 2.0m are similar in particle size distribution, the sample taken at 1.5m has substantially lower fines content, indicative of a layer of greater permeability. Such a layer, if it extends laterally, could be beneficial in the treatment of percolating wastewater should it act as a distribution medium, enabling the treatment process to be effected over a greater area. As the T-test (Table 2.12) was carried out in the B horizon it is not representative of the more extensive C horizon below, which in this case would appear to be of higher permeability. A subsoil with these characteristics has led to the suggestion that the T-test could be changed whereby the T-test hole would be excavated to a depth of 400mm below the invert of the percolation trench. However, this would not take into account the infiltration capacity of the side walls of the percolation trench. As the test stands, the infiltration capacity of an area 150mm above and below the percolation trench is examined thus giving an indication of the hydraulic behaviour of the subsoil along the trench sides and below its base under saturated conditions. However, it is questionable as to whether or not a head of 300mm would build up in the trench. A refinement that might be suggested, therefore, is that the T-test hole is excavated to the depth of the projected invert of the trench and that a smaller volume of water might be more representative of future conditions. The driving force provided by a smaller head could also be seen to better represent the impedance that would be expected by the formation of the biomat along the base and walls of the trench. However, it should be appreciated that any percolation test on undisturbed subsoil only yields information about the subsoil infiltration capacity and will obviously not represent the actual impedance of the subsoil and biomat matrix (after its formation) which appears to be predominantly regulated by the biomat.

As in Site 1, the data for the adapted T-test were also recorded during the standard T-test although it was not possible to time the water level drop below 200mm. While the adapted T-test carried out on Site 2 was therefore incomplete, it is worth noting the similarity between the T-value obtained by this method and that obtained using the standard T-test (Table 2.13).

	Test Hole No. 1			**Test Hole No. 2**		
Fill No.	**Start Time** (at 300mm)	Finish Time (at 200mm)	Δt (minutes)	**Start Time** (at 300mm)	Finish Time (at 200mm)	Δt (minutes)
1	11:45	13:05	80	12:13	14:25	132
2	13:08	14:33	85	14:26	16:53	147
3	14:33	16:10	97	16:53	19:22	149
		AverageΔt (minutes)	87.3		AverageΔt (minutes)	142.7
		Average$\Delta t/4 = t_1$(minutes)	21.8		Average$\Delta t/4 = t_2$(minutes)	35.7
T-value = $(t_1+t_2)/2$ = 28.8 (minutes/25mm)						

Table 2.12 T-test results from Site 2.

Fall of water in hole (mm)	**Time Factor (T_f)**	**Time (min) of fall (T_m)**		**Field-Saturated hydraulic conductivity $K_{fs} = (T_f/T_m)$**		**Equivalent percolation T-value in minutes/25mm $T = 4.45/K_{fs}$**	
		Hole1	Hole 2	Hole1	Hole 2	Hole1	Hole 2
400-350	5.3	25	39	0.21	0.14	21.2	31.8
350-300	6.9	30	48	0.23	0.14	19.3	31.8
300-250	8.1	32	51	0.25	0.16	17.8	27.8
250-200	9.7	48	81	0.20	0.12	22.3	37.8
200-150	11.9	N/A	N/A	N/A	N/A	N/A	N/A
150-100	14.1	N/A	N/A	N/A	N/A	N/A	N/A
					Average T	**26.2**	

Table 2.13 Adapted T-test results from Site 2 (see Mulqueen and Rogers, 2001).

It can be seen that the adapted T-test, for both Sites 1 and 2, under-predicts the standard T-test but if it had been continued to 100mm it is likely to returned a higher average value, due to the lower head, thus resulting in a closer approximation.

SITE OCCUPANCY

For the duration of the project there were five people resident at Site 2, a husband and wife, their daughter and two sons. All the children were students at primary and secondary schools, generally leaving the house at between 08:00 and 08:30 and returning between 15:30 and 16:30, Monday to Friday. The father ran a business from home and the mother generally left home between 09:30 and 10:00 for work, returning between 16:30 and 17:00. It must be considered that in modern society it is common for both spouses to work outside the home, reducing daily loading rates on the wastewater treatment system.

2.4.3 Site 3: Three Wells

Three Wells lies within a region of lower Palaeozoic sandstone and shale till known as the Ribband Group. This group was deposited after the Bray Group, a formation dominated by greywacke sandstones interbedded with slates, shales and distinctive massive quartzite in the north of the county, and consists of mudstones, siltstones, quartzites and volcanic rocks. These rocks outcrop on both sides of the Leinster Granite and are divided into seven formations one of which is the Maulin formation within which Three Wells is located. The Maulin formation consists predominantly of fine grained sedimentary rocks which have been metamorphosed by the intrusion of the granite (GSI, 2003). Site 3 was an elevated site on the side of a hill above the valley at 205m AOD. A trial hole (Figure 2.8) was again used to examine the subsoil profile and characteristics and facilitate the completion of the site characterisation form (Appendix A).

Figure 2.8 Trial Hole on Site 3.

Table 2.14 shows that the subsoil exposed by the trial hole on Site 3 was divided into three distinctive layers. Grain size distribution curves for samples were taken at depths of 1.0m, 1.5m and 2.0m below ground level highlighted the uniformity of the subsoil matrix below the percolation trenches (Table 2.15). While no sedimentation tests were carried out to determine the relative percentages of silt and clay, the results of the BS5930 analysis would suggest that silt formed the greater percentage of the particles less than 0.063mm. Only a standard T-test was carried out on Site 3 and the results are shown in Table 2.16.

	Soil / subsoil Texture & Classification	Soil Structure	Density	Colour	Preferential Flowpaths
0.1m	A Horizon	Crumb	Medium	Dark brown	Roots, some evidence of macropores
0.2m					
0.3m					
0.4m	sandy SILT (w/clay)	Structureless - single grain	Medium	Reddish brown	Some root ends
0.5m					
0.6m	Very gravelly clayey SAND interspersed striated cobbles	Structureless – single grain	Medium	Dark brown	Some macropores evident in pockets of gravel and around cobbles
0.7m					
0.8m					
0.9m					
1.0m					
1.1m					
1.2m					
1.3m					
1.4m					
1.5m					
1.6m					
1.7m					
1.8m					
1.9m					
2.0m					
2.1m					
2.2m					
2.3m	Base of Hole				

Table 2.14 Characterisation of subsoil profile on Site 3.

Depth of sample below ground level	% Gravel	% Sand	% Silt/Clay
1.0m	40.8	26.4	32.8
1.5m	44.7	23.2	32.1
2.0m	35.1	26.5	38.4

Table 2.15 Particle size analysis of soil samples from Site 3.

	Test Hole No. 1			Test Hole No. 2		
Fill No.	Start Time (at 300mm)	Finish Time (at 200mm)	Δt (minutes)	Start Time (at 300mm)	Finish Time (at 200mm)	Δt (minutes)
1	11:11	13:57	166	11:07	12:23	76
2	13:58	16:50	172	12:24	13:58	92
3	16:50	19:45	175	13:58	15:40	102
Average Δt (minutes)			171	Average Δt (minutes)		90.3
Average Δt/4 = t_1(minutes)			42.8	Average Δt/4 = t_2(minutes)		22.6
T-value = (t_1 + t_2)/2 = 32.7 (minutes/25mm)						

Table 2.16 Results of standard T-test from Site3.

SITE OCCUPANCY

There were four people resident at Site 3, a mother and her three children, living in a three bedroom house. Two of the children were in school, generally leaving the house at 08:30 to return at 16:00, while the youngest had yet to start school. He was cared for at home by his mother.

2.4.4 Site 4: Killaveny

Located approximately 10.5km south west of Site 3 in the same valley, the subsoil at Site 4 was also described as a till with lower palaeozoic schists, sandstones, greywackes and shales dominant (GSI, 2003). As with Site 3 it is part of the Maulin formation of the Ribband group. While Site 3 was an elevated site at 205m AOD , Site 4 was located near to the floor of the valley at a lower elevation of approximately 90m AOD.

The opening of a trial hole (Figure 2.9) and the subsequent classification of the exposed material (Table 2.17) revealed the subsoil below the percolation area on Site 4 to be a clayey SAND. As can be seen from Table 2.18, which summarises the particle size distribution graphs in Appendix A, there is a reduction in the silt content with depth and an increase in the gravel content. While the results of the particle size analysis alone would generally suggest high permeability subsoil, the high density of the matrix resulted in a T-value greater than 50 (Table 2.19).

Figure 2.9 Trial hole on Site 4

As can be seen from Table 2.19 one of the t-tests carried out on Site 4 was not completed and the calculated T-value therefore was an average of five rather than six time intervals. This was due to time taken for the 100mm drop in water level to be achieved in test hole number two. It should be noted, however, that experience has shown that there is generally very little difference between the second and third time intervals in a t-test (with the third test normally taking very slightly longer than the second test). The T-value for Site 4 was required to be over a value of 50 for this part of the research project which proved to be the case anyway based on the calculations from the five time intervals.

	Soil / subsoil Texture & Classification	Soil Structure	Density	Colour	Preferential Flowpaths
0.1m	A horizon	Crumb	Medium	Dark brown	Roots, some evidence of macropores
0.2m					
0.3m					
0.4m	clayey SAND with some rounded cobbles	Structureless - single grain	Dense	Light brown	Some root ends
0.5m					
0.6m	gravelly clayey SAND interspersed with gravel and rounded cobbles	Structureless - single grain	Dense	Dark brown	None obvious although pockets of cobbles create macropores
0.7m					
0.8m					
0.9m					
1.0m					
1.1m					
1.2m					
1.3m					
1.4m					
1.5m					
1.6m					
1.7m					
1.8m					
1.9m					
2.0m					
2.1m					
2.2m					
2.3m	Base of hole				

Table 2.17 Characterisation of subsoil profile on Site 4.

Depth of sample below groundlevel	% Gravel	% Sand	% Silt/Clay
1.0m	13.9	53.7	32.4
1.5m	23.0	55.3	21.7
2.0m	35.0	45.9	19.1

Table 2.18 Particle size analysis of soil samples from Site 4.

	Test Hole No. 1			Test Hole No. 2		
Fill No.	Start Time (at 300mm)	Finish Time (at 200mm)	Δt (minutes)	Start Time (at 300mm)	Finish Time (at 200mm)	Δt (minutes)
1	12:12	15:07	175	13:20	17:15	235
2	15:07	18:07	180	17:15	22:15	240
3	18:07	21:14	187	N/A	N/A	N/A
Average Δt (minutes)			180.6	Average Δt (minutes)		237.5
Average $\Delta t/4 = t_1$(minutes)			45.2	Average $\Delta t/4 = t_2$(minutes)		59.4
T-value = $(t_1 + t_2)/2$ = 52.3 (minutes/25mm)						

Table 2.19 Results of standard T-test from Site 4.

SITE OCCUPANCY

There were four people resident at Site 4, a mother, father and their two children. The two children were in school, generally leaving the house at 08:30 to return at 16:00. The mother was a housewife while the father worked locally and returned home for lunch most days. Another daughter was in college and returned home occasionally some weekends.

3 SITE CONSTRUCTION

3.1 Introduction

To comply with the project specifications a septic tank was installed at two sites, with respective T-values in the range 1 to 25 and 25 to 50. A secondary treatment system, preceded by a septic tank, was installed on the other two sites. On Sites 1 and 2 the effluent from each system was split equally (via a distribution box) between four parallel percolation trenches on each site which were built to the EPA specifications (EPA, 2000). On Sites 3 and 4 the effluent was split at the distribution box whereby half was sent to two parallel percolation trenches, again built to the EPA specifications, and the other half diverted to a stratified sand filter constructed at the site. All of the septic tanks contained two chambers although the tank installed at Sites 2, 3 and 4 were of greater volume than that at Site 1, 4000 litres in comparison with 2275 litres. As the capacity of the septic tank on Site 1 was less than the recommended EPA design capacity of 2720 litres there was a concern that an increase in suspended solids content due to a shorter hydraulic retention time would cause a reduction in the desired effluent quality. However, as the project progressed this fear was allayed as, even at the greatest flow rates recorded, a retention time of greater than the recommended 24 hours occurred (Section 5.2). Diversion works were necessary at Sites 1, 2 and 4 to separate surface run-off from the domestic wastewater network and thus prevent the former entering the septic tank.

3.1.1 Puraflo® Secondary Treatment System

The secondary treatment system installed on Sites 2 and 4 was a Puraflo® system produced by Bord na Móna. Puraflo® is a peat based biofiltration system for the treatment of septic tank effluent. Septic tank effluent enters a sump from where it is pumped to a fibrous peat media which is contained in moulded polyethylene modules (Figure 3.1). This pressurised dosing system is activated by a float switch in the pump sump. A distribution manifold is located within the peat media, approximately 150 mm below the surface, to ensure even distribution of the septic tank effluent within the media and to avoid any odour that might occur due to surface ponding. Unlike many other systems available on the Irish market, no mechanical aeration of the treatment media is required as it is naturally aerated through a series of holes at the top of each module thereby reducing the energy demand (Figure 3.2).

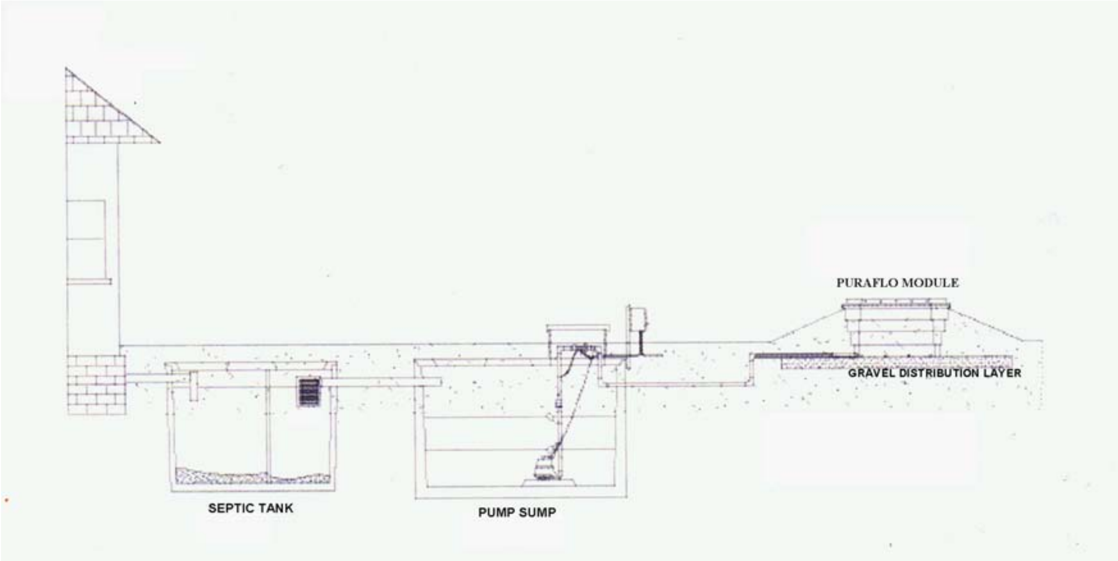


Figure 3.1 Layout of typical Puraflo treatment system.

Figure 3.2 Open Puraflo® module containing fibrous peat media. Note aeration holes along sides of lid and also the collection sump in left of photograph.

The treatment of the septic tank effluent within the fixed media is achieved by a combination of physical (filtration and adsorption), chemical (adsorption and ion exchange) and biological (microbial assimilation) processes resulting from the interactions between the effluent and the peat media and associated biofilm (Henry, 1996). Most of the biological processes are carried out by aerobic and faculatively aerobic heterotrophic bacteria which adhere to the surface of the peat media. The larger numbers of heterotrophic bacteria are found in the upper portions of the filter media with nitrifiers becoming more prevalent at depths of 30 cm or greater where the organic concentrations in the percolating effluent have become relatively low. Therefore, the degradation and assimilation of the carbonaceous element of the waste is effected within the upper portions of the filter bed with nitrification occurring at greater depths provided that sufficient oxygen is available.

In the standard Puraflo® system the treated effluent percolates through the base of the module into gravel distribution trenches from where it enters the subsoil. However, modifications to the design of the system to allow the effluent to be gravity fed to the percolation trenches meant that the treated effluent was collected in a sump from where it flowed to the distribution box. It is from this sump that samples were obtained.

3.2 Construction of Percolation Trenches

3.2.1 Background

As outlined in Section 2.2.3 all sites required the construction of parallel percolation trenches each of 20 m length, four on Sites 1 and 2 (Figure 3.3) and two on Sites 3 and 4 as polishing filters (Figure 3.4). While it is recommended that there should be 450mm cover above the percolation pipes (i.e 800mm cover above the invert of the trench) along its full length, which was achieved at Sites 1, 3 and 4, this depth was unattainable over the whole length of trench on Site 2 due to its topography. The percolation area on Site 2 is located in a corner section of a field from which the land falls in all directions.

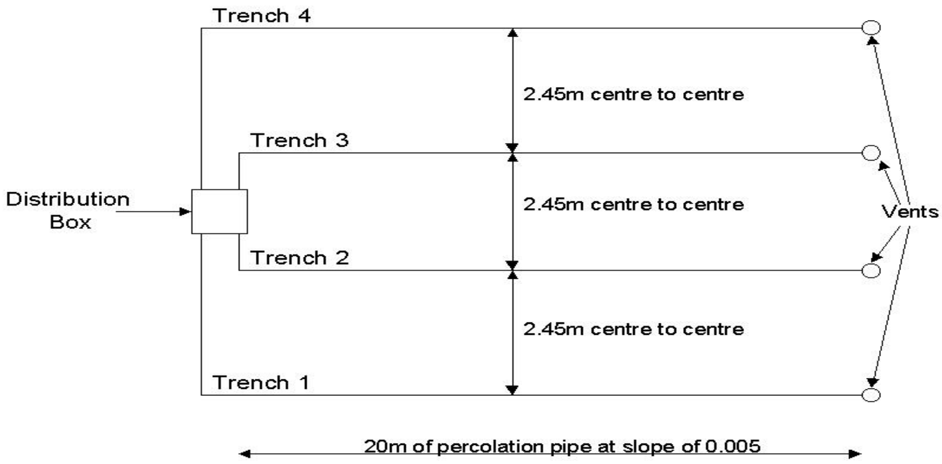


Figure 3.3 Plan of percolation area on Sites 1 and 2 (EPA, 2000).

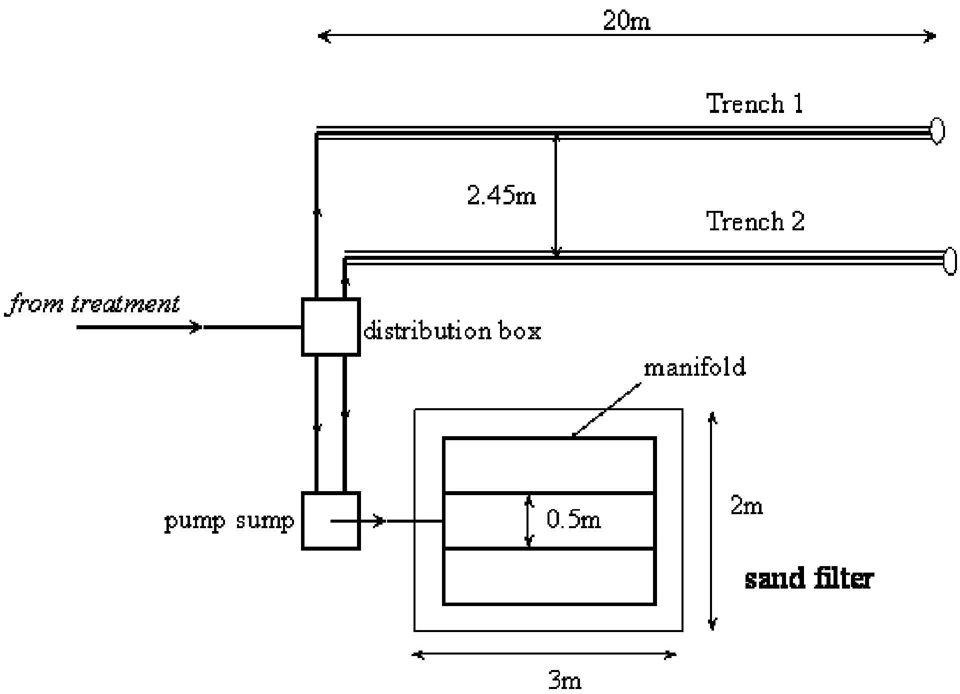


Figure 3.4 Plan view of trenches and stratified sand filter on Sites 3 and 4.

The area required for the percolation trenches was marked out and spot levels taken along the ground surface (Table 3.1). Ground level above the start of Trench 1 was taken as datum. As can be seen from Table 3.1, in order to achieve an invert depth of 800 mm at the end of each trench, a deeper excavation would be required at the start; for example, Trench 4 would require the invert at the start of the trench to be at 1.38 m below ground level. However, this would not allow the installation of the instrumentation to the required depth.

Distance along Trench (m)	Trench Number			
	1	2	3	4
0	0	-0.178	-0.206	-0.256
5	N/A	N/A	-0.436	-0.556
10	-0.266	-0.396	N/A	N/A
20	-0.381	-0.571	-0.786	-0.936

Table 3.1 Levels, in metres, taken at ground surface along the length of proposed percolation trenches on Site 2 (relative to ground level at start of Trench 1).

The depth at which the T-test was carried out and the depth to which the trial hole was excavated must also be considered. Even assuming that the results obtained from the on-site assessment are representative of the layers in which they were performed, and that these layers are isotropic and homogeneous, they might not be representative of the subsoil at the invert of the trenches should the trenches be excavated to a greater depth. As it is the depth and characteristics of subsoil below the base of the percolation trench, rather than that above it that is of critical importance for effluent treatment, it was decided to raise the trenches so that the recommended EPA trench invert depth of 800 mm was achieved at the midpoint (10 m) of each trench (Table 3.2). The minimum 1.2m depth of subsoil beneath the invert was maintained in all trenches.

Distance along Trench (m)	Trench Number			
	1	2	3	4
0	0.946	1.000	1.130	1.225
20	0.665	0.607	0.650	0.645

Table 3.2 Depth, in metres, of trench inverts below ground level at 0m and 20m.

3.2.2 Trench Construction

Prior to construction all material specified by the EPA had to be sourced and delivered to site (Table 3.3). It was necessary, however, to alter the design specifications slightly due to four problems encountered:

1) The percolation pipes specified were of 100 mm bore whereas the standard sewer pipe bore in Ireland is 110 mm and it was therefore necessary to use pipe of this bore.
2) The percolation areas on Sites 1 and 2 were located on grazing land and so all site owners were anxious that land wastage would be kept to a minimum. Rather than installing the vents at the end of each percolation trench (Figure 3.3), it was decided to install them at the start, as this reduced land usage – easier to fence off area adjacent to site boundary. The percolation areas on Sites 3 and 4 were located in the gardens and in these places the vents were located at the end of each percolation pipe.
3) As each trench was treated as a separate entity for research purposes they were not interconnected.
4) The required trench width of 450 mm was achieved using a 457 mm bucket excavator.

Description	Approximate Quantity
Distribution box	1
20–30mm washed gravel*	21.12m^3 (35.52t)
110mm (4”) percolation pipe	84m (supplied in 6m lengths)
110mm (4””) sewer pipe	12m (supplied in 6m lengths)
110mm (4”) sewer swept bend	4
110mm (4”) sewer T branch	4
110mm (4”) sewer collar	4
110mm (4”) sewer plain stopper	4
110mm (4”) soil pipe cowl	4
Geotextile	36m^2

* density of 6.35 –50.8mm gravel = 1682kg/m^3 (Source: www.metric.fsworld.co.uk)

Table 3.3 Material required for the construction of a percolation area.

There are a number of stages involved in the construction of a percolation trench (Figure 3.5). Prior to excavation, the location of the four percolation trenches was marked on the ground surface to aid the JCB driver. To begin with, one of the outside trenches was excavated first; in each case, the soil was left outside the percolation area and later used to backfill the last trench excavated. The soil from the excavation of subsequent trenches was used to backfill the previously excavated trench.

Some of the construction stages are more critical than others and therefore require more attention to detail. Levels were taken along the trench base, at the top of the first gravel layer and on the top of the percolation pipe to ensure that a slope of 0.005 was being achieved to promote even distribution of the effluent. Also of importance were the occurrence of smearing on the trench base and walls due to the compaction and/or glazing of the soil by the bucket – a problem that increases with increasing clay content. As Figure 3.4 (c) highlights, this required scouring with a garden rake to expose a natural soil surface and so prevent reduced infiltration.

(a)

(b)

(c)

Figure 3.5 Construction of percolation area:

(a) Trench excavation.

(b) Smearing on trench wall.

(c) Raking trench wall.

(d) Pouring initial layer of distribution gravel – note white guide tubes for instrumentation.

(e) Percolation pipe in place.

(f) Geotextile in place.

(g) Backfilling trench with soil from the next trench excavation.


(d)


(e)


(f)


(g)

The gravel was placed in the trench in two phases, an initial layer of 250 mm thickness as a distribution layer below the percolation pipe and a subsequent 250 mm thick layer to protect the pipe. Prior to the placement of the distribution gravel in the base of the trench, guide tubes were inserted to allow for the future installation of the monitoring instrumentation (Figure 3.4 (e)). Prior to backfilling, a geotextile, Terram® in this case, was placed over the second gravel layer to prevent fines being washed into the distribution gravel and causing clogging.

On completion of the percolation trenches the distribution box was installed and levelled and a trench excavated on both sides to allow its connection with the percolation pipes (Figure 3.6). The connecting pipes were surrounded by gravel for protection and the trench backfilled with soil. To avoid the creation of preferential flow paths that would facilitate effluent movement from the distribution gravel, this trench was excavated to the depth of the invert of the percolation pipes only and the area around the end of each percolation trench was backfilled with soil. On completion of the percolation areas, grass seed was sown on all sites to achieve representative evapotranspiration rates.

Figure 3.6 Installation of distribution box and connecting pipes.

3.2.3 Distribution Box

The achievement of an equal loading rate on each trench (and an equal split between the trenches and stratified sand filters on Sites 3 and 4) depends upon the attainment of an even distribution within the distribution box, all other factors being equal. After the commissioning of Sites 1 and 2 it was observed that neither distribution box (Figure 3.7) seemed to be producing an even split over the four trenches and therefore some modification was required. A length of 110 mm diameter sewer pipe was cut half along its length to produce a gutter and four 90° V-notch weirs, bevelled on the downstream side, were cut into it to correspond with the outlet channels. This modification was inserted into the inlet pipe and levelled. At low flows it was observed that the nappe failed to spring clear of the notch and clung to the underside of the pipe until it reached the lowest point from where it dropped into the channel below. To curtail this, and force the effluent into the individual outlet channels, the void area underneath the pipe was filled with cement which also ensured that the pipe remained horizontal.

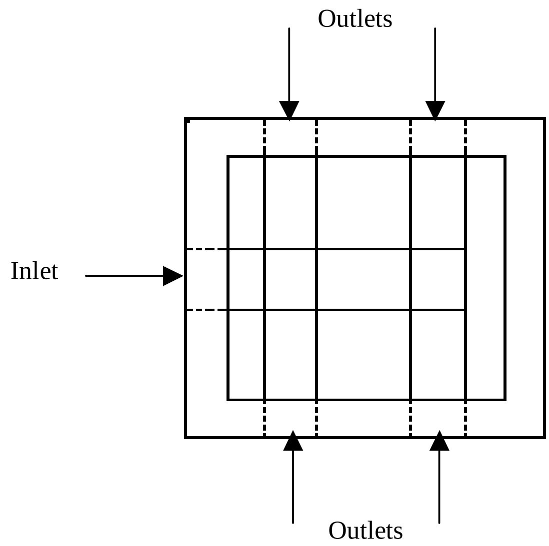


Figure 3.7 Plan of distribution box installed on all sites.

As an adjunct to this project, an analysis was carried out (Gill *et al.*, 2004) on effluent distribution within an identical distribution box using flow data obtained from Site 2 over an eight month period (July 2002 to February 2003). Frequency distribution analysis was carried out on the collated data to calculate the range of flows and the most frequent flow rate recorded. It was discovered that most flows recorded fell within the 0-20 l/min range, with 2 l/min being the most frequent. The behaviour of the distribution box under laboratory conditions, receiving flows between 0.5 and 20 l/min, was examined: flows were increased by 1 l/min increments up to 10 l/min and by 2 l/min increments thereafter up to 20 l/min. Furthermore, it was decided to examine distribution box behaviour in response to shock loads of between 1 and 5 litres instantaneously released into the inlet pipe. In summary, it was found that, at all flowrates, the two outlet channels at the rear received the highest volumes of water, between 60 and 93%, with the right hand one clearly favoured at the critical flowrates below 6 l/min. It was not until a flowrate of 6 l/min was achieved that the front left outlet received any flow. The same distribution pattern was experienced when the system was tested with shock loads. While it was noted that the slope of the front left hand outlet channel was less than that of the corresponding channel on the right, thus preventing water from exiting the channel at low flows, this was not envisaged to have affected the distribution between front and rear outlets. To counteract this distribution problem a form of storage and side weirs was tested similar to that already installed at the two sites, but designed to sit into the distribution box rather than inserted into the inlet pipe (Figure 3.8 (a)). The location of the V-notch weirs with respect to the invert of the modified pipe, and their effect on its storage capacity, was critical in achieving an improved distribution. While a storage capacity was required to dissipate the influent velocity and prevent distribution favouring the two weirs at the rear, it was important that the volume:

(a) should not promote deposition of suspended solids in the gutter, and
(b) should not create a backwater effect in the inlet pipe.

Various pipes with weirs cut at distances of 20mm, 30mm, 40mm and 50mm (and various combinations of same) from the invert were prepared and their performances were recorded under the same conditions under which the unmodified distribution box was tested (the distances were measured along the internal circumference). It was found that the pipes with weirs at 30mm and 40mm, respectively, performed best. While the former gave the required distribution at low flows, the latter was found to perform best over the whole range of flows. It was also found that at high flows the two weirs at the rear were always slightly favoured and therefore some form of baffle located between the front and rear weirs might be advisable to further dissipate the influent flow velocity.

(a)

(b)

Figure 3.8 (a) Modification to standard distribution box and (b) Installed modification – note the occurrence of some deposition under field condition.

As the flowrates at Site 2 were measured upstream of the Puraflo© system the damping effect of this system on the flow profile must be considered. A shallower flow profile than that measured at the septic tank outlet would be expected at the distribution box thereby ensuring that, should the recorded data be representative of the annual flow profile, flowrates experienced here would be within the lower end of the range of those tested. This was corroborated by site inspections in which it was observed that subsequent to saturation of the peat media a more continuous flow seemed to be entering the distribution box compared to the direct septic tank effluent discharges. The ability of the 40mm weir to provide improved distribution over a broad range of flowrates, allied with the damping effect experienced over additional piping (the laboratory analysis was carried out using only 6m length of sewer pipe), warranted its installation on all sites. While the weirs provided improved distribution, regular inspection and maintenance was carried out, which involved cleaning with a small brush, to ensure a continued even flow distribution.

3.3 Construction of Stratified Sand Filters

3.3.1 Background

One of the objectives of the project was to compare the treatment efficiency of stratified sand filters against conventional percolation trenches receiving different types of effluent. Hence, Sites 3 and 4 were designed such that half of the effluent (from the septic tank and secondary treatment plant respectively) flowed by gravity into two distribution trenches and the other half split at the distribution box flowed into a pump sump, as shown on Figure 3.4, from where it was periodically pumped onto the sand filters via a manifold at the surface.

The stratified sand filters were designed to a hydraulic loading rate of 60 $l/m^2.d$ in accordance with the current EPA guidelines (EPA, 2000) which were based on an original design that had been tested in the USA (Nichols *et al.*, 1997). The plan area of each stratified sand filter on both sites was thus 6 m^2, based on a design figure of half of the effluent from a four person house using the EPA recommended per capita production of 180 lcd.

The individual layers of the sand and gravel were constructed in as close accordance as possible to the original EPA guidelines although it was not possible to source the exact particle size characteristics from suppliers in Ireland. After a thorough search the tightest specification to the guidelines (see Figure 3.9) was eventually ordered from specialist water treatment filter sand suppliers in County Tyrone. This issue of availability of the raw material is important and should be considered in future design specifications. Emphasis should be placed on the fact that the important characteristic of such a stratified sand filter, and the reason that it can perform at higher loading rates compared with a mono-grade sand filter, is that the three main layers decrease in particle size with depth. It should be noted that the deepest layer of medium sand (Figure 3.9) was only included on the original design to protect a layer of PVC from puncturing which was placed on the base to collect the effluent in a sump which was then pumped up to percolation trenches. In this research there was no such impermeable layer and the effluent was allowed to percolate straight through the base of both sand filters into the subsoil at a depth of 1.05 m. The fate of this effluent below the sand filters was continually monitored as described in Chapter 4. Each sand layer was separated by a layer of distribution gravel which helps to redistribute any hydraulic short-circuits that may develop in individual layers and also to enhance aeration at depth.

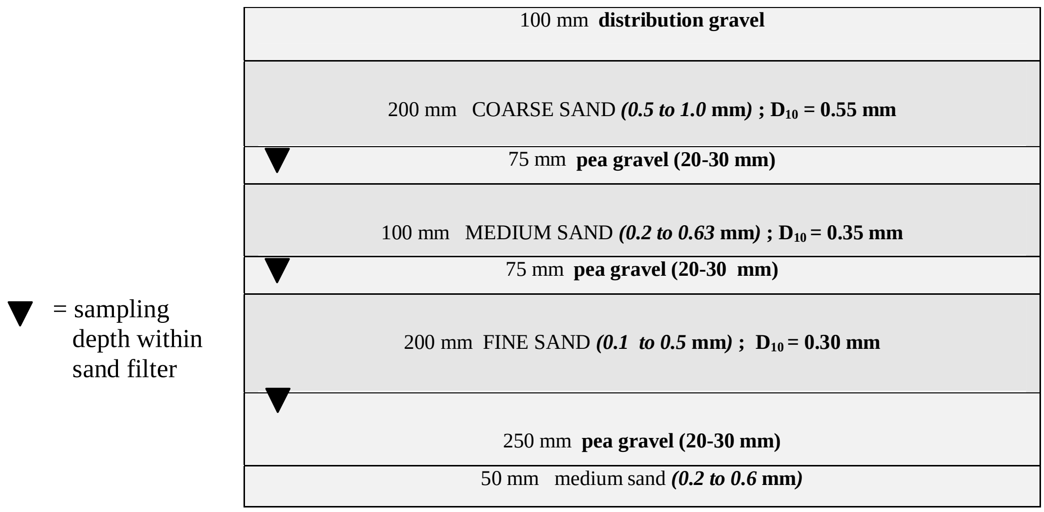


Figure 3.9 Schematic cross-section through stratified sand filter

3.3.2 Stratified Sand Filter Construction

The plan area ($6m^2$) for the stratified sand filters on both sites was dimensioned to be 2 x 3m to ensure compactness and promote even hydraulic distribution. The sand filters on both sites were positioned at least 10m away from the nearest percolation trench to ensure that there was no interference between the percolating effluents from the two systems.

The sand filter dimensions were marked out on the sites and a hole was dug down by JCB to the requisite overall depth 1.05m, as shown on Figure 3.10(a). Two opposite sides of the square holes were lined with plywood sheet which were carefully lowered into position and levelled. The sheets had been accurately marked with the levels of the various sand and gravel layers (see Figure 3.10(b)). The other two vertical sides of the sand filter hole were isolated from the subsoil by impermeable roofing felt which ensured that the effluent would percolate down through the whole depth of the filter and not out through the sides.

The base of the hole was then raked to break up any smearing or compaction that may have occurred during the digging of the hole or the installation of the side walls before the first 50 mm layer of sand was poured into the base to the requisite level (as marked on the plywood). The sand was raked and adjusted until it was exactly level across the filter (checked by theodolite) before the deepest layer of gravel was dug on top to its requisite 250 mm depth. At this point, two of the gravity samplers were embedded into the gravel (Figure 3.10 (c)) so that the top of their receiving cones were at the surface to capture effluent directly as it percolated from beneath the layer of fine sand. These samplers were positioned on opposite sides of the filter and the suction tube fed out of the side of the filter and then up the side to the surface. The construction of the sand filters thus proceeded as above, as shown on Figure 3.10 (d)-(e) with successive layers of sand and distribution gravel added according to Figure 3.9. A total of four more gravity samplers were placed, two samplers beneath the medium sand layer and two samplers directly beneath the top layer of coarse sand, as shown of Figure 3.9. As described previously each pair of samplers were placed on opposite sides of the filter but also positioned in different areas of the filter to ensure that no sampler was located directly beneath any other samplers).

(a)

Figure 3.10

Construction of Stratified Sand Filter:

- **(a)** 3 x 2 m hole excavation.
- **(b)** Plywood sides and bottom sand.
- **(c)** 250 mm gravel layer.
- **(d)** Installation of gravity sampler
- **(e)** beneath sand layers.
- **(f)** Fine sand layer
- **(g)** Gravel layer
- **(h)** Coarse sand layer
- **(i)** Final distribution gravel.

(b)

(c)

(d)

(e)

(f)

(g)

(h)

(i)

3.3.3 Effluent Distribution System

The distribution of the effluent equally between the trenches and the stratified sand filters was achieved by the modified V-notch weir in the distribution box, as discussed in Section 3.2.3. The effluent for the sand filter discharged by gravity into a 0.45 m square concrete sump at approximately 2 m below ground level (see Figure 3.11). From here, the effluent was pumped into a pressurised manifold which distributed the effluent evenly over the surface area of the filter (see Figure 3.12).

Figure 3.11 Effluent diverted into pump sump

Figure 3.12 Distribution manifold placed centrally on top of sand filter

The design of the manifold was based on a combination of hydraulic calculations and empirical tests carried out in the laboratories in the University to develop a system that would ensure an even distribution across the 3 x 2 m area of effluent when pumped under pressure from 2 m below ground level and also to prevent blockages. The final dimensions of the manifold, installed on both sites, are shown in Figure 3.13.

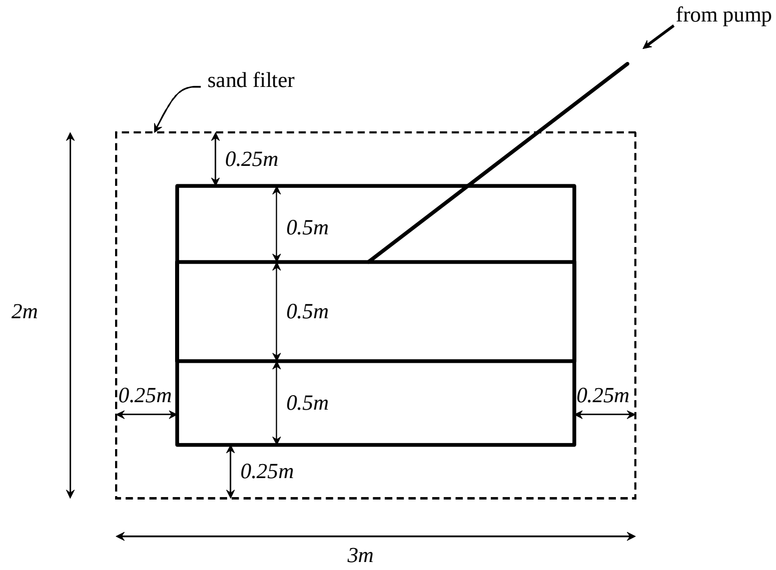


Figure 3.13 Dimensions of distribution manifold on top of sand filter (plan view)

The manifold was made from 38 mm diameter Hydrodare plastic piping which proved simple to cut to the required lengths and then fabricate to the desired dimensions using readily available ancillary joints. The nozzles for the effluent were 2.75 mm diameter holes drilled into the pipe at 200 mm spacings. It was found necessary to clean up any loose burs on the inside of these holes from the drilling process using a fine piece of wire since they could produce fairly large discrepancies in hydraulic distribution. Both manifolds were hydraulically tested for even distribution (see Figure 3.14) before being taken out to the sites. It should be noted that the manifolds were positioned on the stratified sand filters with the nozzles facing down in order to allow the manifold to drain between pumping sequences and thus minimise blockages.

Figure 3.14 Trials for equal distribution on the manifold

The manifolds rested on the top of the distribution gravel and were not covered by any soil or gravel. This allowed periodic checks to be made of the effectiveness of equal distribution across the sand filter plan area. In general, the manifolds performed well, particularly for the secondary treated effluent, however occasional cleaning was required for the septic tank effluent on Site 3. Such a task involved simply undoing the manifold and flushing it through with clean water which was not considered a problem for this research project. However, a more robust manifold design needs to be developed for normal on-site use where manifolds are likely to be buried beneath gravel and not checked for several years. It should be noted that during the research project the exposed manifolds produced no obvious odours and only slight vegetation growth occurred on Site 4 which was receiving nitrified effluent.

A Grundfoss KP150A1 submersible pump was used to pump the effluent from the sump to the manifold on both sites. This pump had the same specification as the one used for pumping the septic tank effluent into the Puraflo® unit. The pump was operated by a float switch which could be adjusted to pump a known volume per cycle which would also thus establish the frequency of pumping events per day. Two of the most critical parameters for a fixed film biological treatment process are the wetting frequency and flushing rate, which for the case of the on-site stratified sand filter are both a function of the frequency of pumping event. The design for the sites was to set a pumping frequency of about once every 2 hours on average based on the design hydraulic loading rates. However, in practice the frequency ranged from 4-8 times per day due to the lower than expected wastewater production from the houses (see Chapters 7 and 8).

4 INSTRUMENT INSTALLATION AND SAMPLING AND ANALYSIS METHODOLOGY

4.1 Introduction

The successful installation of instrumentation to record a number of parameters over the research period was an essential component of the research (Figure 4.1). Automatic samplers and flow monitors were installed downstream of the septic tanks, and secondary treatment system to obtain a profile of the effluent entering the percolation trenches. Suction lysimeters (referred to from now on as lysimeters) and zero-tension samplers were installed along the length of the percolation trenches to obtain soil moisture samples for analysis for some of the characteristic constituents of domestic wastewater effluent (COD, NO_3, NO_2, NH_4, PO_4, Cl and enteric bacteria). Rainfall volume, evapotranspiration and chloride concentration were also analysed to determine the effect of dilution on the system. Tensiometers were installed to monitor the soil moisture pressure below the percolation area.

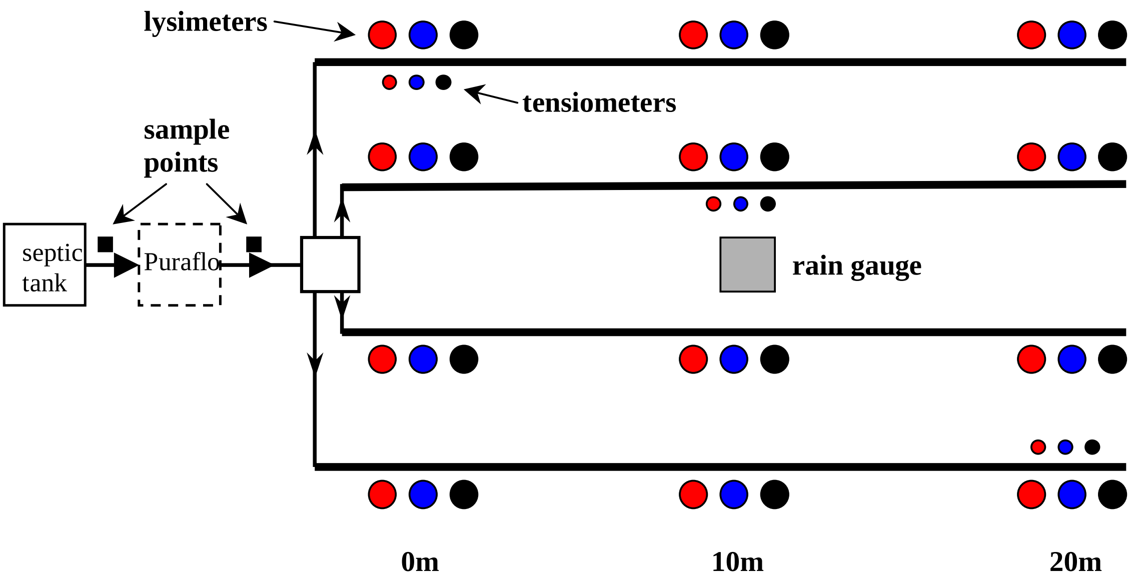


Figure 4.1 Schematic of instrumentation layout on Sites 1 and 2.

4.2 Monitoring of Percolation Trench Influent

4.2.1 Septic Tank and Secondary Effluent Sampling

Bühler Montec xian 1000 automatic samplers (Figure 4.2) were installed on all sites, two on Sites 2 and 4 (downstream of the septic tank and Puraflo® respectively) and one on Sites 1 and 3 (downstream of the septic tank). The installation of samplers upstream and downstream of the Puraflo® system enabled the changes in effluent quality across the secondary treatment system to be assessed.

Figure 4.2 Bühler Montec xian 1000 automatic sampler.

The samplers are designed for open source sampling and employ an air pump vacuum system. Each sampler consists of two modules: the sampling module and a container module that houses multiple containers allowing for the analysis of individual or composite samples. During the course of the project they were programmed to take hourly samples over the 24 hours preceding lysimeter sampling, thus providing a diurnal profile of the influent entering the percolation trenches. The samples were then mixed to provide a composite sample. Several diurnal analyses of septic tank effluent on Sites 1 and 2 as part of a final year undergraduate project (O Luanaigh, 2003) showed little variation in effluent quality over the 24 hour sample period due to the buffering capacity of both tanks (Table 4.1 (a) and (b)). The composite sample was collected in a sterilised 70ml plastic sample tube for analysis in the college laboratory.

Time	Concentration (mg/l)			
	COD	NH_4-N	PO_4-P	Cl
10:00 – 13:00	323	69.2	12.8	84
13:00 – 16:00	226	66.4	11.9	70
16:00 – 19:00	338	66.8	11.6	60
19:00 – 22:00	296	69.6	14.2	58
22:00 – 01:00	310	66.8	13.8	62
01:00 – 04:00	284	66	13.3	69
04:00 – 07:00	328	66.4	11.7	82
07:00 – 10:00	332	672	11.6	83
Average	**318.3**	**67.3**	**12.6**	**71**

(a)

Time	Concentration (mg/l)			
	COD	NH_4-N	PO_4-P	Cl
09:30 – 12:30	705	113.2	14.4	88
12:30 – 15:30	710	114.8	14.6	94
15:30 – 18:30	708	107.2	15.1	92
18:30 – 21:30	630	90	11.8	72
21:30 – 00:30	736	112	14.2	88
00:30 – 03:30	808	110	13.9	90
03:30- 06:30	750	109.2	14	85
06:30 - 09:30	762	108	15.3	85
Average	**729.1**	**108.1**	**14.2**	**86.8**

(b)

Table 4.1 Example of concentration variation within septic tank diurnal samples obtained from (a) Site 1 on 23/12/02 and (b) Site 2 on 30/01/03 (O Luanaigh, 2003).

4.2.2 Flow measurement

Initial measurement of the flowrate into the distribution box was attempted on both Sites 1 and 2 using a Bühler Montec xytec 7300 which is a wrap-around ultrasonic flowmeter. It consists of two ultrasonic transducers secured on opposite sides of a submerged pipe, connected to a microprocessor. This method was unsuccessful due to the sporadic nature of the flow entering the distribution box which resulted in very short duration pulses of low velocity flow in the pipe. It was decided to reduce the diameter of the submerged pipe from 110mm to 50mm in order to increase the flow velocities, thus increasing the signal available to the transducers. However, this did not have the desired affect as the meter took discrete readings at fixed time intervals and a different method of flow measurement was therefore undertaken.

On Sites 2, 3 and 4 it was possible to install an ultrasonic level detector (Milltronics ultrasonic probe with a Lascar EasyLog datalogger) in the sumps (Figure 4.3) downstream of the septic tank (Sites 2 and 3) or downstream of the secondary treatment unit (Site 4). The level detector, which was set to record the effluent level on a one second frequency, was attached to a collar that was cemented onto the sump roof, as shown in Figure 4.4.

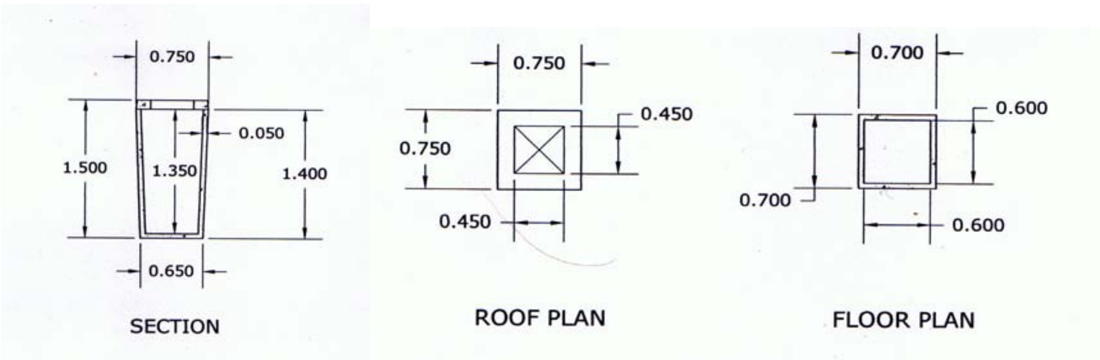


Figure 4.3 Plan of sump installed on Sites 2, 3 & 4.

Figure 4.4 Easylog ultrasonic level detector on Site 2.

The change in effluent level within the sump over any time step, and hence the volumetric flowrate of septic tank (or secondary treated) effluent, was calculated by obtaining the difference in volume calculated using the horizontal surface area of the effluent at any time T_1 and T_2:

At T_1 the horizontal surface area $\mathbf{E^2 = [0.65+2((D_0-D_1)*0.03)]^2}$

where, D_0 = distance from level sensor to base of sump
D_1 = distance from level sensor to effluent surface at T_1

at T_2 the horizontal surface area $\mathbf{F^2 = [E+2((D_1-D_2)*0.03)]^2}$

where, D_2 = distance from level sensor to effluent surface at T_2

Therefore,

$$\mathbf{dV/dT = [(F^2-E^2)\Delta D]/2}$$

where, dV/dT = increase in volume over any time step T_1- T_2.
$\Delta D = D_1-D_2$

The absence of such a sump on Site 1 required the investigation of alternative options. Contact was made with numerous flow meter manufacturers but no suitable device was found, with most manufacturers stating that the nature of the flow (pulse-like, low volume and high suspended solids content) did not lend itself to measurement by orthodox methods. It was therefore decided to install another ultrasonic level monitor (Omega LVU-90 ultrasonic level sensor and SL-L320 datalogger) to measure the septic tank effluent (STE) flowrate into the percolation area. The use of a level monitor required the installation of a pump sump to allow storage of a volume of STE (Figure 4.5). It was essential that this volume of effluent was large enough to allow accurate calculation of flowrate while at the same time small enough to minimise the affect on the natural flow profile of STE entering the percolation area. A further constraining factoring was that the sump also had to be of sufficient size to house the pump.

Figure 4.5 Septic tank effluent flow measurement on Site 1.

Unlike Sites 2, 3 and 4, the flowrate on Site 1 was calculated by measuring the volume of STE pumped each time the pump was triggered (4.5 litres) and using the level monitor to detect when each pumping event took place. To promote quiescent conditions within the sump for accurate level detection a 90° bend was attached to the influent pipe to act as a baffle. It was necessary to reduce the pipe diameter from 110mm to 50mm at the point of inflow due to the constricted space; this was done using a standard reducer with a funnel, with the stem removed, inserted to give a tapering effect thus avoiding deposition within the pipe. The volume for each pump event was checked every few weeks but remained constant throughout the trial period at 4.5 litres.

Weekly flow regimes were recorded by the respective dataloggers and downloaded to a laptop computer on site (Figure 4.4). While the favourable on-site systems with sumps at Sites 2, 3 and 4 allowed the compilation of flow profiles over the entire sampling periods, the problems experienced on Site 1 prevented this. As a result flow records, which commenced in February 2003, are only available for a six-month period. However, it is considered that this reduced data set (see Chapter 5) still gives a representative hydraulic loading regime for the site.

4.3 Percolation Trench Monitoring

4.3.1 Introduction

Nine 50 mm diameter pipes approximately 1 m in length were inserted into each percolation trench during construction (Section 3.2.2) to facilitate the installation of Soilmoisture Equipment Corporation suction lysimeters below the trench (Figure 3.5 (d) – (g)). These guide pipes were placed in groups of three at 10 m intervals (Figure 4.6). When installed, each trio consisted of different length lysimeters, 1.3 m (red), 1.6 m (blue) and 1.9 m (black), installed to different depths below the trench invert (Figure 4.7). Smaller lysimeters (25.4cm) were also placed directly under the invert of the percolation trench on Sites 1 and 2 using a combination of mechanical excavation and hand auger.

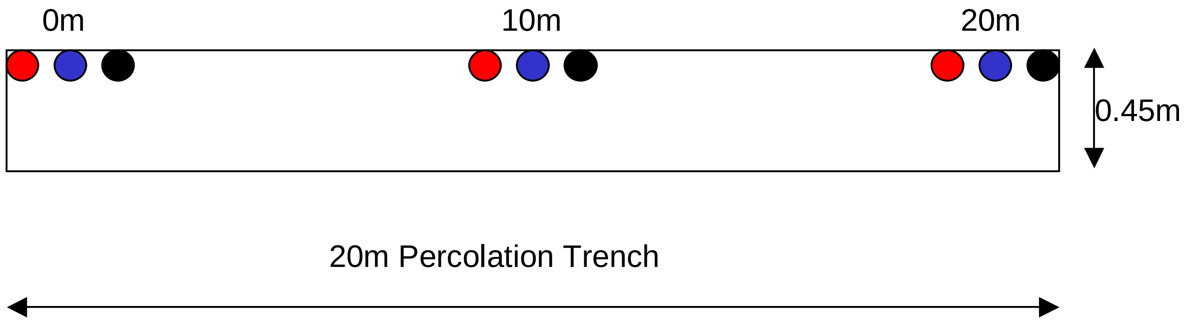


Figure 4.6 Plan view of single percolation trench with location of lysimeter guide tubes.

Three guide pipes, 1m in length, were installed at 0m, 10m and 20m along trenches 1, 2 and 4, respectively, at Site 1 and on trenches 4, 3 and 1, respectively, at Site 2 to facilitate the installation of nine Soil Measurement Systems tensiometers. On Sites 3 and 4 the tensiometers were split between the two percolation trenches. Each trio consisted of tensiometers of 1.0m (red), 1.5m (blue) and 2.0m (black) in length that were installed to different depths below the invert of the percolation trench. Each site also contained a rain gauge and rain sampler.

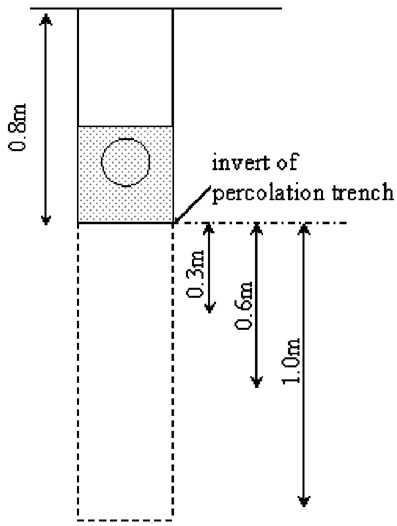


Figure 4.7 Cross-section and typical depths of instrumentation

4.3.2 Lysimeter Installation and Operation

Lysimeter Installation

Lysimeters (Figure 4.8) were used to collect moisture samples from the soil profile. They were installed to a desired depth and left in the soil for the duration of sampling, allowing periodic sampling to occur with minimal disturbance of the subsoil. The samplers consisted of a porous cup (48 mm OD) and sample collection tube (48 mm OD). The lid of the tube consists of a Santoprene stopper with neoprene tubing attached as an access tube for air evacuation and sample extraction. A vacuum is created within the lysimeter using a vacuum pump and moisture extracted from the soil matrix. To install the lysimeters on Sites 1 and 2 a screw/spiral auger of 40 mm diameter (Figure 4.8) was inserted through the guide tube to bore an initial hole to the desired depth. Table 4.2 shows the depth below the percolation trenches to which the lysimeters were installed. As the external diameter of the lysimeter tube was 48 mm, subsequent augering using a 45 mm diameter combination auger (Figure 4.8) was required to increase the bore of the access hole. The initial augering step was required as a screw auger is more robust than a combination auger and subsoil conditions, especially at Site 1 where an unsorted till was encountered, would have resulted in damage to the combination auger.

Figure 4.8 Percolation trench monitoring instrumentation and equipment required for its installation. From left of photograph: 2.0m tensiometer, 1.6m lysimeter, steel reinforcing bar, gouge auger, combination auger, screw auger, auger extension bar, auger handle and stilson wrenches.

While the subsoil conditions at Site 2 would have allowed the use of the combination auger alone this would have slowed the installation process due to its reduced capacity for subsoil removal compared to the screw auger. After each hole was bored the relevant lysimeter (1.3m, 1.6m or 1.9m) was inserted through the guide tube and pushed down to the base of the hole to ensure it fitted.

Distance	Colour	Site 1			
		Trench 1	Trench 2	Trench 3	Trench 4
0m	Red	0.24	0.32	0.49	0.37
	Blue	0.68	0.58	0.91	0.61
	Black	0.74	0.87	1.10	0.79
10m	Red	0.39	0.40	0.62	0.49
	Blue	0.75	0.83	1.08	0.85
	Black	1.10	1.05	1.34	1.17
20m	Red	0.41	0.41	0.6	0.33
	Blue	0.83	0.84	1.14	0.88
	Black	1.14	1.20	1.48	1.19

Distance	Colour	Site 2			
		Trench 1	Trench 2	Trench 3	Trench 4
0m	Red	-	0.25	0.16	0.40
	Blue	0.55	0.72	0.75	0.70
	Black	0.74	0.95	0.99	0.96
10m	Red	0.33	0.35	0.25	0.39
	Blue	0.72	0.77	0.53	0.56
	Black	1.06	1.03	0.94	1.00
20m	Red	0.47	0.30	0.23	0.40
	Blue	0.59	0.70	0.62	0.81
	Black	-	0.78	0.82	0.81

Distance	Colour	Site 3		Site 4	
		Trench 1	Trench 2	Trench 1	Trench 2
0m	Red	0.25	0.17	0.23	0.35
	Blue	0.62	0.44	0.50	0.52
	Black	0.92	0.82	0.96	1.11
10m	Red	0.28	0.24	0.13	0.23
	Blue	0.57	0.68	0.66	0.54
	Black	1.28	0.85	0.99	1.01
20m	Red	0.17	0.16	0.30	0.30
	Blue	0.81	0.47	0.56	0.63
	Black	0.95	0.78	0.88	0.97

Table 4.2 Lysimeter tip depth below percolation trench invert on Sites 1, 2, 3 and 4.

The presence of cobbles in the subsoil on Site 1 inhibited the insertion of some lysimeters and required the use of a steel reinforcing rod and lump hammer to remove the protruding obstructions. The use of an auger with a diameter slightly smaller than the external diameter of the lysimeter was intended to result in good contact between the porous cup and the subsoil matrix.

To maximise contact between the porous cup and the soil matrix the guide holes were partially backfilled with a soil slurry produced by mixing excavated soil, from which any gravel had been removed, with water. The lysimeter was then inserted through the guide tube and pushed into the slurry until the base of the hole was reached. Where the top of the guide tube was flush with, or below, ground level a conical trench was dug around it. The slurry was then poured into the conical trench and the void between the lysimeter and the guide tube also filled. The guide tube was then extracted. A bentonite slurry, consisting of bentonite powder, soil and water, was mixed and poured into the void between the lysimeter and the subsoil. This bentonite slurry was then tamped to ensure a good seal. Where the top guide tube protruded above the ground surface a circular bund was constructed which functioned in a similar manner to the conical trench. It was ensured that there was no depression present around the protruding lysimeters that would facilitate surface water ponding and possible ingress. Figure 4.9 illustrates the installation process.

Due to the gravelly nature of the subsoil on Sites 3 and dense nature of the subsoil on Site 4 it was not possible to install the lysimeters using the hand augers so a 65 mm diameter mechanical auger called a Minute Man was used (Figure 4.10). As a result the lysimeters were installed adjacent to, rather than in, the percolation trenches. The installation process only differed from that on Sites 1 and 2 by the virtue that no guide tubes were required.

(a)

(b)

(c)

(d)

(e)

(f)

Figure 4.9 (a) – (f) Lysimeter installation

Smaller lysimeters (25.4cm) were installed on Sites 1 and 2 directly under trenches 3 and 4 on both sites at distances of 2m, 7m and 15m along the trench length to monitor the development of the biomat along the trench base. To facilitate their installation a 1.0m deep hole was excavated between the trenches at each proposed sample point. The augers were then used to install the lysimeters at an acute angle to the horizontal. However, the installation of these lysimeters proved not to be entirely successful, only providing soil moisture samples over a short period of the sampling period.

Figure 4.10 Installation of lysimeters using the Minute Man.

Lysimeter Sampling

On the morning preceding sampling all lysimeters were put under a suction of 50 cbar using a vacuum-pressure hand pump. While a potential gradient is required to draw moisture from the soil matrix into the lysimeter, too great a suction would result in moisture, that would otherwise be unavailable to recharge due to the adhesive forces between the moisture and the soil matrix, being extracted. Soilmoisture Equipment Corporation advise that the practical limit for water flow in soils is about 65 cbar, although in some soils this value can approach 85 cbar. Thus the application of a suction of 50 cbar should have prevented the extraction of bound moisture. This suction was also recommended by Teagasc. On application of suction the neoprene tubing of the lysimeter was clamped with a plastic ring.

Sampling generally commenced at 08:30 with the clamps on all lysimeters being released and analysis commenced by 13:00, generally concluding by 18:00. The extraction kit for sampling consisted of the vacuum-pressure pump and a 1000 ml conical flask and rubber bung with an extraction tube attached (Figure 4.11). Two types of extraction tube were used:

(i) 2.4 mm O.D. plastic tube that was inserted into the neoprene tube and pushed down to bottom of the sampler

(ii) 6.4 mm O.D. plastic tube that was inserted into the sampler after the stopper was removed.

Figure 4.11 Lysimeter sample extraction kit.

To extract a sample, the vacuum pump was connected to the side arm of the conical flask and the extraction tube inserted into the lysimeter. The full sampling methodology is outlined in Appendix B. Initially sampling was carried out using the smaller diameter extraction tube but this was unsatisfactory as it regularly became kinked and over time these kinks punctured. These problems were overcome by using the larger diameter tubing. The total volume of sample collected in each lysimeter was recorded, samples collected in 70ml sterilised plastic sample tubes and numbered according to Figure 4.11. Samples from the septic tank were coded X while samples from the Puraflo® were coded Y.

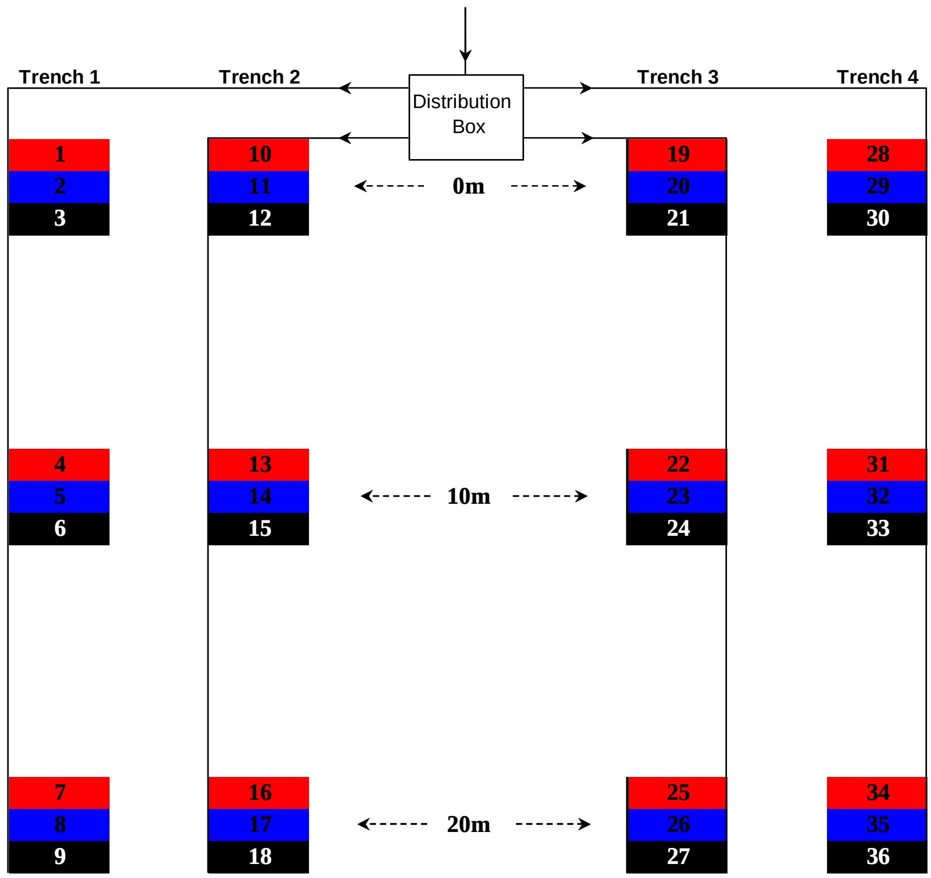


Figure 4.12 Labelling sequence for lysimeter samples.

4.3.3 Zero Tension Sampler Installation

As lysimeter samples were collected under suction it was decided that samples should also be collected at ambient pressure to ensure that the lysimeter samples were representative of the percolating effluent. To this end zero tension samplers were designed and two prototypes produced (Table 4.3). Two of these samplers, which consisted of galvanised steel tubes with pointed tips (Figure 4.13 (a)), were inserted under trench 4 on Sites 1 and 2, the smaller bore sampler at a distance of 2m and depth of 0.2m below the trench invert and the other at a distance of 7m and depth 1.2m below the trench invert. The protruding steel tubes were sealed with bentonite slurry and the top of the samplers covered to prevent infiltration. The samplers were installed at a 45° angle using the back-bucket of a mechanical excavator.

Sampler	Outside Dia.	Grid Length	Grid distance from tip	Gap Width	Bar Width
Small Bore	3.35cm	25cm	27cm	2mm	5mm
Large Bore	6.0cm	25cm	31cm	2mm	4mm

Table 4.3 Specifications of zero tension samplers.

A line was drawn on the sampler tubing from the slotted section to the top to ensure that the sampler did not twist during installation and that the slotted section remained facing the ground surface. However, during the course of the field studies no samples were obtained from the zero tension samplers and on extraction it was discovered that the gaps in the slotted section had been clogged by subsoil – most probably during the installation process (Figure 4.13 (b)).

(a) **(b)**

Figure 4.13 (a) Large and small bore zero tension samplers and (b) clogged large bore sampler.

4.3.4 Tensiometer Installation and Monitoring

Tensiometer Installation

Tensiometers measure the pressure potential or matrix potential of the soil, i.e. the force with which water is held in the soil. They are used to monitor the moisture status of the soil, and where installed at different depths, the pressure gradient within the soil profile. A tensiometer is basically a water-filled tube closed at the bottom with a porous ceramic cup and at the top with an airtight seal. Nine Soil Measurement Systems tensiometers (Figure 4.8), consisting of a 21.5 mm OD plastic tube with a 22.2 mm OD porous ceramic cup attached, were installed on Sites 1 and 2, three at 0m, three at 10m and three at 20m while six were installed on Sites 3 and 4, three at 0m and three at 20m (Figure 4.1). Each trio comprised tensiometers 1.0m (Red), 1.5m (Blue) and 2.0m (Black) in length. In order to obtain a profile of soil moisture tension across the percolation area each trio was installed on a different trench (Figure 4.1). The depths to which the tensiometers were installed are outlined in Tables 4.4 to 4.6. As with lysimeter installation, plastic guide tubes (32mm ID) were inserted into the percolation trenches during construction to facilitate tensiometer installation. Installation proceeded along the same steps as lysimeter installation except that a gouge auger of 30 mm diameter was used (Figure 4.8). Due to the nature of the subsoil on Sites 3 and 4 it was also necessary to install the tensiometers using the Minute Man. As was the case with the lysimeter this resulted in them being located adjacent to, rather than in, the percolation trenches.

Distance	Colour	Trench 1	Trench 2	Trench 3	Trench 4
0m	**Red**	0.07	N/A	N/A	N/A
	Blue	0.64	N/A	N/A	N/A
	Black	1.05	N/A	N/A	N/A
10m	**Red**	N/A	0.06	N/A	N/A
	Blue	N/A	0.63	N/A	N/A
	Black	N/A	1.07	N/A	N/A
20m	**Red**	N/A	N/A	N/A	0.17
	Blue	N/A	N/A	N/A	0.65
	Black	N/A	N/A	N/A	1.15

Table 4.4 Tensiometer tip depth below percolation trench invert on Site 1.

Distance	Colour	Trench 1	Trench 2	Trench 3	Trench 4
0m	**Red**	N/A	N/A	N/A	0.07
	Blue	N/A	N/A	N/A	0.47
	Black	N/A	N/A	N/A	0.60
10m	**Red**	N/A	N/A	0.49	N/A
	Blue	N/A	N/A	0.84	N/A
	Black	N/A	N/A	1.36	N/A
20m	**Red**	0.42	N/A	N/A	N/A
	Blue	**Broken**	N/A	N/A	N/A
	Black	1.29	N/A	N/A	N/A

Table 4.5 Tensiometer tip depth below percolation trench invert on Site 2.

Distance	Colour	Site 3		Site 4	
		Trench		Trench	
		1	2	1	2
0m	**Red**	0.10	N/A	0.08	N/A
	Blue	0.65	N/A	0.69	N/A
	Black	0.93	N/A	0.89	N/A
20m	**Red**	N/A	0.17	N/A	0.11
	Blue	N/A	0.72	N/A	0.70
	Black	N/A	0.97	N/A	0.94

Table 4.6 Tensiometer tip depth below percolation trench invert on Sites 3 and 4.

Tensiometer Monitoring

Once installed, the tensiometers were filled to within 12.5 mm of the top with de-aerated de-ionised water. A septum stopper, which allows measurement of the vacuum within the top of the tensiometer while maintaining an airtight seal, was then inserted in the top of each tensiometer. As UV light degrades the septum stoppers it was important that they were covered to protect them from exposure to sunlight. Tensiometers work by producing hydraulic continuity across the ceramic cup. Under unsaturated conditions the water in the tensiometer is drawn through the porous cup until the water potential in the tensiometer is the same as the soil water potential producing a vacuum under the septum stopper. In contrast, as the soil moisture content increases, water enters the tensiometer thus reducing the vacuum. The vacuum is measured, in mbar, using a tensimeter, which consists of a pressure transducer and attached needle that is inserted through the septum stopper (Figure 4.14). As the tensimeter measures the vacuum, the height (in cm) of the column of water in the tensiometer must be subtracted from the transducer reading to give the actual soil moisture tension. Under continuous unsaturated conditions it is necessary to periodically refill tensiometers with de-aerated de-ionised water.

Figure 4.14 Tensimeter monitoring soil moisture potential below a percolation trench. The tensiometer cover can be seen to the left of the tensimeter.

4.3.5 Stratified Sand filter Instrumentation

Samples of effluent were taken both within the stratified sand filter by means of gravity samplers and also beneath the sand filter by the installation of suction lysimeters.

The gravity samplers consisted of a 200 mm diameter funnel connected at the base to a 100 ml sampling container. A 6.4 mm O.D. plastic tube was sealed into the base of the sampling container from where it was fed horizontally out to the side of the sand filter and through the roof felt (to prevent the creation of any preferential pathways down through the filter media) and then up to the surface on the outside of the filter. The gravity samplers were positioned so that the funnel would intercept effluent coming from the three main sand layers (as shown on Figures 3.9 and 3.10(d)). Two gravity samplers per layer were installed to gain more representative results across each plane, as indicated on Figure 4.15.

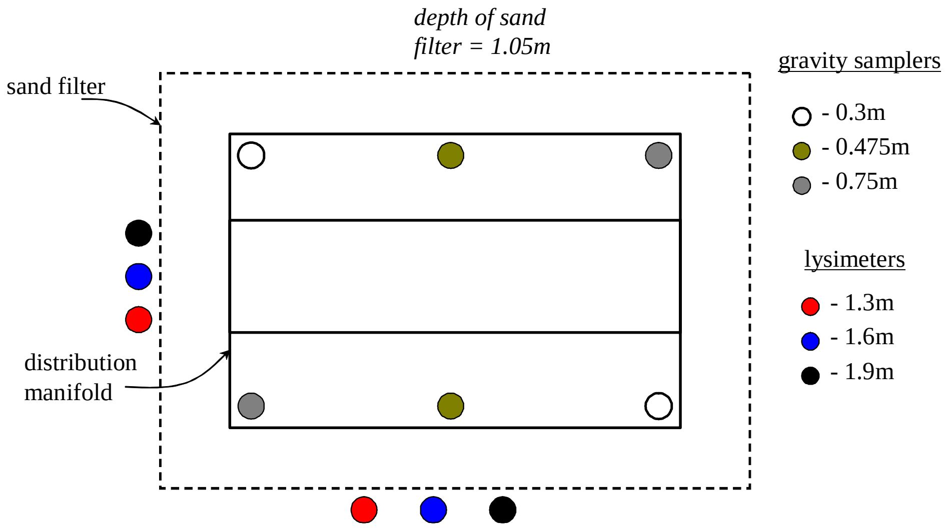


Figure 4.15 Plan view of filter indicating positions of sampling instrumentation (note : all depths expressed relative to ground level).

On the morning preceding sampling, all the gravity samplers were emptied using the vacuum-pressure hand pump as described in Section 4.3.2. The samples were then collected the next by the same method having percolated into the sample containers over the previous 24 hour period.

Six suction lysimeters were also installed adjacent to each sand filter, as shown on Figure 4.15. These were positioned on the lower ground level sides of the sand filters in order to be down gradient of any slight groundwater direction and followed the same red, blue and black depth profiles as for the trench samplers. Finally, a piezometer was also inserted into the middle of each sand filter in order to assess any depth of effluent surcharge in the base of each sand filter. This was achieved by a simple electric dipper which was fed down the inside of the piezometer until it contacted the water level.

4.3.6 Rain gauge and Rain Sampler Installation

Each site had a Casella® tipping bucket rain gauge installed (Figure 4.16). In general, when siting a rain gauge consideration must be given to the effects of shading from surrounding obstacles. A general rule of thumb is that no object should be closer than four times its height to the rain gauge so as not to impede data collection. However, with respect to this project these guidelines could be ignored as it was the precipitation falling on the percolation area rather than the areal precipitation that was of interest. The rain gauges were therefore located in the centre of the percolation areas. Each rain gauge was secured to a 45cm square concrete slab and levelled with the aid of the attached spirit level. The rain gauge funnel and inlet mesh were cleaned weekly and the data downloaded periodically. The rain sampler, which was located beside the rain gauge, consisted simply of a clean plastic container that was anchored to prevent its disturbance. Rainfall samples were collected and analysed for chloride concentrations.

(a) **(b)**

Figure 4.16 Casella® raingauge (a) with cover in place and (b) with cover removed exposing tipping bucket and internal datalogger.

4.4 Analysis Methodology

4.4.1 Chemical Analysis

All septic tank, Puraflo®, soil moisture and sand filter samples were analysed for nitrate (NO_3-N), nitrite (NO_2-N), ammonium (NH_4-N), chemical oxygen demand (COD), orthophosphate (PO_4-P) and chloride (Cl) using a Merck Spectoquant Nova 60® spectrophotometer and associated reagent kits which are USEPA approved.

If parameter concentrations were outside the detectable limit of the specified reagent kit it was possible to dilute the sample with a known volume of distilled water. However, it is important to note that where a sample was diluted, any error in the analysis would be multiplied by the size of the dilution step in the reported concentration. For example, if a 1:20 dilution was used this would mean that a small error in the analysis would result in a 20-fold increase in this error in the reported concentration.

During the sampling period four duplicate sets of samples, seven samples in each set, were sent to CAL Ltd, an accredited laboratory in Dún Laoghaire, as a quality control measure. The results obtained from the samples analysed by CAL were compared against those obtained in the college laboratory and as Figure 4.17 highlights, there was a good correlation between the two sets of data. However, it is important to also consider the slope of the line which should be equal to 1 but in this case is equal to 0.8. Closer examination of the data for the individual parameters, however, reveals an especially poor relationship between both sets of COD results (Table 4.7). This could be due to the delay in sample analysis by CAL.

It can also be seen from Table 4.7 that college laboratory analysis for NO_3 and Cl compares favourably with the results from CAL analysis for the same parameters. While there is a good correlation between both sets of results for NO_2, NH_4 and ortho-PO_4 analysis, the former tends to underestimate the CAL results while the latter two are overestimations. When the results of the two sets of analyses minus the COD results are compiled and compared it shows that, overall, there is a good correlation between the results of the analysis carried out in the college laboratories and those of the accredited laboratory (Figure 4.18).

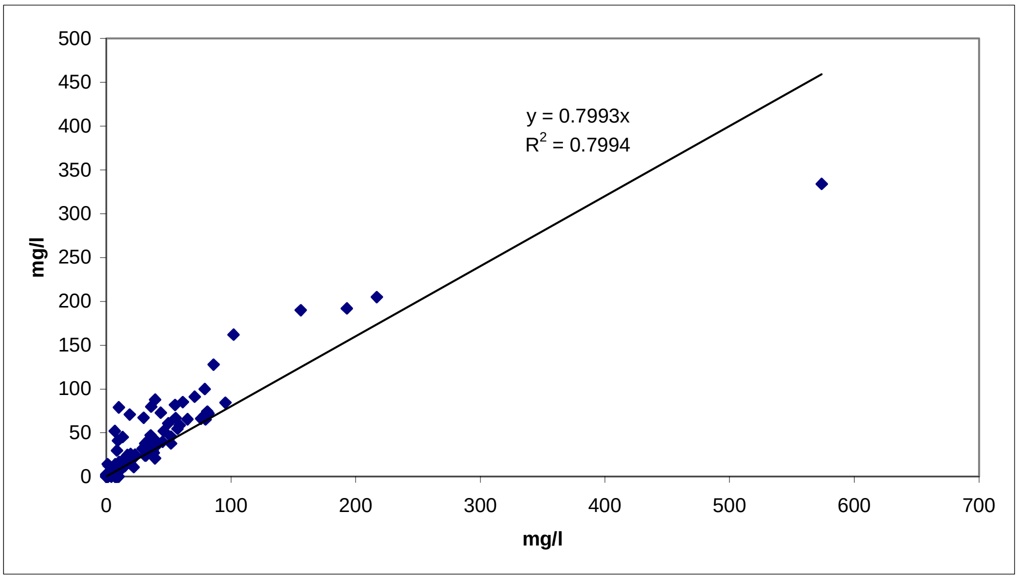


Figure 4.17 Graph of CAL results against TCD results for all parameters.

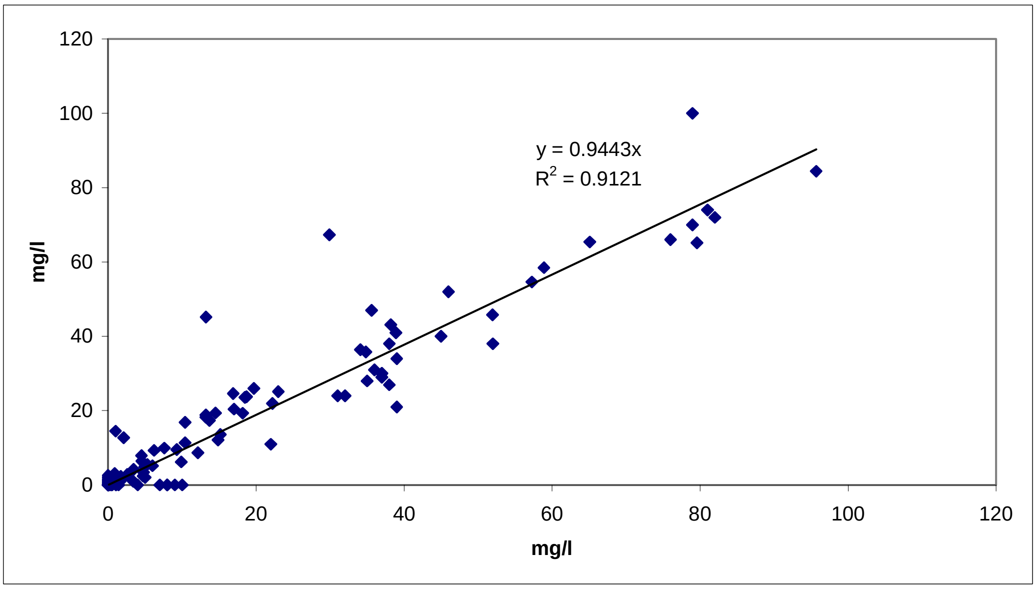


Figure 4.18 Graph of CAL results against TCD results for all parameters except COD.

Parameter	R^2	Slope
COD	0.62	0.77
NO_3-N	0.99	0.91
NO_2-N	0.98	0.80
NH_4-N	0.82	1.26
Ortho-P	0.84	1.36
Cl	0.92	0.89

Table 4.7 Results of comparison of CAL results against the college laboratory.

4.4.2 Bacteriological Analysis

The faeces of a healthy person contains between 1 to 1000 million of each of the following groups of bacteria per gram: enterobacteria (of which *Escherichia coli* is a member), enterococci (of which faecal streptococci is a member), lactobacilli, clostridia, bacteroides, bifidobacteria and eubacteria (Viessman and Hammer, 1998). During a disease event the number of pathogens in domestic effluent is a function of the number of carriers who excrete such organisms. As pathogenic bacteria are generally present in relatively small numbers compared to these indicator bacteria and as it is logistically impractical and prohibitively expensive to test water samples for all of the pathogenic bacteria potentially present, samples are assayed for those bacteria associated with faecal contamination under the premise that their presence is suggestive of the presence of human pathogens. Ideal indicator bacteria should have the following traits:

- They originate only in the digestive tract of humans and warm-blooded animals.
- They must be present when faecal contamination is present.
- They must be present in equal or greater numbers than the target pathogenic bacteria.
- Their survival outside the intestine must be longer than the target organism for which it is a surrogate.
- The indicator bacteria must not reproduce outside of the host organism.
- They must be easily, rapidly, reliably and inexpensively identified and enumerated.

- They must not in themselves be pathogenic.

(adapted from EPA, 2001, Metcalf and Eddy, 2003 and Mihelcic, 1999)

COLIFORMS

The term "total coliforms" refers to a large group of Gram-negative, rod-shaped bacteria that share several characteristics (Bartram and Ballance, 1996). The intestinal tract of humans contains a large population of these coliform bacteria and each person discharges from 100 to 400 billion of them per day (Metcalf and Eddy, 2003). While coliform bacteria are indicator organisms of faecal contamination and the possible presence of pathogens, there are some genera of the coliform group found in water and soil that grow and reproduce on organic matter outside the digestive system (Viessman and Hammer, 1998). Therefore the presence of total coliforms may or may not indicate faecal contamination and a more conclusive method of analysis is thus required.

The term "faecal coliform" is used in water microbiology to denote coliform organisms that grow at 44 or 44.5°C and ferment lactose to produce acid and gas (Bartram and Ballance, 1996). However, in practice some organisms that display these characteristics may not be of faecal origin giving rise to the more correct term "thermotolerant coliform" which is becoming more common. Nevertheless, the presence of thermotolerant coliforms nearly always indicates faecal contamination with usually more than 95% of thermotolerant coliforms isolated from water being *Escherichia coli* (Bartram and Ballance, 1996). *Escherichia coli* (*E. coli*) is a bacteria species exclusively of faecal origin (Mihelcic, 1999). Some *E. coli* are pathogenic causing diarrhoeal diseases in humans. The presence of *E. coli* in a water supply is proof faecal contamination has occurred and it is therefore a definite indication of the risk that enteric pathogens may be present (Standard Methods, 1998). Where *E. coli* are present in large numbers the inference is that heavy, recent pollution by human or animal wastes has occurred; if the *E. coli* numbers are low it is inferred that the pollution from the same source(s) is either less recent or less severe. If coliforms not including *E. coli* are observed the indication is that either the pollution is recent and non-faecal in origin or of remote, faecal origin such that the intestinal coliforms have not survived (EPA, 2001). The reliability of coliform bacteria to indicate the presence of pathogens in water depends on the persistence of the pathogens relative to coliforms. While the die-off rate for pathogenic bacteria is greater than coliforms outside the intestinal tract of humans viruses, protozoal cysts and helminth eggs are more persistent (Viessman and Hammer, 1998).

FAECAL STREPTOCOCCI

As the normal habitat of faecal streptococci is the gastrointestinal tract of humans and animals, their presence in water is also indicative of faecal contamination. While certain streptococci species predominate in some animal species and not in others it is not possible to differentiate the source of faecal contamination based on specification of faecal streptococci (Standard Methods, 1998). As faecal streptococci tend to persist longer in the environment than coliforms and are more resistant to drying it is possible to isolate faecal streptococci from contaminated water that contains few or no coliforms, e.g. where the sampling point is distant in either time or space from the source of contamination (Bartram and Ballance, 1996). It is also useful in clarifying the position of water which shows no *E. coli* but large numbers of coliform bacteria present. The enterococcus group is a subgroup of the faecal streptococci which, despite having some pathogenic properties, is a valuable bacterial indicator for determining the extent of faecal contamination (EPA, 2001 and Standard Methods, 1998). Intestinal enterococci, along with *E. coli,* has also now been chosen as the main indicator for the Bathing Water Directive due to the results of research by the USEPA which found better correlation between its presence and incidents of gastrointestinal illnesses resulting from swimming than the presence of total or faecal coliforms. Where in the past a faecal coliform to faecal streptococci ratio greater than 4 was considered indicative of human faecal contamination, Standard Methods (1998) contends that this ratio cannot be recommended to differentiate between human and animal sources of pollution.

Several sets of bacteriological analyses were carried also out at selected sampling points during the project. All samples were analysed by CAL for total coliforms and *E. coli*, with analysis also carried out for enterococci, faecal streptococci and faecal coliforms on some occasions.

5 ANALYSIS OF RESULTS OBTAINED FROM SITE 1

5.1 Introduction

A successful site assessment was completed for Site 1 on February 7th 2002. However, installation of the septic tank and the construction of the percolation area was delayed and was not completed until 29th May, when the site was commissioned, due to adverse weather conditions hampering site construction. Diversion works, which were required to separate the domestic wastewater effluent from the roof runoff, were also not fully completed until the 19th July. The installation of sampling equipment commenced on 11th June and all equipment was in place by 18th June. Sampling began at Site 1 on 8th August 2002 and continued until 15th July 2003.

5.2 Analysis of Flow Data

The nature of STE flow and the absence of a sump downstream of the septic tank created difficulties for the measurement of flow from the septic tank, as discussed in Section 4.2.2. These difficulties were finally overcome using a small sump with an ultrasonic level sensor and flow measurement commenced on 4th February 2003 (Appendix C).

The average flows on Site 1 can be seen on Table 5.1. The dwelling house and associated wastewater treatment system, having been constructed in the 1950s, consisted of a clay pipe network, for both surface and wastewater, and a single chamber septic tank with associated soakaway. While extensive separation works were carried out upstream of the septic tank during the installation of the septic tank and percolation area, suspicions still remained that some intrusion of surface water into the domestic wastewater network may have been occurring. Periodic inspection of the distribution box during the early stages of the project, prior to the commencement of flow measurement, had aroused the suspicion of surface water intrusion. It was discovered that the diversion works had overlooked a drain in the stable yard that was connected to the septic tank. This drain received a small volume of surface runoff which was a combination of rainfall and daily washings from the stables. However, while there appeared to be no firm correlation between rainfall and STE flow, as can be seen from Figure 5.1, chemical analyses of the STE revealed a fairly weak effluent compared to the other sites which may have been partly due to this contribution (Section 5.3.4).

	Maximum	Minimum	Average
Daily Flow	1228	109.3	418.8
Total Flow	N/A	N/A	400.0

Table 5.1 Septic tank effluent flows measured on Site 1.

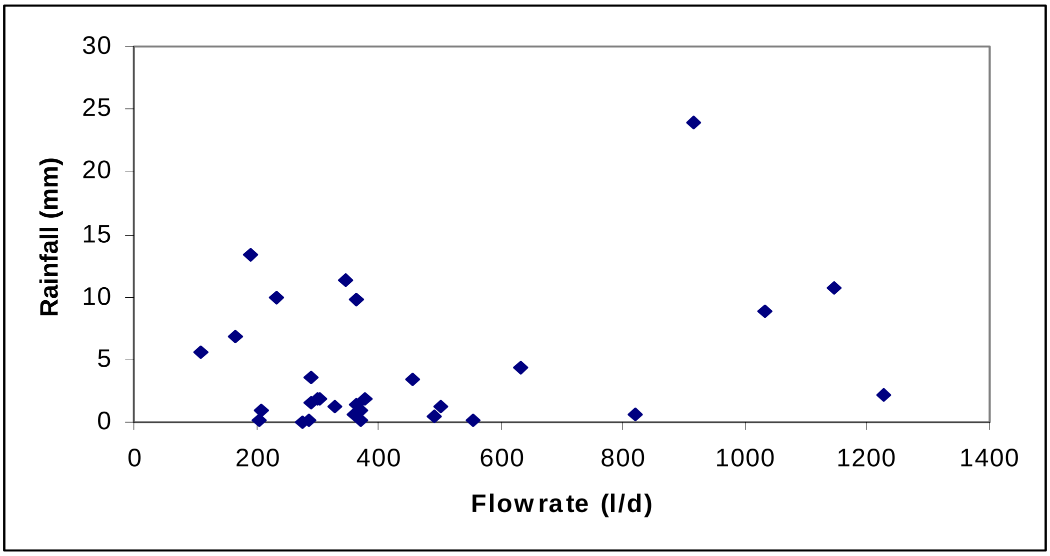


Figure 5.1 Graph of measured flow against rainfall on Site 1.

The average daily flow was recorded as 418.8 l/d which may include a small contribution from surface runoff, and therefore the actual daily average of domestic wastewater generation could be even less than this figure. This real flow rate gives a per capita consumption figure of 105 lcd on Site 1 which should be compared to the design figure of 180 lcd upon which the percolation area was designed based on the recommended loading rate of 25 l/m^{2}d.

The frequency distribution of the recorded flow rates shows that, over the 49 days for which complete daily flow records are available, 67% of the daily flows fall in the range 160 – 380 litres (Figure 5.2). The average flow over this range was 278.2 l/d. It should be noted that there was no prolonged period over the project duration when the dwelling on Site 1 was vacant.

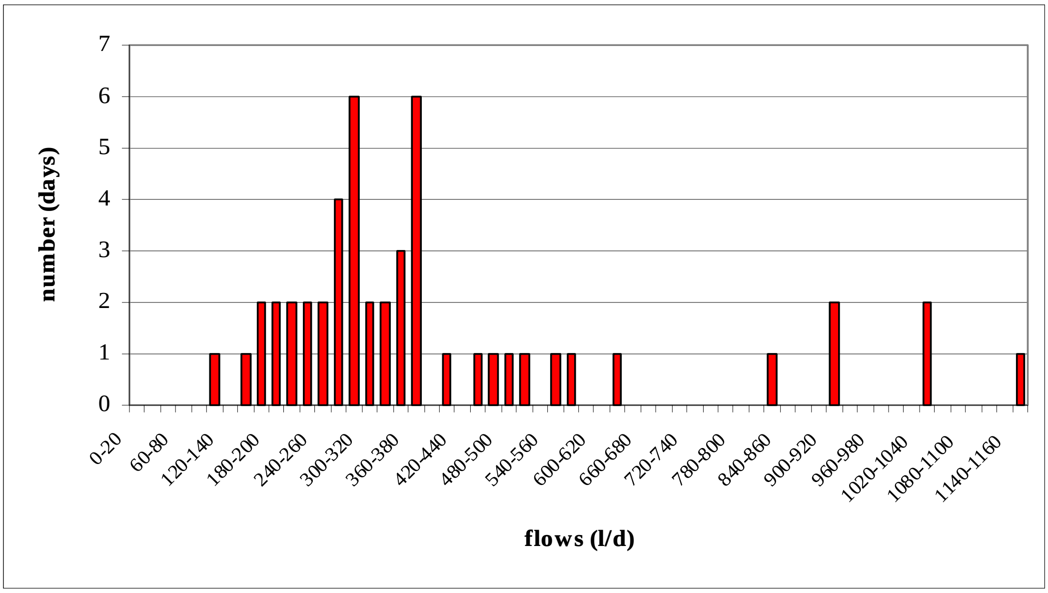


Figure 5.2 Frequency distribution of STE flow s recorded on Site 1.

To attain an even distribution between the four percolation trenches the design of the distribution box would have to take account of the influent flow regime. Analysis of the flow emanating from the septic tank on Site 1 showed that the average flow rate was less than 3.8 l/min for 90% of the monitoring period (Figure 5.3).

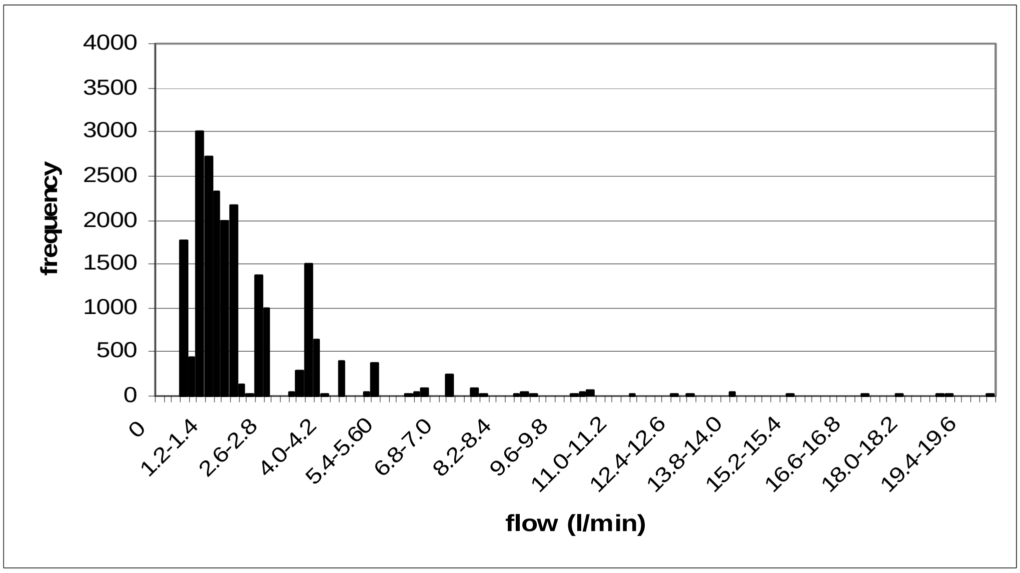


Figure 5.3 Frequency distribution (l/min) of flows recorded on Site 1.

While the modification to the distribution box has been shown, under laboratory conditions, to perform well over the range of flows measured it must be considered that, as STE was pumped from the monitoring sump to the distribution box, it is not a true representation of flowrate into the distribution box on this particular site. This is discussed further in Section 5.3.3.

5.3 Results of Analysis of Septic Tank and Soil Moisture Samples

5.3.1 Method of Analysis

As can be seen from Table 4.1(a) it was not possible to install all identically coloured lysimeters to similar depths and therefore, prior to analysis of the chemical and bacteriological results, reclassification of some lysimeters was required. To achieve this, 3 nominal depths of 0.2m (red), 0.55m (blue) and 0.9m (black) below the invert of the percolation trench, referred to as depth planes, were defined. The subsoil below the percolation trench was divided into 3 sections: 0 to 0.4m, 0.4 to 0.7m and 0.7 to 1.1m. The depth planes were chosen to represent the middle of these sections. The lysimeters were then reclassified, taking into account their location within the subsoil in relation to the invert of the percolation trench, and results reported citing the 3 depth planes. For example, the red lysimeter located at the 20m sample position on trench 4 was reclassified as a blue lysimeter.

As Cl does not take a significant part in any geochemical reactions (Marshall *et al*., 1999) the results of the soil moisture sample analyses for Cl were used to identify differences in loading rates within the percolation area and thus determine the most representative method of reporting the attenuation of the percolating effluent. As is the case with the presentation of all the results of chemical and bacteriological analysis of soil moisture samples, this method assumes homogeneous and isotropic subsoil properties and only takes account of matrix flow.

The results of the laboratory analysis for Cl at the three sample positions along each trench, i.e. 0m, 10m and 20m, were averaged over the depth plane on which they were recorded. This was then plotted over the research period to identify which of the following methods best represented the distribution of effluent within each percolation area:

(i) Planar Average: this method involved the averaging, over the four trenches, of the concentrations of each parameter over the depth plane on which it was measured and comparing the difference between average loading rates calculated for the different planes that is, 0.3m, 0.6m and 1.0m.

(ii) Depth Average: the average concentration, over the four trenches, of each parameter within each plane was calculated at the three different sample distances along the length of the trenches and the corresponding differences in concentration between the planes compared.

When the average Cl concentrations at the three sample positions on the red plane were graphed (Figure 5.4) it suggested that the planar average method was the more representative as little difference in the concentrations was observed between the three sample positions, except on the 08/01/03 where sample 10 had a measured concentration of 212mg/l (this was 2.4 times greater than the next highest Cl measurement and was therefore dismissed as egregious). Similarly when the average Cl concentrations measured at all sample positions (Figure 5.5) and the average planar Cl concentrations (Figure 5.6) are graphed it can be seen that the concentrations measured for the different sample depths are similar. Since the results of the T-test for Site 1 showed it to have a faster percolation rate than Site 2 it appears that the formation of a biomat, discussed in more detail in Section 5.3.3, facilitated the distribution of effluent along the full length of the percolation trenches.

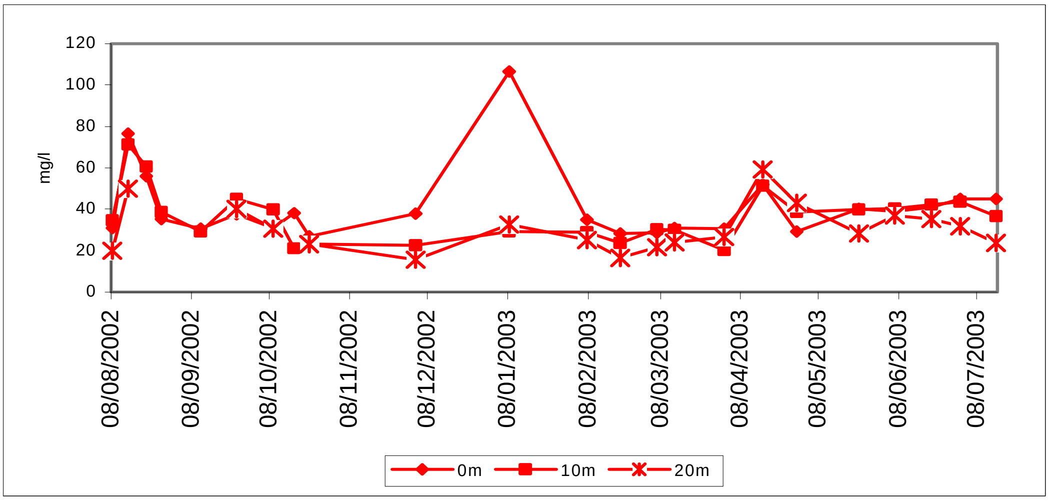


Figure 5.4 Average Cl concentrations measured on the red plane at the 3 sample positions.

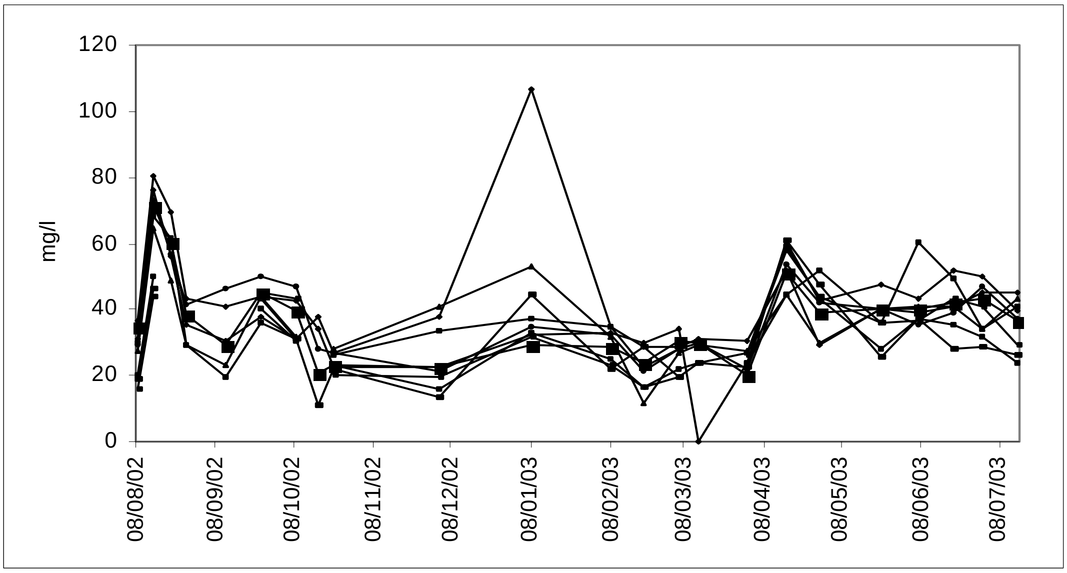


Figure 5.5 Average Cl concentrations measured for the 3 depth planes at the 3 sample positions.

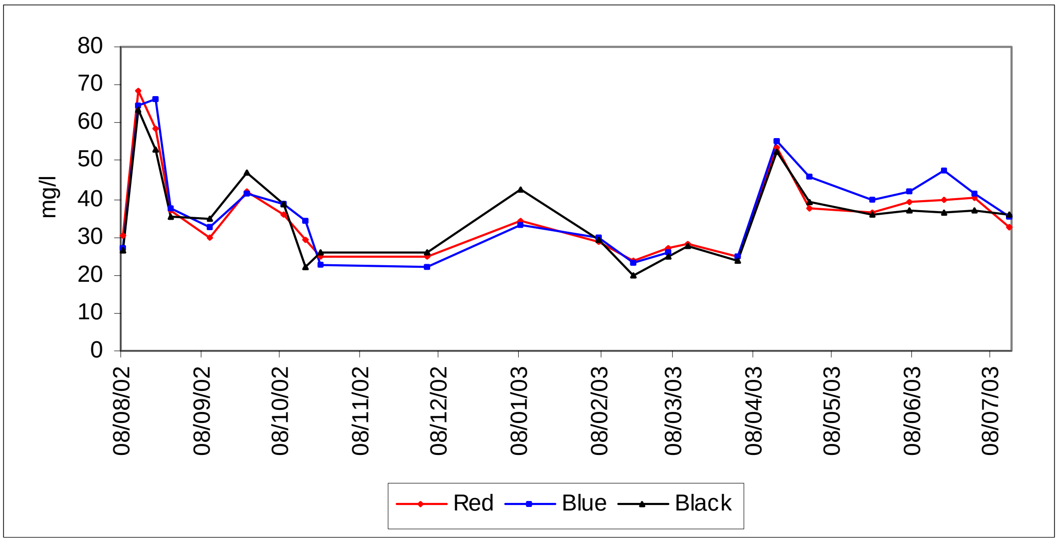


Figure 5.6 Planar average Cl concentrations.

A tracer study, which commenced on the 29th July, was carried out over an eight-day period to validate the findings of the Cl analysis. Sampling was carried out on three consecutive days and then there was a break of two days before the lysimeters were put under suction again to obtain the final sample. An aqueous solution of potassium bromide (KBr) was poured into each outlet pipe in the distribution box. Bromide (Br), like Cl, is an ideal tracer due to its negative charge and has been widely used to investigate water and contaminant transport in agricultural research scenarios (Smith & Davis, 1974; Flury & Papritz, 1993; Jabro *et al*., 1994; Kessavalou *et al.*, 1997; Schuh *et al.*, 1996; Kelly & Pomes, 1998; and Richards, 1999). It has an advantage over Cl of naturally low background concentrations in groundwater [<0.01 – 0.3g Br^- m^{-3}] (Flury & Papritz, 1993) whereas chloride is abundant in the natural environment. The results of the bromide tracer study (Appendix E) corroborated the results of the chloride analyses which revealed the presence of Br in samples taken from all sample positions along the trenches over an 8-day period. While Br was not recovered from all sample positions, it is possible that it arrived at these lysimeters on the days when sampling was not carried out. As can be seen from Table 5.2 the time of travel of the tracer from the distribution box to the individual sample points on the same depth plane varied. It must be considered that, due to the sampling regime, it is possible that the presence of Br in samples on day 8 was not the first incidence of Br at these sample points. The presence of Br on day 2 at the black lysimeter at the 20m sample position on Trench 4 is an isolated event and, as effluent was perceived not to have reached this sample position (Section 5.3.3), could be due to sample contamination.

Sample Position	Depth Plane	Trench			
		1	2	3	4
0m	**Red**	Broken	Day 2	Day 2	Day 2
	Blue	Day 8	Day 8	Day 2**	Day 2
	Black	None	Day 2	Day 3	Day 2
10m	**Red**	Day 2	Day 2	Day 2	Day 2
	Blue	Day 2	Day 2**	Day 2	Day 2
	Black	Day 2	None	Day 2	Day 2
20m	**Red**	Day 3*	Day 3	Day 8	None
	Blue	None	Day 3	Day 8	None**
	Black	Broken	Day 3	Day 2	Day 2

*** denotes lysimeter reclassified as blue; ** denotes lysimeter reclassified as black.**

Table 5.2 Time of first arrival of Br at sample points on Site 1.

During the project it became apparent that certain lysimeters were consistently providing relatively larger sample volumes than others. As can be seen from Table 5.3 average sample volumes obtained from sample points 16, 17, 18, 23, 24 and 33 were substantially larger than sample volumes obtained from the other sample points (a detailed record of sample volumes is contained in Appendix D). It is possible that the installation of these lysimeters, despite implementation of best practice, was not successful and that samples taken at these points were not representative of matrix flow but of preferential flow down the side of the lysimeters due to poor contact between the lysimeter and the subsoil. Analysis of Cl concentrations, due to the fact that Cl does not take a significant part in geochemical reactions, did not reveal any significant difference between the Cl concentrations recorded at these sample points and the other sample points (Table 5.4).

Sample Point	Average Volume	Sample Point	Average Volume	Sample Point	Average Volume	Sample Point	Average Volume
1	N/A	**10**	45	**19**	289	**28**	68
2	65	**11**	43	**20**	192	**29**	110
3	50	**12**	33	**21**	81	**30**	54
4	189	**13**	165	**22**	220	**31**	501
5	452	**14**	39	**23**	734	**32**	471
6	270	**15**	177	**24**	1022	**33**	891
7	279	**16**	841	**25**	391	**34**	111
8	474	**17**	953	**26**	486	**35**	279
9	N/A	**18**	1091	**27**	568	**36**	164

Table 5.3 Average soil moisture sample volumes obtained on Site 1.

Sample Point	Average conc.	Sample Point	Average conc.	Sample Point	Average conc.	Sample Point	Average conc.
1	N/A	**10**	33	**19**	41	**28**	45
2	42	**11**	33	**20**	37	**29**	37
3	39	**12**	36	**21**	36	**30**	37
4	34	**13**	38	**22**	40	**31**	40
5	40	**14**	37	**23**	45	**32**	42
6	38	**15**	36	**24**	44	**33**	45
7	25	**16**	40	**25**	32	**34**	16
8	27	**17**	45	**26**	32	**35**	17
9	N/A	**18**	44	**27**	31	**36**	19

Table 5.4 Average Cl concentrations (mg/l) measured under percolation area on Site 1.

However, analysis of NH_4 for the different sample points did indicate significant differences. Table 5.5 shows that soil moisture samples obtained from these sample points and analysed for NH_4 had a much higher concentration than samples obtained from the other lysimeters. When the reduction in Cl concentration between the STE, which has an average Cl concentration of 57mg/l, and these sample points is considered, i.e. the effect of dilution, the average STE NH_4-N concentration (52.9mg/l) and soil moisture NH_4 concentrations for these sample points are very similar (Table 5.6). Allied to this is the fact that when these lysimeters were removed from the subsoil their bases were dripping with STE and covered by a black biofilm (Figure 5.7) which suggested that they had been submerged in STE. No biofilm was present on the other lysimeters.

Sample Point	Average conc.	Sample Point	Average conc.	Sample Point	Average conc.	Sample Point	Average conc.
1	N/A	**10**	2.5	**19**	20.1	**28**	1.0
2	7.5	**11**	5.3	**20**	3.5	**29**	1.2
3	8.2	**12**	1.6	**21**	1.7	**30**	1.6
4	14.3	**13**	6.8	**22**	22.6	**31**	27.7
5	28.1	**14**	2.6	**23**	39.3	**32**	22.2
6	19.9	**15**	0.9	**24**	35.3	**33**	30.3
7	4.8	**16**	31.76	**25**	11.6	**34**	2.6
8	4.8	**17**	32.3	**26**	9.1	**35**	3.4
9	N/A	**18**	33.4	**27**	9.5	**36**	5.0

Table 5.5 Average NH_4-N concentrations (mg/l) under the percolation area on Site 1.

Sample Point	Concentration (mg/l)		
	Cl	**NH_4-N**	**Adjusted NH_4-N**
X	57	52.9	N/A
16	40	31.7	45.3
17	45	32.3	40.9
18	44	33.4	43.4
23	45	39.3	49.8
24	44	35.3	45.9
33	45	30.3	38.3

Table 5.6 Comparison of STE NH_4-N concentration soil moisture NH_4-N concentrations adjusted for dilution.

Figure 5.7 (a) and (b) Biofilm build-up on preferential flow lysimeters.

For these reasons it was assumed that initial installation of these lysimeters had been unsuccessful and that preferential flowpaths had been created between the invert of the percolation trench and the lysimeter cups. Data from these sample points were therefore excluded from further chemical and biological analysis.

As can be seen from Table 5.4, soil moisture samples 4, 5, 6, 19, 22, 31 and 32 also had high average NH_4 concentrations although these lysimeters did not produce corresponding high sample volumes. On removal, lysimeters 5, 22, 31 and 32 were covered by a black biofilm suggesting that the installation of these lysimeters was also unsuccessful. When the NH_4 concentration for these sample points was graphed against that of sample point 33 they were shown to be very similar (Figure 5.7). This data, as it was not considered to be representative of matrix flow conditions, was therefore excluded from further analysis. Data from points 4, 6 and 19 was not excluded, however, as when NH_4 concentrations measured at these points was graphed against NH_4 concentrations at point 33 it was observed that, after an initial period of similarity, concentrations at points 4, 6 and 19 dropped off (Figure 5.8). It should also be noted that these lysimeters, on removal, were not covered by a biofilm. It is possible, therefore, that while initial installation of these lysimeters might not have been successful any preferential flowpaths created during their installation were blocked over time by fines, biomat formation, or colloidal matter within the effluent. This is reflected in Figure 5.10 which shows the reduction in sample volume obtained from these points with time.

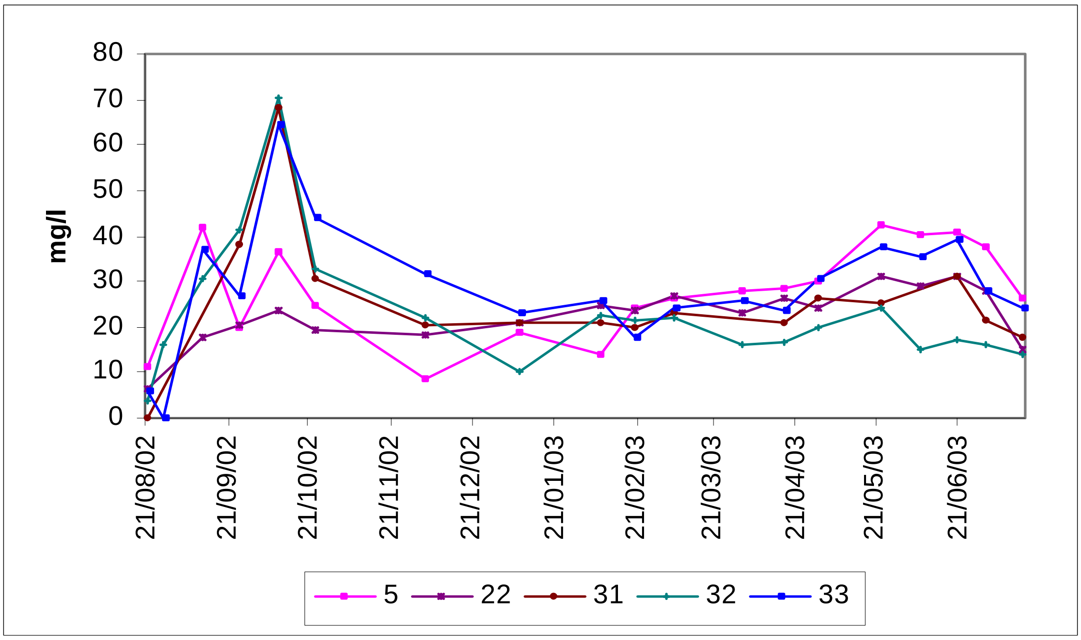


Figure 5.7 NH_4-N concentrations measured at sample points 5, 22, 31, 32 and 33.

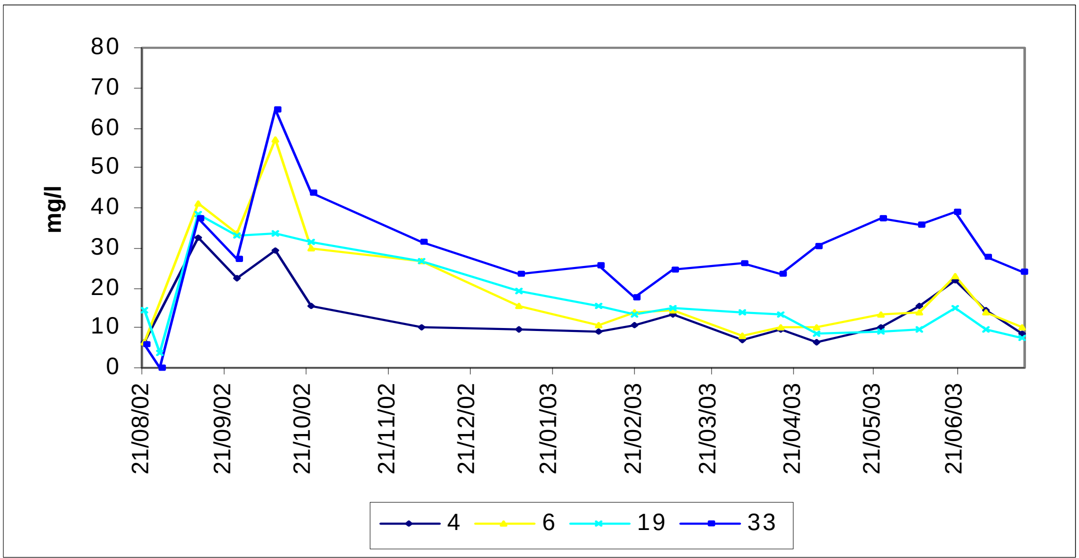


Figure 5.8 NH_4-N concentrations measured at sample points 4, 6, 19 and 33.

Therefore, from a total of 36 lysimeters installed it was necessary to omit data obtained from 10. As two lysimeters were broken during installation this left a total of 24: 7 on the red plane, 6 on the blue plane and 11 on the black depth plane.

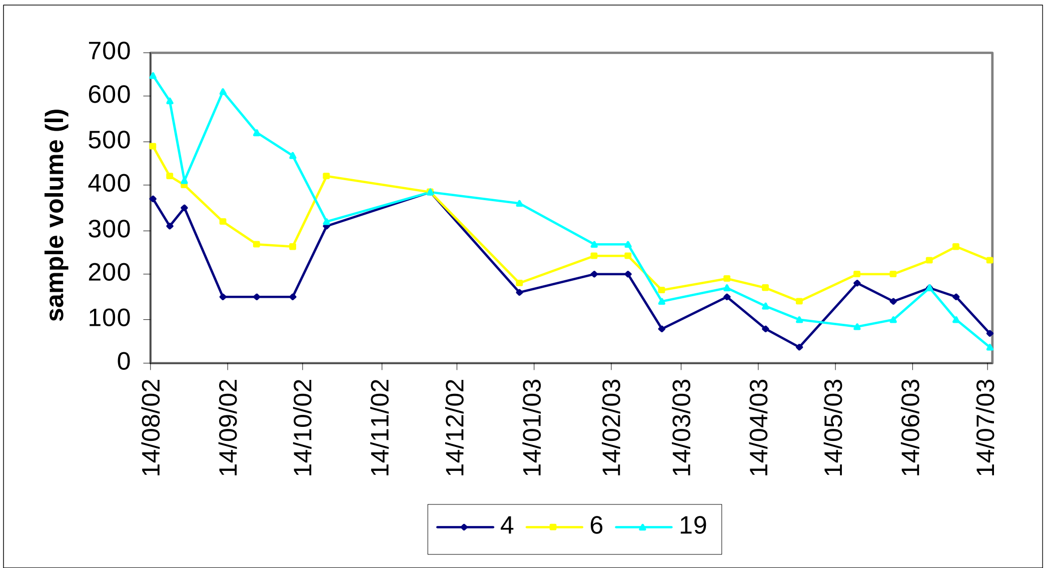


Figure 5.9 Sample volumes measured at points 4, 6 and 19.

5.3.2 The Affect of Dilution on Effluent Attenuation

While the attenuation of the percolating effluent is mostly the result of physical, chemical and biological processes within the subsoil, the effects of dilution must also be considered. The rainfall available for dilution at the depth planes over the project duration, or effective rainfall, was calculated using rainfall figures obtained on site and evapotranspiration figures calculated using data from a meteorological station at Pollardstown Fen, 3.5 km from Site 1 (Appendix F). A model developed by Bartley (2004) based on the FAO Penman-Monteith method (FAO, 1998) of potential evapotranspiration (PET) calculation was used to calculate actual evapotranspiration (AET) (Appendix F). Where SMD was greater than 40 the AET was considered to occur at a slower rate than PET and was therefore calculated using the Aslyng scale:

$$AET = PET\ (120 - SMD^*)/(120 - 40)\ mm$$

where,

SMD* is the accumulated soil moisture deficit at the beginning of each period.

where SMD > 40 it must be updated to SMD*

SMD = SMD* + (AET – RF)

RF = total rainfall (mm) for the period

(Keane, 2001)

Daily effective rainfall, or recharge, was then calculated by subtracting the daily AET and accumulated SMD figures from the daily rainfall measurement (mm).

As the project commenced in August, when a SMD generally exists, it was necessary to determine this SMD at the start of the project to enable the calculation of effective rainfall over the project duration. As SMD is an accumulative number, it was necessary to use historical meteorological data from the weather station at Pollardstown Fen to calculate the SMD at the start of the project. Ideally SMD calculations should start in January, when there is generally no SMD, however due to technical problems experienced at the weather station in early 2002, records only began in March. As meteorological data obtained from the Met Éireann weather station at Casement Aerodrome shows no SMD for the months of January and February it was therefore assumed that the SMD at the beginning of March was at a minimum and any error would be rectified in subsequent calculations where effective rainfall exceeded SMD. Using this method it was found that, for a recorded rainfall of 852.8mm for the period 01/08/02 to 15/07/03, the effective rainfall was 385.5mm.

Potential evapotranspiration was also calculated using the Hargreaves method (Equation 5.1) which is applicable where only limited meteorological data is available (FAO, 1998).

$$PET = 0.0023(T_{mean}+17.8)(T_{max}-T_{min})^{0.5}R_a \qquad \text{(Equation 5.1)}$$

where,

$R_a = 187.013G_{sc}d_r(\omega_s\sin(\varphi)\sin(\delta)+\cos(\varphi)\cos(\delta)\sin(\omega_s))$ [mm]

G_{sc} = solar constant = 0.0820 [$MJm^{-2}min^{-1}$]

d_r = inverse relative distance Earth-Sun

ω_s = sunset hour angle [rad]

φ = latitude [rad]

δ = solar declination [rad]

(FAO, 1998)

The Hargreaves effective rainfall value calculated for Site 1 was 372.5mm. As can be seen in Figures 5.10 and 5.11, dilution of the effluent was greatest during the period of sustained effective rainfall between November 2002 and March 2003. As Cl does not take a significant part in geochemical reactions it is probable that the reduction in Cl concentration between the septic tank and the red plane, during periods of no effective rainfall, is due to the removal of colloidal matter by the combined straining action of the subsoil and associated biomat.

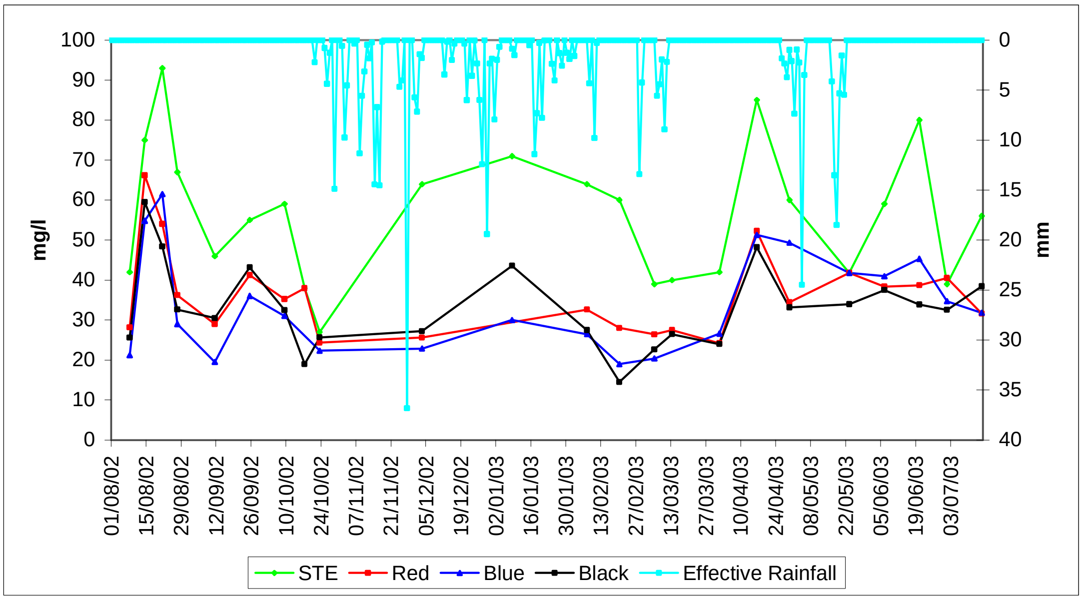


Figure 5.10 The effect of dilution by effective rainfall, calculated by the Penman-Monteith method, on Cl concentrations.

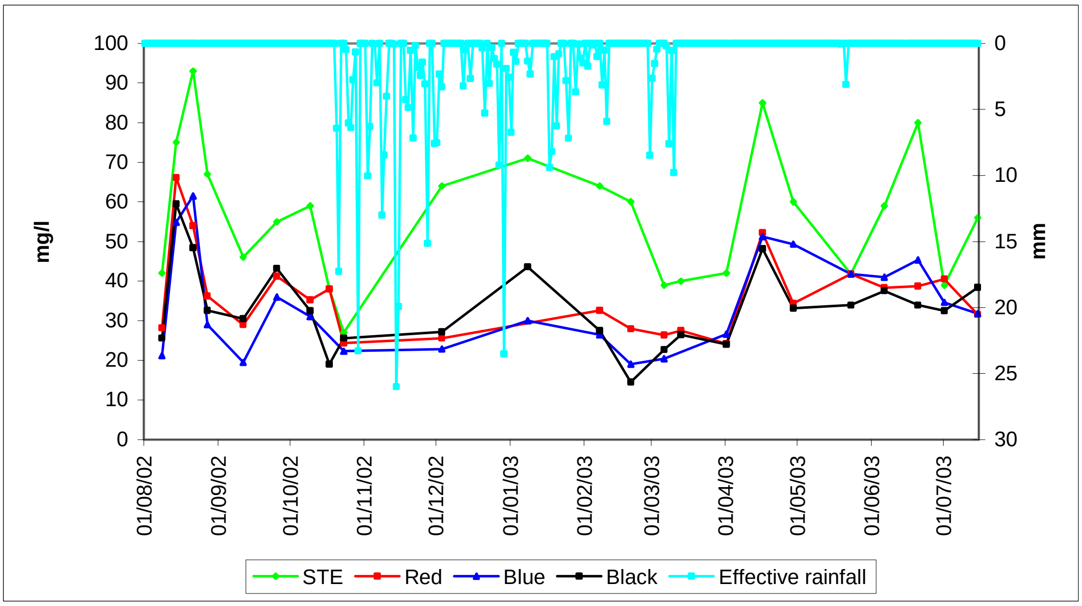


Figure 5.11 The effect of dilution by effective rainfall, calculated by the Hargreaves method, on Cl concentrations.

The Cl concentrations were used as the basis to quantify the contribution of effective rainfall to effluent dilution (Table 5.7). However, as can be seen from Table 5.4, average Cl concentrations at sample points 7, 8, 34, 35 and 36 are lower than average Cl concentrations measured at the other sample points. This is due to the time it takes for the biomat to develop along the entire length of the percolation trench (dealt with in more detail in Section 5.3.3). For this reason all concentrations measured at points 7 and 8 were excluded until 01/04/03 while all concentrations measured at points 34, 35 and 36 were excluded completely. While sample points 25, 26 and 27 are also located at the 20m sample position they provided no sample until 23/10/02. It was found that, on average, a 39.6%, 41.6% and 42.9% reduction in Cl concentration was recorded between the STE and the red, blue and black planes respectively. When the average Cl concentration for rainfall on Site 1 of 3.9mg/l is taken into account this equates to the addition of 0.79 litres, 0.91 litres and 1.02 litres of effective rainfall to every litre of effluent on the red, blue and black depth planes respectively. However, this reduction in Cl concentration is not entirely due to dilution as it also results from the effects of physical straining on the percolating effluent. This effect was quantified by examining the reduction in Cl concentration between the septic tank and red depth plane between 08/08/02 and 17/10/02 when the contribution of effective rainfall was zero.

Date	% reduction in concentration			Equivalent contribution of effective rainfall (l)		
	Red Plane	Blue Plane	Black Plane	Red Plane	Blue Plane	Black Plane
08/08/02	24.76	29.37	33.67	0.38	0.48	0.59
21/08/02	41.94	33.87	47.98	0.78	0.55	1.00
27/08/02	45.90	56.72	51.53	0.95	1.51	1.20
11/09/02	36.96	57.61	33.70	0.68	1.70	0.58
25/09/02	25.00	34.55	21.45	0.37	0.59	0.30
09/10/02	38.42	47.46	42.56	0.70	1.03	0.84
17/10/02	N/A	N/A	50.00	N/A	N/A	1.26
03/12/02	57.03	55.47	52.26	1.55	1.44	1.25
08/01/03	45.92	48.83	42.25	0.94	1.07	0.81
07/02/03	49.06	45.83	57.01	1.09	0.95	1.24
20/02/03	53.33	60.42	75.83	1.33	1.83	4.29
06/03/02	25.64	47.69	27.47	0.40	1.13	0.44
13/03/03	31.25	N/A	33.75	0.53	N/A	0.60
01/04/03	42.38	36.67	42.86	0.88	0.68	0.90
16/04/03	38.53	39.71	43.33	0.68	0.71	0.83
29/04/03	42.67	17.78	44.72	0.84	0.23	0.92
23/05/03	N/A	18.80	N/A	N/A	0.26	N/A
06/06/03	34.97	30.55	36.41	0.60	0.49	0.64
20/06/03	46.25	43.33	57.61	0.95	0.84	1.19
15/07/03	32.14	43.21	31.38	0.53	0.87	0.51
Average	**39.6**	**41.6**	**42.9**	**0.79**	**0.91**	**1.02**

Table 5.7 Reduction of Cl concentration with depth.

It was found that, over this period, an average reduction in Cl concentration of 27.1% was recorded. This is similar to the reduction of 22.6% measured for STE sample filtration on Sites 3 and 4 (Table 7.3). When this was done it was found that the effect of dilution was equivalent, on average, to the addition of 0.25 l/l (or 20.1% reduction in concentration) for the red depth plane, 0.32 l/l (or a 24.2% reduction in concentration) for the blue depth plane and 0.38 l/l (or 28.3% reduction in concentration) for the black depth plane. Using the average daily flow of 418.8 litres (Table 5.1) this equates to an average daily effective rainfall contribution of 104.7 litres, 134.0 litres and 159.1 litres to the red, blue and black depth planes respectively.

When the average effective rainfall contribution for the red plane is calculated for the year it is found to be 38.22m^3. By dividing this by the effective rainfall calculated by the Penman-Monteith method it was possible to estimate that the zone of contribution of effective rainfall was approximately 99.1m^2. Therefore, taking the trench width of 0.45m and an average trench length of 20m this equates to a zone of contribution of approximately 0.4m on all sides of each trench. When the same calculations are carried out for the blue plane and black planes it was found that the zone of contribution was slightly greater and appeared to extend in the region of 0.6 to 0.8m on all sides of each percolation trench. This would be due to the dispersion of the effluent plume below each percolation trench. For these calculations it was assumed that the effluent was evenly distributed over the entire base of Trenches 1 to 3, as was the case for the periods of greatest effective rainfall, but that it was only distributed over 10m of Trench 4.

As effluent on Trench 4 had not reached the 20m sample position it can be seen from Figure 5.12 that the variation in soil moisture tension is a result of varying contribution of effective rainfall over the monitoring period. Figures 5.13 and 5.14, which present the effective rainfall and soil moisture tension records for the 0m and 10m sample points respectively, show that the tensiometer readings are affected more by the percolating effluent that the contribution of effective rainfall.

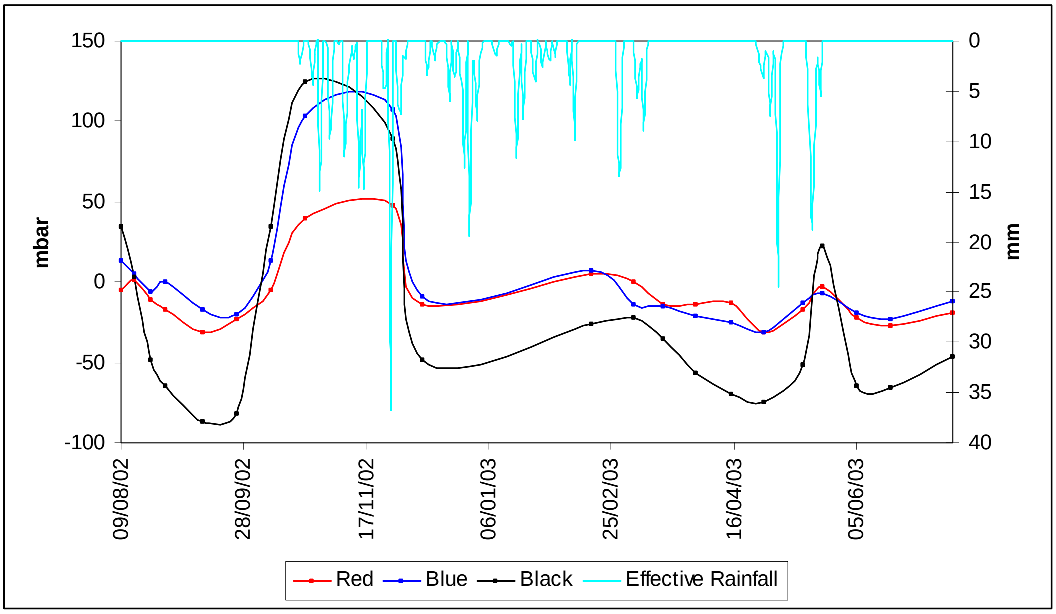


Figure 5.12 Soil moisture tension plotted against effective rainfall for the 20m sample position on Site 1.

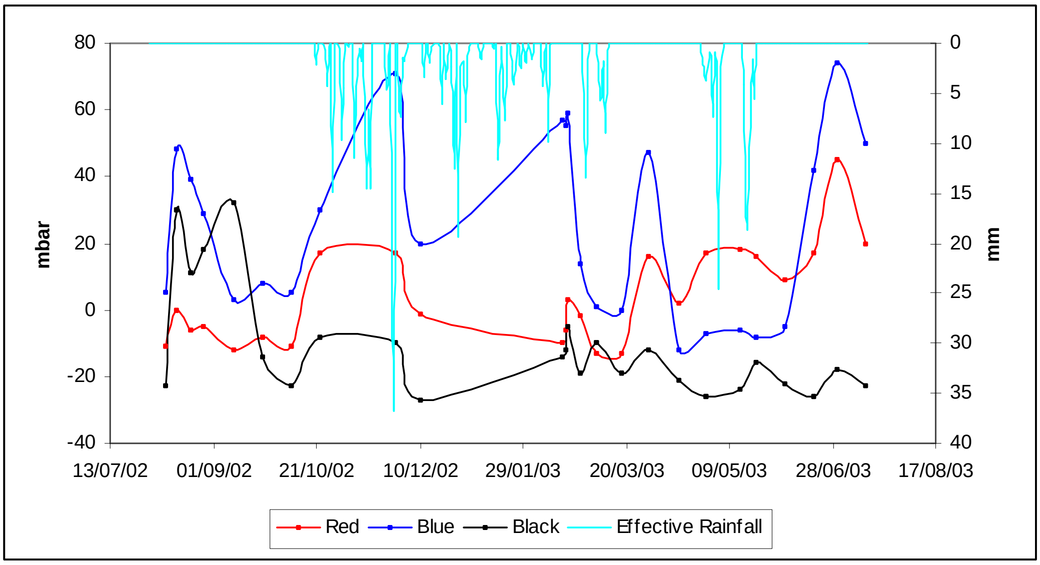


Figure 5.13 Soil moisture tension plotted against effective rainfall for the 0m sample position on Site 1.

This appears to corroborate the evidence of the dilution calculations which show that it is physical, chemical and biological processes rather than dilution that are the more prominent attenuation processes operating in the subsoil. It appears in Figure 5.14 that the red and blue tensiometers at the 10m sampling position were under saturated conditions throughout the monitoring period as a result of preferential flow of effluent from the percolation trench. This was corroborated by the presence of a black biofilm, similar to that seen on the lysimeters (Section 5.3.1), seen on those tensiometers upon removal.

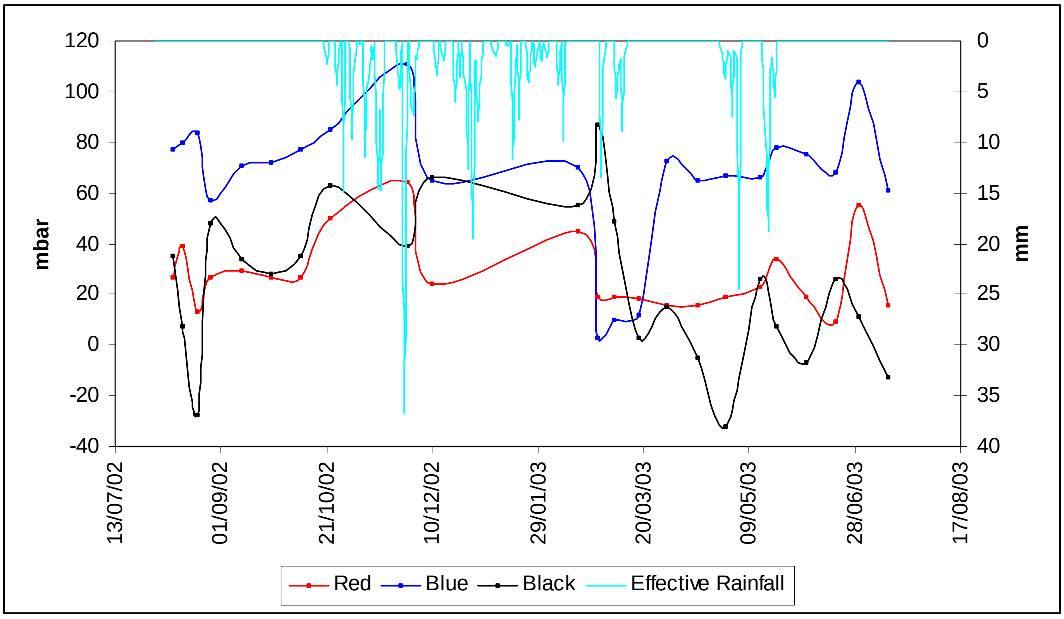


Figure 5.14 Soil moisture tension plotted against effective rainfall for the 10m sample position on Site 1.

5.3.3 Biomat Formation

As outlined in Section 5.3.1, Cl analysis of the soil moisture samples from Site 1 revealed that STE had been distributed along the entire length of the percolation trenches. This would suggest that the organic load of the STE facilitated the formation of a biomat along the effluent subsoil interface thereby promoting distribution along the base of the percolation trench. The presence of elevated Cl levels at the 10m sample position throughout the project suggests that at the commencement of monitoring the biomat had already developed between the 0m and 10m sample positions. This was due to the time lag between site commissioning, 29th May, and the commencement of monitoring, 8th August.

As revealed by the results of the Cl analysis, the presence of effluent was not recorded at the 20m sample position until 25/09/02 and this on Trench 3 only (Figure 5.15). While sample points 16, 17 and 18 were excluded from chemical analysis due to the presence of preferential flowpaths it is worth noting that, when Cl concentrations only are examined, the behaviour of the biomat in Trench 2 mirrored that in Trench 3. As the presence of effluent was not recorded at the 20m sample position on Trench 1 until 01/04/03 and was never recorded at the 20m sample position in Trench 4 during the project, it is clear that the rate of biomat progression was not constant for all trenches. It is possible that the progression of the biomat along Trenches 1 and 4 was slower due to a smaller hydraulic load on these trenches compared to that on Trenches 2 and 3. As the STE was pumped to the distribution box to facilitate flow measurement it is possible that the adjustment to the distribution box, i.e. the addition of the V-notch weirs, while improving distribution, did not equally distribute the effluent between the four outlets but favoured the back two at the relatively high flow rates on each pump event.

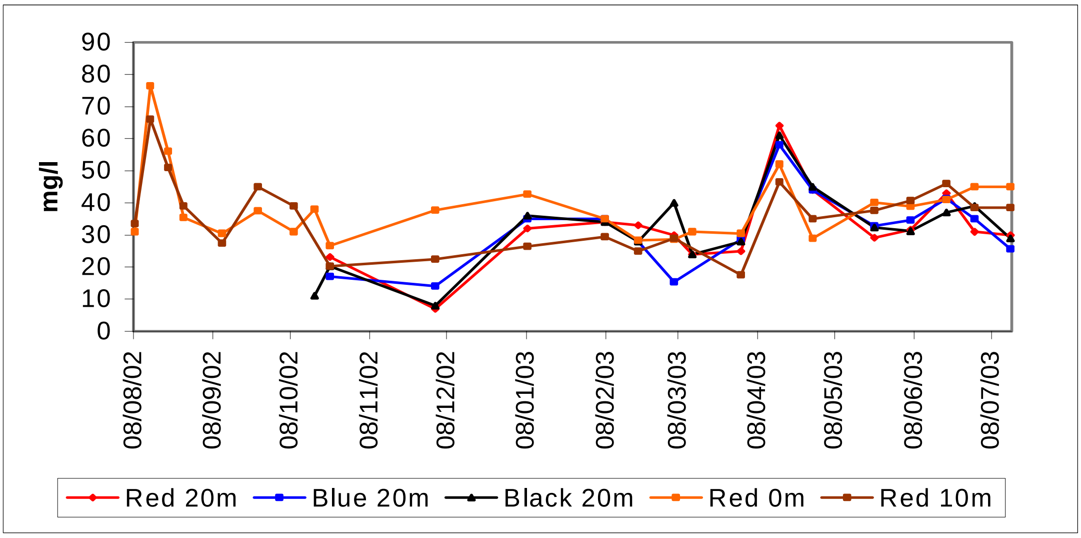


Figure 5.15 Using Cl concentrations to highlight biomat progression.

5.3.4 Results of Chemical Analysis

The results of all chemical analysis carried out on STE and soil moisture samples obtained from Site 1 are contained in Appendix D. While parameter concentrations were measured in the laboratory it was decided that results should also be reported as loading rates in an attempt to quantify the load of a particular parameter in the percolating effluent. To this end the concentrations were multiplied by the daily average flow, for STE concentrations, or the sum of the daily average flow and the contribution of effective rainfall, for soil moisture samples, to give a loading rate (g/d).

Table 5.8 summarises the results relating to the STE. As a result of the anaerobic environment of the septic tank the dominant form of inorganic nitrogen is NH_4. While STE concentrations are similar to those outlined in the Literature Review it can be seen that, overall, the average concentrations in the STE on Site 1 are much lower than those measured on Site 2. This could be due to surface water infiltration as outlined in Section 5.2 which, therefore, could be expected to contribute to the variation in STE concentration throughout the year. However, it must also be considered that, as the house on Site 1 was constructed in the 1950s, many of the water using domestic appliances, such as toilet cisterns, baths, sinks etc. would be of much larger volume than more contemporary designs, thereby also contributing to weaker effluent concentrations.

	Concentration (mg/l)					
	COD	**NO_3-N**	**NO_2-N**	**NH_4-N**	**PO_4-P**	**Cl**
Maximum	638.0	3.4	0.23	72.8	54.8	93.0
Minimum	188.0	0.0	0.08	20.3	5.2	27.0
Average	**383.4**	**0.7**	**0.16**	**53.0**	**14.2**	**56.6**

Table 5.8 Summary of chemical analysis of STE on Site 1.

The characteristics of the STE varied over the sampling period. This is especially apparent for COD and NH_4, and hence total inorganic nitrogen, concentrations. It appears from Figures 5.16 and 5.17 that rainfall events have had an influence on the quality of the STE. While there are periods where the correlation between rainfall volume and STE concentration appears to be stronger than others, it must also be considered that there was a contribution from surface water runoff, other than rainfall. The reduction in COD concentration between 09/10/02 and 23/05/03 corresponds to the period of greatest activity within the stables and therefore the period over which it would be expected to have the greatest contribution of surface runoff, other than rainfall.

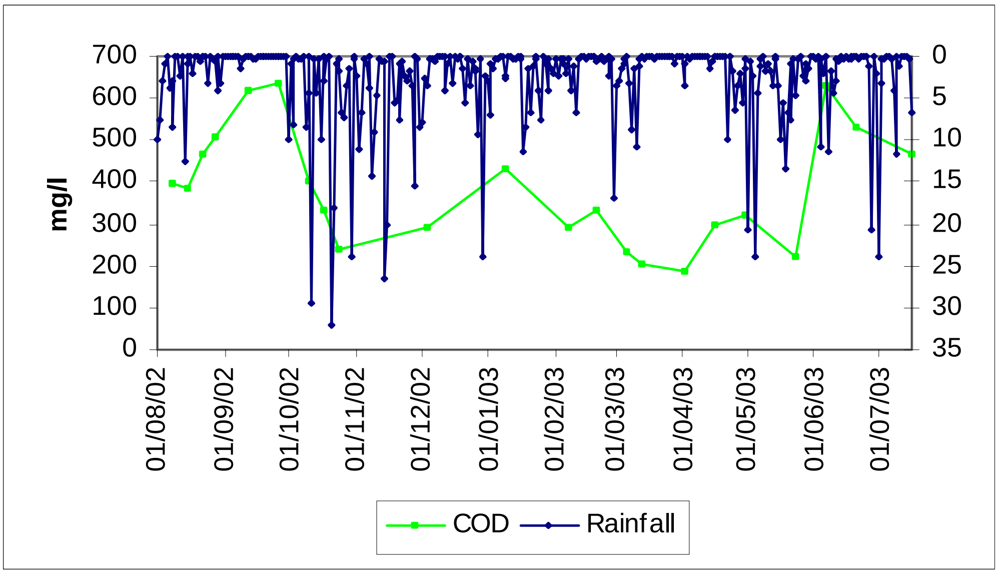


Figure 5.16 The effect of rainfall on STE COD concentration over the sampling period.

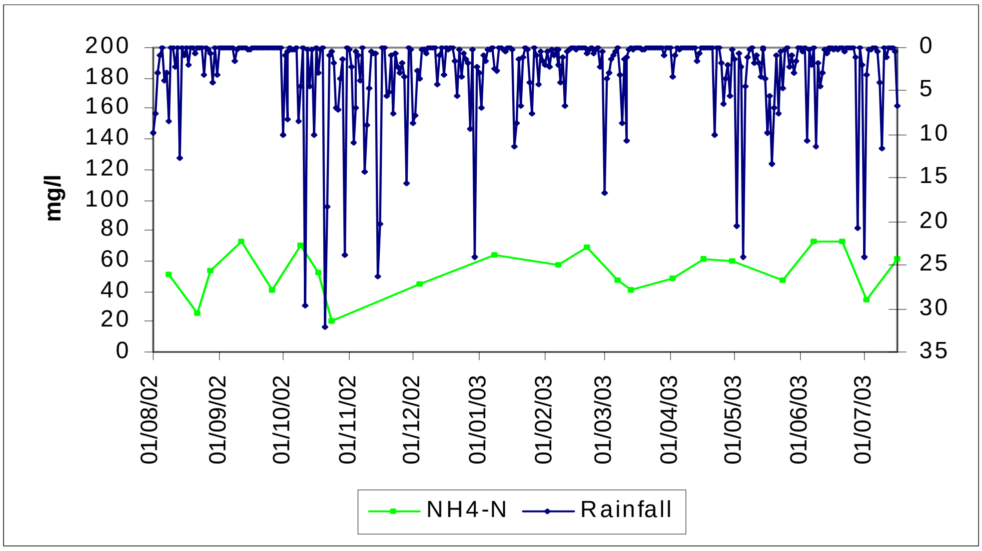


Figure 5.17 The effect of rainfall on STE NH_4-N concentration over the sampling period.

COD

It is clear from Figure 5.18 and Table 5.9 that the greatest reduction in effluent COD load and concentration occurs above the red depth plane. The COD concentration measured on the red, blue and black sample planes is very similar to the COD concentration measured at point 34, which did not receive STE (Section 5.3.3), suggesting that COD concentration had been reduced to background levels. It also appears that the attenuation performance of the subsoil is not affected by the varying organic load of the STE. When Figure 5.19 is examined it can be seen that the concentration at sample point 16, while greater than that for the red sample plane at 20m, is significantly lower than the STE Cl concentration. As sample point 16 has been shown not to be representative of matrix flow, and is receiving effluent from preferential pathways, it appears that the reduction in COD concentration above the red depth plane is probably due to aerobic processes within the percolation trenches. The oxygen demand required to achieve this reduction, 305.4 mg/ld or 0.2 kg/d on average, is present within the distribution gravel in the percolation trench, which is aerated along its full length by means of a ventilation pipe. There is 17.2 m^3 of gravel in the percolation area, 4.3 m^3 in each trench, which has an approximate porosity of 50% providing 8.6 m^3, or 10.32 kg, of air space. Since air is 21% O_2 this means that there is 2.17 kg, of oxygen available in the distribution gravel. When the volume of air contained in the percolation pipe is included this increases to 2.22 kg O_2 which is regarded as more than sufficient to maintain the concentration gradient across the biofilm and to sustain aerobic processes (Boller *et al.*, 1993). Further reduction in COD concentration within the subsoil and incorporated biomat would result from a combination of further biological degradation, adsorption and physical straining.

	Concentration (mg/l)	**Load**	
		(g/d)	**Removal (g/d)**
STE	383.4	160.6	-
Red Depth Plane	78.0	40.8	119.8
Blue Depth Plane	77.7	42.9	-2.1
Black Depth Plane	56.5	32.7	10.2

Table 5.9 Reduction in COD load attributed to the specific treatment steps.

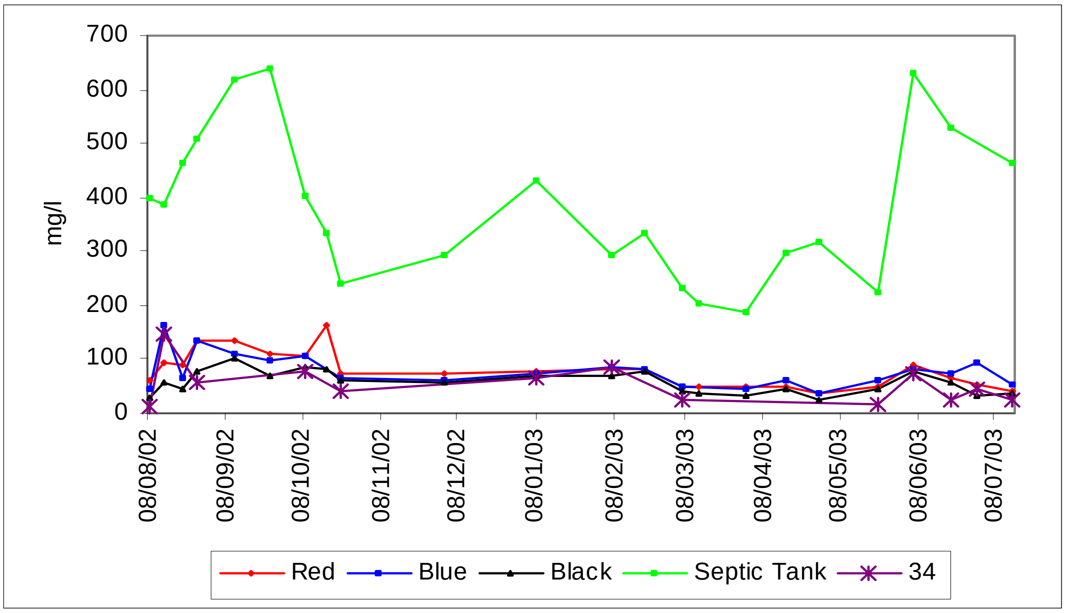


Figure 5.18 Reduction in COD concentration on Site 1.

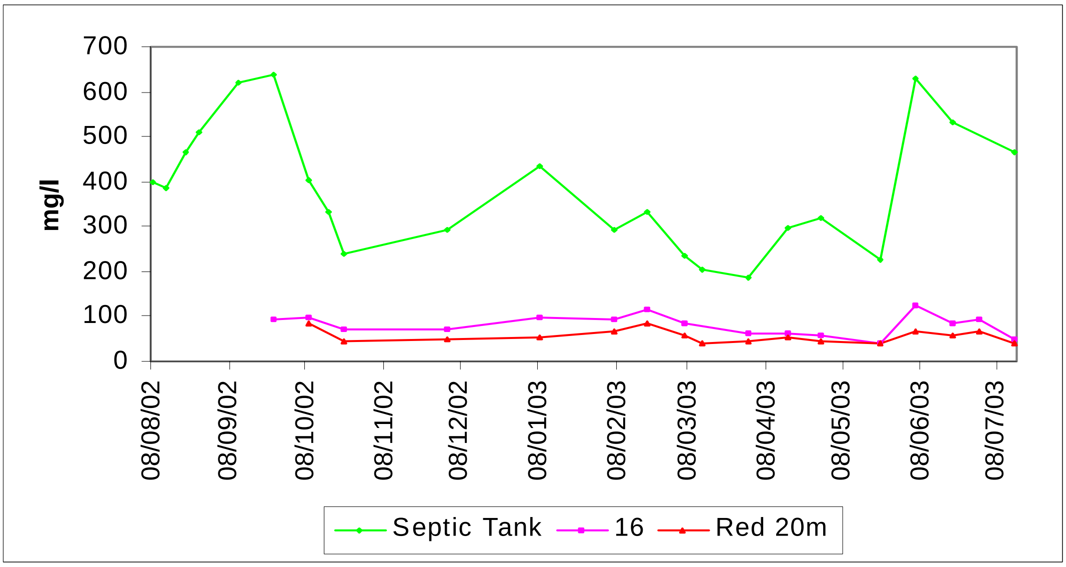


Figure 5.19 Comparison of COD concentrations measured in the STE with those measured at sample point 16 and on the red depth plane at the 20m sample position.

NITROGEN

Similarly, it was found that the greatest reduction in inorganic nitrogen loading was recorded above the red depth plane (Table 5.9). However, unlike COD, it appears that this reduction is a result of chemical and biological processes within the subsoil matrix between the invert of the percolation trench and the red depth plane, rather than processes within the distribution gravel. If Table 5.5 is revisited it can be seen that the NH_4 concentration measured at the preferential sample points is significantly greater than that measured at the corresponding sample points in the other trenches which are monitoring matrix flow. While there is a decrease in NH_4 concentration of the percolating effluent with depth, the corresponding increase in NO_3 concentration is not sufficient to account for this reduction (Table 5.10 and Figures 5.20 and 5.21). It should be noted that the increase in NO_3 concentrations in the subsoil from April 2003 corresponds with a period of minimal effective rainfall (Figures 5.10 and 5.11). This would suggest that the main nitrogen removal mechanism in the subsoil is nitrification followed by denitrification. There is a sufficient organic load in the STE to support this process. The hydraulic load on the system throughout the year probably promoted localised saturated conditions that facilitated denitrification of nitrified NH_4. The reduction in the hydraulic load from April 2003, due to the absence of effective rainfall, would have reduced saturated conditions thereby reducing the effect of denitrification which would in turn lead to higher NO_3 concentrations in the percolating effluent.

	NO_3-N		**NO_2-N**		**NH_4-N**		**Total N**	
	Conc. (mg/l)	**Load (g/d)**	**Conc. (mg/l)**	**Load (g/d)**	**Conc. (mg/l)**	**Load (g/d)**	**Conc. (mg/l)**	**Load (g/d)**
STE	0.7	0.3	0.2	0.1	53.0	22.2	54.0	22.6
Red	4.1	2.1	0.2	0.1	9.9	6.5	14.5	8.8
Blue	6.8	3.8	0.3	0.2	5.1	2.8	12.0	6.6
Black	6.7	3.9	0.2	0.1	5.8	3.4	12.8	7.4

Table 5.10 Average concentration and loading rate of NO_3-N, NO_2-N, NH_4-N and Total inorganic N measured in the STE and at the three depth planes.

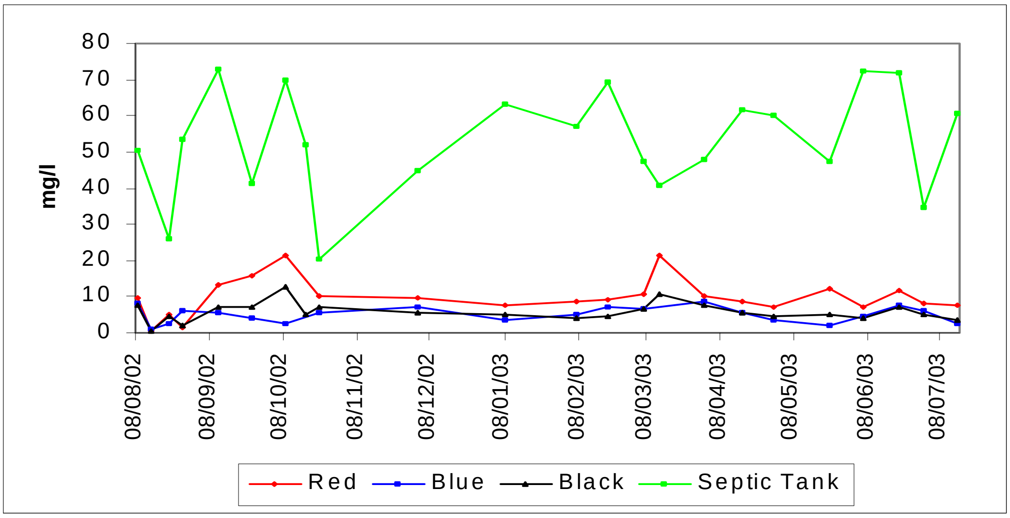


Figure 5.20 NH_4-N concentrations measured on Site 1.

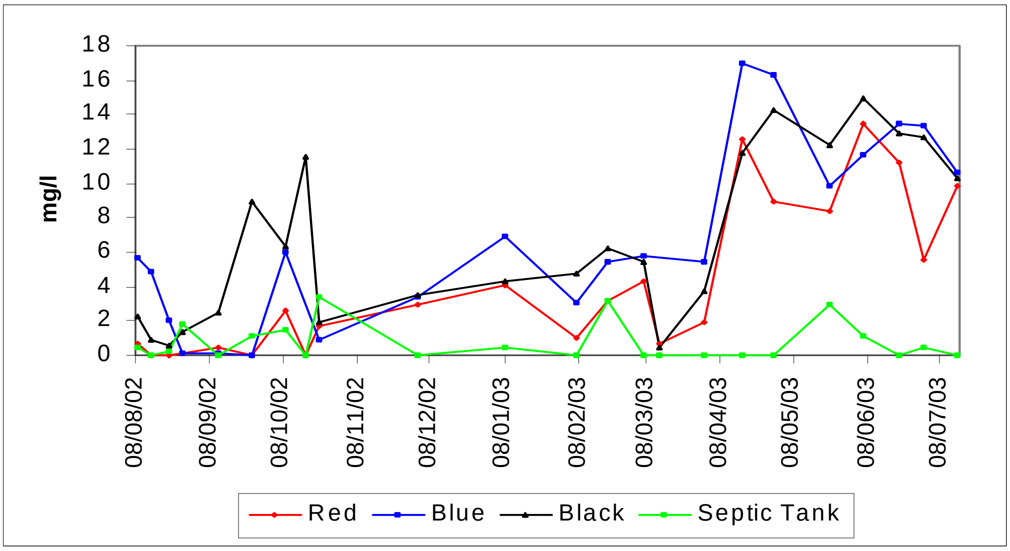


Figure 5.21 NO_3-N concentrations measured on Site 1.

As the formation of a biomat along the base of the trenches would lead to increased biological activity, it is also possible that some of this reduction in inorganic nitrogen is due to biological uptake. Microbes metabolise carbonaceous materials for synthesis of organic compounds and also to obtain energy. However, they must also obtain sufficient nitrogen to synthesise nitrogen-containing cellular components such as amino acids, enzymes and DNA. On average, therefore, soil microbes must incorporate into their cells about one part of nitrogen for every eight parts of carbon (Brady and Weil, 2002).

PHOSPHOROUS

Removal of phosphorous from the percolating effluent is controlled by soil adsorption and mineral precipitation. The ability of a soil to fix phosphorous is dependent, not only on its clay content, but also on the presence of Al, Fe, or Mn in acidic soils, either as dissolved ions, as oxides or as hydrous oxides, and the presence of Ca in alkaline soils. The disparity between the ortho-PO_4 concentration of the STE analysed on 09/10/02 and the samples analysed on other dates suggests that an error occurred during sample analysis and it was therefore omitted from further analysis. As outlined earlier the ortho-PO_4 concentration of the STE varied throughout the year. The high clay content of the subsoil below the percolation area on Site 1, revealed by the particle size analysis contained in Appendix A, suggests that the removal of phosphate from the percolating effluent is controlled by soil adsorption. The large specific surface of clay particles, their generally platy shapes allied with the iron, aluminium and hydrous oxides coating the subsoil clay minerals and magnesium-hydroxy clusters on the weathered surfaces of ferromagnesium minerals provide excellent sorption sites. As was the case with COD and inorganic nitrogen reduction, it can be seen from Table 5.11 and Figure 5.22 that the greatest reduction in effluent ortho-PO_4 concentration and load occurs above the red depth plane. It is important to note, however, that any given soil only has a limited capacity to fix phosphorous. While it appears that the fixation capacity of the subsoil above the red depth plane has not yet been exhausted, it must be considered that this project was only carried out over a 12-month period and therefore, in time, the subsoil below this depth plane may become the dominant zone of ortho-PO_4 fixation.

	Concentration	**Load**	
	(mg/l)	**(g/d)**	**Removal (g/d)**
STE	12.2	5.9	-
Red Depth Plane	2.2	1.2	4.7
Blue Depth Plane	1.2	0.7	0.5
Black Depth Plane	1.0	0.6	0.1

Table 5.11 Reduction in ortho-PO_4-P attributed to the specific treatment steps.

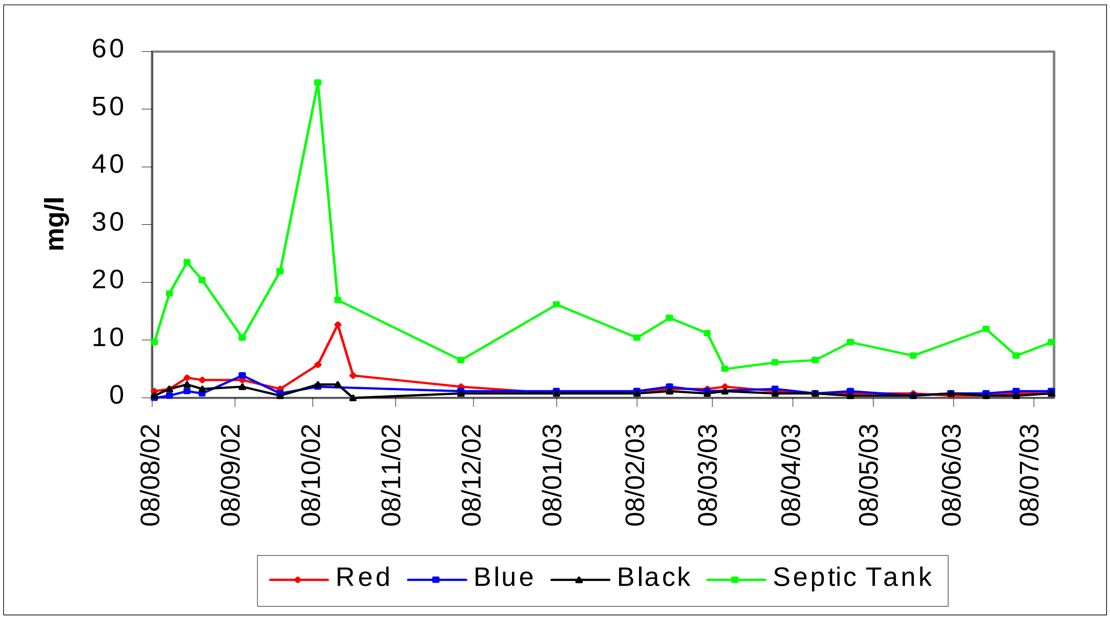


Figure 5.22 Ortho-PO_4-P concentrations measured on Site 1.

5.3.5 Results of Bacteriological Analysis

During the course of the bacteriological analysis it was necessary to dilute some of the soil moisture samples as volumes were too small, or concentrations too large, for analysis. This effects the minimum detection level of the bacterial concentrations and results are therefore expressed in the form <x cfu/100ml to take account of the dilution. For example, if the result of the analysis on a sample for *E. coli* is <10 cfu/100ml this means that the original sample underwent a 1 in 10 dilution with distilled water and while the presence of *E. coli* was not detected the dilution step must be accounted for. The results of the bacteriological analysis are contained in Appendix E.

Table 5.12 presents the results of sample analysis for *E. coli* on four separate occasions over the research period. Assuming that the results obtained from the bacterial analysis are representative of the whole percolation area it can be seen that almost complete removal of enteric bacteria is achieved within the system.

	Number of Samples	Number of samples with concentration (cfu/100ml)			
		<10	10-100	101-1000	>1000
STE	4				4
Red Plane	14	14			
Blue Plane	9	7	1	1	
Black Plane	11	9	1		1

Table 5.12 Concentrations of *E. coli* measured on four separate occasions at Site 1.

The presence of *E. coli* on the black depth plane is confined to samples obtained from points 15 and 27. However, a reduction in bacterial concentration with time is evident at point 27 with no *E. coli* evident on the latter two sampling days, 15/05/03 and 28/08/03. It is possible, therefore, that the initial high concentrations experienced may be due the presence of macropores that facilitated the initial movement of bacteria to the lysimeter porous cup but became blocked with time. If the results of bacteriological analysis for these two latter sample dates only are considered therefore, and allowing for the factor of safety introduced due to the sample dilutions, it was found that complete removal of *E. coli* was achieved within the percolation area on 15/05/03 but that 10 cfu/100ml was detected on the black plane, at point 15, on the 28/08/03. It should be noted that a value of 10 cfu/100ml actually equates to a single bacterium picked up in the sample analysis (due to the method of dilutions).

The results of the bromide tracer test showed that after 8 days all of sample points from which samples for bacteriological analysis had been taken had received effluent containing the bromide. While the main mechanisms for the removal of bacteria in the subsoil are inactivation/die-off, filtration and adsorption, analysis of these results allied with literary evidence of enteric bacterial survival times in subsoils suggests that filtration and adsorption were the dominant removal mechanisms at work.

5.4 Summary

Analysis of flow from the septic tank revealed that the hydraulic loading experienced on Site 1 was less than the design hydraulic load of 25l/m^{2}d. The average daily flow of 418.8 litres would only require 37m of percolation trench, as opposed to the 80m constructed, and so, with respect to the EPA guidelines (EPA, 2000), the percolation area could be considered to be hydraulically over-designed. However, it must be noted that at the hydraulic load recorded on Site 1 most of the surface area of the percolation trenches was utilised. It must also be noted that the flow records include a small contribution by surface runoff which would have the effect of over-estimating the daily wastewater generation and diluting the STE.

The chemical and bacteriological analysis of soil moisture samples obtained from below the percolation area reveal that most of the effluent attenuation takes place above the red depth plane. Apart from a dilution effect due to effective rainfall of between 7% and 10%, the attenuation was due to physical, chemical and biological activity within the percolation area. The analysis also highlights the fact that the organic load of the STE was sufficient to facilitate the development of a biomat along the trench length, apart from on Trench 4, thereby facilitating the distribution of effluent along the entire trench length.

6 ANALYSIS OF RESULTS OBTAINED FROM SITE 2

6.1 Introduction

A successful site assessment was completed for Site 2 on February 4th 2002. However, due to adverse weather conditions, installation of the septic tank and secondary treatment system and the construction of the percolation area was not completed until 30th May, when it was commissioned. Diversion works were then required to separate the domestic wastewater effluent from the roof runoff, which was diverted to a soakaway. The installation of sampling equipment commenced on 21st June and all equipment was in place by 12th July. Sampling began at Site 2 on 9th August 2002 and continued until 22nd July 2003.

6.2 Analysis of Flow Data

As outlined in Section 4.2.2 a datalogger and ultrasonic sensor were installed in the sump downstream of the septic tank. Flow from the septic tank was measured from 20th July 2002 until 21st August 2003 (Appendix C). Apart from a few brief periods, where the data storage capacity of the datalogger had been reached, it represents a continuous record of flow to the percolation area over this period.

The percolation area was designed and constructed to the EPA specifications (EPA, 2000), which recommend a combined percolation trench length of 80m based on a loading rate of 25 l/m^{2}d and a typical daily hydraulic loading of 180 lcd. However, this daily hydraulic loading figure was found to overestimate the measured flows on Site 2. As Table 6.1 highlights, the average flow measured over the research period was 288.3 l/d. This was calculated by averaging the sum of the hourly flowrates` measured and multiplying by 24 to give the *total average*. A *daily average* was also calculated which is the average of all the complete daily records of flow. As the datalogger was normally activated during the daytime, and daily flows calculated from midnight, this resulted in incomplete daily records for some of the days on which the datalogger was activated and also for days on which the capacity of the datalogger was reached. This data, while used in the total average calculation, were excluded from the calculation of the daily average which was calculated as 56.3 lcd. When the flow data is adjusted to take into account holiday periods, i.e. when the house was vacant, it can be seen that both the total and daily averages increase as does the minimum flow measured. This adjusted daily average, which is essentially the average daily wastewater generation, equated to 59.0 lcd.

	Flows (l/d)			
	Max.	**Min.**	**Total Average**	**Daily Average**
Measured Flow	642.5	0.0	288.3	281.7
Adjusted Flow	642.5	93.0	300.9	294.9

Table 6.1 Flows measured on Site 2 (Adjusted Flow takes account of holiday periods).

While design of the percolation area must account for the maximum projected hydraulic load it was found that, even when the greatest flow measured (642.5l/d) was taken into consideration, the percolation area was hydraulically over-designed with respect to the EPA (2000) specifications. It must also be considered that in the current socio-economic climate it is not uncommon for both of a cohabiting couple to work outside the home. As the holdings on Site 2 contained an office, from which the husband ran his business, it is possible that these measured flows are greater than might be the case in other dwellings.

While Table 6.1 gives an overview of flow behaviour on Site 2 it is important to also consider the frequency distribution of the recorded flowrates. As can be seen from Figure 6.1, the maximum flow of 642.5 l/d was an isolated event and only 7% of flows recorded were greater than 440 l/d. The majority of flows recorded, or 84%, were in the range 140 l/d to 440 l/d and when figures were adjusted to take the holiday periods into account this rose to 87% (Figure 6.2). The daily average flow recorded for this period was 281.9 l/d and this increased to 284.1 l/d after the holiday periods were accounted for.

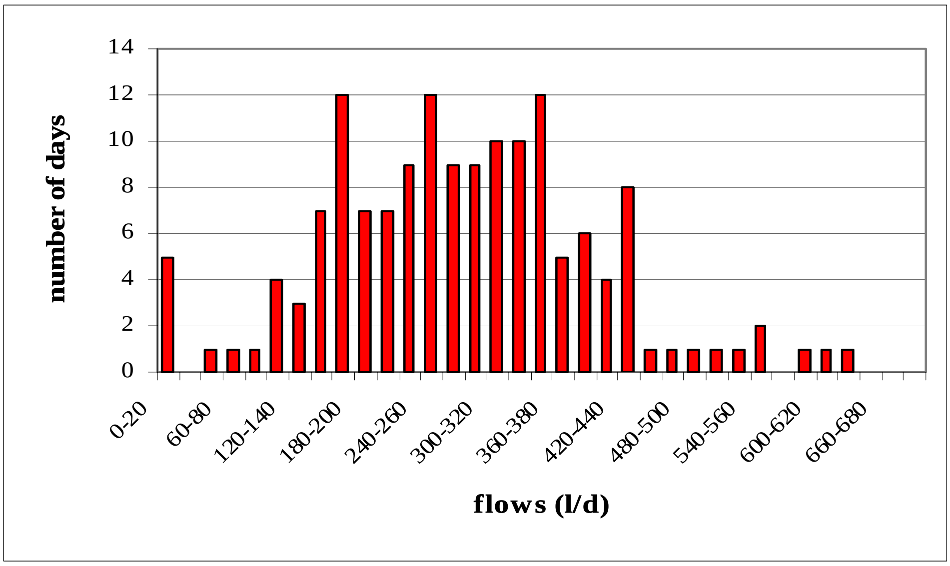


Figure 6.1 Frequency distribution of flows recorded on Site 2.

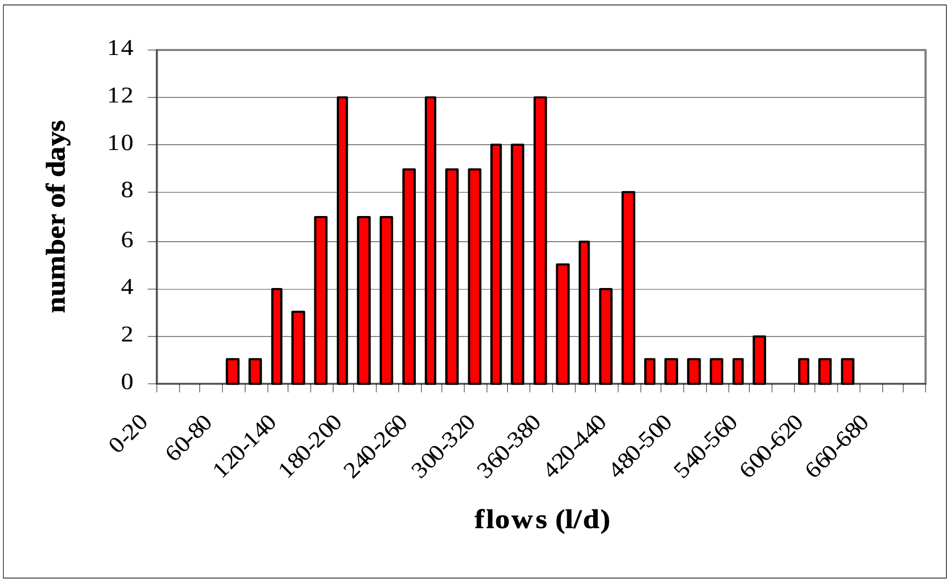


Figure 6.2 Frequency distribution of flows recorded on Site 2 adjusted to take account of holiday periods.

To attain an even distribution between the four percolation trenches the design of the distribution box would have to take account of the influent flow regime. Analysis of the flow emanating from the septic tank on Site 2 showed that the average flow rate was less than 0.8 l/min for 82% of the monitoring period (Figure 6.3). However, it must be considered that the installation of the Puraflo® system modified the flow characteristics of the STE arriving at the distribution box.

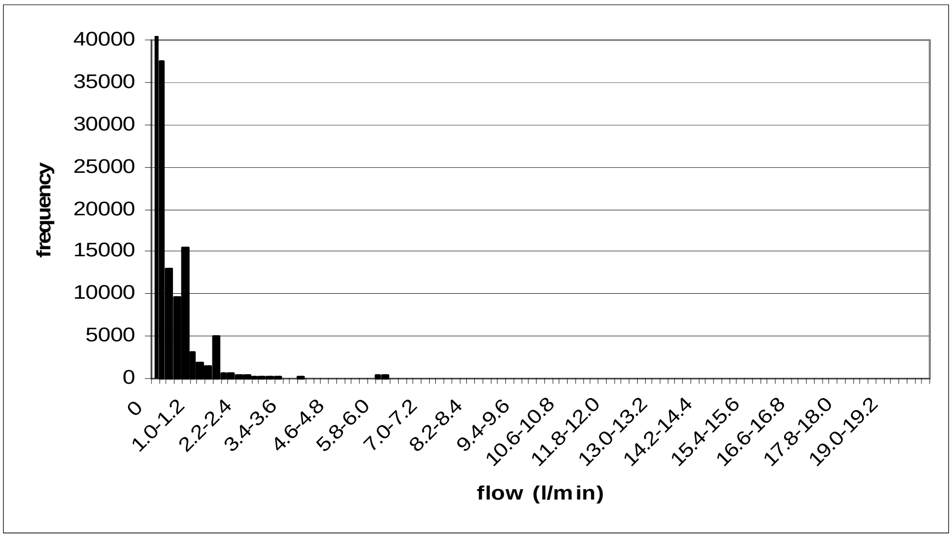


Figure 6.3 Frequency distribution (l/min) of flows recorded at Site 2.

To ensure that the separation work was successful and that the measured flow data accurately reflected the domestic wastewater effluent generation, and was not influenced by surface water intrusion, flowrates were graphed against the rainfall recorded on that day. It appears from Figure 6.4 that there was no correlation between rainfall and septic tank effluent flowrate and hence surface water separation works had been successful. This was corroborated when the surface water shores were examined for connectivity with the septic tank revealing no connection.

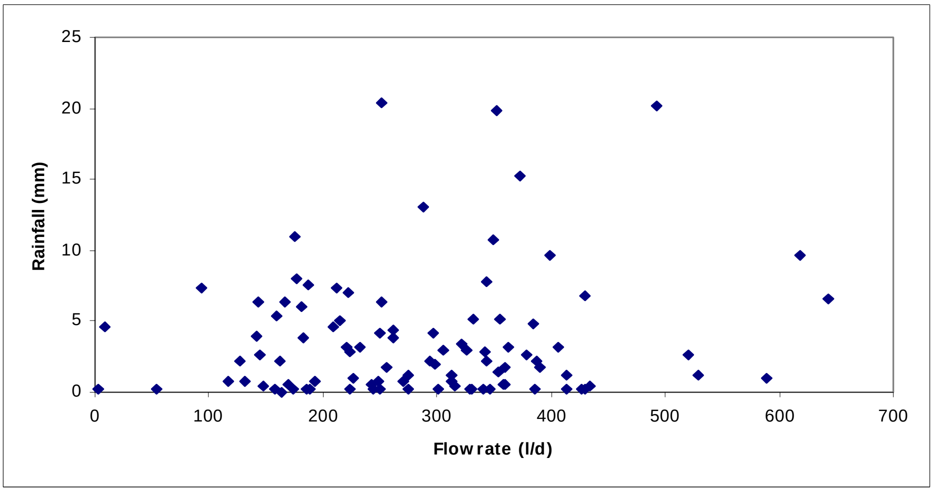


Figure 6.4 Graph of flowrate against rainfall for Site 2.

6.3 Results of the Analysis of Septic Tank and Secondary Effluent

6.3.1 Results of Chemical Analysis

Appendix D contains the results of the chemical analysis carried out on all samples taken from Site 2. Table 6.2, which summarises the results relating to the STE, shows high concentrations of organics and nutrients, characteristic of STE. The anaerobic environment of the septic tank facilitated the breakdown of organic nitrogen and phosphorous to their inorganic forms, ammonium and orthophosphate respectively, which were the prevalent nutrient forms in the STE. It was also responsible for the low concentration of NO_3 and NO_2. The NO_3, NO_2 and NH_4 concentrations in the STE remained stable throughout the year. As inorganic nitrogen is more likely to exist in its reduced (NH_4) or oxidised (NO_3) form in the subsoil (Brady and Weil, 1996), NO_2 concentrations were measured to enable the calculation of total inorganic nitrogen concentration in the percolating effluent rather than as an indicator of effluent attenuation.

	Concentration (mg/l)					
	COD	**NO_3-N**	**NO_2-N**	**NH_4-N**	**PO_4-P**	**Cl**
Maximum	1630.0	5.3	0.42	161.5	61.9	290.0
Minimum	484.0	0.0	0.00	98.8	19.3	74.1
Average	**791.6**	**1.4**	**0.28**	**131.0**	**32.3**	**117.8**

Table 6.2 Summary of chemical analysis of STE on Site 2.

There was little variation in the COD concentration until the 29/05/03 from where it increased to an annual high of 1630 mg/l on the 25/06/03 before it dropped to 1329 mg/l, which was recorded on the final day of testing. There was no corresponding change in the daily routine over this period to explain this increased organic load which must therefore be due to the increasing biological degradation of the cumulative settled organic matter within the septic tank by anaerobic processes to yield more soluble forms of organic compounds which would pass out in the effluent. Anaerobic processes are relatively slow and temperature dependant; it is possible, therefore, that their impact on STE COD concentrations were only noticeable towards the end of the project (since the septic tank started empty at the beginning) which also coincided with warmer temperatures moving into summer. Apart from two highs of 61.90 mg/l and 55.60 mg/l on the 26/09/02 and 24/10/02 the orthophosphate concentration showed little variation throughout the year. The chloride (Cl) value of 290 mg/l measured on the 15/08/02 was 2.3 times greater than the next highest Cl measurement and was therefore dismissed as egregious and omitted from further calculations. As the Cl values for all samples on this date are unusually high when compared to values recorded over the remainder of the sample period it is possible that these rogue values arose due to an error in analytical procedures such as the failure to calibrate the spectrometer. It is interesting to note that, overall, the concentrations of the chemical parameters measured in the STE at Site 2 were found to be higher than those reported in the Literature Review.

The aerated environment of the secondary treatment system promoted nitrification and the aerobic degradation of organic matter which, combined with the physical straining action of the bio-media, resulted in an effluent with a lower organic and higher nitrate concentration (Table 6.3). The aerobic and facutatively aerobic bacteria are found largely in the upper portion of the filter media with nitrifers becoming more prevalent with depth (>30cm) (Henry, 1995). Therefore, the degradation and assimilation of the carbonaceous element of the waste is effected within the upper portions of the filter media with nitrification occurring at greater depths provided that sufficient oxygen is available. It appears, from Figure 6.5, that there was no reduction in nitrification over the winter months.

	Concentration (mg/l)					
	COD	**NO_3-N**	**NO_2-N**	**NH_4-N**	**PO_4-P**	**Cl**
Maximum	316.0	60.5	13.6	45.2	85.6	185.0
Minimum	98.0	15.3	0.8	6.9	16.8	51.3
Average	**188.1**	**36.9**	**7.4**	**19.7**	**33.6**	**92.6**

Table 6.3 Summary of the results of chemical analysis of SE on Site 2.

	% of total inorganic N			Average
	NO_3-N	NO_2-N	NH_4-N	pH
Septic Tank Effluent (STE)	0.9	0.2	98.9	7.9
Secondary Effluent (SE)	57.8	11.1	31.2	6.4

Table 6.4 The average breakdown of inorganic N in STE and secondary effluent.

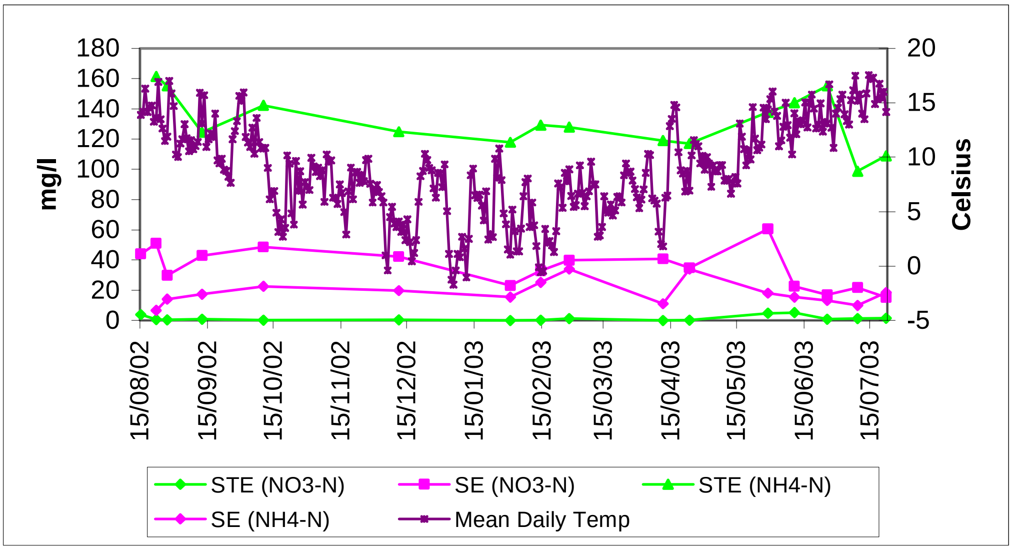


Figure 6.5 The effect of nitrification on secondary system effluent quality: (a) NH_4-N concentration and (b) NO_3-N concentration.

While Table 6.4 and Figure 6.5 show the effects of partial nitrification, highlighted by the drop in pH, within the secondary treatment system on effluent quality, they do not highlight the reduction in overall nitrogen loading achieved by the secondary treatment over the research period as seen in Figure 6.6. It was found, on average, that there was a 51.6% reduction in inorganic N loading across the secondary treatment system which must be due to denitrification within the peat module. This takes into account any subsequent mineralisation of organic nitrogen that might occur within the secondary system. It is probable that modifications to the design of the modules containing the peat medium created anoxic conditions in the base of the module. The treatment modules are usually placed on a gravel bed and the effluent allowed percolate through perforations in the base into the gravel distribution layer from where it enters the subsoil. However, the modules had to be adapted for this project to enable the effluent to be evenly distributed between the percolation trenches. To this end the base of the treatment modules was not perforated and the effluent was gravity fed to a collection chamber, by pipes inserted 5cm above the base of modules side-walls, from where it entered the distribution box. It is likely, therefore, that slightly flooded conditions along the base of the module promoted denitrification. An Institute for Industrial Research and Standards (IIRS) report produced in 1988 at the behest of Bord na Móna confirmed the occurrence of denitrification in flooded modules.

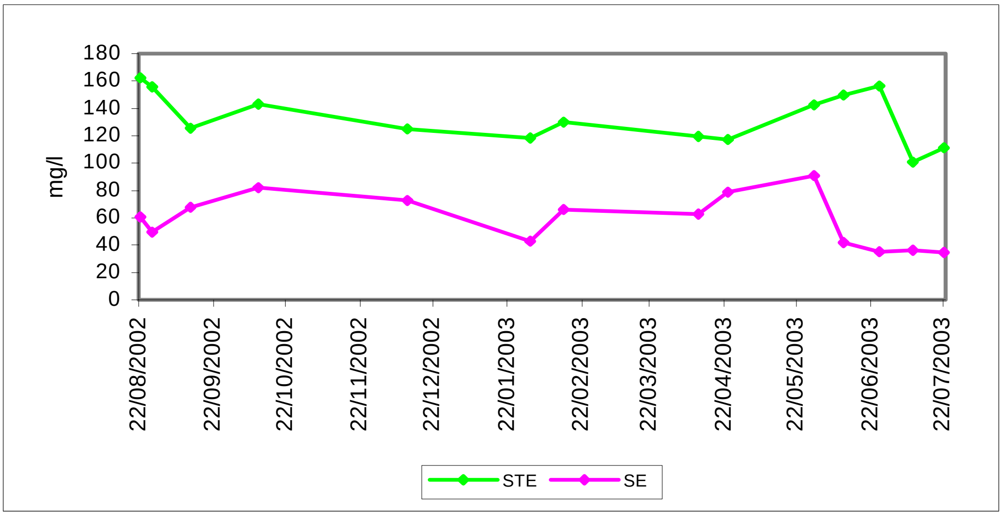


Figure 6.6 Reduction in Total inorganic N concentration across the secondary treatment system.

The installation of the secondary system on Site 2 reduced the organic load on the percolation area by an average of 76.2% (Figure 6.7). While the increase in COD concentration in the STE over the last 2 months of the analysis is reflected by an increase in the COD concentration in the secondary effluent (SE), the relative magnitude of this increase is much smaller. This suggests an ability by the secondary treatment system to treat influent of varying organic quality while maintaining a relatively constant effluent concentration.

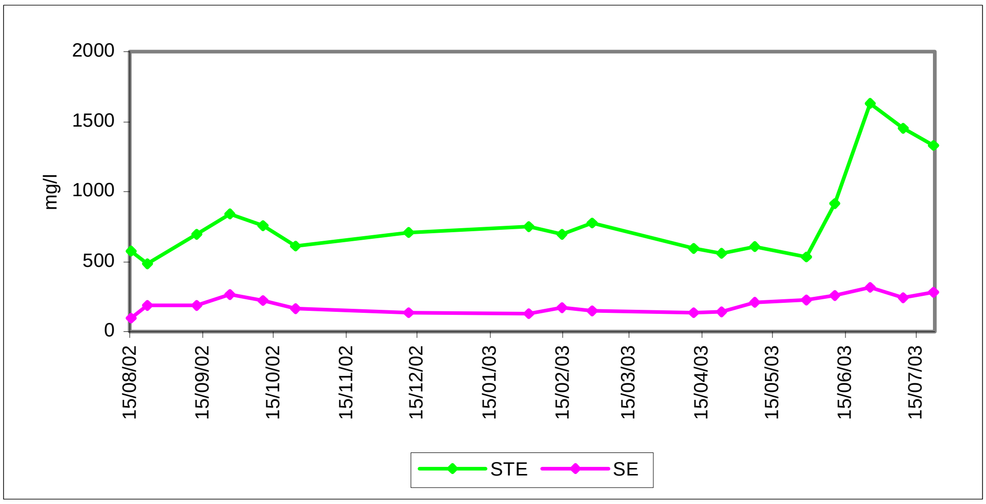


Figure 6.7 Comparison of COD concentration in septic tank and secondary system effluent.

While phosphate removal within the Puraflo® is due to biological activity and is generally in the order of 10-15% (Paul Bolger, Bord na Móna) it was found that ortho-PO_4 concentration in the septic tank and secondary effluent from Site 2 was similar throughout the research period. There were incidents where the SE ortho-PO_4 concentration was greater than that of the STE (Figure 6.8). This can be explained due to the fact that while biological phosphate removal of the order of 10 to 15% is achieved across the Puraflo®, 80-90% of organic phosphate in the STE is also mineralised (Paul Bolger, Bord na Móna). It is possible therefore that the ortho-PO_4 concentration of the SE could be greater that that of the STE. It must also be considered that the analysis procedure for ortho-PO_4 required the dilution of samples with distilled water as their concentration was outside the detectable limit of 5 mg/l. As a 1:5, 1:10 or 1:20 dilution was used this meant that a small error in the analysis of the diluted sample would result in a 5, 10 or 20 fold increase in any error in the reported concentration.

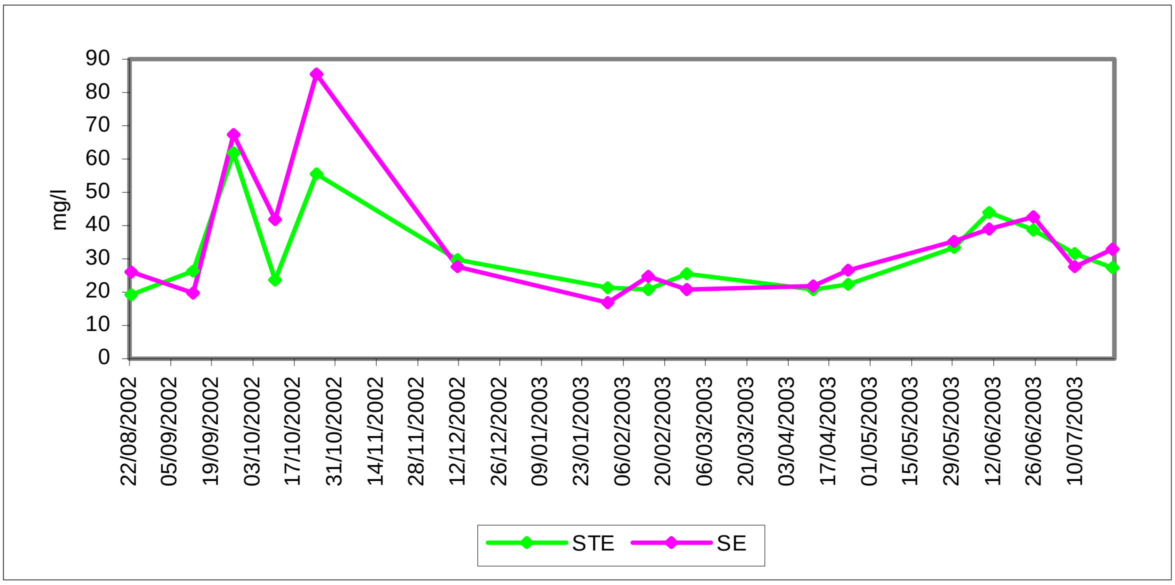


Figure 6.8 Comparison of ortho-PO_4-P concentration in STE and SE.

Taking into account the rogue value for Cl concentration on 15/08/02, it can be seen that, on average, there is an 18.2% difference in concentration between the STE and the SE (Figure 6.9). As the secondary treatment system is sealed, preventing intrusion by precipitation, allied with the fact that Cl does not take part significantly in any reactions within the peat medium, it is probable that the reduction in Cl concentration across the secondary treatment system is due to the removal of colloidal matter by the physical straining action of the peat fibres and associated biofilm. While STE samples analysed for Cl were not filtered during sample analysis for Sites 1 and 2, they were for Sites 3 and 4. It was found that, for 18 sets of STE samples analysed, there was on average a 22.6% reduction in the Cl concentration between unfiltered and filtered samples (Section 7.3.2). This would suggest that the difference between unfiltered samples of STE and SE was due to the removal of particulate matter within the Puraflo®.

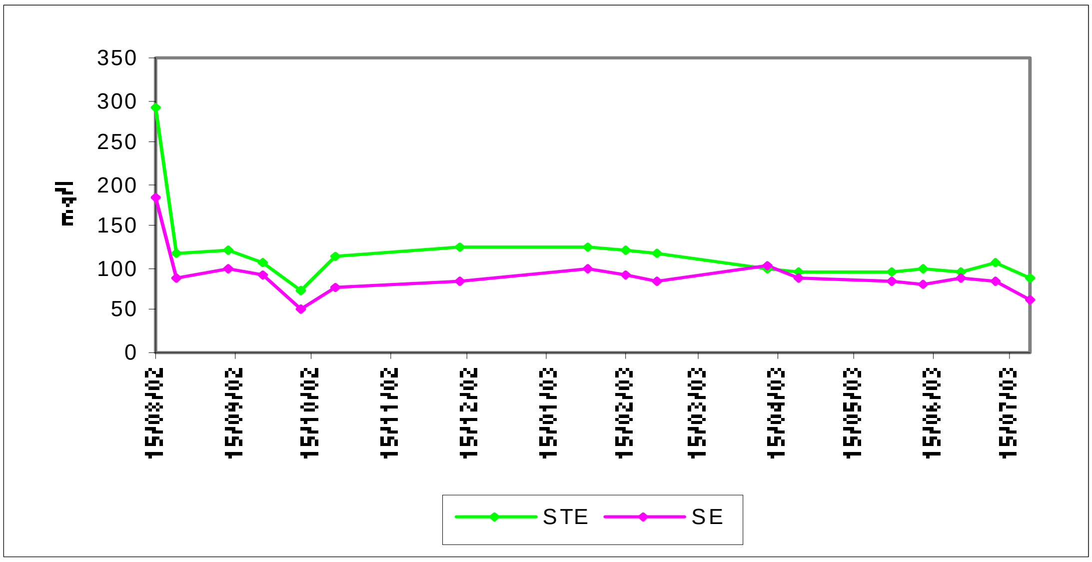


Figure 6.9 Comparison of Cl concentration in STE and SE.

Based on the chemical analysis alone it is clear that while the installation of a secondary treatment system downstream of the septic tank reduces the organic and nitrogen load of the domestic wastewater effluent, further treatment is required prior to its discharge to groundwater.

6.3.2 Results of Bacteriological Analysis

While the project's main aim was the assessment of the attenuation capacity of subsoil receiving domestic wastewater, and was therefore mostly concerned with the quality of the distribution box influent, some bacteriological analysis was carried out on STE. The results of all bacteriological analysis are contained in Appendix D. Samples were not analysed for the presence of viruses as this was beyond the scope of the project. The installation of a secondary treatment system on the site greatly reduced the bacterial loading on the percolation area as highlighted by the 6 results shown in Table 6.5.

Date	Bacteria	Effluent Concentration (cfu/100ml)		% Removal
		Septic Tank	Puraflo® System	
15/05/03	*E. coli*	397,260	4,320	98.91%
15/05/03	Faecal coliforms	>486,840	17,200	>96.47%
28/08/03	*E. coli*	1,416,600	5,040	99.99%
28/08/03	*Enterococci*	238,200	600	99.99%
28/08/03	Faecal coliforms	1,553,100	6,010	99.99%
28/8/03	Total coliforms	>2,419,200	130,000	>94.62%

Table 6.5 Example of the reduction in bacteria concentration of domestic wastewater effluent resulting from the installation of a Puraflo® system on Site 2.

However, even when the removal efficiency of the secondary treatment system is taken into account, the high concentrations of bacteria measured in the SE still deem it unsuitable for discharge to groundwater prior to further treatment (Table 6.6).

Date	Effluent Concentration (cfu/100ml)				
	Total coliforms	E. coli	Faecal Coliforms	Enterococci	Faecal Streptococci
17/10/02	3,000,000	200,000			620
13/03/03	203,000	31,000			63,000
15/05/03	77,460	4,320			17,200
28/08/03	130,000	5,040	6,010	600	

Table 6.6 Concentrations of bacteria measured in SE on 4 separate dates.

6.4 Results of the Analysis of Soil Moisture Sample

6.4.1 Method of Analysis

As can be seen from Table 4.1(b) it was not possible to install identically coloured lysimeters to similar depths and therefore, prior to analysis of the chemical and bacteriological results, reclassification of some lysimeters was required. To achieve this, 3 nominal depths of 0.3m, 0.6m and 1.0m below the invert of the percolation trench, referred to as depth planes, were defined. The subsoil below the percolation trench was divided into 3 sections: 0 to 0.4m, 0.4 to 0.8m and 0.8 to 1.2m. The depth planes were chosen to represent the middle of these sections. As no lysimeter tip was installed in the first half of the 0 to 0.4 section, and the 0.2 to 1.2m section of the soil profile had been similarly classified, a depth of 0.3m was decided to be more representative of the lysimeter tip situation. The lysimeters were then reclassified, taking into account their location within the subsoil, and results reported citing the 3 depth planes. For example, the red lysimeter located at the 0m sample position on trench 3 was reclassified as a blue lysimeter.

During the research period it was only possible to obtain 4 samples from the 1.0m depth plane at the 0m sample position. However, as only a depth of 0.6m of unsaturated subsoil is required below the invert of the percolation trench on a site deemed suitable to receive SE (EPA, 2000) the absence of a complete set of samples from the lower plane was not of concern.

The results of the analysis of soil moisture samples for Cl were used to determine which of the two methods outlined in Section 5.1.1, planar average or depth average, was the better method for representing the distribution of SE within the percolation area. When the average Cl concentrations measured for each of the sample positions were plotted it was found that the concentration at the 0m sample position, at all depths, was, on average, 8 to 9 times greater than the concentration measured at the other sample positions (Figure 6.10). When the average Cl concentration for each depth plane at the 0m sample position were plotted it was discovered that they were very similar (Figure 6.11). This would suggest that the SE effluent was only reaching the 0m sample position and that the reduction in the organic load of the STE brought about by the installation of the secondary treatment system inhibited the formation of a biomat along the base of the percolation trench, preventing dispersion of the SE along the entire trench length and thus confining loading to less than the first 10m of the trenches. It would also suggest that as the Cl concentrations for the 3 depth planes at 0m are very similar, the influence of dilution on effluent attenuation between these planes was small (Section 6.4.2). This pattern was maintained throughout highlighting the fact that the SE, and hence the biomat, had not progressed 10m along any trench.

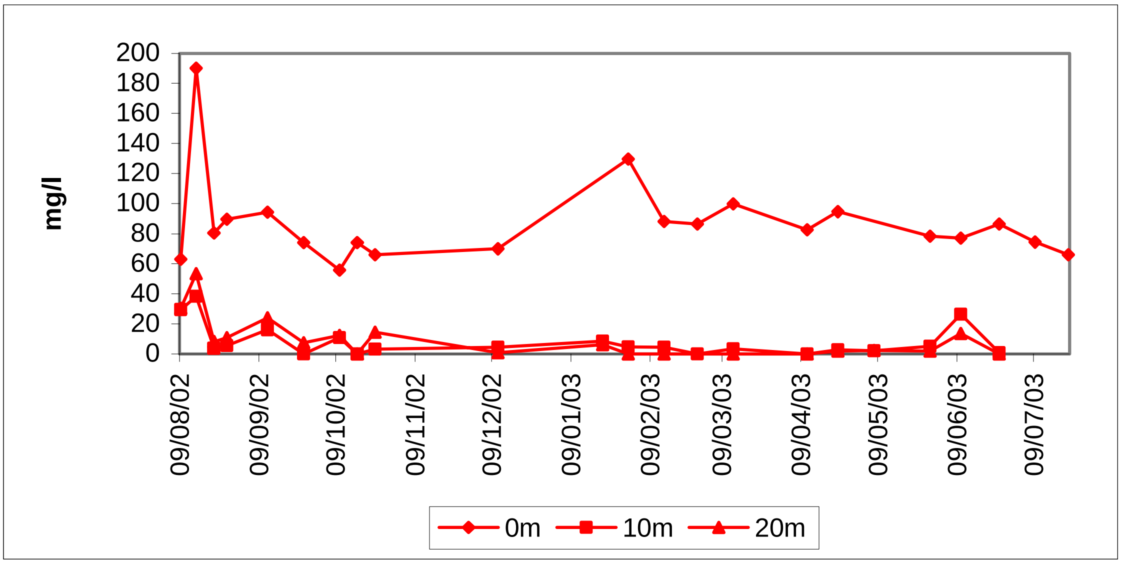


Figure 6.10 Cl concentration on the red depth plane at the 3 sample positions.

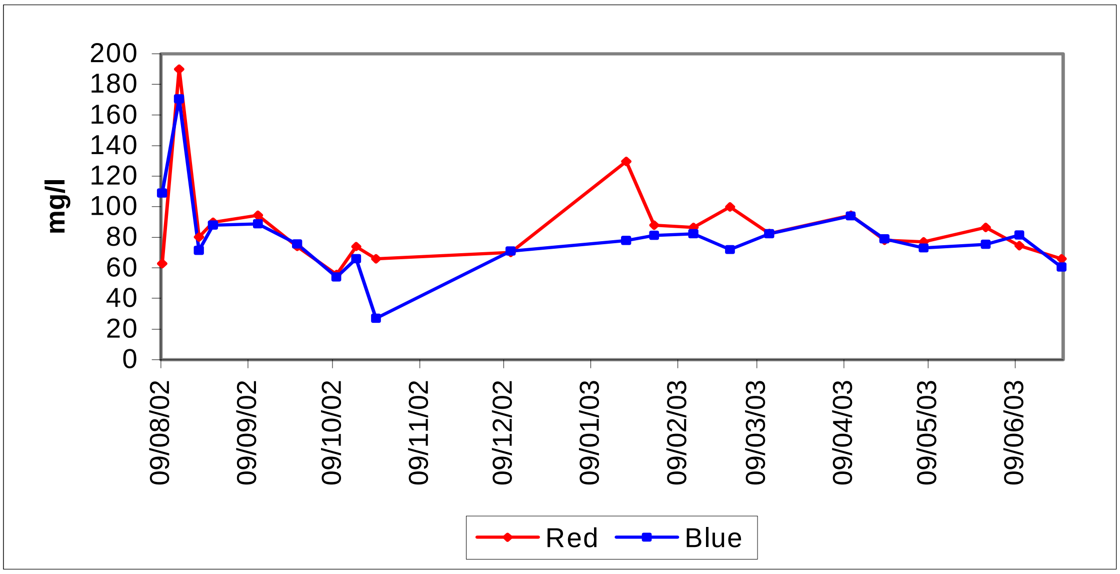


Figure 6.11 Cl concentration measured on the 3 depth planes at the 0m sample position.

The findings of the chloride analyses were corroborated by the results of the bromide tracer study (Appendix E) carried out on the same day as for Site 1 which showed that, over an 8-day period, Br was recorded in all the lysimeters at the 0m sample position, except the blue lysimeter on Trench 2 (Appendix E). It is possible, however, that Br arrived at the blue lysimeter on Trench 2 on the days when sampling was not carried out.

As can be seen from Table 6.7 the time of travel of the tracer from the distribution box to the individual sample points on the same depth plane varied. It is possible, therefore, that the presence of Br in samples on day 8 was not the first incidence of Br at these sample points. No tracer was sampled at any point at either the 10m or 20m sample positions.

Depth Plane	**Trench Number**			
	1	**2**	**3**	**4**
Red	Day 2	Day 8	Day 3*	Day 8
Blue	Day 2	None	Day 8**	Day 2
Black	Day 2*	Broken	Day 3	Day 2*

** denotes lysimeter reclassified as blue; ** denotes lysimeter reclassified as black.*

Table 6.7 Time of first arrival of Br at the 0m sample position on Site 2.

6.4.2 The Affect of Dilution on Effluent Attenuation

As was the case for Site 1, the effective rainfall over the project duration was calculated using rainfall data obtained on site and meteorological data obtained from the meteorological station at Pollardstown Fen 14 km away. As outlined in Section 5.1.2, PET was calculated using the model developed by Bartley (2004) and AET was calculated using the Aslying scale.

The measured rainfall for Site 2 from the 01/08/02 to 22/07/03 was 950.0 mm. Using the Penman-Monteith method it was calculated that the effective rainfall over this period was 419.3 mm. Using the Hargreaves method to calculate the daily effective rainfall it was found that the effective rainfall for the period 01/08/02 to 22/07/03 was 407.9 mm. It can be seen from Figures 6.12 and 6.13 that the effect of dilution, i.e. the difference between Puraflo® and soil moisture Cl concentrations, was greatest during the period of sustained effective rainfall between November 2002 and March 2003. The reduction in Cl concentration between the Puraflo® and both the red and blue depth planes was examined as a method of quantifying this dilution effect and calculating the zone of contribution around each trench (Table 6.8). This assumes that the reduction in chloride concentrations due to the effects of physical straining as seen in the subsoil for Site 1 had already been accounted for in the peat media of the secondary treatment unit and that any further reductions in chloride concentration in the subsoil were due to dilution. As can be seen from Figure 6.14, Cl concentrations on the blue depth plane on the 24/10/02 and 31/01/03 do not correspond as closely to Cl concentrations in the SE and red depth plane as on most other dates.

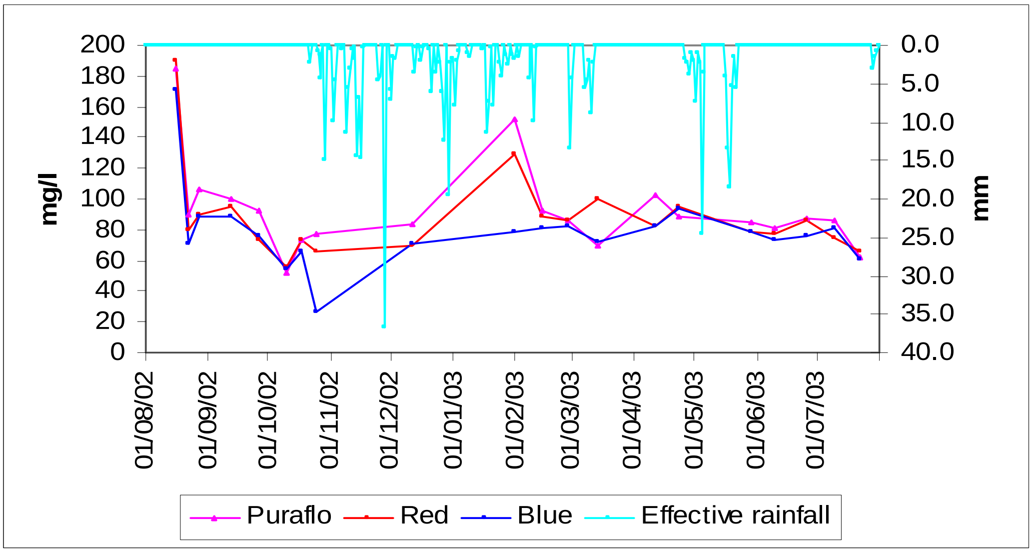


Figure 6.12 The effect of dilution by effective rainfall, calculated by the Penman-Monteith method, on Cl concentration.

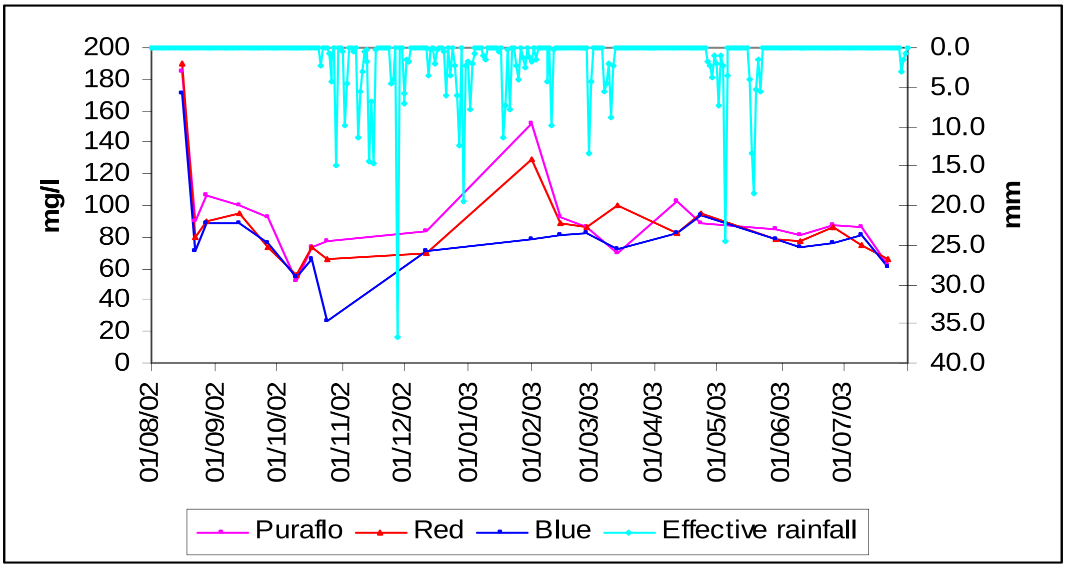


Figure 6.13 The effect of dilution by effective rainfall, calculated by the Hargreaves method, on Cl concentration.

Date	% reduction in concentration		Equivalent contribution of effective rainfall (l)	
	Red Plane	Blue Plane	Red Plane	Blue Plane
15/08/02	0.00	7.89	0.00	0.09
22/08/02	10.74	20.67	0.13	0.28
27/08/02	15.41	16.98	0.19	0.22
12/09/02	5.67	11.20	0.06	0.13
26/09/02	19.57	17.75	0.26	0.23
17/10/02	0.00	10.81	0.00	0.13
24/10/02	14.29	N/A	0.18	N/A
11/12/02	16.67	15.48	0.21	0.20
31/01/03	14.69	N/A	0.18	N/A
14/02/03	4.35	11.59	0.05	0.14
27/02/03	0.00	4.26	0.00	0.05
11/04/03	19.90	20.06	0.26	0.27
29/05/03	8.05	7.40	0.09	0.09
10/06/03	5.52	10.57	0.06	0.13
25/06/03	0.57	13.41	0.01	0.17
09/07/03	13.37	5.23	0.16	0.06
22/07 /03	0.00	2.42	0.00	0.03
Average	**10.63**	**13.72**	**0.13**	**0.15**

Table 6.8 Calculation of the contribution of effective rainfall to dilution.

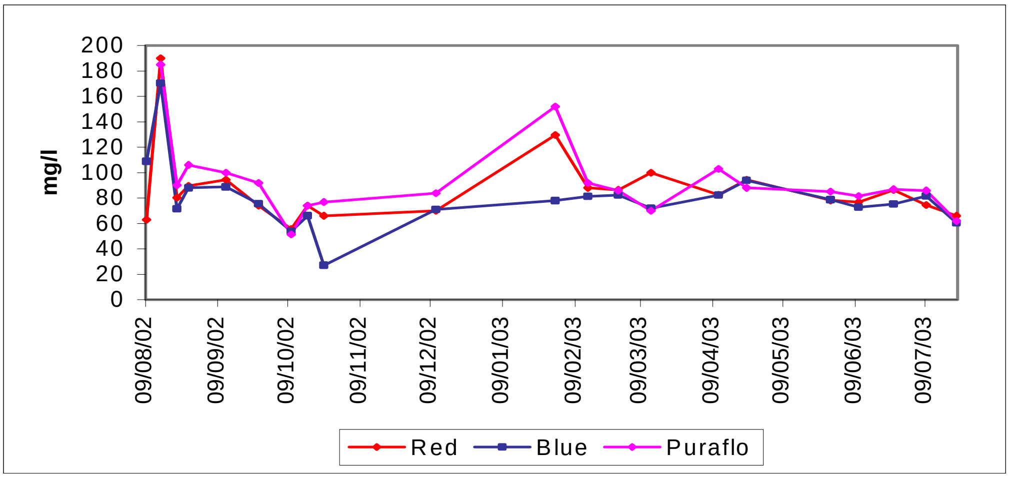


Figure 6.14 Comparison of Cl concentrations as an indicator of effluent dilution.

When the Cl concentrations for these dates were omitted from dilution calculations it was found that the effect of dilution was equivalent to, on average, the addition of 0.13 litres (or 10.63% reduction in concentration) and 0.15 litres (or 13.72% reduction in concentration) of effective rainfall per litre of effluent on the red and blue depth plane respectively. The average Cl concentration of rainfall at Site 2 was 4.8 mg/l. Using the daily average flow of 281.7 l/d (Table 6.1) this equates to an average daily effective rainfall contribution of 36.6 litres across the whole red plane and 42.3 litres across the whole blue plane.

Using the same method as outlined in Section 5.3.2, when the average effective rainfall contribution for the red plane is calculated for the year it is found to be 13.4 m^3 which equates to a zone of contribution of effective rainfall of approximately 32.0 m^2. As highlighted in Section 6.4.1, less than 10m of percolation trench was utilised. Where data is available for the smaller lysimeters installed below the invert of Trenches 3 and 4 it can be seen that, while effluent was being measured at the 2m sample point, it was not present at the 7m sample point (Appendix D). Therefore, taking the trench width of 0.45m and an average trench length of 4m this equates to a zone of contribution of approximately 0.5m on all sides of each trench. As was the case for Site 1, when the same calculation was carried out for the blue plane it was found that the zone of contribution was slightly greater at 36.8 m^2 due to the dispersion of the effluent plume below each percolation trench.

Examination of the soil moisture tension values from the tensiometers installed at the 0m and 20m sample positions on Site 2 also suggest that it is physical, chemical and biological processes rather than dilution that are the more prominent attenuation processes operating in the subsoil. As can be seen by Figure 6.15 tensiometers at the 20m sample position, where no effluent was recorded, react to the variation in effective rainfall over the sampling period. If Figure 6.16 is examined, however, it can be seen that the tensiometer readings are more affected by the percolating effluent rather than the contribution of effective rainfall suggesting that the contribution of dilution to effluent attenuation is small.

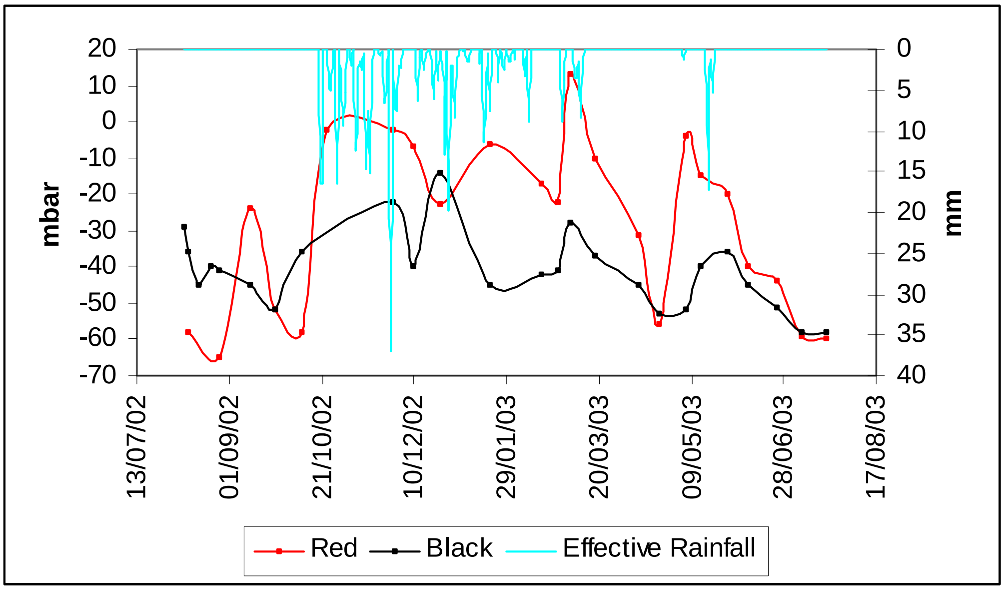


Figure 6.15 Soil moisture tension plotted against effective rainfall for the 20m sample position on Site 2.

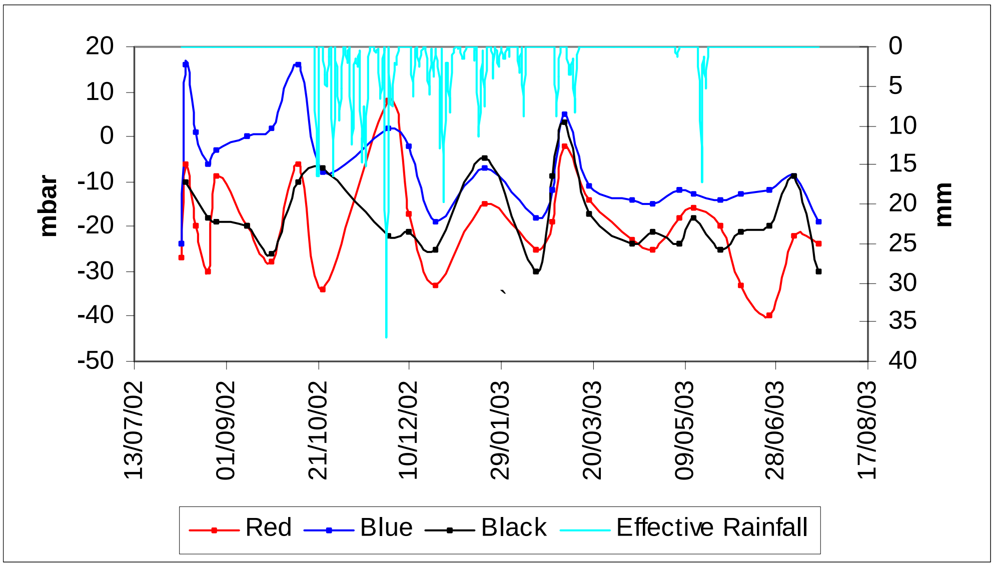


Figure 6.16 Soil moisture tension plotted against effective rainfall for the 0m sample position on Site 2.

6.4.3 Results of Chemical Analysis

COD

The reduction in COD concentration and load of the percolating SE with subsoil depth (Table 6.9) is small when compared to the reduction that takes place across the secondary treatment system. While this reduction in COD within the subsoil results from aeration, physical straining and biological degradation, the reduced organic load of the SE has obviously failed to generate enough microbiological activity along the subsoil-effluent interface to promote significant biomat formation along the entire base and side-walls of the percolation trenches. This has had the effect of concentrating the effluent on less than half the percolation area thereby reducing the effects of other attenuation processes such as dilution, dispersion and advection within the unsaturated subsoil. Similarly the potential bacteriological and chemical load on groundwater would be concentrated over a smaller area thus effecting attenuation processes within the saturated zone which could lead to elevated contaminant concentrations in the groundwater and therefore have health implications for adjacent water supply sources.

Sample Position	Concentration	Load	
	(mg/l)	(g/d)	Removal (g/d)
STE	791.6	223.0	-
SE	188.1	55.5	167.5
Red Depth Plane	107.5	30.9	24.6
Blue Depth Plane	76.2	21.9	9.0

Table 6.9 Reduction in COD load attributed to the specific treatment steps.

NITROGEN

The effluent from the secondary treatment underwent further slight nitrification within the subsoil as can be seen by Table 6.10 which shows the average concentrations and loading rates of NO_3, NO_2, and NH_4 measured on the red and blue depth planes over the project duration. While near complete nitrification has occurred by the blue depth plane there is little change in the total inorganic N concentration with depth throughout the research period (Figures 6.17, 6.18 and 6.19).

Depth Plane	NO_3-N		NO_2-N		NH_4-N		Total N	
	Conc. (mg/l)	Load (g/d)	Conc. (mg/l)	Load (g/d)	Conc. (mg/l)	Load (g/d)	Conc. (mg/l)	Load (g/d)
SE	37.1	10.5	7.4	2.1	20.5	5.8	64.0	18.0
Red	52.0	14.9	3.3	0.9	5.8	1.7	59.2	17.0
Blue	56.2	16.1	0.6	0.2	1.5	0.4	57.9	16.6

Table 6.10 Average concentration and loading rate of NO_3-N, NO_2-N, NH_4-N and Total inorganic N measured on the red and blue depth planes.

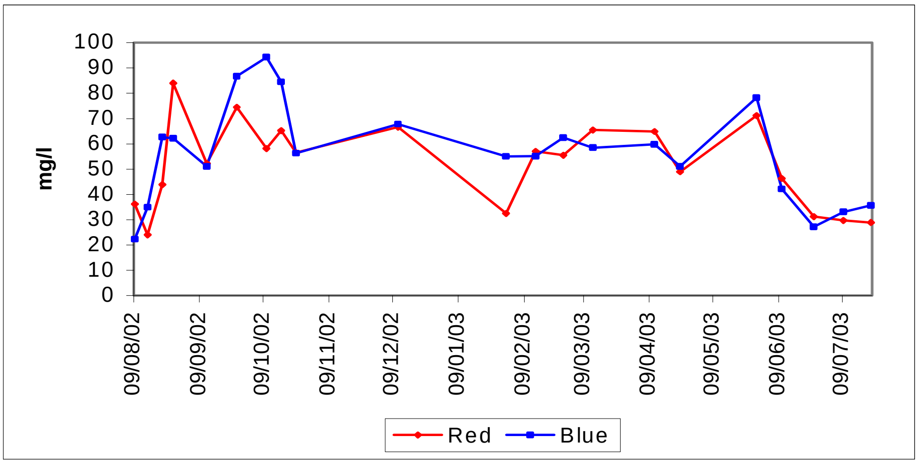


Figure 6.17 Average NO_3-N concentrations at the 0m sample position.

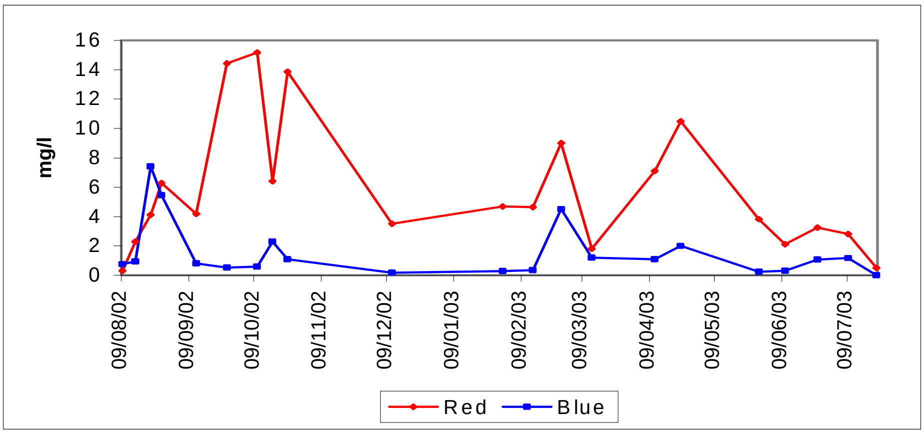


Figure 6.18 Average NH_4-N concentrations at the 0m sample position.

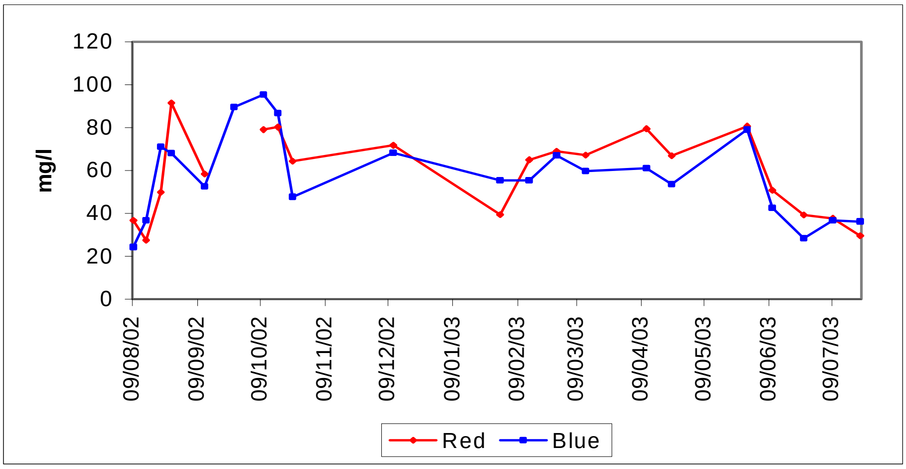


Figure 6.19 Average total inorganic N concentrations at the 0m sample position.

As outlined in the Literature Review, inorganic nitrogen, in the form of both NO_3 and NH_4, can be removed from the percolating effluent by immobilisation and/or denitrification. However, the inhibition to biomat formation along the percolation trench base, resulting from the reduction in organic load attributed to secondary treatment, would result in a reduction in microbial activity thereby reducing demand for inorganic nitrogen in the decomposition of organic matter. The absence of a biomat along the trench base would also have promoted unsaturated conditions. Bacteria responsible for denitrification are facultative anaerobic heterotrophs and as such require, not only saturated subsoil conditions, but also a supply of organic material from which to obtain their energy and carbon for metabolism. While unsaturated conditions appeared to be prevalent in the subsoil directly below the percolation trenches, there were isolated incidents of saturation (Figure 6.16). Where these occurred it is possible that the organic load was insufficient to promote significant denitrification.

PHOSPHOROUS

Figure 6.20 shows only a small decrease in ortho-PO_4 loading in the subsoil above the blue depth plane with a noticeable increase in ortho-PO_4 fixation between the blue and black planes (Table 6.11). Particle size analysis of a sample taken at 1.0m depth, or 0.2m below the invert of the percolation pipe, shows a higher clay content than samples at 1.5m and 2.0m depth suggesting a greater affinity for phosphate sorption (Appendix A). Furthermore, while no particle size data is available for the subsoil between the base of the percolation trench and the 1.0m sample depth it has been classified, using BS5930, as a sandy CLAY (w/silt) while the subsoil below this point was classified as a sandy SILT (w/clay). X-ray diffraction analysis of a sample taken from the sandy SILT (w/clay) layer shows that while it contains calcite, it is void of Al, Fe and Mn, oxides, hydrous oxides or dissolved ions (Appendix A) and therefore, in such a medium, fixation would be confined to the high pH range, generally occurring at a pH > 8. This can be seen on the few occasions where data is available from the black plane (Table 6.12).

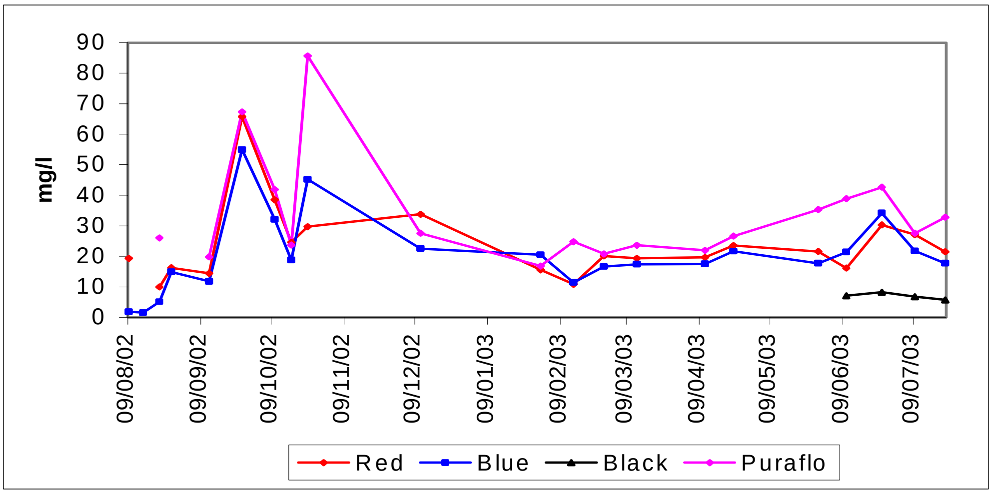


Figure 6.20 Average ortho-PO_4-P concentrations measured.

	Conc. (mg/l)	Loading (g/d)	pH
SE	33.6	9.5	6.42
Red Depth Plane	23.9	6.9	6.30
Blue Depth Plane	20.3	5.8	7.22

Table 6.11 Average ortho-PO_4-P concentration and loading rates measured over project duration.

	Conc. (mg/l)	Loading (g/d)	pH
SE	35.5	10.0	7.17
Red Depth Plane	23.8	6.8	6.47
Blue Depth Plane	23.8	6.8	7.24
Black Depth Plane	6.9	2.2	8.15

Table 6.12 Average ortho-PO_4-P concentration and loading rates measured on the four occasions where black depth plane samples were available.

6.4.4 Results of Bacteriological Analysis

While the installation of the secondary treatment system greatly reduced the bacteriological load on the percolation area, as outlined in Section 6.3.2, it can be seen from Table 6.13, which presents the results of sample analysis for *E. coli* at the 0m sample position on 4 separate occasions over the research period, that there is evidence of enteric bacterial contamination with depth.

Depth Plane	Number of Samples	Number of samples with concentration (cfu/100ml)			
		<10	10-100	101-1000	>1000
SE	4				4
Red	5	5			
Blue	5	5			
Black	1		1		

Table 6.13 Concentrations of *E. coli* on sample planes on 4 separate occasions.

While samples were also analysed for total coliforms, the results of this analysis was excluded from Table 6.13 as their presence in the soil moisture samples at low concentrations is not conclusive of domestic wastewater contamination. While there is no evidence of bacteriological contamination on the red and blue depth planes, the one sample taken from the black plane was contaminated with enteric bacteria. As the particle size analysis of the subsoil revealed it to have a high sand content it is therefore possible that the associated grain size, and consequently pore size, facilitated the movement of bacteria through the subsoil. The reduced biomat development, the presence of which would improve filtration of the percolating effluent, would also have the effect of increasing the hydraulic load per unit area.

The tracer tests carried out on site show that by day 8 the presence of bromide had been recorded on the 3 depth planes of the 0m sample position. While the main mechanisms for the removal of enteric bacteria from the percolating effluent are inactivation/die-off, filtration and adsorption, analysis of these results allied with literary evidence of enteric bacterial survival times in subsoils suggests that filtration and adsorption, rather than die-off, were the dominant removal mechanisms at work.

6.5 Summary

As was the case on Site 1, analysis of flow from the septic tank revealed that the hydraulic loading experienced on Site 2 was less than the design hydraulic load of 25 l/m^2d. On this basis therefore, the percolation area was hydraulically over-designed as the adjusted daily average flow measured over the project duration, 294.9 l/d, would only require 26m of percolation trench rather then the 80m constructed (EPA, 2000). Where samples were obtained from the small lysimeters it was found that, less than 26m of percolation trench was utilised which suggests that the design loading rate of 25 l/m^2d under estimates that experienced on Site 2 whereby the area that did receive SE experienced a higher loading rate of 39 l/m^2d. However, as this site was only monitored for a year it is not possible to know how much more biomat formation along the base of the percolation trenches would occur with time, which would promote more even distribution laterally across the percolation area.

The installation of a secondary treatment system in the form of a Puraflo® unit greatly reduced the bacterial and organic load on the percolation area. This reduction in organic load also had the effect of inhibiting biomat formation and thus the distribution of effluent over a greater area. While the aerobic environment of the Puraflo® facilitated the nitrification of NH_4, a reduction in overall nitrogen loading of over 50% was experienced across the system due to perceived saturation in the base of the modules which would mean that the total nitrogen loading to the groundwater could, for many other secondary treatment systems, be higher.

Within the subsoil it can be seen that most of the attenuation of the percolating effluent occurred above the red depth plane (Tables 6.14 and 6.15). Allowing for the effects of dilution by effective rainfall, it appears that approximately 98% of this reduction was due to chemical, physical and biological activity within the subsoil. While the blue depth plane represents the minimum recommended thickness of unsaturated soil above the water table, or the point of discharge of effluent to groundwater, the potential for further effluent contamination between this point of discharge and any potential target must also be considered.

Sample Point	Average Concentration (mg/l)		
	COD	Total Inorganic N	PO_4-P
Puraflo® effluent	188.05	64.04	33.50
Red Depth Plane	107.54	59.23	23.90
Blue Depth Plane	76.17	57.90	20.55

Table 6.14 Average concentrations measured on Site 2.

Sample Position	Number of Samples	Number of samples with concentration (cfu/100ml)			
		<10	10-100	101-1000	>1000
Puraflo®	4				4
Red Plane	5	5			
Blue Plane	5	5			

Table 6.15 Comparison of *E. coli* concentrations measured during the project.

7 ANALYSIS OF RESULTS OBTAINED FROM SITE 3

7.1 Introduction

A successful site assessment was completed for Site 3 on 13th May 2003. While the septic tank treatment system was commissioned on 9th July, sampling did not begin until 23rd September 2003. During this period the sampling instrumentation was removed from Sites 1 and 2, cleaned and then installed on Sites 3 and 4. The experience from Sites 1 and 2 had shown that there would be little relevance from any results gained from sampling over the first couple of months whilst both the septic tank and percolation areas started to become established. As the dwelling on Site 3 had just been completed and any surface water drainage had, on the word of the builder, been diverted to a soakaway, diversion works were not required. The installation of sampling equipment commenced on 27th August and all equipment was in place by 29th August 2003. Sampling was carried out from 23rd September 2003 until 18th March 2004.

7.2 Analysis of Flow Data

The ultrasonic level probe with attached datalogger, previously installed on Site 2, was installed in the pump sump for the stratified sand filter downstream of the distribution box on Site 3. As the effluent was evenly split by the distribution box between the sand filter and the percolation trenches, measured flows at the pump sump were doubled to produce the actual overall flow emanating from the household. Flows were measured from 15th September 2003 until 19th March 2004 (Appendix C). Apart from a few brief periods where the storage capacity of the datalogger had been reached it represents a continuous record of flow from the septic tank over the sampling period.

The average daily flow recorded on Site 3 (Table 7.1) equates to a hydraulic load of 82.3 lcd which is again less than the typical daily hydraulic load of 180 lcd specified by the EPA (EPA, 2000). As can be seen from Table 10.1, the calculation of the average daily flow included days where zero flow was recorded. Unlike the flow calculations for Site 2, these were not excluded as they were isolated incidents, i.e. did not represent prolonged periods of absence such as holidays.

	Maximum	Minimum	Average
Daily Flow (l/d)	1054.0	0.0	329.2
Total Flow (l/d)	N/A	N/A	334.1

Table 7.1 STE flows measured on Site 3.

While the dwelling at Site 3 had only been completed in June 2003 and the builder had guaranteed separation of surface runoff and domestic wastewater it appears from Figure 7.1 that this was not the case. While there is variation in the STE flow at times of low rainfall, and also in the absence of rainfall, it appears that there seemed to be an enhancement of peak flows during rainfall events. Allied to this was the fact that some flow was observed at the distribution box during rainfall events when there was no activity within the dwelling. This means that the measured flow includes a contribution by rainfall and therefore overestimates the average domestic wastewater production. When the STE flow was averaged over the days when no rainfall was recorded it was found to be 312.2 l/d or 78.1 lcd which would be a better estimate of the average daily wastewater production.

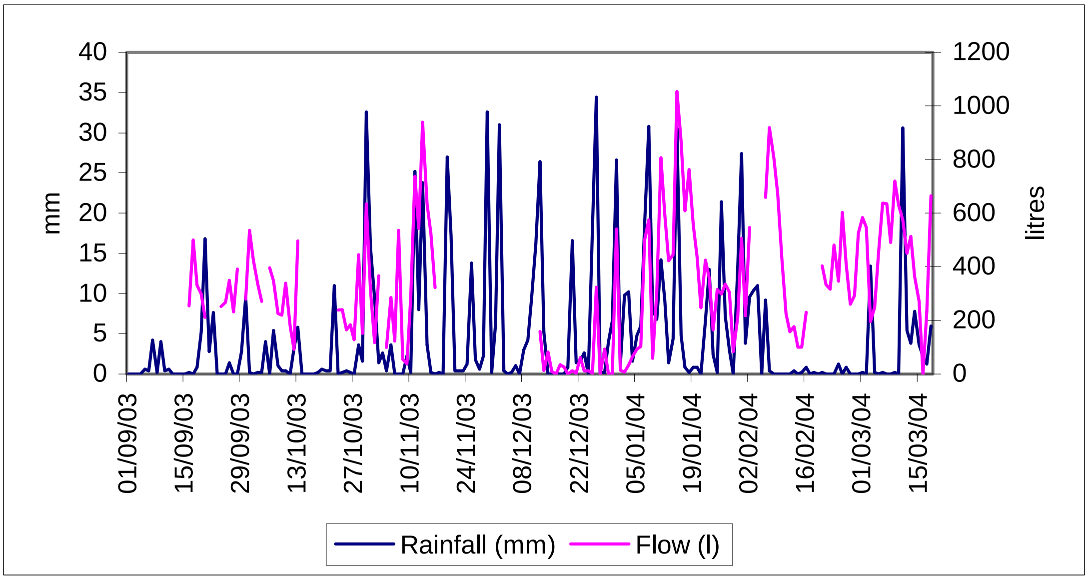


Figure 7.1 Graph of measured flow against rainfall in Site 3.

There were 15 days over the research period when zero flow was recorded. When these records are excluded, the frequency distribution of the recorded flow rates (Figure 7.2) shows that 70% of the flows recorded fall within the range 20 – 480 l/d. The average flow over this range was 215.2 l/d. When the daily flow regime emanating from the septic tank was examined in greater detail it was found that 80% of flows were in the range 0 - 1.8 l/min (Figure 7.3). The same V-notch modification used on Sites 1 and 2 was used to achieve even distribution within the distribution box, which had been shown to be particularly effective over this flow range, as discussed in Section 3.2.3.

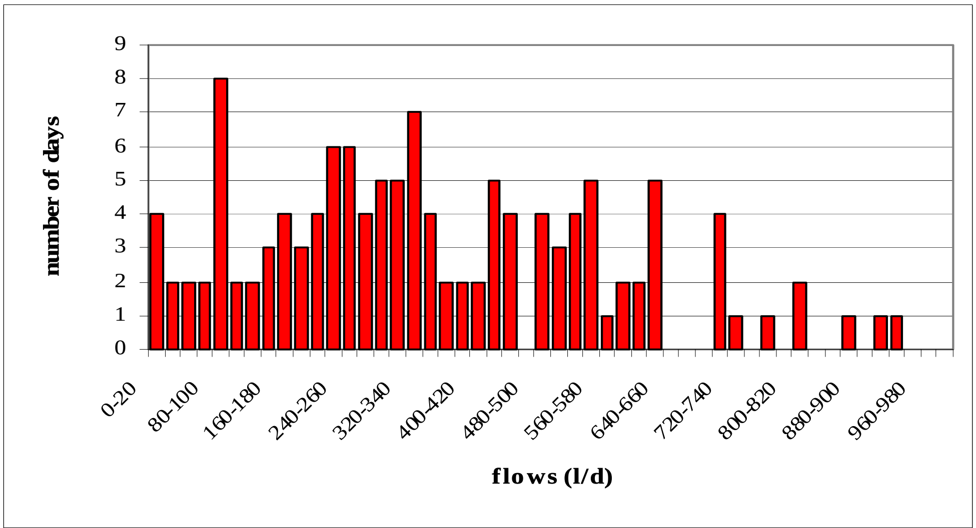


Figure 7.2 Frequency distribution of STE flows recorded on Site 3.

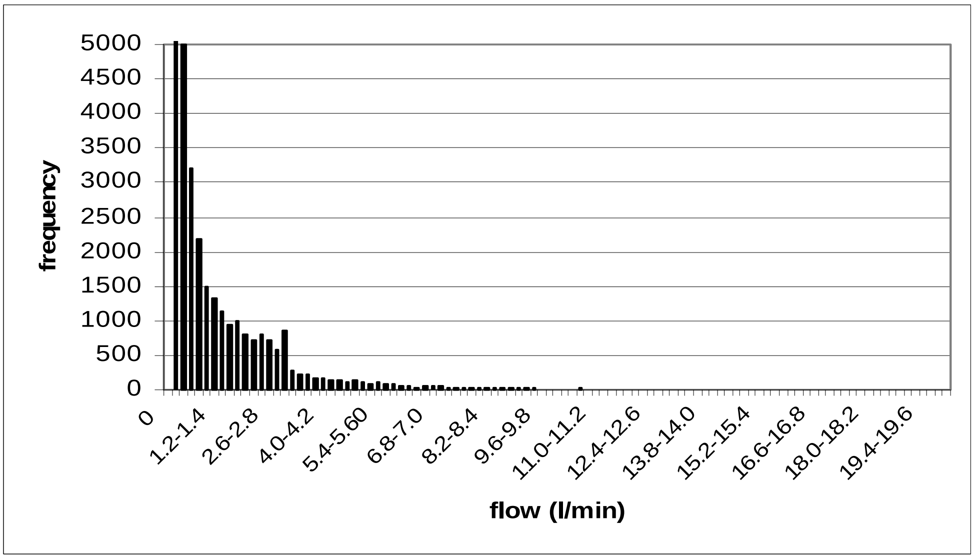


Figure 7.3 Frequency distribution (l/min) of flows recorded on Site 3.

7.3 Results of Analysis of Septic Tank and Soil Moisture Samples

7.3.1 Method of Analysis

To enable the representation of effluent attenuation by the subsoil below the percolation trench the subsoil was again divided into 3 sections: 0 to 0.4m, 0.4 to 0.8m and 0.8 to 1.2m. Three nominal depths of 0.2m (red), 0.6m (blue) and 1.0m (black) were then defined to represent the middle of these sections and thus the location of the lysimeters porous cups. As can be seen from Table 4.2 it was not possible to install the black lysimeter at the 20m sample position to the desired depth and it had to be reclassified as a blue lysimeter prior to chemical and bacteriological analysis.

The results of soil moisture samples for Cl were again used to determine which of the two methods outlined in Section 5.3.1, planar average or depth average, was the better method for representing the distribution of STE within the percolation area. When the average Cl concentrations at the three sample positions were graphed (Figure 7.4) it suggested that the depth average method (and not the planar average method) was the more representative as background-only Cl concentrations were measured at the other sample positions (Table 7.2). When the average Cl concentrations for each depth plane at the 0m sample position were plotted it was discovered that they were very similar (Figure 7.5) suggesting that the effluent was distributed over less than the first 10m of both percolation trenches. While there were isolated incidents of elevated Cl concentration at 10m it appears that biomat formation along the base of the percolation trench on Site 3 had not been as successful in effluent distribution as on Site 1. These incidents on the 03/02/04 and 18/03/04 were preceded by periods of high STE flow and it is possible that this increased hydraulic load facilitated the distribution of STE along a greater length of percolation trench. These increases were mirrored on the blue and black planes also. It is also possible that increases were due to the development of the biomat along the base of the trenches but as no further sampling was possible this could not be corroborated. There was no perceived explanation for the elevated concentrations measured on the 20/09/03 and 04/11/03. While the reduction in Cl concentration between 04/11/03 and03/02/04 appears to be due to an increased contribution of effective rainfall (Section 7.3.2), the drop in measured Cl concentration on 19/02/04 is thought to be due to analysis being carried out in the absence of the regular analysts on those dates.

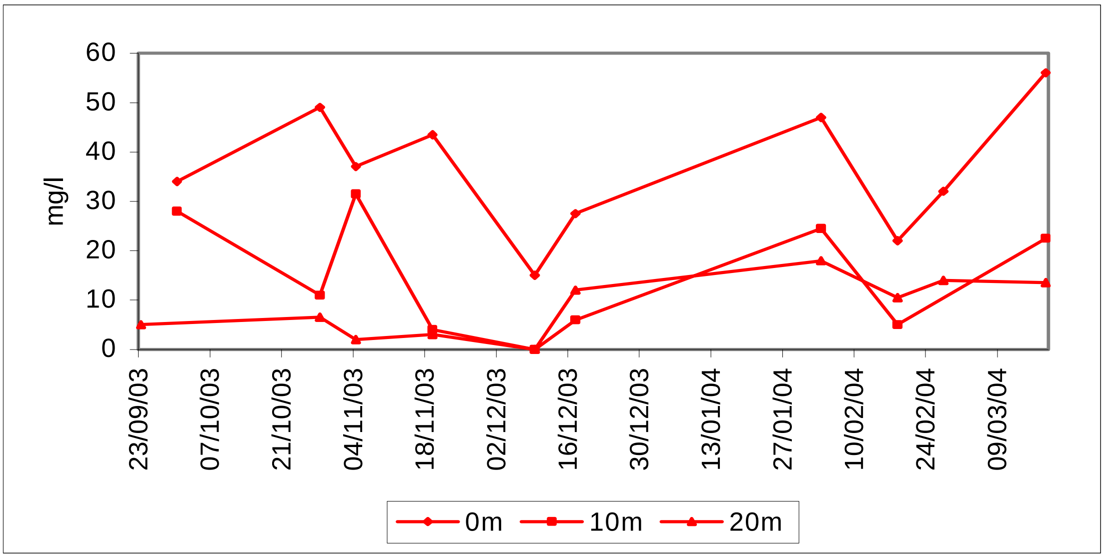


Figure 7.4 Average Cl concentrations on the red depth plane at the 3 sample positions.

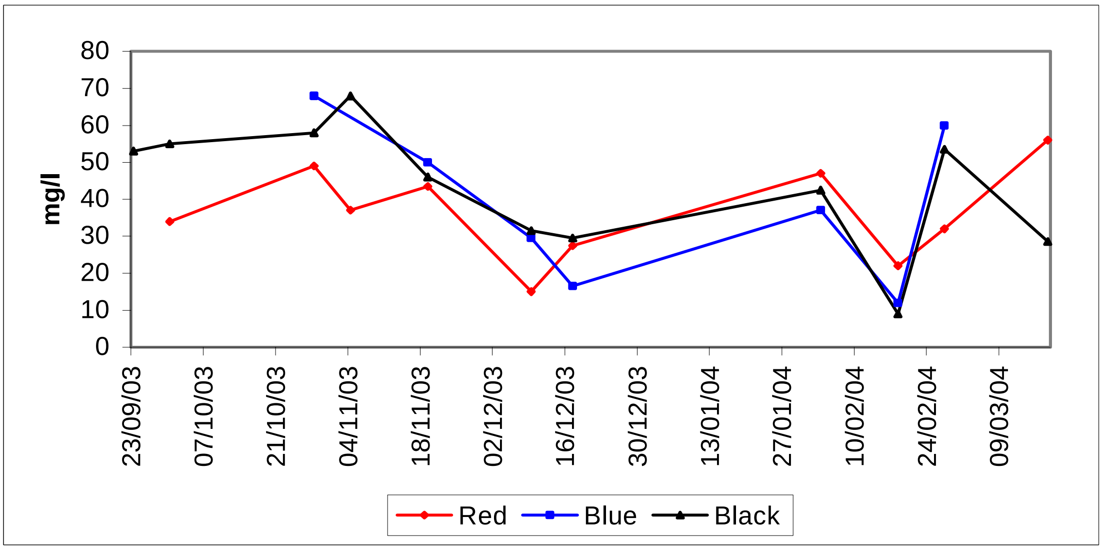


Figure 7.5 Cl concentration measured on the 3 depth planes at the 0m sample position.

Sample Point	1	2	3	4	5	6	7	8	9
Average concentration	29.5	35.2	39.3	9.29	11.3	9.8	9.3	9.7	9.8
Sample Point	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Average concentration	39.4	32.9	39.0	18.6	8.3	8.6	8.0	8.4	6.6

Table 7.2 Average Cl concentrations (mg/l) measured under percolation area on Site 3.

Although the T-value of 33 on Site 3 was twice the T-value recorded on Site 1, it is possible that it is not a true reflection of the overall percolation characteristics of the subsoil. As the subsoil has been described under BS5930 as very gravely clayey SAND with some cobbles (Section 2.4.3) the abundance of gravel and cobbles within the subsoil matrix lends itself to the possibility of the presence of preferential flowpaths. The presence of such preferential flowpaths over the first 10m of percolation trench may have mitigated against distribution of the effluent along the base of the whole trench. It would also reduce the residence time of the effluent within the trench thus impeding biomat formation. However, if such preferential flowpaths existed they were obviously not reflected at the two discrete T-test hole locations. It should also be considered that preferential flowpaths receiving such septic tank effluent with high organic concentrations could have a tendency to block up with time as biofilms develop under such high organic loading. However, although there was some evidence of such a phenomenon it could not be firmly established on either Sites 1 or 3 and is outside the scope of research carried out. Moreover, the location of the lysimeters, as outlined in Section 7.3.2 also has to be considered with respect to the results from this site.

7.3.2 The Effect of Dilution on Effluent Attenuation

The quantification of effluent dilution within the subsoil and estimation of the zone of contribution proved problematic for Site 3 for a number of reasons. Due to the dense and gravelly nature of the subsoil on Site 3 it was not possible to install the lysimeters directly below the percolation trenches although they were installed as close as possible to the edge of the distribution gravel placed below the percolation pipe. As a result, the ceramic cups, especially those on the red depth plane, might not have been fully immersed in the effluent plume. With effluent dispersion the deeper lysimeters would be more centrally located within the plume resulting in lower Cl concentrations at the shallower lysimeters as highlighted in Figure 7.4. This is borne out by the soil moisture tension measurements. As with the lysimeters the tensiometers were installed adjacent to, rather than in, the percolation trenches. As no effluent was recorded at the 20m sample position it appears from Figures 7.6 and 7.7 that both sets of tensiometers responded to effective rainfall rather than the percolating effluent. This suggests that the tensiometers at the 0m sample position were installed outside the effluent plume. While the tensiometers on Site 4 were also installed adjacent to the percolation trenches it is possible that the higher T-value of the subsoil on Site 4 promoted lateral plume dispersal. As the tensiometers and lysimeters on Site 3 were located similar distances from the edge of the percolation trench it is possible that some lysimeters did not sample STE, although the affect of suction on obtaining a sample must be considered. It is therefore possible that as the lysimeters at the 10m and the lysimeters and tensiometers at the 20m sample positions were installed further from the trench edge than those at the 0m sample position, due to the inability of the Minute Man to obtain the correct depth at those sample positions, and due to the narrow width of the effluent plume, as highlighted by the tensiometer readings, that the effluent actually reached the 10m and/or 20m sample positions but was not sampled.

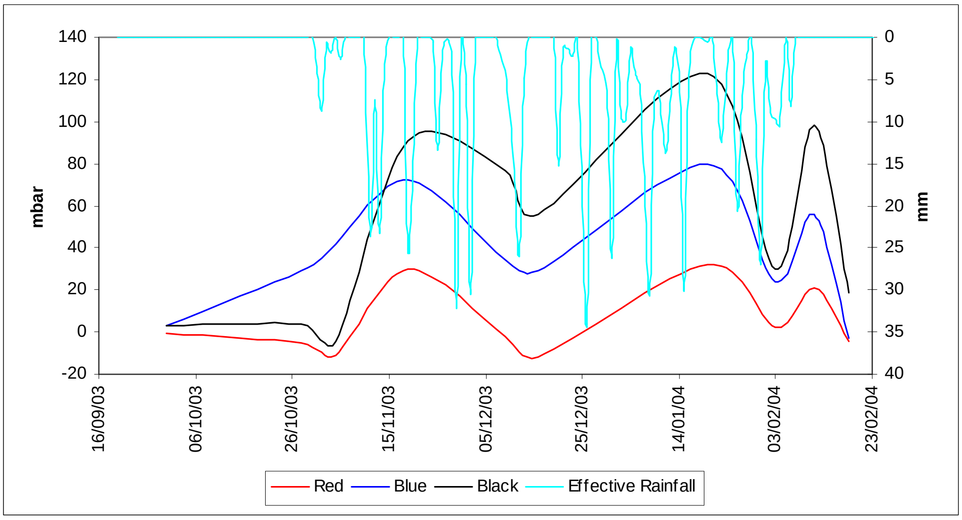


Figure 7.6 Soil moisture tension plotted against effective rainfall for the 0m sample position on Site 3.

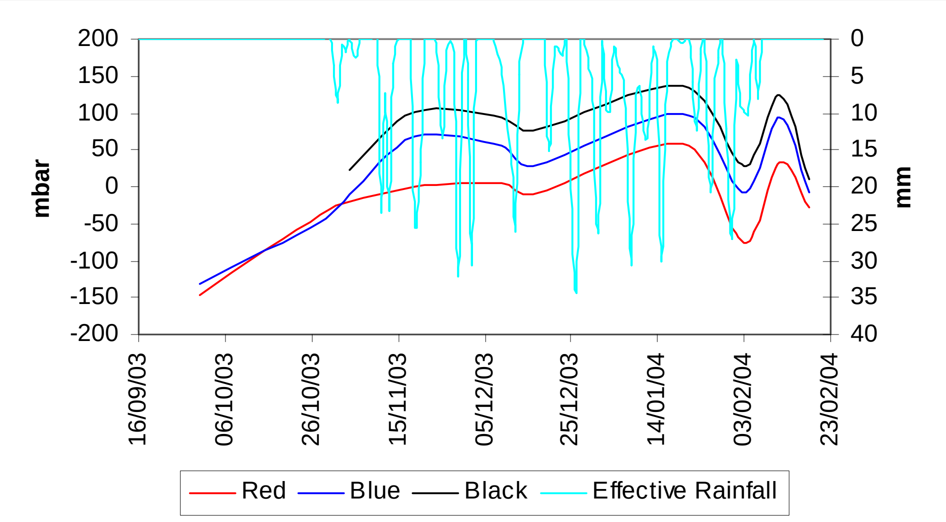


Figure 7.7 Soil moisture tension plotted against effective rainfall for the 20m sample position on Site 3.

While a rain gauge was installed on site, no other local meteorological data was available and it was therefore necessary to use data obtained from the weather station on Pollardstown Fen approximately 52km to the north-west to calculate the potential evapotranspiration. While this distance was a concern with respect to the suitability of the data it was decided that, since local rainfall data was available and as the Agroclimatic Atlas of Ireland (AGMET, 1996) showed evapotranspiration to be similar for the two areas, the Pollardstown data would be useful in estimating the contribution of effective rainfall to effluent dilution. The potential evapotranspiration was calculated using the Hargreaves method (Equation 5.1) as only limited meteorological data was available from the station at Pollardstown Fen. The rainfall at Site 3 for the period 01/09/03 to 18/03/04 was measured as 922.8mm and using the Hargreaves method the effective rainfall for this period was calculated as 697.3mm. As expected, the influence of effective rainfall was greatest during the winter months when there was no soil moisture deficit; rainfall was higher and temperatures and plant respiration, hence evapotranspiration, were lower. This affect on soil moisture content, and hence dilution, is seen in the reduction in soil moisture tension highlighted by the tensiometer readings in Figures 7.6 and 7.7.

During the analysis of the results for Site 2 it was noticed that Cl concentrations measured in the STE were greater than Cl concentrations measured in the SE. As the Puraflo® modules were sealed preventing rainwater infiltration and as Cl does not react with the peat media, it was suspected that this reduction in Cl concentration was a result of physical straining of the effluent by the peat media thus reducing its turbidity. As this also occurred on Site 2 it was decided to analyse both filtered and unfiltered samples of STE for Sites 3 and 4 for Cl in an attempt to quantify this reduction in Cl concentration caused by the removal of particulate matter. It should also be noted that the soil moisture samples were also filtered by the porous cups, which had a maximum pore size of 1.3 μm and therefore, to maintain consistency, both STE and SE samples should be filtered. Filter paper used was Whatman GF/C paper with a retention of 1.2 μm. A 23% reduction in the Cl concentration was found on average when the STE sample was filtered (Table 7.3). As Cl concentrations measured on the black depth plane were, in general, greater than those measured on the other two depth planes (for reasons outlined above) it was decided to use the difference in Cl concentration between the filtered STE and the black depth plane to estimate the contribution of the effective rainfall to effluent dilution and the other two depth planes using a 2% difference between each depth plane. However, it can be seen from Figure 7.8 that the relationship between effective rainfall and effluent dilution was not as well defined for this data set as it was for Sites 1 and 2. That is to say there appears to be no correlation between the volume of effective rainfall and the difference in Cl concentration between the STE and the black depth plane. As it was not possible therefore to quantify the contribution of effective rainfall to effluent dilution and the loading rate of the various wastewater constituents at the three depth planes, it had to be estimated using the STE flow rate and an estimation of the dilution effect which was calculated using the average dilution effect for Sites 1 and 2. This equated to a dilution effect equivalent to, on average, the addition of 0.13 l/l (or 11.6% reduction in concentration) for the red depth plane, 0.16 l/l (or 14.1% reduction in concentration) for the blue depth plane and 0.20 l/l (or 16.6% reduction in concentration) for the black depth plane.

Concentration (mg/l)			
Site 3		Site 4	
Unfiltered	Filtered	Unfiltered	Filtered
43	35	103	61
96	75	135	105
80	76	132	64
82	71	57	44
100	81	85	54
159	116	63	60
42	45	56	48
140	122	62	58
63	48	103	76
Average Reduction (%)		**22.6**	

Table 7.3 Reduction in Cl concentration in STE due to filtration

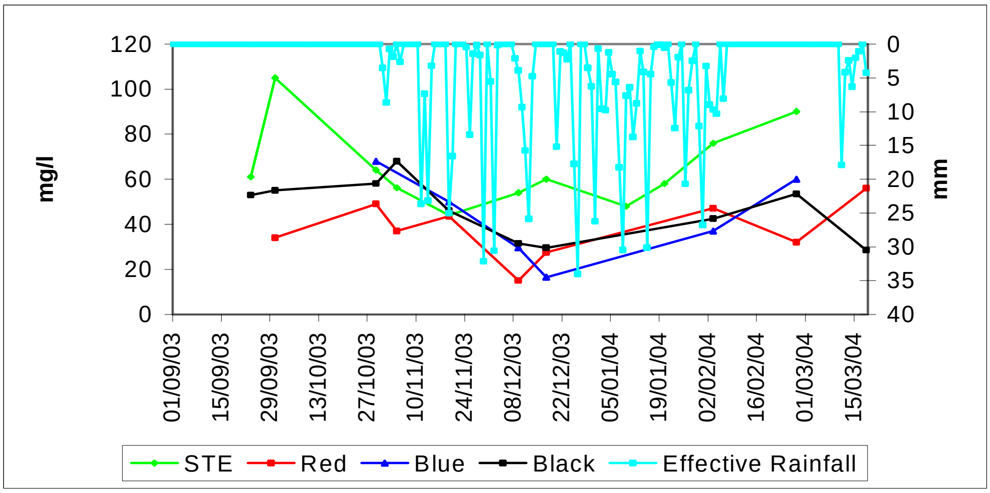


Figure 7.8 Graph showing Cl concentrations and effective rainfall between 01/09/03 and 18/03/04.

When the Cl concentration of the STE was graphed against the rainfall measured on Site 3 for the project duration it was found that, as rainfall increased, there was a corresponding decrease in the Cl concentration of the STE (Figure 7.9). This is reflected in the variation of the other STE constituents over the sampling period (Figures 7.10 to

7.12). This appears to corroborate the findings of the flow data analysis (Section 7.2) which suggested that domestic wastewater effluent was being diluted by surface water.

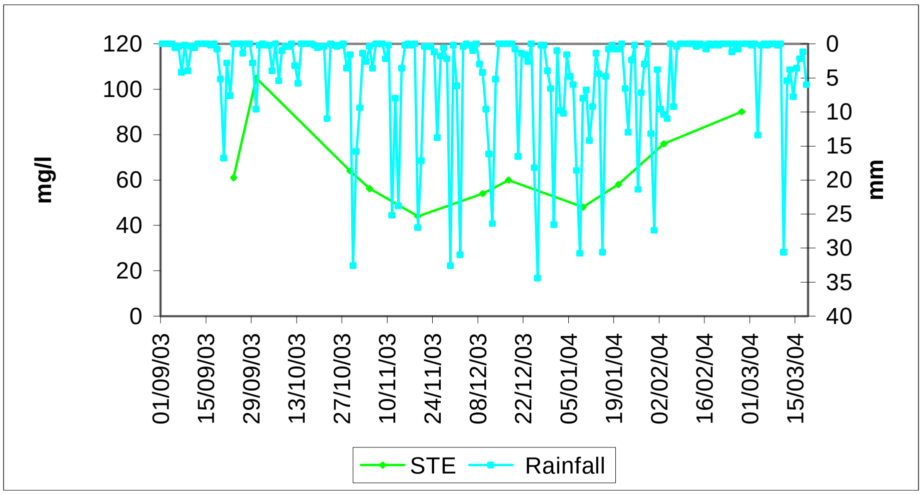


Figure 7.9 The effect of rainfall on STE Cl concentrations at Site 3.

7.3.3 Results of Chemical Analysis (percolation area)

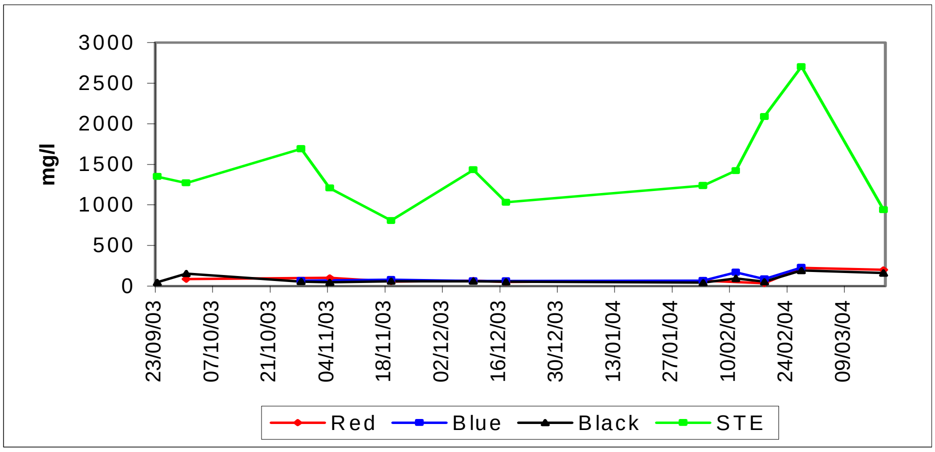
The results of all chemical analysis carried out on STE and soil moisture samples are contained in Appendix D. Table 7.4 summarises the results of the STE chemical analysis.

	Concentration (mg/l)					
	COD	**NH_4-N**	**NO_2-N**	**NO_3-N**	**PO4-P**	**Cl**
Maximum	2703.0	71.1	0.7	4.3	16.7	135
Minimum	540.0	19.8	0.22	0.5	3.0	56
Average	***1307.8***	***41.7***	***0.45***	***2.0***	***7.4***	***88.4***

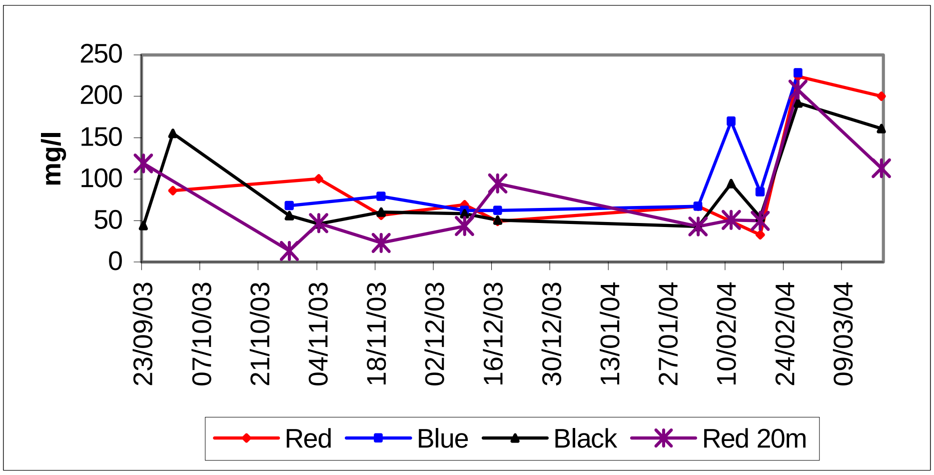
Table 7.4 Summary of chemical analysis of STE on Site 3.

COD

As the lysimeters are slightly offset from the percolation trenches and therefore not centrally located within the effluent plume it is difficult to quantify the attenuation above the red depth plane and between the red depth plane and the other depth planes. It is clear from Figure 7.9 (a) and (b) and Table 7.5, however, that there is, on average, a 94% reduction in COD concentration between the STE and the black depth plane. Due to the similarity between the COD concentration on each depth plane it is clear that the majority of the reduction in COD concentration occurs above the red depth plane. It is also clear from Figure 7.9 (b) that when COD concentrations measured at the 0m sample position were compared with those measured at 20m, where STE was not present, that they are very similar. This suggests that the organic content of the STE has been reduced to background levels by the black depth plane.



(a)



(b)

Figure 7.10 Comparison of COD concentrations **(a)** between STE and the subsoil and **(b)** between the three depth planes at 0m and the red depth plane at 20m.

It appears from the results achieved in Site 1 that the majority of this reduction occurs within the percolation gravel and possibly the top few centimetres of the subsoil rather than deep within the subsoil. The oxygen required to achieve this reduction in COD concentration between the STE and the red depth plane, 1303.7 mg/ld or 0.4kg/d on average, is present within the distribution gravel in the percolation trench, which is aerated by means of a ventilation pipe. As only two percolation trenches were in use on Site 3, as opposed to four on Sites 1 and 2, there is 1.1kg of O_2 available within the percolation trenches to meet demand. Further reduction in COD concentration within the subsoil would result from a combination of physical, chemical and biological processes.

	Concentration	Load	
	(mg/l)	(g/d)	Removal (g/d)
STE	1307.2	215.1	-
Red Depth Plane	128.5	23.9	191.2
Blue Depth Plane	102.7	19.6	4.3
Black Depth Plane	84.7	16.7	2.9

Table 7.5 Average reduction in COD on Site 3.

NITROGEN

The reduction in total inorganic nitrogen concentration of STE from November 2003 corresponds to a period of increased rainfall, as outlined in Section 7.3.2. This period of increased rainfall resulted in an increase in effective rainfall although this had less of an influence on the total inorganic nitrogen concentration measured on the red and black depth planes in the subsoil (Figure 7.11). It was only possible to calculate total inorganic nitrogen concentrations for four occasions on the blue depth plane. It appears from Figure 7.11 and Table 7.6 that the greatest reduction in nitrogen concentration occurred between the red plane and the black plane. While nitrification was evident from the high concentration of NO_3 measured in soil moisture samples obtained from the red and blue depth planes there was no parallel denitrification over the same subsoil thickness. It is possible that due to the location of these lysimeters within the fringe of the effluent plume that the hydraulic load was not sufficient to produce saturated conditions which would promote denitrification. It is therefore possible that denitrification would occur on the same depth planes at a more central location within the plume where conditions would be more favourable, as seen on Site 1. It is also possible that the increase in soil moisture content with depth, as highlighted by the tensiometer readings in Figure 7.6, led to the creation of anoxic conditions thereby promoting denitrification between the blue and black depth planes. It is also possible that the saturated conditions experienced directly below the percolation trench promoted removal of NH_4 from the percolating effluent by cation exchange.

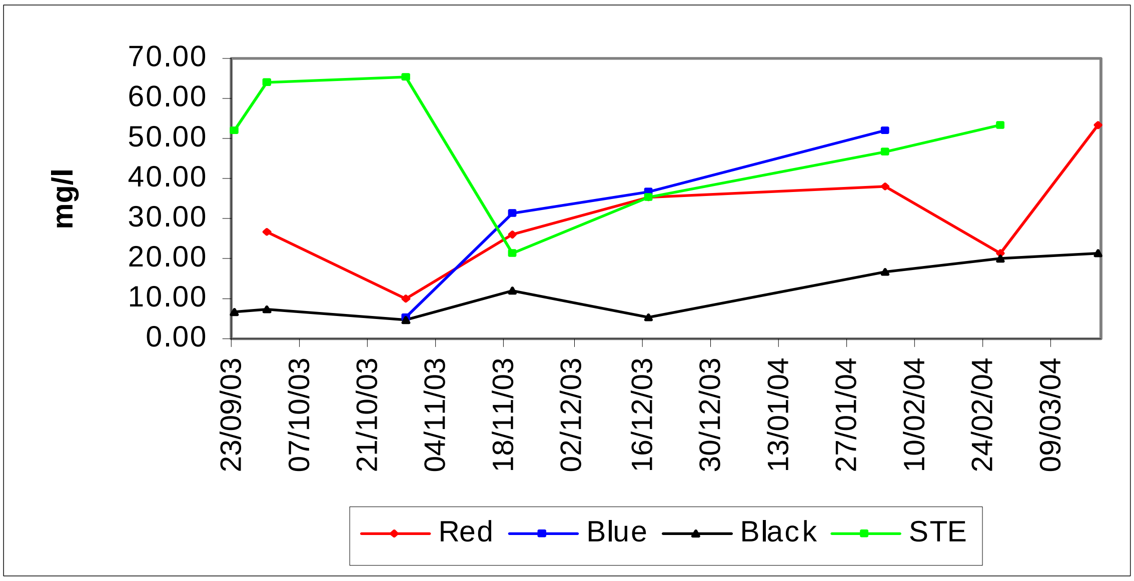


Figure 7.11 Total inorganic nitrogen (mg/l) measured on Site 3.

Depth Plane	NO_3-N		NO_2-N		NH_4-N		Total inorg. N		pH
	Conc. (mg/l)	Load (g/d)	Conc. (mg/l)	Load (g/d)	Conc. (mg/l)	Load (g/d)	Conc. (mg/l)	Load (g/d)	
STE	2.0	0.4	0.5	0.09	41.7	8.08	48.4	8.57	7.68
Red	22.0	3.6	0.3	0.05	5.1	0.9	30.1	4.55	6.80
Blue	20.9	3.4	0.7	0.12	7.2	1.2	31.3	4.72	6.78
Black	6.1	1.0	0.4	0.07	3.8	0.6	11.7	1.67	6.97

Table 7.6 Average NO_3-N, NO_2-N, NH_4-N and Total inorganic N concentration measured on Site 3.

PHOSPHOROUS

The ortho-PO_4 concentration in the STE was, on average, very similar to those values discovered in the Literature Review even though it appeared that the STE had been diluted by some rainwater. As was the case with COD reduction it can be seen from Table 7.7 and Figure 7.12 that the greatest reduction in effluent ortho-PO_4 concentration occurred above the red depth plane. The high clay content of the subsoil below the percolation area on Site 3, revealed by the particle size analysis contained in Appendix A, suggests that the removal of phosphate from the percolating effluent was controlled by soil adsorption. As the subsoil only has a finite capacity to adsorb PO_4 and as soil moisture samples were only analysed over an eight-month period, this depth of subsoil active in PO_4 fixation will increase with time.

	Concentration	**Load**	
	(mg/l)	**(g/d)**	**Removal (g/d)**
STE	7.4	1.22	-
Red Depth Plane	0.4	0.07	1.15
Blue Depth Plane	0.2	0.04	0.03
Black Depth Plane	0.1	0.02	0.02

Table 7.7 Average reduction in ortho-PO_4-P on Site 3.

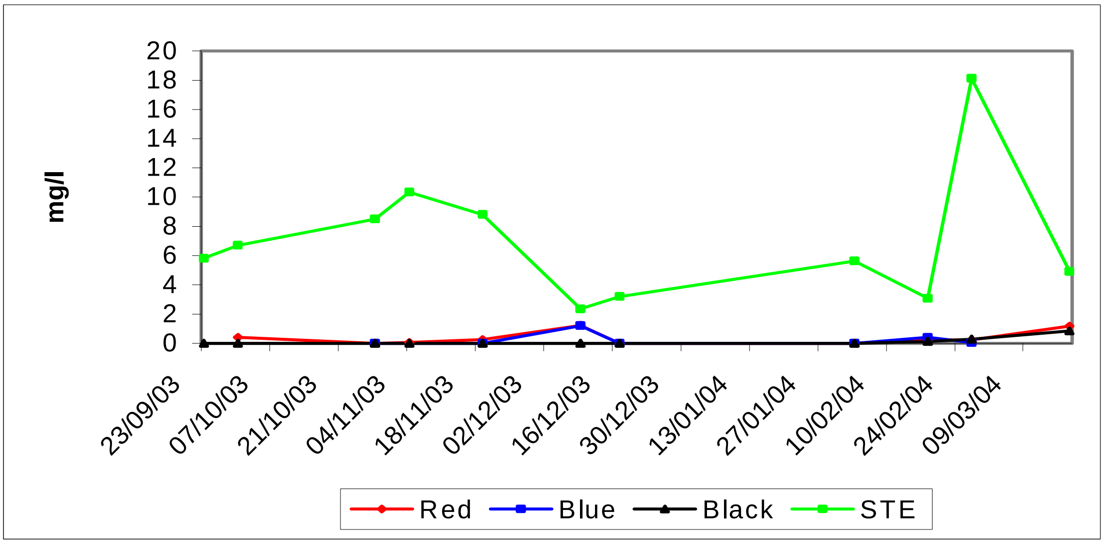


Figure 7.12 Ortho-PO_4-P concentrations measured on Site 3.

7.3.4 Results of Bacteriological Analysis (percolation area)

Due to financial constraints and the fact that the area was shut off for 4 weeks whilst the high loading trial on the stratified sand filter was carried out, it was only possible to send two sets of samples from Site 3 for bacteriological analysis. On both occasions samples sent for analysis were obtained from Trench 2 only. Assuming that the results obtained from the bacteriological analysis of these samples are representative of the sample position from which they were obtained it can be seen from Table 7.8 that, allowing for the factor of safety introduced due to sample dilutions, there was complete removal of enteric bacteria by the black depth plane.

	Number of Samples	Number of samples with concentration (cfu/100ml)			
		<10	10-100	10^2-10^3	>10^3
STE	2				2
Red Plane	2	1	1		
Blue Plane	1	1			
Black Plane	2	2			

Table 7.8 Concentrations of enteric bacteria measured on Site 3.

7.4 Results of Analysis of Stratified Sand Filter

7.4.1 Hydraulic loading

The average hydraulic load on the sand filter during the year was 172 l/d equating to a loading rate of 28.6 l/m^2d with a dosing frequency of 3.48 pumps per day on average. However, from 14th December – 21st January 2004 a high loading trial was carried out for five weeks whereby all the flow from the distribution box was directed onto the sand filter (ie none to the trenches). This was carried out to assess the filter's performance at higher loading rates which are closer to the original design value of 60 l/m^2d. During this period there was an increase in the average hydraulic loading rate to 57.2 l/m^2d which equated to 8.26 pumps per day.

The T-value of the subsoil beneath the sand filter was 33. The piezometers in the sand filters revealed no significant head during the year at the lower loading rate of 28.9 l/m^2d but a continually rising head at the higher loading rate of 57 l/m^2d, increasing to 0.4m above the base at the end of the trial after five weeks. This indicates that such a loading rate is probably too high for a filter receiving septic tank effluent discharging into subsoil with a T-value of 33.

7.4.2 Results of Chemical Analysis (Stratified Sand Filter)

The results of all chemical analysis carried out on the stratified sand filter and soil moisture samples are contained in Appendix E. The load calculations have been calculated according to the average hydraulic loading rates for each period (the normal and high loading trials) augmented by the average rainfall values across each respective period, assuming no significant evapotranspiration due to the high permeability of the filter and the absence of vegetation. This resulted in a 13 % dilution during the normal trial and 15% dilution in the high loading trial.

COD

The results of the COD analyses are shown on Table 7.9 which gives the average values for both the normal and high hydraulic loading trial periods down through the sand filter layers and into the soil beneath.

	COD conc. (mg/l)	COD load (g/d)	Load removed (g/d)
STE	1432.2 (660.0)	246.0 (226.6)	- -
Coarse sand (depth 0.3m)	579.7 (500.0)	113.1 (197.4)	132.9 (29.2)
Medium sand (depth 0.475m)	261.3 (276.0)	51.0 (109.0)	62.1 (88.4)
Fine sand (depth 0.75m)	218.5 (276)	42.7 (109.0)	8.3 (0.0)
Subsoil (depth 1.3m)	79.9 (70.0)	15.6 (27.5)	27.1 (82.0)
Subsoil (depth 1.6m)	64.5 (53.0)	12.6 (20.9)	3.0 (6.6)
Subsoil (depth 1.9m)	70.1 (52.9)	13.7 (20.9)	-1.1 (0.0)

Table 7.9 Average COD concentrations and loads in sand filter and subsoil.
Note: figures in brackets indicate values during high loading trial

Although the hydraulic loading rate during the high loading trial was approximately double that experienced during the rest of the year, the effluent concentration from the septic tank happened to be a lot weaker on average which meant that the average COD load onto the filter was approximately the same during both periods. This period of weaker effluent coincided with the period of greatest rainfall thus confirming the contribution of surface runoff to STE. During the normal hydraulic loading period (28.6 l/m^2d), the greatest COD removal was in the upper layers of the filter as expected for such a biofilm process. At shallow depths there are high organic concentration gradients across the biofilm and also a plentiful supply of oxygen at the level closest to the surface. As the COD concentrations decreased with filter depth, there was a reduction in load removed, although a surprising drop in performance in the lowest fine sand layer which could be indicative of slightly anoxic conditions due to the extra hydraulic resistance through the finer sand promoting partially saturated conditions. The process performance graph for COD removal across the whole stratified sand filter is shown in Figure 7.13 which gives an overall performance coefficient, k=0.77. When similar performance graphs are plotted across each sand layer the respective performance coefficients are: coarse sand layer (k=0.52), medium sand layer (k=0.54) and fine sand layer(k=0.11), which again confirms the poor performance of the fine sand layer with respect to COD removal.

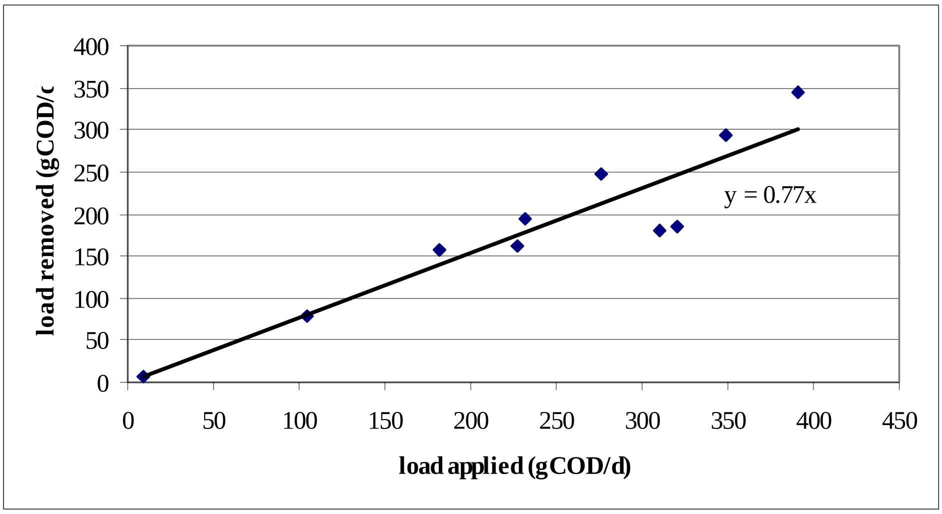


Figure 7.13 Graph of process performance for COD removal across whole filter

The COD concentrations measured below the filter in the subsoils at 1.3m depth (i.e. 0.25m below the sand filter) shows that there has been further COD removal, in the distribution gravel, base sand layer and top 250mm of subsoil. At the two deeper sample depths the COD removal was negligible with a concentration of 70 mg/l recorded at 0.85m below the base of the sand filter.

The COD analyses at the higher hydraulic loading rate (57.2 l/m^2d) revealed that the highest COD removal is in the medium layer of sand. This indicated that the effluent was percolating too quickly through the coarse layer of sand for an optimal removal at such a hydraulic loading rate, although it should be noted that the COD concentrations were much lower than the comparable levels during the normal loading rate across the rest of the year. The effluent concentrations from the lowest fine layer of sand are the same as those from the middle level, which confirms the measurements from the piezometer that this level was flooded at this higher hydraulic loading rate. The COD concentrations below the filter in the subsoil at 1.3m depth show that further removal of COD has occurred in the distribution gravel, base sand layer and top 250mm of subsoil indicating unsaturated conditions once the effluent has moved passed through the resistance offered by the fine sand. Again, below these levels in the subsoil the COD removal is negligible in the subsoil down to 1.9m depth where it has reached a concentration of 53 mg/l. Hence, these results indicate that the maximum hydraulic loading rate for a stratified sand filter used as a secondary treatment process for septic tank effluent should be no greater than 30 l/m^2d if such a fine sand specification for the bottom layer is adopted.

NITROGEN

The results of the analyses for the nitrogen species are shown on Tables 7.10 and 7.11. At the normal hydraulic loading rate the filter was acting to nitrify the effluent with depth, the ammonia being converted into nitrate which resulted in a reduction in pH from 7.8 to 7.3. However, in the fine sand layer there was also denitrification occurring with a reduction of approximately half of the nitrogen load giving further evidence of partially saturated conditions as discussed previously in relation to COD removal. Nitrification continued as the effluent percolated from the fine sand into the distribution gravel, base sand layer and top 250mm of subsoil. The nitrified effluent was also gradually denitrified with depth resulting in a total nitrogen load of 1.74 g/d at a depth of 1.9m. At the higher hydraulic loading rate of 57.2 l/m^2d, there was little evidence of nitrification in the top two layers of sand due to the higher organic loading at these levels favouring the heterotrophic bacteria over the nitrifiers. There was a significant reduction in the nitrogen load in the fine sand layer but there was no particular evidence of nitrification of the NH_4 before subsequent denitrification. This reduction in both NO_3 and NH_4 may be an indication of simultaneous nitrification and denitrification or possible evidence of the anaerobic oxidation of ammonia, the so-called Annamox pathway, under saturated conditions. Once the effluent has moved through the fine sand layer and infiltrated the subsoil the NH_4 is further nitrified under unsaturated conditions and lower organic concentrations which is completed by 1.6m depth in the subsoil. The nitrified effluent is then denitrified in the subsoil leaving a total nitrogen load of 2.31 g/d at a depth of 1.9m.

	NH_4-N	NO_2-N	NO_3-N	*Total N*
STE	47.0 (28.5)	0.5 (0.2)	2.3 (1.1)	*49.7* *(29.7)*
Coarse sand (depth 0.3m)	27.6 (28.6)	0.4 (0.2)	4.4 (0.5)	*32.2* *(29.3)*
Medium sand (depth 0.475m)	14.6 (25.3)	0.5 (0.1)	14.7 (0.5)	*29.3* *(25.9)*
Fine sand (depth 0.75m)	7.4 (19.0)	0.3 (0.1)	12.2 (0.7)	*19.8* *(19.8)*
Subsoil (depth 1.3m)	1.6 (10.6)	0.1 (0.5)	14.4 (8.8)	*16.1* *(19.9)*
Subsoil (depth 1.6m)	1.4 (0.2)	0.0 (0.1)	9.8 (9.2)	*11.2* *(9.5)*
Subsoil (depth 1.9m)	1.9 (0.2)	0.0 (0.3)	7.0 (5.4)	*8.9* *(5.8)*

Table 7.10 Average nitrogen concentrations (mg/l) in sand filter (Site 3).
Note: figures in brackets indicate values during high loading trial.

	NH_4-N	NO_2-N	NO_3-N	*Total N*	pH
STE	8.08 (9.77)	0.09 (0.06)	0.40 (0.38)	*8.53* *(9.33)*	7.8 (7.2)
Coarse sand (depth 0.3m)	5.38 (11.90)	0.08 (0.10)	0.85 (0.83)	*6.29* *(12.82)*	7.8 (7.3)
Medium sand (depth 0.475m)	2.85 (10.00)	0.10 (0.05)	2.87 (0.18)	*5.76* *(10.22)*	7.7 (7.5)
Fine sand (depth 0.75m)	1.44 (7.49)	0.07 (0.04)	2.38 (0.29)	*3.87* *(7.82)*	7.3 (7.3)
Subsoil (depth 1.3m)	0.31 (4.19)	0.02 (0.19)	2.81 (3.48)	*3.13* *(7.85)*	7.1 (6.7)
Subsoil (depth 1.6m)	0.27 (0.08)	0.01 (0.05)	1.92 (3.63)	*2.19* *(3.76)*	6.7 (6.6)
Subsoil (depth 1.9m)	0.37 (0.06)	0.01 (0.14)	1.36 (2.11)	*1.74* *(2.31)*	6.99 (6.50)

Table 7.11 Average nitrogen loads (g/d) in sand filter (Site 3).
Note: figures in brackets indicate values during high loading trial.

PHOSPHOROUS

The results of the analyses for ortho-PO_4 are shown in Table 7.12 which reveals that significant load removal occurred in both the coarse and medium sand layers under the normal hydraulic loading regime.

	Ortho-PO_4 conc (mg/l)	Ortho-PO_4 load (g/d)	Load removed (g/d)
STE	9.15 (2.96)	1.57 (1.02)	- -
Coarse sand (depth 0.3m)	4.56 (3.02)	0.89 (1.09)	0.68 (-0.07)
Medium sand (depth 0.475m)	1.83 (0.24)	0.36 (0.09)	0.53 (1.00)
Fine sand (depth 0.75m)	1.48 (0.27)	0.29 (0.11)	0.07 (-0.02)
Subsoil (depth 1.3m)	0.28 (0.01)	0.05 (0.00)	0.24 (0.11)
Subsoil (depth 1.6m)	0.06 (0.01)	0.01 (0.00)	0.04 (0.00)
Subsoil (depth 1.9m)	0.06 (0.01)	0.01 (0.00)	0.00 (0.00)

Table 7.12 Average ortho-PO_4-P concentrations and loads in sand filter and subsoil.
Note: figures in brackets indicate values during high loading trial

This was explained by investigation of the mineralogy of the three types of sand used in the filters using X-ray diffraction analysis (Figure 7.14) which revealed the existence of goethite in both the coarse and medium sands but not in the fine sand. Goethite is ferric oxide (Fe_20_3) which will act as an adsorption site for the soluble phosphate to form a ferric phosphate precipitate. The final removal of ortho-PO_4 by the 1.3m depth in the subsoil could be attributed to the thin layer of 50 mm of medium sand bedding on the base of the filter, although results from the percolation trenches indicate that the mineralogy of the subsoil is also conducive to phosphate adsorption on this site.

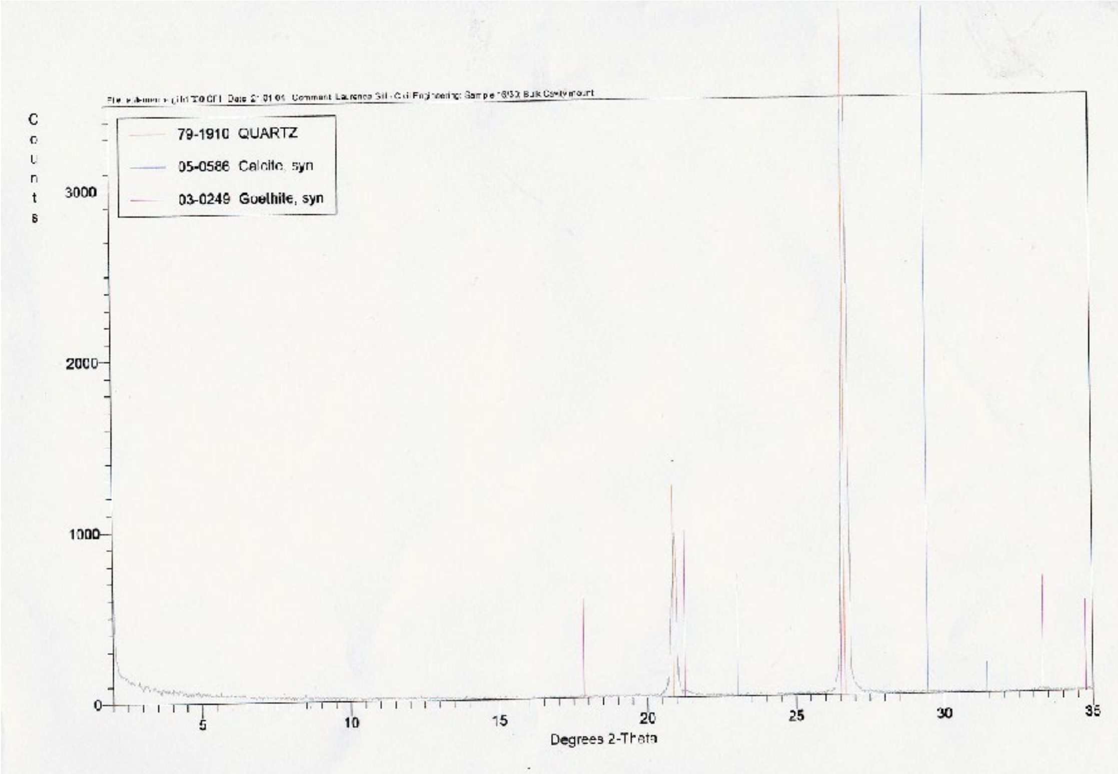


Figure 7.14 X-ray diffraction analyses of the coarse sand. (Note, similar results were found for the medium sand).

During the high loading trial ortho-PO_4 concentrations from the septic tank were significantly lower than the average values for the rest of the year. At these low concentrations and double the hydraulic loading rate the main phosphate removal takes place in medium sand layer. No removal was observed in the coarse sand (as had been measured at the slower rate with higher concentrations) since the effluent presumably moved too quickly through the sand for adsorption to occur at the lower concentrations. Again, all the remaining phosphate is removed by the 1.3m depth in the subsoil.

It should be recognised that the capacity for phosphate removal is specific to the type of sand used for the construction of the filter and is finite. The lifespan of a sand type with regards to phosphate adsorption could potentially be calculated with some simple experiments, for example, to calculate the Langmuir and Freudlich isotherms. The concept of using a sacrificial layer of sand could also be considered in areas of particularly nutrient sensitivity whereby an adsorptive layer of sand can be replaced by fresh sand periodically after its sorption capacity has been saturated. An analysis of the phosphate removal with time is shown for the stratified sand filter on Site 3 on Figure 7.15 which indicates no observable drop off in phosphate removal over the duration of the trial.

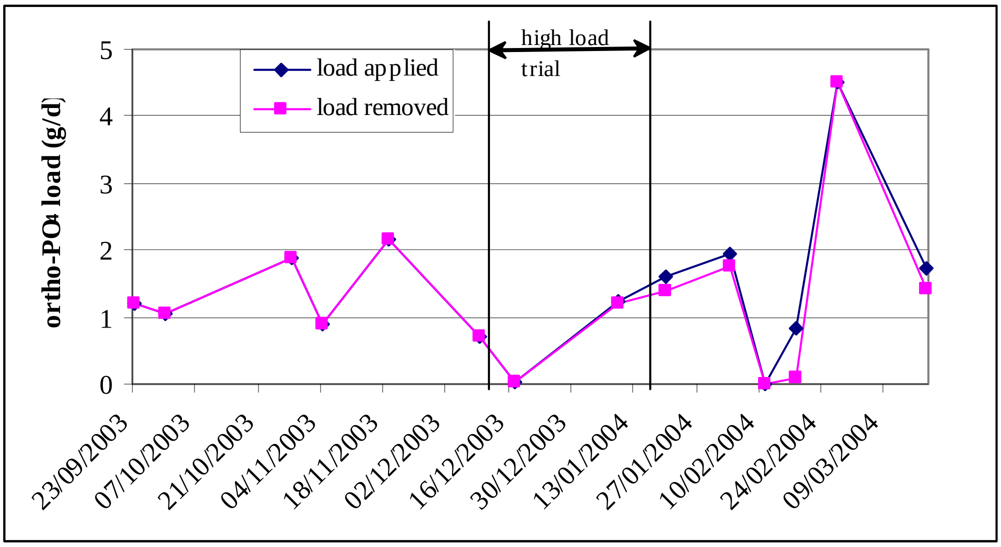


Figure 7.15 Ortho-PO_4-P loads applied and removed in the sand filter (Site 3)

7.4.3 Results of Bacteriological Analysis (Stratified Sand Filter)

The general performance of the sand filter with respect to bacterial removal can be gauged by examining the total coliform concentration since the filter is not in direct contact with the soil. Analysis of total coliform concentration through the stratified sand filter (Figure 7.16) during the two different hydraulic loading periods revealed a far better removal efficiency at the lower hydraulic loading rate than at the higher rate, whereby the bacteria are removed at approximately twice the rate with an inactivation kinetic k = -8.7 at 29 l/m^2d compared to k = -4.6 at 57 l/m^2d.

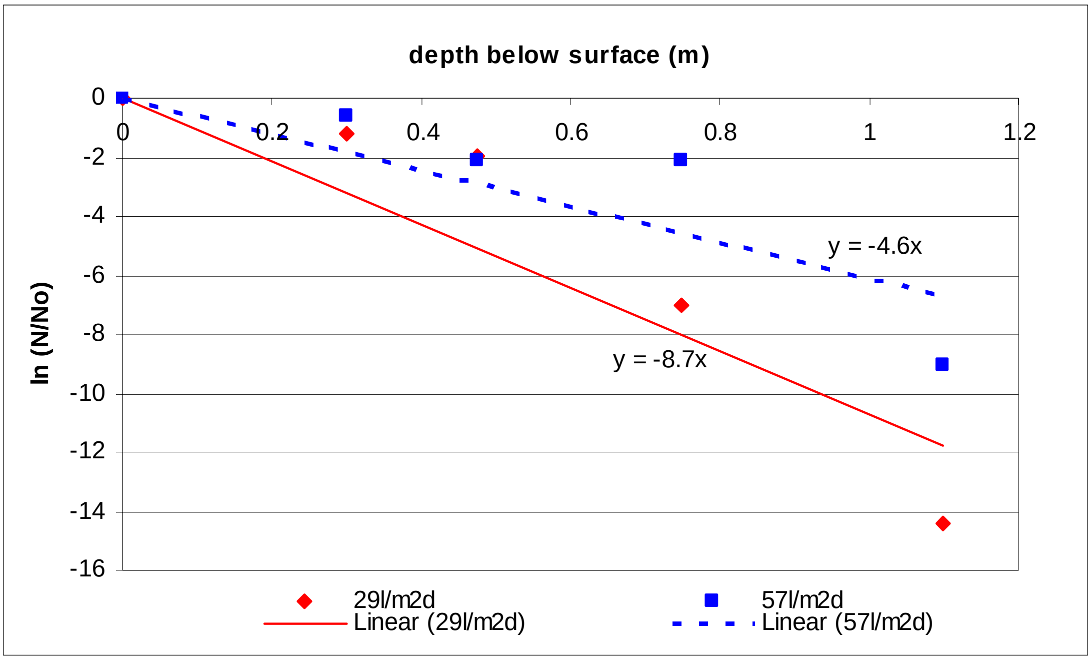


Figure 7.16 Removal of Total coliforms with depth through the sand filter (Site 3). N= number bacteria, N_0= original number from septic tank

	Number of Samples	Number of samples with concentration (cfu/100ml)				
		<10	10-100	10^2-10^3	10^3-10^4	>10^4
STE	2 (1)				 (1)	2
Coarse sand **(depth 0.3m)**	2 (1)		 (1)			2
Medium sand **(depth 0.475m)**	2 (1)		 (1)		1	1
Fine sand **(depth 0.75m)**	2 (1)		1 (1)	2		
Subsoil **(depth 1.3m)**	2 (1)	1	 (1)			
Subsoil **(depth 1.6m)**	2 (1)	1	 (1)			
Subsoil **(depth 1.9m)**	2 (1)	1	 (1)			

Table 7.14 *E. coli* concentrations in sand filter and subsoil (Site 3).
Note: figures in brackets indicate values during high loading trial

This is confirmed by the analyses of *E. coli* sampled in the filter and in the subsoil beneath (Table 7.14) which shows viable concentration throughout the subsoil at the higher loading rate even though the initial septic tank effluent concentration was an order of magnitude less during that period. No viable *E. coli* were sampled beneath the sand filter at the lower loading rates. Hence, this breakthrough of enteric bacteria again confirmed that the design hydraulic loading rate for stratified sand filters used as secondary treatment process should be no greater than 30 l/m^2d.

7.5 Summary

The analysis of sample results obtained from Site 3 was more difficult than experienced for either Site 1 or Site 2 due the problems already outlined relating to the installation of the lysimeters and the dilution of STE by surface water runoff.

The chemical analysis of soil moisture samples in the **percolation area** revealed that less than 10m of each percolation trench was utilised over the project duration. It appears from samples obtained at the 0m sample position that while the greatest attenuation of ortho-phosphate and COD occurs above the red depth plane, the greatest reduction in nitrogen load was measured between the red and black depth planes (i.e. 1.0m and 1.8m below ground level). Bacteriological analysis revealed that most of the reduction in enteric bacteria concentration occurred above the red depth plane and, allowing for the factor of safety introduced due to the sample dilutions, no enteric bacteria was recorded at the black depth plane.

The analysis of the **stratified sand filter** used as an intermittent filter (i.e. secondary treatment process) has revealed that the original design loading rate of 60 l/m^2d appears to be too high based on the breakthrough of enteric bacteria and the hydraulic resistance from the fine sand layer. A more reasonable level should be fixed at 30 l/m^2d for such an application. Phosphate removal has been shown to be dependant on the mineral composition of the coarse and medium sand used for the filter

A comparison of the loading levels at the three different subsoil depth planes beneath the percolation trenches and the stratified sand filter (at an average loading rate of 29 l/m^2d)

is presented in Table 7.15. It should be remembered that the stratified sand filter is 1.05m depth and the effluent percolates out of the base directly into the subsoil beneath. The effluent beneath the stratified sand filter has been treated to a slightly higher quality by the 1.3m depth plane which is not surprising since it has passed through a 1.05m sand filter compared to 0.3m of subsoil beneath the percolation pipes. This is also revealed from the bacteriological analysis where one incidence of enteric bacteria was sampled at 1.3m depth in the percolation area (Table 7.8). However, by the time the effluent has reached 1.9m in the subsoil (black plane) the performance of both systems is similar with loading rates for all parameters reduced down to similar levels.

	Loading Rate (g/d)					
	COD	**NO_3-N**	**NO_2-N**	**NH_4-N**	***Total N***	**PO_4-P**
STE	215.3	0.40	0.09	8.08	*8.57*	1.57
Red	21.2	3.6	0.05	0.9	*4.55*	0.07
(1.1-1.3m depth)	15.6	2.81	0.02	0.31	*3.14*	0.05
Blue	16.9	3.4	0.12	1.2	*4.72*	0.03
(1.4-1.6m depth)	12.6	1.92	0.01	0.27	*2.20*	0.01
Black	13.9	1.0	0.07	0.6	*1.67*	0.02
(1.8-1.9m depth)	13.7	1.36	0.01	0.37	*1.74*	0.01

Table 7.15 Comparison of average loading rates in the subsoil at the different depth planes beneath the percolation areas (in black) and beneath the stratified sand filter (in green) on Site 3.

8 ANALYSIS OF RESULTS OBTAINED FROM SITE 4

8.1 Introduction

A successful site assessment was completed for Site 4 on 6th February 2003. While the septic tank treatment system and secondary treatment system were commissioned on 15th July 2003 sampling did not begin until 23rd September as for Site 3. The installation of sampling equipment commenced on 25th August and all equipment was in place by 27th August. Sampling continued until 18th March 2004.

8.2 Analysis of Flow Data

The Omega ultrasonic level sensor and datalogger was installed in the pump sump for the stratified sand filter downstream of the distribution box on Site 4. Flow was monitored from 4th September 2003 to 18th March 2004 (Appendix C). Apart from a few brief periods where there were technical difficulties with the datalogger it represents a continuous record of the flow from the Puraflo® over the sampling period. It should be noted that while on Sites 1 to 3 the flow records represent the effluent emanating directly from the septic tanks, the datalogger on Site 4 measured flow emanating from the Puraflo® module and hence presents an interesting result in the way that the peat filter modifies the septic tank flow profile.

As was found with flow measurements on the other research sites, the average daily flow to the percolation area and sand filter on Site 4 was less than the typical hydraulic load of 180 lcd estimated by the EPA (EPA, 2000). The average daily hydraulic load of 492.1 litres (equating to 123.0 lcd) also includes a contribution by surface runoff, as seen in Figure 8.1, and therefore over-estimates the average daily domestic wastewater generation on site. Prior to the commencement of sampling all of the surface water drains around the house, three at the back and three at the front, were examined to identity whether or not they were connected to the septic tank. It was found that two of the six shores, one at the front and one at the back were in fact connected. One of these two drains received effluent from the household dishwater and washing machine as well as the surface runoff from a gutter that ran the full length of the house while the second shore received runoff from a small section of roof at the front of the house. As the gutter at the back of the house had a down-pipe at both ends, one of which was connected to a soakaway, it was possible to divert the roof runoff. However, no arrangement was possible to divert the runoff from the front section of the roof. When the flow emanating from the Puraflo® on days of no rainfall was examined, i.e. the adjusted daily flow, it was found that the average flow was 452.1 litres or 113.0 lcd (Table 8.1). This provides a more accurate approximation of daily wastewater generation on Site 4 from a statistical point of view. However, for purposes of the results analysis for this site the measured daily flow rates have been used.

	Maximum	Minimum	Average
Daily Flow (l/d)	1754.2	108.4	492.1
Adjusted Daily Flow (l/d)	892.4	160.2	452.1
Total Flow (l/d)	N/A	N/A	510.6

Table 8.1 SE flows measured on Site 4.

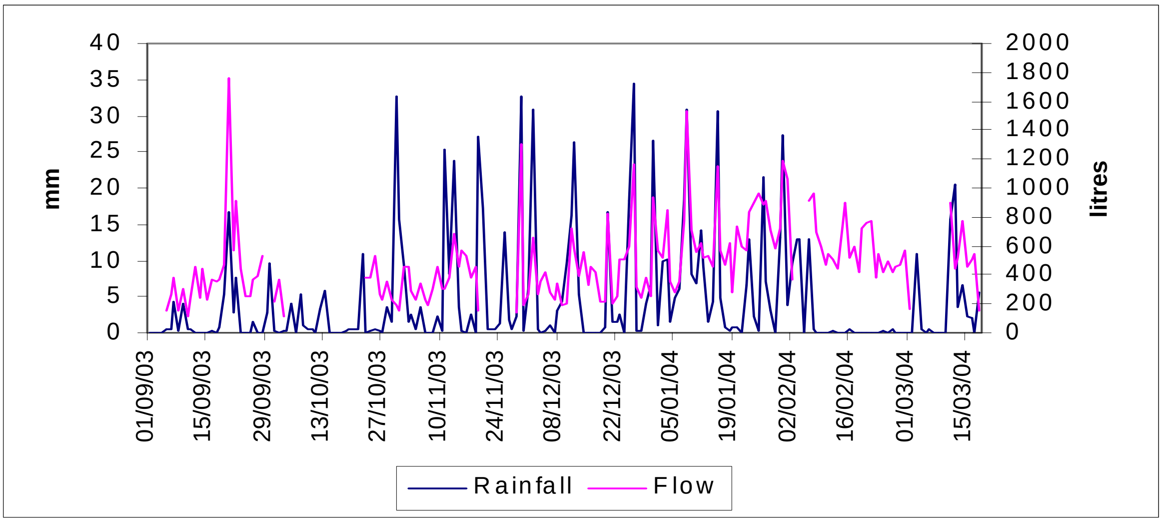


Figure 8.1 Graph of measured flow against rainfall on Site 4.

It can be seen from Figure 8.2 that the most common SE flow range over the sampling period was 440 to 460 l/d. It can also be seen that 80% of flows recorded were between 100 and 620 l/d. The average flow over this range was 375.7 l/d. When the flows on days when no rainfall was recorded were examined it was found that 87% of them fell within this spectrum and that the average flow for this range was 406.2 l/d. When the daily flow profile emanating from the Puraflo® was examined it was found that 90% of the flows fell within the range 0.4 to 3.4 l/min (Figure 8.3).

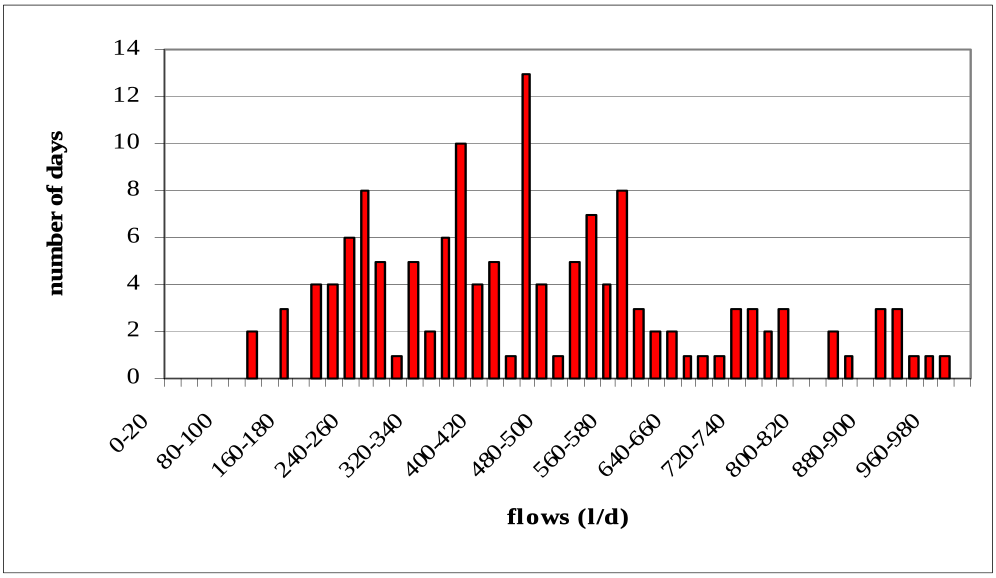


Figure 8.2 Frequency distribution of SE flows recorded on Site 4.

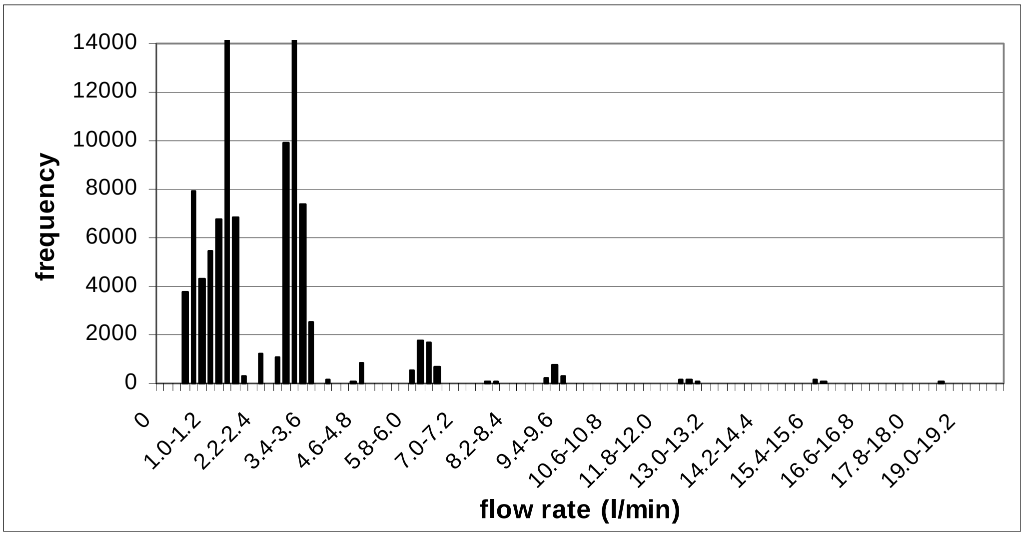


Figure 8.3 Frequency distribution (l/min) of flows recorded on Site 4.

The percolation characteristics of the peat seem to modify the flow rates from the septic tanks (Figures 5.3, 6.3 and 7.3) such that the frequency distribution of flow rates gather around discrete quanta, as seen in Figure 8.3. This is presumably associated with the water retention capacity of the peat media. Again, the same V-notch modification used on Sites 1 and 2 was used to achieve even distribution within the distribution box, which had been shown to be particularly effective over the typical flow range experienced from the peat filter.

8.3 Results of the Analysis of Septic Tank and Secondary Effluent

8.3.1 Results of Chemical Analysis

The results of the chemical analysis of all samples obtained from Site 4 are contained in Appendix D. As can be seen from Table 8.2 results of the analysis of the STE from Site 4 show it to contain high concentrations of organics and nutrients in the form of ortho-PO_4 and NH_4. Conversely it can be seen from Table 8.3 that after undergoing treatment by the aerated peat and associated bio-media of the Puraflo® module the SE had a reduced organic concentration compared to the STE but still had a high concentration of nutrients, even though the NH_4 had undergone nitrification. The associated reduction in pH from an average of 7.3 for the STE to an average of 6.2 for the SE was also seen.

	Concentration (mg/l)				
	COD	**NH_4-N**	**Total N**	**PO_4-P**	**Cl**
Maximum	1393.0	83.0	85.2	13.9	116
Minimum	446.0	27.8	29.13	3.8	33.3
Average	**812.6**	**56.6**	**57.85**	**7.9**	**68.8**

Table 8.2 Summary of the results of chemical analysis of STE on Site 4.

	Concentration (mg/l)				
	COD	**NO_3-N**	**Total N**	**PO_4-P**	**Cl**
Maximum	370.0	63.4	66.3	11.8	85.0
Minimum	68.0	23.6	31.8	5.1	20.1
Average	**215.8**	**42.0**	**48.7**	**8.1**	**55.4**

Table 8.3 Summary of the results of chemical analysis of SE on Site 4.

The COD concentration of the STE varied throughout the year peaking at 1393 mg/l on the 17/12/03. While this variation in the STE COD concentration, which is greatest between 04/11/03 and 20/01/04, is reflected in the SE COD concentration (Figure 8.4), the relative size of this increase is greater for the SE. However, an average reduction in COD concentration of 71% for the two peak STE COD concentrations measured over this period suggests, as was the case on Site 2, that the Puraflo® system has the ability to provide a high level of treatment to influent of varying organic quality.

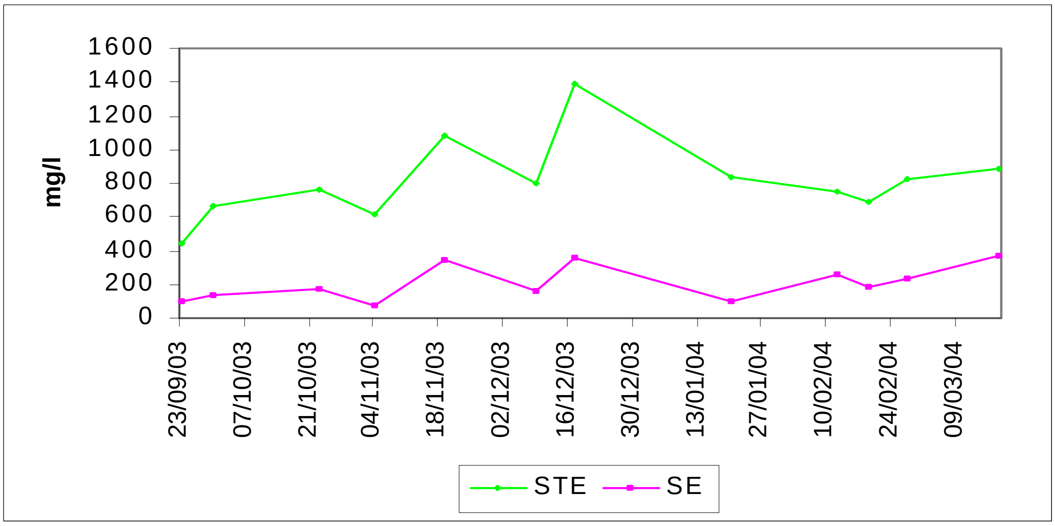


Figure 8.4 Comparison of COD concentration in STE and SE for Site 4.

While Tables 8.2 and 8.3 highlight the effects of nitrification within the secondary treatment system they also show a reduction in the overall inorganic nitrogen concentration between the STE and SE. This reduction, which averages 25% across the sampling period, is highlighted in Figure 8.5. As discussed in Section 6.3.1 it results from modifications to the standard Puraflo® unit that produced saturated conditions at the base of the module. While the effect of denitrification on Site 4 was less than half that recorded on Site 2 it must be considered that, as the achievement of denitrification is not a goal in the design of the Puraflo® system, it would be reasonable to expect that the effects of denitrification to vary from module to module. The concentrations of total nitrogen were also significantly higher on Site 2. While SE total inorganic N concentration for the year remained fairly constant there was considerable variation in STE total inorganic nitrogen concentration. As 93% of the STE total inorganic nitrogen, on average, was in the form NH_4 it can be seen from Figure 8.6 that this variation was due to variations in STE NH_4 concentration over the sampling period. In contrast it can be seen, also in Figure 8.6, that the SE NO_3 concentration, and hence the SE total inorganic nitrogen concentration, showed a lot less variation over the sampling period.

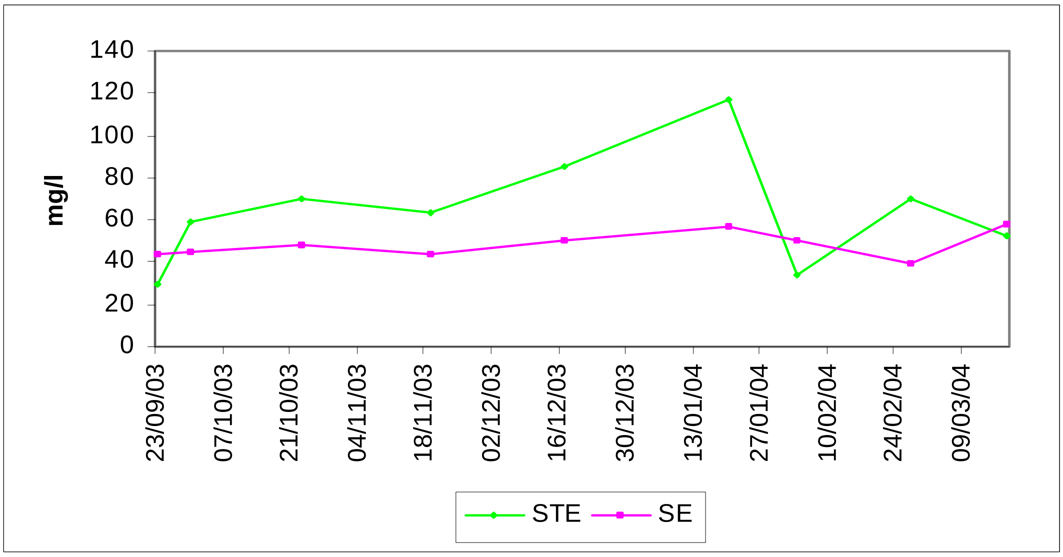


Figure 8.5 Reduction in total inorganic nitrogen concentration across the Puraflo®.

There were three incidences where the total inorganic nitrogen concentration of the STE was reported to be less than that of the SE (Figure 8.5) possibly due to analytical errors, or maybe due to the time lag effect between the unit processes, whereby weaker STE had not passed through the filter during the sampling period. As a result, the reported effect of denitrification over the sampling period was reduced. When the data from these dates was therefore omitted it was found that the effect of denitrification led, on average, to a 38% reduction in total inorganic nitrogen concentration.

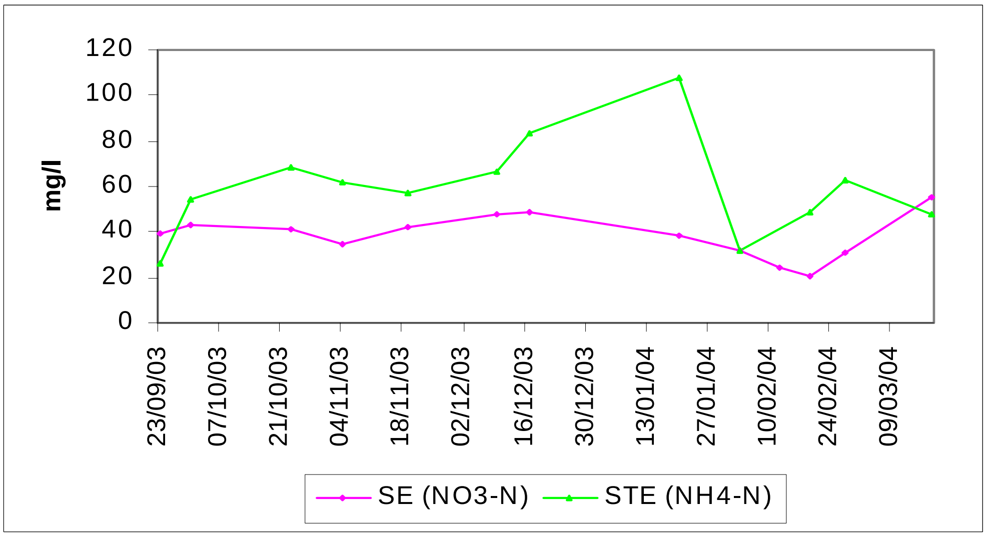


Figure 8.6 Comparison of SE NO_3-N concentration and STE NH_4-N concentration.

Tables 8.2 and 8.3 show that, as was the case on Site 2, there was very little difference in the average STE and SE concentrations of ortho-PO_4 on Site 4. This was to be expected as the Puraflo®, apart from the 10-15% phosphate uptake by micro-organisms, does not have an affinity for phosphate removal. As was found in Figure 6.7 there were incidences when the reported SE ortho-PO_4 concentration was greater than the STE ortho-PO_4 concentration (Figure 8.7). This could be due to the mineralisation of organic phosphate within the Puraflo® or the result of an error within the sampling procedure that was multiplied in the reported concentration as a result of the necessity to dilute samples.

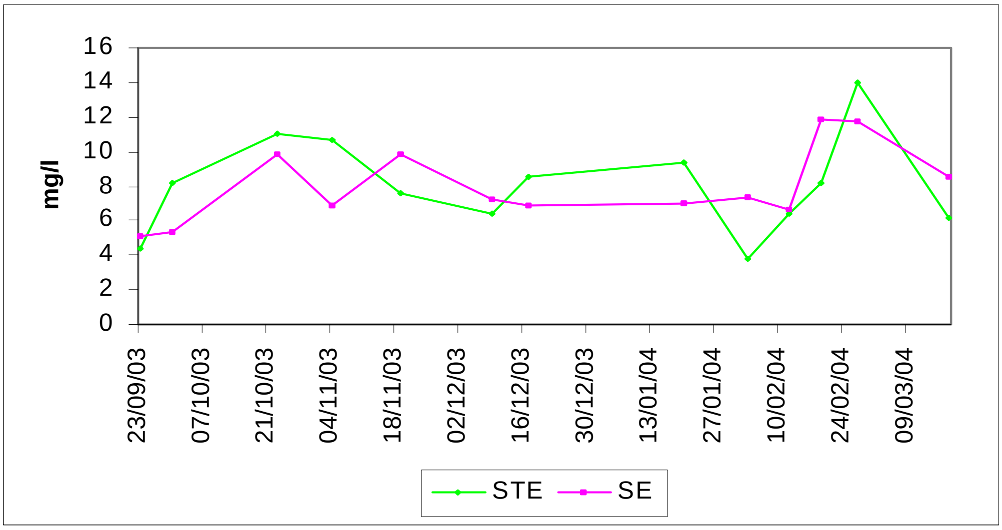


Figure 8.7 Comparison of ortho-PO_4-P concentration in STE and SE on Site 4.

While there was an average reduction of 30% in Cl concentration across the Puraflo® (Figure 8.8), a comparison of filtered STE samples to unfiltered SE samples meant that this was reduced to 16.8%. There was also an 8.6% reduction in Puralfo® Cl concentration. This meant that there was still a reduction of 22% in Cl concentration across the Puraflo® when filtered samples were compared. This is similar to the reduction of 21% recorded on Site 2. Even when both sets of samples were filtered the SE samples appeared less turbid than the STE samples. It is possible therefore that finer particles were removed by the filtering action of the peat and associated bio-media or that the saturated conditions at the base of the module provided quiescent conditions and sufficient residence time for the settling out of particulate matter.

Figure 8.8 Comparison of Cl concentration in STE and SE on Site 4.

When Cl concentrations in the STE were compared against rainfall over the project duration it was found that, even though STE flow included a contribution of surface runoff (Figure 8.1), the volume of this contribution was insufficient to effect STE quality (Figure 8.9) due to the buffering capacity of the septic tank.

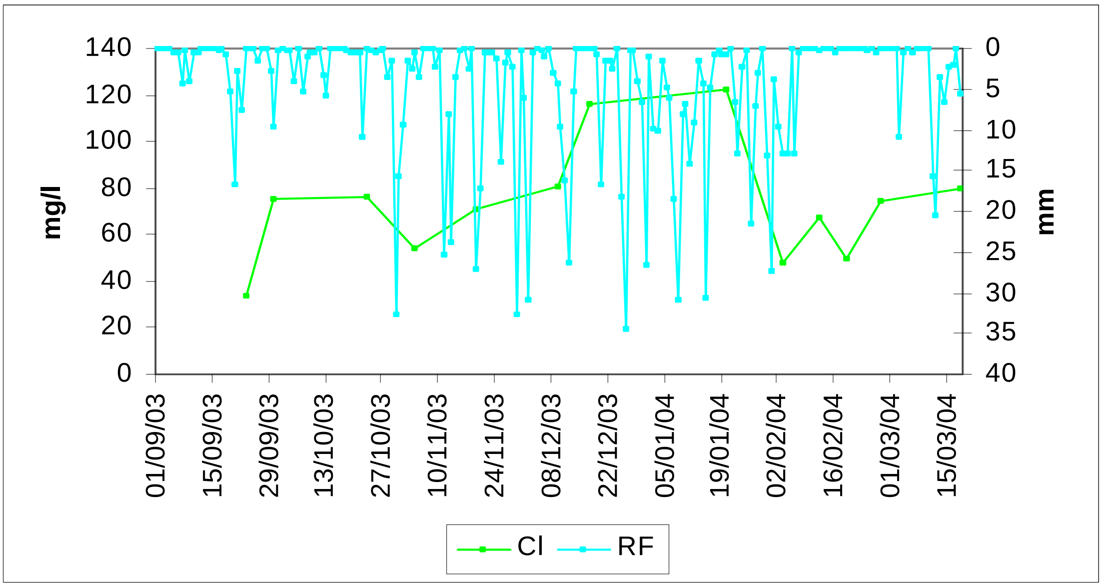


Figure 8.9 STE Cl concentration graphed against rainfall for the project duration.

8.3.2 Results of Bacteriological Analysis

Table 8.5 shows that even with the high bacterial removal efficiency associated with the installation of a Puraflo® system, the presence of enteric bacteria in SE samples analysed on two occasions over the project duration highlighted the requirement of SE to undergo further treatment prior to discharge to groundwater.

Date	Bacteria	Concentration (cfu/100ml)		% Removal
		STE	SE	
02/12/03	Total coliforms	21,600,000	2,000	99.99
02/12/03	*E. coli*	616,000	58	99.99
02/12/03	*Enterococci*	2,696	2	99.93
02/12/03	Faecal coliforms	760,000	72	99.99
11/04/04	Total coliforms	4,110,000	5,480	99.87
11/04/04	*E. coli*	24,190	710	97.06

Table 8.4 Reduction in bacterial concentration across the Puraflo® on Site 4.

8.4 Results of the Analysis of Soil Moisture Samples

8.4.1 Method of Analysis

As was the case for analysis of results for the other three sites, the subsoil below the percolation area on Site 4 was divided into three sections: 0 to 0.4m (red), 0.4 to 0.8m (blue) and 0.8m to 1.2m (black). Three nominal depths of 0.2m, 0.6m and 1.0m were again defined to represent the location of the lysimeter tips within these sections. Unlike the other sites there was no reclassification of lysimeters required at Site 4 (Table 4.2). Examination of the results of soil moisture samples for Cl revealed that, of the two methods outlined in Section 5.3.1, the depth average method was the more representative in highlighting the behaviour of the SE in and below the percolation trenches (Figures 8.10 and 8.11). This would suggest that, as appeared to be the case on Site 2, the reduction in STE organic load brought about by the installation of a secondary treatment system inhibited the formation of a biomat along the base of the percolation trenches thus confining effluent loading to less than the first 10m of both trenches. As the Cl concentration for the three depth planes at the 0m sample position are very similar it would suggest that the influence of dilution on effluent attenuation between these planes was small (Figure 8.11).

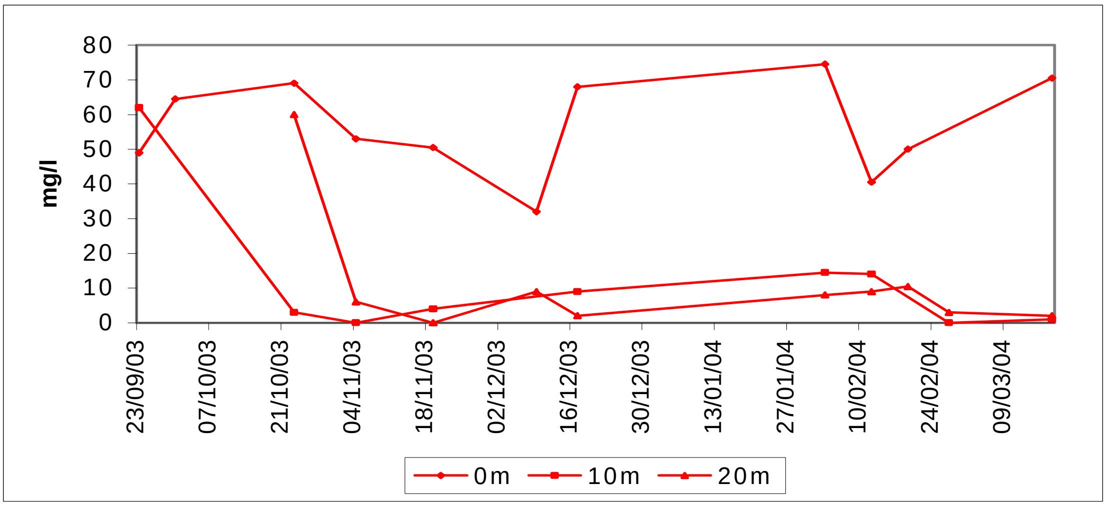


Figure 8.10 Cl concentration measured on the red depth plane at the three sample positions on Site 4.

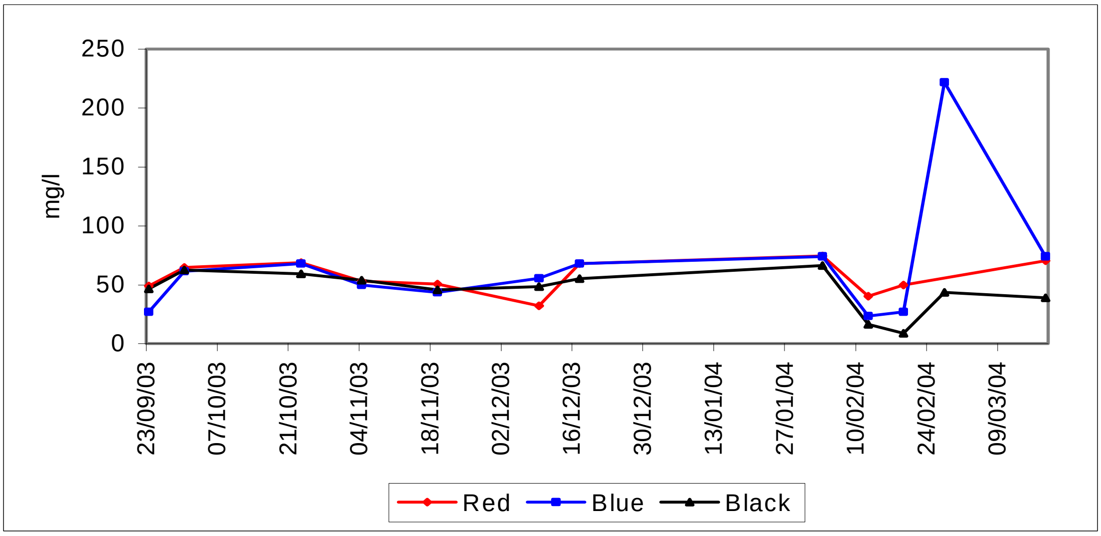


Figure 8.11 Cl concentration measured on the three depth planes at the 0m sample position on Site 4.

While the high Cl concentrations measured on the red depth plane at 0m over the sampling period (Figure 8.10) are reflected by high NO_3 concentrations, as would be expected, the initial high Cl concentrations measured on the blue and black planes are not. It appears, therefore, that they are due to experimental error. It can be seen from Figure 8.11 that there is a drop off in Cl concentration, to background concentrations in the case of the black depth plane, on the 12/2/04 and 19/2/04. This reduction is also reflected in the Cl concentration of the SE. There is also a reduction in other parameters on these two dates. It is not clear whether this reduction in overall effluent quality is an indication of the development of the biomat and thus reduction in loading rate or whether is due to the analysis being carried out in the absence of the resident analysts on those dates. It can also be seen from Figure 8.11 that the Cl concentration on the blue plane on 27/2/04 is greater than twice that measured at any time on the blue depth plane and over twice that measured in the SE. It was therefore regarded as egregious and omitted.

8.4.2 The Effect of Dilution on Effluent Attenuation

Due to dense nature of the subsoil on Site 4 it was not possible to install the sampling equipment directly below the percolation trenches. As was the case at Site 3 the lysimeters were offset from the percolation trenches and it is therefore possible that the shallower lysimeters, especially those located in the red depth plane, were not centrally located in the effluent plume. Hence, analysis for Cl on Site 4 was not as successful as for Sites 1 and 2 (see Figure 8.12). As samples obtained from the shallower lysimeters might not therefore be characteristic of the effluent plume it was decided, for the purpose of the quantification of effluent dilution by effective rainfall, to compare Cl concentrations between the Puraflo® and the black depth plane only.

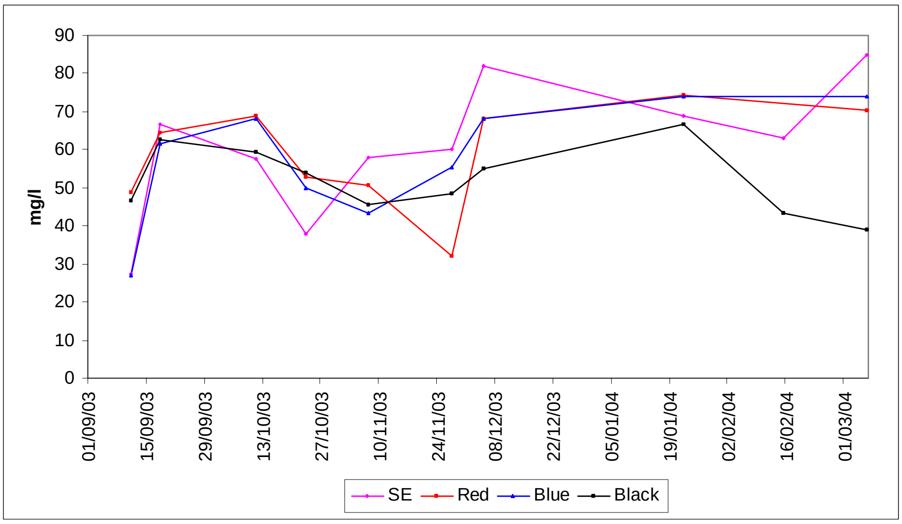


Figure 8.12 Results of sample analysis for Cl on Site 4.

While a rain gauge was installed on Site 4, no other local meteorological data was available, and for reasons outlined in Section 5.3.2, it was decided to use data obtained at the weather station on Pollardstown Fen to calculate the effective rainfall. The Hargreaves method (Equation 5.1) was again used to calculate potential evapotranspiration. It was calculated that, for a measured rainfall of 640.4mm between 01/09/03 and 18/03/04, the effective rainfall was 414.9mm. While the representation of effluent dilution was not as successful for Site 4 as it was for Sites 1 and 2 due to problems associated with the analysis procedure, it still appears from Figure 8.13 that the dilution effect was greatest over the period of sustained effective rainfall between 19/11/03 and 03/02/04. As there was little effective rainfall, and hence dilution, outside this period it was decided to let the difference in Cl concentration between Puraflo® and black depth plane samples obtained on these sample dates be equal to zero. These data were then used to approximate the effect of dilution on effluent attenuation and also the zone of contribution of effective rainfall. This quantification of the dilution effect, in association with the average daily flow, was used to approximate the average organic and nutrient load on the black depth plane over the sampling period.

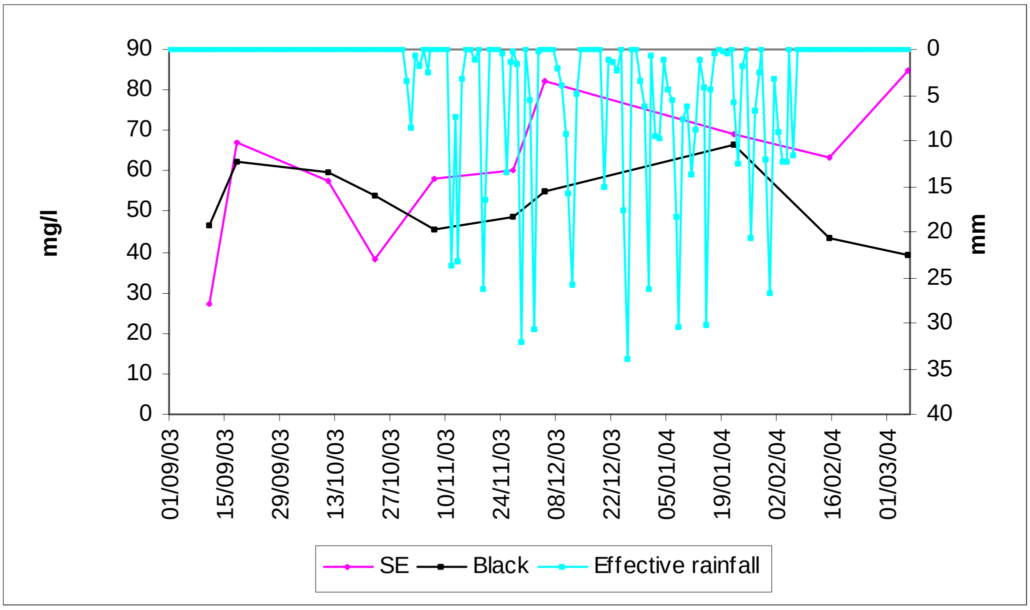


Figure 8.13 Graph showing Cl concentrations and effective rainfall on Site 4 over the sampling period.

The average load of each parameter on the red and blue depth planes was estimated on consultation of the analysis from Sites 1 and 2, by assuming a 2% difference between sample planes.

When the reduction in Cl concentration between the Puraflo® and the black depth plane between 19/11/02 and 03/02/04 was calculated (Table 8.5) it was found that the effect of dilution was equivalent to, on average, the addition of 0.28 litres of effective rainfall, which had an average Cl concentration of 3 mg/l, per litre of effluent (or 19.3% reduction in concentration).

Date	% reduction in concentration	Equivalent contribution of effective rainfall (l)
19/11/03	21.6	0.29
09/12/03	19.2	0.25
17/12/03	32.9	0.52
03/02/04	3.6	0.04
Average	**19.3**	**0.28**

Table 8.5 Calculation of the contribution of effect rainfall to effluent dilution on the black depth plane

However, when the effect of dilution over the entire sampling was calculated, letting the effect of effective rainfall on dilution be equal to zero on the other sampling dates, it was equal to 0.11 litres per litre of effluent, or a 7.7% reduction in concentration.

Using half the daily flow average of 496.5 l/d (Table 8.1) this equates to an effective rainfall contribution of 27.3 l/d or 10.0 m^3/year. By dividing this by the effective rainfall it was possible to estimate that the zone of contribution of effective rainfall was approximately 14.3 m^2. Taking a 2% reduction in the affect of dilution between the black and blue depth planes and between the blue and red depth planes the affect of dilution on the red and blue depth planes was then estimated as resulting in a 3.7% and 5.7% reduction in concentration, respectively. By dividing the yearly contribution of effective rainfall to dilution by the yearly effective rainfall it was possible to estimate that the zone of contribution of effective rainfall. This was equated to an approximate zone of contribution of 10.9 m^2, 17.5 m^2 and 24.1m^2 for the red, blue and black depth planes respectively. While it was clear from Section 8.4.1 that less than 10m of percolation trench was utilised, there was no way to approximate the length of trench over which the effluent was distributed and so it was estimated at 5m. Therefore, taking the trench width of 0.45m this equates to a zone of contribution of approximately 0.3m, 0.5m and 0.7m on all sides of each trench for the red, blue and black depth planes, respectively.

It appears from Figures 8.14 and 8.15 that, as was the case on Sites 1 and 2, the soil moisture tension readings corroborate the chemical analysis in that they show that it is physical, chemical and biological processes, rather than dilution, which are the more prominent effluent attenuation processes. It appears from Figure 8.14 that the tensiometers installed at the 20m sample position, where no effluent was recorded, react to the variation in effective rainfall over the sampling period while the tensiometers installed at the 0m sample position (Figure 8.15) appear to be uninfluenced by effective rainfall. This suggests that it is the percolating effluent that influences the change in soil moisture tension and that the contribution of dilution to effluent attenuation is small, as calculated by the chemical analysis.

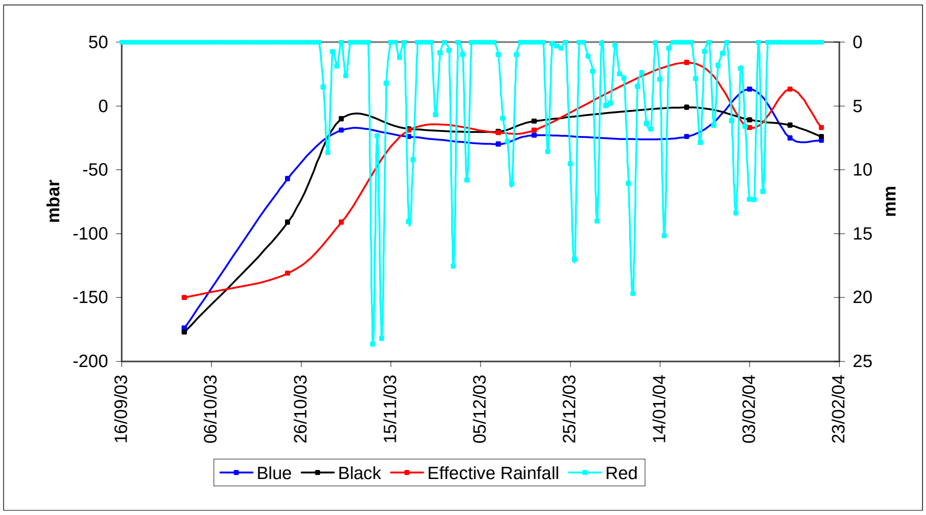


Figure 8.14 Soil moisture tension plotted against effective rainfall for the 20m sample position on Site 4.

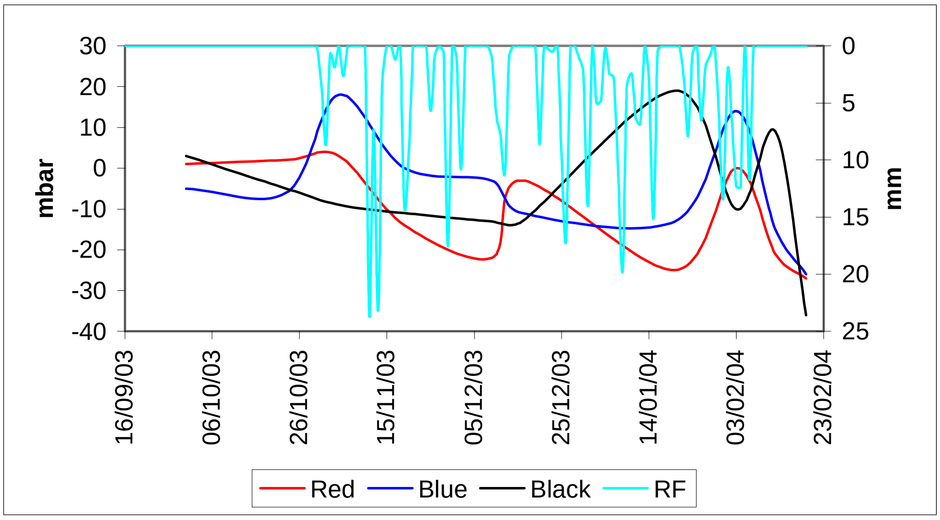


Figure 8.15 Soil moisture tension plotted against effective rainfall for the 0m sample position on Site 4.

8.4.3 Results of Chemical Analysis (percolation area)

While the presence of a minimum of 0.6m of unsaturated subsoil below the invert of the percolation trenches is one of the requirements to satisfy the EPA recommendations for site suitability, lysimeters were also installed to a deeper depth. This allowed the benefits, if any, of a greater thickness of unsaturated subsoil below the percolation area to be examined.

COD

The reduction in COD concentration of the domestic wastewater effluent with depth is small when compared to the reduction that takes place across the Puraflo® unit (Table 8.6). This reduction in organic load has had the effect of concentrating the effluent over less than half the percolation area by inhibiting the formation of a biomat along the subsoil-effluent interface. The similarity between the COD results obtained from Sites 2 and 4 (Table 6.9), especially between the SE and the red depth plane given the very different nature of the subsoils, again suggests that the majority of COD reduction within the percolation area occurs above the red depth plane or within the distribution gravel. In fact it can be seen from Figure 8.16 that, given the similarity between the COD concentration on the red depth plane at all three sample positions, almost complete attenuation of the organic content of the domestic wastewater has been achieved within the system.

	Concentration (mg/l)	Load (g/d)	Removal (g/d)
STE	812.6	200.0	-
SE	215.8	53.1	146.9
Red Depth Plane	109.3	28.0	25.1
Blue Depth Plane	89.5	22.0	6.0
Black Depth Plane	89.7	22.0	0.0

Table 8.6 Reduction in COD concentration attributed to the specific treatment steps.

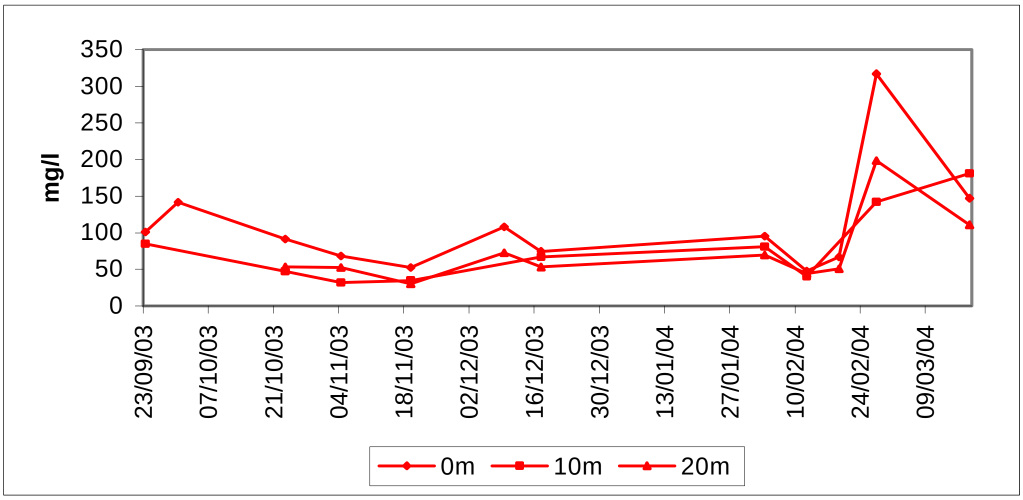


Figure 8.16 COD concentrations measured on the red depth plane at the three sample positions.

NITROGEN

There was a reduction in the total inorganic nitrogen concentration with subsoil depth (Table 8.7 and Figure 8.17). The reduction in NH_4 concentration with depth was not reflected by a corresponding increase in NO_3 concentration. In fact it can be seen that there was a decrease in NO_3 concentration with depth (Figures 8.18 and 8.19), reflected by an increase in pH. This reduction in both NO_3 and NH_4 suggests that dilution was the chief mechanism of nitrogen attenuation in the subsoil This is feasible considering the reduction in organic load of the STE, to near background concentrations, would inhibit denitrification. This may be an indication of simultaneous nitrification and denitrification or the Anammox pathway.

Depth Plane	NO_3-N		NO_2-N		NH_4-N		Total inorg. N		pH
	Conc. (mg/l)	Load (g/d)	Conc. (mg/l)	Load (g/d)	Conc. (mg/l)	Load (g/d)	Conc. (mg/l)	Load (g/d)	
SE	42.0	10.3	0.2	0.06	6.5	1.6	48.7	12.0	6.4
Red	50.6	12.9	0.4	0.10	3.8	1.0	53.7	13.7	6.0
Blue	48.5	12.7	0.3	0.08	3.0	0.8	50.5	13.2	6.2
Black	45.6	12.1	0.1	0.03	2.1	0.6	46.9	12.5	6.6

Table 8.7 Average concentration of NO_3-N, NO_2-N, NH_4-N and Total inorganic N measured on the three depth planes.

Figures 8.17, 8.18 and 8.19 also show that while total inorganic nitrogen for the red and blue depth planes remained stable throughout the sampling period there appeared to be a fall off in nitrification over the penultimate month of sampling. It can be seen from Figure 8.14 that this coincides with a period of increased saturation.

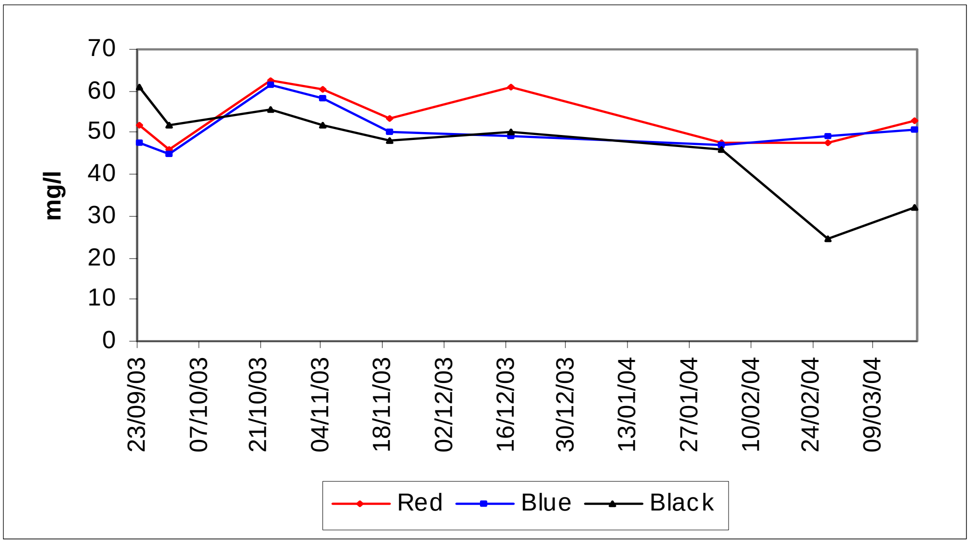


Figure 8.17 Average total inorganic N concentrations at the 0m sample position.

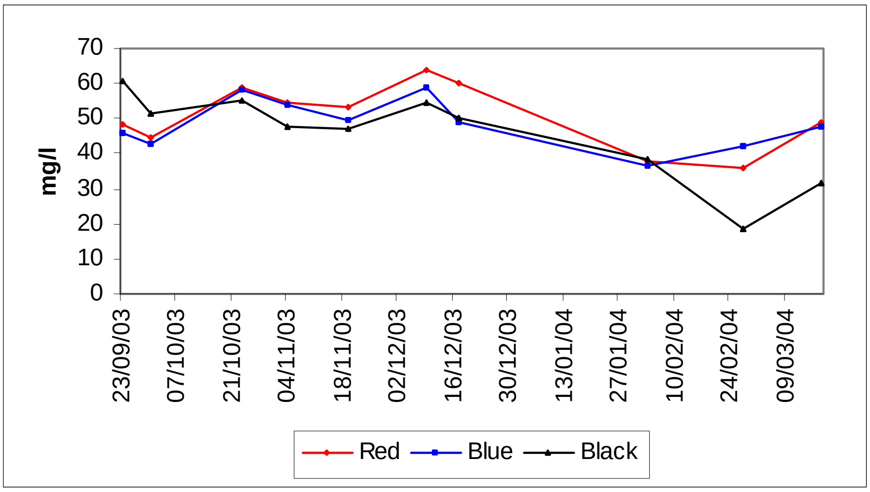


Figure 8.18 Average NO_3-N concentrations measured on Site 4.

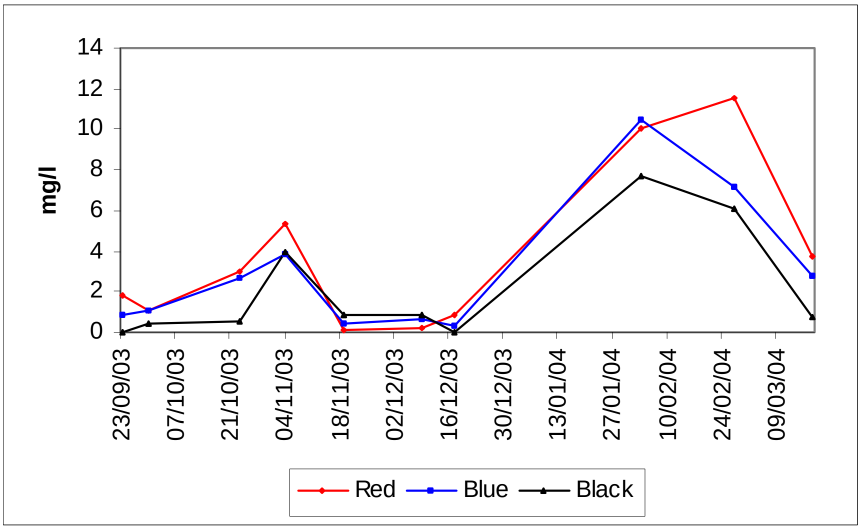


Figure 8.19 Average NH_4-N concentrations measured on Site 4.

PHOPHOROUS

Examination of the subsoil exposed by the trial hole and the results of particle size analysis of three subsoil samples taken at 1.0m, 1.5m and 2.0m below ground level resulted in a uniform classification of the subsoil below the invert of the percolation trenches (Appendix A). However, as can be seen by Figure 8.20 and Table 8.8 the greatest reduction in ortho-PO_4 concentration occurred between the blue and black depth planes. The low clay and high sand content of the subsoil would suggest a reduced capacity for phosphate fixation and it can be seen that there is only a small reduction in concentration between the SE and the red depth plane and also between the red and blue depth planes. As the pH of the soil moisture samples were acidic this suggested that the ability of the soil to fix PO_4 depended not only on the clay content but also on the presence of Al, Fe and/or Mn as dissolved ions, oxides or hydrous ions. In the absence of X-ray diffraction analysis of the subsoil samples it was not possible to determine whether there was a change in mineralogy within this uniformly classified subsoil layer which would increase affinity for PO_4 removal.

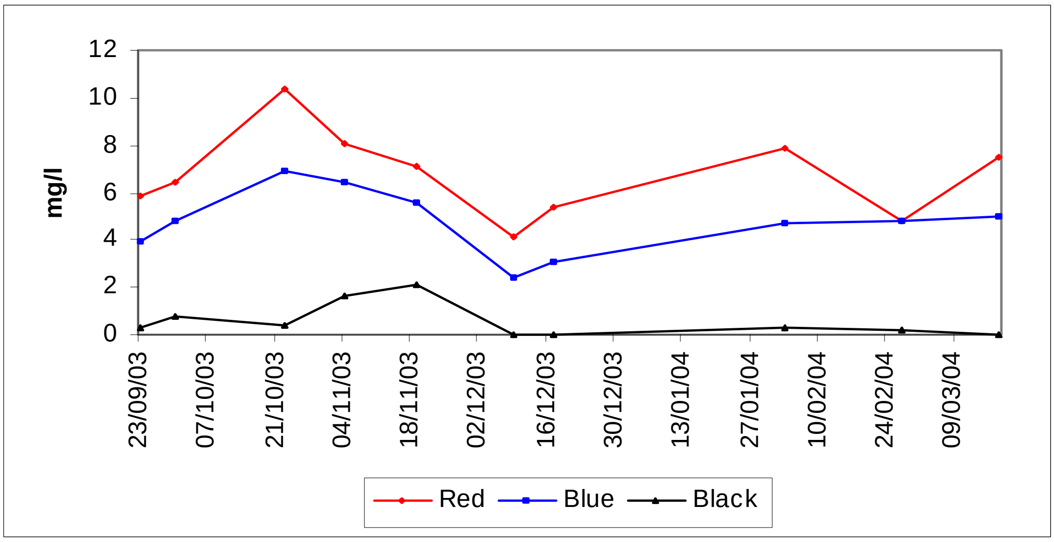


Figure 8.20 ortho-PO_4-P fixation within the subsoil matrix.

	Concentration	Load	
	(mg/l)	(g/d)	Reduction (g/d)
STE	8.1	2.0	-
Red Depth Plane	6.8	1.7	0.3
Blue Depth Plane	4.8	1.3	0.4
Black Depth Plane	0.6	0.2	1.1

Table 8.8 Reduction in ortho-PO_4-P concentration attributed to the specific treatment steps.

8.4.4 Results of Bacteriological Analysis (percolation area)

For reasons outlined in Section 7.3.4 it was only possible to send two sets of samples from Site 4 for bacteriological analysis. Both sets of samples were obtained from Trench 1 only. Assuming that these samples are representative of the sample position from which they were obtained it can be seen from Table 8.9 that, allowing for the factor of safety introduced due to sample dilutions, there was complete removal of enteric bacteria by the black depth plane. Analysis of the first sample which was obtained on the 02/12/04 showed the presence of enteric bacteria on the red and black depth planes at the10m sample position and on the blue and black depth planes at the 20m sample position. However, as the chemical analysis highlighted the absence of SE at these locations it suggests a non-anthropogenic source, which also serves to highlight the sensitivity and significance of the microbiological results returning low concentrations around 10 cfu/100ml.

	Number of Samples	**Number of samples with concentration (cfu/100ml)**			
		<10	**10-100**	**101-1000**	**>1000**
SE	2		1	1	
Red Plane	2	2			
Blue Plane	2	2			
Black Plane	1	1			

Table 8.9 Concentration of *E. coli* measured at the 0m sample position on Site 4.

8.5 Results of Analysis of Stratified Sand Filter

8.4.1 Hydraulic loading

The average hydraulic load on the sand filter during the year was 246 l/d equating to a loading rate of 41.0 l/m^{2}d with a dosing frequency of 7.33 pumps per day on average. A high loading trial was carried out from 14th December – 21st January 2004 whereby all the flow from the distribution box was directed onto the sand filter. During this period there was an increase in the average hydraulic loading rate to 97.9 l/m^{2}d which equated to 18.8 pumps per day over this period.

The T-value of the subsoil beneath the sand filter was 52. The piezometers in the sand filters revealed no significant head during the year at either the lower or higher loading rates of 41.0 l/m^{2}d and 97.9 l/m^{2}d respectively. Since the subsoil has a higher T-value than Site 3, this absence of flooding in the bottom of the filter is indicative of reduced biofilm development in the fine sand layer due to the low organic load of the SE.

8.4.2 Results of Chemical Analysis (Stratified Sand Filter)

The results of all chemical analysis carried out on the stratified sand filter and soil moisture samples are contained in Appendix E. The load calculations have been augmented by the average rainfall values across each respective period, as for Site 3 resulting in a 7% dilution during the normal trial and 5% dilution in the high loading trial.

COD

The results of the COD analyses are shown on Table 8.10 which gives the average values for both the normal and high hydraulic loading trials periods down through the sand filter layers and into the soil beneath.

	COD conc. (mg/l)	COD load (g/d)	Load removed (g/d)
SE	215.8 (106.0)	53.1 (62.3)	- -
Coarse sand (depth 0.3m)	239.3 (175.0)	63.2 (107.6)	-10.1 (-45.3)
Medium sand (depth 0.475m)	208.9 (181.0)	55.2 (111.3)	8.0 (-3.7)
Fine sand (depth 0.75m)	183.9 (143.8)	48.5 (88.4)	6.7 (22.9)
Subsoil (depth 1.3m)	91.1 (45.0)	24.1 (27.7)	24.4 (60.7)
Subsoil (depth 1.6m)	71.9 (31.0)	19.0 (19.1)	5.1 (8.6)
Subsoil (depth 1.9m)	62.2 (36.0)	16.4 (22.1)	2.6 (-3.0)

Table 8.10 Average COD concentrations and loads in sand filter and subsoil.
Note: figures in brackets indicate values during high loading trial

The results show that there is little organic removal using the filter as a polishing filter at either the normal loading rate of 41 l/m^2d or the high loading rate of 98 l/m^2d. In fact there appears to be an increase in COD levels at the higher loading rate in the filter in the coarse and medium layers which could be due to the increased hydraulic loading creating high shear stress on the biofilm and removing some of the thickness that had accumulated during the lower loaded period. There is a significant COD removal between the bottom of the filter and the 1.3m depth in the subsoil by which point the organic concentration was down to low levels comparable to those measured on Site 3.

NITROGEN

The results of the analyses for the nitrogen species are shown on Tables 8.11 and 8.12. At an average hydraulic loading rate of 41 l/m^2d there does not seem to have been a large change in the nitrogen compounds in the filter apart from some small nitrification of any remaining ammonia in the secondary effluent in the first coarse sand level.

	NH_4-N	NO_2-N	NO_3-N	*Total N*
SE	6.5 (11.6)	0.2 (0.2)	42.0 (31.3)	*48.7* *(43.1)*
Coarse sand **(depth 0.3m)**	3.2 (4.6)	0.4 (0.4)	44.5 (38.3)	*47.6* *(43.2)*
Medium sand **(depth 0.475m)**	2.5 (6.3)	0.2 (0.3)	40.5 (35.6)	*42.8* *(42.2)*
Fine sand **(depth 0.75m)**	2.8 (1.6)	0.1 (0.2)	44.3 (35.0)	*44.3* *(36.9)*
Subsoil **(depth 1.3m)**	2.2 (0.0)	0.1 (0.1)	41.1 (38.3)	*43.4* *(38.4)*
Subsoil **(depth 1.6m)**	2.5 (0.3)	0.1 (0.1)	36.4 (41.6)	*38.9* *(42.0)*
Subsoil **(depth 1.9m)**	2.1 (0.0)	0.0 (0.0)	32.2 (38.4)	*34.3* *(38.4)*

Table 8.11 Average nitrogen concentrations (mg/l) in sand filter (Site 4).
Note: figures in brackets indicate values during high loading trial.

	NH_4-N	NO_2-N	NO_3-N	*Total N*	pH
SE	1.64 (6.83)	0.06 (0.08)	10.34 (18.39)	*12.04* *(25.29)*	6.39 (6.09)
Coarse sand **(depth 0.3m)**	0.84 (2.81)	0.10 (0.24)	11.76 (23.52)	*12.57* *(26.57)*	6.71 (6.28)
Medium sand **(depth 0.475m)**	0.66 (3.89)	0.05 (0.20)	10.68 (21.86)	*11.53* *(25.95)*	6.92 (6.54)
Fine sand **(depth 0.75m)**	0.75 (1.01)	0.04 (0.12)	10.94 (21.54)	*11.65* *(22.67)*	6.81 (6.81)
Subsoil **(depth 1.3m)**	0.59 (0.01)	0.02 (0.05)	10.85 (23.55)	*11.45* *(23.61)*	6.68 (6.72)
Subsoil **(depth 1.6m)**	0.65 (0.21)	0.02 (0.02)	9.60 (25.8)	*10.27* *(25.81)*	6.63 (6.67)
Subsoil **(depth 1.9m)**	0.54 (0.01)	0.01 (0.02)	8.51 (26.32)	*9.06* *(23.65)*	6.86 (6.35)

Table 8.12 Average nitrogen loads (g/d) in sand filter (Site 4).
Note: figures in brackets indicate values during high loading trial.

There was evidence of some denitrification in the subsoil (and no further nitrification) which could indicate slightly saturated conditions in this slowly percolating soil. At the higher hydraulic loading rate of 98 l/m^2d there appeared to be some loss of nitrogen in the fine sand layer but no change in the nitrate loading which would either suggest nitrification in the top of the layer with subsequent denitrification in a saturated lower section due to such a high hydraulic load or possibly the direct conversion to nitrogen of ammonia by the Anammox pathway. Within in the subsoil there is no strong evidence of further reductions in nitrogen load at the higher hydraulic loading rate.

PHOSPHOROUS

The results of the analyses for ortho-PO_4 are shown in Table 8.13 which reveals that significant load removal occurs in the medium sand layer and to a lesser extent in the coarse sand layer under an average hydraulic loading regime of 41 l/m^2d, presumably associated with the presence of goethite as discussed in Section 7.4.2. However, at the higher hydraulic loading rate of 98 l/m^2d there is a much reduced removal of phosphate in the medium sand layer although there is some removal in the fine sand layer. As was observed in Site 3 there is little phosphate adsorption in the coarse sand layer at the higher hydraulic loading rates even though this sand has been shown to contain some goethite. Once the effluent has left the filter the rest of the phosphate has been removed (in both loading cases) by 1.3m depth in the subsoil. As discussed in Section 8.4.3, there was little phosphate removed in the subsoil beneath the percolation trenches by the 1.3m depth and hence the phosphate removal beneath the fine sand layer in the filter must be associated either with the 50mm layer of medium sand bedding on the base of the filter or possibly the layer of subsoil found beneath percolation trenches between the blue and black levels (which was shown to adsorb the ortho-PO_4) located at a shallower depth beneath the sand filter.

	Ortho-PO_4 conc (mg/l)	**Ortho-PO_4 load (g/d)**	**Load removed (g/d)**
SE	8.42 (6.29)	2.07 (3.69)	- -
Coarse sand **(depth 0.3m)**	7.18 (5.91)	1.90 (3.64)	0.17 (-0.05)
Medium sand **(depth 0.475m)**	4.37 (5.60)	1.15 (3.44)	0.75 (0.20)
Fine sand **(depth 0.75m)**	4.45 (5.00)	1.17 (3.07)	-0.02 (0.33)
Subsoil **(depth 1.3m)**	0.22 (0.01)	0.06 (0.01)	1.11 (3.06)
Subsoil **(depth 1.6m)**	0.03 (0.01)	0.01 (0.01)	0.05 (0.00)
Subsoil **(depth 1.9m)**	0.12 (0.01)	0.03 (0.01)	-0.02 (0.00)

Table 8.13 Average ortho-PO_4-P concentrations and loads in sand filter and subsoil.
Note: figures in brackets indicate values during high loading trial

An analysis of the ortho-PO_4 removal with time is shown for the stratified sand filter on Site 4 on Figure 8.21 which indicates a distinct drop off in phosphate removal during the high loading trial. There also seems to be a reduction in adsorption efficiency of the filter after the high loading trial had finished which could be an indication that the adsorption capacity of the sand has started to be reached.

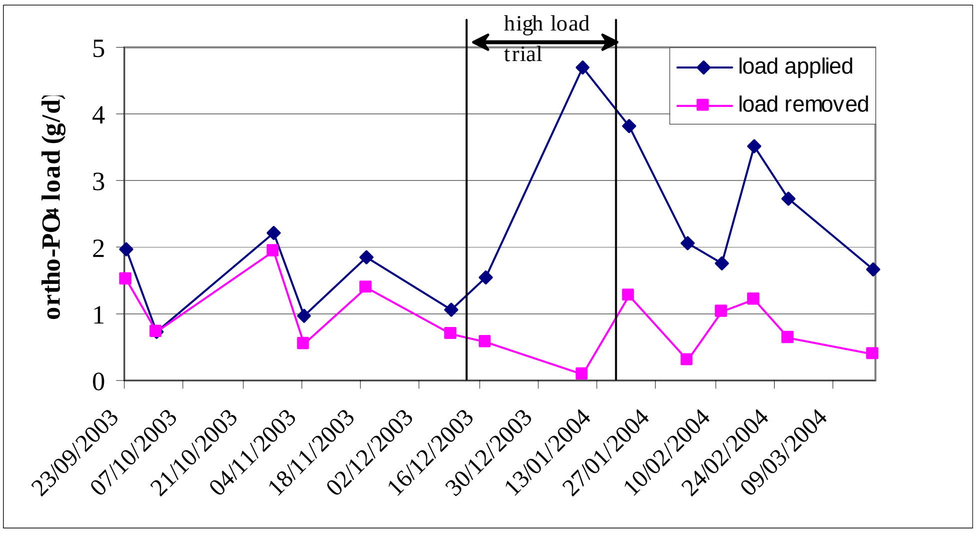


Figure 8.21 Ortho-PO_4-P loads applied and removed in the sand filter (Site 4)

However, when the cumulative loads removed by the identical filters on the two sites by the end of the trials are compared, only 220g was removed on Site 4 compared to 340g removed by the identical filter on Site 3, which had shown no sign of any reduction in adsorption capacity. The drop off in phosphate removal efficiency could therefore be affected by some other compound in the effluent in Site 4 being preferentially adsorbed or possibly due to the higher hydraulic loading rates and slightly higher phosphate concentrations on Site 4 compared to Site 3.

8.4.3 Results of Bacteriological Analysis (Stratified Sand Filter)

Analysis of total coliforms concentration through the stratified sand filter reveals indeterminate removal rates between the two loading rates since the average total coliforms concentration in the secondary treated effluent was only 5000 cfu/ml. Analysis of *E. coli* sampled in the filter and in the subsoil beneath (Table 8.14) shows that viable concentrations were found throughout the depth of the sand filter at both loading rates and that the filter only affected a 1 log reduction in the enteric bacteria from the typically low concentrations in the secondary treated effluent. However, no viable *E. coli* concentrations were sampled beneath the sand filter at any depths (up to 1.9m) at either loading rate.

	Number of Samples	Number of samples with concentration (cfu/100ml)			
		<10	10-100	10^2-10^3	>10^3
SE	2 (1)		1 (1)	1	
Coarse sand (depth 0.3m)	2 (1)		1 (1)	1	
Medium sand (depth 0.475m)	2 (1)		2 (1)		
Fine sand (depth 0.75m)	2 (1)		2 (1)		
Subsoil (depth 1.3m)	2 (1)	2 (1)			
Subsoil (depth 1.6m)	2 (1)	2 (1)			
Subsoil (depth 1.9m)	2 (1)	2 (1)			

Table 8.14 *E. coli* concentrations in sand filter and subsoil (Site 4).
Note: figures in brackets indicate values during high loading trial

8.6 Summary

As was the case on Site 2, the installation of a Puraflo® system greatly reduced the bacterial and organic load on the percolation area and also brought about a degree of denitrification. This reduction in organic load also had the effect of inhibiting biomat formation and thus the distribution of effluent over a greater trench area. Analysis of the chloride levels in the soil moisture samples in the percolation area revealed that less than 10m of each percolation trench was utilised.

The analysis of soil moisture sample results was difficult due to the location of the lysimeters. The loading rate on the red and blue depth planes was calculated, therefore, by estimating a 2% reduction in concentration between each depth plane due to dilution. When parameter concentrations were examined it was found that the greatest reduction in COD concentrations occurred between the SE and the red depth plane while the greatest reduction in ortho-phosphate concentrations occurred between the blue and black depth planes. When the difference in loading rates between the SE and black depth plane were compared it was found that, while there had been complete removal of enteric bacteria and a reduction of COD to almost background levels, the effluent still contained a substantial nutrient load (Table 8.15).

The sand filter was used at a polishing filter on this site. It can be seen that it only had a moderate enhancement on the secondary effluent when compared to the standard percolation trenches, although it should be remembered that it requires a significantly smaller footprint. The nitrogen loads down through the subsoil are still high, although there is a moderate 30% reduction in the overall load when compared to the trenches at a depth of 1.9m. The main advantage of using the sand filter was the phosphate removal in the filter associated with the mineral composition of the sand. This removal was shown to be efficient at an average hydraulic loading rate of 41 l/m^2d but dropped away sharply at a higher loading rate of 98 l/m^2d. Hence, it is recommended that the existing design figure of 60 l/m^2d is maintained for use of the stratified sand filter as a polishing treatment process.

	Loading Rate (g/d)					
	COD	**NO_3-N**	**NO_2-N**	**NH_4-N**	***Total N***	**PO_4-P**
SE	53.1	10.34	0.06	1.64	*12.09*	2.07
Red	27.1	12.53	0.99	0.94	*13.57*	1.70
(1.1-1.3m depth)	24.1	10.85	0.02	0.59	*11.53*	0.06
Blue	22.2	12.01	0.07	0.74	*12.82*	1.20
(1.4-1.6m depth)	19.0	9.60	0.02	0.65	*10.27*	0.01
Black	24.7	11.29	0.02	0.52	*12.90*	0.22
(1.8-1.9m depth)	16.4	8.51	0.01	0.54	*9.06*	0.03

Table 8.15 Comparison of average loading rates in the subsoil beneath the percolation areas (in black) and beneath the stratified sand filter (in green) on Site 4.

9 DISCUSSION AND COMPARISONS

The results from the trials on the four sites have yielded interesting results particularly in terms of the differences between the fate of contaminants in the subsoil from septic tank effluent compared to secondary treated effluent. However, the project has also revealed other issues worthy of consideration with respect to the existing EPA policy as set out in the current guidelines (EPA, 2000) such as typical on-site wastewater production figures at the four sites and more practical points concerning the construction of the on-site systems and the availability and suitability of materials in Ireland. Finally, it should be noted that the trials were only carried out for a period of 12 months on Sites 1 and 2 and 9 months on Sites 3 and 4. If the sites had been monitored over a longer period, further development of the biomat (and thus percolation characteristics) on all sites would have been expected and also possibly a reduction in phosphate removal over time.

9.1 On-site wastewater production

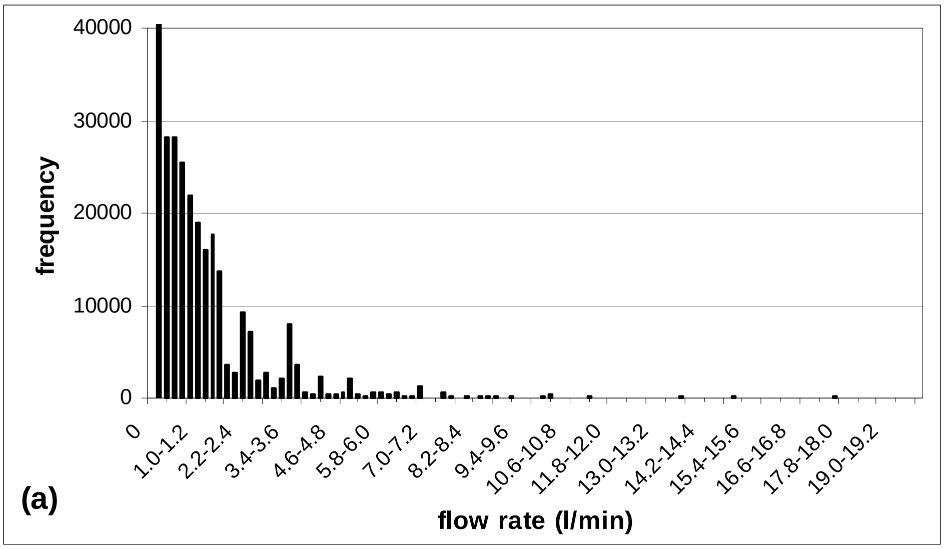
The average wastewater production at each site was as follows,

Site 1: 105 lcd (4 adults)
Site 2: 56 lcd (2 adults, 3 children)
Site 3: 82 lcd (1 adult, 3 children)
Site 4: 123 lcd (2 adults, 2 children)

It should be noted that there were suspicions that there may have been small contributions of surface water into the wastewater network on Sites 1, 3 and 4 which would slightly enhance the flow rate figures. It should also be recognised that these are new on-site systems that were closely scrutinised during construction for the research project and so the figures are likely to represent all wastewater production from the dwellings without any leakage upstream of the percolation areas. Nevertheless, this indicates that the EPA guideline figure of 180 lcd appears to over-estimate the per capita domestic wastewater production and therefore a figure of around 100 lcd would seem to be a more reasonable design figure for individual family houses.

This does not mean to say that the length of trenches specified in the EPA manual should necessarily be changed however, since it is not clear whether the theoretical hydraulic loading rate used (25 l/m^2d) in the case of septic tank effluent takes into account the hydraulic resistance of the biomat and its effect on the distribution of the effluent. This project indicates that the biomat has a large influence in the extent of distribution of the effluent across the percolation area.

An interesting result from the project is the analysis of flow distributions emanating from the on-site systems which are received at the distribution box. Such information should be carefully considered in the design of any effective distribution box. The three separate flow distributions for Sites 1,2 and 3 have been normalised and then combined to produce an average distribution of flow rates emanating from a septic tank (see Figures 9.1(a) and (b)). These statistics reveal the average flow frequency was 1.3 litre/minute but the average flow rate per unit volume of effluent was typically discharged at 3.6 litre/minute.



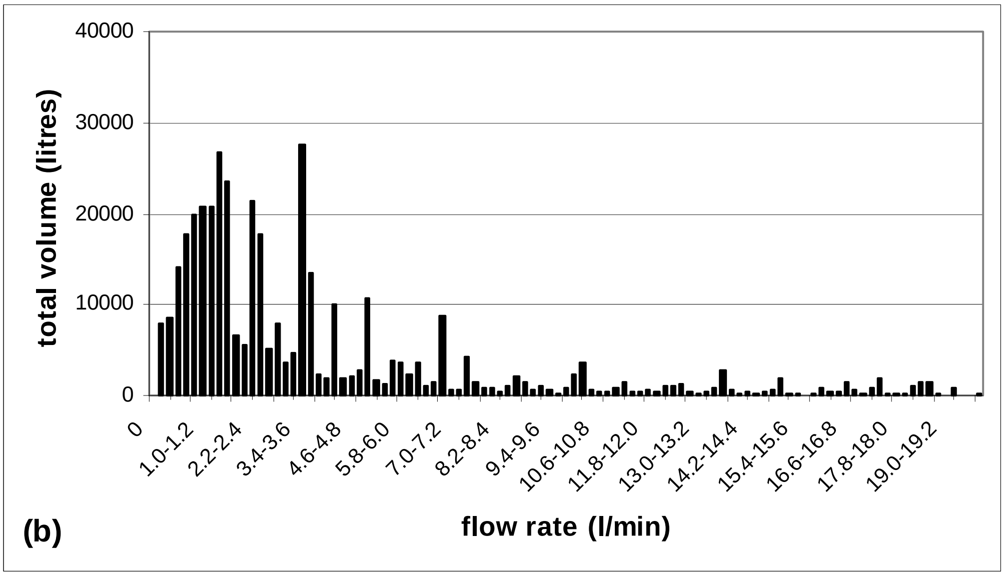
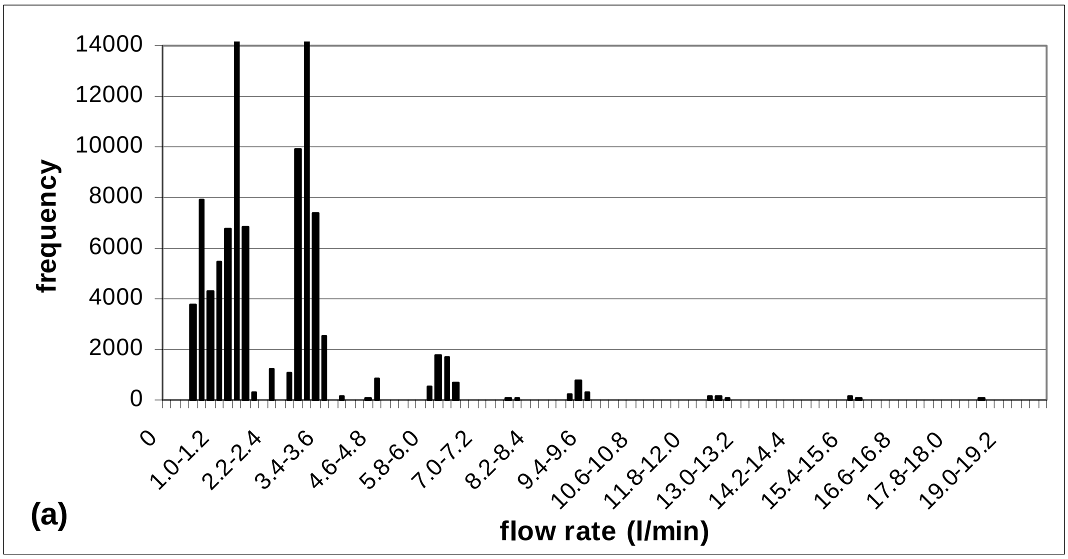


Figure 9.1 (a) Flow frequency and **(b)** total volume with respect to flow rate coming from a septic tank.

Equally, the flows measured on Site 4 were downstream of a peat filter which was fed by septic tank effluent pumped periodically from a sump. Hence, a fixed pumped flow rate is obviously imposed upon the natural hydraulic regime which can be clearly seen in Figures 9.2(a) and (b).



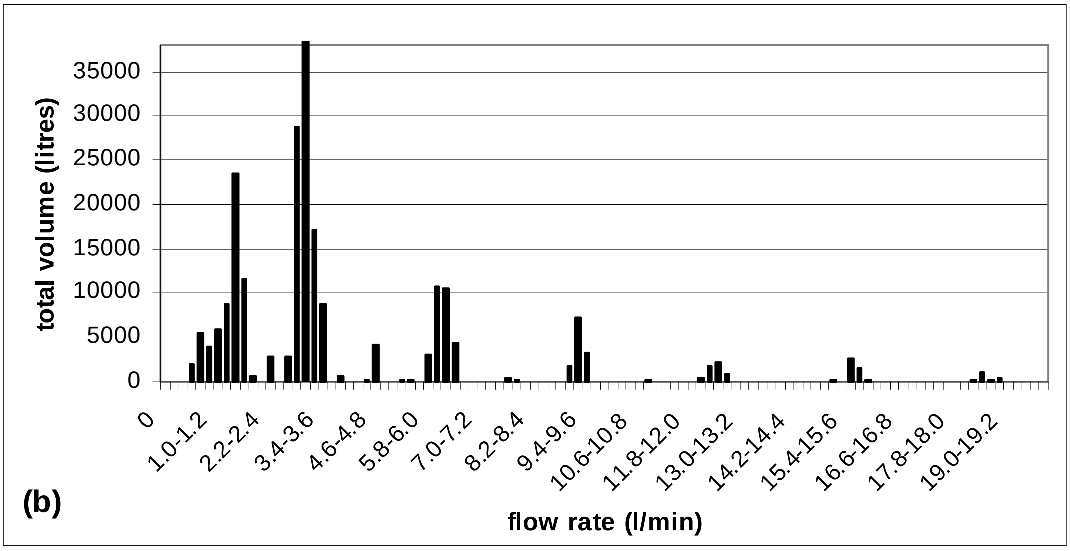


Figure 9.2 (a) Flow frequency and **(b)** total volume with respect to flow rate coming from the peat filter.

The majority of flow frequencies form a tight band from 2-3.5 litre/minute but also discrete higher rates are evident, presumably linked to the frequency of pumping events. The average flow frequency was 3.3 litre/minute, whilst the average volume of effluent was typically discharged in the range 2-4 litre/minute.

9.2 Comparison of on-site treatment systems

The results from the project demonstrate a clear difference between the fate of septic tank effluent on Sites 1 and 3 discharged into the subsoil and the fate of the secondary treated effluent on Sites 2 and 4 from the peat filter.

The depths of the lysimeters did vary slightly between sites, as shown in Table 9.1, however the red blue and black planes represented more or less similar depths beneath the percolation trench and so direct comparisons can legitimately be made.

	Site 1	Site 2	Site 3	Site 4
Red depth plane	0.2	0.3	0.2	0.2
Blue depth plane	0.55	0.6	0.6	0.6
Black depth plane	0.9	1.0	1.0	1.0

Table 9.1 Summary of nominal depths of lysimeters beneath invert of percolation trenches for all sites.

The average quality of the effluent discharged from the septic tanks on Sites 1 and 3 was broadly similar (see Tables 5.8 and 7.4) apart from the COD levels which were significantly lower on Site 1. However, both sites revealed that the vast majority of COD removal occurred above the red plane depth, in the percolation gravel and top 300mm of subsoil. Equally, there was a significant drop in the nitrogen load in this zone on both sites due to nitrification of the ammonia in the effluent and then subsequent denitrification in localised saturated pockets. As the effluent percolated down through the subsoil to the black plane a slight improvement in the quality of the effluent was noticed on both sites but the main removal had already occurred in the first 300mm of subsoil. The high bacteriological load in the septic tank effluent was also predominantly eliminated by the red plane although there were incidences of low concentrations of viable *E. coli* (10 cfu/100ml) sampled at isolated points at depth in the subsoil on both sites.

The installation of the secondary treatment systems in the form of a Puraflo® peat filter on Sites 2 and 4 greatly reduced the bacterial and organic load onto the percolation area. The strength of the effluent from both Puraflo® systems was broadly of the same order apart from the phosphate concentrations on Site 2 which were four times the level in Site 4 presumably due to some type of detergent being used in the house (see Tables 6.3 and 8.3). The peat filter also acted to nitrify most of the ammonia in the septic tank effluent to nitrate at both sites. A similar pattern on both sites was observed with respect to the fate of the pollutants in the percolation area, whereby the effluent was only picked up at the 0m sampling points on all trenches, an indication that the biomat had not developed very far along the trench. Hence, when the effluent is distributed across the subsoil there is little substrate for the heterotrophic bacteria in the soil to survive on resulting in a muted development of the biomat when compared to the sites receiving septic tank effluent. This has the effect of promoting a more intense plume moving down through the subsoil than if the effluent had been distributed over a wider area. This can be seen when looking at the nitrogen loads on Sites 2 and 4 which remain high (in nitrate form) all the way down through the subsoil with no significant evidence of denitrification due to the fact that there is very little organic matter left in the secondary treated effluent. The overall nutrient load on the groundwater is therefore potentially higher from the more treated effluent than from the septic tank effluent which has a more balanced recipe of pollutants for natural attenuation in the subsoil (see Table 9.2). It also must be remembered that the results on Sites 2 and 4 probably represent a best case scenario in terms of nitrogen loads since the specific design of the Puraflo® system for this project had promoted some unintentional nitrogen removal from the effluent (due to the perceived saturation in the base of the modules) of up to 50% before entering the subsoil which would not necessarily be the case with other package plants. With regards to bacterial removal, however, no enteric bacteria were found in the subsoil at 0.6m depth, the secondary treatment step removing significant quantities, although other incidences of *E. coli* was found on Site 2 at the lower black plane depth. There were also measured incidences of enteric bacteria at both the 10m and 20m sampling points on Site 4 where the effluent was known not to have extended (Section 8.4.4).

The results from the sites have shown that, under the subsoil conditions tested, the septic tank system with a carefully constructed percolation area provides a comparable if not better attenuation of the chemical pollutants in on-site domestic wastewater effluent compared to the secondary treatment system with percolation area. There also does not appear to be any advantage in specifying 1.2m depth of unsaturated subsoil for septic tank effluent but only 0.6m depth for secondary effluent. The evidence from this research indicates that the septic tank effluent has achieved an equivalent quality to the secondary treated effluent after percolating through 0.6m depth of unsaturated subsoil. However, the secondary treatment system does seem to ensure a slightly higher removal of enteric bacteria in the subsoil compared to the septic tank effluent where more frequent isolated incidences of low concentrations of indicator bacteria were found. It must be stated though that the levels of enteric bacteria found in the subsoil on all sites were very low and, as demonstrated on Sites 2 and 4, such levels could be from non-anthropogenic sources or merely a result of sampling and analytical errors. The extra 0.6m of unsaturated subsoil required for septic tank effluent can thus be considered to act as a safety buffer, particularly in terms of microbiological pollutants, on sites for example with high permeability subsoils (low T-values) - conditions which have not been explicitly been tested in this study. Alternatively, in more slowly percolating subsoils (high T-values) the extra depth will provide the requisite depth of unsaturated subsoil in the case, for example, where effluent starts to back up due to a less permeable layer between the 0.6 and 0.9m depth.

Thought should possibly be given in the guidance manual to change the design of the distribution system in the percolation area for secondary treated effluent which would force it to be distributed over a larger area without relying on the action of a biomat. This could be achieved, for example, by distributing the effluent between several shorter trenches rather than a few long trenches which is currently the practice, or having some form of pressurised distribution manifold. Secondary treatment manufactures could also be encouraged to incorporate a simple denitrification retrofit to their designs to lower the nitrogen load onto the subsoil and groundwater beneath.

	Site 1 (STE)	**Site 3 (STE)**	**Site 2 (SE)**	**Site 4 (SE)**
	Total N load (g/d)	**Total N load (g/d)**	**Total N load (g/d)**	**Total N load (g/d)**
Effluent (STE / SE)	22.6	17.14	18.0	24.2
Red	8.8	9.1	17.0	27.1
Blue	6.6	9.4	16.6	25.6
Black	7.4	3.3	-	25.8

Table 9.2 Comparison of average total nitrogen loading rates in the subsoil beneath the percolation areas on all sites *(note: the measured load rates on Sites 3 and 4 have been multiplied by two to give the comparative equivalent loads to Sites 1 and 2 where the effluent had been distributed across four trenches).*

9.3 Comparison of subsoils

The on-site effluent from the four sites was discharged into different subsoils, all with an unsaturated depth greater than 2m, classified according to the percolation test T-values, as follows,

Site 1: T-value 15 [septic tank effluent]
Site 2: T-value 29 [secondary effluent]
Site 3: T-value 33 [septic tank effluent]
Site 4: T-value 52 [secondary effluent]

It might have been expected therefore that Site 1, with the fastest percolating subsoil, would have demonstrated the slowest development of lateral distribution of the effluent across the percolation area. However, the opposite result has been obtained whereby Site 1 was the only site where effluent was shown to be distributed along the whole length of the trenches across the whole percolation area (except the last 10m on Trench 4). On Sites 2 and 4 this can be explained by the much reduced biomat formation due to low organic loads in the secondary treated effluent suggesting that the development of the biomat (a function of both the effluent and subsoil characteristics) has the biggest influence on percolation and distribution over the area. However, Site 3, with highly concentrated organic effluent and a T-value of 33 would have been expected to behave similarly to Site 1, whereas the effluent was only reliably picked up at the 0m sampling points on the trenches, although there were incidences of effluent reaching the 10m mark particularly after higher flow events. The apparent lack of biomat formation on Site 3 could be attributed to a number of factors: the trenches only receiving effluent for 7 months in reality (due to the five week trial on the stratified sand filter); the possibility of preferential flowpaths due to the presence of gravel and cobbles within the subsoil matrix; and the lysimeters being installed slightly outside the effluent plume. It could also be evidence of non-isotropic subsoil conditions on the site compared to the assumed conditions gained from the site investigation.

Comparing the percolation characteristics of the four sites, there does not appear to be any significant evidence of saturation throughout the subsoil depths in the percolation area. Apart from a few periodic and isolated incidents (for example Sites 1 and 2 in October), saturated conditions were not picked up by the tensiometer measurements nor, was there any evidence of extensive denitrification at depth through the subsoil (which could indicate saturated conditions) apart from above the red plane in the gravel layer and first 300mm due to localised pockets in the biomat. There is no evidence that a T-value of above 50 creates any particular problem for the secondary treated effluent in terms of ponding. Indeed more slowly percolating subsoil, should act to distribute the effluent more widely along the trenches although this could not be observed from the limited lateral sampling positions along the trenches between Sites 2 and 4.

Finally, one main difference between the subsoils that could be observed was that ortho-phosphate removal was seen to be dependent on subsoil characteristics which varied between the different subsoil layers on each site. For example, the high clay content in Sites 1 and 3 proved to be excellent for phosphate adsorption whereas little phosphate removal on Sites 2 and 4 occurred until the effluent reached the black depth plane at which depth there was a change in the subsoil characteristics. Another reason for this, however, could be that the adsorption of phosphate was muted due to the more acidic nature of the secondary treated effluent due to the nitrification of the effluent in the treatment plant and lack of recovery of pH with subsequent denitrification in the subsoil as was observed in Sites 1 and 3.

9.4 Comparison of stratified sand filters

The two stratified sand filters performed well on each site and actually performed slightly better than the equivalent parallel percolation areas. One of the main advantages of the stratified sand filters compared with the standard percolation areas was that they enabled a smaller footprint to be used. However, they also required pumping with associated maintenance.

The stratified sand filter has been used as a successful secondary treatment process on Site 3 but its design hydraulic load should be reduced to 30 l/m^2d to prevent hydraulic surcharge (in the fine sand layer) and also the breakthrough of bacteria. Indeed the specification of the fine sand layer should be examined in more detail. This layer does not appear to be achieving very much apart from creating the limiting hydraulic resistance of the filter. However, this phenomenon does inadvertently promote some denitrification of the effluent due to the saturated conditions which could be incorporated as a useful design aim. The organic loading of the filter was 41 $gCOD/m^2d$ which is comparable to many of the sand filters considered in the Literature Review and close to the limiting value in the region of 50 $gCOD/m^2d$ reported in several studies (Darby *et al.*, 1996; Schwager and Boller, 1997; Van Buuren *et al.*, 1999), thus confirming the hydraulic loading rate of 30 l/m^2d to be reasonable design figure for Irish conditions. In comparison to the performance of the original stratified filter design at 51 l/m^2d upon which it was based (Nichols *et al.*, 1997), the organic loading rates cannot be directly compared due to different methods of analyses. The ammonia loading from the septic tank was 8 gNH_3-N/d on Site 3 compared to the previous trial 20 gNH_3-N/d and showed similar levels of nitrification and overall better levels of nitrogen removal achieving 54% N-removal compared to 34%. A similar performance with regards to enteric coliforms was achieved with effluent concentrations from both filters in the range 10-100 CFU/100ml.

The sand filter was used as a polishing filter on Site 4 and only created a moderate enhancement to the quality of the secondary effluent when compared to the standard percolation trenches. The main advantage is the phosphate removal in the filter which was shown to be efficient at an average hydraulic loading rate of 41 l/m^2d but dropped away sharply at a higher loading rate of 98 l/m^2d. Hence, it is recommended that the existing design figure of 60 l/m^2d is maintained for use of the stratified sand filter as a polishing treatment process.

It should be noted that the ortho-phosphate removal in both the sand filters was attributed to the presence of goethite in both the coarse and medium sand layers. The mineral composition of sand will differ according to its source and so such phosphate removal in sand filters may not always exist. The effect of hydraulic loading rate on phosphate removal efficiency for both sand filters can be seen in Figure 9.3 which shows the drop off in efficiency at the higher hydraulic loading rate of 98 l/m^{2}d. The adsorption capacity of the sand is finite and will reduce with time as seemed to be evident in the sand filter on Site 4 towards the end of the trial period.

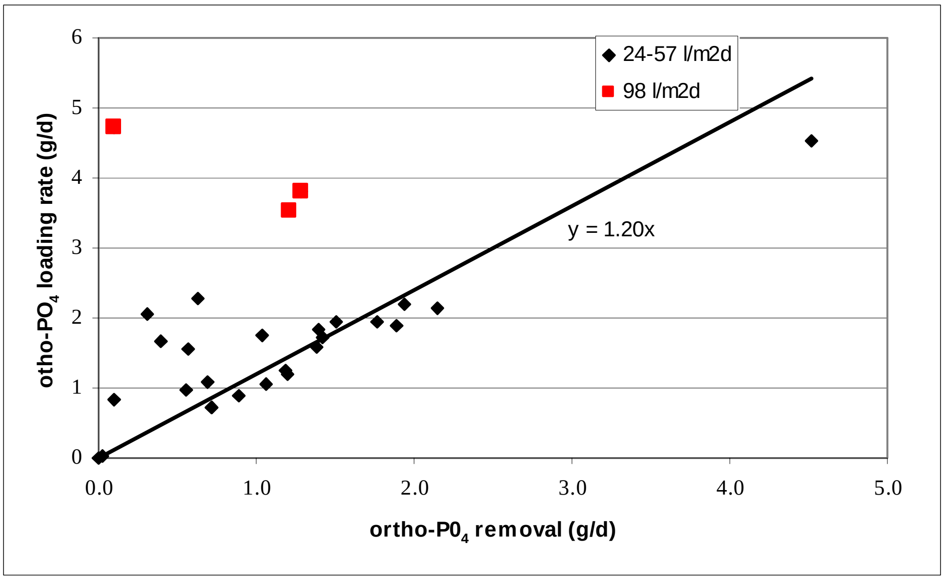


Figure 9.3 Graph of loading rate versus removal for ortho-phosphate for both stratified sand filters (Sites 3 and 4).

9.5 Construction of on-site systems

The construction of four separate percolation areas and two stratified sand filters for the project provided an interesting exposure to the existing practice of on-site system installation amongst practitioners in Ireland and also the practicality of using the EPA guidelines (EPA, 2000).

In terms of construction, it seemed to be common practice for builders to divert at least some storm water drains into the septic tank, presumably because this saves on the expense and time involved in laying extra pipework. This did not significantly affect the loading rates on the sites chosen for this project, which were still very low compared to the EPA guideline figure of 180 lcd, but would be likely much higher perhaps in the situation where a builder is not under the constant scrutiny of a research team as was the case here. Another area of concern was a lack of care taken when connecting the effluent pipe to the septic tank where a proper sealed joint must be ensured; otherwise the effluent just dribbles directly down the tank and never reaches the percolation area.

A major weakness in the implementation of the guidelines is the question of how to achieve an even effluent distribution between percolation trenches. Trials carried out both on site and in the laboratory proved that the current distribution box designs available in Ireland fail to distribute evenly between four trenches at the range of hydraulic loads experienced from on-site wastewater disposal, even if they are installed with care and exactly level. Again, on-site experience demonstrated that the correct distribution of effluent did not appear to be an issue that was of particular concern during the installation of on-site systems and yet it is fundamental to the whole principle of on-site wastewater treatment and disposal. The levelling of the percolation trenches to gain the correct 1:200 gradient also requires much care (and a staff and theodolite), particularly on a sloping site. The distribution of the effluent onto the stratified sand filter effluent also needs to be properly researched in order to develop a more robust manifold design.

Finally, the specification of the materials used in the on-site systems such as gravel and sand should be considered with regards to availability in Ireland since the current guidance manual has primarily taken specifications from research carried out in other countries.

10 CONCLUSONS AND RECOMMENDATIONS

10.1 Conclusions

- For the range of subsoil characteristics tested, the septic tank and percolation system provided a comparable treatment performance with respect to groundwater protection to the packaged secondary treatment system without the need for ongoing maintenance or energy consumption.

- The majority of the treatment of the septic tank effluent took place in the distribution gravel and first 300mm of subsoil where there was also a reduction in the total nitrogen load.

- The 1.2m of unsaturated subsoil did not fully remove all enteric bacteria from the septic tank effluent. Isolated incidences of low concentrations of *E. coli* were found in the subsoil on both septic tank sites.

- Secondary treated effluent discharged onto a percolation area did not develop a significant biomat and hence the effluent was concentrated over a relatively small area.

- Secondary treated effluent did not receive a significant treatment in the subsoil, (with the exception of phosphate which is dependent on the mineral characteristics of the subsoil) and resulted in higher nitrogen loads moving down to the groundwater when compared to the septic tank effluent percolation system.

- Secondary treatment systems significantly reduced the on-site wastewater bacterial loads to levels where only one incidence of enteric bacteria was found in the subsoils across both sites.

- At the sites investigated there did not appear to be any advantage in specifying 1.2m depth of unsaturated subsoil for septic tank effluent but only 0.6m depth for secondary effluent. The evidence from this research indicates that the septic tank effluent has achieved an equivalent quality to the secondary treated effluent after percolating through 0.6m depth of unsaturated subsoil.

- No discernable differences in treatment performance could be found between the sites according to their different percolation characteristic (T-values in the range 18-52). The actual distribution of effluent and percolation characteristics seemed to depend more on the development of the biomat which is a primary function of the organic load in the effluent.

- The possibility of the existence of preferential flow paths on Site 3 would be worth further examination and continuing long term observation.

- The stratified sand filters performed slightly better compared to the percolation areas on both sites receiving septic tank and secondary treated effluent respectively. They fared particularly well with regards to phosphate removal which was demonstrated to be due to the particular mineral composition of the sand used in the filters.

- A stratified sand filter used as a secondary treatment process should be designed to receive a hydraulic loading rate of 30 l/m^2d to prevent ponding in the base and breakthrough of bacteria.

- A stratified sand filter used as polishing filter should be designed to receive a hydraulic loading rate of 60 l/m^2d to optimize phosphate removal.

- The current distribution boxes available in Ireland do not distribute the effluent effectively. Emphasis should be placed on even distribution between trenches in the guidance manual and the development of a functional design.

- The wastewater generation in the four sites was much lower than the EPA guidance value of 180 lcd: a value of 100 lcd would seem to be a more reasonable design figure.

- The installation of on-site systems needs to be regulated since there is currently no guarantee that the systems specified in the guidelines after a thorough site investigation will actually be installed below ground surface due to poor work practices in the industry.

10.2 Recommendations for further research

- Further trials on sites with T-values in the range 1-5, with special focus on bacteria and viruses.

- Trials on sites for secondary effluent discharging into subsoils with T-values greater than 75 to assess whether the reduced permeability promotes more extensive lateral distribution of the effluent.

- Long term trials to assess the effect of the development of the biomat over a period of years on sites receiving septic tank and secondary effluent. Also research into the existence of preferential flow paths and whether they become blocked with time especially with septic tank effluent.

- Research into methods of distributing secondary treated effluent over wider percolation area

- Research into a simple denitrification retrofit for package treatment plants.

- Development of an effective distribution box for on-site systems.

Sand filter research

- Effect of different sand sizes on stratified sand filter and whether the stratification makes any difference to treatment performance compared to a monograde filter.

- Effect of ventilation pipes down into sand filter to improve aeration at depth and potentially increase the design loading rates.

- Design of balanced distribution manifold for filters which prevents blockages.

- Research into the concept of using a sacrificial layer of sand in areas of particularly nutrient sensitivity whereby an adsorptive layer of sand can be replaced by fresh sand periodically when its capacity has been reached.

- Analysis of sand types available in Ireland with regard to phosphate removal.

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Details of Project Partners

The project was undertaken by the Department of Civil, Structural and Environmental Engineering in Trinity College Dublin (TCD). The project leader was Laurence Gill assisted by Paul Johnston and Bruce Misstear. The research assistant on the project was Cormac Ó Súilleabháin who carried out the majority of the site selection tests, site construction, field work and data analyses. The project co-ordinators for the Agency were Ger O'Leary followed by Frank Clinton who were both assisted by Margaret Keegan.

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APPENDIX A

SITE ASSESSMENT FORMS & PARTICLE SIZE DISTRIBUTION CURVES

SITE CHARACTERISATION FORM – Site 1

1.0 GENERAL DETAILS (from planning application)

PLANNING APPLICATION Ref. No. : **XXXX**

NAME & ADDRESS OF APPLICANT : Site 1

SITE LOCATION AND TOWNLAND : The Curragh

XXXX

TELEPHONE No. :

FAX No. : **E-MAIL :**

MAXIMUM No. OF RESIDENTS 4 **No. OF DOUBLE BEDROOMS :** 2 **No. OF SINGLE BEDROOMS :** 3

PROPOSED CAPACITY OF SEPTIC TANK (litres) : 2275 litres **NUMBER OF CHAMBERS :** 2

PROPOSED WATER SUPPLY : (tick as appropriate)	**Mains**	**Private well / borehole**	**Group well / borehole**
	√		

2.0 DESK STUDY

Soil type: Grey-Brown Podzolic	**Bedrock type:** Richardstown Limestone (RK) – dark grey limestones, commonly cherty, partly dolomitised
Subsoil type: Gravels	**Aquifer type:** Rg – regionally important sand/gravel aquifer
Vulnerability class: High	**Groundwater Protection Response:** R1

Presence of significant sites:
(archaeological, natural and historical)

There is a barrow, a prehistoric tomb covered by a mound of earth, located approximately 250m south west of the site at 27880E 21275N.

Zoning in county development plan:

Not zoned

Past experience in the area:

None

Comments:

While the desk study judged the site characteristics to be consistent with the criteria outlined in the Wastewater Treatment Manuals (EPA 2000) and Groundwater Protection Schemes (Dept. of the Environment and Local Government, EPA and GSI, 2000) for the location of wastewater treatment systems an on-site assessment will be necessary to confirm its suitability

Sketch of site showing measurement to Trial Hole location and Percolation Test Hole locations, wells and direction of groundwater flow, proposed house (incl. distances from boundaries) **adjacent houses, watercourses, significant sites and other features. North point should always be included.**

3.0 ON-SITE ASSESSMENT

3.1 Visual Assessment

TOPOGRAPHY: Sloping towards stream in north. **LANDSCAPE:** Free-draining farmland **GEOLOGY:** No obvious geological features.	**SLOPE:** STEEP (>1:5) SHALLOW (1:5 – 1:20) √ RELATIVELY FLAT (<1:20)

SURFACE FEATURES

OUTCROPS: None

HOUSES: Cottage which will be serviced by septic tank and constructed wetland in the process of being renovated approximately 30m north east. School 100m to south east.

DITCHES: Ditch with stream at bottom of field – 50m north.

WELLS: None.

SPRINGS: None

KARST FEATURES: None

ROADS: Regional road R413 passes approximately 60m to south west.

WATERCOURSE : Site slopes towards steam 50m to north.

LAKES/SURFACE WATER PONDING/ BEACH/SHELLFISH AREAS/ WETLANDS :

None

SITE BOUNDARIES : Clearance distances as outlined in EPA 2000 adhered to.

EXISTING LAND USE : Grazing for horses.

LOCAL DRAINAGE: No obvious indicators of poor drainage in the vicinity of proposed percolation area.

TYPE OF VEGETATION : Grassland,, docks, dandelions and daisies visible absence of indicators of poor drainage.

GROUND CONDITIONS: Dry and solid underfoot

COMMENTS: The potential targets that exist for contamination from the discharge of wastewater are the groundwater and the adjacent stream there are no obvious surface indicators to suggest that site would be unsuitable for installation of domestic wastewater treatment system. The degree of risk and hence the appropriate treatment system will thus depend on the trial hole inspection and results of the percolation test.

3.2 Trial Hole

Depth of Trial Hole: 2.2m	**Date and Time of excavation:** 6//02/02 11:00 **Date and Time of examination:** 8//02/02 13:00

Depth from ground surface to bedrock (m): Bedrock not reached

Depth from ground surface to water table (m): Watertable not reached

Soil Type: Clay loam **Subsoil Type** : sandy Clay (w/silt)

Soil / Subsoil Information

	Soil / subsoil Texture & Classification	**Soil Structure**	**Density**	**Colour**	**Preferential Flowpaths**
0.1M 0.2M 0.3M	A Horizon	Crumb	Medium	Dark brown	Roots
0.4M 0.5M **0.6M** 0.7M	Silt/Clay	Structureless -massive	Low	Brown	Some root ends and macropores present
0.8M 0.9M 1.0M 1.1M	sandy Clay (w/silt) interspersed with rounded cobbles	Structureless -massive	Medium	Reddish Brown	Macropores, cracks & voids around some cobble
1.2M 1.3M 1.4M 1.5M 1.6M 1.7M 1.8M 1.9M 2.0M 2.1M 2.2M	sandy Clay (w/silt) interspersed with rounded cobbles	Structureless -massive	Medium	Brown	Macropores, cracks & voids around some cobble
2.3M 2.4M 2.5M	Base of hole				

BS 5930 Analysis:
Cohesive Test : Yes **Thread Test :** High plasticity **Ribbon Test :** 110mm
Dilatancy Test : No **Result** : sandy Clay (w/silt)

3.3 Percolation Test

Type of Test *(T-test or P-test)* T-test

Percolation Test hole	1	2
Depth from ground surface to top of hole (mm) – **A**	550mm	550mm
Depth from ground surface to bottom of hole (mm) – **B**	950mm	950mm
Depth of hole (mm) [**B-A**]	400mm	400mm
Dimensions of hole [length x breadth (mm)]	300mm x 300mm	300mm x 300mm
Date of Test	7/2/2002	6/2/2002
Date pre-soaking started	6/2/2002	6/2/2002
Time filled to 400mm	11:19	11:21
Time water level at 300mm	12:04	11:38

	Test Hole No. 1			Test Hole No. 2		
Fill No.	**Start Time** (at 300mm)	Finish Time (at 200mm)	Δt (minutes)	**Start Time** (at 300mm)	Finish Time (at 200mm)	Δt (minutes)
1	12:04	13:11	67	11:38	12:15	37
2	13:11	14:30	79	12:15	13:00	45
3	14:30	15:46	76	13:00	13:47	47
		AverageΔt (minutes)	**74**		AverageΔt (minutes)	**43**

At hole no. 1 : average $\Delta t/4 = t_1 = 18$ At hole no. 2 : average $\Delta t/4 = t_2 = 10$

T value = $(t_1 + t_2)/2 =$ **14** (minute/25mm) → Result of Test **PASSED**

Comments

Site suitable for conventional septic tank with adequate percolation area in accordance with the EPA Guidance Manual (2000). Also suitable for mechanically aerated system or intermittent filter system.

Note : P-test not required.

4.0 CONCLUSION

Integrate the information from the desk study and on-site assessment (i.e. visual assessment. Trial hole and percolation tests) above and conclude the type of system that is appropriate. This information is also used to choose the optimum final disposal route of the treated wastewater.

Suitable for :

(a) Septic tank & soil percolation system **SUITABLE**

(b) Septic tank and intermittent filter system and polishing unit ; or septic tank & constructed wetland & polishing unit. **SUITABLE**

(c) Mechanical aeration system & polishing unit. **SUITABLE**

And SUITABLE for discharge to ***GROUNDWATER.***

5.0 RECOMMENDATION

Propose to install: Septic tank with soil percolation system

And discharge to : Groundwater

Signed : XXXX Address : XXX
Qualifications : XXXX
Date of report:

Phone : Fax : E-mail :

6.0 REVIEW (by Local Authority)

Site Visit Date :

Inspection of trial hole Date :

Inspection of percolation Test Holes Date :

Comments :

Signed : Date :

SITE CHARACTERISATION FORM – Site 2

1.0 GENERAL DETAILS (from planning application)

PLANNING APPLICATION Ref. No. : **XXXX**

NAME & ADDRESS OF APPLICANT : Site 2

SITE LOCATION AND TOWNLAND : Rochestown
Brannockstown
Co. Kildare

TELEPHONE No. :

FAX No. : **E-MAIL :**

MAXIMUM No. OF RESIDENTS 5 **No. OF DOUBLE BEDROOMS** : 1 **No. OF SINGLE BEDROOMS :** 3

PROPOSED CAPACITY OF SEPTIC TANK (litres) : 4000 litres **NUMBER OF CHAMBERS :** 2

PROPOSED WATER SUPPLY : (tick as appropriate)	**Mains**	**Private well / borehole**	**Group well / borehole**
	√		

2.0 DESK STUDY

Soil type: Grey-Brown Podzolic

Bedrock type: Carrighill (CZ) formation – calcareous greywacke & shale

Subsoil type: Gravels

Aquifer type: Pu – bedrock generally unproductive

Vulnerability class: High

Groundwater Protection Response: R1

Presence of significant sites:
(archaeological, natural and historical)

None

Zoning in county development plan:

Not zoned

Past experience in the area:

None

Comments:

The proposed percolation area lies within the catchment area of the Liffey river. However, the river lies approximately 0.75 km to the north and thus the minimum separation distances outlined by the EPA (EPA, 2000) are met.

Sketch of site showing measurement to Trial Hole location and Percolation Test Hole locations, wells and direction of groundwater flow, proposed house (incl. distances from boundaries) **adjacent houses, watercourses, significant sites and other features. North point should always be included.**

3.0 ON-SITE ASSESSMENT

3.1 Visual Assessment

TOPOGRAPHY: Site located in a hollow. **LANDSCAPE:** Free-draining farmland **GEOLOGY:** No obvious geological features.	**SLOPE:** STEEP (>1:5) SHALLOW (1:5 – 1:20) RELATIVELY FLAT (<1:20) √

SURFACE FEATURES

OUTCROPS: None

HOUSES: Nearest dwelling 0.7 km to north east.

DITCHES: None

WELLS: One on site that is no longer in use. When dipped the water level was found to be 7m below ground level or approximately 4.2m below the invert of the percolation trench.

SPRINGS: None

KARST FEATURES: None

ROADS: Site adjacent to regional road R413

WATERCOURSE : Stream flowing in ditch approximately 150m to west in direction of Liffey that is 0.75 km to north.

LAKES/SURFACE WATER PONDING/
BEACH/SHELLFISH AREAS/ WETLANDS :
Adjacent field approximately 40m north of the proposed percolation area experiences surface ponding during the winter months.

SITE BOUNDARIES : Clearance distances as outlined in EPA 2000 adhered to.

EXISTING LAND USE : Grazing for livestock.

LOCAL DRAINAGE: No obvious indicators of poor drainage in immediate vicinity of proposed percolation area.

TYPE OF VEGETATION : Grassland, nettles, docks, dandelions and daisies.

GROUND CONDITIONS: Dry and solid underfoot

COMMENTS:
The potential targets that exist for contamination from the discharge of wastewater are the groundwater and the adjacent stream. The degree of risk and hence the appropriate treatment system will thus depend on the trial hole inspection and results of the percolation test.

3.2 Trial Hole

Depth of Trial Hole: 2.1m	**Date and Time of excavation:** 4/2/02 11:00 **Date and Time of examination:** 8/2/02 10:00

Depth from ground surface to bedrock (m): Bedrock not reached

Depth from ground surface to water table (m): Watertable not reached

Soil Type: Clay loam **Subsoil Type** : sandy Silt (w/clay)

Soil / Subsoil Information

	Soil / subsoil Texture & Classification	**Soil Structure**	**Density**	**Colour**	**Preferential Flowpaths**
0.1M 0.2M 0.3M	A Horizon	Crumb	Medium	Dark brown	Roots
0.4M 0.5M 0.6M 0.7M 0.8M 0.9M	sandy Clay (w/silt)	Structureless -massive	Medium	Reddish brown	Some roots and macropores
1.0M 1.1M 1.2M 1.3M 1.4M 1.5M 1.6M 1.7M 1.8M 1.9M 2.0M 2.1M	sandy Silt (w/clay)	Structureless -massive	Medium	Brown	None evident
2.2M 2.3M 2.4M 2.5M	Base of hole				

BS5930 Analysis :
Cohesive Test : Yes **Thread Test :** Moderate plasticity **Ribbon Test :** 55 mm
Dilatancy Test : Slow **Result** : sandy Silt (w/clay)

3.3 Percolation Test

Type of Test *(T-test or P-test)* T-test

Percolation Test hole	1	2
Depth from ground surface to top of hole (mm) – **A**	550mm	550mm
Depth from ground surface to bottom of hole (mm) – **B**	950mm	950mm
Depth of hole (mm) [**B-A**]	400mm	400mm
Dimensions of hole [length x breadth (mm)]	300mm x 300mm	300mm x 300mm
Date of Test	5/2/2002	5/2/2002
Date pre-soaking started	4/2/2002	4/2/2002
Time filled to 400mm	10:50	10:46
Time water level at 300mm	11:45	12:13

	Test Hole No. 1			Test Hole No. 2		
Fill No.	**Start Time** (at 300mm)	Finish Time (at 200mm)	Δt (minutes)	**Start Time** (at 300mm)	Finish Time (at 200mm)	Δt (minutes)
1	11:45	13:05	80	12:13	14:25	132
2	13:08	14:33	85	14:26	16:53	147
3	14:33	16:10	97	16:53	19:22	149
		AverageΔt (minutes)	**87**		AverageΔt (minutes)	**144**

At hole no. 1 : average $\Delta t/4 = t_1 = 22$ At hole no. 2 : average $\Delta t/4 = t_2 = 36$

T value = $(t_1 + t_2)/2 =$ **28** (minute/25mm) → Result of Test **PASSED**

Comments

Site suitable for conventional septic tank with adequate percolation area in accordance with the EPA Guidance Manual (2000). Also suitable for mechanically aerated system or intermittent filter system.

Note : P-test not required.

4.0 CONCLUSION

Integrate the information from the desk study and on-site assessment (i.e. visual assessment. Trial hole and percolation tests) above and conclude the type of system that is appropriate. This information is also used to choose the optimum final disposal route of the treated wastewater.

Suitable for :	
(d) Septic tank & soil percolation system	**SUITABLE**
(e) Septic tank and intermittent filter system and polishing unit ; or septic tank & constructed wetland & polishing unit.	**SUITABLE**
(f) Mechanical aeration system & polishing unit.	**SUITABLE**
And SUITABLE for discharge to ***GROUNDWATER.***	

5.0 RECOMMENDATION

Propose to install : Septic tank and mechanical aeration system with soil percolation system

And discharge to : Groundwater

Signed : XXXX Address : XXX
Qualifications : XXXX
Date of report:

Phone : E-mail :

6.0 REVIEW (by Local Authority)

Site Visit	Date :
Inspection of trial hole	Date :
Inspection of percolation Test Holes	Date :
Comments :	
Signed :	**Date :**

SITE CHARACTERISATION FORM – Site 3

1.0 GENERAL DETAILS (from planning application)

PLANNING APPLICATION Ref. No. : **XXXX**

NAME & ADDRESS OF APPLICANT : **Site 3**

SITE LOCATION AND TOWNLAND : Three Wells

Co. Wicklow

TELEPHONE No. :

FAX No. : **E-MAIL :**

MAXIMUM No. OF RESIDENTS 4 **No. OF DOUBLE BEDROOMS :** 1 **No. OF SINGLE BEDROOMS :** 3

PROPOSED CAPACITY OF SEPTIC TANK (litres) : 4000 litres **NUMBER OF CHAMBERS :** 2

PROPOSED WATER SUPPLY : (tick as appropriate)	**Mains**	**Private well / borehole**	**Group well / borehole**
		√	

2.0 DESK STUDY

Soil type: Clay loam	**Bedrock type:** Ribband group, Maulin formation - Slate, phylite, schist, basalt & quartzite
Subsoil type: Till with lower palaeozoic schists, sandstones, greywackes and shales dominant.	**Aquifer type:** Ll
Vulnerability class: Extreme (E)	**Groundwater Protection Response:** R2[1]

Presence of significant sites:
(archaeological, natural and historical)

None

Zoning in county development plan:

Not zoned under 1999 County Development Plan.

Past experience in the area:

None

Comments:

While the desk study judged the site characteristics to be consistent with the criteria outlined in the Wastewater Treatment Manuals (EPA 2000) and Groundwater Protection Schemes (Dept. of the Environment and Local Government, EPA and GSI, 2000) for the location of wastewater treatment systems an on-site assessment will be necessary to confirm its suitability.

Sketch of site showing measurement to Trial Hole location and Percolation Test Hole locations, wells and direction of groundwater flow, proposed house (incl. distances from boundaries) **adjacent houses, watercourses, significant sites and other features. North point should always be included.**

3.0 ON-SITE ASSESSMENT

3.1 Visual Assessment

TOPOGRAPHY: Slightly sloping towards south west. **LANDSCAPE:** Immediate area is free-draining grassland and tillage land sloping towards the south eat **GEOLOGY:** No obvious geological features.	**SLOPE:** STEEP (>1:5) SHALLOW (1:5 – 1:20) √ RELATIVELY FLAT (<1:20)

SURFACE FEATURES

OUTCROPS: Outcrop behind house exposing 2.5m of unsaturated subsoil.

HOUSES: Nearest dwelling approximately 100m south east.

DITCHES: None

WELLS: Borehole 60m up gradient to west.

SPRINGS: None

KARST FEATURES: None

ROADS: Site adjacent to 3rd class road (c.f. site map)

WATERCOURSE : None

LAKES/SURFACE WATER PONDING/
BEACH/SHELLFISH AREAS/ WETLANDS : None

SITE BOUNDARIES : N/A

EXISTING LAND USE : N/A.

LOCAL DRAINAGE: Naturally well drained

TYPE OF VEGETATION : Grassland.

GROUND CONDITIONS: Dry and solid underfoot

COMMENTS:	The potential target that exist for contamination from the discharge of wastewater is the groundwater. The degree of risk and hence the appropriate treatment system will thus depend on the trial hole inspection and results of the percolation test.

3.2 Trial Hole

Depth of Trial Hole: 2.2mm	**Date and Time of excavation:** 10/05/03 09:30 **Date and Time of examination:** 12/05/03 11:00

Depth from ground surface to bedrock (m): Bedrock not reached

Depth from ground surface to water table (m): Watertable not evident

Soil Type: Clay loam **Subsoil Type** : clayey Sand

Soil / Subsoil Information

	Soil / subsoil Texture & Classification	**Soil Structure**	**Density**	**Colour**	**Preferential Flowpaths**
0.1M 0.2M 0.3M	A horizon	Crumb	Medium	Dark brown	Roots, some evidence of macropores
0.4M 0.5M	sandy Silt (w/clay)	Structureless -single grain	Medium	Reddish brown	Some root ends
0.6M 0.7M 0.8M 0.9M 1.0M 1.1M **1.2M** 1.3M 1.4M 1.5M 1.6M 1.7M 1.8M 1.9M 2.0M 2.1M 2.2M	Very gravelly clayey Sand interspersed striated cobbles	Structureless – single grain	Medium	Dark brown	Some macropores evident in pockets of gravel and around cobbles
2.3M					

3.3 Percolation Test

Type of Test T-test

Percolation Test hole	1	2
Depth from ground surface to top of hole (mm) – **A**	550mm	550mm
Depth from ground surface to bottom of hole (mm) – **B**	950mm	950mm
Depth of hole (mm) [**B-A**]	400mm	400mm
Dimensions of hole [length x breadth (mm)]	300mm x 300mm	300mm x 300mm
Date of Test	12/05/2003	12/05/03
Date pre-soaking started	11/05/03	11/05/03
Time filled to 400mm	10:08	10:09
Time water level at 300mm	11:11	11:07

	Test Hole No. 1			Test Hole No. 2		
Fill No.	Start Time (at 300mm)	Finish Time (at 200mm)	Δt (minutes)	Start Time (at 300mm)	Finish Time (at 200mm)	Δt (minutes)
1	11:11	13:57	166	11:07	12:23	76
2	13:58	16:50	172	12:24	13:58	92
3	16:50	19:45	175	13:58	15:40	102
		AverageΔt (minutes)	**171**		AverageΔt (minutes)	**90.3**

At hole no. 1 : average Δt/4 = t_1 = 42.8 At hole no. 2 : average Δt/4 = t_2 = 22.6

T value = (t_1 + t_2)/2 = **32.7** minute/25mm) Result of Test **PASSED**

Comments

Site suitable for conventional septic tank with adequate percolation area in accordance with the EPA Guidance Manual (2000). Also suitable for mechanically aerated system or intermittent filter system.

Note : P-test not required.

4.0 CONCLUSION

Integrate the information from the desk study and on-site assessment (i.e. visual assessment. Trial hole and percolation tests) above and conclude the type of system that is appropriate. This information is also used to choose the optimum final disposal route of the treated wastewater.

Suitable for :

(g) Septic tank & soil percolation system **SUITABLE**

(h) Septic tank and intermittent filter system and polishing unit ; or septic tank & constructed wetland & polishing unit. **SUITABLE**

(i) Mechanical aeration system & polishing unit. **SUITABLE**

And SUITABLE for discharge to ***GROUNDWATER.***

5.0 RECOMMENDATION

Propose to install : Septic Tank with Soil Percolation system

And discharge to : Groundwater

Signed : XXXX Address : XXX
Qualifications : XXXX
Date of report:

Phone : Fax : E-mail :

6.0 REVIEW (by Local Authority)

Site Visit	Date :
Inspection of trial hole	Date :
Inspection of percolation Test Holes	Date :
Comments :	
Signed :	**Date :**

SITE CHARACTERISATION FORM – Site 4

1.0 GENERAL DETAILS (from planning application)

PLANNING APPLICATION Ref. No. : XXXX

NAME & ADDRESS OF APPLICANT : Site 4

SITE LOCATION AND TOWNLAND : Killaveny
Tinahely
Co. Wicklow

TELEPHONE No. :

FAX No. :

E-MAIL :

MAXIMUM No. OF RESIDENTS	5	**No. OF DOUBLE BEDROOMS :**	1	**No. OF SINGLE BEDROOMS :**	4

PROPOSED CAPACITY OF SEPTIC TANK (litres) :	4000 litres	**NUMBER OF CHAMBERS :**	2

PROPOSED WATER SUPPLY : (tick as appropriate)	**Mains**	**Private well / borehole**	**Group well / borehole**
		√	

2.0 DESK STUDY

Type: Clay loam	**Bedrock type:** Ribband group, Maulin formation - Slate, phylite, schist, basalt & quartzite
Subsoil type Till with lower palaeozoic schists, sandstones, greywackes and shales dominant.	**Aquifer type:** Ll
Vulnerability class: Extreme (E)	**Groundwater Protection Response:** R2[1]

Presence of significant sites:
(archaeological, natural and historical)

None

Zoning in county development plan:

Not zoned under 1999 County Development Plan.

Past experience in the area:

None

Comments:

While the desk study judged the site characteristics to be consistent with the criteria outlined in the Wastewater Treatment Manuals (EPA 2000) and Groundwater Protection Schemes (Dept. of the Environment and Local Government, EPA and GSI, 2000) for the location of wastewater treatment systems an on-site assessment will be necessary to confirm its suitability.

Sketch of site showing measurement to Trial Hole location and Percolation Test Hole locations, wells and direction of groundwater flow, proposed house (incl. distances from boundaries) **adjacent houses, watercourses, significant sites and other features. North point should always be included.**

3.0 ON-SITE ASSESSMENT

3.1 Visual Assessment

TOPOGRAPHY: Gently sloping towards floor of valley to north west. **LANDSCAPE:** Immediate area is free-draining grassland and tillage land sloping towards the north west **GEOLOGY:** No obvious geological features.	**SLOPE:** STEEP (>1:5) SHALLOW (1:5 – 1:20) √ RELATIVELY FLAT (<1:20)

SURFACE FEATURES

OUTCROPS: None

HOUSES: Nearest dwelling approximately 100m north.

DITCHES: None

WELLS: Bore hole on site.

SPRINGS: None

KARST FEATURES: None

ROADS: Site adjacent to regional road (c.f. site map)

WATERCOURSE : Stream approximately 300m to north east.

LAKES/SURFACE WATER PONDING/ BEACH/SHELLFISH AREAS/ WETLANDS : None

SITE BOUNDARIES : N/A

EXISTING LAND USE : N/A

LOCAL DRAINAGE: Naturally well drained

TYPE OF VEGETATION : Grassland.

GROUND CONDITIONS: Dry and solid underfoot.

COMMENTS:	The potential targets that exist for contamination from the discharge of wastewater is the adjacent stream and the groundwater. The degree of risk and hence the appropriate treatment system will thus depend on the trial hole inspection and results of the percolation test.

3.2 Trial Hole

Depth of Trial Hole: 2.2mm	**Date and Time of excavation:** 24/1/03 09:30 **Date and Time of examination:** 27/1/03 11:00

Depth from ground surface to bedrock (m): Bedrock not reached

Depth from ground surface to water table (m): Watertable not evident

Soil Type: Clay loam **Subsoil Type** : clayey Sand

Soil / Subsoil Information

	Soil / subsoil Texture & Classification	**Soil Structure**	**Density**	**Colour**	**Preferential Flowpaths**
0.1M 0.2M 0.3M	A horizon	Crumb	Medium	Dark brown	Roots, some evidence of macropores
0.4M 0.5M	clayey Sand with some rounded cobbles	Structureless -single grain	Dense	Light brown	Some root ends
0.6M 0.7M 0.8M 0.9M 1.0M 1.1M **1.2M** 1.3M 1.4M 1.5M 1.6M 1.7M 1.8M 1.9M 2.0M 2.1M 2.2M	gravelly clayey Sand interspersed with gravel and rounded cobbles	Structureless - single grain	Dense	Dark brown	None obvious although pockets of cobbles create macropores
2.3M	Base of hole				

3.3 Percolation Test

Type of Test T-test

Percolation Test hole	1	2
Depth from ground surface to top of hole (mm) – **A**	850mm	900mm
Depth from ground surface to bottom of hole (mm) – **B**	1250mm	1300mm
Depth of hole (mm) [**B-A**]	400mm	400mm
Dimensions of hole [length x breadth (mm)]	300mm x 300mm	300mm x 300mm
Date of Test	27/1/2003	27/1/03
Date pre-soaking started	26/1/03	26/1/03
Time filled to 400mm	10:22	10:00
Time water level at 300mm	12:12	13:20

	Test Hole No. 1			Test Hole No. 2		
Fill No.	Start Time (at 300mm)	Finish Time (at 200mm)	Δt (minutes)	Start Time (at 300mm)	Finish Time (at 200mm)	Δt (minutes)
1	12:12	15:07	175	13:20	17:15	235
2	15:07	18:07	180	17:15	22:15	240
3	18:07	21:14	187			
		AverageΔt (minutes)	**180.6**		AverageΔt (minutes)	**237.5**

At hole no. 1 : average $\Delta t/4 = t_1 =$ 45.2   At hole no. 2 : average $\Delta t/4 = t_2 = 59.4$

T value = $(t_1 + t_2)/2 =$ **52.3** (minute/25mm) → Result of Test **FAILED**

Comments

T-value deems site unsuitable for conventional septic tank system (EPA, 2000). While a P-test might deem the site suitable for installation of a secondary treatment system in accordance with the Guidance Manual (2000) no P-test was carried out as the site met the project specifications.

4.0 CONCLUSION

Integrate the information from the desk study and on-site assessment (i.e. visual assessment. Trial hole and percolation tests) above and conclude the type of system that is appropriate. This information is also used to choose the optimum final disposal route of the treated wastewater.

Suitable for :	
(j) Septic tank & soil percolation system	**UNSUITABLE**
(k) Septic tank and intermittent filter system and polishing unit ; or septic tank & constructed wetland & polishing unit.	**N/A**
(l) Mechanical aeration system & polishing unit.	**N/A**
And SUITABLE for discharge to ***GROUNDWATER.***	

5.0 RECOMMENDATION

Propose to install : Puraflo® with effluent split between stratified sand filter ($6m^2$) and 20m of percolation trenches

And discharge to : Groundwater

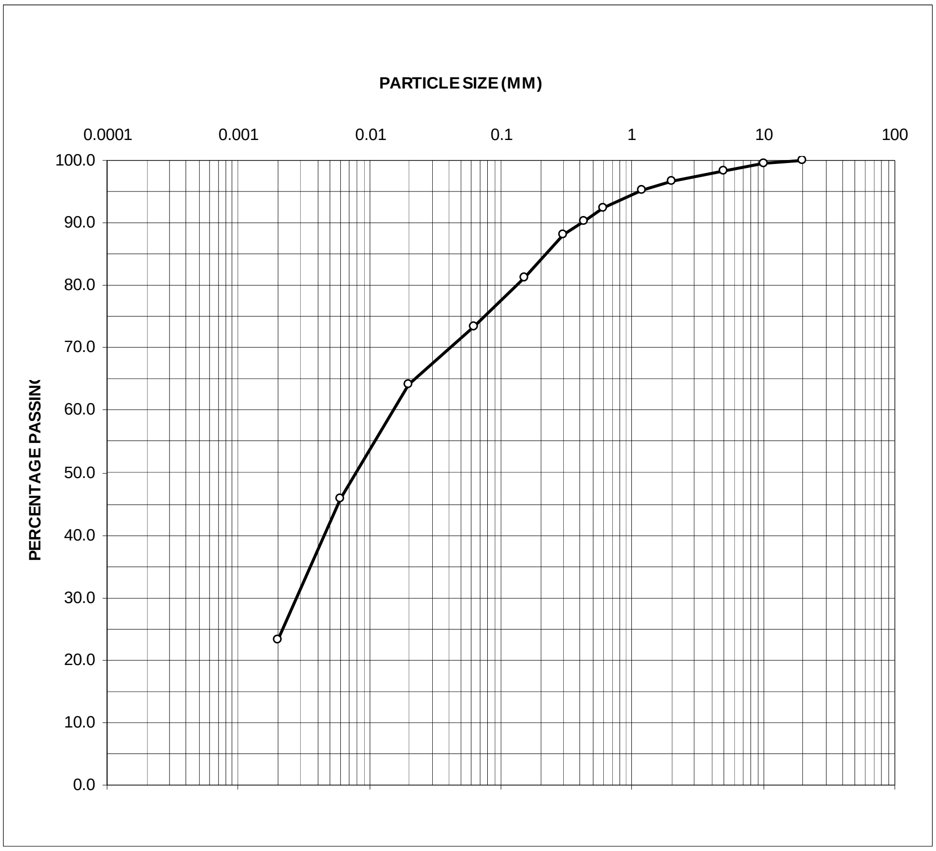
Signed : XXXX Address : XXX
Qualifications : XXXX
Date of report:

Phone : Fax : E-mail :

6.0 REVIEW (by Local Authority)

Site Visit	Date :
Inspection of trial hole	Date :
Inspection of percolation Test Holes	Date :
Comments :	
Signed :	**Date :**

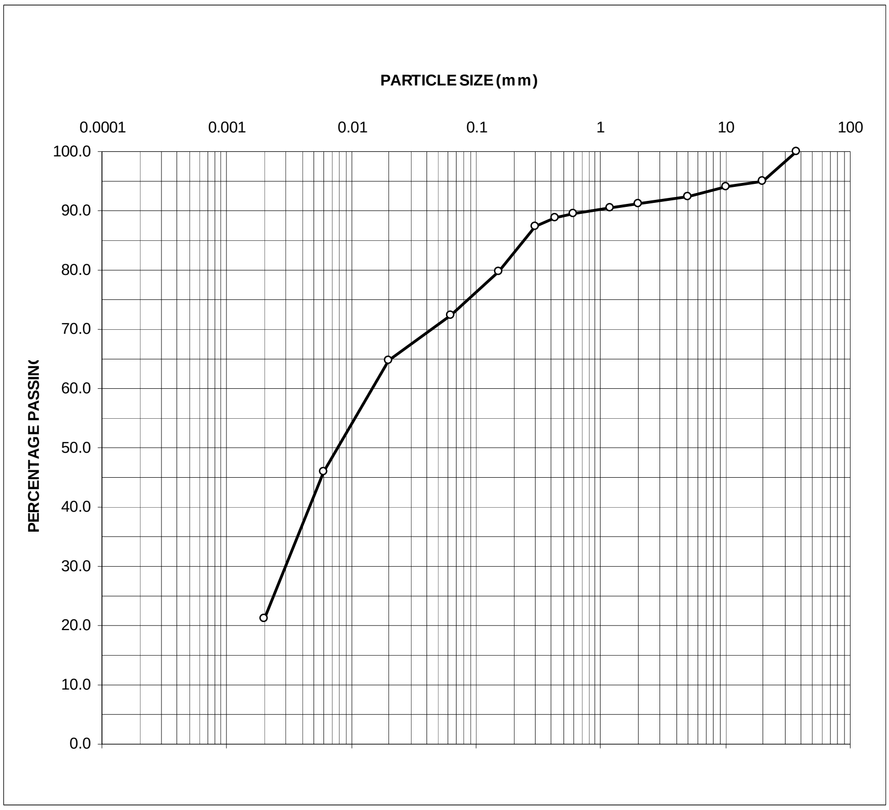
Particle Size Analysis – Site 1 (sample 1.0m)



B.S. Sieve Size (mm)	% passing
20	100
10	99.6
5	98.3
2	96.7
1.18	95.4
0.6	92.5
0.425	90.4
0.3	88.2
0.15	81.3
0.063	73.4
0.02	64.1
0.006	45.7
0.002	23.3

Soil Fraction	Total %
Cobbles	0.0
Gravel	3.3
Sand	23.3
Silt	50.1
Clay	23.3

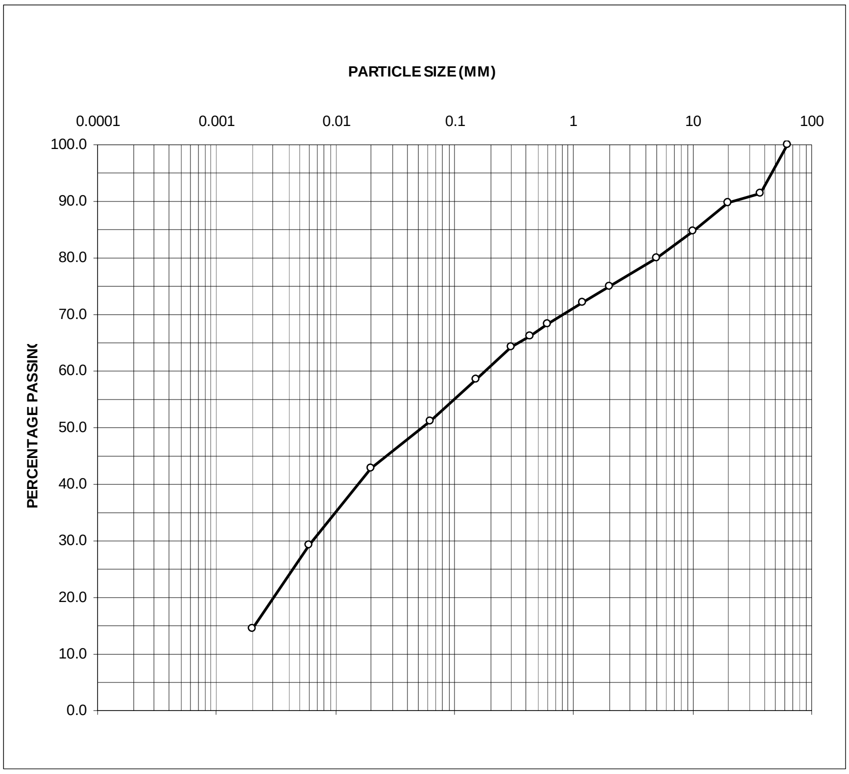
Particle Size Analysis – Site 1 (sample 1.5m)



B.S. Sieve Size (mm)	% passing
37.5	100
20	95.0
10	94.1
5	92.5
2	91.2
1.18	90.6
0.6	89.6
0.425	88.8
0.3	87.5
0.15	79.8
0.063	72.4
0.02	64.8
0.006	45.9
0.002	21.2

Soil Fraction	Total %
Cobbles	0.0
Gravel	8.8
Sand	18.9
Silt	51.1
Clay	21.2

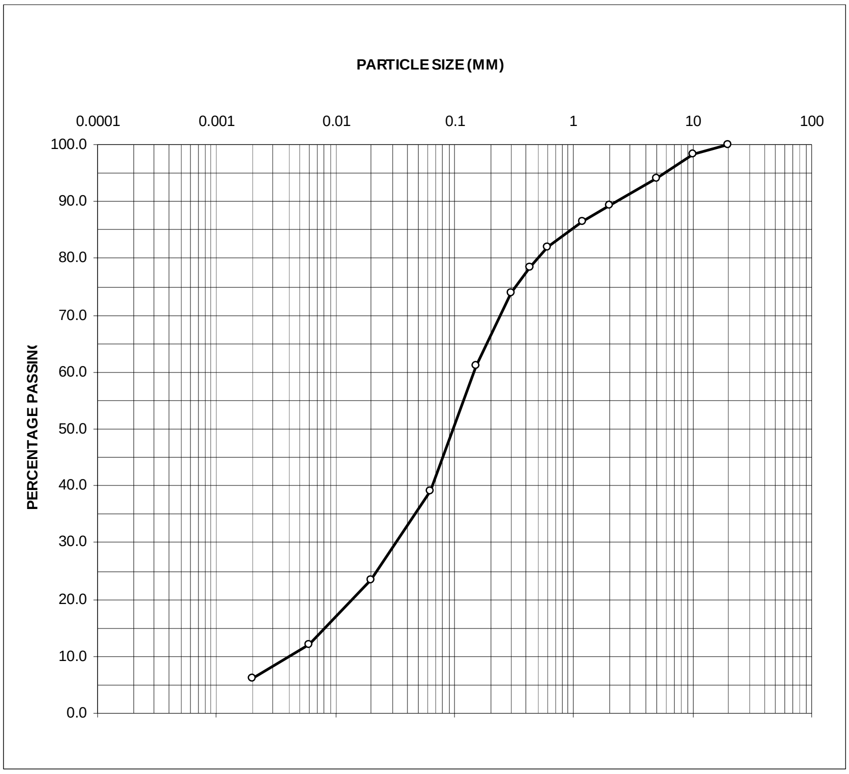
Particle Size Analysis – Site 1 (sample 2.0m)



B.S. Sieve Size (mm)	% passing
63	100
37.5	91.4
20	89.7
10	84.9
5	79.9
2	75.1
1.18	72.1
0.6	68.4
0.425	66.2
0.3	64.3
0.15	58.6
0.063	51.2
0.02	42.8
0.006	29.2
0.002	14.4

Soil Fraction	Total %
Cobbles	0.0
Gravel	24.9
Sand	23.8
Silt	36.8
Clay	14.4

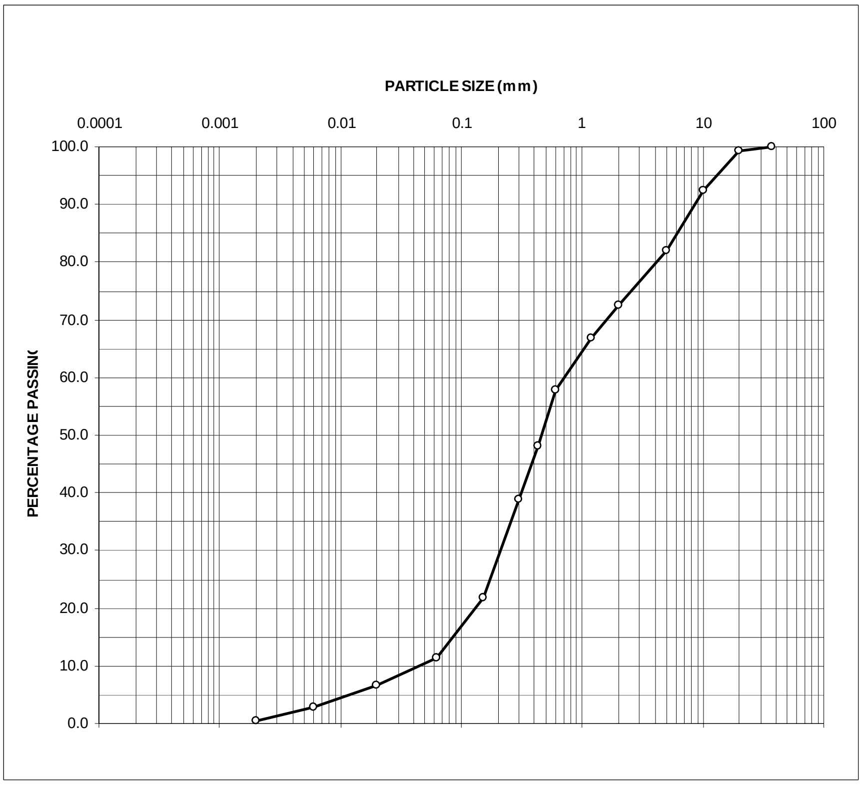
Particle Size Analysis – Site 2 (sample 1.0m)



B.S. Sieve Size (mm)	% passing
20	100
10	98.3
5	94.1
2	89.4
1.18	86.5
0.6	82.1
0.425	78.5
0.3	73.9
0.15	61.2
0.063	39.1
0.02	23.4
0.006	12.1
0.002	6.3

Soil Fraction	Total %
Cobbles	0.0
Gravel	10.6
Sand	50.3
Silt	32.8
Clay	6.3

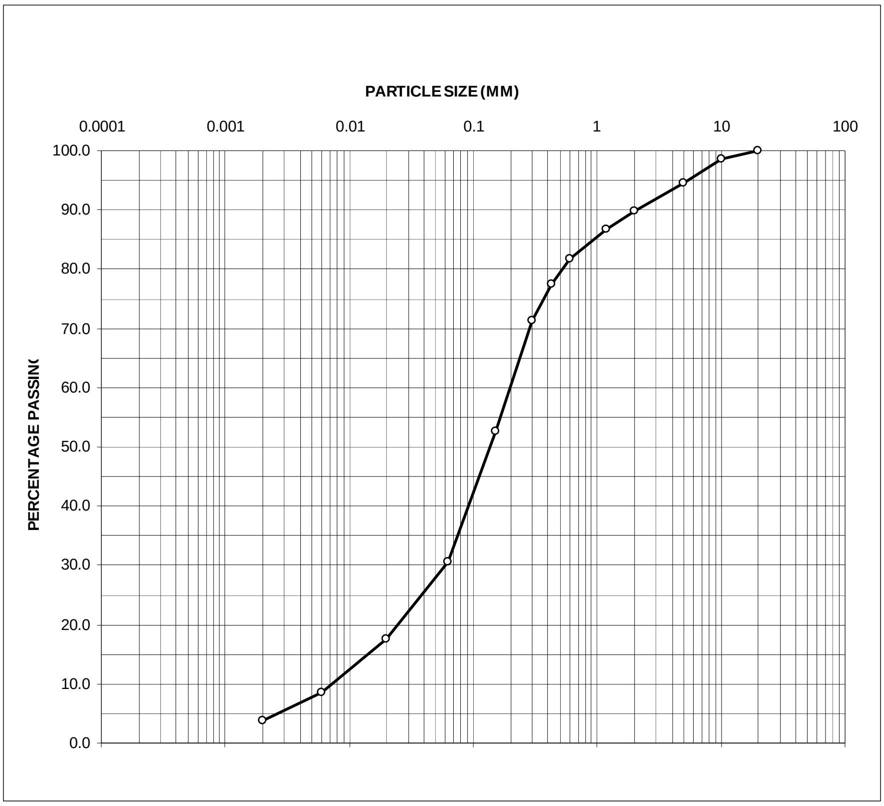
Particle Size Analysis – Site 2 (sample 1.5m)



B.S. Sieve Size (mm)	% passing
37.5	100
20	99.4
10	92.4
5	82.0
2	72.5
1.18	66.9
0.6	57.8
0.425	48.1
0.3	38.8
0.15	21.7
0.063	11.4
0.02	6.6
0.006	2.9
0.002	0.6

Soil Fraction	Total %
Cobbles	0.0
Gravel	27.5
Sand	61.1
Silt	10.8
Clay	0.6

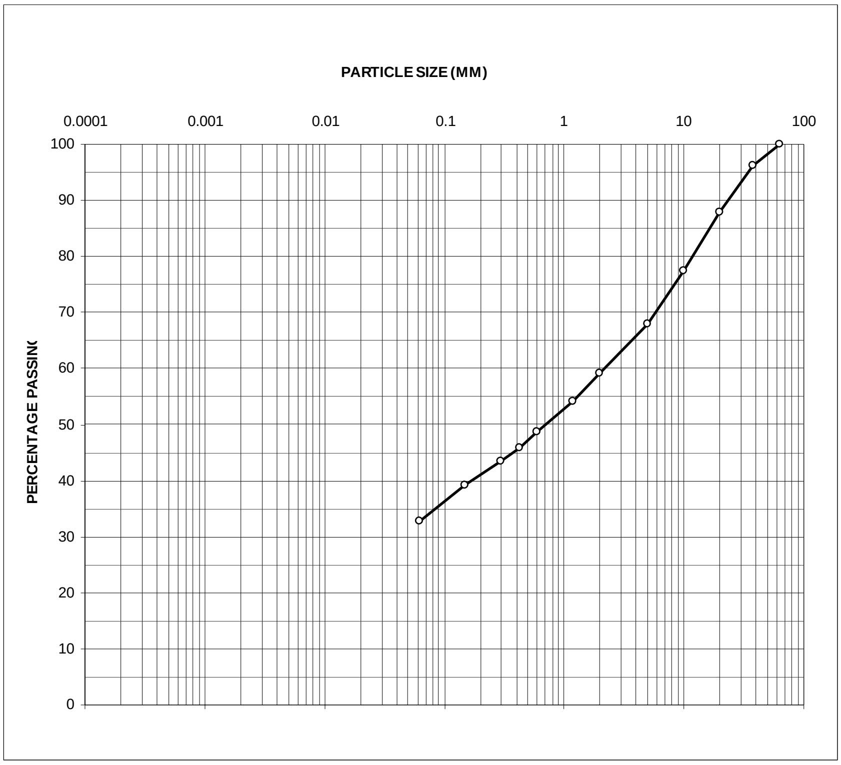
Particle Size Analysis – Site 2 (sample 2.0m)



B.S. Sieve Size (mm)	% passing
20	100.0
10	98.7
5	94.6
2	89.9
1.18	86.8
0.6	81.8
0.425	77.5
0.3	71.4
0.15	52.5
0.063	30.6
0.02	17.4
0.006	8.6
0.002	3.8

Soil Fraction	Total %
Cobbles	0.0
Gravel	10.1
Sand	59.3
Silt	26.8
Clay	3.8

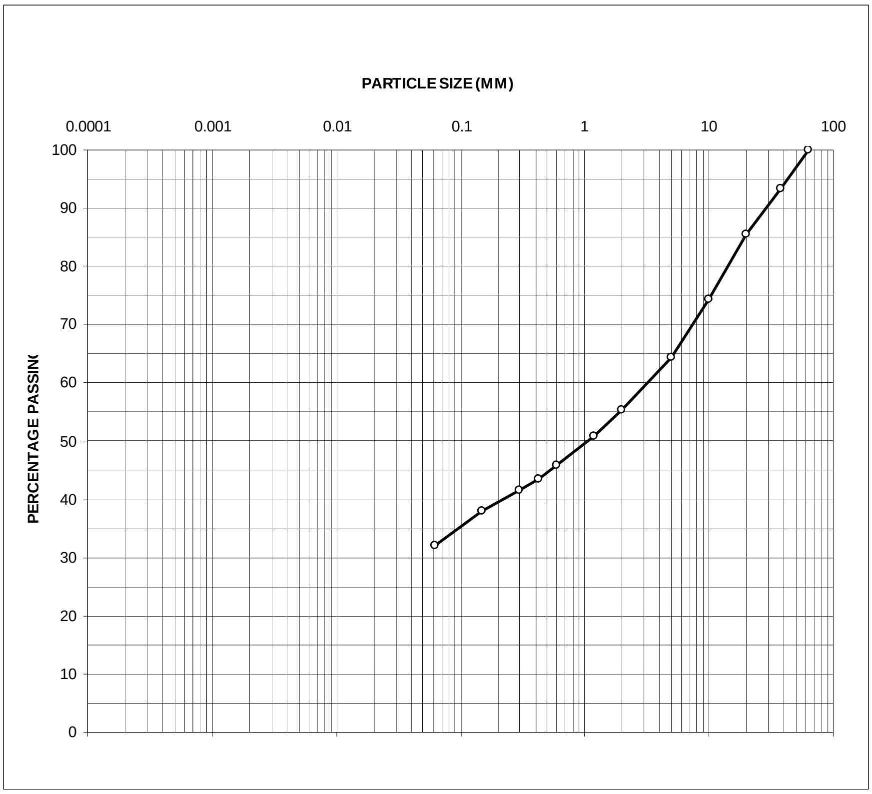
Particle Size Analysis – Site 3 (sample 1.0m)



B.S. Sieve Size (mm)	% passing
63	100
37.5	96.2
20	87.8
10	77.5
5	68.0
2	59.2
1.18	54.1
0.6	48.6
0.425	45.9
0.3	43.6
0.15	39.2
0.063	32.8

Soil Fraction	Total %
Gravel	40.8
Sand	26.4
Silt / Clay	32.8

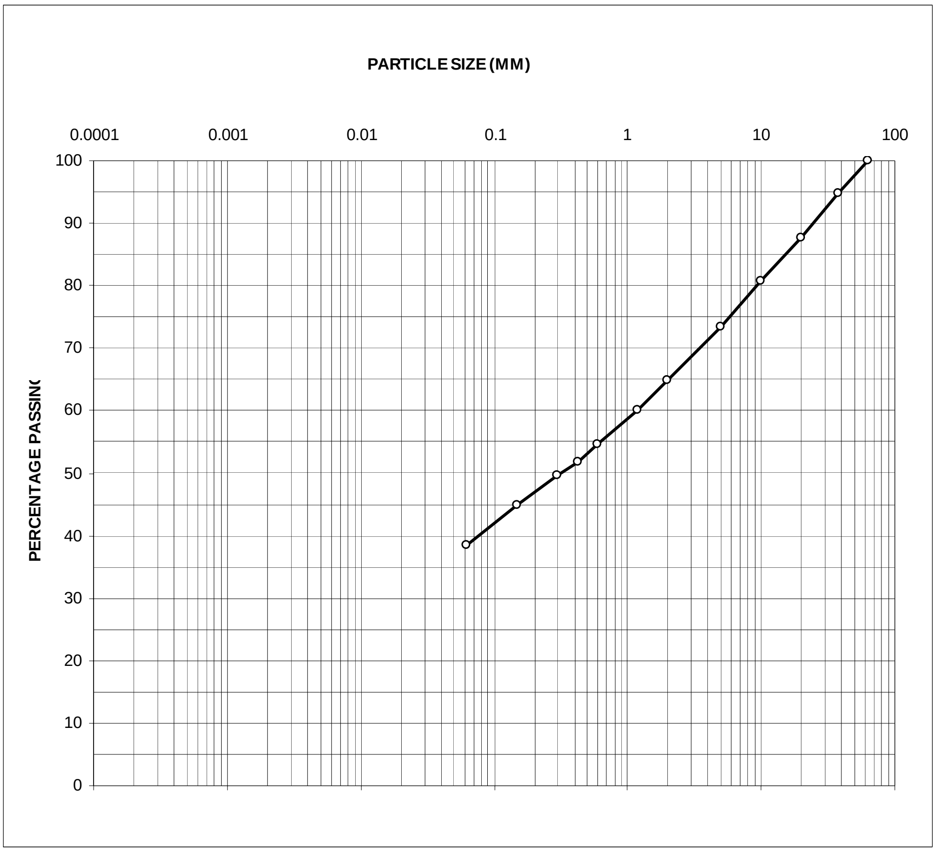
Particle Size Analysis – Site 3 (sample 1.5m)



B.S. Sieve Size (mm)	% passing
63	100
37.5	93.3
20	85.4
10	74.3
5	64.3
2	55.3
1.18	50.9
0.6	45.9
0.425	43.5
0.3	41.7
0.15	37.9
0.063	32.1

Soil Fraction	Total %
Gravel	44.7
Sand	23.2
Silt / Clay	32.1

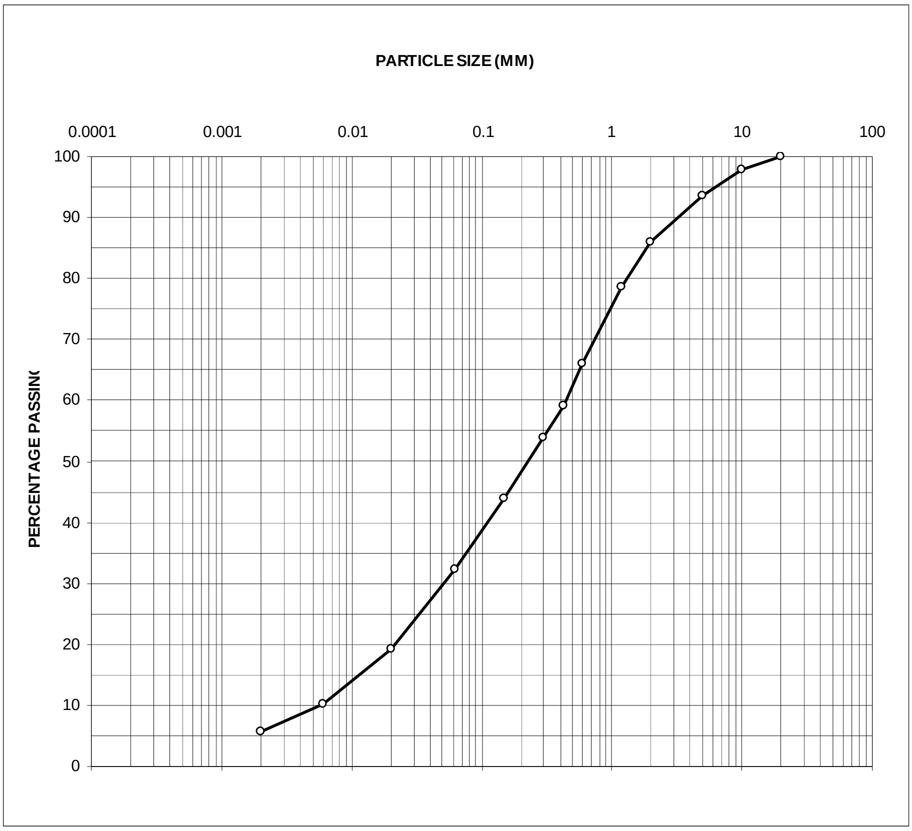
Particle Size Analysis – Site 3 (sample 2.0m)



B.S. Sieve Size (mm)	% passing
63	100
37.5	94.9
20	87.6
10	80.8
5	73.4
2	64.9
1.18	60.0
0.6	54.5
0.425	51.8
0.3	49.5
0.15	45.0
0.063	38.4

Soil Fraction	Total %
Gravel	35.1
Sand	26.5
Silt / Clay	38.4

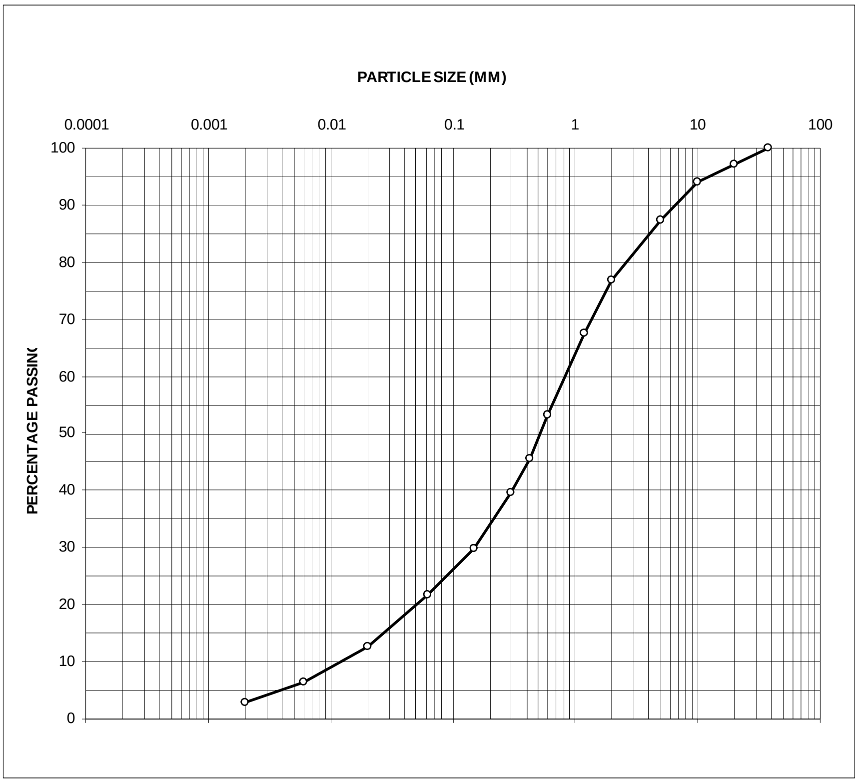
Particle Size Analysis – Site 4 (sample 1.0m)



B.S. Sieve Size (mm)	% passing
20	100
10	97.9
5	93.5
2	86.1
1.18	78.6
0.6	65.9
0.425	59.1
0.3	53.8
0.15	43.9
0.063	32.4
0.02	19.3
0.006	10.3
0.002	5.8

Soil Fraction	Total %
Cobbles	0.0
Gravel	13.9
Sand	53.7
Silt	26.6
Clay	5.8

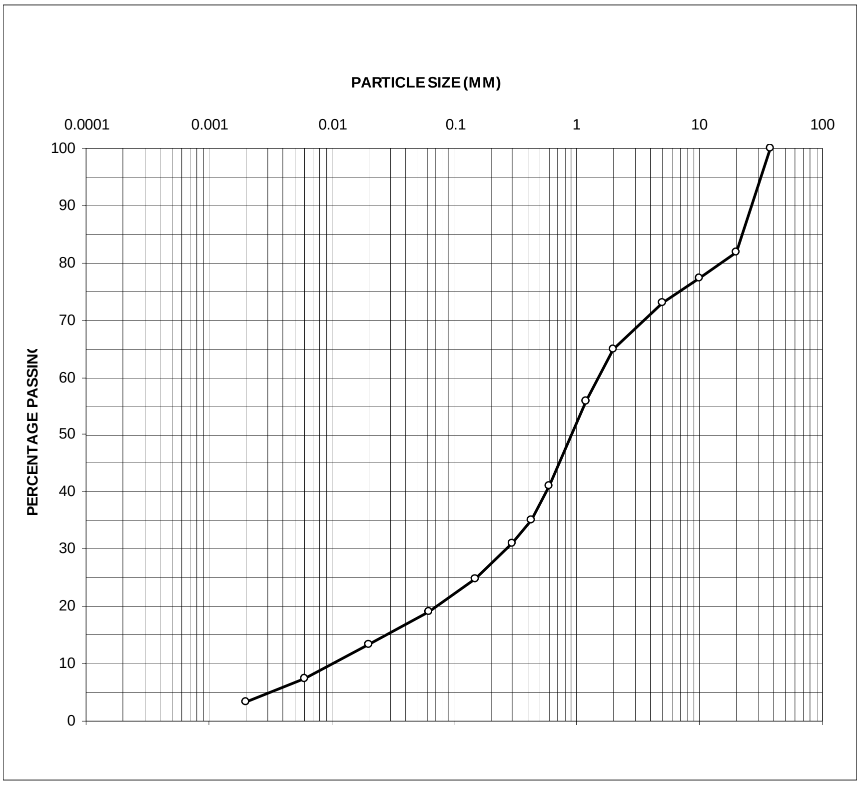
Particle Size Analysis – Site 4 (sample 1.5m)



B.S. Sieve Size (mm)	% passing
37.5	100
20	97.2
10	93.9
5	87.4
2	77.0
1.18	67.7
0.6	53.2
0.425	45.5
0.3	39.5
0.15	29.8
0.063	21.7
0.02	12.7
0.006	6.5
0.002	2.9

Soil Fraction	Total %
Cobbles	0.0
Gravel	23.0
Sand	55.3
Silt	18.8
Clay	2.9

Particle Size Analysis – Site 4 (sample 2.0m)



B.S. Sieve Size (mm)	% passing
37.5	100.0
20	82.0
10	77.4
5	73.1
2	65.0
1.18	55.8
0.6	41.0
0.425	35.1
0.3	31.1
0.15	24.9
0.063	19.1
0.02	13.3
0.006	7.4
0.002	3.2

Soil Fraction	Total %
Cobbles	0.0
Gravel	35.0
Sand	45.9
Silt	15.9
Clay	3.2

APPENDIX B

SAMPLING METHODOLOGY

SAMPLING METHODOLOGY

Preparation

i. Put all lysimeters under suction of 50 mbar and start sampler programs - record time.

Sampling

ii. Remove all clamps and leave beside lysimeters. When finished sampling slip clamp ring over upright tubing - easy to distinguish between sampled and unsampled lysimeters.

iii. Insert extraction tube until you feel it touch porous cup - inserting further can cause kinks. Ensure no kinks present and if present remove with pliers.

iv. Put conical flask under maximum suction and clamp sidearm. Put ear to side of conical flask to ensure sample being extracted.

v. Once sampling finished reattach vacuum pump, push down extraction tube and put under suction again - ensuring sampling complete.

vi. Ensure sample tube and lip of conical flask clean.

vii. Write sample number on side of sample tube, pour in sample and pour x's into graduated cylinder. Record total volume (Graduated cylinder + 70ml (large sample tube) or 40ml (small sample tube)).

viii. Dispose of any excess effluent down gradient and outside percolation area.

ix. Clean conical flask and extraction tube by inserting into distilled H_2O and putting under suction. At end of week rinse out with dilute Milton solution.

Notes

1. Ensure no liquid enters vacuum pump as causes pump failure. If this occurs unscrew silver casing and fix valves - "o ring" usually falls off.
2. If at step iv no sample entering conical flask but flask is remaining under suction extraction tubing - usually kinked.
3. If lysimeter won't hold suction check seals, extraction tubing and examine for hole.
4. Recharge sampler batteries after 3 sample runs. use (fully charge battery will allow at least 2 sample runs).
5. Clean out sampler after sample run with dilute Milton solution.

TENSIOMETERS

1. Ensure tensimeter reading is zero.
2. Insert needle into tensiometer
3. Record tensimeter reading.
4. Remove needle and ensure it returns to zero.
5. If required remove septum stopper to refill tensiometer, to within half an inch of top, with distilled H_2O.

APPENDIX C

FLOW DATA

Site 1 daily flow data

Total flow = 24744.15 litres

Total time = 1484.18 hours

Average volume per day

399.96 litres / day

4-Feb-03	*90.25*	**16-Apr-03**	*167.50*
11-Feb-03	*163.87*	**17-Apr-03**	275.5
17-Feb-03	*15.50*	**18-Apr-03**	180.5
18-Feb-03	*76*	**19-Apr-03**	337.3
19-Feb-03	*137.75*	**20-Apr-03**	175.8
20-Feb-03	*35.35*	**21-Apr-03**	232.8
21-Feb-03	*72.82*	**22-Apr-03**	*161.5*
22-Feb-03	313.5	**2-May-03**	821.3
23-Feb-03	*185.25*	**3-May-03**	1228.0
3-Mar-03	*35.77*	**4-May-03**	916.0
4-Mar-03	*313.5*	**5-May-03**	632.0
7-Mar-03	*72.82*	**6-May-03**	328.0
8-Mar-03	1030.8	**7-May-03**	285.3
9-Mar-03	365.8	**8-May-03**	348.0
10-Mar-03	1144.8	**9-May-03**	380.0
11-Mar-03	503.5	**10-May-03**	210.3
12-Mar-03	*180.5*	**11-May-03**	299.3
14-Mar-03	*73.44*	**12-May-03**	456.0
15-Mar-03	228.0	**13-May-03**	555.8
16-Mar-03	299.3	**14-May-03**	299.3
17-Mar-03	916.8	**15-May-03**	291.0
18-Mar-03	371.4	**16-May-03**	365.8
19-Mar-03	204.3	**17-May-03**	109.3
20-Mar-03	142.5	**18-May-03**	190.0
21-Mar-03	*99.75*	**19-May-03**	166.3
22-Mar-03	*95*	**20-May-03**	370.5
23-Mar-03	251.8	**21-May-03**	1036.7
24-Mar-03	570.0	**22-May-03**	*256.5*
25-Mar-03	*213.75*	**6-Jun-03**	*152*
7-Apr-03	*110.50*	**7-Jun-03**	346.8
8-Apr-03	251.8	**8-Jun-03**	304.0
9-Apr-03	418.0	**9-Jun-03**	*133*
10-Apr-03	479.8	**19-Jun-03**	*251.75*
11-Apr-03	266.0	**20-Jun-03**	275.5
12-Apr-03	270.8	**21-Jun-03**	490.4
13-Apr-03	289.8	**22-Jun-03**	351.5
14-Apr-03	361.0	**23-Jun-03**	*266*
15-Apr-03	*104.5*	**30-Jun-03**	*199.5*
		1-Jul-03	*142.5*

note: figures in italics are not over full 24 hour period

Site 2 daily flow data

Total flow = 49094.98 litres

Total time = 4087.63 hours

Average volume per day

288.26 litres / day

20-Jul-02	*72.03*	**5-Nov-02**	131.3	**26-Feb-03**	*125.75*
21-Jul-02	178.1	**6-Nov-02**	*50.92*	**27-Feb-03**	*257.38*
22-Jul-02	116.3	**28-Nov-02**	*124.36*	**5-Mar-03**	*293.90*
23-Jul-02	144.6	**29-Nov-02**	174.2	**6-Mar-03**	274.7
24-Jul-02	107.3	**30-Nov-02**	187.2	**7-Mar-03**	343.6
25-Jul-02	109.1	**1-Dec-02**	177.0	**8-Mar-03**	215.3
26-Jul-02	168.9	**2-Dec-02**	127.4	**9-Mar-03**	519.6
27-Jul-02	287.3	**3-Dec-02**	*159.48*	**10-Mar-03**	618.8
28-Jul-02	250.5	**24-Dec-02**	*190.44*	**11-Mar-03**	*4.65*
29-Jul-02	320.9	**25-Dec-02**	342.5	**12-Mar-03**	*98.99*
30-Jul-02	143.8	**26-Dec-02**	166.0	**13-Mar-03**	289.3
31-Jul-02	142.2	**27-Dec-02**	288.5	**14-Mar-03**	157.5
13-Aug-02	*218.37*	**28-Dec-02**	147.1	**15-Mar-03**	300.4
14-Aug-02	249.1	**29-Dec-02**	251.8	**16-Mar-03**	417.4
15-Aug-02	226.0	**30-Dec-02**	223.7	**17-Mar-03**	436.8
16-Aug-02	331.0	**31-Dec-02**	*378.24*	**18-Mar-03**	369.6
17-Aug-02	2.9	**20-Jan-03**	*170.86*	**19-Mar-03**	188.4
18-Aug-02	0.0	**21-Jan-03**	357.6	**20-Mar-03**	217.9
19-Aug-02	250.3	**22-Jan-03**	163.1	**21-Mar-03**	223.3
20-Aug-02	359.4	**23-Jan-03**	328.3	**22-Mar-03**	329.3
21-Aug-02	285.0	**24-Jan-03**	296.4	**23-Mar-03**	333.1
22-Aug-02	399.3	**25-Jan-03**	208.5	**24-Mar-03**	330.3
23-Aug-02	326.0	**26-Jan-03**	394.1	**25-Mar-03**	160.4
24-Aug-02	8.9	**30-Jan-03**	*128.88*	**26-Mar-03**	435.9
25-Aug-02	0.0	**31-Jan-03**	342.7	**27-Mar-03**	*44.69*
26-Aug-02	*288.87*	**1-Feb-03**	414.3	**28-Mar-03**	*150.65*
11-Oct-02	*148.61*	**2-Feb-03**	387.2	**29-Mar-03**	340.0
12-Oct-02	184.9	**3-Feb-03**	329.8	**30-Mar-03**	454.9
13-Oct-02	159.7	**4-Feb-03**	223.7	**31-Mar-03**	318.7
14-Oct-02	206.5	**14-Feb-03**	*78.93*	**1-Apr-03**	221.2
15-Oct-02	93.0	**15-Feb-03**	422.2	**2-Apr-03**	315.3
16-Oct-02	104.9	**16-Feb-03**	548.2	**3-Apr-03**	*3.68*
17-Oct-02	*69.71*	**17-Feb-03**	*75.3*	**7-Apr-03**	*67.63*
23-Oct-02	*188.20*	**19-Feb-03**	*305.59*	**8-Apr-03**	252.0
24-Oct-02	*156.13*	**20-Feb-03**	274.2	**9-Apr-03**	177.4
1-Nov-02	*147.58*	**21-Feb-03**	346.0	**10-Apr-03**	268.9
2-Nov-02	174.9	**22-Feb-03**	313.2	**11-Apr-03**	242.4
3-Nov-02	180.8	**23-Feb-03**	528.6	**12-Apr-03**	314.3
4-Nov-02	293.2	**24-Feb-03**	386.3	**13-Apr-03**	*66.22*

14-Apr-03	*165.81*	**2-Jun-03**	330.1
15-Apr-03	465.2	**3-Jun-03**	349.9
16-Apr-03	233.0	**5-Jun-03**	*199.81*
17-Apr-03	204.4	**6-Jun-03**	300.8
18-Apr-03	225.9	**7-Jun-03**	359.1
19-Apr-03	303.5	**8-Jun-03**	642.3
20-Apr-03	*67.68*	**9-Jun-03**	332.4
22-Apr-03	*103.92*	**10-Jun-03**	383.9
23-Apr-03	212.4	**11-Jun-03**	430.3
24-Apr-03	379.2	**12-Jun-03**	270.2
25-Apr-03	251.7	**13-Jun-03**	541.7
26-Apr-03	261.8	**14-Jun-03**	318.5
27-Apr-03	232.5	**23-Jun-03**	*142.27*
28-Apr-03	355.5	**24-Jun-03**	150.7
29-Apr-03	162.6	**25-Jun-03**	632.3
30-Apr-03	362.4	**26-Jun-03**	588.9
1-May-03	*24.23*	**27-Jun-03**	491.9
9-May-03	*95.38*	**28-Jun-03**	272.0
10-May-03	390.5	**29-Jun-03**	*16.57*
11-May-03	256.0	**8-Jul-03**	*136.57*
12-May-03	261.2	**9-Jul-03**	267.3
13-May-03	413.4	**10-Jul-03**	297.4
14-May-03	164.0	**11-Jul-03**	298.3
15-May-03	305.9	**12-Jul-03**	165.9
16-May-03	221.7	**13-Jul-03**	312.9
17-May-03	372.0	**14-Jul-03**	*9.51*
18-May-03	351.6	**29-Jul-03**	*274.5*
19-May-03	430.2	**30-Jul-03**	183.0
20-May-03	405.9	**31-Jul-03**	244.0
21-May-03	211.6	**1-Aug-03**	427.0
22-May-03	243.2	**2-Aug-03**	54.0
23-May-03	293.8	**3-Aug-03**	10.8
24-May-03	353.5	**4-Aug-03**	*8*
25-May-03	434.5	**6-Aug-03**	*102.79*
26-May-03	*106.49*	**7-Aug-03**	244.0
29-May-03	*189.28*	**8-Aug-03**	183.0
30-May-03	126.0	**9-Aug-03**	427.0
31-May-03	270.6	**10-Aug-03**	244.0
1-Jun-03	193.5	**11-Aug-03**	366.0
		12-Aug-03	*52.46*
		20-Aug-03	*327.57*
		21-Aug-03	*184.40*

<u>Site 3 daily flow data</u>

Total flow = 47967.93 litres

Total time = 3416.78 hours

Average volume per day

336.93 litres / day

15-Sep-03	*200.4*	**24-Oct-03**	240.5	**24-Dec-03**	11.9
16-Sep-03	254.0	**25-Oct-03**	164.6	**25-Dec-03**	3.0
17-Sep-03	500.8	**26-Oct-03**	183.3	**26-Dec-03**	324.1
18-Sep-03	330.6	**27-Oct-03**	126.7	**27-Dec-03**	0.0
19-Sep-03	297.5	**28-Oct-03**	445.9	**28-Dec-03**	92.0
20-Sep-03	211.1	**29-Oct-03**	152.3	**29-Dec-03**	0.0
21-Sep-03	*11.59*	**30-Oct-03**	634.8	**30-Dec-03**	0.9
23-Sep-03	*197.5*	**31-Oct-03**	314.9	**31-Dec-03**	541.1
24-Sep-03	252.2	**1-Nov-03**	117.3	**1-Jan-04**	14.0
25-Sep-03	267.8	**2-Nov-03**	365.4	**2-Jan-04**	7.8
26-Sep-03	350.1	**3-Nov-03**	*202.2*	**3-Jan-04**	33.8
27-Sep-03	231.5	**4-Nov-03**	97.9	**4-Jan-04**	63.1
28-Sep-03	391.6	**5-Nov-03**	284.4	**5-Jan-04**	92.2
29-Sep-03	*138.42*	**6-Nov-03**	122.8	**6-Jan-04**	103.3
30-Sep-03	279.4	**7-Nov-03**	536.8	**7-Jan-04**	500.0
1-Oct-03	536.6	**8-Nov-03**	55.3	**8-Jan-04**	575.6
2-Oct-03	425.4	**9-Nov-03**	37.6	**9-Jan-04**	57.4
3-Oct-03	333.3	**10-Nov-03**	288.8	**10-Jan-04**	309.6
4-Oct-03	270.1	**11-Nov-03**	737.8	**11-Jan-04**	806.8
5-Oct-03	231.1	**12-Nov-03**	544.0	**12-Jan-04**	594.4
6-Oct-03	395.9	**13-Nov-03**	939.9	**13-Jan-04**	422.5
7-Oct-03	347.3	**14-Nov-03**	632.8	**14-Jan-04**	444.7
8-Oct-03	224.9	**15-Nov-03**	523.6	**15-Jan-04**	1054.0
9-Oct-03	219.6	**16-Nov-03**	322.7	**16-Jan-04**	868.0
10-Oct-03	337.8	**17-Nov-03**	*458.9*	**17-Jan-04**	609.2
11-Oct-03	180.0	**11-Dec-03**	*0*	**18-Jan-04**	762.9
12-Oct-03	90.6	**12-Dec-03**	158.6	**19-Jan-04**	556.2
13-Oct-03	495.9	**13-Dec-03**	13.5	**20-Jan-04**	436.7
14-Oct-03	*182.0*	**14-Dec-03**	82.3	**21-Jan-04**	246.7
15-Oct-03	*0.69*	**15-Dec-03**	8.9	**22-Jan-04**	424.8
16-Oct-03	*1.88*	**16-Dec-03**	0.0	**23-Jan-04**	357.4
17-Oct-03	*-0.81*	**17-Dec-03**	35.4	**24-Jan-04**	165.2
18-Oct-03	*-1.72*	**18-Dec-03**	25.7	**25-Jan-04**	315.2
19-Oct-03	*2.21*	**19-Dec-03**	0.3	**26-Jan-04**	297.8
20-Oct-03	*10.55*	**20-Dec-03**	11.1	**27-Jan-04**	335.5
21-Oct-03	*0.66*	**21-Dec-03**	3.5	**28-Jan-04**	304.6
22-Oct-03	*199.2*	**22-Dec-03**	61.1	**29-Jan-04**	83.4
23-Oct-03	238.0	**23-Dec-03**	12.2	**30-Jan-04**	210.4

31-Jan-04	505.6	**28-Feb-04**	292.1
1-Feb-04	216.7	**29-Feb-04**	524.7
2-Feb-04	546.1	**1-Mar-04**	584.2
6-Feb-04	658.9	**2-Mar-04**	546.3
7-Feb-04	919.3	**3-Mar-04**	194.7
8-Feb-04	804.9	**4-Mar-04**	248.8
9-Feb-04	670.7	**5-Mar-04**	449.0
10-Feb-04	429.4	**6-Mar-04**	638.3
11-Feb-04	224.1	**7-Mar-04**	634.9
12-Feb-04	157.0	**8-Mar-04**	490.2
13-Feb-04	176.6	**9-Mar-04**	719.4
14-Feb-04	99.6	**10-Mar-04**	629.5
15-Feb-04	100.0	**11-Mar-04**	573.4
16-Feb-04	229.8	**12-Mar-04**	449.0
20-Feb-04	402.7	**13-Mar-04**	513.8
21-Feb-04	332.0	**14-Mar-04**	362.4
22-Feb-04	317.1	**15-Mar-04**	270.5
23-Feb-04	481.4	**16-Mar-04**	0.0
24-Feb-04	346.2	**17-Mar-04**	232.6
25-Feb-04	602.4	**18-Mar-04**	665.3
26-Feb-04	409.0	**19-Mar-04**	454.4
27-Feb-04	259.6		

<u>Site 4 daily flow data</u>

Total flow = 78193.84 litres

Total time = 3675.09 hours

Average volume per day

510.64 litres / day

4-Sep-03	*134.3*	**30-Oct-03**	188.2	**16-Dec-03**	451.9
5-Sep-03	155.2	**31-Oct-03**	151.1	**17-Dec-03**	419.9
6-Sep-03	260.2	**1-Nov-03**	453.3	**18-Dec-03**	221.4
7-Sep-03	382.6	**2-Nov-03**	453.3	**19-Dec-03**	215.8
8-Sep-03	151.8	**3-Nov-03**	291.4	**20-Dec-03**	828.5
9-Sep-03	300.8	**4-Nov-03**	226.6	**21-Dec-03**	204.0
10-Sep-03	108.4	**5-Nov-03**	337.0	**22-Dec-03**	258.0
11-Sep-03	245.5	**6-Nov-03**	232.1	**23-Dec-03**	507.3
12-Sep-03	455.2	**7-Nov-03**	186.4	**24-Dec-03**	507.6
13-Sep-03	242.2	**8-Nov-03**	302.2	**25-Dec-03**	599.3
14-Sep-03	446.5	**9-Nov-03**	453.3	**26-Dec-03**	1161.2
15-Sep-03	230.8	**10-Nov-03**	302.2	**27-Dec-03**	313.5
16-Sep-03	364.9	**11-Nov-03**	302.2	**28-Dec-03**	243.4
17-Sep-03	352.7	**12-Nov-03**	377.7	**29-Dec-03**	381.9
18-Sep-03	366.5	**13-Nov-03**	679.9	**30-Dec-03**	249.1
19-Sep-03	471.3	**14-Nov-03**	453.3	**31-Dec-03**	931.6
20-Sep-03	1754.2	**15-Nov-03**	569.6	**1-Jan-04**	571.4
21-Sep-03	575.4	**16-Nov-03**	528.8	**2-Jan-04**	520.2
22-Sep-03	912.1	**17-Nov-03**	377.7	**3-Jan-04**	849.8
23-Sep-03	441.8	**18-Nov-03**	453.3	**4-Jan-04**	356.2
24-Sep-03	255.5	**19-Nov-03**	151.1	**5-Dec-03**	278.6
25-Sep-03	249.9	**28-Nov-03**	139.9	**6-Dec-03**	352.9
26-Sep-03	365.6	**29-Nov-03**	1300.8	**7-Dec-03**	774.6
27-Sep-03	395.0	**30-Nov-03**	186.8	**8-Dec-03**	1531.1
28-Sep-03	528.3	**1-Dec-03**	259.6	**9-Jan-04**	710.0
29-Sep-03	*139.2*	**2-Dec-03**	652.9	**10-Jan-04**	561.7
30-Sep-03	*604.5*	**3-Dec-03**	271.3	**11-Jan-04**	625.5
1-Oct-03	217.2	**4-Dec-03**	358.7	**12-Jan-04**	522.0
2-Oct-03	364.2	**5-Dec-03**	417.2	**13-Jan-04**	530.7
3-Oct-03	113.8	**6-Dec-03**	276.9	**14-Jan-04**	450.4
4-Oct-03	*61.3*	**7-Dec-03**	233.5	**15-Jan-04**	1152.1
22-Oct-03	*302.2*	**8-Dec-03**	347.0	**16-Jan-04**	564.2
23-Oct-03	377.7	**9-Dec-03**	195.3	**17-Jan-04**	470.9
24-Oct-03	377.7	**10-Dec-03**	207.1	**18-Jan-04**	621.0
25-Oct-03	528.8	**11-Dec-03**	723.6	**19-Jan-04**	283.0
26-Oct-03	270.5	**12-Dec-03**	577.0	**20-Jan-04**	740.4
27-Oct-03	226.6	**13-Dec-03**	396.5	**21-Jan-04**	589.3
28-Oct-03	359.7	**14-Dec-03**	559.8	**22-Jan-04**	565.9
29-Oct-03	229.8	**15-Dec-03**	323.7	**23-Jan-04**	831.4

24-Jan-04	895.1	**18-Feb-04**	416.7
25-Jan-04	956.5	**19-Feb-04**	725.5
26-Jan-04	880.2	**20-Feb-04**	757.9
27-Jan-04	915.4	**21-Feb-04**	778.1
28-Jan-04	708.5	**22-Feb-04**	379.0
29-Jan-04	583.0	**23-Feb-04**	542.1
30-Jan-04	717.2	**24-Feb-04**	417.0
31-Jan-04	1192.3	**25-Feb-04**	492.3
1-Feb-04	1058.7	**26-Feb-04**	419.2
2-Feb-04	367.9	**27-Feb-04**	457.5
6-Feb-04	906.6	**28-Feb-04**	463.2
7-Feb-04	962.4	**29-Feb-04**	565.1
8-Feb-04	700.0	**1-Mar-04**	160.2
9-Feb-04	600.4	**11-Mar-04**	902.3
10-Feb-04	469.6	**12-Mar-04**	437.5
11-Feb-04	545.1	**13-Mar-04**	512.8
12-Feb-04	510.5	**14-Mar-04**	775.5
13-Feb-04	445.8	**15-Mar-04**	454.3
14-Feb-04	737.8	**16-Mar-04**	500.8
15-Feb-04	892.4	**17-Mar-04**	542.6
16-Feb-04	524.8	**18-Mar-04**	157.4
17-Feb-04	600.5		

APPENDIX D

RESULTS OF CHEMICAL & BACTERIOLOGICAL ANALYSIS

Site 1 – Chemical Analysis

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	pH
Septic Tank	**RLX**	08/08/2002	399	0.5		50.4	9.5	42	
	RLX	14/08/2002	386	<0.10	0.11	1.49	18.08	75	
	RLX	21/08/2002	464	0.2	0.12	26.01	23.4	93	
	RLX	27/08/2002	508	1.8	0.21	53.4	20.4	67	
	RLX	11/09/2002	620	<0.10	0.14	72.8	104	46	
	RLX	25/09/2002	638	1.1	0.15	41.4	22.1	55	
	RLX	09/10/2002	404	1.5	0.18	70	54.75	59	
	RLX	17/10/2002	334	0	0.2	52	55.7	38	
	RLX	23/10/2002	240	3.4	0.15	20.3	54.25	27	
	RLX	03/12/2002	292	0	0.16	44.9	6.63	64	7.6
	RLX	08/01/2003	432	0.5	0.23	63.2	16.2	71	7.81
	RLX	07/02/2003	294	0	0.19	57.1	10.42	64	7.83
	RLX	20/02/2003	334	3.2	0.18	69.1	13.68	60	7.82
	RLX	06/03/2003	234	0	0.14	47.3	11		7.86
	RLX	13/03/2003	205	0	0.14	41	5.18	40	7.32
	RLX	01/04/2003	188	0	0.14	48	6.28	42	8.33
	RLX	16/04/2003	296	0	0.15	61.7	6.67	85	7.9
	RLX	29/04/2003	318	0	0.17	60	9.84	60	7.66
	RLX	15/05/2003							
	RLX	23/05/2003	224	2.9	0.103	47.4	7.16	41.8	7.59
	RLX	06/06/2003	630	1.10	0.163	72.3	>10	59	7.38
	RLX	20/06/2003	530	6.7	0.3	87	12.6	106	7.66
	RLX	01/07/2003		7.1	0.21	41.3	8.14	60	
	RLX	15/07/2003	465	0	0.21	60.8	9.6	56	7.65

TRENCH 1

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	VOL
1,Red,0m	RL1	08/08/2002							
1,Red,0m	RL1	14/08/2002							
1,Red,0m	RL1	21/08/2002							
1,Red,0m	RL1	27/08/2002							
1,Red,0m	RL1	11/09/2002							
1,Red,0m	RL1	25/09/2002							
1,Red,0m	RL1	09/10/2002							
1,Red,0m	RL1	17/10/2002							
1,Red,0m	RL1	23/10/2002							
1,Red,0m	RL1	03/12/2002							
1,Red,0m	RL1	08/01/2003							
1,Red,0m	RL1	07/02/2003							
1,Red,0m	RL1	20/02/2003							
1,Red,0m	RL1	06/03/2003							
1,Red,0m	RL1	13/03/2003							
1,Red,0m	RL1	01/04/2003							
1,Red,0m	RL1	16/04/2003							
1,Red,0m	RL1	29/04/2003							
1,Red,0m	RL1	15/05/2003							
1,Red,0m	RL1	23/05/2003							
1,Red,0m	RL1	06/06/2003							
1,Red,0m	RL1	20/06/2003							
1,Red,0m	RL1	01/07/2003							
1,Red,0m	RL1	15/07/2003							
1,Blue,0m	RL2	08/08/2002	39.3	16.7	-	16.4	0.2	31	
1,Blue,0m	RL2	14/08/2002	300	<0.10	<0.005	0.6	0.49	64	88
1,Blue,0m	RL2	21/08/2002	54	<0.10	<0.005	4.56	1.38	61	80
1,Blue,0m	RL2	27/08/2002	164	0.2	<0.005	10.95	1.58	29	70
1,Blue,0m	RL2	11/09/2002	78	0.3	0.81	9.9	1.07	17	60
1,Blue,0m	RL2	25/09/2002	104	<0.10	0.7	6.5	1.43	41	50
1,Blue,0m	RL2	09/10/2002	68	10.7	0.31	3.7	3.21	35	47
1,Blue,0m	RL2	17/10/2002							
1,Blue,0m	RL2	23/10/2002	71	1.4	0.19	10.9	25.88	29	150
1,Blue,0m	RL2	03/12/2002	46	4.5	0.13	9.5	1.11	35	
1,Blue,0m	RL2	08/01/2003							
1,Blue,0m	RL2	07/02/2003	64	3.6	0.09	4	1	39	60
1,Blue,0m	RL2	20/02/2003	92	6.1	0.09	5.5	0.82	16	40
1,Blue,0m	RL2	06/03/2003							
1,Blue,0m	RL2	13/03/2003							
1,Blue,0m	RL2	01/04/2003							
1,Blue,0m	RL2	16/04/2003	63	6.6	0.11	9	0.23	46	50
1,Blue,0m	RL2	29/04/2003	18	11.1	0.07	5	0.53	69	100
1,Blue,0m	RL2	15/05/2003							
1,Blue,0m	RL2	23/05/2003	169	10	0.238	1.85	0.2		20
1,Blue,0m	RL2	06/06/2003	86	19.3	0.141	1.92	0	60.2	75
1,Blue,0m	RL2	20/06/2003	108	27.1	0.27	24	1.64	80	50
1,Blue,0m	RL2	01/07/2003	65	15.4	1.4	21.5	1.2	62	170
1,Blue,0m	RL2	15/07/2003	55.6	13.8	0.52	3.5	0.52	42	70

1,Black,0m	**RL3**	08/08/2002							
1,Black,0m	**RL3**	14/08/2002	54	<0.10	<0.005	0.64	0.51	61	120
1,Black,0m	**RL3**	21/08/2002	52	<0.10	<0.005	5.51	0.93	56	45
1,Black,0m	**RL3**	27/08/2002	81	<0.10	<0.005	7.55	1.48	36	60
1,Black,0m	**RL3**	11/09/2002							
1,Black,0m	**RL3**	25/09/2002							
1,Black,0m	**RL3**	09/10/2002							
1,Black,0m	**RL3**	17/10/2002							
1,Black,0m	**RL3**	23/10/2002	70	1.1	0.18	13.4	21.44	23.8	300
1,Black,0m	**RL3**	03/12/2002	43	10.4	0.1	6.8	0.53	33	
1,Black,0m	**RL3**	08/01/2003							
1,Black,0m	**RL3**	07/02/2003	42	9.1	0.16	5.3	0.38	25	35
1,Black,0m	**RL3**	20/02/2003							
1,Black,0m	**RL3**	06/03/2003							
1,Black,0m	**RL3**	13/03/2003							
1,Black,0m	**RL3**	01/04/2003							
1,Black,0m	**RL3**	16/04/2003							
1,Black,0m	**RL3**	29/04/2003							
1,Black,0m	**RL3**	15/05/2003							150
1,Black,0m	**RL3**	23/05/2003	101	9.7	0.224	8.79	0.33	50.3	20
1,Black,0m	**RL3**	06/06/2003							
1,Black,0m	**RL3**	20/06/2003	53	40.3	0.35	25	1.07	74	60
1,Black,0m	**RL3**	01/07/2003	39.9	23.8	1.2	17.5	0.74	34	90
1,Black,0m	**RL3**	15/07/2003	54.8	12.1	0.5	5.9	0.44	46	50
1,Red,10m	**RL4**	08/08/2002	35.6	3.1	-	19.9	0.9	36	
1,Red,10m	**RL4**	14/08/2002	70	<0.10	0.72	0.76	1.39	63	370
1,Red,10m	**RL4**	21/08/2002	78	0.1	<0.005	6.17	2.33	40	310
1,Red,10m	**RL4**	27/08/2002	106	<0.10	<0.005	>15	1.16	39	350
1,Red,10m	**RL4**	11/09/2002	112	<0.10	<0.005	32.1	2.76	32	150
1,Red,10m	**RL4**	25/09/2002	90	<0.10	0.93	22.3	0.68	43	150
1,Red,10m	**RL4**	09/10/2002	60	6.4	0.6	29.1	5.28	40	150
1,Red,10m	**RL4**	17/10/2002							
1,Red,10m	**RL4**	23/10/2002	43	1.5	0.04	15.5	3.72	12.6	310
1,Red,10m	**RL4**	03/12/2002	32	5.8	0.09	10.1	1.14	17	
1,Red,10m	**RL4**	08/01/2003	42	2.9	0.02	9.8	1.21	13	160
1,Red,10m	**RL4**	07/02/2003	49	2.9	0.02	9.3	0.51	38	200
1,Red,10m	**RL4**	20/02/2003	72	6.9	0.04	10.8	0.84	23	110
1,Red,10m	**RL4**	06/03/2003	27	5.6	0.03	13.2	2.59		75
1,Red,10m	**RL4**	13/03/2003							
1,Red,10m	**RL4**	01/04/2003	37	5.7	0.15	7	0.53	25	150
1,Red,10m	**RL4**	16/04/2003	35	4	0.6	9.4	0.32	46	75
1,Red,10m	**RL4**	29/04/2003	11	10.9	0.12	6.4	0.61	32	35
1,Red,10m	**RL4**	15/05/2003							90
1,Red,10m	**RL4**	23/05/2003	35	5.1	0.101	10.33	0.23	36.3	180
1,Red,10m	**RL4**	06/06/2003	82	5.06	0.149	15.4	0.38	40.6	140
1,Red,10m	**RL4**	20/06/2003	45	10.2	0.26	37	1.11	72	170
1,Red,10m	**RL4**	01/07/2003	30.1	13.2	0.26	21.1	1.01	39	150
1,Red,10m	**RL4**	15/07/2003	31.4	8.8	0.25	8.5	0.26	40	65

1,Blue,10m	**RL5**	08/08/2002	49.4	0.6	-	32.9	1.5	37	
1,Blue,10m	**RL5**	14/08/2002	80	<0.10	0.58	1	2.68	70	580
1,Blue,10m	**RL5**	21/08/2002	79	<0.10	<0.005	11.42	3.69	65	520
1,Blue,10m	**RL5**	27/08/2002	224	<0.10	<0.005	>15	3.54	42	490
1,Blue,10m	**RL5**	11/09/2002	140	<0.10	<0.005	41.8	3.74	40	530
1,Blue,10m	**RL5**	25/09/2002	91	<0.10	0.31	19.7	1.44	43	340
1,Blue,10m	**RL5**	09/10/2002	67	0	0.43	36.6	3.14	33	420
1,Blue,10m	**RL5**	17/10/2002							
1,Blue,10m	**RL5**	23/10/2002	30	1.2	0.06	24.5	5.88	20.7	580
1,Blue,10m	**RL5**	03/12/2002	39	11.4	0.15	8.7	2.3	25	
1,Blue,10m	**RL5**	08/01/2003	59	3	0.01	19	3.42	37	610
1,Blue,10m	**RL5**	07/02/2003	57	2.3	0.02	13.7	1.68	27	500
1,Blue,10m	**RL5**	20/02/2003	80	1.6	0.02	24.3	3.76	28	320
1,Blue,10m	**RL5**	06/03/2003	47	3.4	0.02	26.3	4		280
1,Blue,10m	**RL5**	13/03/2003							
1,Blue,10m	**RL5**	01/04/2003	33	0	0.04	28	3.68	26	470
1,Blue,10m	**RL5**	16/04/2003	58	1.8	0.01	28.6	3.94	64	400
1,Blue,10m	**RL5**	29/04/2003	36	0.6	0.02	30.3	3.93	32	290
1,Blue,10m	**RL5**	15/05/2003							190
1,Blue,10m	**RL5**	23/05/2003	95	1.9	0.039	42.2	3.05	42.1	300
1,Blue,10m	**RL5**	06/06/2003	153	0.43	0.13	40.4	2.47	44.1	320
1,Blue,10m	**RL5**	20/06/2003	92	7	0.21	56	3.47	77	370
1,Blue,10m	**RL5**	01/07/2003	59	7.5	0.2	44.6	4.1	62	360
1,Blue,10m	**RL5**	15/07/2003	50.7	0	0.15	26.3	4.7	38	300
1,Black,10m	**RL6**	08/08/2002	33.3	0.6	-	27.2	0.8	31	
1,Black,10m	**RL6**	14/08/2002	67	<0.10	0.24	1.1	0.41	65	490
1,Black,10m	**RL6**	21/08/2002	41	<0.10	<0.005	6.25	2.82	20	420
1,Black,10m	**RL6**	27/08/2002	83	<0.10	<0.005	>15	1.92	48	400
1,Black,10m	**RL6**	11/09/2002	140	<0.10	<0.005	41.2	2.93	61	320
1,Black,10m	**RL6**	25/09/2002	82	<0.10	1.05	33.5	0.66	48	270
1,Black,10m	**RL6**	09/10/2002	83	9.6	0.76	57.3	3.14	31	260
1,Black,10m	**RL6**	17/10/2002							
1,Black,10m	**RL6**	23/10/2002	69	1.4	0.06	29.7	3.14	20.7	420
1,Black,10m	**RL6**	03/12/2002	49	1.3	1.15	26.6	1.67	24	
1,Black,10m	**RL6**	08/01/2003	54	4.8	0.15	15.7	2.04	27	180
1,Black,10m	**RL6**	07/02/2003	68	10.1	0.18	10.9	1.49	30	240
1,Black,10m	**RL6**	20/02/2003	77	12.9	0.19	13.9	2.06	24	230
1,Black,10m	**RL6**	06/03/2003	44	10.4	0.12	14.4	1.64		163
1,Black,10m	**RL6**	13/03/2003							
1,Black,10m	**RL6**	01/04/2003	22	1.8	0.18	8	0.84	20	190
1,Black,10m	**RL6**	16/04/2003	31	13.8	0.15	10.4	1.96	57	170
1,Black,10m	**RL6**	29/04/2003	16	21.3	0.15	9.9	1.3	41	140
1,Black,10m	**RL6**	15/05/2003							410
1,Black,10m	**RL6**	23/05/2003	37	7.7	0.324	13.22	1.78	41.6	200
1,Black,10m	**RL6**	06/06/2003	65	12.92	0.339	14	1.08	44.7	200
1,Black,10m	**RL6**	20/06/2003	54	21.1	0.63	38	2.09	65	230
1,Black,10m	**RL6**	01/07/2003	32.3	16.9	0.47	20.6	2.04	67	260
1,Black,10m	**RL6**	15/07/2003	33.9	13.9	0.4	9.9	2.52	32	230

1,Red,20m	**RL7**	08/08/2002	18	6.7	-	0.6	<0.1	8	
1,Red,20m	**RL7**	14/08/2002	56	1.3	<0.005	0.27	0.66	34	440
1,Red,20m	**RL7**	21/08/2002							
1,Red,20m	**RL7**	27/08/2002							
1,Red,20m	**RL7**	11/09/2002							
1,Red,20m	**RL7**	25/09/2002							
1,Red,20m	**RL7**	09/10/2002							
1,Red,20m	**RL7**	17/10/2002							
1,Red,20m	**RL7**	23/10/2002	50	1	0.05	2.4		16.2	670
1,Red,20m	**RL7**	03/12/2002	35	2.5	0.01	2.5	3.13	12	
1,Red,20m	**RL7**	08/01/2003	37	5.4	0.03	1.9	0.21	24	180
1,Red,20m	**RL7**	07/02/2003							
1,Red,20m	**RL7**	20/02/2003							
1,Red,20m	**RL7**	06/03/2003	34	6.5	0.02	1.4	0.17		105
1,Red,20m	**RL7**	13/03/2003							
1,Red,20m	**RL7**	01/04/2003	40	1.5	0.17	0	1.13	32	840
1,Red,20m	**RL7**	16/04/2003							
1,Red,20m	**RL7**	29/04/2003							
1,Red,20m	**RL7**	15/05/2003							180
1,Red,20m	**RL7**	23/05/2003	30	4.4	0.046	2.49	0.42	30.1	500
1,Red,20m	**RL7**	06/06/2003	70	0.39	0.019	9.23	0.75	37.5	570
1,Red,20m	**RL7**	20/06/2003	65	17.4	0.27	25	1.08	66	180
1,Red,20m	**RL7**	01/07/2003	50	24.8	1.3	9.4	1.96	51	470
1,Red,20m	**RL7**	15/07/2003	28.4	8.6	0.08	2	0.96	16	250
1,Blue,20m	**RL8**	08/08/2002	25.9	7.8	-	1	<0.1	9	
1,Blue,20m	**RL8**	14/08/2002	54	5.5	<0.005	0.28	0.51	35	670
1,Blue,20m	**RL8**	21/08/2002							
1,Blue,20m	**RL8**	27/08/2002							
1,Blue,20m	**RL8**	11/09/2002							
1,Blue,20m	**RL8**	25/09/2002							
1,Blue,20m	**RL8**	09/10/2002							
1,Blue,20m	**RL8**	17/10/2002							
1,Blue,20m	**RL8**	23/10/2002	47	0.1	0.27	3		21.5	1110
1,Blue,20m	**RL8**	03/12/2002	37	3.3	0.01	0.9	4.66	11	
1,Blue,20m	**RL8**	08/01/2003	49	12.4	0.02	4.1	0.91	17	400
1,Blue,20m	**RL8**	07/02/2003	44	3.7	0.01	0	0.54	2	90
1,Blue,20m	**RL8**	20/02/2003	63	5.9	0	1.8	0.88	0	130
1,Blue,20m	**RL8**	06/03/2003	44	9	0.02	0.8	0.31		297.5
1,Blue,20m	**RL8**	13/03/2003							
1,Blue,20m	**RL8**	01/04/2003	34	13.5	0.23	12	2.45	26	1020
1,Blue,20m	**RL8**	16/04/2003	46	4.6	0.96	5	0.74	46	220
1,Blue,20m	**RL8**	29/04/2003							240
1,Blue,20m	**RL8**	15/05/2003							
1,Blue,20m	**RL8**	23/05/2003	35	5.3	0.215	3.61	0.73	40.5	860
1,Blue,20m	**RL8**	06/06/2003	77	0.96	0.299	11.5	0.97	40	850
1,Blue,20m	**RL8**	20/06/2003	76	11.9	0.36	28	1.63	74	600
1,Blue,20m	**RL8**	01/07/2003	303	36.5	1.6	11.3	2.29	65	530
1,Blue,20m	**RL8**	15/07/2003	84	10.1	0.31	5.6	0.85	32	640

1,Black,20m	RL9	08/08/2002							
1,Black,20m	RL9	14/08/2002							
1,Black,20m	RL9	21/08/2002							
1,Black,20m	RL9	27/08/2002							
1,Black,20m	RL9	11/09/2002							
1,Black,20m	RL9	25/09/2002							
1,Black,20m	RL9	09/10/2002							
1,Black,20m	RL9	17/10/2002							
1,Black,20m	RL9	23/10/2002							
1,Black,20m	RL9	03/12/2002							
1,Black,20m	RL9	08/01/2003							
1,Black,20m	RL9	07/02/2003							
1,Black,20m	RL9	20/02/2003							
1,Black,20m	RL9	06/03/2003							
1,Black,20m	RL9	13/03/2003							
1,Black,20m	RL9	01/04/2003							
1,Black,20m	RL9	16/04/2003							
1,Black,20m	RL9	29/04/2003							
1,Black,20m	RL9	15/05/2003							
1,Black,20m	RL9	23/05/2003							
1,Black,20m	RL9	06/06/2003							
1,Black,20m	RL9	20/06/2003							
1,Black,20m	RL9	01/07/2003							
1,Black,20m	RL9	15/07/2003							

TRENCH 2

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	VOL
2,Red,0m	**RL10**	08/08/2002	38.4	<0.3	-	1.1	<0.1	22	
2,Red,0m	**RL10**	14/08/2002	69	<0.10	<0.005	0.29	0.46	57	60
2,Red,0m	**RL10**	21/08/2002	67	<0.10	0.17	2.47	2.3	39	50
2,Red,0m	**RL10**	27/08/2002	109	0.4	0.21	0.57	3	24	55
2,Red,0m	**RL10**	11/09/2002							
2,Red,0m	**RL10**	25/09/2002	53	<0.10	0.06	1.44	0.65	31	40
2,Red,0m	**RL10**	09/10/2002							
2,Red,0m	**RL10**	17/10/2002							
2,Red,0m	**RL10**	23/10/2002	68	1.1	0.03	1		22.9	75
2,Red,0m	**RL10**	03/12/2002	65	1.4	0.05	5	4.3	34	
2,Red,0m	**RL10**	08/01/2003	53	4.4	0.04	1.7	0.21	212	125
2,Red,0m	**RL10**	07/02/2003							
2,Red,0m	**RL10**	20/02/2003	70	8	0.05	2.9	2.6	18	20
2,Red,0m	**RL10**	06/03/2003	39	7.4	0.05	3.2	0.09		55
2,Red,0m	**RL10**	13/03/2003							
2,Red,0m	**RL10**	01/04/2003							
2,Red,0m	**RL10**	16/04/2003							
2,Red,0m	**RL10**	29/04/2003	39	4.2	0.04	2.8	0.31	28	45
2,Red,0m	**RL10**	15/05/2003							140
2,Red,0m	**RL10**	23/05/2003	50	8.1	0.097	2.002	0.03	37.4	75
2,Red,0m	**RL10**	06/06/2003	85	9.33	0.09	1.56	0.06	36	70
2,Red,0m	**RL10**	20/06/2003	73	17.2	0.22	21	0.73	62	70
2,Red,0m	**RL10**	01/07/2003	41	16	1.5	10.6	0.69	61	60
2,Red,0m	**RL10**	15/07/2003							
2,Blue,0m	**RL11**	08/08/2002	27.1	0.4	-	6.5	0.3	29	
2,Blue,0m	**RL11**	14/08/2002	62	1.6	<0.005	1.49	0.42	64	80
2,Blue,0m	**RL11**	21/08/2002							
2,Blue,0m	**RL11**	27/08/2002							
2,Blue,0m	**RL11**	11/09/2002							
2,Blue,0m	**RL11**	25/09/2002							
2,Blue,0m	**RL11**	09/10/2002							
2,Blue,0m	**RL11**	17/10/2002							
2,Blue,0m	**RL11**	23/10/2002	60	0.5	0.11	5.9		25.7	75
2,Blue,0m	**RL11**	03/12/2002	49	2.6	1.07	8.8	0.82	26	
2,Blue,0m	**RL11**	08/01/2003	46	12.3	0.44	2.8	0.24	34	55
2,Blue,0m	**RL11**	07/02/2003							
2,Blue,0m	**RL11**	20/02/2003	44	10.4	0.47	5.4	1.18	24	40
2,Blue,0m	**RL11**	06/03/2003	35	10.4	0.7	2.6	0.17		70
2,Blue,0m	**RL11**	13/03/2003							
2,Blue,0m	**RL11**	01/04/2003	43	8.8	0.6	5	1.02	23	20
2,Blue,0m	**RL11**	16/04/2003							
2,Blue,0m	**RL11**	29/04/2003							
2,Blue,0m	**RL11**	15/05/2003							140
2,Blue,0m	**RL11**	23/05/2003	29	7.4	0.395	2.51	0	34.5	120
2,Blue,0m	**RL11**	06/06/2003							
2,Blue,0m	**RL11**	20/06/2003	73	13.8	0.56	26	0.66	60	120
2,Blue,0m	**RL11**	01/07/2003	19	17.6	1.9	9.6	0.91	58	70
2,Blue,0m	**RL11**	15/07/2003							

2,Black,0m	**RL12**	08/08/2002	21	0.9	-	0.6	<0.1	29	
2,Black,0m	**RL12**	14/08/2002	45	<0.10	<0.005	0.35	0.52	64	90
2,Black,0m	**RL12**	21/08/2002	55	<0.10	<0.005	131	2.86	39	60
2,Black,0m	**RL12**	27/08/2002	71	<0.10	<0.005	0.95	0.72	31	60
2,Black,0m	**RL12**	11/09/2002	96	1.1	0.03	0.36	534	20	30
2,Black,0m	**RL12**	25/09/2002							
2,Black,0m	**RL12**	09/10/2002							
2,Black,0m	**RL12**	17/10/2002							
2,Black,0m	**RL12**	23/10/2002	63	1.1	0.08	3.3		30.5	75
2,Black,0m	**RL12**	03/12/2002	32	0	0.06	1.7	1.16	41	
2,Black,0m	**RL12**	08/01/2003							
2,Black,0m	**RL12**	07/02/2003							
2,Black,0m	**RL12**	20/02/2003							
2,Black,0m	**RL12**	06/03/2003	40	4.2	0.06	1.1	0.06		35
2,Black,0m	**RL12**	13/03/2003							
2,Black,0m	**RL12**	01/04/2003							
2,Black,0m	**RL12**	16/04/2003							
2,Black,0m	**RL12**	29/04/2003							
2,Black,0m	**RL12**	15/05/2003							5
2,Black,0m	**RL12**	23/05/2003	48	5.8	0.126	1.01	N/A	33.3	20
2,Black,0m	**RL12**	06/06/2003							
2,Black,0m	**RL12**	20/06/2003	53	9.7	0.15	20	1.08	64	70
2,Black,0m	**RL12**	01/07/2003	23.6	10.7	0.18	8.1	0.79	60	60
2,Black,0m	**RL12**	15/07/2003							
2,Red,10m	**RL13**	08/08/2002	20.4	0.4	-	2.2	0.5	31	
2,Red,10m	**RL13**	14/08/2002	53	<0.10	<0.005	0.64	0.45	69	160
2,Red,10m	**RL13**	21/08/2002	49	<0.10	<0.005	1.76	4.57	62	130
2,Red,10m	**RL13**	27/08/2002							
2,Red,10m	**RL13**	11/09/2002	80	<0.10	<0.005	0.5	3.09	23	70
2,Red,10m	**RL13**	25/09/2002	73	<0.10	0.06	2	0.37	47	80
2,Red,10m	**RL13**	09/10/2002	98	1.5	0.36	3.6	6.71	38	30
2,Red,10m	**RL13**	17/10/2002							
2,Red,10m	**RL13**	23/10/2002	75	0	0.05	5.5		27.8	200
2,Red,10m	**RL13**	03/12/2002	98	0	0	5.5	0.71	28	
2,Red,10m	**RL13**	08/01/2003	68	0	0	5.8	0.05	40	240
2,Red,10m	**RL13**	07/02/2003	52	0	0.02	4.8	0.52	21	250
2,Red,10m	**RL13**	20/02/2003	50	0	0	10.6	1.03	27	110
2,Red,10m	**RL13**	06/03/2003	39	1.9	0.01	7.9	0.24		154
2,Red,10m	**RL13**	13/03/2003							
2,Red,10m	**RL13**	01/04/2003	32	0	0.09	9	0.72	10	150
2,Red,10m	**RL13**	16/04/2003	39	0	0.02	5.7	0.44	47	170
2,Red,10m	**RL13**	29/04/2003	16	0	0.05	9.7	0.27	38	110
2,Red,10m	**RL13**	15/05/2003							170
2,Red,10m	**RL13**	23/05/2003	32	3.6	0.012	7.16	0.05	38.8	160
2,Red,10m	**RL13**	06/06/2003	64	1.33	0.94	8.8	0.22	40.8	140
2,Red,10m	**RL13**	20/06/2003	49	8	0.3	33	0.76	72	220
2,Red,10m	**RL13**	01/07/2003	33	11	0.3	16.3	1	80	160
2,Red,10m	**RL13**	15/07/2003	32	1.2	0.3	10.3	0.24	37	190

2,Blue,10m	**RL14**	08/08/2002	14.3	0.7	-	2.9	0.2	24	
2,Blue,10m	**RL14**	14/08/2002	39	1.4	0.31	0.5	0.43	63	80
2,Blue,10m	**RL14**	21/08/2002	9	4.1	0.32	1.39	2.97	60	30
2,Blue,10m	**RL14**	27/08/2002	44	4.6	0.34	1.6	2.88	30	60
2,Blue,10m	**RL14**	11/09/2002							
2,Blue,10m	**RL14**	25/09/2002							
2,Blue,10m	**RL14**	09/10/2002	61	1.7	0.02	5	4.98	33	130
2,Blue,10m	**RL14**	17/10/2002							
2,Blue,10m	**RL14**	23/10/2002	57	0	0.11	1.5		30.7	65
2,Blue,10m	**RL14**	03/12/2002	56	2.9	0.01	3.2	0.21	19	
2,Blue,10m	**RL14**	08/01/2003							
2,Blue,10m	**RL14**	07/02/2003							
2,Blue,10m	**RL14**	20/02/2003							
2,Blue,10m	**RL14**	06/03/2003							
2,Blue,10m	**RL14**	13/03/2003							
2,Blue,10m	**RL14**	01/04/2003							
2,Blue,10m	**RL14**	16/04/2003							
2,Blue,10m	**RL14**	29/04/2003							
2,Blue,10m	**RL14**	15/05/2003							100
2,Blue,10m	**RL14**	23/05/2003	46	9.6	N/A	8.82	N/A	38.4	15
2,Blue,10m	**RL14**	06/06/2003	68	17.73	0.027	0.96	0.12	36.4	30
2,Blue,10m	**RL14**	20/06/2003	27	24.5	0.17	15	0.59	62	100
2,Blue,10m	**RL14**	01/07/2003	20.3	25.3	1.5	11.6	0.66	60	110
2,Blue,10m	**RL14**	15/07/2003	18.5	10.6	0.06	0.3	0.65	40	110
2,Black,10m	**RL15**	08/08/2002	13.6	6.9	-	0.5	0.2	31	
2,Black,10m	**RL15**	14/08/2002	58	6.1	0.1	0.28	0.72	75	200
2,Black,10m	**RL15**	21/08/2002	24	3.2	0.07	1.15	1.77	63	170
2,Black,10m	**RL15**	27/08/2002	60	5.3	0.07	0.44	1.56	38	140
2,Black,10m	**RL15**	11/09/2002	66	11.2	0.03	0.6	0.2	29	170
2,Black,10m	**RL15**	25/09/2002	43	42.8	0.03	0.08	<0.05	36	220
2,Black,10m	**RL15**	09/10/2002	85	23.1	0.12	2	2.44	44	210
2,Black,10m	**RL15**	17/10/2002							
2,Black,10m	**RL15**	23/10/2002	29	0.1	0.01	0.5		30.2	280
2,Black,10m	**RL15**	03/12/2002	41	9.7	0.01	0.6	0.44	21	
2,Black,10m	**RL15**	08/01/2003	43	6.3	0	1.2	0.04	36	150
2,Black,10m	**RL15**	07/02/2003	50	6.2	0.01	0.6	0.44	24	180
2,Black,10m	**RL15**	20/02/2003	53	15.9	0	1.4	0.3	0	110
2,Black,10m	**RL15**	06/03/2003	10	14.2	0	1.6	0.15		140
2,Black,10m	**RL15**	13/03/2003							
2,Black,10m	**RL15**	01/04/2003	25	15.3	0.02	2	0.13	17	160
2,Black,10m	**RL15**	16/04/2003	30	18.8	0.01	0.7	0.07	37	170
2,Black,10m	**RL15**	29/04/2003		23.2	0	1.1	0.27	24	150
2,Black,10m	**RL15**	15/05/2003							40
2,Black,10m	**RL15**	23/05/2003	15	28.68	0.023	0.178	0.17	35	190
2,Black,10m	**RL15**	06/06/2003	50	30.03	0.03	0.746	0.08	30.9	140
2,Black,10m	**RL15**	20/06/2003	20	23.4	0.13	16	0.98	58	170
2,Black,10m	**RL15**	01/07/2003	12.2	24.9	1.1	8.4	0.65	62	180
2,Black,10m	**RL15**	15/07/2003	15	20.3	0.3	0.2	1.22	38	180

2,Red,20m	**RL16**	08/08/2002	35.7	2	-	15.9	2.6	29	
2,Red,20m	**RL16**	14/08/2002	66	26.1	1.23	0.44	2.25	64	192
2,Red,20m	**RL16**	21/08/2002							
2,Red,20m	**RL16**	27/08/2002							
2,Red,20m	**RL16**	11/09/2002							
2,Red,20m	**RL16**	25/09/2002	91	1.6	0.12	16	3.87	40	650
2,Red,20m	**RL16**	09/10/2002	99	1.2	0.6	50.7	6.64	29	770
2,Red,20m	**RL16**	17/10/2002							
2,Red,20m	**RL16**	23/10/2002	69	1.9	1.64	24.4		25.6	1030
2,Red,20m	**RL16**	03/12/2002	71	6.2	0.29	12.9	2.98	26	
2,Red,20m	**RL16**	08/01/2003	98	1	0.06	23.1	4.63	54	890
2,Red,20m	**RL16**	07/02/2003	92	0	0.03	27.8	2.39	30	1230
2,Red,20m	**RL16**	20/02/2003	115	1.2	0.02	30.4	3.78	0	970
2,Red,20m	**RL16**	06/03/2003	84	1.5	0.03	34.2	3.19		856.8
2,Red,20m	**RL16**	13/03/2003							
2,Red,20m	**RL16**	01/04/2003	63	0	0.02	36	3.07	28	1000
2,Red,20m	**RL16**	16/04/2003	64	0	0.03	37.8	2.06	54	890
2,Red,20m	**RL16**	29/04/2003	58	0	0.14	34.9	1.56	42	750
2,Red,20m	**RL16**	15/05/2003							950
2,Red,20m	**RL16**	23/05/2003	42	2.4	0.029	41	2.01	40.9	830
2,Red,20m	**RL16**	06/06/2003	122	0.27	0.04	41	3.51	42.4	950
2,Red,20m	**RL16**	20/06/2003	86	6.6	0.14	61	4.56	76	940
2,Red,20m	**RL16**	01/07/2003	92	6.7	0.14	45.2	3.82	75	850
2,Red,20m	**RL16**	15/07/2003	50.9	0	0.02	28.1	5.9	35	1020
2,Blue,20m	**RL17**	08/08/2002	34.4	<0.3	-	12.1	1.4	30	
2,Blue,20m	**RL17**	14/08/2002	75	28.7	1.47	0.38	1.21	63	420
2,Blue,20m	**RL17**	21/08/2002							
2,Blue,20m	**RL17**	27/08/2002							
2,Blue,20m	**RL17**	11/09/2002							
2,Blue,20m	**RL17**	25/09/2002	104	1.8	0.14	13	2.54	45	660
2,Blue,20m	**RL17**	09/10/2002	91	1.8	0.37	23	3.02	43	980
2,Blue,20m	**RL17**	17/10/2002							
2,Blue,20m	**RL17**	23/10/2002	67	0	0.23	26.6		26.1	1070
2,Blue,20m	**RL17**	03/12/2002	70	0	0.11	26.7	6.64	18	
2,Blue,20m	**RL17**	08/01/2003	106	0.2	0.03	30	3.29	50	1490
2,Blue,20m	**RL17**	07/02/2003	101	0	0.03	28.6	2.49	33	1490
2,Blue,20m	**RL17**	20/02/2003	107	1.3	0.02	32	4.28	22	1070
2,Blue,20m	**RL17**	06/03/2003	59	3.1	0.04	32	2.88		1029
2,Blue,20m	**RL17**	13/03/2003							
2,Blue,20m	**RL17**	01/04/2003	67	0	0.02	40	2.69	19	1220
2,Blue,20m	**RL17**	16/04/2003	65	0	0.02	33.2	2.22	57	970
2,Blue,20m	**RL17**	29/04/2003	62	0	0.09	42.4	1.74	44	770
2,Blue,20m	**RL17**	15/05/2003							970
2,Blue,20m	**RL17**	23/05/2003	48	2.9	0.029	47.8	1.7	45.5	690
2,Blue,20m	**RL17**	06/06/2003	105	0.56	0.05	46.3	2.8	43.1	900
2,Blue,20m	**RL17**	20/06/2003	83	7.6	0.27	56	4.2	74	950
2,Blue,20m	**RL17**	01/07/2003	61	7	0.3	47.9	3.71	79	730
2,Blue,20m	**RL17**	15/07/2003	45.2	0	0.05	34.1	4.8	40	920

2,Black,20m	**RL18**	08/08/2002	35.7	<0.3	-	13.6	1.8	28	
2,Black,20m	**RL18**	14/08/2002	74	26.5	1.23	0.61	1.44	70	450
2,Black,20m	**RL18**	21/08/2002							
2,Black,20m	**RL18**	27/08/2002							
2,Black,20m	**RL18**	11/09/2002							
2,Black,20m	**RL18**	25/09/2002	87	<0.10	0.42	8.5	1.78	43	770
2,Black,20m	**RL18**	09/10/2002	84	2.3	0.88	43.3	2.36	37	1200
2,Black,20m	**RL18**	17/10/2002							
2,Black,20m	**RL18**	23/10/2002	65	1.9	0.15	24.2		27.2	1340
2,Black,20m	**RL18**	03/12/2002	71	0.9	1.72	18.6	2.38	22	
2,Black,20m	**RL18**	08/01/2003	110	0.5	0.01	34.7	3.49	43	1620
2,Black,20m	**RL18**	07/02/2003	86	0	0.03	28.3	2.64	26	1690
2,Black,20m	**RL18**	20/02/2003	103	1.3	0.04	34	3.62	29	1190
2,Black,20m	**RL18**	06/03/2003	65	0.7	0.04	33.6	2.94		1190
2,Black,20m	**RL18**	13/03/2003							
2,Black,20m	**RL18**	01/04/2003	68	0	0.02	46	2.62	17	1420
2,Black,20m	**RL18**	16/04/2003	60	0	0.05	35.7	1.98	61	1080
2,Black,20m	**RL18**	29/04/2003	60	0	0.2	37.7	1.66	50	820
2,Black,20m	**RL18**	15/05/2003							1070
2,Black,20m	**RL18**	23/05/2003	38	2.6	0.011	47.6	1.55	45.6	760
2,Black,20m	**RL18**	06/06/2003	102	0.20	0.03	43.2	2.76	43.4	1020
2,Black,20m	**RL18**	20/06/2003	94	6.7	0.45	60	4.11	75	1020
2,Black,20m	**RL18**	01/07/2003	53	7	0.28	46.8	3.68	75	760
2,Black,20m	**RL18**	15/07/2003	49	0	0.02	33.5	6.5	35	1060

TRENCH 3

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	VOL
3,Red,0m	RL19	08/08/2002	127.5	<0.3	-	25.7	3.6	37	
3,Red,0m	RL19	14/08/2002	156	<0.10	0.28	0.48	4.01	86	650
3,Red,0m	RL19	21/08/2002	156	<0.10	<0.005	14.27	6.78	60	590
3,Red,0m	RL19	27/08/2002	184	<0.10	<0.005	3.56	7.02	44	410
3,Red,0m	RL19	11/09/2002	250	0.8	<0.005	38.6	4.97	32	610
3,Red,0m	RL19	25/09/2002	218	<0.10	0.01	33	4.34	44	520
3,Red,0m	RL19	09/10/2002	182	0.9	0.18	33.8	6.84	31	470
3,Red,0m	RL19	17/10/2002	162	0	0.4	67.3	12.72	38	360
3,Red,0m	RL19	23/10/2002	99	1.2	0.06	31.4		25.4	320
3,Red,0m	RL19	03/12/2002	101	0	0.16	26.6	2.5	41	
3,Red,0m	RL19	08/01/2003	125	1	0.09	19.4	0.9	45	360
3,Red,0m	RL19	07/02/2003	88	0	0.04	15.3	2.27	33	270
3,Red,0m	RL19	20/02/2003	90	1.5	0.06	13.5	2.03	28	150
3,Red,0m	RL19	06/03/2003	67	1.1	0.07	14.9	2.03		140
3,Red,0m	RL19	13/03/2003	61	1.1	0.08	18.2	0.99	31	120
3,Red,0m	RL19	01/04/2003	39	1.6	0.07	14	1.46	25	170
3,Red,0m	RL19	16/04/2003	70	0	0.16	13.3	1.57	52	130
3,Red,0m	RL19	29/04/2003	61	0	0.14	8.5	0.97	30	100
3,Red,0m	RL19	15/05/2003							160
3,Red,0m	RL19	23/05/2003	64	4.9	0.12	9.33	0.8	43.2	80
3,Red,0m	RL19	06/06/2003	93	3.43	0.152	9.74	0.59	41.7	100
3,Red,0m	RL19	20/06/2003	86	8.8	0.17	30	1.3	70	170
3,Red,0m	RL19	01/07/2003	93	9.3	0.57	16.5	0.76	72	100
3,Red,0m	RL19	15/07/2003	54.7	2	0.48	7.7	0.59	45	35
3,Blue,0m	RL20	08/08/2002	37.4	<0.3	-	1	0.2	28	
3,Blue,0m	RL20	14/08/2002	72	<0.10	<0.005	0.35	7.5	63	130
3,Blue,0m	RL20	21/08/2002	54	<0.10	0.06	1.59	2.84	37	160
3,Blue,0m	RL20	27/08/2002	92	<0.10	0.26	0.87	2.48	31	150
3,Blue,0m	RL20	11/09/2002	96	1.1	0.02	0.82	1.8	31	190
3,Blue,0m	RL20	25/09/2002	75	0.9	0.07	0.88	0.32	38	180
3,Blue,0m	RL20	09/10/2002	123	0.6	0.43	2.7	1.16	25	160
3,Blue,0m	RL20	17/10/2002	88	1.1	0.1	2.8	1.48	27	190
3,Blue,0m	RL20	23/10/2002	71	0	0.04	4.2		28.3	170
3,Blue,0m	RL20	03/12/2002	126	0	0.02	4.2	0.51	47	
3,Blue,0m	RL20	08/01/2003	72	0.7	0.01	2.5	0.08	69	280
3,Blue,0m	RL20	07/02/2003	72	1.4	0.05	1.3	0.27	31	290
3,Blue,0m	RL20	20/02/2003	75	0.6	0.04	1.3	0.12	0	170
3,Blue,0m	RL20	06/03/2003	49	0.9	0.06	3.6	0.11		186.2
3,Blue,0m	RL20	13/03/2003							
3,Blue,0m	RL20	01/04/2003	53	0	0.05	8	0.18	28	300
3,Blue,0m	RL20	16/04/2003	54	0	0.05	4.3	0.24	44	100
3,Blue,0m	RL20	29/04/2003	40	0.5	0.08	3.7	0.5	33	150
3,Blue,0m	RL20	15/05/2003							270
3,Blue,0m	RL20	23/05/2003	25	4.2	0.066	4.59	0.06	42	140
3,Blue,0m	RL20	06/06/2003	107	2.13	0.193	5.31	0.36	43.5	90
3,Blue,0m	RL20	20/06/2003	87	7.3	0.17	29	1.09	67	240
3,Blue,0m	RL20	01/07/2003	50	11.1	0.51	12.5	0.82	60	130
3,Blue,0m	RL20	15/07/2003	48.1	0.7	0.19	1.8	0.18	50	150

3,Black,0m	**RL21**	08/08/2002	34.7	0.3	-	0.7	<0.1	23	
3,Black,0m	**RL21**	14/08/2002	51	<0.10	<0.005	1.03	1.78	58	70
3,Black,0m	**RL21**	21/08/2002	58	0.2	<0.005	1.37	2.98	52	75
3,Black,0m	**RL21**	27/08/2002	79	<0.10	<0.005	0.68	0.82	22	80
3,Black,0m	**RL21**	11/09/2002	81	0.7	<0.005	0.42	0.9	21	70
3,Black,0m	**RL21**	25/09/2002	77	0.8	0.01	0.06	0.09	56	63
3,Black,0m	**RL21**	09/10/2002	89	0.9	0.07	1.4	1.22	33	70
3,Black,0m	**RL21**	17/10/2002							
3,Black,0m	**RL21**	23/10/2002	69	1.3	0.03	4.8		29.1	75
3,Black,0m	**RL21**	03/12/2002	64	0	0.01	2	0.12	43	
3,Black,0m	**RL21**	08/01/2003	105	1.7	0.01	1.5	0.27	37	100
3,Black,0m	**RL21**	07/02/2003	86	0	0.02	0.6	0.09	34	90
3,Black,0m	**RL21**	20/02/2003	86	2.8	0.01	1	0.45	8	80
3,Black,0m	**RL21**	06/03/2003	33	0.7	0.03	2.6	0.31		163.1
3,Black,0m	**RL21**	13/03/2003	38	0	0.04	1.6	0.42	29	90
3,Black,0m	**RL21**	01/04/2003	21	1.3	0.03	0	0.26	27	75
3,Black,0m	**RL21**	16/04/2003	46	0	0.03	0.7	0.12	44	60
3,Black,0m	**RL21**	29/04/2003	22	0	0.09	1	0.07	30	65
3,Black,0m	**RL21**	15/05/2003							100
3,Black,0m	**RL21**	23/05/2003	42	5.5	0.037	0.959	0	38	70
3,Black,0m	**RL21**	06/06/2003	96	1.33	0.05	1.71	0.03	38.4	60
3,Black,0m	**RL21**	20/06/2003	53	8	0.19	21	1.24	71	130
3,Black,0m	**RL21**	01/07/2003	26.1	13	0.26	11.6	1.36	66	60
3,Black,0m	**RL21**	15/07/2003							
3,Red,10m	**RL22**	08/08/2002	42.7	<0.3	-	13.2	1	34	
3,Red,10m	**RL22**	14/08/2002	85	<0.10	<0.005	1.17	1.97	78	240
3,Red,10m	**RL22**	21/08/2002	43	0.5	<0.005	6.39	5.74	70	240
3,Red,10m	**RL22**	27/08/2002	113	<0.10	<0.005	>15	1.7	35	220
3,Red,10m	**RL22**	11/09/2002	138	<0.10	0.06	17.8	3.74	32	230
3,Red,10m	**RL22**	25/09/2002	143	<0.10	0.06	20.2	2.47	45	250
3,Red,10m	**RL22**	09/10/2002	127	1.8	0.07	23.8	3.42	42	220
3,Red,10m	**RL22**	17/10/2002	85	0.6	0.1	26	14.48	21	260
3,Red,10m	**RL22**	23/10/2002	54	1.9	0.02	19.2		31.3	280
3,Red,10m	**RL22**	03/12/2002	74	0	0.08	18.5	2.03	25	
3,Red,10m	**RL22**	08/01/2003	114	1.5	0.04	21.1	3.36	39	250
3,Red,10m	**RL22**	07/02/2003	226	0	0.02	24.7	2.77	32	260
3,Red,10m	**RL22**	20/02/2003	119	1.5	0.03	23.6	3.24	20	150
3,Red,10m	**RL22**	06/03/2003	72	3.2	0.06	27.1	2.48		490
3,Red,10m	**RL22**	13/03/2003	73	0.9	0.06	25.1	2.41	30	133
3,Red,10m	**RL22**	01/04/2003	52	2.7	0.05	23	1.55	26	110
3,Red,10m	**RL22**	16/04/2003	57	5.1	0.1	26.4	1.36	51	100
3,Red,10m	**RL22**	29/04/2003	35	3.7	0.07	23.9	2.17	40	110
3,Red,10m	**RL22**	15/05/2003							170
3,Red,10m	**RL22**	23/05/2003	62	4.6	0.062	31.4	1.93	47.9	150
3,Red,10m	**RL22**	06/06/2003	118	14.61	0.823	28.8	0.94	39.5	60
3,Red,10m	**RL22**	20/06/2003	102	23.9	3.85	46	0.78	65	270
3,Red,10m	**RL22**	01/07/2003	47	15.9	1.5	34.7	1.46	78	210
3,Red,10m	**RL22**	15/07/2003	105	7.9	0.22	14.9	1.55	38	180

3,Blue,10m	**RL23**	08/08/2002	52.4	<0.3	-	22.3	3	34	
3,Blue,10m	**RL23**	14/08/2002	115	<0.10	0.46	1.58	3.43	87	670
3,Blue,10m	**RL23**	21/08/2002	84	<0.10	<0.005	4.91	1.9	73	780
3,Blue,10m	**RL23**	27/08/2002	142	<0.10	<0.005	>15	5.98	46	690
3,Blue,10m	**RL23**	11/09/2002	181	0.8	<0.005	43.4	6.34	48	760
3,Blue,10m	**RL23**	25/09/2002	157	<0.10	<0.005	27.2	6.58	44	840
3,Blue,10m	**RL23**	09/10/2002	130	2	0.03	56.4	8	50	850
3,Blue,10m	**RL23**	17/10/2002	91	0	0.1	47	9.28	34	745
3,Blue,10m	**RL23**	23/10/2002	92	0.5	0.31	30.6		20.7	720
3,Blue,10m	**RL23**	03/12/2002	75	2.5	0.45	4.1	4.89	28	
3,Blue,10m	**RL23**	08/01/2003	104	0	0.01	49.9	6.64	36	1020
3,Blue,10m	**RL23**	07/02/2003	87	0	0.02	39.4	11.44	46	1050
3,Blue,10m	**RL23**	20/02/2003	50	2.9	0.02	41.9	7.16	27	780
3,Blue,10m	**RL23**	06/03/2003	63	2.7	0.03	49.2	6.49		770
3,Blue,10m	**RL23**	13/03/2003	64	6.2	1.1	53	2.51	24	350
3,Blue,10m	**RL23**	01/04/2003							
3,Blue,10m	**RL23**	16/04/2003	68	0	0.43	49.2	2.53	60	700
3,Blue,10m	**RL23**	29/04/2003	57	0	0.03	47.3	5.86	50	610
3,Blue,10m	**RL23**	15/05/2003							710
3,Blue,10m	**RL23**	23/05/2003	71	4.5	0.026	55.2	5.62	51.5	470
3,Blue,10m	**RL23**	06/06/2003	77	1.68	0.479	49	4.45	42.6	440
3,Blue,10m	**RL23**	20/06/2003	96	11.8	3.6	61	1.78	68	570
3,Blue,10m	**RL23**	01/07/2003	57	6.9	0.19	50.3	3.24	81	530
3,Blue,10m	**RL23**	15/07/2003	104	0	0	27.1	6.1	43	630
3,Black,10m	**RL24**	08/08/2002	51.7	<0.3	-	25.3	3.4	31	
3,Black,10m	**RL24**	14/08/2002	113	<0.10	<0.005	0.3	4.91	85	910
3,Black,10m	**RL24**	21/08/2002	58	<0.10	<0.005	4.23	2.03	69	640
3,Black,10m	**RL24**	27/08/2002	160	<0.10	0.03	>15	5.64	45	570
3,Black,10m	**RL24**	11/09/2002	82	<0.10	0.04	34.6	6.59	50	600
3,Black,10m	**RL24**	25/09/2002	153	<0.10	0.05	23.8	9.4	56	1330
3,Black,10m	**RL24**	09/10/2002	118	1.6	0.05	44.2	10.6	78	1100
3,Black,10m	**RL24**	17/10/2002	82	0	0.1	36.4	9.96	28	720
3,Black,10m	**RL24**	23/10/2002	74	0.3	0.47	25.9		22.6	1370
3,Black,10m	**RL24**	03/12/2002	84	0	0.04	31.1	4.86	22	
3,Black,10m	**RL24**	08/01/2003	102	0.4	0.06	45.3	6.2	50	1135
3,Black,10m	**RL24**	07/02/2003	128	0.3	0.03	40.4	11.7	47	1570
3,Black,10m	**RL24**	20/02/2003	122	1.1	0.03	22.6	7.72	30	1630
3,Black,10m	**RL24**	06/03/2003	94	0	0.05	51.6	9.95		1423.31
3,Black,10m	**RL24**	13/03/2003	67	0	0.03	43.1	5.55	30	1000
3,Black,10m	**RL24**	01/04/2003	80	0.6	0.42	48	4.81	28	570
3,Black,10m	**RL24**	16/04/2003	60	0	0.01	44.1	3.47	59	730
3,Black,10m	**RL24**	29/04/2003	53	0	0.03	43.7	5.12	50	570
3,Black,10m	**RL24**	15/05/2003							
3,Black,10m	**RL24**	23/05/2003	68	2.2	0.037	44	4.82	36.6	1100
3,Black,10m	**RL24**	06/06/2003	98	0.57	0.256	33.3	3.34	29.3	300
3,Black,10m	**RL24**	20/06/2003	81	9.5	0.72	53	2.36	68	330
3,Black,10m	**RL24**	01/07/2003	107	7.7	0.2	41.5	5.63	71	1610
3,Black,10m	**RL24**	15/07/2003	180	0	0.29	25.9	6.3	35	1770

3,Red,20m	**RL25**	08/08/2002							
3,Red,20m	**RL25**	14/08/2002							
3,Red,20m	**RL25**	21/08/2002							
3,Red,20m	**RL25**	27/08/2002							
3,Red,20m	**RL25**	11/09/2002							
3,Red,20m	**RL25**	25/09/2002							
3,Red,20m	**RL25**	09/10/2002	84	1.8	0.09	19.5	4.44	-	20
3,Red,20m	**RL25**	17/10/2002							
3,Red,20m	**RL25**	23/10/2002	46	1.5	2.04	7.4		23.2	890
3,Red,20m	**RL25**	03/12/2002	48	4.6	0.59	10.5	3.27	7	
3,Red,20m	**RL25**	08/01/2003	54	13.7	0.84	7.9	3.15	32	450
3,Red,20m	**RL25**	07/02/2003	68	1.6	0.34	12.8	2.55	34	830
3,Red,20m	**RL25**	20/02/2003	86	1.2	0.02	15.9	3.1	33	760
3,Red,20m	**RL25**	06/03/2003	56	6.1	0.44	24.7	3.2		716.8
3,Red,20m	**RL25**	13/03/2003	38	0	0.24	20.4	2.86	24	820
3,Red,20m	**RL25**	01/04/2003	46	0.2	0.11	20	2.45	25	270
3,Red,20m	**RL25**	16/04/2003	55	46.4	?	7.2	1.57	64	300
3,Red,20m	**RL25**	29/04/2003	46	29.5	1	8.8	2.87	44	270
3,Red,20m	**RL25**	15/05/2003							240
3,Red,20m	**RL25**	23/05/2003	38	21.68	0.346	5.57	2.43	29.2	370
3,Red,20m	**RL25**	06/06/2003	66	56.90	0.055	6.81	1.25	31.6	30
3,Red,20m	**RL25**	20/06/2003	59	56.3	0.3	19	1.73	69	35
3,Red,20m	**RL25**	01/07/2003	66	12.7	0.55	17.8	4.48	52	700
3,Red,20m	**RL25**	15/07/2003	41.2	27.5	0.38	3.6	2.67	30	70
3,Blue,20m	**RL26**	08/08/2002							
3,Blue,20m	**RL26**	14/08/2002							
3,Blue,20m	**RL26**	21/08/2002							
3,Blue,20m	**RL26**	27/08/2002							
3,Blue,20m	**RL26**	11/09/2002							
3,Blue,20m	**RL26**	25/09/2002							
3,Blue,20m	**RL26**	09/10/2002							
3,Blue,20m	**RL26**	17/10/2002							
3,Blue,20m	**RL26**	23/10/2002	43	0.7	1.72	5.4		17	1150
3,Blue,20m	**RL26**	03/12/2002	62	6.5	0.77	9.1	2.71	14	
3,Blue,20m	**RL26**	08/01/2003	70	7.2	0.8	7.2	2.92	35	460
3,Blue,20m	**RL26**	07/02/2003	84	4.3	0.22	10.5	2.09	35	1250
3,Blue,20m	**RL26**	20/02/2003	75	3.4	0.09	16.7	3.22	28	1360
3,Blue,20m	**RL26**	06/03/2003	55	2.1	0.06	25.9	5.08		1400
3,Blue,20m	**RL26**	13/03/2003							
3,Blue,20m	**RL26**	01/04/2003	46	3.2	0.07	23	2.79	28	200
3,Blue,20m	**RL26**	16/04/2003	69	55.7	0.91	8.6	1.78	70	400
3,Blue,20m	**RL26**	29/04/2003	25	37.7	0.3	6.1	2.89	44	600
3,Blue,20m	**RL26**	15/05/2003							750
3,Blue,20m	**RL26**	23/05/2003	32	30.03	0.105	1.02	1.58	27.8	620
3,Blue,20m	**RL26**	06/06/2003	53	35.90	0.051	0.8	1.66	26.2	60
3,Blue,20m	**RL26**	20/06/2003	16	46.8	0.28	16	2.35	62	35
3,Blue,20m	**RL26**	01/07/2003	55.8	17.4	0.54	17.4	3.82	52	550
3,Blue,20m	**RL26**	15/07/2003	31.9	20.8	0.3	0.9	2.6	29	220

3,Black,20m	**RL27**	08/08/2002							
3,Black,20m	**RL27**	14/08/2002							
3,Black,20m	**RL27**	21/08/2002							
3,Black,20m	**RL27**	27/08/2002							
3,Black,20m	**RL27**	11/09/2002							
3,Black,20m	**RL27**	25/09/2002							
3,Black,20m	**RL27**	09/10/2002							
3,Black,20m	**RL27**	17/10/2002	71	21.9	0.24	7.9	3.12	11	12
3,Black,20m	**RL27**	23/10/2002	44	10.3	2.36	4.6		20.2	1260
3,Black,20m	**RL27**	03/12/2002	40	6.6	0.4	5.7	1.11	8	
3,Black,20m	**RL27**	08/01/2003	69	7.9	0.52	5.4	2.16	36	890
3,Black,20m	**RL27**	07/02/2003	83	4	0.12	9.4	1.49	34	1610
3,Black,20m	**RL27**	20/02/2003	75	1.1	0.48	9.5	1.99	28	950
3,Black,20m	**RL27**	06/03/2003	51	3.3	0.03	22.3	3.53		927.5
3,Black,20m	**RL27**	13/03/2003	32	1	0.6	19.3	2.25	24	550
3,Black,20m	**RL27**	01/04/2003	41	0	0.14	20	1.91	28	690
3,Black,20m	**RL27**	16/04/2003	58	35.3	0.79	17	1.19	61	670
3,Black,20m	**RL27**	29/04/2003	18	38	0.5	10.6	1.3	45	540
3,Black,20m	**RL27**	15/05/2003							490
3,Black,20m	**RL27**	23/05/2003	24	35.23	0.314	6.79	0.98	32.3	550
3,Black,20m	**RL27**	06/06/2003	62	35.68	0.535	3.8	1.97	31.2	130
3,Black,20m	**RL27**	20/06/2003	72	37.3	6.1	16	1.62	63	50
3,Black,20m	**RL27**	01/07/2003	25	39.3	1.7	10.1	2.13	60	290
3,Black,20m	**RL27**	15/07/2003	33..2	12.1	0.39	6	1.54	29	380

TRENCH 4

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	VOL
4,Red,0m	RL28	08/08/2002	83.8	<0.3	-	0.7	<0.1	34	
4,Red,0m	RL28	14/08/2002	116	<0.10	<0.005	0.5	0.5	86	80
4,Red,0m	RL28	21/08/2002	89	<0.10	0.28	1.39	0.68	69	65
4,Red,0m	RL28	27/08/2002	142	0.04	<0.005	0.46	0.72	38	70
4,Red,0m	RL28	11/09/2002	95	0.5	0.03	0.5	0.82	29	40
4,Red,0m	RL28	25/09/2002							
4,Red,0m	RL28	09/10/2002							
4,Red,0m	RL28	17/10/2002							
4,Red,0m	RL28	23/10/2002	97	5	0.01	0.6		31.8	220
4,Red,0m	RL28	03/12/2002	104	5.9	0.02	0.7	0.31	38	
4,Red,0m	RL28	08/01/2003	111	2.6	0	1.3	0.23	62	130
4,Red,0m	RL28	07/02/2003	143	0.7	0	1	0.48	37	80
4,Red,0m	RL28	20/02/2003	120	1.1	0.01	0	0.17	39	80
4,Red,0m	RL28	06/03/2003	76	3.5	0.03	0.5	0.17		105
4,Red,0m	RL28	13/03/2003							
4,Red,0m	RL28	01/04/2003	82	2.1	0	2	0.54	36	10
4,Red,0m	RL28	16/04/2003							
4,Red,0m	RL28	29/04/2003							
4,Red,0m	RL28	15/05/2003							
4,Red,0m	RL28	23/05/2003	68	6.7	0.023	0	0.04	39.8	70
4,Red,0m	RL28	06/06/2003	108	5.06	0.021	0.062			60
4,Red,0m	RL28	20/06/2003	73	10.5	0.42	19	1.19	69	30
4,Red,0m	RL28	01/07/2003	53	11	0.2	9.3	1.21	65	80
4,Red,0m	RL28	15/07/2003							
4,Blue,0m	RL29	08/08/2002	71	<0.3	-	1.2	<0.1	29	
4,Blue,0m	RL29	14/08/2002	122	13.1	<0.005	0.49	0.56	77	110
4,Blue,0m	RL29	21/08/2002	77	1.9	<0.005	1.71	0.77	62	120
4,Blue,0m	RL29	27/08/2002	102	<0.10	<0.005	1.29	0.32	29	100
4,Blue,0m	RL29	11/09/2002	140	<0.10	0.08	1.4	654	22	160
4,Blue,0m	RL29	25/09/2002	92	<0.10	<0.005	1.55	0.16	31	80
4,Blue,0m	RL29	09/10/2002	140	1.3	0.03	1.5	0.42	27	75
4,Blue,0m	RL29	17/10/2002							
4,Blue,0m	RL29	23/10/2002	85	0.8	0.03	0.7		24.6	150
4,Blue,0m	RL29	03/12/2002	84	0.1	0.04	0.5	0.39	39	
4,Blue,0m	RL29	08/01/2003	101	1.2	0	1.3	0.24	40	160
4,Blue,0m	RL29	07/02/2003	110	1.4	0.01	0.4	0.35	30	150
4,Blue,0m	RL29	20/02/2003	107	1.8	0.01	0.2	2.45	27	110
4,Blue,0m	RL29	06/03/2003	71	0.8	0.02	2.4	0.72		93.1
4,Blue,0m	RL29	13/03/2003							
4,Blue,0m	RL29	01/04/2003	69	0	0.01	3	0.12	24	110
4,Blue,0m	RL29	16/04/2003	71	0.8	0	0.6	0.08	43	70
4,Blue,0m	RL29	29/04/2003	61	0	0	0	0.09	35	50
4,Blue,0m	RL29	15/05/2003							65
4,Blue,0m	RL29	23/05/2003	64	2.2	0.02	0.223	0.02	36.8	150
4,Blue,0m	RL29	06/06/2003	126	1.62	0.019	0.67			60
4,Blue,0m	RL29	20/06/2003	98	7.8	0.15	18	0.78	86	50
4,Blue,0m	RL29	01/07/2003	73	8.2	0.19	7.5	0.78	46	60
4,Blue,0m	RL29	15/07/2003	55.1	0	0.38	0.7	0.13	40	55

4,Black,0m	**RL30**	08/08/2002	42	<0.3	-	1.1	<0.1	29	
4,Black,0m	**RL30**	14/08/2002	85	<0.10	0.1	1.24	0.55	78	100
4,Black,0m	**RL30**	21/08/2002	60	<0.10	0.05	1.59	0.69	60	50
4,Black,0m	**RL30**	27/08/2002	103	1	<0.005	1.24	0.78	25	90
4,Black,0m	**RL30**	11/09/2002	140	1	0.03	0.34	0.55	21	70
4,Black,0m	**RL30**	25/09/2002	77	0.15	0.01	0.32	0.18	38	50
4,Black,0m	**RL30**	09/10/2002	74	2	0.08	9.1	1.64	37	40
4,Black,0m	**RL30**	17/10/2002							
4,Black,0m	**RL30**	23/10/2002	61	2	0.04	1.6		28.7	80
4,Black,0m	**RL30**	03/12/2002	77	0.3	0	1.9	0.1	39	
4,Black,0m	**RL30**	08/01/2003							
4,Black,0m	**RL30**	07/02/2003	86	2.1	0.01	0	0.21	37	50
4,Black,0m	**RL30**	20/02/2003	93	3.9	0.01	0	1.26	27	45
4,Black,0m	**RL30**	06/03/2003	50	4	0	0.9	0.76		46.2
4,Black,0m	**RL30**	13/03/2003							
4,Black,0m	**RL30**	01/04/2003							
4,Black,0m	**RL30**	16/04/2003		2.9	0.03	1.3	1.67	46	30
4,Black,0m	**RL30**	29/04/2003	24	2.6	0.01	0.3	0.1	26	40
4,Black,0m	**RL30**	15/05/2003							40
4,Black,0m	**RL30**	23/05/2003	50	4	0.044	0.9367	0	37.4	70
4,Black,0m	**RL30**	06/06/2003	86	4.70	0.329	2.31			30
4,Black,0m	**RL30**	20/06/2003	95	10.3	0.25	17	0.73	58	90
4,Black,0m	**RL30**	01/07/2003	63	8.3	0.17	8.3	0.98	56	40
4,Black,0m	**RL30**	15/07/2003	50.1	2.2	0.02	2.5	0.1	34	60
4,Red,10m	**RL31**	08/08/2002	84.1	<0.3	-	29.7	4.8	37	
4,Red,10m	**RL31**	14/08/2002	74	0.8	<0.005	0.98	4.84	75	500
4,Red,10m	**RL31**	21/08/2002	99	<0.10	<0.005	12.7	5.05	70	590
4,Red,10m	**RL31**	27/08/2002	165	<0.10	<0.005	>15	7.5	42	500
4,Red,10m	**RL31**	11/09/2002	140	<0.10	0.022	38.1	9.13	45	820
4,Red,10m	**RL31**	25/09/2002							
4,Red,10m	**RL31**	09/10/2002	121	0.2	0.02	68.4	10.72	39	810
4,Red,10m	**RL31**	17/10/2002							
4,Red,10m	**RL31**	23/10/2002	74	1.5	0	30.8		20.1	1020
4,Red,10m	**RL31**	03/12/2002	49	3.5	0.24	20.2	3.54	20	
4,Red,10m	**RL31**	08/01/2003	163	1.7	0.1	20.9	4.66	24	350
4,Red,10m	**RL31**	07/02/2003	71	0.6	0.4	21.1	2.79	24	660
4,Red,10m	**RL31**	20/02/2003	81	4.5	0.42	19.9	3.4	25	300
4,Red,10m	**RL31**	06/03/2003	20	2.1	0.59	23.1	1.11		210
4,Red,10m	**RL31**	13/03/2003							
4,Red,10m	**RL31**	01/04/2003							
4,Red,10m	**RL31**	16/04/2003	63	9.9	0.65	21.2	1.98	61	530
4,Red,10m	**RL31**	29/04/2003	37	2.2	0.08	26.3	3.22	45	460
4,Red,10m	**RL31**	15/05/2003							570
4,Red,10m	**RL31**	23/05/2003	50	3.8	0.115	25.2	5.04	36.8	400
4,Red,10m	**RL31**	06/06/2003							
4,Red,10m	**RL31**	20/06/2003	72	14.5	0.54	31	2.28	63	500
4,Red,10m	**RL31**	01/07/2003	97	9.2	0.24	28.4	4.42	61	500
4,Red,10m	**RL31**	15/07/2003	106	0	0.13	17.7	7.2	31	640

4,Blue,10m	**RL32**	08/08/2002	75.2	<0.3	-	12.4	<0.1	38	
4,Blue,10m	**RL32**	14/08/2002	303	4.3	0.81	1.97	1.25	85	540
4,Blue,10m	**RL32**	21/08/2002	73	<0.10	<0.005	4.01	1.34	70	580
4,Blue,10m	**RL32**	27/08/2002	139	<0.10	<0.005	16.05	2.34	41	500
4,Blue,10m	**RL32**	11/09/2002	115	<0.10	<0.005	30.4	2.31	35	590
4,Blue,10m	**RL32**	25/09/2002	166	<0.10	0.03	41..2	2.27	45	500
4,Blue,10m	**RL32**	09/10/2002	137	0	0.05	40.2	2.72	45	620
4,Blue,10m	**RL32**	17/10/2002							
4,Blue,10m	**RL32**	23/10/2002	58	3.2	0.01	32.5		26.3	
4,Blue,10m	**RL32**	03/12/2002	57	4.4	1.96	22.2	1.58	15	
4,Blue,10m	**RL32**	08/01/2003	82	9.8	2.04	10.4	2.35	23	610
4,Blue,10m	**RL32**	07/02/2003	85	0.9	0.02	22.4	2.7	25	620
4,Blue,10m	**RL32**	20/02/2003	71	2.8	0.14	21.6	2.8	35	760
4,Blue,10m	**RL32**	06/03/2003	47	0	1.01	21.8	0.98		262.5
4,Blue,10m	**RL32**	13/03/2003							
4,Blue,10m	**RL32**	01/04/2003	43	5.7	0.25	16	0.48	22	210
4,Blue,10m	**RL32**	16/04/2003	58	11.9	0.55	16.7	0.31	57	400
4,Blue,10m	**RL32**	29/04/2003	35	0.7	0.21	19.7	1.21	46	370
4,Blue,10m	**RL32**	15/05/2003							470
4,Blue,10m	**RL32**	23/05/2003	46	3	0.043	24	3.34	49.3	280
4,Blue,10m	**RL32**	06/06/2003	145		0.12	15.1			130
4,Blue,10m	**RL32**	20/06/2003	52	19.8	0.7	32	1.1	88	490
4,Blue,10m	**RL32**	01/07/2003	39.6	10	0.33	22.9	1.71	70	370
4,Blue,10m	**RL32**	15/07/2003	150	0	0.17	14.1	3.7	37	500
4,Black,10m	**RL33**	08/08/2002							
4,Black,10m	**RL33**	14/08/2002	236	1.1	0.27	0.3	2.23	77	1000
4,Black,10m	**RL33**	21/08/2002	123	<0.10	<0.005	5.69	2.3	71	1000
4,Black,10m	**RL33**	27/08/2002	154	<0.10	<0.005	>15	3.16	46	810
4,Black,10m	**RL33**	11/09/2002	78	<0.10	<0.005	37.3	3.96	44	700
4,Black,10m	**RL33**	25/09/2002	159	<0.10	<0.005	27.1	4.06	59	1270
4,Black,10m	**RL33**	09/10/2002	126	1.6	0	64.5	8.8	49	1120
4,Black,10m	**RL33**	17/10/2002							
4,Black,10m	**RL33**	23/10/2002	87	0.4	0.07	43.8		29.1	1070
4,Black,10m	**RL33**	03/12/2002	60	0.4	0.32	31.5	3.41	21	
4,Black,10m	**RL33**	08/01/2003	92	1.5	0.21	23.3	3.24	26	1340
4,Black,10m	**RL33**	07/02/2003	78	0	0.02	25.6	3.8	27	1230
4,Black,10m	**RL33**	20/02/2003	68	1.9	0.54	17.6	2.23	31	360
4,Black,10m	**RL33**	06/03/2003	29	0.1	0.59	24.3	2.06		630
4,Black,10m	**RL33**	13/03/2003							
4,Black,10m	**RL33**	01/04/2003	34	0	0.02	26	2.96	23	710
4,Black,10m	**RL33**	16/04/2003	74	0	0.05	23.5	1.86	62	640
4,Black,10m	**RL33**	29/04/2003	72	0	0.01	30.5	3.07	53	530
4,Black,10m	**RL33**	15/05/2003							650
4,Black,10m	**RL33**	23/05/2003	84	1.7	0.04	37.4	4.81	49.5	400
4,Black,10m	**RL33**	06/06/2003	137	0.34	0.054	35.7			380
4,Black,10m	**RL33**	20/06/2003	101	10.9	0.23	54	0.91	71	760
4,Black,10m	**RL33**	01/07/2003	72	7.4	0.19	34.6	4.04	80	620
4,Black,10m	**RL33**	15/07/2003	144	0	0.09	24	6.8	40	770

4,Red,20m	**RL34**	08/08/2002	13.1	13.6	-	0.4	0.3	11	
4,Red,20m	**RL34**	14/08/2002	147	<0.10	<0.005	0.25	0.53	36	160
4,Red,20m	**RL34**	21/08/2002							
4,Red,20m	**RL34**	27/08/2002	57	10.8	<0.005	0.99	0.7		17
4,Red,20m	**RL34**	11/09/2002							
4,Red,20m	**RL34**	25/09/2002							
4,Red,20m	**RL34**	09/10/2002	79	10.4	0.26	11.4	1.63	32	150
4,Red,20m	**RL34**	17/10/2002							
4,Red,20m	**RL34**	23/10/2002	41	1.7	0.41	7.4		20.6	680
4,Red,20m	**RL34**	03/12/2002	61	9.3	0.53	3.5	1.21	14	
4,Red,20m	**RL34**	08/01/2003	64	14.8	0.08	1.3	1.8	12	35
4,Red,20m	**RL34**	07/02/2003	86	23.6	0.08	2.1	0.89	11.5	30
4,Red,20m	**RL34**	20/02/2003							
4,Red,20m	**RL34**	06/03/2003	25	21	0.03	2.1	3.76		60
4,Red,20m	**RL34**	13/03/2003							
4,Red,20m	**RL34**	01/04/2003							
4,Red,20m	**RL34**	16/04/2003							
4,Red,20m	**RL34**	29/04/2003							
4,Red,20m	**RL34**	15/05/2003							60
4,Red,20m	**RL34**	23/05/2003	18	14.1	0.052	0.72	0.37	14.4	80
4,Red,20m	**RL34**	06/06/2003	72	2.71	0.277	1.52			20
4,Red,20m	**RL34**	20/06/2003	26	15.7	0.37	15	0.92	39	80
4,Red,20m	**RL34**	01/07/2003	42.8	13.3	0.18	9.3	1.72	31	140
4,Red,20m	**RL34**	15/07/2003	24.5	5.1	0.03	0	0.88	6	90
4,Blue,20m	**RL35**	08/08/2002	20.3	15.4	-	0.4	0.4	10	
4,Blue,20m	**RL35**	14/08/2002	96	11.5	<0.005	0.36	0.65	33	380
4,Blue,20m	**RL35**	21/08/2002							
4,Blue,20m	**RL35**	27/08/2002							
4,Blue,20m	**RL35**	11/09/2002							
4,Blue,20m	**RL35**	25/09/2002							
4,Blue,20m	**RL35**	09/10/2002	66	11.3	0.94	7.3	1.14	31	540
4,Blue,20m	**RL35**	17/10/2002							
4,Blue,20m	**RL35**	23/10/2002	43	3.3	0.67	10.4		20.2	1380
4,Blue,20m	**RL35**	03/12/2002	56	9.4	0.28	4.3	1.46	15	
4,Blue,20m	**RL35**	08/01/2003	96	9.6	0.5	1.1	1.32	87	420
4,Blue,20m	**RL35**	07/02/2003	55	5.2	0.1	1.3	1.01	5	80
4,Blue,20m	**RL35**	20/02/2003							
4,Blue,20m	**RL35**	06/03/2003	22	9.5	0.02	3.4	1.43		140
4,Blue,20m	**RL35**	13/03/2003							
4,Blue,20m	**RL35**	01/04/2003							
4,Blue,20m	**RL35**	16/04/2003							
4,Blue,20m	**RL35**	29/04/2003							
4,Blue,20m	**RL35**	15/05/2003							75
4,Blue,20m	**RL35**	23/05/2003	26	7.3	0.036	0.06	0.56	12.3	180
4,Blue,20m	**RL35**	06/06/2003							
4,Blue,20m	**RL35**	20/06/2003	83	14.1	0.19	20	1.25	37	50
4,Blue,20m	**RL35**	01/07/2003	28	9.2	0.23	11.2	1.69	20	440
4,Blue,20m	**RL35**	15/07/2003	33.2	5.6	0.01	0	2.09	15	100

4,Black,20m	**RL36**	08/08/2002							
4,Black,20m	**RL36**	14/08/2002	81	8.1	<0.005	0.31	1.2	35	140
4,Black,20m	**RL36**	21/08/2002							
4,Black,20m	**RL36**	27/08/2002							
4,Black,20m	**RL36**	11/09/2002							
4,Black,20m	**RL36**	25/09/2002							
4,Black,20m	**RL36**	09/10/2002	81	9.3	0.44	15.2	3.86	26	370
4,Black,20m	**RL36**	17/10/2002							
4,Black,20m	**RL36**	23/10/2002	49	3	0.55	11.8		19.7	1600
4,Black,20m	**RL36**	03/12/2002	61	17.5	0.41	1	1.46	9	
4,Black,20m	**RL36**	08/01/2003	76	10.5	0.44	2.3	1.92	13	110
4,Black,20m	**RL36**	07/02/2003							
4,Black,20m	**RL36**	20/02/2003							
4,Black,20m	**RL36**	06/03/2003	28	7.8	0.03	0.6	1.03		140
4,Black,20m	**RL36**	13/03/2003							
4,Black,20m	**RL36**	01/04/2003							
4,Black,20m	**RL36**	16/04/2003							
4,Black,20m	**RL36**	29/04/2003							
4,Black,20m	**RL36**	15/05/2003							65
4,Black,20m	**RL36**	23/05/2003	31	8.1	0.046	0	0.76	12.8	120
4,Black,20m	**RL36**	06/06/2003							
4,Black,20m	**RL36**	20/06/2003	50	19.1	0.24	19	1.36	40	30
4,Black,20m	**RL36**	01/07/2003	67	9	0.37	12	1.83	42	420
4,Black,20m	**RL36**	15/07/2003							

3, TS, 2m	**A**	08/08/2002	19.4	6.3	-	1.2	0.4	35	
3, TS, 2m	**A**	14/08/2002	81	1.6	<0.005	0.28	0.44	70	
3, TS, 2m	**A**	21/08/2002	33	3.6	0.05	1.37	0.65	69	65
3, TS, 2m	**A**	27/08/2002	115	5.9	0.03	0.18			20
3, TS, 2m	**A**	25/09/2002							
3, TS, 2m	**A**	09/10/2002	68	2.6	0.02	0.9	0.68	39	25
3, TS, 2m	**A**	23/10/2002	64	40.1	0.07	0.2		15.6	270
3, TS, 2m	**A**	03/12/2002	85	7.9	0.44	6.6	6.53	38	
3, TS, 2m	**A**	08/01/2003	95	0.8	0.03	9.5	0.22	29	120
3, TS, 2m	**A**	07/02/2003	97	0	0.34	8.4	0.13	25	200
3, TS, 2m	**A**	20/02/2003	92	0	0.06	11.3	0.26	33	450
3, TS, 2m	**A**	06/03/2003	66	0	0.01	21.8	1.08		402.5
3, TS, 2m	**A**	01/04/2003	44	0.8	0.03	22	0.65	26	360
3, TS, 2m	**A**	16/04/2003							
3, TS, 2m	**A**	29/04/2003	51	26.8	9	1.1	N/A	34	10
3, TS, 2m	**A**	23/05/2003	30	21	0.27	1.58	0.08	20.3	280
3, TS, 2m	**A**	06/06/2003							

3, TS, 7m	**B**	08/08/2002	46.4	1	-	0.5	0.5	3		
3, TS, 7m	**B**	14/08/2002	59	10.4	0.1	0.31	0.44	77	120	
3, TS, 7m	**B**	21/08/2002	45	4	0.07	1.07	1.2	68	160	
3, TS, 7m	**B**	27/08/2002	91	5.9	-	0.02			10	
3, TS, 7m	**B**	25/09/2002	72	0.1	-	0.25	0.41	44	25	
3, TS, 7m	**B**	09/10/2002	59	3.4	0.03	0.1	6.71	36	20	
3, TS, 7m	**B**	23/10/2002	41	13.9	1.52	1.6		21.2	200	
3, TS, 7m	**B**	03/12/2002	54	2.7	0.27	1.9	0.52	28		
3, TS, 7m	**B**	08/01/2003	77	0.8	0.2	7.3	0.23	33	90	
3, TS, 7m	**B**	07/02/2003	85	0	0.06	15.6	0.34	34	170	
3, TS, 7m	**B**	20/02/2003	90	0	0.02	14.2	0.58	23	300	
3, TS, 7m	**B**	06/03/2003	91	2.2	0.1	9.4	0.37		210	
3, TS, 7m	**B**	01/04/2003	18	5.9	0.14	2	0.2	29	40	
3, TS, 7m	**B**	16/04/2003	32	20.3	0.03	1.4	0.88	N/A	20	
3, TS, 7m	**B**	29/04/2003	40	25.8	0	1.2	1.19	32	15	
3, TS, 7m	**B**	23/05/2003	21	20.77	0.021	0.005	0.03	40	35	
3, TS, 7m	**B**	06/06/2003	69						90	

3, TS, 15m	**C**	08/08/2002	28.4	23.2	-	0.4	0.5	34	
3, TS, 15m	**C**	14/08/2002	75	32.9	0.93	0.47	1.14	70	120
3, TS, 15m	**C**	21/08/2002	49	17.6	<0.005	1.07	0.73	64	60
3, TS, 15m	**C**	27/08/2002	85	36	<0.005	0.18	0.38	31	50
3, TS, 15m	**C**	25/09/2002	127	3.9	<0.005	1.15	0.17	39	65
3, TS, 15m	**C**	09/10/2002	56	15	0.42	0.8	1.22	38	300
3, TS, 15m	**C**	23/10/2002	22	34	0.61	1.3		23.2	370
3, TS, 15m	**C**	03/12/2002	53	3.3	0.19	1.6	1.07	29	
3, TS, 15m	**C**	08/01/2003	72	0.2	0.04	4.5	0.38	28	80
3, TS, 15m	**C**	07/02/2003	52	0	0	1.9	0.35	23	150
3, TS, 15m	**C**	20/02/2003	82	2.4	0.08	0.4	0.46	26	270
3, TS, 15m	**C**	06/03/2003	29	0	0.21	1.3	0.96		280
3, TS, 15m	**C**	01/04/2003	50	3.3	0.03	2	0.16	27	180
3, TS, 15m	**C**	16/04/2003	35	5.2	0.21	2.7	0.21	47	330
3, TS, 15m	**C**	29/04/2003	8	16.5	0	0.9	0.57	0	140
3, TS, 15m	**C**	23/05/2003	34	13.5	0.143	0.523	0.12	46.6	400
3, TS, 15m	**C**	06/06/2003	15						60

4, TS, 2m	**D**	08/08/2002	21.3	0.6	-	1.1	0.3	32	
4, TS, 2m	**D**	14/08/2002	62	9.3	<0.005	0.37		72	160
4, TS, 2m	**D**	21/08/2002	47	0.3	0.16	1.13	1.06	66	50
4, TS, 2m	**D**	27/08/2002	81	0.8	0.26	0.17	0.76	34	120
4, TS, 2m	**D**	25/09/2002	110	<0.10	0.14	0.11	0.06	42	75
4, TS, 2m	**D**	09/10/2002	50	2.1	0.06	0	0.46	25	110
4, TS, 2m	**D**	23/10/2002	66	3	0.11	2		27.4	320
4, TS, 2m	**D**	03/12/2002	50	2.8	0.11	1.2	1.32	20	
4, TS, 2m	**D**	08/01/2003	55	0.7	0.01	1.9	0.05	22	35
4, TS, 2m	**D**	07/02/2003	47	0	0.01	0.6	0.22	21	100
4, TS, 2m	**D**	20/02/2003	77	1.1	0	1.5	0.76	21	130
4, TS, 2m	**D**	06/03/2003	23	0	0.03	2.8	0.21		140
4, TS, 2m	**D**	01/04/2003	49	3	0	5	0.21	25	20
4, TS, 2m	**D**	16/04/2003	33	1.5	0.01	1.9	0.14	44	100
4, TS, 2m	**D**	29/04/2003	30	1.2	0.01	2	0.14	32	70
4, TS, 2m	**D**	23/05/2003	26	7.2	0.042	1.553	0	40.7	100
4, TS, 2m	**D**	06/06/2003	23						70

4, TS, 7m	**E**	08/08/2002	12.4	24.8	-	0.4	0.3	28	
4, TS, 7m	**E**	14/08/2002	88	3.1	0.42	0.36	1.75	69	100
4, TS, 7m	**E**	21/08/2002	49	0.2	<0.005	1.49	0.94	70	230
4, TS, 7m	**E**	27/08/2002	155	1.2	0.38	1.64	0.54	39	120
4, TS, 7m	**E**	25/09/2002	137	1.5	0.1	0.43	0.14	36	75
4, TS, 7m	**E**	09/10/2002	91	1.5	0.65	8.8	6.59	28	110
4, TS, 7m	**E**	23/10/2002	39	52.7	0.07	2.9		21	
4, TS, 7m	**E**	03/12/2002	55	14.5	0.01	0.3	0.17	11	
4, TS, 7m	**E**	08/01/2003	47	1.7	0	0.8	2.09	11	0
4, TS, 7m	**E**	07/02/2003	48	13.4	0	0.1	0.11	10.5	70
4, TS, 7m	**E**	20/02/2003	71	15.7	0.04	0.2	0.31	18	80
4, TS, 7m	**E**	06/03/2003	26	10.8	0.02	1.6	0.59		140
4, TS, 7m	**E**	01/04/2003	37	22.8	0.01	2	0.2	18	70
4, TS, 7m	**E**	16/04/2003	26	31	0.11	1.9	0.01	45	270
4, TS, 7m	**E**	29/04/2003	15	10.5	0.15	1.1	0.15	41	180
4, TS, 7m	**E**	23/05/2003	24	9.1	0.01	0.135	0	26	340
4, TS, 7m	**E**	06/06/2003	176						60

Small ZT		07/02/2003	92	0	0.01	0.7	0.57	22	120
		20/02/2003					5.32		30
		06/03/2003					0.78		20
		01/04/2003	92	0	0.02	3	0.11	0	85
		06/06/2003					0.02		100
Big ZT		07/02/2003	79	0	0	0.5	0.72	6	200
		20/02/2003					6.08		0
		06/03/2003					1.44		35
		01/04/2003							
		06/06/2003					0.07		100

Site 1 – Microbiological Analysis

TRENCHES

Bacteria (cfu/100ml)		**RLX**	**RL19**	**RL20**	**RL21**	**RL22**	**RL23**	**RL24**	**RL25**	**RL26**	**RL27**
Total Coliforms	*17/10/2002*	**3600000**	20000	660000		42000	240000	530000			3100000
	13/03/2003	**663000**	<100		<100	630		780000	<100		200
	15/05/2003	**>241920**	12		88	2			70	2	<1
	13/08/2003	**>2419200**	1223000	13000	990	1986300	15530	8160	660	2220	<20
E.Coli	*17/10/2002*	**530 000**	<10	<10		<10	310	150000			42000
	13/03/2003	**189000**	<100		<100	<100		282000	<100		100
	15/05/2003	**120330**	<2		<4	<2			<2	<1	<1
	13/08/2003	**1986300**	<10	<10	<10	<10	<10	<10	<10	10	<10
Faecal Streptococci	*17/10/2002*	**1300**	1780	<10		<10	<10	100			<100
	13/03/2003	**26020**	<100		200	<100		1890	<100		<100
	15/05/2003	**8390**	<2		<4	<2			<2	<1	<1
	13/08/2003										
Faecal Coliforms	*13/08/2003*	**1732900**	<10	<10	<10	<10	<10	<10	<10	10	<10
Enterococci	*13/08/2003*	**19200**	<20	<20	<20	<20	<20	<20	<20	<20	<20

Bacteria (cfu/100ml)		**RLX**	**RL10**	**RL11**	**RL12**	**RL13**	**RL14**	**RL15**	**RL16**	**RL17**	**RL18**
Total Coliforms	*13/08/2003*	**>2419200**	580	<10	2140	250	960	122000	>2419200	12030	930
E.Coli	*13/08/2003*	**1986300**	<10	<10	<10	<10	<10	10	<10	<10	<10
Faecal Coliforms	*13/08/2003*	**1732900**	<10	<10	<10	<10	<10	30	<10	<10	<10
Enterococci	*13/08/2003*	**19200**	<20	<20	<20	<20	<20	<20	<20	<20	<20

Site 2 – Chemical Analysis

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	pH
Puraflo	JKY	15/08/2002	98	44.0	3	12.21	>5	185	
	JKY	22/08/2002	189	51.0	2.84	6.85	26	90	
	JKY	27/08/2002	102	29.8	5.8	14.1	>80	106	
	JHY	12/09/2002	188	43.0	7.1	17.4	19.8	100	
	JKY	26/09/2002	264	77.5	>1	19.8	67.4	92	
	JKY	10/10/2002	224	48.5	10.7	22.6	41.9	51.3	
	JHY	17/10/2002	192	54.6	13.6	45.2	23.7	74	
	JKY	24/10/2002	164	44.7	*0.04	3.59	85.6	77	
	JKY	21/01/2003	122						
	JHY	31/01/2003	128	23.0	4.5	15.5	16.8	152	6.49
	JKY	14/02/2003	172	32.8	8.2	25.2	24.8	92	6.22
	JKY	27/02/2003	150	39.8	>10	34	20.8	86	6.36
	JHY	13/03/2003	190	45.8	10	35.8	23.6	70	3.94
	JKY	11/04/2003	136	40.7	11.1	11.1	21.92	103	6.29
	JKY	23/04/2003	144	34.8	10.1	34	26.64	88	6.41
	JHY	07/05/2003	210			8.2			6.27
	JKY	29/05/2003	226	60.5	12.24	18	35.3	85.1	6.07
	JKY	10/06/2003	260	22.7	3.88	15.5	38.9	81.5	6.4
	JHY	25/06/2003	316	17.1	4.87	13.4	42.7	87	7.61
	JKY	09/07/2003	243	21.9	4.1	10.1	27.6	86	
	JKY	22/07/2003	283	15.3	0.78	18.6	32.8	62	7.49

Septic Tank	JKX	15/08/2002	576	3.9	0.31	>20	>5	290	
	JKX	22/08/2002	484	0.6	0.2	61.5	19.26	117	
	JKX	27/08/2002	524	0.4	0.22	155.1	46.8	125	
	JKX	12/09/2002	696	0.9	0.22	124.4	26.4	123	
	JKX	26/09/2002	842	1.5	0.21	>75	61.9	106	
	JKX	10/10/2002	758	0.3	0.27	142.4	23.6	74.1	
	JKX	24/10/2002	612	1.8	0.23	51.6	55.6	114	
	JKX	21/01/2003	782						
	JKX	31/01/2003	752	0	0.39	118	21.3	124	8.12
	JKX	14/02/2003	696	0.2	0.33	129.2	20.7	123	8.39
	JKX	27/02/2003	776	1.4	0.4	128	25.5	117	7.56
	JKX	11/04/2003	594	0	0.26	119	20.76	98	7.93
	JKX	23/04/2003	560	0.2	0.25	117	22.32	95	8.09
	JKX	07/05/2003	610			87			8.12
	JKX	29/05/2003	533	4.7	0.205	137.8	33.5	96.2	7.72
	JKX	10/06/2003	916	5.3	0.257	144	43.9	98.3	7.65
	JKX	25/06/2003	1630	0.9	0.42	155.2	38.7	97	7.3
	JKX	09/07/2003	1453	1.3	0.4	98.8	31.7	107	
	JKX	22/07/2003	1329	1.6	0.4	109	27.3	90	7.46

TRENCH 1

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	VOL
1,Red,0m	JK1	09/08/2002	30	>35	0.03	0.1	22	96	100
1,Red,0m	JK1	15/08/2002	71	18	0.89	1.86	>5	185	240
1,Red,0m	JK1	22/08/2002	92	77.6	1.92	4.19	13.44	90	420
1,Red,0m	JK1	27/08/2002	118	70.2	1.4	9.6	19.8	95	290
1,Red,0m	JK1	12/09/2002	139	57.5	4.3	12.4	25.2	93	170
1,Red,0m	JK1	26/09/2002	168	74.5	>1	14.44	64.5	71	310
1,Red,0m	JK1	10/10/2002	153	56	9.4	21.2	57.2	56.2	320
1,Red,0m	JK1	17/10/2002							
1,Red,0m	JK1	24/10/2002	97	50.2	0.04	15.5	38.8	69	300
1,Red,0m	JK1	28/11/2002							
1,Red,0m	JK1	21/01/2003	124						
1,Red,0m	JK1	31/01/2003	79	42.7	6.9	13.2	15.4	214	150
1,Red,0m	JK1	14/02/2003	113	46.5	9.9	13.2	18.1	102	150
1,Red,0m	JK1	27/02/2003	132	42.5	8.5	17	25.6	94	180
1,Red,0m	JK1	13/03/2003							
1,Red,0m	JK1	11/04/2003		47.4	14.8	12.4	22	79	110
1,Red,0m	JK1	23/04/2003	151	43.6	14.7	21	21.52	97	100
1,Red,0m	JK1	07/05/2003	128			7.5			100
1,Red,0m	JK1	29/05/2003	193	69.1	11.38	7.58	20	81	70
1,Red,0m	JK1	10/06/2003	164	41.5	7.04	5.7	21.6	76.1	190
1,Red,0m	JK1	25/06/2003	186	37.9	10	14.3	27.5	104	190
1,Red,0m	JK1	09/07/2003	249	32.3	8	11.4	25.4	98	160
1,Red,0m	JK1	22/07/2003	155	33.5	0.3	1	17.6	65	110
1,Blue,0m	JK2	09/08/2002							
1,Blue,0m	JK2	15/08/2002	57	79.6	0.17	0.56	0.58	184	260
1,Blue,0m	JK2	22/08/2002	57	76.6	<0.005	0.08	5.7	89	360
1,Blue,0m	JK2	27/08/2002	53	103.6	0.03	9.4	12.88	98	220
1,Blue,0m	JK2	12/09/2002	84	40.3	0.07	<0.01	15.05	95	360
1,Blue,0m	JK2	26/09/2002	52	100	0	0.68	49.4	74	170
1,Blue,0m	JK2	10/10/2002	72	108	0	0.15	39.5	53.2	200
1,Blue,0m	JK2	17/10/2002							
1,Blue,0m	JK2	24/10/2002	48	66.8	0.59	0.78	19.4	67	170
1,Blue,0m	JK2	28/11/2002							
1,Blue,0m	JK2	21/01/2003	80						
1,Blue,0m	JK2	31/01/2003							
1,Blue,0m	JK2	14/02/2003	158	59.5	0.01	0.15	8.2	77	120
1,Blue,0m	JK2	27/02/2003	95	58.3	0.12	8	17.8	84	110
1,Blue,0m	JK2	13/03/2003							
1,Blue,0m	JK2	11/04/2003		61.6	0.18	1.1	16.68	88	120
1,Blue,0m	JK2	23/04/2003	67	51	0.7	2	21.6	101	100
1,Blue,0m	JK2	07/05/2003	63			0.7			140
1,Blue,0m	JK2	29/05/2003	100	72.94	1.32	0.7	23.35	82.5	60
1,Blue,0m	JK2	10/06/2003	99	25.11	0.24	0.2	30.9	75	190
1,Blue,0m	JK2	25/06/2003	131	27.6	0.34	10	33.9	115	130
1,Blue,0m	JK2	09/07/2003	123	38.5	2.6	8.5	26	105	220
1,Blue,0m	JK2	22/07/2003	59	32.6	2	0	19.6	63	110

1,Black,0m	**JK3**	09/08/2002							
1,Black,0m	**JK3**	15/08/2002							
1,Black,0m	**JK3**	22/08/2002							
1,Black,0m	**JK3**	27/08/2002							
1,Black,0m	**JK3**	12/09/2002	92	55	3.6	<0.01	3.49	96	90
1,Black,0m	**JK3**	26/09/2002	62	82.5	>1	>3	-	78	20
1,Black,0m	**JK3**	10/10/2002							
1,Black,0m	**JK3**	17/10/2002							
1,Black,0m	**JK3**	24/10/2002	61	-	2.92	0.9	-	-	30
1,Black,0m	**JK3**	28/11/2002							
1,Black,0m	**JK3**	21/01/2003							
1,Black,0m	**JK3**	31/01/2003							
1,Black,0m	**JK3**	14/02/2003							
1,Black,0m	**JK3**	27/02/2003							
1,Black,0m	**JK3**	13/03/2003							
1,Black,0m	**JK3**	11/04/2003							
1,Black,0m	**JK3**	23/04/2003							
1,Black,0m	**JK3**	07/05/2003							
1,Black,0m	**JK3**	29/05/2003	61	86.03	0.2	0.045	7.75	77.5	60
1,Black,0m	**JK3**	10/06/2003	96	63.59	0.28	0.1	6.1	76.1	100
1,Black,0m	**JK3**	25/06/2003	61	57.4	0.37	7.8	16.5	140	80
1,Black,0m	**JK3**	09/07/2003	37	46	2.8	8.6	8.7	108	80
1,Black,0m	**JK3**	22/07/2003	42	42.4	0.2	0	8.2	62	65
1,Red,10m	**JK4**	09/08/2002							
1,Red,10m	**JK4**	15/08/2002							
1,Red,10m	**JK4**	22/08/2002	58	43	-	0.29	8.18	-	20
1,Red,10m	**JK4**	27/08/2002	71	12	<0.005	0.58	>5	10	50
1,Red,10m	**JK4**	12/09/2002							
1,Red,10m	**JK4**	26/09/2002							
1,Red,10m	**JK4**	10/10/2002							
1,Red,10m	**JK4**	17/10/2002							
1,Red,10m	**JK4**	24/10/2002	46	50.8	0.24	0.37	-	13	440
1,Red,10m	**JK4**	28/11/2002							
1,Red,10m	**JK4**	21/01/2003	37						
1,Red,10m	**JK4**	31/01/2003	29	0.1	0	0.14	0.29	0	390
1,Red,10m	**JK4**	14/02/2003	35	2.9	0.01	0.01	0	0	310
1,Red,10m	**JK4**	27/02/2003	49	3.9	0.02	0.5	0.6	0	240
1,Red,10m	**JK4**	13/03/2003							
1,Red,10m	**JK4**	11/04/2003		0	0	0.7	0.17	0	130
1,Red,10m	**JK4**	23/04/2003	33	1.2	0	0	0.39	0	70
1,Red,10m	**JK4**	07/05/2003	13			0			140
1,Red,10m	**JK4**	29/05/2003	47	3.3	0.01	0	0.03	1.07	170
1,Red,10m	**JK4**	10/06/2003	40	4.2	0.007	0.012	0.04	0.9	240
1,Red,10m	**JK4**	25/06/2003	37	7.9	0.11	8.9	1.29	36	160
1,Red,10m	**JK4**	09/07/2003	5	7.2	0.16	8.7	1.5	36	110
1,Red,10m	**JK4**	22/07/2003	19	1	0.04	0	0.1	0	70

1,Blue,10m	**JK5**	09/08/2002	6	17.4	<0.005	0.53	11.76	35	200
1,Blue,10m	**JK5**	15/08/2002	42	11	0.11	0.3	0.48	57	110
1,Blue,10m	**JK5**	22/08/2002	47	8.6	<0.005	<0.01	2.46	89	130
1,Blue,10m	**JK5**	27/08/2002	104	7.8	<0.005	0.41	2.4	11	150
1,Blue,10m	**JK5**	12/09/2002	58	2.9	<0.005	<0.01	0.58	28	150
1,Blue,10m	**JK5**	26/09/2002	43	9.5	<0.02	0.13	7.82	3	70
1,Blue,10m	**JK5**	10/10/2002	61	11.5	0	0.4	10.5	22.2	70
1,Blue,10m	**JK5**	17/10/2002							
1,Blue,10m	**JK5**	24/10/2002	20	6.9	0	0.13	26.2	0	160
1,Blue,10m	**JK5**	28/11/2002							
1,Blue,10m	**JK5**	21/01/2003	25						
1,Blue,10m	**JK5**	31/01/2003	28	0.1	0.1	0.13	1.22	17	230
1,Blue,10m	**JK5**	14/02/2003	37	0.1	0	0.03	0.06	0	150
1,Blue,10m	**JK5**	27/02/2003	56	4.7	0.02	0.1	0.37	0	160
1,Blue,10m	**JK5**	13/03/2003							
1,Blue,10m	**JK5**	11/04/2003		0	0	0.1	0.26	0	80
1,Blue,10m	**JK5**	23/04/2003	23	0.5	0	0	0.73	0	70
1,Blue,10m	**JK5**	07/05/2003	17			0			60
1,Blue,10m	**JK5**	29/05/2003	45	2	0.014	0	0	1.52	170
1,Blue,10m	**JK5**	10/06/2003	50	9.4	0.008	0.013	0.01	3.7	210
1,Blue,10m	**JK5**	25/06/2003	38	9.2	0.12	10.2	1.03	30	170
1,Blue,10m	**JK5**	09/07/2003	10.2	8.1	0.11	8.8	0.66	35	140
1,Blue,10m	**JK5**	22/07/2003	12	2.6	0	0	0	0	130
1,Black,10m	**JK6**	09/08/2002							
1,Black,10m	**JK6**	15/08/2002	35	4.7	0.13	0.32	0.74	45	67
1,Black,10m	**JK6**	22/08/2002	38	3.7	<0.005	<0.01	4.88	4	70
1,Black,10m	**JK6**	27/08/2002	47	<0.1	<0.005	0.36	1.73	7	70
1,Black,10m	**JK6**	12/09/2002	65	0.8	<0.005	0.2	0.15	16	70
1,Black,10m	**JK6**	26/09/2002	60	4.3	<0.02	0.1	0.32	<10	60
1,Black,10m	**JK6**	10/10/2002	48	1.1	0	0.57	3.27	11.2	30
1,Black,10m	**JK6**	17/10/2002							
1,Black,10m	**JK6**	24/10/2002	25	2.4	0.01	0.27	13.8	0	30
1,Black,10m	**JK6**	28/11/2002							
1,Black,10m	**JK6**	21/01/2003	23						
1,Black,10m	**JK6**	31/01/2003	16	0	0.01	0.09	2.61	9	110
1,Black,10m	**JK6**	14/02/2003	53	1	0	0.28	0.13	3	70
1,Black,10m	**JK6**	27/02/2003	68	2.5	0.07	3.6	0.62	1	65
1,Black,10m	**JK6**	13/03/2003							
1,Black,10m	**JK6**	11/04/2003		0	0.01	0	0.47	0	30
1,Black,10m	**JK6**	23/04/2003	28	2.1	0	1	1.43	0	30
1,Black,10m	**JK6**	07/05/2003							
1,Black,10m	**JK6**	29/05/2003	47	2.4	0.01	0	0.05	3.7	120
1,Black,10m	**JK6**	10/06/2003	44	4	0.008	0	0.04	4.4	150
1,Black,10m	**JK6**	25/06/2003	45	7.8	0.11	8.4	0.78	38	130
1,Black,10m	**JK6**	09/07/2003	14.1	7.2	0.11	8.6	0.69	28	80
1,Black,10m	**JK6**	22/07/2003	12	1.2	0.03	0.2	0	0	100

1,Red,20m	**JK7**	09/08/2002	8	25	<0.005	0.33	3.55	38	380
1,Red,20m	**JK7**	15/08/2002	39	6.3	0.11	0.28	0.39	38	440
1,Red,20m	**JK7**	22/08/2002	43	12.4	<0.005	<0.01	3.94	4	460
1,Red,20m	**JK7**	27/08/2002	68	9.2	<0.005	0.34	1.91	5	380
1,Red,20m	**JK7**	12/09/2002	63	9	<0.005	0.7	1.65	13	100
1,Red,20m	**JK7**	26/09/2002	35	8.7	<0.02	0.13	1.4	<10	300
1,Red,20m	**JK7**	10/10/2002	35	8.2	0	0.42	1.1	6.5	220
1,Red,20m	**JK7**	17/10/2002							
1,Red,20m	**JK7**	24/10/2002	<10	6.1	0.01	0.36	0.33	0	330
1,Red,20m	**JK7**	28/11/2002							
1,Red,20m	**JK7**	21/01/2003	8						
1,Red,20m	**JK7**	31/01/2003	28	0	0	0.03	0.37	4	550
1,Red,20m	**JK7**	14/02/2003	48	0	0.02	0.02	0.08	0	470
1,Red,20m	**JK7**	27/02/2003	62	2.3	0.02	1.2	0.64	0	400
1,Red,20m	**JK7**	13/03/2003							
1,Red,20m	**JK7**	11/04/2003		0	0	0	1.12	0	290
1,Red,20m	**JK7**	23/04/2003	23	0	0	1	0.37	0	310
1,Red,20m	**JK7**	07/05/2003	10			0			360
1,Red,20m	**JK7**	29/05/2003	49	0.2	0.01	0	0	1.1	270
1,Red,20m	**JK7**	10/06/2003	49	1.5	0.01	0	0	0.7	500
1,Red,20m	**JK7**	25/06/2003	38	7.3	0.11	0.43	0.98	33	380
1,Red,20m	**JK7**	09/07/2003	13.3	6.1	0.14	10.6	1.27	29	400
1,Red,20m	**JK7**	22/07/2003	18	0	0	0	0.06	0	330
1,Blue,20m	**JK8**	09/08/2002	6	9	<0.005	0.3	1.59	34	50
1,Blue,20m	**JK8**	15/08/2002	57	6.4	0.12	0.27	0.43	36	65
1,Blue,20m	**JK8**	22/08/2002	56	6.5	<0.005	<0.01	4.82	2	80
1,Blue,20m	**JK8**	27/08/2002	61	3	<0.005	0.78	2.49	4	110
1,Blue,20m	**JK8**	12/09/2002	62	3.2	<0.005	<0.01	0.36	9	460
1,Blue,20m	**JK8**	26/09/2002	49	7.8	0.02	0.21	1.43	<10	65
1,Blue,20m	**JK8**	10/10/2002	55	5.2	0	0.27	6.06	8.4	50
1,Blue,20m	**JK8**	17/10/2002							
1,Blue,20m	**JK8**	24/10/2002	10	7.2	0	0	0.19	0	90
1,Blue,20m	**JK8**	28/11/2002							
1,Blue,20m	**JK8**	21/01/2003	14						
1,Blue,20m	**JK8**	31/01/2003	33	0.7	0	0.1	0.31	0	100
1,Blue,20m	**JK8**	14/02/2003	46	1	0.01	0.02	0	0	70
1,Blue,20m	**JK8**	27/02/2003	52	1.8	0.03	0	0.36	0	70
1,Blue,20m	**JK8**	13/03/2003							
1,Blue,20m	**JK8**	11/04/2003							
1,Blue,20m	**JK8**	23/04/2003	26	0	0	0	5.1	0	35
1,Blue,20m	**JK8**	07/05/2003	28			0			20
1,Blue,20m	**JK8**	29/05/2003	46	0.35	0.012	0	0	1.56	60
1,Blue,20m	**JK8**	10/06/2003	37	2.1	0.008	0.007	0	0.45	170
1,Blue,20m	**JK8**	25/06/2003	44	7.3	0.13	8.5	1.39	32	170
1,Blue,20m	**JK8**	09/07/2003	11.7	6.2	0.15	8.7	0.7	33	150
1,Blue,20m	**JK8**	22/07/2003	11	0.2	0	0	0	0	110

1,Black,20m	**JK9**	09/08/2002	8	8.1	<0.005	0.55	13.76	34	150
1,Black,20m	**JK9**	15/08/2002	45	4.6	0.1	0.29	0.43	37	170
1,Black,20m	**JK9**	22/08/2002	38	6.8	<0.005	<0.01	1.36	3	180
1,Black,20m	**JK9**	27/08/2002		3.1	<0.005	0.62	>5	6	200
1,Black,20m	**JK9**	12/09/2002	53	3.7	<0.005	<0.01	0.12	18	160
1,Black,20m	**JK9**	26/09/2002	35	5.7	<0.02	0.33	2.97	<10	90
1,Black,20m	**JK9**	10/10/2002	36	2.9	0	0	6.26	9.7	170
1,Black,20m	**JK9**	17/10/2002							
1,Black,20m	**JK9**	24/10/2002	17	5.6	0	0.05	16.4	0	160
1,Black,20m	**JK9**	28/11/2002							
1,Black,20m	**JK9**	21/01/2003	14						
1,Black,20m	**JK9**	31/01/2003	36	1.2	0.02	0.13	0.05	7	240
1,Black,20m	**JK9**	14/02/2003	44	0.6	0	0.05	0.19	0	180
1,Black,20m	**JK9**	27/02/2003	47	4.5	0.02	0.8	0.25	0	160
1,Black,20m	**JK9**	13/03/2003							
1,Black,20m	**JK9**	11/04/2003		0	0	0.5	0.03	0	80
1,Black,20m	**JK9**	23/04/2003	10	0	0	0	0.44	0	110
1,Black,20m	**JK9**	07/05/2003	10			0			100
1,Black,20m	**JK9**	29/05/2003	43	0.43	0.009	0.038	0.04	0.98	210
1,Black,20m	**JK9**	10/06/2003	46	3.2	0.026	0.694	0.1	0	250
1,Black,20m	**JK9**	25/06/2003	43	8	0.2	10.1	0.86	25	240
1,Black,20m	**JK9**	09/07/2003	14.4	7.3	0.24	8.9	1.3	25	120
1,Black,20m	**JK9**	22/07/2003	18	0.8	0	0	0	0	190

TRENCH 2

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	VOL
2,Red,0m	JK10	09/08/2002	55	36.2	0.1	0.5	16.76	30	200
2,Red,0m	JK10	15/08/2002	96	30	1.74	2.72	>5	195	370
2,Red,0m	JK10	22/08/2002	86	32.5	3.62	7.7	13.72	91	450
2,Red,0m	JK10	27/08/2002	86	88.8	2.16	4.51	>16	98	300
2,Red,0m	JK10	12/09/2002	102	78	1.3	<0.01	17.6	99	240
2,Red,0m	JK10	26/09/2002	101	105	>1	4.8	67.2	77	210
2,Red,0m	JK10	10/10/2002	116	56.7	7.9	24	57.5	55.1	250
2,Red,0m	JK10	17/10/2002	128	65.2	8.7	6.4	24.6	74	250
2,Red,0m	JK10	24/10/2002	119	56.8	0.12	25.5	38.4	63	300
2,Red,0m	JK10	28/11/2002							
2,Red,0m	JK10	21/01/2003	55						
2,Red,0m	JK10	31/01/2003	71	45.5	0.01	0.6	10.6	93	160
2,Red,0m	JK10	14/02/2003	65	68.4	0.24	0.43	11.3	89	130
2,Red,0m	JK10	27/02/2003	95	68.4	0.53	1	14.6	79	115
2,Red,0m	JK10	13/03/2003	45	65.4	0.01	1.8	19.4	100	240
2,Red,0m	JK10	11/04/2003		82.4	0	1.8	17.24	86	220
2,Red,0m	JK10	23/04/2003	64	54.4	0	0	25.44	92	140
2,Red,0m	JK10	07/05/2003	68			0			130
2,Red,0m	JK10	29/05/2003	101	73.16	0.16	0.069	23.15	75.5	70
2,Red,0m	JK10	10/06/2003	85	46.65	0.16	0.12	26.2	78.5	250
2,Red,0m	JK10	25/06/2003	94	39.6	0.13	7.5	33	125	220
2,Red,0m	JK10	09/07/2003	113	39.4	2.6	8.6	29.8	97	230
2,Red,0m	JK10	22/07/2003	153	24.2	0.15	0	25.4	67	190
2,Blue,0m	JK11	09/08/2002	36	38.6	0.46	0.29	1.88	109	180
2,Blue,0m	JK11	15/08/2002	75	30.4	0.21	0.84	2.42	186	390
2,Blue,0m	JK11	22/08/2002	69	42.8	<0.005	<0.01	5.3	89	460
2,Blue,0m	JK11	27/08/2002	66	60	0.04	5.3	>16	96	300
2,Blue,0m	JK11	12/09/2002	94	29.7	<0.005	2.69	12.75	80	310
2,Blue,0m	JK11	26/09/2002	112	77.5	0.64	0.38	60.5	75	230
2,Blue,0m	JK11	10/10/2002	69	148	0.12	0.25	63.5	53	300
2,Blue,0m	JK11	17/10/2002	80	84.4	0.02	2.3	18.8	66	350
2,Blue,0m	JK11	24/10/2002	16	7.6	0.02	0.05	61.5	0	180
2,Blue,0m	JK11	28/11/2002							
2,Blue,0m	JK11	21/01/2003	50						
2,Blue,0m	JK11	31/01/2003	58	55	0.14	0.29	20.5	78	230
2,Blue,0m	JK11	14/02/2003	65	50.7	0.01	0.57	10.7	83	200
2,Blue,0m	JK11	27/02/2003	78	66.5	0.02	1	15.9	82	180
2,Blue,0m	JK11	13/03/2003	30	58.5	0.01	1.2	17.4	72	250
2,Blue,0m	JK11	11/04/2003		58	0.24	1.1	16.08	84	150
2,Blue,0m	JK11	23/04/2003							
2,Blue,0m	JK11	07/05/2003	37			0			150
2,Blue,0m	JK11	29/05/2003	82	75.65	0.16	0.005	22.05	76.4	80
2,Blue,0m	JK11	10/06/2003	73	46.47	0.12	0	26.1	75.1	260
2,Blue,0m	JK11	25/06/2003	59	40.6	0.19	7.7	61.4	110	210
2,Blue,0m	JK11	09/07/2003	184	29.6	2.6	8.8	29.6	108	210
2,Blue,0m	JK11	22/07/2003	62	28.7	0.45	0	25.4	62	140

2,Black,0m	**JK12**	09/08/2002							
2,Black,0m	**JK12**	15/08/2002							
2,Black,0m	**JK12**	22/08/2002							
2,Black,0m	**JK12**	27/08/2002							
2,Black,0m	**JK12**	12/09/2002							
2,Black,0m	**JK12**	26/09/2002							
2,Black,0m	**JK12**	10/10/2002							
2,Black,0m	**JK12**	17/10/2002							
2,Black,0m	**JK12**	24/10/2002							
2,Black,0m	**JK12**	28/11/2002							
2,Black,0m	**JK12**	21/01/2003							
2,Black,0m	**JK12**	31/01/2003							
2,Black,0m	**JK12**	14/02/2003							
2,Black,0m	**JK12**	27/02/2003							
2,Black,0m	**JK12**	13/03/2003							
2,Black,0m	**JK12**	11/04/2003							
2,Black,0m	**JK12**	23/04/2003							
2,Black,0m	**JK12**	07/05/2003							
2,Black,0m	**JK12**	29/05/2003							
2,Black,0m	**JK12**	10/06/2003							
2,Black,0m	**JK12**	25/06/2003							
2,Black,0m	**JK12**	09/07/2003							
2,Black,0m	**JK12**	22/07/2003							
2,Red,10m	**JK13**	09/08/2002	8	28.3	<0.005	0.5	2.09	38	280
2,Red,10m	**JK13**	15/08/2002	56	10.5	0.11	0.33	0.47	46	280
2,Red,10m	**JK13**	22/08/2002	27	22	<0.005	<0.01	8.96	7	220
2,Red,10m	**JK13**	27/08/2002	58	15.8	<0.005	0.6	2.36	6	250
2,Red,10m	**JK13**	12/09/2002	82	12	<0.005	<0.01	0.13	17	70
2,Red,10m	**JK13**	26/09/2002	47	23.2	<0.02	0.21	0.63	<10	105
2,Red,10m	**JK13**	10/10/2002	35	18	0.31	0.04	2.1	13.6	90
2,Red,10m	**JK13**	17/10/2002	30	11.4	0	0.36	1.14	0	195
2,Red,10m	**JK13**	24/10/2002	25	2.4	0	0.02	8.8	0	170
2,Red,10m	**JK13**	28/11/2002							
2,Red,10m	**JK13**	21/01/2003	60						
2,Red,10m	**JK13**	31/01/2003	51	27.3	0.02	0.02	0.19	31	220
2,Red,10m	**JK13**	14/02/2003	56	16.1	0	0	0.23	19	160
2,Red,10m	**JK13**	27/02/2003	72	21.6	0.01	0.9	0.49	18	110
2,Red,10m	**JK13**	13/03/2003	16	4.2	0.02	0	0.84	0	240
2,Red,10m	**JK13**	11/04/2003		6.6	0.01	1.1	1.36	5	50
2,Red,10m	**JK13**	23/04/2003	30	1.1	0	0	1.4	0	40
2,Red,10m	**JK13**	07/05/2003	18			0			110
2,Red,10m	**JK13**	29/05/2003	54	0.94	0.009	0	0.16	1.24	90
2,Red,10m	**JK13**	10/06/2003	37	1.5	0.007	0	0.06	0	210
2,Red,10m	**JK13**	25/06/2003	56	7	0.11	7.5	1.27	35	170
2,Red,10m	**JK13**	09/07/2003	24	28.1	0.13	9.1	1.52	97	120
2,Red,10m	**JK13**	22/07/2003	14	1.3	0	0	0.83	3	150

2,Blue,10m	**JK14**	09/08/2002	8	21.6	<0.005	0.2	1.04	43	200
2,Blue,10m	**JK14**	15/08/2002	51	10.4	0.12	0.29	0.39	53	220
2,Blue,10m	**JK14**	22/08/2002	47	15.1	<0.005	<0.01	2.98	3	200
2,Blue,10m	**JK14**	27/08/2002	57	12.9	<0.005	0.47	5.54	6	230
2,Blue,10m	**JK14**	12/09/2002	37	11.2	<0.005	<0.01	0.07	17	90
2,Blue,10m	**JK14**	26/09/2002	39	17.4	<0.02	0.28	0.2	<10	120
2,Blue,10m	**JK14**	10/10/2002	23	12.7	0	0.91	3.85	14.5	130
2,Blue,10m	**JK14**	17/10/2002							
2,Blue,10m	**JK14**	24/10/2002							
2,Blue,10m	**JK14**	28/11/2002							
2,Blue,10m	**JK14**	21/01/2003	21						
2,Blue,10m	**JK14**	31/01/2003	25	7.6	0	0	0.29	22	300
2,Blue,10m	**JK14**	14/02/2003	41	7.9	0	0.03	0.2	11	210
2,Blue,10m	**JK14**	27/02/2003	63	13.7	0.01	0	0.35	17	160
2,Blue,10m	**JK14**	13/03/2003							
2,Blue,10m	**JK14**	11/04/2003		2.5	0.01	0	0.28	7	310
2,Blue,10m	**JK14**	23/04/2003	22	1.1	0	0	1.17	0	100
2,Blue,10m	**JK14**	07/05/2003	19			0			100
2,Blue,10m	**JK14**	29/05/2003	51	0	0.011	0.008	0.04	0.98	210
2,Blue,10m	**JK14**	10/06/2003	41	2.2	0.006	0	0	0	270
2,Blue,10m	**JK14**	25/06/2003	29	7.5	0.11	11.6	0.76	33	230
2,Blue,10m	**JK14**	09/07/2003	0	7.5	0.13	8.7	0.85	45	180
2,Blue,10m	**JK14**	22/07/2003	17	0	0.04	0	0	0	160
2,Black,10m	**JK15**	09/08/2002	14	8.2	<0.005	0.4	1.28	31	160
2,Black,10m	**JK15**	15/08/2002	50	4.3	0.1	0.33	0.43	47	210
2,Black,10m	**JK15**	22/08/2002	40	5.4	<0.005	<0.01	11.3	4	210
2,Black,10m	**JK15**	27/08/2002	62	5.2	<0.005	1.83	4.99	6	210
2,Black,10m	**JK15**	12/09/2002	51	<0.1	<0.005	<0.01	0	22	620
2,Black,10m	**JK15**	26/09/2002	24	7.7	<0.02	1.28	0.99	<10	180
2,Black,10m	**JK15**	10/10/2002	32	3.6	0	0.11	2.49	8.3	170
2,Black,10m	**JK15**	17/10/2002	41	4.9	0.1	1.9	0.86	0	150
2,Black,10m	**JK15**	24/10/2002	12	3.9	0	0.07		0	210
2,Black,10m	**JK15**	28/11/2002							
2,Black,10m	**JK15**	21/01/2003	6						
2,Black,10m	**JK15**	31/01/2003	28	5.5	0	0.08	0.15	15	270
2,Black,10m	**JK15**	14/02/2003	39	5.8	0.02	0.85	0.15	2	220
2,Black,10m	**JK15**	27/02/2003	65	6.2	0.02	1.5	0.1	0	200
2,Black,10m	**JK15**	13/03/2003	8	2.4	0.01	0	1.04	0	260
2,Black,10m	**JK15**	11/04/2003		3.7	0	2.6	0.54	2	150
2,Black,10m	**JK15**	23/04/2003	13	3.4	0	0	0.3	0	110
2,Black,10m	**JK15**	07/05/2003	13			0			120
2,Black,10m	**JK15**	29/05/2003	51	2.5	0.012	0	0	3.98	140
2,Black,10m	**JK15**	10/06/2003	35	7.9	0.008	0.025	0	0.5	260
2,Black,10m	**JK15**	25/06/2003	21	7.4	0.13	8.5	1.17	27	270
2,Black,10m	**JK15**	09/07/2003	0	7	0.13	7.5	0.59	26	230
2,Black,10m	**JK15**	22/07/2003	12	0	0	0	0	0	190

2,Red,20m	**JK16**	09/08/2002	9	19.7	<0.005	0.28	1.55	31	120
2,Red,20m	**JK16**	15/08/2002	50	13.8	0.11	0.28	0.4	43	170
2,Red,20m	**JK16**	22/08/2002	25	13.4	<0.005	0.02	3.6	3	130
2,Red,20m	**JK16**	27/08/2002	47	22.3	<0.005	0.55	2.26	5	160
2,Red,20m	**JK16**	12/09/2002	50	10.3	<0.005	0.26	0.29	23	100
2,Red,20m	**JK16**	26/09/2002	26	15.6	<0.02	0.3	0.47	<10	70
2,Red,20m	**JK16**	10/10/2002	31	11.4	0	0.17	2.4	9.9	45
2,Red,20m	**JK16**	17/10/2002	79	9.5	0	0.15	0.2	0	200
2,Red,20m	**JK16**	24/10/2002	17	8.9	0	0.1	13.4	58	130
2,Red,20m	**JK16**	28/11/2002							
2,Red,20m	**JK16**	21/01/2003	26						
2,Red,20m	**JK16**	31/01/2003							
2,Red,20m	**JK16**	14/02/2003	52	0	0	0.03	0.34	0	35
2,Red,20m	**JK16**	27/02/2003							
2,Red,20m	**JK16**	13/03/2003							
2,Red,20m	**JK16**	11/04/2003							
2,Red,20m	**JK16**	23/04/2003							
2,Red,20m	**JK16**	07/05/2003							
2,Red,20m	**JK16**	29/05/2003							
2,Red,20m	**JK16**	10/06/2003	54	3	0.009	0.052	0	3.06	70
2,Red,20m	**JK16**	25/06/2003	44	7.1	0.16	9	0.81	21	80
2,Red,20m	**JK16**	09/07/2003	16.9	6.6	0.17	7.4	0.85	30	50
2,Red,20m	**JK16**	22/07/2003	26	0.9	0.05	0	0	0	55
2,Blue,20m	**JK17**	09/08/2002	42	6	<0.005	0.54	2.81	45	130
2,Blue,20m	**JK17**	15/08/2002	35	8.2	0.1	0.35	0.4	27	200
2,Blue,20m	**JK17**	22/08/2002	42	6.6	<0.005	<0.01	1.76	0	180
2,Blue,20m	**JK17**	27/08/2002	57	3.6	<0.005	0.66	1.77	2	210
2,Blue,20m	**JK17**	12/09/2002	44	5.7	<0.005	0.45	5.18	16	220
2,Blue,20m	**JK17**	26/09/2002	14	9.7	<0.02	0.28	1.24	<10	190
2,Blue,20m	**JK17**	10/10/2002	30	11.5	0	0.01	2.08	6.5	170
2,Blue,20m	**JK17**	17/10/2002							
2,Blue,20m	**JK17**	24/10/2002							
2,Blue,20m	**JK17**	28/11/2002							
2,Blue,20m	**JK17**	21/01/2003	33						
2,Blue,20m	**JK17**	31/01/2003	14	0	0	0.06	0.14	0	250
2,Blue,20m	**JK17**	14/02/2003	53	1.6	0	0.02	0.11	0	180
2,Blue,20m	**JK17**	27/02/2003	46	3.5	0	0.6	0.23	0	170
2,Blue,20m	**JK17**	13/03/2003	0	0	0	1.5	0.32	2	280
2,Blue,20m	**JK17**	11/04/2003		0	0	0	0.3	0	120
2,Blue,20m	**JK17**	23/04/2003	18	0.3	0	0	4.49	0	140
2,Blue,20m	**JK17**	07/05/2003	29			0			120
2,Blue,20m	**JK17**	29/05/2003	46	1.14	0.009	0.008	0.01	2.6	120
2,Blue,20m	**JK17**	10/06/2003	34	7	0.007	0.014	0	4.43	260
2,Blue,20m	**JK17**	25/06/2003	38	7.8	0.1	0.34	0.77	35	290
2,Blue,20m	**JK17**	09/07/2003	12.3	7.3	0.16	7.9	0.87	35	220
2,Blue,20m	**JK17**	22/07/2003	23	1.1	0.02	0	0	0	190

2,Black,20m	**JK18**	09/08/2002								
2,Black,20m	**JK18**	15/08/2002	31	3.8	0.11	0.29	0.4	31	180
2,Black,20m	**JK18**	22/08/2002	35	5.6	<0.005	<0.01	2.8	1	180
2,Black,20m	**JK18**	27/08/2002	68	4.2	<0.005	0.64	4.04	3	200
2,Black,20m	**JK18**	12/09/2002	28	2.5	<0.005	0.67	3.6	14	220
2,Black,20m	**JK18**	26/09/2002	34	6.4	<0.02	0.82	6.25	<10	170
2,Black,20m	**JK18**	10/10/2002	39	3.4	0	0.09	0.86	9.3	160
2,Black,20m	**JK18**	17/10/2002	52	3.4	0	0.33	2.52	0	200
2,Black,20m	**JK18**	24/10/2002							
2,Black,20m	**JK18**	28/11/2002							
2,Black,20m	**JK18**	21/01/2003	179						
2,Black,20m	**JK18**	31/01/2003	16	1.9	0	0.01	0.1	0	320
2,Black,20m	**JK18**	14/02/2003	36	2.1	0	0.05	0.73	0	270
2,Black,20m	**JK18**	27/02/2003	48	3	0.02	1.5	0.38	0	220
2,Black,20m	**JK18**	13/03/2003	14	1.1	0.02	0.6	0.24	0	320
2,Black,20m	**JK18**	11/04/2003		0.4	0	0	0.25	0	110
2,Black,20m	**JK18**	23/04/2003	10	0	0.1	0	0.35	0	110
2,Black,20m	**JK18**	07/05/2003	31			0			70
2,Black,20m	**JK18**	29/05/2003	48	1	0.009	0	0	1.15	130
2,Black,20m	**JK18**	10/06/2003	47	2.4	0.008	0.025	0	2.58	250
2,Black,20m	**JK18**	25/06/2003	65	8.4	0.17	0.42	0.76	25	240
2,Black,20m	**JK18**	09/07/2003	13.8	7	0.14	7.4	1.37	29	200
2,Black,20m	**JK18**	22/07/2003	22	0.5	0.02	0	0	0	160

TRENCH 3

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	VOL
3,Red,0m	JK19	09/08/2002							
3,Red,0m	JK19	15/08/2002	51	4.4	0.12	0.36	0.47	125	45
3,Red,0m	JK19	22/08/2002	57	77.6	<0.005	0.09	5.66	12	50
3,Red,0m	JK19	27/08/2002	76	27.3	<0.005	0.48	9.32	60	30
3,Red,0m	JK19	12/09/2002	52	78	0.04	0.92	25.35	84	50
3,Red,0m	JK19	26/09/2002							
3,Red,0m	JK19	10/10/2002	91	4	0.26	0.1	>4	-	23
3,Red,0m	JK19	17/10/2002							
3,Red,0m	JK19	24/10/2002	64	60.8	-	0.8	58.3	0	20
3,Red,0m	JK19	28/11/2002							
3,Red,0m	JK19	21/01/2003							
3,Red,0m	JK19	31/01/2003							
3,Red,0m	JK19	14/02/2003	96	56	3.1	2.55	15.3	84	62
3,Red,0m	JK19	27/02/2003	103	77.9	1.2	2	16.1	81	75
3,Red,0m	JK19	13/03/2003							
3,Red,0m	JK19	11/04/2003		58.6	0.2	1.8	19.76	75	35
3,Red,0m	JK19	23/04/2003	89	50.4	0.44	2	21.8	87	20
3,Red,0m	JK19	07/05/2003							
3,Red,0m	JK19	29/05/2003							
3,Red,0m	JK19	10/06/2003	107	33	0.14	0.39	20.1	57	100
3,Red,0m	JK19	25/06/2003	135	13.4	0.2	9.3	31	54	70
3,Red,0m	JK19	09/07/2003	56	38.6	2.6	8.1	20.6	112	120
3,Red,0m	JK19	22/07/2003	78	37.9	0.15	0	16.5	62	65
3,Blue,0m	JK20	09/08/2002							
3,Blue,0m	JK20	15/08/2002							
3,Blue,0m	JK20	22/08/2002							
3,Blue,0m	JK20	27/08/2002							
3,Blue,0m	JK20	12/09/2002							
3,Blue,0m	JK20	26/09/2002							
3,Blue,0m	JK20	10/10/2002							
3,Blue,0m	JK20	17/10/2002							
3,Blue,0m	JK20	24/10/2002							
3,Blue,0m	JK20	28/11/2002							
3,Blue,0m	JK20	21/01/2003							
3,Blue,0m	JK20	31/01/2003							
3,Blue,0m	JK20	14/02/2003							
3,Blue,0m	JK20	27/02/2003							
3,Blue,0m	JK20	13/03/2003							
3,Blue,0m	JK20	11/04/2003							
3,Blue,0m	JK20	23/04/2003							
3,Blue,0m	JK20	07/05/2003							
3,Blue,0m	JK20	29/05/2003							
3,Blue,0m	JK20	10/06/2003							
3,Blue,0m	JK20	25/06/2003							
3,Blue,0m	JK20	09/07/2003	45	38.9	2.6	8.4	7.4	104	50
3,Blue,0m	JK20	22/07/2003							

3,Black,0m	**JK21**	09/08/2002							
3,Black,0m	**JK21**	15/08/2002							
3,Black,0m	**JK21**	22/08/2002							
3,Black,0m	**JK21**	27/08/2002							
3,Black,0m	**JK21**	12/09/2002							
3,Black,0m	**JK21**	26/09/2002							
3,Black,0m	**JK21**	10/10/2002							
3,Black,0m	**JK21**	17/10/2002							
3,Black,0m	**JK21**	24/10/2002							
3,Black,0m	**JK21**	28/11/2002							
3,Black,0m	**JK21**	21/01/2003							
3,Black,0m	**JK21**	31/01/2003							
3,Black,0m	**JK21**	14/02/2003							
3,Black,0m	**JK21**	27/02/2003							
3,Black,0m	**JK21**	13/03/2003							
3,Black,0m	**JK21**	11/04/2003							
3,Black,0m	**JK21**	23/04/2003							
3,Black,0m	**JK21**	07/05/2003							
3,Black,0m	**JK21**	29/05/2003							
3,Black,0m	**JK21**	10/06/2003	60	42.81	0.14	0.04	7.1	58.5	30
3,Black,0m	**JK21**	25/06/2003	25	52.2	0.26	9.5	8.2	92	35
3,Black,0m	**JK21**	09/07/2003	31	50.8	2.6	8.6	7.1	95	30
3,Black,0m	**JK21**	22/07/2003	48	41	0.2	0	5.68	54	25
3,Red,10m	**JK22**	09/08/2002	10	4.8	<0.005	0.33	0.93	27	320
3,Red,10m	**JK22**	15/08/2002	33	16.9	0.11	0.27	0.47	27	350
3,Red,10m	**JK22**	22/08/2002	32	6	<0.005	<0.01	2.04	1	320
3,Red,10m	**JK22**	27/08/2002	65	1.6	<0.005	0.47	4.54	2	380
3,Red,10m	**JK22**	12/09/2002	37	2.9	<0.005	0.32	6.43	18	280
3,Red,10m	**JK22**	26/09/2002	26	5.4	0.01	0.14	5.98	<10	210
3,Red,10m	**JK22**	10/10/2002	34	45.1	0	0.01	0.82	6.8	190
3,Red,10m	**JK22**	17/10/2002							
3,Red,10m	**JK22**	24/10/2002	11	1.2	0	0.11	11.8	0	250
3,Red,10m	**JK22**	28/11/2002							
3,Red,10m	**JK22**	21/01/2003	37						
3,Red,10m	**JK22**	31/01/2003	22	0.2	0	0	0.08	0	280
3,Red,10m	**JK22**	14/02/2003	56	0	0	0.07	0.29	0	260
3,Red,10m	**JK22**	27/02/2003	62	2.9	0.03	0.4	0.26	0	200
3,Red,10m	**JK22**	13/03/2003							
3,Red,10m	**JK22**	11/04/2003		0	0	0	0.47	3	150
3,Red,10m	**JK22**	23/04/2003	19	0.1	0	0	0.84	0	140
3,Red,10m	**JK22**	07/05/2003	16			0			210
3,Red,10m	**JK22**	29/05/2003	52	1.51	0.016	0.005	0.11	3.01	150
3,Red,10m	**JK22**	10/06/2003	33	2.7	0.01	0.022	0.01	2.65	270
3,Red,10m	**JK22**	25/06/2003	38	9.3	0.13	8.8	0.91	26	270
3,Red,10m	**JK22**	09/07/2003	8	7.1	2.6	8.5	0.65	31	180
3,Red,10m	**JK22**	22/07/2003	21	1.2	0.04	0	0.1	0	200

3,Blue,10m	**JK23**	09/08/2002	12	8.1	<0.005	0.55	1.26	23	220
3,Blue,10m	**JK23**	15/08/2002	33	4.9	0.11	0.31	0.43	39	320
3,Blue,10m	**JK23**	22/08/2002	35	7.3	<0.005	<0.01	2.1	3	290
3,Blue,10m	**JK23**	27/08/2002	77	4.2	<0.005	0.7	>5	6	320
3,Blue,10m	**JK23**	12/09/2002	39	3.9	<0.005	<0.01	6.03	16	290
3,Blue,10m	**JK23**	26/09/2002	31	13.5	<0.02	0.04	6.08	2	190
3,Blue,10m	**JK23**	10/10/2002	30	3.7	0	0.02	0.46	10.4	150
3,Blue,10m	**JK23**	17/10/2002							
3,Blue,10m	**JK23**	24/10/2002	<10	2.9	0	0.07	11.96	0	320
3,Blue,10m	**JK23**	28/11/2002							
3,Blue,10m	**JK23**	21/01/2003	30						
3,Blue,10m	**JK23**	31/01/2003	14	0	0	0.05	0.03	0	380
3,Blue,10m	**JK23**	14/02/2003	40	0	0	0.05	0.28	0	320
3,Blue,10m	**JK23**	27/02/2003	45	2.3	0.02	0.4	0.4	0	250
3,Blue,10m	**JK23**	13/03/2003							
3,Blue,10m	**JK23**	11/04/2003		0.1	0	0.7	0.28	0	150
3,Blue,10m	**JK23**	23/04/2003	7	0	0	0	0.54	0	110
3,Blue,10m	**JK23**	07/05/2003	25			0			210
3,Blue,10m	**JK23**	29/05/2003	39	0.41	0.012	0	0.01	4.08	210
3,Blue,10m	**JK23**	10/06/2003	35	1.3	0.007	0	0	3.39	310
3,Blue,10m	**JK23**	25/06/2003	58	6.7	0.13	9.1	1.57	37	260
3,Blue,10m	**JK23**	09/07/2003	0	7.2	0.14	8.1	0.7	30	120
3,Blue,10m	**JK23**	22/07/2003	17	0.6	0.03	0	0	0	170
3,Black,10m	**JK24**	09/08/2002	36	6.6	<0.005	1.08	0.84	20	220
3,Black,10m	**JK24**	15/08/2002	36	4.2	0.11	0.29	0.47	57	280
3,Black,10m	**JK24**	22/08/2002	31	7.1	<0.005	<0.01	4.94	3	410
3,Black,10m	**JK24**	27/08/2002	66	4.9	<0.005	2.17	>5	6	450
3,Black,10m	**JK24**	12/09/2002	43	2.4	<0.005	<0.01	1.05	13	360
3,Black,10m	**JK24**	26/09/2002	67	5.8	<0.02	0.34	5.64	<10	400
3,Black,10m	**JK24**	10/10/2002	42	7.5	0	1.36	0.7	5.8	370
3,Black,10m	**JK24**	17/10/2002							
3,Black,10m	**JK24**	24/10/2002	25	5.5	0	0.71	22.2	0	430
3,Black,10m	**JK24**	28/11/2002							
3,Black,10m	**JK24**	21/01/2003	35						
3,Black,10m	**JK24**	31/01/2003	15	0	0.01	0.12	0.07	0	480
3,Black,10m	**JK24**	14/02/2003	46	0	0.01	1.13	0.38	0	370
3,Black,10m	**JK24**	27/02/2003	62	0.4	0.02	0.6	0.39	1	350
3,Black,10m	**JK24**	13/03/2003							
3,Black,10m	**JK24**	11/04/2003		0	0	0	0.32	0	260
3,Black,10m	**JK24**	23/04/2003	15	0	0	2	0.44	0	270
3,Black,10m	**JK24**	07/05/2003	32			0			270
3,Black,10m	**JK24**	29/05/2003	37	0.17	0.009	0	0.01	4.58	350
3,Black,10m	**JK24**	10/06/2003	24	1.6	0.006	0	0	5.09	450
3,Black,10m	**JK24**	25/06/2003	130	7.4	0.13	8.1	1.27	38	450
3,Black,10m	**JK24**	09/07/2003	0	6.7	0.14	8.4	0.55	31	350
3,Black,10m	**JK24**	22/07/2003	17	0.2	0.01	0	0	0	320

3,Red,20m	**JK25**	09/08/2002	44	11.4	<0.005	0.04	0.97	21	230
3,Red,20m	**JK25**	15/08/2002	12	6.6	0.11	0.28	0.4	104	360
3,Red,20m	**JK25**	22/08/2002	46	19.8	<0.005	0.03	8.02	25	360
3,Red,20m	**JK25**	27/08/2002	70	30.8	<0.005	0.81	3.17	29	220
3,Red,20m	**JK25**	12/09/2002	18	4.1	<0.005	<0.01	0.43	36	220
3,Red,20m	**JK25**	26/09/2002	30	41.2	<0.02	0.15	0.22	29	150
3,Red,20m	**JK25**	10/10/2002	41	31.7	0	0	0	26.4	130
3,Red,20m	**JK25**	17/10/2002							
3,Red,20m	**JK25**	24/10/2002	40	18.5	0	0.1	9.9	0	200
3,Red,20m	**JK25**	28/11/2002							
3,Red,20m	**JK25**	21/01/2003	65						
3,Red,20m	**JK25**	31/01/2003	26	0	0.01	0.1	0.67	10	40
3,Red,20m	**JK25**	14/02/2003	52	0.4	0	0.02	0.05	0	170
3,Red,20m	**JK25**	27/02/2003	61	3.3	0.02	0	1.86	0	130
3,Red,20m	**JK25**	13/03/2003							
3,Red,20m	**JK25**	11/04/2003		45.7	0	0	0.2	0	150
3,Red,20m	**JK25**	23/04/2003	18	0	0	3	1.7	0	50
3,Red,20m	**JK25**	07/05/2003	22			0			130
3,Red,20m	**JK25**	29/05/2003	51	0.26	0.01	0.019	0.03	2.19	190
3,Red,20m	**JK25**	10/06/2003	35	2.2	0.007	0.021	0	3.03	240
3,Red,20m	**JK25**	25/06/2003	59	7.2	0.16	9.3	1.1	30	220
3,Red,20m	**JK25**	09/07/2003	14.6	6.5	0.16	8.5	0.64	32	190
3,Red,20m	**JK25**	22/07/2003	16	0	0.02	0	0	0	160
3,Blue,20m	**JK26**	09/08/2002	8	9.3	<0.005	0.42	0.95	31	210
3,Blue,20m	**JK26**	15/08/2002	24	4.9	0.11	0.29	0.49	33	270
3,Blue,20m	**JK26**	22/08/2002	33	4.9	<0.005	<0.01	0	2	360
3,Blue,20m	**JK26**	27/08/2002	57	5.9	<0.005	0.51	2.54	3	300
3,Blue,20m	**JK26**	12/09/2002	19	2.3	<0.005	<0.01	1.29	17	330
3,Blue,20m	**JK26**	26/09/2002	27	8.5	<0.02	0.05	0.17	<10	230
3,Blue,20m	**JK26**	10/10/2002	44	7	0	0	0.81	10.5	220
3,Blue,20m	**JK26**	17/10/2002							
3,Blue,20m	**JK26**	24/10/2002	20	10	0	0.4	4.3	0	200
3,Blue,20m	**JK26**	28/11/2002							
3,Blue,20m	**JK26**	21/01/2003	33						
3,Blue,20m	**JK26**	31/01/2003							
3,Blue,20m	**JK26**	14/02/2003	49	17.1	0	0.07	0.07	18	260
3,Blue,20m	**JK26**	27/02/2003	46	21.5	0.03	1.6	0.62	6	250
3,Blue,20m	**JK26**	13/03/2003							
3,Blue,20m	**JK26**	11/04/2003		14.1	0.02	0	0.75	15	180
3,Blue,20m	**JK26**	23/04/2003	12	2.4	0	1	2.2	3	200
3,Blue,20m	**JK26**	07/05/2003	20			0			180
3,Blue,20m	**JK26**	29/05/2003	37	1.5	0.016	0	0	2.03	240
3,Blue,20m	**JK26**	10/06/2003	52	1.2	0.005	0.01	0	2.94	340
3,Blue,20m	**JK26**	25/06/2003	37	7.6	0.14	8.5	0.98	31	350
3,Blue,20m	**JK26**	09/07/2003	12.9	6.7	0.16	8.2	0.87	30	310
3,Blue,20m	**JK26**	22/07/2003	7	0	0.01	0	0	0	270

3,Black,20m	**JK27**	09/08/2002	36	7.3	<0.005	0.41	0.89	20	70
3,Black,20m	**JK27**	15/08/2002	22	3.9	0.11	0.37		29	40
3,Black,20m	**JK27**	22/08/2002	17	4.8	<0.005	0.09	8.66	2	130
3,Black,20m	**JK27**	27/08/2002	49	3.8	<0.005	0.51	>5	4	170
3,Black,20m	**JK27**	12/09/2002	24	<0.1	<0.005	<0.01	0.58	8	170
3,Black,20m	**JK27**	26/09/2002	15	6.5	0.01	0.23	<0.05	<10	130
3,Black,20m	**JK27**	10/10/2002	68	4	0	0	0.4	6	130
3,Black,20m	**JK27**	17/10/2002							
3,Black,20m	**JK27**	24/10/2002	30	6.2	0	0.01	3.93	40	100
3,Black,20m	**JK27**	28/11/2002							
3,Black,20m	**JK27**	21/01/2003	43						
3,Black,20m	**JK27**	31/01/2003	10	0	0.01	0.06	0.11	13	170
3,Black,20m	**JK27**	14/02/2003	51	6.9	0.01	0.03	0.02	5	110
3,Black,20m	**JK27**	27/02/2003	24	19.7	0.03	0.4	0.77	9	120
3,Black,20m	**JK27**	13/03/2003							
3,Black,20m	**JK27**	11/04/2003		2.4	0	0	0.37	7	70
3,Black,20m	**JK27**	23/04/2003	20	16.7	0	1	0.33	9	80
3,Black,20m	**JK27**	07/05/2003	9			0			60
3,Black,20m	**JK27**	29/05/2003	36	9.7	0.012	0	0	15.8	150
3,Black,20m	**JK27**	10/06/2003	37	4.2	0.007	0.021	0	11.8	200
3,Black,20m	**JK27**	25/06/2003	59	7.7	0.13	10.5	0.98	33	170
3,Black,20m	**JK27**	09/07/2003	14.8	6.4	0.15	9.1	0.58	33	170
3,Black,20m	**JK27**	22/07/2003	19	0.5	0.04	0	0.06	0	160

TRENCH 4

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	VOL
4,Red,0m	JK28	09/08/2002							
4,Red,0m	JK28	15/08/2002							
4,Red,0m	JK28	22/08/2002	53	21.5	0.15	0.5	2.62	60	48
4,Red,0m	JK28	27/08/2002	67	92.9	0.17	4.7	12.8	76	30
4,Red,0m	JK28	12/09/2002	34	21	0.38	0.14	0.36	91	70
4,Red,0m	JK28	26/09/2002							
4,Red,0m	JK28	10/10/2002	70	61.6	0	0.32	0.74	-	15
4,Red,0m	JK28	17/10/2002							
4,Red,0m	JK28	24/10/2002	70	62.4	0.01	0.6	12	-	37
4,Red,0m	JK28	28/11/2002							
4,Red,0m	JK28	21/01/2003							
4,Red,0m	JK28	31/01/2003	24	9.4	0	0.27	20.8	82	40
4,Red,0m	JK28	14/02/2003	83	56	0.02	0.28	3.1	73	15
4,Red,0m	JK28	27/02/2003							
4,Red,0m	JK28	13/03/2003							
4,Red,0m	JK28	11/04/2003							
4,Red,0m	JK28	23/04/2003							
4,Red,0m	JK28	07/05/2003							
4,Red,0m	JK28	29/05/2003							
4,Red,0m	JK28	10/06/2003	67	50.67	0.12	0.51	0.8	76.4	30
4,Red,0m	JK28	25/06/2003							
4,Red,0m	JK28	09/07/2003							
4,Red,0m	JK28	22/07/2003							
4,Blue,0m	JK29	09/08/2002							
4,Blue,0m	JK29	15/08/2002	87	25.4	2.88	1.99	2.02	174	30
4,Blue,0m	JK29	22/08/2002	65	73	2.76	33.9	0.36	80	80
4,Blue,0m	JK29	27/08/2002							
4,Blue,0m	JK29	12/09/2002							
4,Blue,0m	JK29	26/09/2002							
4,Blue,0m	JK29	10/10/2002	102	104.8	2.9	1.46	12.92	55.4	110
4,Blue,0m	JK29	17/10/2002							
4,Blue,0m	JK29	24/10/2002	130	66	0.08	1.26	52.3	68	30
4,Blue,0m	JK29	28/11/2002							
4,Blue,0m	JK29	21/01/2003	65						
4,Blue,0m	JK29	31/01/2003							
4,Blue,0m	JK29	14/02/2003							
4,Blue,0m	JK29	27/02/2003	55			0			55
4,Blue,0m	JK29	13/03/2003							
4,Blue,0m	JK29	11/04/2003							
4,Blue,0m	JK29	23/04/2003							
4,Blue,0m	JK29	07/05/2003							
4,Blue,0m	JK29	29/05/2003							
4,Blue,0m	JK29	10/06/2003	87	34.86	0.14	0.84	24.7	76.5	120
4,Blue,0m	JK29	25/06/2003	123	34.9	0.13	10.2	31.7	97	70
4,Blue,0m	JK29	09/07/2003	61	41.5	2.6	8.2	24.6	98	280
4,Blue,0m	JK29	22/07/2003	73	36.5	0.3	0	18.8	55	55

4,Black,0m	**JK30**	09/08/2002							
4,Black,0m	**JK30**	15/08/2002	56	5.9	2.04	1.23	2.29	183	210
4,Black,0m	**JK30**	22/08/2002	81	43.3	2.4	2.99	8.44	87	190
4,Black,0m	**JK30**	27/08/2002	84	58	1.8	6.6	22.48	98	130
4,Black,0m	**JK30**	12/09/2002	51	52.2	0.12	0.45	2.51	89	50
4,Black,0m	**JK30**	26/09/2002							
4,Black,0m	**JK30**	10/10/2002	91	106	0	0.93	12.56	54.5	170
4,Black,0m	**JK30**	17/10/2002							
4,Black,0m	**JK30**	24/10/2002	152	80	>2	2.78	34.4	0	150
4,Black,0m	**JK30**	28/11/2002							
4,Black,0m	**JK30**	21/01/2003							
4,Black,0m	**JK30**	31/01/2003							
4,Black,0m	**JK30**	14/02/2003							
4,Black,0m	**JK30**	27/02/2003							
4,Black,0m	**JK30**	13/03/2003							
4,Black,0m	**JK30**	11/04/2003							
4,Black,0m	**JK30**	23/04/2003							
4,Black,0m	**JK30**	07/05/2003							
4,Black,0m	**JK30**	29/05/2003							
4,Black,0m	**JK30**	10/06/2003	67	49.36	0.18	0.29	20.7	77.6	70
4,Black,0m	**JK30**	25/06/2003	95	34.7	0.15	8.2	30.3	104	65
4,Black,0m	**JK30**	09/07/2003	45	41.6	2.6	8	24.3	96	170
4,Black,0m	**JK30**	22/07/2003	59	35.7	0.3	0	17.6	59	50
4,Red,10m	**JK31**	09/08/2002	8	9.3	<0.005	0.4	0.79	23	80
4,Red,10m	**JK31**	15/08/2002	33	26.7	0.1	0.29	0.43	42	160
4,Red,10m	**JK31**	22/08/2002	44	5.1	<0.005	<0.01	1.24	3	140
4,Red,10m	**JK31**	27/08/2002	59	5.4	<0.005	0.55	>5	4	130
4,Red,10m	**JK31**	12/09/2002	28	1.6	<0.005	<0.01	6.35	13	110
4,Red,10m	**JK31**	26/09/2002	26	8.7	-	-	5.58	<10	70
4,Red,10m	**JK31**	10/10/2002	42	5.7	0	0.05	5.96	11.8	65
4,Red,10m	**JK31**	17/10/2002							
4,Red,10m	**JK31**	24/10/2002	34	7.9	0	0.03	8.64	0	110
4,Red,10m	**JK31**	28/11/2002							
4,Red,10m	**JK31**	21/01/2003	31						
4,Red,10m	**JK31**	31/01/2003	27	0	0	0.03	0.12	3	190
4,Red,10m	**JK31**	14/02/2003	34	0.6	0.01	0.08	0.16	0	150
4,Red,10m	**JK31**	27/02/2003	51	2.3	0	0.5	0.55	0	110
4,Red,10m	**JK31**	13/03/2003							
4,Red,10m	**JK31**	11/04/2003		0.8	0	0.6	0.95	6	55
4,Red,10m	**JK31**	23/04/2003	16	0	0	1	0.57	0	70
4,Red,10m	**JK31**	07/05/2003	22			0			110
4,Red,10m	**JK31**	29/05/2003	43	2.94	0.013	0.154	0.72	5.36	150
4,Red,10m	**JK31**	10/06/2003	46	3.1	0.006	0.17	0	4.63	150
4,Red,10m	**JK31**	25/06/2003	44	7.8	0.11	9.2	0.7	33	150
4,Red,10m	**JK31**	09/07/2003	17.5	8.7	0.14	8	0.65	33	130
4,Red,10m	**JK31**	22/07/2003	0	1.3	0	0	0.21	0	120

4,Blue,10m	**JK32**	09/08/2002	9	10.7	<0.005	0.59	0.54	24	160
4,Blue,10m	**JK32**	15/08/2002	18	4.3	0.1	0.25	0.43	43	100
4,Blue,10m	**JK32**	22/08/2002	70	3	<0.005	<0.01	1	2	130
4,Blue,10m	**JK32**	27/08/2002	62	4.1	<0.005	0.78	>5	7	140
4,Blue,10m	**JK32**	12/09/2002	35	0.5	<0.005	<0.01	0.31	17	100
4,Blue,10m	**JK32**	26/09/2002	28	8.6	<0.02	0.16	5.62	<10	75
4,Blue,10m	**JK32**	10/10/2002	44	5.1	0	0.04	3.46	9.3	70
4,Blue,10m	**JK32**	17/10/2002							
4,Blue,10m	**JK32**	24/10/2002	13	4.1	0	0.05	18.76	0	90
4,Blue,10m	**JK32**	28/11/2002							
4,Blue,10m	**JK32**	21/01/2003	42						
4,Blue,10m	**JK32**	31/01/2003	36	7.4	0.02	0.07	1.06	10	170
4,Blue,10m	**JK32**	14/02/2003	39	0.5	0.01	0	0.81	3	140
4,Blue,10m	**JK32**	27/02/2003	29	2.8	0.02	1	0.85	0	110
4,Blue,10m	**JK32**	13/03/2003							
4,Blue,10m	**JK32**	11/04/2003		0.5	0	0.6	0.73	0	45
4,Blue,10m	**JK32**	23/04/2003	16	0.5	0.2	0	1.1	0	75
4,Blue,10m	**JK32**	07/05/2003	16			0			80
4,Blue,10m	**JK32**	29/05/2003	57	1.49	0.016	0.023	0.18	4.93	50
4,Blue,10m	**JK32**	10/06/2003	26	10.7	0.014	0.6	0	6.01	180
4,Blue,10m	**JK32**	25/06/2003	63	10.3	0.13	8.5	1.8	39	160
4,Blue,10m	**JK32**	09/07/2003	8	7.8	0.17	6.7	0.72	34	140
4,Blue,10m	**JK32**	22/07/2003	23	1.2	0	0	0	0	130
4,Black,10m	**JK33**	09/08/2002	36	7.1	<0.005	0.63	0.54	29	340
4,Black,10m	**JK33**	15/08/2002	11	3.2	0.1	0.24	0.44	11	360
4,Black,10m	**JK33**	22/08/2002	41	2.5	<0.005	<0.01	1.52	0	370
4,Black,10m	**JK33**	27/08/2002	80	3	<0.005	1.53	>5	3	400
4,Black,10m	**JK33**	12/09/2002	26	0.7	<0.005	<0.01	0.07	20	400
4,Black,10m	**JK33**	26/09/2002	33	5.2	<0.02	0.09	5.58	<10	360
4,Black,10m	**JK33**	10/10/2002	49	1.9	0	0.07	5.02	6.5	310
4,Black,10m	**JK33**	17/10/2002							
4,Black,10m	**JK33**	24/10/2002	25	2.2	0	0.86	5.3	0	450
4,Black,10m	**JK33**	28/11/2002							
4,Black,10m	**JK33**	21/01/2003	33						
4,Black,10m	**JK33**	31/01/2003	31	1.1	0	0.43	0.03	1	430
4,Black,10m	**JK33**	14/02/2003	49	0.9	0	1.07	0.12	2	200
4,Black,10m	**JK33**	27/02/2003	17	5.1	0.03	0.7	0.25	0	270
4,Black,10m	**JK33**	13/03/2003							
4,Black,10m	**JK33**	11/04/2003		0	0	1.4	0.37	0	110
4,Black,10m	**JK33**	23/04/2003	14	0	0	0	0.67	0	230
4,Black,10m	**JK33**	07/05/2003	15			0			180
4,Black,10m	**JK33**	29/05/2003	74	0.31	0.015	0.014	0	3.98	180
4,Black,10m	**JK33**	10/06/2003	27	1.3	0.006	0.015	0.02	5.48	350
4,Black,10m	**JK33**	25/06/2003	38	6.8	0.13	0.45	0.84	37	370
4,Black,10m	**JK33**	09/07/2003	10.9	6.4	0.15	9.1	0.99	36	330
4,Black,10m	**JK33**	22/07/2003	26	0	0	0	0	0	280

4,Red,20m	**JK34**	09/08/2002	740	12.6	<0.005	0.11	0.7	32	190
4,Red,20m	**JK34**	15/08/2002	93	6.7	0.11	0.24	0.45	28	530
4,Red,20m	**JK34**	22/08/2002	43	1.4	<0.005	<0.01	5.6	1	560
4,Red,20m	**JK34**	27/08/2002	68	8.9	<0.005	0.45	5.41	4	490
4,Red,20m	**JK34**	12/09/2002	23	<0.1	<0.005	<0.01	0.19	24	490
4,Red,20m	**JK34**	26/09/2002	45	12.2	<0.02	<0.05	<0.05	<10	320
4,Red,20m	**JK34**	10/10/2002	34	6.5	0	0.04	1.36	6.2	290
4,Red,20m	**JK34**	17/10/2002							
4,Red,20m	**JK34**	24/10/2002	23	10.7	0	0.13	2.91	0	460
4,Red,20m	**JK34**	28/11/2002							
4,Red,20m	**JK34**	21/01/2003	30						
4,Red,20m	**JK34**	31/01/2003	38	0.7	0	0.02	0.18	4	550
4,Red,20m	**JK34**	14/02/2003	49	1.2	0	0.14	0.08	0	550
4,Red,20m	**JK34**	27/02/2003	21	1.9	0.01	0.6	0.37	0	440
4,Red,20m	**JK34**	13/03/2003							
4,Red,20m	**JK34**	11/04/2003		0	0	3.3	0.2	0	320
4,Red,20m	**JK34**	23/04/2003	26	0	0	0	4.45	0	390
4,Red,20m	**JK34**	07/05/2003	10			0			400
4,Red,20m	**JK34**	29/05/2003	36	0.96	0.012	0	0	2.49	370
4,Red,20m	**JK34**	10/06/2003	41	5.6	0.006	0.01	0.16	2.74	520
4,Red,20m	**JK34**	25/06/2003	0	9	0.14	0.56	0.8	23	470
4,Red,20m	**JK34**	09/07/2003	18.1	8.1	0.11	7	0.62	33	390
4,Red,20m	**JK34**	22/07/2003	18	1.3	0.02	0	0	0	150
4,Blue,20m	**JK35**	09/08/2002	2	6.2	<0.005	<0.01	0.78	25	90
4,Blue,20m	**JK35**	15/08/2002	30	4,7	0.1	0.26	0.41	25	170
4,Blue,20m	**JK35**	22/08/2002	50	2	<0.005	0.03	2.1	0	140
4,Blue,20m	**JK35**	27/08/2002	66	2.3	<0.005	0.62	4.7	1	160
4,Blue,20m	**JK35**	12/09/2002	12	<0.1	<0.005	<0.01	0.16	17	180
4,Blue,20m	**JK35**	26/09/2002	81	5.7	<0.02	0.09	0.06	<10	130
4,Blue,20m	**JK35**	10/10/2002	35	4.2	0	0.08	1.33	11	100
4,Blue,20m	**JK35**	17/10/2002							
4,Blue,20m	**JK35**	24/10/2002	28	44	0	0.43	6.19	0	140
4,Blue,20m	**JK35**	28/11/2002							
4,Blue,20m	**JK35**	21/01/2003	41						
4,Blue,20m	**JK35**	31/01/2003	47	1.7	0	0.05	0.12	0	170
4,Blue,20m	**JK35**	14/02/2003	47	1.1	0	0.05	0.11	0	130
4,Blue,20m	**JK35**	27/02/2003	19	2	0.03	1.4	0.96	0	110
4,Blue,20m	**JK35**	13/03/2003							
4,Blue,20m	**JK35**	11/04/2003		0.8	0	4.3	0.39	0	80
4,Blue,20m	**JK35**	23/04/2003	16	0.7	0	0	2.08	0	80
4,Blue,20m	**JK35**	07/05/2003	26			0			100
4,Blue,20m	**JK35**	29/05/2003	47	0.86	0.012	0.017	0.42	2.57	150
4,Blue,20m	**JK35**	10/06/2003	37	5.2	0.008	0.018	0.03	3.2	200
4,Blue,20m	**JK35**	25/06/2003	92	8.3	0.14	0.53	0.92	23	200
4,Blue,20m	**JK35**	09/07/2003	0	7.6	0.13	8.3	0.59	32	180
4,Blue,20m	**JK35**	22/07/2003	17	1.2	0.03	0	0	0	250

4,Black,20m	**JK36**	09/08/2002	30	5.2	<0.005	0.37	0.54	26	110
4,Black,20m	**JK36**	15/08/2002	22	4.4	0.1	0.25	0.41	33	100
4,Black,20m	**JK36**	22/08/2002	55	0	<0.005	<0.01	4.26	0	150
4,Black,20m	**JK36**	27/08/2002	94	1.1	<0.005	0.65	4	2	160
4,Black,20m	**JK36**	12/09/2002	73	0.3	<0.005	<0.01	0.55	14	220
4,Black,20m	**JK36**	26/09/2002	49	2.4	<0.02	0.01	0.16	<10	170
4,Black,20m	**JK36**	10/10/2002	75	2.7	0	0.04	4.53	5.4	150
4,Black,20m	**JK36**	17/10/2002							
4,Black,20m	**JK36**	24/10/2002	18	3.7	0	0.11	6.8	0	130
4,Black,20m	**JK36**	28/11/2002							
4,Black,20m	**JK36**	21/01/2003	31						
4,Black,20m	**JK36**	31/01/2003	23	0.6	0	0.02	0.26	0	80
4,Black,20m	**JK36**	14/02/2003	46	2.3	0.01	0.14	0.01	0	150
4,Black,20m	**JK36**	27/02/2003	19	3.4	0.02	2	0.46	0	140
4,Black,20m	**JK36**	13/03/2003							
4,Black,20m	**JK36**	11/04/2003		0	0.01	1.6	4.07	10	80
4,Black,20m	**JK36**	23/04/2003	16	0.8	0	0	1.78	0	120
4,Black,20m	**JK36**	07/05/2003	28			0			110
4,Black,20m	**JK36**	29/05/2003	34	1.09	0.014	0	0.02	3.43	170
4,Black,20m	**JK36**	10/06/2003	35	4.7	0.06	0.011	0	3.26	240
4,Black,20m	**JK36**	25/06/2003	82	7.9	0.13	0.5	0.59	25	280
4,Black,20m	**JK36**	09/07/2003	0	7.3	0.11	8.7	0.7	27	250
4,Black,20m	**JK36**	22/07/2003	25	0.3	0.01	0	0.26	0	250

3, TS, 2m	**A**	15/08/2002	221	19.2				282	7
3, TS, 2m	**A**	22/08/2002	96	85.2	<0.005	0.87	1.68	83	250
3, TS, 2m	**A**	27/08/2002	118	58	<0.005	3.08	-	83	220
3, TS, 2m	**A**	12/09/2002	154	110	-	-	-	103	
3, TS, 2m	**A**	26/09/2002							
3, TS, 2m	**A**	10/10/2002							
3, TS, 2m	**A**	24/10/2002	70	59.3	0	1.83	1.57	34	200
3, TS, 2m	**A**	21/01/2003	125						
3, TS, 2m	**A**	14/02/2003							
3, TS, 2m	**A**	27/02/2003	294						5
3, TS, 2m	**A**	11/04/2003		18.2	0.1	1.9	0.44	22	35
3, TS, 2m	**A**	07/05/2003	92			0			190

3, TS, 7m	**B**	15/08/2002	20	4.3	0.1	0.32	0.45	38	180
3, TS, 7m	**B**	22/08/2002	59	0.6	<0.005	<0.01	2.58	0	170
3, TS, 7m	**B**	27/08/2002	94	0.5	<0.005	0.56	-	4	170
3, TS, 7m	**B**	12/09/2002	57	0.4	<0.005	0.4	0.17	16	
3, TS, 7m	**B**	26/09/2002	119	2.8	<0.02	0.09	6.01	6.01	140
3, TS, 7m	**B**	10/10/2002							
3, TS, 7m	**B**	24/10/2002	123	3.7	0	0.2	3.21	0	180
3, TS, 7m	**B**	21/01/2003	40						
3, TS, 7m	**B**	14/02/2003	59	0.9	0	0.18	0.06	0	100
3, TS, 7m	**B**	27/02/2003	26	4.2	0.04	0	0.36	0	120
3, TS, 7m	**B**	11/04/2003		3.2	0.02	0	0.22	0	130
3, TS, 7m	**B**	07/05/2003	32			0			140

3, TS, 15m	**C**	15/08/2002	65	3.9	0.11	0.33	0.44	35	80
3, TS, 15m	**C**	22/08/2002	80	2.2	<0.005	0.04	4.12	1	35
3, TS, 15m	**C**	27/08/2002							
3, TS, 15m	**C**	12/09/2002	57	0.3	<0.005	<0.01	-	15	
3, TS, 15m	**C**	26/09/2002	124	3.4	<0.02	0.04	2.08	2.08	65
3, TS, 15m	**C**	10/10/2002	98	2.9	0	0.09	4.11	-	30
3, TS, 15m	**C**	24/10/2002	29	3.2	0	0.11	1.15	0	100
3, TS, 15m	**C**	21/01/2003	54						
3, TS, 15m	**C**	14/02/2003							
3, TS, 15m	**C**	27/02/2003	21	9.4	0	0.6	0.52	0	110
3, TS, 15m	**C**	11/04/2003		4.5	n/a	0	0.98	0	15
3, TS, 15m	**C**	07/05/2003	34			0			60

4, TS, 2m	**D**	15/08/2002							
4, TS, 2m	**D**	22/08/2002							
4, TS, 2m	**D**	27/08/2002							
4, TS, 2m	**D**	12/09/2002							
4, TS, 2m	**D**	26/09/2002							
4, TS, 2m	**D**	10/10/2002							
4, TS, 2m	**D**	24/10/2002							
4, TS, 2m	**D**	21/01/2003	114						
4, TS, 2m	**D**	14/02/2003							
4, TS, 2m	**D**	27/02/2003							
4, TS, 2m	**D**	11/04/2003							
4, TS, 2m	**D**	07/05/2003							

4, TS, 7m	**E**	15/08/2002	54	3.4	0.11	0.32	0.46	34	140
4, TS, 7m	**E**	22/08/2002	48	1.6	<0.005	0	4.02	0	150
4, TS, 7m	**E**	27/08/2002	72	4.2	<0.005	0.48		5	100
4, TS, 7m	**E**	12/09/2002	38	4	<0.005	0.5	-	20	
4, TS, 7m	**E**	26/09/2002	82	5.7	<0.02	0.06	0.8	0.8	110
4, TS, 7m	**E**	10/10/2002	81	4.8	0	0.28	2.18	7.5	100
4, TS, 7m	**E**	24/10/2002	144	5	0	0.07	0.85	0	150
4, TS, 7m	**E**	21/01/2003	201						
4, TS, 7m	**E**	14/02/2003	82	7	0	0.06	1.31	2	120
4, TS, 7m	**E**	27/02/2003	274	8.5	0.02	0.3	0.55	0	110
4, TS, 7m	**E**	11/04/2003		3.1	n/a	1	0.82	0	110
4, TS, 7m	**E**	07/05/2003	41			0.1			120

4, TS, 15m	**F**	15/08/2002	132	5.8		0.36		57	20
4, TS, 15m	**F**	22/08/2002	299	8.1	-	-	7.6	-	10
4, TS, 15m	**F**	27/08/2002	301	9	<0.005	-		12	10
4, TS, 15m	**F**	12/09/2002							
4, TS, 15m	**F**	26/09/2002	309	-	-	-	-	-	5
4, TS, 15m	**F**	10/10/2002	-	9.5	-	-	-	-	4
4, TS, 15m	**F**	24/10/2002	190	7.3	0.01	0.95	0.78	0	30
4, TS, 15m	**F**	21/01/2003	182						
4, TS, 15m	**F**	14/02/2003	9	2.5	N/A	0.32	0.14	N/A	15
4, TS, 15m	**F**	27/02/2003	165	4	N/A	1.3	N/A	N/A	5
4, TS, 15m	**F**	11/04/2003		0	0.01	0.5	0.88	n/a	0
4, TS, 15m	**F**	07/05/2003	96			0			20

Site 2 – Microbiological Analysis

TRENCHES

Bacteria (cfu/100ml)		JKX	JKY	JK10	JK11	JK12	JK13	JK14	JK15	JK16	JK17	JK18
Total Coliforms	*17/10/2002*		**3000000**	20000	530		<10		<100	<10		<10
	13/03/2003		**203000**	310	310		<100		<100		<100	<100
	15/05/2003	**>483840**	**77460**	84	10		69		38		4	18
	13/08/2003	**>2419200**	**130000**	14140	13000		280	<10	620	3870	1370	890
E.Coli	*17/10/2002*		**200000**	<10	<10		<10		<100	<10		<10
	13/03/2003		**31000**	<10	<100		<100		<100		<100	<100
	15/05/2003	**397260**	**4320**	<3	8		12		8		<2	14
	13/08/2003	**1413600**	**5040**	<10	<10		20	<10	<10	20	50	<10
Faecal Streptococci	*17/10/2002*		**620**	<10	<10		<10		<100	<10		<10
	13/03/2003		**63000**	<10	<100		<100		<100		<100	<100
	15/05/2003	**>483840**	**17200**	6	2		6		<2		<2	<2
	13/08/2003											
Faecal Coliforms	*13/08/2003*	**1553100**	**6010**	<10	<10	<10	40	<10	<10	30	50	<10
Enterococci	*13/08/2003*	**238200**	**600**	<20	<20	<20	<20	<20	<20	<20	<20	<20

Bacteria (cfu/100ml)		JKX	JKY	JK1	JK2	JK3	JK4	JK5	JK6	JK7	JK8	JK9
Total Coliforms	*13/08/2003*	**>2419200**	**130000**	105000	150	1300	930	430	220	340	370	1860
E.Coli	*13/08/2003*	**1413600**	**5040**	<10	<10	10	70	10	10	60	<10	<10
Faecal Coliforms	*13/08/2003*	**1553100**	**6010**	<10	<10	<10	90	10	10	70	<10	<10
Enterococci	*13/08/2003*	**238200**	**600**	<20	<20	20	<20	<20	<20	<20	<20	<20

Site 3 – Chemical Analysis

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	pH
Septic Tank	NKX	23/09/2003	1351	1.90	1.72	55.00	8.35	82	7.7
Septic Tank	NKX	30/09/2003	1270	0.80	0.00	69.10	7.85	120	
Septic Tank	NKX	28/10/2003	1692	2.35	0.44	67.85	12.60	98	8.5
Septic Tank	NKX	04/11/2003	1208	6.80		49.60	10.35	73	8.4
Septic Tank	NKX	19/11/2003	807	0.50	0.24	20.40	9.52	50.5	
Septic Tank	NKX	09/12/2003	1434	3.05		47.00	3.70	69.5	7.7
Septic Tank	NKX	17/12/2003	1033	1.25	0.47	33.75	3.13	61.5	7.2
Septic Tank	NKX	09/01/2004	680	1.20	0.21	27.30	2.73	52	7.4
Septic Tank	NKX	20/01/2004	640	1.00	0.16	29.60	3.19	60	7.0
Septic Tank	NKX	03/02/2004	1238	2.15	0.33	48.85	6.93	89.5	7.6
Septic Tank	NKX	11/02/2004	1422						
Septic Tank	NKX	18/02/2004	2088	3.40		14.20	4.50	42	7.6
Septic Tank	NKX	27/02/2004	2703	1.20	0.51	57.30	26.50	117	
Septic Tank	NKX	18/03/2004	940	1.95		54.10	7.17		

TRENCH 1

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	VOL
1,Red,0m	NK1	23/09/2003							0
1,Red,0m	NK1	30/09/2003							0
1,Red,0m	NK1	28/10/2003							0
1,Red,0m	NK1	04/11/2003							15
1,Red,0m	NK1	19/11/2003	72	21.5	0.5	11.5	0.01	33	770
1,Red,0m	NK1	09/12/2003	69	1.1		9.3	1.22	15	130
1,Red,0m	NK1	17/12/2003	97	40.6	0.73	1.5	0.01	22	35
1,Red,0m	NK1	09/01/2004							
1,Red,0m	NK1	20/01/2004							
1,Red,0m	NK1	03/02/2004	87	19	0.04	5.9	0.01	62	70
1,Red,0m	NK1	11/02/2004	458						
1,Red,0m	NK1	18/02/2004							
1,Red,0m	NK1	27/02/2004	223	9.4	0.52	8.8	0.27	33	
1,Red,0m	NK1	18/03/2004							
1,Blue,0m	NK2	23/09/2003							0
1,Blue,0m	NK2	30/09/2003							0
1,Blue,0m	NK2	28/10/2003							0
1,Blue,0m	NK2	04/11/2003							0
1,Blue,0m	NK2	19/11/2003	92	13.1	0.5	11.1	0.01	59	60
1,Blue,0m	NK2	09/12/2003	67	15.1		6.9	2.4	38	530
1,Blue,0m	NK2	17/12/2003	106	14.3	0.73	1.3	0.01	30	65
1,Blue,0m	NK2	09/01/2004							
1,Blue,0m	NK2	20/01/2004							
1,Blue,0m	NK2	03/02/2004							0
1,Blue,0m	NK2	11/02/2004	211						550
1,Blue,0m	NK2	18/02/2004	134	1.2		6.9	0.84	14	30
1,Blue,0m	NK2	27/02/2004							0
1,Blue,0m	NK2	18/03/2004							0
1,Black,0m	NK3	23/09/2003							0
1,Black,0m	NK3	30/09/2003							0
1,Black,0m	NK3	28/10/2003							0
1,Black,0m	NK3	04/11/2003							0
1,Black,0m	NK3	19/11/2003	87	1.4	0.24	15.9	0.01	68	130
1,Black,0m	NK3	09/12/2003	76	3.2		11.2	0.01	52	520
1,Black,0m	NK3	17/12/2003	41	2.2	0.26	5.3	0.01	50	190
1,Black,0m	NK3	09/01/2004							
1,Black,0m	NK3	20/01/2004							
1,Black,0m	NK3	03/02/2004	36	10.2	0.11	4.7	0.01	41	130
1,Black,0m	NK3	11/02/2004	108						10
1,Black,0m	NK3	18/02/2004	65	0.6		5.2	0.28	9	120
1,Black,0m	NK3	27/02/2004	191	7.9	1.46	10.8	0.37	36	
1,Black,0m	NK3	18/03/2004	150	3.7	1.33	2.7	1.1	19	50

1,Red,10m	**NK4**	23/09/2003							0
1,Red,10m	**NK4**	30/09/2003							0
1,Red,10m	**NK4**	28/10/2003	60	7.6	0.04	2.2	1.01	18	35
1,Red,10m	**NK4**	04/11/2003	61	12.7		1.3	0.46	3	30
1,Red,10m	**NK4**	19/11/2003	56	7.2	0.1	0.01	0.01	5	370
1,Red,10m	**NK4**	09/12/2003	50	4.5		8.9	0.01	2	470
1,Red,10m	**NK4**	17/12/2003	17	5.5	0.12	0.01	0.01	7	230
1,Red,10m	**NK4**	09/01/2004							
1,Red,10m	**NK4**	20/01/2004							
1,Red,10m	**NK4**	03/02/2004	45	40.6	0.01	5.9	0.01	15	270
1,Red,10m	**NK4**	11/02/2004	76						
1,Red,10m	**NK4**	18/02/2004	53	3.4	0.01	0.01			40
1,Red,10m	**NK4**	27/02/2004							
1,Red,10m	**NK4**	18/03/2004	138	5.3	0.03	1.4	0.67	17	200
1,Blue,10m	**NK5**	23/09/2003							5
1,Blue,10m	**NK5**	30/09/2003	104	12.5	0.05	0.6	0.01	14	60
1,Blue,10m	**NK5**	28/10/2003		9.4	0.01	3.7	0.01	10	310
1,Blue,10m	**NK5**	04/11/2003	35	12.1		1	0.01	2	210
1,Blue,10m	**NK5**	19/11/2003	45	3	0.45	0.6	0.01	14	1000
1,Blue,10m	**NK5**	09/12/2003	45	3.1		3.2	0.01	2	1200
1,Blue,10m	**NK5**	17/12/2003	42	2.9	0.15	0.01	0.01	11	850
1,Blue,10m	**NK5**	09/01/2004							
1,Blue,10m	**NK5**	20/01/2004							
1,Blue,10m	**NK5**	03/02/2004	44	9.6	0.04	7	0.01	27	190
1,Blue,10m	**NK5**	11/02/2004	82						
1,Blue,10m	**NK5**	18/02/2004							
1,Blue,10m	**NK5**	27/02/2004							
1,Blue,10m	**NK5**	18/03/2004	111	16.4	0.01	1.5	0.5	12	400
1,Black,10m	**NK6**	23/09/2003							0
1,Black,10m	**NK6**	30/09/2003							0
1,Black,10m	**NK6**	28/10/2003	41	5.4	0.11	0.6	0.01	7	35
1,Black,10m	**NK6**	04/11/2003	42	10.8		3.2	3.39	7	100
1,Black,10m	**NK6**	19/11/2003	46	5.2	0.25	1.1	0.01	18	1050
1,Black,10m	**NK6**	09/12/2003	37	3.2		2.5	0.01	2	1750
1,Black,10m	**NK6**	17/12/2003	129	2	0.15	0.01	0.01	6	1290
1,Black,10m	**NK6**	09/01/2004							
1,Black,10m	**NK6**	20/01/2004							
1,Black,10m	**NK6**	03/02/2004	58	3.6	0.01	5	0.01	21	800
1,Black,10m	**NK6**	11/02/2004	70						
1,Black,10m	**NK6**	18/02/2004	43	1.8	0.01	0.01	0.01	8	480
1,Black,10m	**NK6**	27/02/2004							
1,Black,10m	**NK6**	18/03/2004	138	9.7	0.02	0.9	1.01	11	300

1,Red,20m	**NK7**	23/09/2003							0
1,Red,20m	**NK7**	30/09/2003							0
1,Red,20m	**NK7**	28/10/2003	0	3.6	0.06	0.5	0.01	7	190
1,Red,20m	**NK7**	04/11/2003	45	9.9		1.7	0.01	2	270
1,Red,20m	**NK7**	19/11/2003	12	4.7	0.04	0.01	0.01	5	830
1,Red,20m	**NK7**	09/12/2003	48	1.6		2	0.01	2	740
1,Red,20m	**NK7**	17/12/2003	100	3.9	0.13	0.01	0.01	12	550
1,Red,20m	**NK7**	09/01/2004							
1,Red,20m	**NK7**	20/01/2004							
1,Red,20m	**NK7**	03/02/2004	50	6.5	0.01		0.01	18	
1,Red,20m	**NK7**	11/02/2004	54						
1,Red,20m	**NK7**	18/02/2004	37	7.4		0.01	0.01	12	460
1,Red,20m	**NK7**	27/02/2004	217	2.3	0.01	9.3	0.15	21	
1,Red,20m	**NK7**	18/03/2004	128	10.7	0.02	2.9	1.01	9	500
1,Blue,20m	**NK8**	23/09/2003							0
1,Blue,20m	**Nk8**	30/09/2003							0
1,Blue,20m	**NK8**	28/10/2003							0
1,Blue,20m	**NK8**	04/11/2003							0
1,Blue,20m	**NK8**	19/11/2003	37	15.3	0.01	0.01	0.01	8	580
1,Blue,20m	**NK8**	09/12/2003	50	15.8		22.3	0.01	2	1350
1,Blue,20m	**NK8**	17/12/2003	80	9	0.13	0.01	0.01	15	700
1,Blue,20m	**NK8**	09/01/2004							
1,Blue,20m	**NK8**	20/01/2004							
1,Blue,20m	**NK8**	03/02/2004	65	8.3	0.01		0.01	20	
1,Blue,20m	**NK8**	11/02/2004	82						
1,Blue,20m	**NK8**	18/02/2004	36	3.1	0.01		0.01	7	30
1,Blue,20m	**NK8**	27/02/2004	210	5.8	0.01	8.5	0.22	20	
1,Blue,20m	**NK8**	18/03/2004	84	6.5	0.02	0.8	0.66	18	200
1,Black,20m	**NK9**	23/09/2003							0
1,Black,20m	**NK9**	30/09/2003							0
1,Black,20m	**NK9**	28/10/2003							0
1,Black,20m	**NK9**	04/11/2003	29	21.5		1.2	0.01	9	500
1,Black,20m	**NK9**	19/11/2003	33	3.2	0.01	1	0.01	9	1020
1,Black,20m	**NK9**	09/12/2003	37	4.5		0.01	0.01	2	1750
1,Black,20m	**NK9**	17/12/2003		2.1	0.12	0.01	0.01	10	1420
1,Black,20m	**NK9**	09/01/2004							
1,Black,20m	**NK9**	20/01/2004							
1,Black,20m	**NK9**	03/02/2004	85	2.3	0.01		0.01	21	
1,Black,20m	**NK9**	11/02/2004	68						
1,Black,20m	**NK9**	18/02/2004	18	2.6		4.8	0.01	6	
1,Black,20m	**NK9**	27/02/2004	228	2.9	0.01	8	0.37	11	
1,Black,20m	**NK9**	18/03/2004	248	6	0.02	1.9	1.59	12	150

TRENCH 2

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	VOL
2,Red,0m	NK10	23/09/2003							0
2,Red,0m	NK10	30/09/2003	86	25	0.12	1.3	0.42	34	25
2,Red,0m	NK10	28/10/2003	2	10	0.01	0.2	0.01	49	120
2,Red,0m	NK10	04/11/2003	69	22.6		9.4	0.01	62	40
2,Red,0m	NK10	19/11/2003	41	10	0.03	1.7	0.03	54	140
2,Red,0m	NK10	09/12/2003							0
2,Red,0m	NK10	17/12/2003	2	27.1	0.87	0.01	0.01	33	110
2,Red,0m	NK10	09/01/2004							
2,Red,0m	NK10	20/01/2004							
2,Red,0m	NK10	03/02/2004	47	85.9	0.05	7.9	0.01	32	
2,Red,0m	NK10	11/02/2004	104						
2,Red,0m	NK10	18/02/2004	33	14.3		2	0.24	22	5
2,Red,0m	NK10	27/02/2004	225	18	0.14	6.1	0.19	31	
2,Red,0m	NK10	18/03/2004	200	51.2	0.05	2	1.18	56	250
2,Blue,0m	NK11	23/09/2003							0
2,Blue,0m	NK11	30/09/2003							0
2,Blue,0m	NK11	28/10/2003	68	1.2	0.04	4.2	0.01	68	160
2,Blue,0m	NK11	04/11/2003							0
2,Blue,0m	NK11	19/11/2003	67	19.3	0.6	17.2	0.01	41	820
2,Blue,0m	NK11	09/12/2003	58	32.1		12.8	0.01	21	700
2,Blue,0m	NK11	17/12/2003	19	50.1	1.21	5.8	0.01	3	230
2,Blue,0m	NK11	09/01/2004							
2,Blue,0m	NK11	20/01/2004							
2,Blue,0m	NK11	03/02/2004	67	91.8	0.59	5.3	0.01	37	
2,Blue,0m	NK11	11/02/2004	128						
2,Blue,0m	NK11	18/02/2004	35	10.8		0.01	0.01	10	5
2,Blue,0m	NK11	27/02/2004	228		0.7	10.2	0.06	60	
2,Blue,0m	NK11	18/03/2004							
2,Black,0m	NK12	23/09/2003	44	6.3	0.36	0.01	0.01	53	90
2,Black,0m	NK12	30/09/2003	155	5.2	0.08	1.9	0.01	55	70
2,Black,0m	NK12	28/10/2003	56	1.4	0.05	3.5	0.01	58	290
2,Black,0m	NK12	04/11/2003	46	7.3		2.4	0.01	68	100
2,Black,0m	NK12	19/11/2003	34	1.5	0.06	4.5	0.01	24	690
2,Black,0m	NK12	09/12/2003	41	5.3		1.1	0.01	11	820
2,Black,0m	NK12	17/12/2003	61	3.2	0.18	0.01	0.01	9	340
2,Black,0m	NK12	09/01/2004							
2,Black,0m	NK12	20/01/2004							
2,Black,0m	NK12	03/02/2004	50	11.4	0.22	6.3	0.01	44	
2,Black,0m	NK12	11/02/2004	82						
2,Black,0m	NK12	18/02/2004	43	2.9		0.01	0.01	9	90
2,Black,0m	NK12	27/02/2004	193	8.5		10.7	0.17	71	
2,Black,0m	NK12	18/03/2004	172	31.4	0.56	2.7	0.59	38	200

2,Red,10m	**NK13**	23/09/2003							0
2,Red,10m	**NK13**	30/09/2003	78	7.2	0.09	0.01	0.01	28	60
2,Red,10m	**NK13**	28/10/2003	11	13.3	0.01	0.01	0.01	4	340
2,Red,10m	**NK13**	04/11/2003		27.4		3.1	0.33	60	35
2,Red,10m	**NK13**	19/11/2003	26	14.1	0.01	0.01	0.86	3	340
2,Red,10m	**NK13**	09/12/2003	36	22.4		6	0.01	2	300
2,Red,10m	**NK13**	17/12/2003	44	28.9	0.1	0.3	0.01	5	290
2,Red,10m	**NK13**	09/01/2004							
2,Red,10m	**NK13**	20/01/2004							
2,Red,10m	**NK13**	03/02/2004	74	68.6	0.06	5.4	0.01	34	
2,Red,10m	**NK13**	11/02/2004	76						
2,Red,10m	**NK13**	18/02/2004	38	3.4		0.01	0.12	5	80
2,Red,10m	**NK13**	27/02/2004							
2,Red,10m	**NK13**	18/03/2004	74	42.2	0.01	1.4	0.41	28	150
2,Blue,10m	**NK14**	23/09/2003							0
2,Blue,10m	**NK14**	30/09/2003							0
2,Blue,10m	**NK14**	28/10/2003	29	7.8	0.03	1.6	0.01	10	80
2,Blue,10m	**NK14**	04/11/2003	43	10.2		1.2	0.67	12	400
2,Blue,10m	**NK14**	19/11/2003	32	6.2	0.01	0.01	0.57	10	680
2,Blue,10m	**NK14**	09/12/2003	41	5.2		1.4	0.01	2	700
2,Blue,10m	**NK14**	17/12/2003		7.3	0.13	3.5	0.01	3	250
2,Blue,10m	**NK14**	09/01/2004							
2,Blue,10m	**NK14**	20/01/2004							
2,Blue,10m	**NK14**	03/02/2004	49	4.7	0.01	8.6	0.01	12	
2,Blue,10m	**NK14**	11/02/2004	48						
2,Blue,10m	**NK14**	18/02/2004	40	2.8		2.1	0.01	7	250
2,Blue,10m	**NK14**	27/02/2004	180	5.2	0.27	7.7	0.21		
2,Blue,10m	**NK14**	18/03/2004	86	4.2	0.02	1.3	0.22	21	400
2,Black,10m	**NK15**	23/09/2003							0
2,Black,10m	**NK15**	30/09/2003							0
2,Black,10m	**NK15**	28/10/2003	43	3.1	0.06	0.01	0.01	11	60
2,Black,10m	**NK15**	04/11/2003	38	13.1		1.4	0.22	2	170
2,Black,10m	**NK15**	19/11/2003	33	8.4	0.01	0	0.01	8	740
2,Black,10m	**NK15**	09/12/2003	75	7.1		17.7	0.01	2	970
2,Black,10m	**NK15**	17/12/2003	37	13	0.17	0.5	0.01	9	330
2,Black,10m	**NK15**	09/01/2004							
2,Black,10m	**NK15**	20/01/2004							
2,Black,10m	**NK15**	03/02/2004	49	15.6	0.03	6.8	0.01	15	
2,Black,10m	**NK15**	11/02/2004	54						
2,Black,10m	**NK15**	18/02/2004	51	12		0.01	0.01	4	400
2,Black,10m	**NK15**	27/02/2004	210	4.1		7	0.09	12	
2,Black,10m	**NK15**	18/03/2004	104	9.2	0.04	0.3	0.01	17	150

2,Red,20m	**NK16**	23/09/2003	119	7.5	0.2	0.01	0.37	5	30
2,Red,20m	**NK16**	30/09/2003							0
2,Red,20m	**NK16**	28/10/2003	27	9	0.06	1.4	0.01	6	190
2,Red,20m	**NK16**	04/11/2003	49	20.4		0.6	0.23	4	160
2,Red,20m	**NK16**	19/11/2003	34	9.8	0.01	0.01	0.85	1	200
2,Red,20m	**NK16**	09/12/2003	39	6.5		0.5	0.01	2	35
2,Red,20m	**NK16**	17/12/2003	90	15.8	0.13	1.8	0.01	12	180
2,Red,20m	**NK16**	09/01/2004							
2,Red,20m	**NK16**	20/01/2004							
2,Red,20m	**NK16**	03/02/2004	36	22.9	0.06		0.01	18	
2,Red,20m	**NK16**	11/02/2004	48						
2,Red,20m	**NK16**	18/02/2004	63	0.8		0.01	0.1	9	180
2,Red,20m	**NK16**	27/02/2004	199	14.7	0.34	5.8	0.26	7	
2,Red,20m	**NK16**	18/03/2004	98	23.4	0.04	0.3	0.43	18	300
2,Blue,20m	**NK17**	23/09/2003							0
2,Blue,20m	**NK17**	30/09/2003							0
2,Blue,20m	**NK17**	28/10/2003	32	5.8	0.12	2	0.64	9	25
2,Blue,20m	**NK17**	04/11/2003	48	19		1.7	0.37	12	60
2,Blue,20m	**NK17**	19/11/2003	24	12	0.01	0.5	1.19	8	460
2,Blue,20m	**NK17**	09/12/2003	45	15.1		0	0.01	2	370
2,Blue,20m	**NK17**	17/12/2003	9	17.1	0.11	1.6	0.01	5	140
2,Blue,20m	**NK17**	09/01/2004							
2,Blue,20m	**NK17**	20/01/2004							
2,Blue,20m	**NK17**	03/02/2004	36	14.6	0.01		0.01	18	
2,Blue,20m	**NK17**	11/02/2004	60						
2,Blue,20m	**NK17**	18/02/2004	42	1.2		0.01	0.01	5	120
2,Blue,20m	**NK17**	27/02/2004	186	9.2	0.01	6.5	0.03	8	
2,Blue,20m	**NK17**	18/03/2004	94	11.2	0.03	1.3	0.69	11	200
2,Black,20m	**NK18**	23/09/2003							0
2,Black,20m	**NK18**	30/09/2003							0
2,Black,20m	**NK18**	28/10/2003	48	1.2	0.02	2.2	0.01	10	55
2,Black,20m	**NK18**	04/11/2003							0
2,Black,20m	**NK18**	19/11/2003	13	2.4	0.01	0.8	1.15	2	400
2,Black,20m	**NK18**	09/12/2003	42	2.4		0.01	0.01	2	470
2,Black,20m	**NK18**	17/12/2003	49	3.4	0.09	0.7	0.01	7	180
2,Black,20m	**NK18**	09/01/2004							
2,Black,20m	**NK18**	20/01/2004							
2,Black,20m	**NK18**	03/02/2004	54	3	0.02		0.01	11	
2,Black,20m	**NK18**	11/02/2004	52						
2,Black,20m	**NK18**	18/02/2004	44	0.4		0.01	0.01	4	450
2,Black,20m	**NK18**	27/02/2004	197	3.4	0.01	6.7	0.08	6	
2,Black,20m	**NK18**	18/03/2004	84	3	0.15	0.7	0.41	15	120

Site 3 - Stratified Sand Filter

Inside sand filter

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	pH	VOL
Top sand filter	**NKA**	23/09/2003	394	1.5	0.47	15	1.71	63	7.42	100
Top sand filter	**NKA**	30/09/2003	229	5	0.83	16.5	0.73	91		80
Top sand filter	**NKA**	28/10/2003	400	0.7	0.16	32.2	6.65	84	8.38	90
Top sand filter	**NKA**	04/11/2003	340	7.8		20.1	2.42	46	8.45	70
Top sand filter	**NKA**	19/11/2003	362	3.2	0.38	16.3	2.87	37		70
Top sand filter	**NKA**	09/12/2003								0
Top sand filter	**NKA**	17/12/2003								0
Top sand filter	**NKA**	09/01/2004	630	0.7	0.4	20.2	5.38	35		25
Top sand filter	**NKA**	20/01/2004	370	0.4	0.18	42	2.26	59	6.93	
Top sand filter	**NKA**	03/02/2004	518	2.2	0.39	39.5	4.29	78	7.59	
Top sand filter	**NKA**	11/02/2004	684							
Top sand filter	**NKA**	18/02/2004	1092	8.4		18.3	8.42	37	7.76	65
Top sand filter	**NKA**	27/02/2004	922	1.8	0.93	49.5	7.8	146	7.55	
Top sand filter	**NKA**	18/03/2004	734	2.4	0.32	46.2	4.8	91	6.89	
Middle sand filter	**NKB**	23/09/2003								0
Middle sand filter	**NKB**	30/09/2003								0
Middle sand filter	**NKB**	28/10/2003								0
Middle sand filter	**NKB**	04/11/2003	338	11.9		14.9	1.84	48	8.06	70
Middle sand filter	**NKB**	19/11/2003	124	10.4	0.07	11.4	2.04	35		70
Middle sand filter	**NKB**	09/12/2003	150	52.2		4.7		30	7.9	70
Middle sand filter	**NKB**	17/12/2003								0
Middle sand filter	**NKB**	09/01/2004	348	0.2	0.32	14		31	7.72	70
Middle sand filter	**NKB**	20/01/2004	290	0.2	0.1	50	1.04	45	7.09	
Middle sand filter	**NKB**	03/02/2004	156	6	0.99	29.1	0.95	43	7.72	
Middle sand filter	**NKB**	11/02/2004	362							
Middle sand filter	**NKB**	18/02/2004	254	7.3		12.9	6.94	23	7.39	60
Middle sand filter	**NKB**	27/02/2004	212	5		18.5	0.52	54	7.8	
Middle sand filter	**NKB**	18/03/2004								0
Bottom sand filter	**NKC**	23/09/2003								0
Bottom sand filter	**NKC**	30/09/2003								0
Bottom sand filter	**NKC**	28/10/2003								0
Bottom sand filter	**NKC**	04/11/2003								0
Bottom sand filter	**NKC**	19/11/2003	164	14.1	0.12		0.01	33		Flooded
Bottom sand filter	**NKC**	09/12/2003								0
Bottom sand filter	**NKC**	17/12/2003	246	8.8	0.03	5		23	7.13	70
Bottom sand filter	**NKC**	09/01/2004	320	1.3	0.2	12.6		29	7.51	60
Bottom sand filter	**NKC**	20/01/2004	310	0	0.06	39	0.23	41	7.11	
Bottom sand filter	**NKC**	03/02/2004	196	6	0.96	17.3	1.11	44	7.88	
Bottom sand filter	**NKC**	11/02/2004	214							
Bottom sand filter	**NKC**	18/02/2004	256	2.8		10.6	5.12	20	7.51	
Bottom sand filter	**NKC**	27/02/2004								
Bottom sand filter	**NKC**	18/03/2004								

Top sand filter	**NKD**	23/09/2003	895	4	0.52	20	2.79	80	7.54	50
Top sand filter	**NKD**	30/09/2003	366	1.4	0.35	32.8	3.96	106		60
Top sand filter	**NKD**	28/10/2003	758	4.2	0.24	43.6	10.2	108	8.43	55
Top sand filter	**NKD**	04/11/2003	516	11.7		25.9	2.66	53	8.59	35
Top sand filter	**NKD**	19/11/2003	291	2	0.09	21.9	3.7	65		70
Top sand filter	**NKD**	09/12/2003	496	3.4		18		57	8.26	70
Top sand filter	**NKD**	17/12/2003								0
Top sand filter	**NKD**	09/01/2004								15
Top sand filter	**NKD**	20/01/2004								
Top sand filter	**NKD**	03/02/2004								
Top sand filter	**NKD**	11/02/2004	494							
Top sand filter	**NKD**	18/02/2004	932	6.1		17.1	7.38	29	7.43	120
Top sand filter	**NKD**	27/02/2004								
Top sand filter	**NKD**	18/03/2004	394	5.9	0.07	31.5	4.45	85	6.7	
Middle sand filter	**NKE**	23/09/2003								0
Middle sand filter	**NKE**	30/09/2003								0
Middle sand filter	**NKE**	28/10/2003								0
Middle sand filter	**NKE**	04/11/2003	260	27.9		1.9	0.28	25	8.71	40
Middle sand filter	**NKE**	19/11/2003	128	14.9	0.35	6.7	0.01	39		60
Middle sand filter	**NKE**	09/12/2003								0
Middle sand filter	**NKE**	17/12/2003								0
Middle sand filter	**NKE**	09/01/2004	226	0.9	0.13	2.3	0.01	18	7.95	50
Middle sand filter	**NKE**	20/01/2004	240	0.7	0.02	39	0.07	36	7.19	
Middle sand filter	**NKE**	03/02/2004								
Middle sand filter	**NKE**	11/02/2004	408							
Middle sand filter	**NKE**	18/02/2004	586	5.8		8.2	7.1	18	7.27	65
Middle sand filter	**NKE**	27/02/2004								
Middle sand filter	**NKE**	18/03/2004	342	5	0.24	23.3	1.24	74	6.82	
Bottom sand filter	**NKF**	23/09/2003								0
Bottom sand filter	**NKF**	30/09/2003								0
Bottom sand filter	**NKF**	28/10/2003								0
Bottom sand filter	**NKF**	04/11/2003								0
Bottom sand filter	**NKF**	19/11/2003	66	17.8	0.1	2.2	0.01	38		Flooded
Bottom sand filter	**NKF**	09/12/2003								0
Bottom sand filter	**NKF**	17/12/2003								0
Bottom sand filter	**NKF**	09/01/2004	244	1.8	0.14	8.8		18	7.56	60
Bottom sand filter	**NKF**	20/01/2004	230	2.3	0.06	22	0.27	28	7.11	
Bottom sand filter	**NKF**	03/02/2004								
Bottom sand filter	**NKF**	11/02/2004	248							
Bottom sand filter	**NKF**	18/02/2004	250	4.1		11.8	5.4	25	7.6	65
Bottom sand filter	**NKF**	27/02/2004								
Bottom sand filter	**NKF**	18/03/2004	270	26.5	0.18	2.7	1.29	50	6.58	

Beneath sand filter

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	pH	VOL
Right red front of sand	NK19	23/09/2003	48	34.4	0.3	0	0.34	44	6.65	70
Right red front of sand	NK19	30/09/2003	103	3	0.08	1.3	0.27	19		90
Right red front of sand	NK19	28/10/2003	30	42	0.03	1.5	0.01	65	6.95	120
Right red front of sand	NK19	04/11/2003	42	43.7		1.6	0.22	67	7.43	70
Right red front of sand	NK19	19/11/2003	34	21.7	0.01	0.01	0.01	25		870
Right red front of sand	NK19	09/12/2003	76	16.9		0.01	0.01	13	7.04	1100
Right red front of sand	NK19	17/12/2003	112	13.9	0.01	1.2	0.01	19	6.71	120
Right red front of sand	NK19	09/01/2004	82	12.5	0.73	2.2	0.01	23	6.63	1070
Right red front of sand	NK19	20/01/2004	57	5.1	0.24	19	0.01	41	6.68	
Right red front of sand	NK19	03/02/2004	63	2.3	0.12	5.2	0.01	35	7.06	
Right red front of sand	NK19	11/02/2004	102							
Right red front of sand	NK19	18/02/2004	64	12.8		2.3	**2.3**	17	6.84	440
Right red front of sand	NK19	27/02/2004	189	2.3	0.07	5.5	0.11	29	7.21	
Right red front of sand	NK19	18/03/2004	108	1.3	0.05	2.3	0.59	23	7.3	200
Right blue front of sand	NK20	23/09/2003	57	4.1	0.05	0.01	0.01	24	6.55	100
Right blue front of sand	NK20	30/09/2003								0
Right blue front of sand	NK20	28/10/2003	14	14.1	0.05	0.2	0.01	22	6.8	280
Right blue front of sand	NK20	04/11/2003	36	22.8		1.4	0.01	24	7.04	170
Right blue front of sand	NK20	19/11/2003	20	18.2	0.06	0.01	0.01	24		680
Right blue front of sand	NK20	09/12/2003	43	16.5		0.01	0.01	19	7.03	1000
Right blue front of sand	NK20	17/12/2003	14	7	0.01	0.9	0.01	23	6.46	380
Right blue front of sand	NK20	09/01/2004	43	12.8	0.18	0.26	0.01	18	6.58	1000
Right blue front of sand	NK20	20/01/2004	63	5.6	0.06	0.12	0.01	26	6.63	
Right blue front of sand	NK20	03/02/2004	59	3.2	0.02	8.3	0.01	30	6.91	
Right blue front of sand	NK20	11/02/2004	134							
Right blue front of sand	NK20	18/02/2004	160	12.4		0.01	0.01	12	7.04	230
Right blue front of sand	NK20	27/02/2004								0
Right blue front of sand	NK20	18/03/2004								0
Right black front of sand	NK21	23/09/2003	35	3.4	0.03	0.01	0.01	6	6.83	100
Right black front of sand	NK21	30/09/2003	150	2	0.05	0.7	0.24	13		50
Right black front of sand	NK21	28/10/2003	48	8.5	0.02	0.01	0.01	12	6.97	210
Right black front of sand	NK21	04/11/2003	50	14		1	0.12	8	7.63	270
Right black front of sand	NK21	19/11/2003	3	15.1	0.01	0.01	0.01	19		1070
Right black front of sand	NK21	09/12/2003	49	14		0.01	0.01	13	6.85	2050
Right black front of sand	NK21	17/12/2003	32	12.7	0.01	1.6	0.01	22	6.22	760
Right black front of sand	NK21	09/01/2004	66	6.6	0.43	0.1	0.01	19	6.44	1630
Right black front of sand	NK21	20/01/2004	40	4.1	0.26	0.2	0.01	24	6.56	
Right black front of sand	NK21	03/02/2004	68	1.7	0.03	8.9	0.01	38	6.87	
Right black front of sand	NK21	11/02/2004	87							
Right black front of sand	NK21	18/02/2004	59	8.9		0.01	0.01	10	7.12	540
Right black front of sand	NK21	27/02/2004	176	1.1	0.01	6.7	0.04	30	6.9	
Right black front of sand	NK21	18/03/2004	110	2.1	0.02	1.4		16	7.08	350

Left red front of sand	**NK22**	23/09/2003	64	1.5	0.02	0.01	0.01	9	6.93	70
Left red front of sand	**NK22**	30/09/2003	101	40.5	0.4	0.01	0.51	65		65
Left red front of sand	**NK22**	28/10/2003	30	1.5	0.03	0.01	0.01	8	7.16	270
Left red front of sand	**NK22**	04/11/2003	37	9.7		0.1	0.14	8	8	35
Left red front of sand	**NK22**	19/11/2003								-
Left red front of sand	**NK22**	09/12/2003								-
Left red front of sand	**NK22**	17/12/2003								-
Left red front of sand	**NK22**	09/01/2004								
Left red front of sand	**NK22**	20/01/2004								
Left red front of sand	**NK22**	03/02/2004								
Left red front of sand	**NK22**	11/02/2004	84							
Left red front of sand	**NK22**	18/02/2004	44	2.8		0.01	0.62	18	7.14	45
Left red front of sand	**NK22**	27/02/2004								
Left red front of sand	**NK22**	18/03/2004	112	9.8	0.09	1.5	0.73	34	7.82	120
Left blue front of sand	**NK23**	23/09/2003								0
Left blue front of sand	**NK23**	30/09/2003	124	7.1	0.04	1.9	0.01	16		90
Left blue front of sand	**NK23**	28/10/2003	38	2.9	0.04	0.2	0.01	8	7.42	50
Left blue front of sand	**NK23**	04/11/2003								0
Left blue front of sand	**NK23**	19/11/2003								-
Left blue front of sand	**NK23**	09/12/2003								-
Left blue front of sand	**NK23**	17/12/2003								-
Left blue front of sand	**NK23**	09/01/2004								
Left blue front of sand	**NK23**	20/01/2004								
Left blue front of sand	**NK23**	03/02/2004								
Left blue front of sand	**NK23**	11/02/2004	70							
Left blue front of sand	**NK23**	18/02/2004	65	1.4		0.01	0.3	14	7.28	300
Left blue front of sand	**NK23**	27/02/2004								
Left blue front of sand	**NK23**	18/03/2004	116	3.9	0.01	1.2	0.41	34	7.41	250
Left black front of sand	**NK24**	23/09/2003								75
Left black front of sand	**NK24**	30/09/2003	83	3.7	0.01	0.9	0.01	12		80
Left black front of sand	**NK24**	28/10/2003	74	1.2	0.05	0.5	0.01	9	7.03	160
Left black front of sand	**NK24**	04/11/2003								70
Left black front of sand	**NK24**	19/11/2003								-
Left black front of sand	**NK24**	09/12/2003								-
Left black front of sand	**NK24**	17/12/2003								-
Left black front of sand	**NK24**	09/01/2004								
Left black front of sand	**NK24**	20/01/2004								
Left black front of sand	**NK24**	03/02/2004								
Left black front of sand	**NK24**	11/02/2004	82							
Left black front of sand	**NK24**	18/02/2004	51	1.7		0.01	0.28	8	7.49	610
Left black front of sand	**NK24**	27/02/2004								
Left black front of sand	**NK24**	18/03/2004	112	1.5	0.03	1.5	0.14	23	7.48	200

Site 3 – Microbiological Analysis

TRENCHES

Bacteria (cfu/100ml)		**NKX**	**NK10**	**NK11**	**NK12**	**NK13**	**NK14**	**NK15**	**NK16**	**NK17**	**NK18**
Total Coliforms	*02/12/2003*	**6880000000**	1160	75800	472	1096	456	156	156	42	210
	11/03/2004	**241900000**	260		20		840	<10	20	<10	
E.Coli	*02/12/2003*	**344000**	<2	<2	<2	<2	<2	<2	<2	<2	<2
	11/03/2004	**24190**	20		<10		20	<10	<10	<10	
Enterococci	*02/12/2003*	**6000**	<2	<2	<2	4	<2	<2	<2	<2	<2
	11/03/2004										
Faecal Coliforms	*02/12/2003*	**520000**	<2	<2	<2	<2	<2	<2	<2	<2	<2
	11/03/2004										

FILTER

Bacteria (cfu/100ml)		**NKX**	**NKA**	**NKB**	**NKC**	**NK19**	**NK20**	**NK21**
Total Coliforms	*02/12/2003*	**6880000000**	6520000000	967600000	13200000	730	428	176
	23/01/2004	**1723000000**	959000000	11199000	201000000	201000	20000	3448000
	11/03/2004	**241900000**	24190000		100000	680		1030
E.Coli	*02/12/2003*	**344000**	154000	40000	870	<2	<2	<2
	23/01/2004	**5170**	10	20	20	10	20	10
	11/03/2004	**24190**	24190		10	<10		<10
Enterococci	*02/12/2003*	**6000**	4838	28000	4838	<2	<2	<2
	23/01/2004							
	11/03/2004							
Faecal Coliforms	*02/12/2003*	**520000**	248000	40000	1226	<2	<2	<2
	23/01/2004							
	11/03/2004							

Site 4 – Chemical Analysis

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	pH
Puraflo	**JHY**	**23/09/2003**	102	45.2	0.1	4.7	5.3	30	6.16
	JHY	**30/09/2003**	130	49.6	1.1	0	5.55	73	6.02
	JHY	**28/10/2003**	168	47.2	0.25	7.2	10.3	63	
	JHY	**04/11/2003**	68	34.7		13.4	6.92	38	7.74
	JHY	**19/11/2003**	350	43.8	0.01	0.85	10.21	57.5	
	JHY	**09/12/2003**	154	51.7		9.05	7.51	71.5	5.95
	JHY	**17/12/2003**	356	51.5	0.03	2.55	7.15	84.5	5.57
	JHY	**09/01/2004**	110	21.4	0.145	7.25	3.9	42	5.77
	JHY	**20/01/2004**	102	41.2	0.125	16	7.4	71.5	6.4
	JHY	**03/02/2004**		34.5	0.14	15.7	7.67	71	7
	JHY	**11/02/2004**	260	27.8		10.8	6.92	42	
	JHY	**19/02/2004**	184	23.6		3.7	12.35	22	6.23
	JHY	**27/02/2004**	232	35.8	0.1	9.2	12.3	69	6.06
	JHY	**18/03/2004**	370	62.7	0.06	2.8	8.9	85	6.8
Septic Tank	**JHX**	**23/09/2003**	446	0.8	0.28	31	5.75	43	6.08
	JHX	**30/09/2003**	670	1.3	0.3	64	10.35	96	7.27
	JHX	**28/10/2003**	766	1.2	0.32	71.4	11.375	80	
	JHX	**04/11/2003**	616	8.5	0.3	62.2	10.7	54	8.27
	JHX	**19/11/2003**	1086	3.45	0.45	65.3	9.41	82	
	JHX	**09/12/2003**	804	2.75	0.3	72.1	7.04	100	7.8
	JHX	**17/12/2003**	1393	1.85	0.38	101.5	8.4	159	7.16
	JHX	**09/01/2004**	350	12.1	1.175	16.3	4.66	42	7.29
	JHX	**20/01/2004**	842	5	0.185	104.5	9.87	140	6.91
	JHX	**03/02/2004**		1.75	0.11	34	4.43	63	7.54
	JHX	**11/02/2004**	748	0.01		46.2	8.42	47	7.35
	JHX	**19/02/2004**	692	1.8		28.4	10.8	64	6.91
	JHX	**27/02/2004**	826	2.8	0.23	73.6	18.4	96	7.86
	JHX	**18/03/2004**	892	1.6	0.01	56.3	8.2	80	7.31

TRENCH 1

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	VOL
1,Red,0m	**JH1**	23/09/2003	73	51.4	2	1.3	6.4	61	490
1,Red,0m	**JH1**	30/09/2003	169	48.6	0.4	0.01	7.5	68	400
1,Red,0m	**JH1**	23/10/2003	60	61.8	0.9	3	10.6	75	510
1,Red,0m	**JH1**	04/11/2003	79	51.9	1	6.8	8.82	48	480
1,Red,0m	**JH1**	19/11/2003	57	52	0.18	0.1	7.86	50	410
1,Red,0m	**JH1**	09/12/2003	65	65.4		0.5	5.42	64	530
1,Red,0m	**JH1**	17/12/2003	86	62.2	0.03	1.7	7.01	68	470
1,Red,0m	**JH1**	09/01/2004							
1,Red,0m	**JH1**	20/01/2004							
1,Red,0m	**JH1**	03/02/2004	80	37.6	0.1	9.7	9.36	77	520
1,Red,0m	**JH1**	11/02/2004	24	42.2		4.1	8.14	47	400
1,Red,0m	**JH1**	19/02/2004	67	22		2.9	6.4	72	90
1,Red,0m	**JH1**	27/02/2004	317	35.8	0.01	11.5	4.8	250	
1,Red,0m	**JH1**	18/03/2004	108	50.2	0.21	3.6	9.24	60	800
1,Blue,0m	**JH2**	23/09/2003	46	48.9	1.4	1.7	5.68	32	1050
1,Blue,0m	**JH2**	30/09/2003	88	42.6	1.6	2.1	5.25	64	650
1,Blue,0m	**JH2**	23/10/2003	48	55	0.4	3.2	8	58	590
1,Blue,0m	**JH2**	04/11/2003	48	54.2	0.85	5.3	8.06	41	700
1,Blue,0m	**JH2**	19/11/2003	45	45.4	0.1	0.4	6.58	48	290
1,Blue,0m	**JH2**	09/12/2003	137	62.8		0.2	4.8	62	580
1,Blue,0m	**JH2**	17/12/2003	63	42.4	0.01	0.01	6.24	70	480
1,Blue,0m	**JH2**	09/01/2004							
1,Blue,0m	**JH2**	20/01/2004							
1,Blue,0m	**JH2**	03/02/2004	82	39.6	0.09	12.9	8.22	92	820
1,Blue,0m	**JH2**	11/02/2004	48	36.8	0.01	7.9	4.82	28	300
1,Blue,0m	**JH2**	19/02/2004	83	19.8		0.01	0.9	22	70
1,Blue,0m	**JH2**	27/02/2004	235	42.2	0.01	7.2	4.84	222	
1,Blue,0m	**JH2**	18/03/2004	118	54.2	0.03	2.7	8.94	73	1200
1,Black,0m	**JH3**	23/09/2003	52	63.1	0.4	0.01	0.61	35	80
1,Black,0m	**JH3**	30/09/2003	108	50.8	0.1	0.8	1.14	65	80
1,Black,0m	**JH3**	23/10/2003	55	53.2	0.05	1	0.73	55	130
1,Black,0m	**JH3**	04/11/2003	52	48.9	0.24	4.7	2.5	52	35
1,Black,0m	**JH3**	19/11/2003	40	47.6	0.03	1.8	3.64	42	35
1,Black,0m	**JH3**	09/12/2003	70	56.4		0.01		51	80
1,Black,0m	**JH3**	17/12/2003	51	54	0.01	0.01	0.5	60	60
1,Black,0m	**JH3**	09/01/2004							
1,Black,0m	**JH3**	20/01/2004							
1,Black,0m	**JH3**	03/02/2004	70	41.6	0.02	7.1	0.5	83	130
1,Black,0m	**JH3**	11/02/2004	29	23.6		4.2	0.92	19	190
1,Black,0m	**JH3**	19/02/2004							
1,Black,0m	**JH3**	27/02/2004	226	37.2	0.01	6.8	0.44	57	
1,Black,0m	**JH3**	18/03/2004	154	39.8	0.03	1.3	0.01	44	200

1,Red,10m	**JH4**	23/09/2003	85	20.1	0.3	0.01	0.01	62	50
1,Red,10m	**JH4**	30/09/2003							40
1,Red,10m	**JH4**	23/10/2003	47	8.3	0.08	0.8	0.01	3	110
1,Red,10m	**JH4**	04/11/2003	32	7.1	0.04	2.6	0.21	2	240
1,Red,10m	**JH4**	19/11/2003	35	2.7	0.02	0.01	0.01	4	450
1,Red,10m	**JH4**	09/12/2003							0
1,Red,10m	**JH4**	17/12/2003	67	7.9	0.01	0.01	0.01	9	35
1,Red,10m	**JH4**	09/01/2004							
1,Red,10m	**JH4**	20/01/2004							
1,Red,10m	**JH4**	03/02/2004	67	0.9	0.02	6	0.01	14	80
1,Red,10m	**JH4**	11/02/2004	36	0.01		2.2	0.27	7	460
1,Red,10m	**JH4**	19/02/2004							
1,Red,10m	**JH4**	27/02/2004	142	14.2	0.01	6	0.03	0.1	
1,Red,10m	**JH4**	18/03/2004	160	0.01	0.01	1.1	0.01	0.1	800
1,Blue,10m	**JH5**	23/09/2003							
1,Blue,10m	**JH5**	30/09/2003							
1,Blue,10m	**JH5**	23/10/2003							
1,Blue,10m	**JH5**	04/11/2003	32	7.5	0.04	3.5	0.23	5	300
1,Blue,10m	**JH5**	19/11/2003	38	1.1	0.01	0.01	0.01	11	440
1,Blue,10m	**JH5**	09/12/2003	96	1.7		0.3	0.01	12	300
1,Blue,10m	**JH5**	17/12/2003	24	1.1	0.01	0.01	0.01	5	320
1,Blue,10m	**JH5**	09/01/2004							
1,Blue,10m	**JH5**	20/01/2004							
1,Blue,10m	**JH5**	03/02/2004	91	0.9	0.01	7.7	0.01	20	420
1,Blue,10m	**JH5**	11/02/2004	48	0.01		0.01	0.09	12	480
1,Blue,10m	**JH5**	19/02/2004	57	0.01		0.01	0.03	8	50
1,Blue,10m	**JH5**	27/02/2004	204	0.01	0.01	7.9	0.01	0.01	
1,Blue,10m	**JH5**	18/03/2004	150	0.01	0.02	1.9	0.01	8	300
1,Black,10m	**JH6**	23/09/2003							0
1,Black,10m	**JH6**	30/09/2003							0
1,Black,10m	**JH6**	23/10/2003							0
1,Black,10m	**JH6**	04/11/2003	61	7.7	0.02	2.8	0.01	2	420
1,Black,10m	**JH6**	19/11/2003	30	2.5	0.01	0.01	0.01	4	340
1,Black,10m	**JH6**	09/12/2003	112	1.4		0.01	0.01	13	280
1,Black,10m	**JH6**	17/12/2003	44	1.8	0.01	0.01	0.01	7	330
1,Black,10m	**JH6**	09/01/2004							
1,Black,10m	**JH6**	20/01/2004							
1,Black,10m	**JH6**	03/02/2004	79	1	0.03	6.4	0.01	13	810
1,Black,10m	**JH6**	11/02/2004	62	0.01		0.01	0.01	8	780
1,Black,10m	**JH6**	19/02/2004	55	0.01		0.01	0.01	12	140
1,Black,10m	**JH6**	27/02/2004	201	0.01	0.01	7	0.45	0.01	
1,Black,10m	**JH6**	18/03/2004	274	0.01	0.01	0.9	0.01	13	1000

1,Red,20m	**JH7**	23/09/2003							
1,Red,20m	**JH7**	30/09/2003							
1,Red,20m	**JH7**	23/10/2003							
1,Red,20m	**JH7**	04/11/2003	69	10.1	0.02	3.1	0.3	12	80
1,Red,20m	**JH7**	19/11/2003	26	2.9	0.01	0.01	0.01	2	180
1,Red,20m	**JH7**	09/12/2003	78	2.5		0.1	1.81	18	140
1,Red,20m	**JH7**	17/12/2003	50	3.6	0.01	0.1	0.01	4	130
1,Red,20m	**JH7**	09/01/2004							
1,Red,20m	**JH7**	20/01/2004							
1,Red,20m	**JH7**	03/02/2004	107	1.5	0.01		0.01	12	160
1,Red,20m	**JH7**	11/02/2004	55	0.01		3.8	0.01	10	160
1,Red,20m	**JH7**	19/02/2004	53	0.01		0.01	0.09	11	90
1,Red,20m	**JH7**	27/02/2004	203	0.01	0.01	7.7	0.14	0.01	
1,Red,20m	**JH7**	18/03/2004	94	0.1	0.03	1.7	0.01	3	400
1,Blue,20m	**JH8**	23/09/2003							
1,Blue,20m	**JH8**	30/09/2003							
1,Blue,20m	**JH8**	23/10/2003							
1,Blue,20m	**JH8**	04/11/2003							
1,Blue,20m	**JH8**	19/11/2003	6	2	0.03	1.3	0.79	4	240
1,Blue,20m	**JH8**	09/12/2003	109	1.7		0.01	0.01	2	130
1,Blue,20m	**JH8**	17/12/2003	104	1.6	0.01	0.01	0.01	6	140
1,Blue,20m	**JH8**	09/01/2004							
1,Blue,20m	**JH8**	20/01/2004							
1,Blue,20m	**JH8**	03/02/2004	91	0.9	0.02		0.01	4	500
1,Blue,20m	**JH8**	11/02/2004	41	0.01		0.01	0.14	6	610
1,Blue,20m	**JH8**	19/02/2004		0.01		0.01	0.01	4	410
1,Blue,20m	**JH8**	27/02/2004	181	0.01	0.01	6.9	0.02	0.01	
1,Blue,20m	**JH8**	18/03/2004	92	0.01	0.01	1.7	0.01	59	800
1,Black,20m	**JH9**	23/09/2003							820
1,Black,20m	**JH9**	30/09/2003							0
1,Black,20m	**JH9**	23/10/2003							0
1,Black,20m	**JH9**	04/11/2003							0
1,Black,20m	**JH9**	19/11/2003	23	2.6	0.01	0.01	0.01	2	390
1,Black,20m	**JH9**	09/12/2003	102	2.2		1.4	0.01	2	330
1,Black,20m	**JH9**	17/12/2003	57	2.5	0.01	0.4	0.01	7	330
1,Black,20m	**JH9**	09/01/2004							
1,Black,20m	**JH9**	20/01/2004							
1,Black,20m	**JH9**	03/02/2004	74	0.3	0.13		0.01	12	850
1,Black,20m	**JH9**	11/02/2004	58	0.01		0.01	0.26	7	600
1,Black,20m	**JH9**	19/02/2004	42	0.01		0.01	0.01	7	450
1,Black,20m	**JH9**	27/02/2004	234	3.6	0.01	5.6	0.06	3	
1,Black,20m	**JH9**	18/03/2004	172	0.4	0.03	2.2	0.01	8	900

TRENCH 2

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	VOL
2,Red,0m	JH10	23/09/2003	129	45.8	0.6	2.4	5.28	37	410
2,Red,0m	JH10	30/09/2003	207	40.5	0.2	2.1	5.4	61	420
2,Red,0m	JH10	23/10/2003	123	56	0.5	2.4	10.1	63	480
2,Red,0m	JH10	04/11/2003	57	57.3	0.11	3.8	7.4	58	140
2,Red,0m	JH10	19/11/2003	48	54.8	0.01	0.2	6.38	51	210
2,Red,0m	JH10	09/12/2003	151	61.6		0.01	2.8	61	90
2,Red,0m	JH10	17/12/2003	63	58	0.01	0.1	3.7	68	60
2,Red,0m	JH10	09/01/2004							
2,Red,0m	JH10	20/01/2004							
2,Red,0m	JH10	03/02/2004	111	37.6	0.07	10.4	6.3	72	210
2,Red,0m	JH10	11/02/2004	71	10.4				34	20
2,Red,0m	JH10	19/02/2004		19.7		0.8	2.1	28	
2,Red,0m	JH10	27/02/2004							
2,Red,0m	JH10	18/03/2004	186	47.8	0.18	3.8	5.82	81	300
2,Blue,0m	JH11	23/09/2003	45	42.6	0.3	0.01	2.17	22	90
2,Blue,0m	JH11	30/09/2003	127	43.2	0.2	0.01	4.3	59	820
2,Blue,0m	JH11	23/10/2003	46	61.8	0.3	2.1	5.9	78	370
2,Blue,0m	JH11	04/11/2003	52	54.2	0.07	2.4	4.86	59	240
2,Blue,0m	JH11	19/11/2003	38	54.2	0.01	0.5	4.62	39	300
2,Blue,0m	JH11	09/12/2003	146	54.6		1	0.01	49	240
2,Blue,0m	JH11	17/12/2003	60	55	0.01	0.7	0.01	66	220
2,Blue,0m	JH11	09/01/2004							
2,Blue,0m	JH11	20/01/2004							
2,Blue,0m	JH11	03/02/2004	92	33.4	0.04	8	1.28	56	210
2,Blue,0m	JH11	11/02/2004	59	6.9			0.12	19	200
2,Blue,0m	JH11	19/02/2004	85	15.3		0.01	1.4	32	120
2,Blue,0m	JH11	27/02/2004							
2,Blue,0m	JH11	18/03/2004	122	41.2	0.01	2.9	1.13	75	400
2,Black,0m	JH12	23/09/2003	71	58.1	0.08	0.01	0.04	58	
2,Black,0m	JH12	30/09/2003	114	52.1	0.2	0.01	0.4	60	100
2,Black,0m	JH12	23/10/2003	32	57.2	0.04	0.01	0.01	64	140
2,Black,0m	JH12	04/11/2003	38	46.6	0.02	3.3	0.68	56	120
2,Black,0m	JH12	19/11/2003	37	47.1	0.01	0.01	0.54	49	180
2,Black,0m	JH12	09/12/2003	81	53.2		1.7	0.01	46	90
2,Black,0m	JH12	17/12/2003	131	46.8	0.06	0.01	0.01	50	80
2,Black,0m	JH12	09/01/2004							
2,Black,0m	JH12	20/01/2004							
2,Black,0m	JH12	03/02/2004	72	35.2	0.03	8.3	0.01	50	70
2,Black,0m	JH12	11/02/2004	40	8.2			0.01	14	180
2,Black,0m	JH12	19/02/2004	68	14.7		0.01	0.09	9	40
2,Black,0m	JH12	27/02/2004	214	0.01	0.01	5.3	0.03	30	
2,Black,0m	JH12	18/03/2004	188	23.2	0.02	0.3	0.01	34	250

2,Red,10m	**JH13**	23/09/2003							
2,Red,10m	**JH13**	30/09/2003							
2,Red,10m	**JH13**	23/10/2003							
2,Red,10m	**JH13**	04/11/2003							
2,Red,10m	**JH13**	19/11/2003							
2,Red,10m	**JH13**	09/12/2003							
2,Red,10m	**JH13**	17/12/2003							
2,Red,10m	**JH13**	09/01/2004							
2,Red,10m	**JH13**	20/01/2004							
2,Red,10m	**JH13**	03/02/2004	95	5.7	0.03	11.2	0.73	15	40
2,Red,10m	**JH13**	11/02/2004	45	0.6			0.01	21	80
2,Red,10m	**JH13**	19/02/2004							
2,Red,10m	**JH13**	27/02/2004							
2,Red,10m	**JH13**	18/03/2004	196	0.01	0.01	2.9	0.69	2	100
2,Blue,10m	**JH14**	23/09/2003							
2,Blue,10m	**JH14**	30/09/2003							
2,Blue,10m	**JH14**	23/10/2003							
2,Blue,10m	**JH14**	04/11/2003	48	18	0.04	0.2	0.1	24	440
2,Blue,10m	**JH14**	19/11/2003	46	3.8	0.01	0.01	1.23	10	570
2,Blue,10m	**JH14**	09/12/2003	99	2		2.2	0.01	18	410
2,Blue,10m	**JH14**	17/12/2003	9	2.8	0.02	1.5	0.01	12	380
2,Blue,10m	**JH14**	09/01/2004							
2,Blue,10m	**JH14**	20/01/2004							
2,Blue,10m	**JH14**	03/02/2004	53	1.1	0.01	6.8	0.01	4	400
2,Blue,10m	**JH14**	11/02/2004	52	0.08			0.01	12	440
2,Blue,10m	**JH14**	19/02/2004	72	0.01		0.01	0.01	10	270
2,Blue,10m	**JH14**	27/02/2004	217	0.01	0.01	5.7	0.01	5	
2,Blue,10m	**JH14**	18/03/2004	78	0.01	0.01	1.1	0.01	8	700
2,Black,10m	**JH15**	23/09/2003							
2,Black,10m	**JH15**	30/09/2003							
2,Black,10m	**JH15**	23/10/2003							
2,Black,10m	**JH15**	04/11/2003							
2,Black,10m	**JH15**	19/11/2003							
2,Black,10m	**JH15**	09/12/2003							
2,Black,10m	**JH15**	17/12/2003							
2,Black,10m	**JH15**	09/01/2004							
2,Black,10m	**JH15**	20/01/2004							
2,Black,10m	**JH15**	03/02/2004							
2,Black,10m	**JH15**	11/02/2004	37	0.01				9	25
2,Black,10m	**JH15**	19/02/2004	71	24.1		0.01	0.01	14	100
2,Black,10m	**JH15**	27/02/2004							
2,Black,10m	**JH15**	18/03/2004							

2,Red,20m	**JH16**	23/09/2003							
2,Red,20m	**JH16**	30/09/2003							
2,Red,20m	**JH16**	23/10/2003	53	6.7	0.1	1.2	0.16	60	30
2,Red,20m	**JH16**	04/11/2003	36	8.5	0.03	2.8	0.27	0.01	310
2,Red,20m	**JH16**	19/11/2003	35	0.6	0.05	0.01	0.01	0.01	380
2,Red,20m	**JH16**	09/12/2003	67	1		0.01	0.01	0.01	310
2,Red,20m	**JH16**	17/12/2003	56	2.5	0.01	0.01	0.01	0.01	330
2,Red,20m	**JH16**	09/01/2004							
2,Red,20m	**JH16**	20/01/2004							
2,Red,20m	**JH16**	03/02/2004	32	0.7	0.01	7.1	0.01	4	470
2,Red,20m	**JH16**	11/02/2004	33	0.4			0.01	8	530
2,Red,20m	**JH16**	19/02/2004	48	0.01		0.01	0.01	10	400
2,Red,20m	**JH16**	27/02/2004	194	0.01	0.01	7.7	0.03	6	
2,Red,20m	**JH16**	18/03/2004	128	0.01	0.07	2.1	0.01	1	700
2,Blue,20m	**JH17**	23/09/2003							
2,Blue,20m	**JH17**	30/09/2003							
2,Blue,20m	**JH17**	23/10/2003	57	9	0.07	2.5	0.23	61	30
2,Blue,20m	**JH17**	04/11/2003	40	11	0.01	1.7	0.01	6	340
2,Blue,20m	**JH17**	19/11/2003	55	3.5	0.02	0.01	0.01	0.01	510
2,Blue,20m	**JH17**	09/12/2003	52	2.5		0.01	0.01	0.01	430
2,Blue,20m	**JH17**	17/12/2003	39	1.6	0.03	0.01	0.01	3	420
2,Blue,20m	**JH17**	09/01/2004							
2,Blue,20m	**JH17**	20/01/2004							
2,Blue,20m	**JH17**	03/02/2004	30	0.8	0.3	8.6	0.01	6	700
2,Blue,20m	**JH17**	11/02/2004	28	0.01			0.01	10	580
2,Blue,20m	**JH17**	19/02/2004	37	0.01	0.01		0.01	6	600
2,Blue,20m	**JH17**	27/02/2004	190	1.8	0.01	7	0.01	4	
2,Blue,20m	**JH17**	18/03/2004	218	0.1	0.02	3.5	0.01	0.01	1200
2,Black,20m	**JH18**	23/09/2003							
2,Black,20m	**JH18**	30/09/2003							
2,Black,20m	**JH18**	23/10/2003							
2,Black,20m	**JH18**	04/11/2003							
2,Black,20m	**JH18**	19/11/2003	37	5.6	0.01	0.5	0.01	4	30
2,Black,20m	**JH18**	09/12/2003							
2,Black,20m	**JH18**	17/12/2003							
2,Black,20m	**JH18**	09/01/2004							
2,Black,20m	**JH18**	20/01/2004							
2,Black,20m	**JH18**	03/02/2004	27	1.1	0.01		0.01	15	55
2,Black,20m	**JH18**	11/02/2004	40	0.01			0.01	6	570
2,Black,20m	**JH18**	19/02/2004	35	0.01			0.05	8	410
2,Black,20m	**JH18**	27/02/2004	197	1	0.01	6.6	0.01	0.01	
2,Black,20m	**JH18**	18/03/2004	168	0.3	0.03	0.6	0.01	1	700

Site 4 - Stratified Sand Filter

Inside sand filter

Sample Position	Ref	Date	COD	NO_3-N	NO_2-N	NH_4-N	Ortho-P	Cl	pH	VOL
Top sand filter	**JHA**	23/09/2003	96	39.4	1.2	3.8	5.28	31	6.88	45
Top sand filter	**JHA**	30/09/2003	172	44.6		3.5	10.3	76	6.67	50
Top sand filter	**JHA**	23/10/2003								0
Top sand filter	**JHA**	04/11/2003	109	45.9		5.5	5.74	23	7.36	50
Top sand filter	**JHA**	19/11/2003	483	55.2	0.1	1.5	7.16	43		70
Top sand filter	**JHA**	09/12/2003	128	76.4		4.3	5.96	78	6.77	70
Top sand filter	**JHA**	17/12/2003	313	62.6	0.02	0.01	6.88	81	6.6	35
Top sand filter	**JHA**	09/01/2004	270	31.2	0.27	6.1	7.8	55	5.8	60
Top sand filter	**JHA**	20/01/2004								
Top sand filter	**JHA**	03/02/2004	258	40.6	0.43	6.5	8.36	83	6.29	
Top sand filter	**JHA**	11/02/2004	110	12.6			2.88	39		65
Top sand filter	**JHA**	19/02/2004	348	47.4		4.8	12.2	58	6.34	30
Top sand filter	**JHA**	27/02/2004								
Top sand filter	**JHA**	18/03/2004	378	48.4	0.04	2.3	9.64	58	6.09	
Middle sand filter	**JHB**	23/09/2003		33.8		0	1.4			10
Middle sand filter	**JHB**	30/09/2003	84	46.2		0	3.28	74	7.19	50
Middle sand filter	**JHB**	23/10/2003	145	52.5	0.34	3.5	3.98	48		50
Middle sand filter	**JHB**	04/11/2003		28.4		6.9	3.74			5
Middle sand filter	**JHB**	19/11/2003	234	59.8	0.05	0.1	4.7	38		35
Middle sand filter	**JHB**	09/12/2003	110	60.8		2.2		84	7.21	35
Middle sand filter	**JHB**	17/12/2003	350	60	0.04	1.4	4.19	70	7	40
Middle sand filter	**JHB**	09/01/2004	202	23.6	0.38	3.1	5.32	51	6.71	45
Middle sand filter	**JHB**	20/01/2004	160	46.8	0.4	9	6.3	68	6.36	
Middle sand filter	**JHB**	03/02/2004	200	43	0.19	5.8	7.22	90	6.63	
Middle sand filter	**JHB**	11/02/2004	246	18.4			3.14	26		60
Middle sand filter	**JHB**	19/02/2004	206	28.8		2.6	8.6	17	6.4	300
Middle sand filter	**JHB**	27/02/2004								
Middle sand filter	**JHB**	18/03/2004								
Bottom sand filter	**JHC**	23/09/2003		39.4		0.01				5
Bottom sand filter	**JHC**	30/09/2003								0
Bottom sand filter	**JHC**	23/10/2003	116	22	0.7	3.2		30		15
Bottom sand filter	**JHC**	04/11/2003	71	28.6		3.5	2.82	35	7.92	60
Bottom sand filter	**JHC**	19/11/2003	154	55.4	0.17	0.01	2.82	15		80
Bottom sand filter	**JHC**	09/12/2003	116	65.2		1.7	2.46	69	7.07	50
Bottom sand filter	**JHC**	17/12/2003	311	51.4	0.02	0.4	3.62	75	7.07	50
Bottom sand filter	**JHC**	09/01/2004	188	30.2	0.24	2.1	4.86	50	7.06	40
Bottom sand filter	**JHC**	20/01/2004								
Bottom sand filter	**JHC**	03/02/2004	226	44	0.08	6.6	6.72	80	6.37	
Bottom sand filter	**JHC**	11/02/2004	226	16.3			2.26	47		60
Bottom sand filter	**JHC**	19/02/2004	158	22.4		2.1	9.4	28	6.58	120
Bottom sand filter	**JHC**	27/02/2004	142	58	0.03	6.1	9.48	73	6.69	
Bottom sand filter	**JHC**	18/03/2004	330	45	0.15	5.3	8.34	58	5.95	

Top sand filter	**JHD**	23/09/2003								
Top sand filter	**JHD**	30/09/2003								
Top sand filter	**JHD**	23/10/2003	136	51.5	0.42	3.8	8	84		35
Top sand filter	**JHD**	04/11/2003								
Top sand filter	**JHD**	19/11/2003								
Top sand filter	**JHD**	09/12/2003	220	62.8		2.1	3.5	68	7.05	35
Top sand filter	**JHD**	17/12/2003	328	61.2	0.13	0.1	6.03	79	7	35
Top sand filter	**JHD**	09/01/2004	178	26.6	0.38	2	5.08	48	6.97	40
Top sand filter	**JHD**	20/01/2004	126	47.6	0.4	5	5.9	62	6.17	
Top sand filter	**JHD**	03/02/2004								
Top sand filter	**JHD**	11/02/2004	358	19.7			6.12	63		60
Top sand filter	**JHD**	19/02/2004	224	40.4		3.5	9.8	63		30
Top sand filter	**JHD**	27/02/2004								
Top sand filter	**JHD**	18/03/2004	350	44.4	0.12	0.9	8.64	53	6.77	
Middle sand filter	**JHE**	23/09/2003								
Middle sand filter	**JHE**	30/09/2003								
Middle sand filter	**JHE**	23/10/2003								
Middle sand filter	**JHE**	04/11/2003								
Middle sand filter	**JHE**	19/11/2003								
Middle sand filter	**JHE**	09/12/2003	165	20	0.21	3.4	6.24	35	7.1	40
Middle sand filter	**JHE**	17/12/2003								
Middle sand filter	**JHE**	09/01/2004								
Middle sand filter	**JHE**	20/01/2004								
Middle sand filter	**JHE**	03/02/2004								
Middle sand filter	**JHE**	11/02/2004	246	22.1			2.94	19		55
Middle sand filter	**JHE**	19/02/2004	234	37.6		0.01	7.4	40	6.65	50
Middle sand filter	**JHE**	27/02/2004								
Middle sand filter	**JHE**	18/03/2004	264	41	0.17	4.1	5.37	59	7	
Bottom sand filter	**JHF**	23/09/2003		47.1		0.7	1.2			5
Bottom sand filter	**JHF**	30/09/2003								0
Bottom sand filter	**JHF**	23/10/2003	91	52.3	0.14	2.2	1.25	58		50
Bottom sand filter	**JHF**	04/11/2003	119	37.6		10.5	3.2	30	7.85	55
Bottom sand filter	**JHF**	19/11/2003								
Bottom sand filter	**JHF**	09/12/2003	97	60		0.01	3.16	68	6.89	50
Bottom sand filter	**JHF**	17/12/2003	400	61	0.15	0.01	5.08	81	6.8	50
Bottom sand filter	**JHF**	09/01/2004	179	26.6	0.13	2.7	5.8	49	6.98	60
Bottom sand filter	**JHF**	20/01/2004	104	43.2	0.05	1.42	5.13	65	6.19	
Bottom sand filter	**JHF**	03/02/2004								
Bottom sand filter	**JHF**	11/02/2004	190	14.2			3.36	24		60
Bottom sand filter	**JHF**	19/02/2004	156	18		0.01	6.8	28	6.58	30
Bottom sand filter	**JHF**	27/02/2004								
Bottom sand filter	**JHF**	18/03/2004	252	41.6	0.08	2	5.25	58	6.44	

Beneath sand filter

Sample Position	Ref	Date	COD	NO3-N	NO2-N	NH4-N	Ortho-P	Cl	pH	VOL
Right red front of sand	JH19	23/09/2003	102	55	0.3	0.01	0.01	59	6.38	220
Right red front of sand	JH19	30/09/2003	104	48.6	0.1	2.8	0.01	48	6.2	170
Right red front of sand	JH19	23/10/2003	37	49	0.04	0.01	0.01	65		250
Right red front of sand	JH19	04/11/2003	28	54.5		0.01	0.23	50	7.16	300
Right red front of sand	JH19	19/11/2003	30	53.3	0.01	0.01	1.8	47		420
Right red front of sand	JH19	09/12/2003	26	50.3		0.01	0.01	42	6.75	190
Right red front of sand	JH19	17/12/2003	59	50.5	0.01	0.3	0.01	60	6.06	200
Right red front of sand	JH19	09/01/2004	45	36.2	0.07	0.01	0.01	57	6.72	440
Right red front of sand	JH19	20/01/2004	45	40.4	0.09	0.01	0.01	58		
Right red front of sand	JH19	03/02/2004	57	36.4	0.02	6.5	0.08	73	6.66	250
Right red front of sand	JH19	11/02/2004	81	11.6		8.9	0.24	42		100
Right red front of sand	JH19	19/02/2004	127	21.4		0.01	0.03	48	6.44	140
Right red front of sand	JH19	27/02/2004	220	52	0.01	7.5	0.15	75	6.61	
Right red front of sand	JH19	18/03/2004	202	43.6	0.01	0.8	0.01	82	7.1	100
Right blue front of sand	JH20	23/09/2003	51	44.9	0.3	0.01	0.01	53	6.38	350
Right blue front of sand	JH20	30/09/2003	70	52.6	0.5	2.4	0.06	64	6.15	310
Right blue front of sand	JH20	23/10/2003	34	47.9	0.04	0.9	0.01	55		380
Right blue front of sand	JH20	04/11/2003	31	55.1		1.9	0.08	47	7.03	350
Right blue front of sand	JH20	19/11/2003	33	48.2	0.04	1.9	0.16	52		280
Right blue front of sand	JH20	09/12/2003	65	41.6		0.4	0.01	37	6.7	320
Right blue front of sand	JH20	17/12/2003	22	40.7	0.01	1.9	0.01	45	6.08	310
Right blue front of sand	JH20	09/01/2004	44	41.6	0.01	0.01	0.01	53	6.32	600
Right blue front of sand	JH20	20/01/2004	18	41.6	0.05	0.67	0.01	64	6.41	
Right blue front of sand	JH20	03/02/2004	49	34.8	0.01	6	0.01	74	6.67	300
Right blue front of sand	JH20	11/02/2004	63	4.8		8.1	0.01	21		350
Right blue front of sand	JH20	19/02/2004	55	10.1		0.01	0.01	54	6.61	50
Right blue front of sand	JH20	27/02/2004	208	49.2		6.4	0.01	56	6.71	
Right blue front of sand	JH20	18/03/2004	144	41.6	0.01	0.6	0.01	68	7.02	400
Right black front of sand	JH21	23/09/2003	65	22.3	0.08	0.01	0.07	21	6.91	130
Right black front of sand	JH21	30/09/2003	98	31.4	0.1	2.3	0.01	44	6.85	110
Right black front of sand	JH21	23/10/2003	30	42.1	0.04	2.3	0.01	46		180
Right black front of sand	JH21	04/11/2003	29	50.8		1	0.1	44	7.5	150
Right black front of sand	JH21	19/11/2003	31	48.1	0.01	0.01	1.14	53		240
Right black front of sand	JH21	09/12/2003	46	47.4		0.4	0.01	43	6.97	150
Right black front of sand	JH21	17/12/2003	46	44.2	0.01	0.2	0.01	47	6.33	130
Right black front of sand	JH21	09/01/2004	32	39.2	0.06	0.01	0.01	52	6.32	840
Right black front of sand	JH21	20/01/2004	40	37.6	0.02	0.01	0.01	67	6.38	
Right black front of sand	JH21	03/02/2004	37	41	0.01	7.1	0.01	80	6.62	200
Right black front of sand	JH21	11/02/2004	39	3.9		3.9	0.01	28		280
Right black front of sand	JH21	19/02/2004	40	1.8		0.01	0.12	23	6.69	60
Right black front of sand	JH21	27/02/2004	189	49.2	0.01	7.6	0.02	49	6.72	
Right black front of sand	JH21	18/03/2004	94	15.3	0.01	2.5	0.01	26	7.32	400

Left red front of sand	**JH22**	23/09/2003								
Left red front of sand	**JH22**	30/09/2003	183	17.3	0.31	0.01	0.26	24	7.02	60
Left red front of sand	**JH22**	23/10/2003	33	33.1	0.06	0.8	0.01	37		30
Left red front of sand	**JH22**	04/11/2003	31	40.3	0.01	2.2	0.01	38	7.51	90
Left red front of sand	**JH22**	19/11/2003								-
Left red front of sand	**JH22**	09/12/2003								-
Left red front of sand	**JH22**	17/12/2003								-
Left red front of sand	**JH22**	09/01/2004								
Left red front of sand	**JH22**	20/01/2004								
Left red front of sand	**JH22**	03/02/2004								
Left red front of sand	**JH22**	11/02/2004								
Left red front of sand	**JH22**	19/02/2004	50	13.3		0.01	0.06	49	6.83	50
Left red front of sand	**JH22**	27/02/2004								
Left red front of sand	**JH22**	18/03/2004	242	47	0.01	0.6	0.01	81	7.06	400
Left blue front of sand	**JH23**	23/09/2003								0
Left blue front of sand	**JH23**	30/09/2003	94	18.6	0.12	0.01	0.01	30	6.45	130
Left blue front of sand	**JH23**	23/10/2003	38	21	0.08	0.6	0.01	19		110
Left blue front of sand	**JH23**	04/11/2003	32	39.6	0.01	1.6	0.02	20	7.14	190
Left blue front of sand	**JH23**	19/11/2003								-
Left blue front of sand	**JH23**	09/12/2003								-
Left blue front of sand	**JH23**	17/12/2003								-
Left blue front of sand	**JH23**	09/01/2004								
Left blue front of sand	**JH23**	20/01/2004								
Left blue front of sand	**JH23**	03/02/2004								
Left blue front of sand	**JH23**	11/02/2004	37	8.4			0.08	22		250
Left blue front of sand	**JH23**	19/02/2004	42	7		0.01	0.09	31	6.79	40
Left blue front of sand	**JH23**	27/02/2004								
Left blue front of sand	**JH23**	18/03/2004	230	47.6	0.01	1.4	0.01	90	7.02	500
Left black front of sand	**JH24**	23/09/2003								75
Left black front of sand	**JH24**	30/09/2003	57	18	0.05	0.01	0.01	32	6.87	300
Left black front of sand	**JH24**	23/10/2003	37	12.5	0.04	0.01	0.01	22		140
Left black front of sand	**JH24**	04/11/2003	40	34	0.01	2.2	0.01	30	7.5	300
Left black front of sand	**JH24**	19/11/2003								-
Left black front of sand	**JH24**	09/12/2003								-
Left black front of sand	**JH24**	17/12/2003								-
Left black front of sand	**JH24**	09/01/2004								
Left black front of sand	**JH24**	20/01/2004								
Left black front of sand	**JH24**	03/02/2004								
Left black front of sand	**JH24**	11/02/2004	52	5.2			0.01	28		100
Left black front of sand	**JH24**	19/02/2004	39	0.01		0.01	0.01	30	6.56	45
Left black front of sand	**JH24**	27/02/2004								
Left black front of sand	**JH24**	18/03/2004	110	54.2	0.01	0.5	0.01	74	7.1	300

Site 4 – Microbiological Analysis

TRENCHES

Bacteria (cfu/100ml)		X	Y	1	2	3	4	5	6	7	8	9
Total Coliforms	*02/12/2003*	**21600000**	**2000**	1298	4838	1534	1732	182	3972	3466	582	6200
	11/03/2004	**4110000**	**5480**	170	240		70	130	20	40	400	260
E.Coli	*02/12/2003*	**616000**	**58**	<2	<2	<2	20	<2	2	<2	2	12
	11/03/2004	**24190**	**710**	<10	<10		<10	<10	<10	<10	<10	<10
Enterococci	*02/12/2003*	**2696**	**2**	<2	<2	<2	116	<2	2	<2	<2	14
Faecal Coliforms	*02/12/2003*	**760000**	**72**	<2	<2	<2	28	<2	2	<2	2	12

FILTER

Bacteria (cfu/100ml)		X	Y	A	B	C	19	20	21
Total Coliforms	*02/12/2003*	21600000	2000			3464	2092	28600	1034000
	21/01/2004	97000000	52000	24192	121000	73000	148000	12033	3255
	11/03/2004	4110000	5480	4570	2500		20	30	
E.Coli	*02/12/2003*	616000	58			26	<2	<2	<2
	21/01/2004	52000	52	10	63	10	<10	<10	<10
	11/03/2004	24190	710	810	60	10	<10	<10	
Enterococci	*02/12/2003*	2696	2			13	158	44	20
Faecal Coliforms	*02/12/2003*	760000	72			13	<2	<2	10

APPENDIX E

RESULTS OF BROMIDE ANALYSIS

Site 1

Bromide tracer test results *(all results in mg/l)*

Tracer injected: 29/07/03

+ 1 DAY (30/07/03) ***no Br found in any samples***

+ 2 DAYS (31/07/03)

		Trench			
Sample position	**Depth plane**	**1**	**2**	**3**	**4**
0m	**Red**	-	0.26	0.27	0.27
	Blue	0	0	0.29	0.31
	Black	0	0.25	-	0.26
10m	**Red**	4.90	4.10	9.28	2.61
	Blue	24.62	0.82	9.34	2.56
	Black	5.60	0	16.26	2.90
20m	**Red**	0	0	0	0
	Blue	0	0	-	0
	Black	-	0	0.3	0.31

+ 3 DAYS (1/08/03)

		Trench			
Sample position	**Depth plane**	**1**	**2**	**3**	**4**
0m	**Red**	-	-	0.25	0
	Blue	0	0	0.29	0.32
	Black	0	0	0.25	0.28
10m	**Red**	4.80	2.79	4.36	1.71
	Blue	11.82	0.34	9.32	1.72
	Black	4.35	0	16.26	2.35
20m	**Red**	0.29	6.63	0	0
	Blue	0	0.48	0	0
	Black	-	0.27	0	0

+ 8 DAYS (6/08/03)

		Trench			
Sample position	**Depth plane**	**1**	**2**	**3**	**4**
0m	**Red**	-	0.26	0.28	0
	Blue	0.25	0.25	0	0.29
	Black	0	-	0	0.27
10m	**Red**	2.95	1.85	1.42	0.62
	Blue	5.66	0.26	3.24	0.90
	Black	4.56	0	1.56	1.04
20m	**Red**	0	19.14	0.70	0
	Blue	0	8.44	1.50	0
	Black	-	5.65	0	0

Site 2

Bromide tracer test results *(all results in mg/l)*

Tracer injected: 29/07/03

+ 1 DAY (30/07/03) *no Br found in any samples*

+ 2 DAYS (31/07/03)

		Trench			
Sample position	**Depth plane**	**1**	**2**	**3**	**4**
0m	**Red**	0.46	0	-	-
	Blue	3.83	0	-	12.15
	Black	0.43	-	-	1.00
10m	**Red**	0	0	0	0
	Blue	0	0	0	0
	Black	0	0	0	-
20m	**Red**	0	0	0	0
	Blue	0	0	0	0
	Black	0	0	0	0

+ 3 DAYS (1/08/03)

		Trench			
Sample position	**Depth plane**	**1**	**2**	**3**	**4**
0m	**Red**	0.97	0	2.69	-
	Blue	3.95	0	0	9.60
	Black	0.37	-	0.34	1.23
10m	**Red**	0	-	0	0
	Blue	0	-	0	0
	Black	0	-	0	0
20m	**Red**	0	0	0	0
	Blue	0	0	0	0
	Black	0	0	0	0

+ 8 DAYS (6/08/03)

		Trench			
Sample position	**Depth plane**	**1**	**2**	**3**	**4**
	Red	1.23	0.32	2.20	3.62
0m	**Blue**	2.21	0	0.36	19.32
	Black	0	-	0.27	-
	Red	0	0	0	0
10m	**Blue**	0	0	0	0
	Black	0	0	0	0
	Red	0	0	0	0
20m	**Blue**	0	0	0	0
	Black	0	0	0	0

APPENDIX F

CALCULATION OF EVAPOTRANSPIRATION AND EFFECTIVE RAINFALL

Site 1 - Evapotranspiration Calculations

(Penman method)

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
04/03/2002	0.40	0.82	0.00	0.00	**0.40**
05/03/2002	0.20	1.36	1.16	1.36	**0.00**
06/03/2002	0.20	1.16	2.12	1.16	**0.00**
07/03/2002	0.00	1.12	3.24	1.12	**0.00**
08/03/2002	2.80	1.53	1.97	1.53	**0.00**
09/03/2002	10.40	1.00	0.00	1.00	**7.43**
10/03/2002	6.40	1.32	0.00	1.32	**5.08**
11/03/2002	0.00	1.55	1.55	1.55	**0.00**
12/03/2002	0.20	1.03	2.38	1.03	**0.00**
13/03/2002	0.60	1.17	2.95	1.17	**0.00**
14/03/2002	0.00	1.08	4.02	1.08	**0.00**
15/03/2002	0.40	0.89	4.51	0.89	**0.00**
16/03/2002	0.40	1.66	5.77	1.66	**0.00**
17/03/2002	1.40	1.06	5.43	1.06	**0.00**
18/03/2002	1.60	0.99	4.82	0.99	**0.00**
19/03/2002	0.20	1.12	5.74	1.12	**0.00**
20/03/2002	2.40	1.10	4.44	1.10	**0.00**
21/03/2002	0.40	1.92	5.96	1.92	**0.00**
22/03/2002	0.00	1.44	7.41	1.44	**0.00**
23/03/2002	0.00	0.96	8.37	0.96	**0.00**
24/03/2002	0.20	0.91	9.08	0.91	**0.00**
25/03/2002	0.60	1.53	10.01	1.53	**0.00**
26/03/2002	0.20	1.84	11.65	1.84	**0.00**
27/03/2002	0.00	1.98	13.63	1.98	**0.00**
28/03/2002	0.00	2.13	15.76	2.13	**0.00**
29/03/2002	0.20	1.85	17.41	1.85	**0.00**
30/03/2002	4.40	1.93	14.94	1.93	**0.00**
31/03/2002	1.00	1.59	15.53	1.59	**0.00**
01/04/2002	3.60	1.55	13.48	1.55	**0.00**
02/04/2002	2.80	1.40	12.09	1.40	**0.00**
03/04/2002	3.80	2.28	10.56	2.28	**0.00**
04/04/2002	0.00	1.86	12.42	1.86	**0.00**
05/04/2002	0.00	1.62	14.04	1.62	**0.00**
06/04/2002	0.00	1.84	15.88	1.84	**0.00**
07/04/2002	0.00	2.41	18.29	2.41	**0.00**
08/04/2002	0.20	1.94	20.03	1.94	**0.00**
09/04/2002	0.00	2.08	22.10	2.08	**0.00**
10/04/2002	0.00	1.77	23.87	1.77	**0.00**
11/04/2002	0.20	1.51	25.19	1.51	**0.00**
12/04/2002	0.40	1.79	26.58	1.79	**0.00**
13/04/2002	0.20	1.57	27.95	1.57	**0.00**
14/04/2002	1.00	2.06	29.01	2.06	**0.00**
15/04/2002	0.00	2.19	31.20	2.19	**0.00**
16/04/2002	0.40	1.95	32.75	1.95	**0.00**
17/04/2002	36.60	1.26	0.00	1.26	**2.60**
18/04/2002	1.60	2.49	0.89	2.49	**0.00**
19/04/2002	0.60	2.25	2.54	2.25	**0.00**
20/04/2002	1.60	1.35	2.29	1.35	**0.00**
21/04/2002	10.20	1.19	0.00	1.19	**6.72**
22/04/2002	0.00	2.01	2.01	2.01	**0.00**
23/04/2002	0.00	3.13	5.14	3.13	**0.00**
24/04/2002	0.80	2.12	6.46	2.12	**0.00**
25/04/2002	1.80	2.02	6.69	2.02	**0.00**
26/04/2002	9.40	2.16	0.00	2.16	**0.56**
27/04/2002	9.80	1.27	0.00	1.27	**8.53**
28/04/2002	9.40	1.77	0.00	1.77	**7.63**
29/04/2002	1.40	2.19	0.79	2.19	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
30/04/2002	5.40	2.17	0.00	2.17	**2.44**
01/05/2002	4.00	2.25	0.00	2.25	**1.75**
02/05/2002	2.80	2.53	0.00	2.53	**0.27**
03/05/2002	0.40	2.42	2.02	2.42	**0.00**
04/05/2002	0.00	3.28	5.30	3.28	**0.00**
05/05/2002	0.00	2.80	8.10	2.80	**0.00**
06/05/2002	0.00	2.32	10.42	2.32	**0.00**
07/05/2002	1.00	2.10	11.53	2.10	**0.00**
08/05/2002	0.00	2.53	14.05	2.53	**0.00**
09/05/2002	0.00	2.35	16.40	2.35	**0.00**
10/05/2002	0.20	2.15	18.35	2.15	**0.00**
11/05/2002	0.00	2.88	21.24	2.88	**0.00**
12/05/2002	0.80	2.19	22.63	2.19	**0.00**
13/05/2002	5.00	2.29	19.92	2.29	**0.00**
14/05/2002	1.20	2.35	21.07	2.35	**0.00**
15/05/2002	0.00	2.25	23.32	2.25	**0.00**
16/05/2002	0.20	2.62	25.73	2.62	**0.00**
17/05/2002	29.00	2.19	0.00	2.19	**1.08**
18/05/2002	0.20	2.59	2.39	2.59	**0.00**
19/05/2002	3.20	2.66	1.85	2.66	**0.00**
20/05/2002	4.20	2.77	0.42	2.77	**0.00**
21/05/2002	3.00	1.90	0.00	1.90	**0.67**
22/05/2002	5.80	2.76	0.00	2.76	**3.04**
23/05/2002	5.60	2.18	0.00	2.18	**3.42**
24/05/2002	6.80	1.76	0.00	1.76	**5.04**
25/05/2002	3.40	2.33	0.00	2.33	**1.07**
26/05/2002	0.40	2.19	1.79	2.19	**0.00**
27/05/2002	1.60	2.30	2.49	2.30	**0.00**
28/05/2002	8.80	2.40	0.00	2.40	**3.91**
29/05/2002	3.40	2.62	0.00	2.62	**0.78**
30/05/2002	3.20	3.18	0.00	3.18	**0.02**
31/05/2002	0.00	2.62	2.62	2.62	**0.00**
01/06/2002	1.00	3.10	4.73	3.10	**0.00**
02/06/2002	7.80	2.66	0.00	2.66	**0.42**
03/06/2002	4.20	2.90	0.00	2.90	**1.30**
04/06/2002	1.60	2.17	0.57	2.17	**0.00**
05/06/2002	0.00	3.30	3.87	3.30	**0.00**
06/06/2002	0.00	2.85	6.72	2.85	**0.00**
07/06/2002	4.00	2.61	5.34	2.61	**0.00**
08/06/2002	1.60	1.83	5.56	1.83	**0.00**
09/06/2002	9.80	2.55	0.00	2.55	**1.69**
10/06/2002	6.20	2.82	0.00	2.82	**3.38**
11/06/2002	1.00	2.80	1.80	2.80	**0.00**
20/09/2002	0.00	1.45	63.35	0.93	**0.00**
21/09/2002	0.00	1.59	64.34	1.00	**0.00**
22/09/2002	0.00	1.18	65.07	0.73	**0.00**
23/09/2002	0.00	1.63	66.07	0.99	**0.00**
24/09/2002	0.00	1.32	66.86	0.79	**0.00**
25/09/2002	0.00	1.58	67.80	0.94	**0.00**
26/09/2002	0.00	1.41	68.61	0.82	**0.00**
27/09/2002	0.00	0.87	69.11	0.50	**0.00**
28/09/2002	0.00	1.33	69.86	0.75	**0.00**
29/09/2002	0.00	1.93	70.94	1.07	**0.00**
30/09/2002	10.00	1.49	61.75	0.81	**0.00**
01/10/2002	1.00	1.35	61.62	0.87	**0.00**
02/10/2002	8.20	1.71	54.53	1.11	**0.00**
03/10/2002	0.40	1.57	55.28	1.15	**0.00**
04/10/2002	0.00	1.68	56.49	1.21	**0.00**
05/10/2002	0.20	1.58	57.40	1.11	**0.00**
06/10/2002	0.20	0.90	57.83	0.63	**0.00**
07/10/2002	0.00	1.24	58.68	0.85	**0.00**
08/10/2002	8.40	0.81	50.83	0.55	**0.00**
09/10/2002	4.40	0.76	47.02	0.59	**0.00**
10/10/2002	0.00	0.92	47.77	0.75	**0.00**
11/10/2002	29.60	0.78	18.80	0.63	**0.00**
12/10/2002	0.20	1.20	19.80	1.20	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
13/10/2002	4.40	0.76	16.16	0.76	**0.00**
14/10/2002	0.20	0.75	16.71	0.75	**0.00**
15/10/2002	10.00	0.87	7.58	0.87	**0.00**
16/10/2002	0.00	1.07	8.64	1.07	**0.00**
17/10/2002	3.00	0.55	6.19	0.55	**0.00**
18/10/2002	0.20	0.75	6.74	0.75	**0.00**
19/10/2002	0.00	0.46	7.20	0.46	**0.00**
20/10/2002	32.00	0.77	0.00	0.77	**24.03**
21/10/2002	18.20	0.82	0.00	0.82	**17.38**
22/10/2002	0.80	0.99	0.19	0.99	**0.00**
23/10/2002	0.40	0.88	0.67	0.88	**0.00**
24/10/2002	1.80	1.15	0.02	1.15	**0.00**
25/10/2002	6.80	0.92	0.00	0.92	**5.86**
26/10/2002	7.20	1.26	0.00	1.26	**5.94**
27/10/2002	3.60	1.47	0.00	1.47	**2.13**
28/10/2002	1.40	0.82	0.00	0.82	**0.58**
29/10/2002	23.80	0.43	0.00	0.43	**23.37**
30/10/2002	0.00	0.50	0.50	0.50	**0.00**
31/10/2002	0.20	0.69	0.99	0.69	**0.00**
01/11/2002	2.20	1.05	0.00	1.05	**0.16**
02/11/2002	11.00	1.59	0.00	1.59	**9.41**
03/11/2002	6.80	0.57	0.00	0.57	**6.23**
04/11/2002	0.40	0.95	0.55	0.95	**0.00**
05/11/2002	1.00	1.05	0.60	1.05	**0.00**
06/11/2002	3.80	1.06	0.00	1.06	**2.14**
07/11/2002	0.00	0.67	0.67	0.67	**0.00**
08/11/2002	14.20	1.07	0.00	1.07	**12.46**
09/11/2002	9.00	0.48	0.00	0.48	**8.52**
10/11/2002	4.60	0.63	0.00	0.63	**3.97**
11/11/2002	0.40	0.56	0.16	0.56	**0.00**
12/11/2002	0.60	0.73	0.29	0.73	**0.00**
13/11/2002	0.60	0.56	0.26	0.56	**0.00**
14/11/2002	26.40	0.41	0.00	0.41	**25.74**
15/11/2002	20.20	0.31	0.00	0.31	**19.89**
16/11/2002	0.00	0.33	0.33	0.33	**0.00**
17/11/2002	0.00	0.32	0.65	0.32	**0.00**
18/11/2002	5.60	0.99	0.00	0.99	**3.95**
19/11/2002	5.20	0.51	0.00	0.51	**4.69**
20/11/2002	1.00	0.75	0.00	0.75	**0.25**
21/11/2002	7.60	0.60	0.00	0.60	**7.00**
22/11/2002	0.60	0.73	0.13	0.73	**0.00**
23/11/2002	2.20	0.62	0.00	0.62	**1.45**
24/11/2002	2.80	0.57	0.00	0.57	**2.23**
25/11/2002	1.80	0.52	0.00	0.52	**1.28**
26/11/2002	3.40	0.62	0.00	0.62	**2.78**
27/11/2002	15.60	1.02	0.00	1.02	**14.58**
28/11/2002	0.00	0.40	0.40	0.40	**0.00**
29/11/2002	0.20	0.23	0.43	0.23	**0.00**
30/11/2002	8.60	0.71	0.00	0.71	**7.46**
01/12/2002	7.80	0.48	0.00	0.48	**7.32**
02/12/2002	2.60	0.29	0.00	0.29	**2.31**
03/12/2002	3.60	0.43	0.00	0.43	**3.17**
04/12/2002	0.20	0.56	0.36	0.56	**0.00**
05/12/2002	0.20	0.36	0.52	0.36	**0.00**
06/12/2002	0.20	-0.02	0.30	-0.02	**0.00**
07/12/2002	0.60	0.18	0.00	0.18	**0.12**
08/12/2002	0.00	0.18	0.18	0.18	**0.00**
09/12/2002	0.00	0.23	0.41	0.23	**0.00**
10/12/2002	0.00	0.25	0.66	0.25	**0.00**
11/12/2002	0.00	0.20	0.86	0.20	**0.00**
12/12/2002	4.20	0.16	0.00	0.16	**3.18**
13/12/2002	0.80	-0.15	0.00	-0.15	**0.95**
14/12/2002	0.00	0.35	0.35	0.35	**0.00**
15/12/2002	3.20	0.27	0.00	0.27	**2.58**
16/12/2002	0.00	0.20	0.20	0.20	**0.00**
17/12/2002	0.20	0.07	0.07	0.07	**0.00**
18/12/2002	0.00	0.45	0.52	0.45	**0.00**
19/12/2002	0.00	0.51	1.03	0.51	**0.00**
20/12/2002	1.60	0.22	0.00	0.22	**0.36**
21/12/2002	5.60	0.43	0.00	0.43	**5.17**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
22/12/2002	0.20	0.32	0.12	0.32	**0.00**
23/12/2002	3.40	0.75	0.00	0.75	**2.52**
24/12/2002	0.60	0.40	0.00	0.40	**0.20**
25/12/2002	1.40	0.30	0.00	0.30	**1.10**
26/12/2002	1.80	0.06	0.00	0.06	**1.74**
27/12/2002	9.40	0.18	0.00	0.18	**9.22**
28/12/2002	0.20	0.26	0.06	0.26	**0.00**
29/12/2002	24.00	0.65	0.00	0.65	**23.29**
10/04/2003	0.00	1.37	43.34	1.18	**0.00**
11/04/2003	0.00	1.39	44.53	1.18	**0.00**
12/04/2003	0.00	1.35	45.66	1.14	**0.00**
13/04/2003	1.60	1.70	45.46	1.40	**0.00**
14/04/2003	0.60	2.03	46.55	1.68	**0.00**
15/04/2003	0.00	2.69	48.74	2.20	**0.00**
16/04/2003	0.00	2.95	51.08	2.33	**0.00**
17/04/2003	0.00	3.19	53.52	2.45	**0.00**
18/04/2003	0.00	2.78	55.58	2.05	**0.00**
19/04/2003	0.00	2.13	57.10	1.52	**0.00**
20/04/2003	0.00	1.73	58.31	1.21	**0.00**
21/04/2003	10.00	1.31	49.20	0.90	**0.00**
22/04/2003	0.00	2.40	51.09	1.89	**0.00**
23/04/2003	0.00	2.62	53.10	2.01	**0.00**
24/04/2003	1.80	2.32	53.03	1.73	**0.00**
25/04/2003	6.40	2.46	48.46	1.83	**0.00**
26/04/2003	3.60	2.51	46.86	2.00	**0.00**
27/04/2003	2.00	2.39	46.80	1.94	**0.00**
28/04/2003	5.60	1.51	42.42	1.23	**0.00**
29/04/2003	0.20	2.72	44.56	2.34	**0.00**
30/04/2003	1.40	2.15	44.96	1.80	**0.00**
01/05/2003	20.60	2.09	26.11	1.74	**0.00**
02/05/2003	0.60	2.73	28.23	2.73	**0.00**
03/05/2003	2.20	2.06	28.09	2.06	**0.00**
04/05/2003	24.00	1.62	5.71	1.62	**0.00**
05/05/2003	4.40	2.72	4.03	2.72	**0.00**
06/05/2003	1.20	2.69	5.52	2.69	**0.00**
07/05/2003	0.20	2.50	7.82	2.50	**0.00**
08/05/2003	0.00	2.99	10.80	2.99	**0.00**
09/05/2003	1.80	2.88	11.88	2.88	**0.00**
10/05/2003	1.00	2.78	13.66	2.78	**0.00**
11/05/2003	1.80	2.59	14.45	2.59	**0.00**
12/05/2003	3.40	2.53	13.58	2.53	**0.00**
13/05/2003	0.20	3.24	16.62	3.24	**0.00**
14/05/2003	0.00	3.04	19.67	3.04	**0.00**
15/05/2003	3.60	1.91	17.98	1.91	**0.00**
16/05/2003	9.80	2.31	10.48	2.31	**0.00**
17/05/2003	5.60	2.25	7.13	2.25	**0.00**
18/05/2003	13.40	2.50	0.00	2.50	**3.77**
19/05/2003	6.80	1.96	0.00	1.96	**4.84**
20/05/2003	1.00	1.91	0.91	1.91	**0.00**
21/05/2003	7.60	2.19	0.00	2.19	**4.50**
22/05/2003	0.40	2.50	2.10	2.50	**0.00**
23/05/2003	4.60	2.58	0.08	2.58	**0.00**
24/05/2003	0.20	2.49	2.37	2.49	**0.00**
25/05/2003	0.00	2.14	4.51	2.14	**0.00**
26/05/2003	2.20	2.29	4.60	2.29	**0.00**
27/05/2003	1.00	2.08	5.68	2.08	**0.00**
28/05/2003	3.00	2.06	4.75	2.06	**0.00**
29/05/2003	1.60	2.89	6.04	2.89	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
30/05/2003	0.00	4.84	10.88	4.84	**0.00**
31/05/2003	0.00	3.01	13.89	3.01	**0.00**
01/06/2003	0.40	3.26	16.75	3.26	**0.00**
02/06/2003	0.00	3.17	19.92	3.17	**0.00**
03/06/2003	10.80	1.89	11.01	1.89	**0.00**
04/06/2003	0.20	2.60	13.41	2.60	**0.00**
05/06/2003	2.00	2.44	13.85	2.44	**0.00**
06/06/2003	0.00	3.96	17.81	3.96	**0.00**
07/06/2003	11.40	3.27	9.67	3.27	**0.00**
08/06/2003	1.80	3.12	10.99	3.12	**0.00**
09/06/2003	4.40	2.39	8.98	2.39	**0.00**
10/06/2003	3.00	2.98	8.95	2.98	**0.00**
11/06/2003	0.20	2.67	11.43	2.67	**0.00**
12/06/2003	0.60	3.32	14.15	3.32	**0.00**
13/06/2003	0.00	2.99	17.14	2.99	**0.00**
14/06/2003	0.20	3.86	20.79	3.86	**0.00**
15/06/2003	0.00	3.44	24.23	3.44	**0.00**
16/06/2003	0.20	3.12	27.16	3.12	**0.00**
17/06/2003	0.00	2.84	30.00	2.84	**0.00**
18/06/2003	0.20	2.95	32.75	2.95	**0.00**
19/06/2003	0.00	3.00	35.75	3.00	**0.00**
20/06/2003	0.00	3.44	39.19	3.44	**0.00**
21/06/2003	0.40	2.59	41.38	2.59	**0.00**
22/06/2003	0.00	2.66	43.71	2.33	**0.00**
23/06/2003	0.00	2.76	46.05	2.34	**0.00**
24/06/2003	0.00	2.76	48.31	2.26	**0.00**
25/06/2003	0.00	4.14	51.61	3.30	**0.00**
26/06/2003	1.20	2.83	52.56	2.15	**0.00**
27/06/2003	20.80	2.95	33.97	2.21	**0.00**
28/06/2003	0.00	2.53	36.50	2.53	**0.00**
29/06/2003	2.00	3.20	37.70	3.20	**0.00**
30/06/2003	24.00	2.46	16.16	2.46	**0.00**
01/07/2003	3.20	2.19	15.14	2.19	**0.00**
02/07/2003	0.20	3.38	18.33	3.38	**0.00**
03/07/2003	0.20	2.15	20.28	2.15	**0.00**
04/07/2003	0.00	1.88	22.16	1.88	**0.00**
05/07/2003	0.00	1.98	24.13	1.98	**0.00**
06/07/2003	0.40	2.35	26.08	2.35	**0.00**
07/07/2003	4.00	2.49	24.57	2.49	**0.00**
08/07/2003	11.60	2.99	15.96	2.99	**0.00**
09/07/2003	0.00	2.53	18.49	2.53	**0.00**
10/07/2003	1.20	3.53	20.83	3.53	**0.00**
11/07/2003	0.00	3.28	24.10	3.28	**0.00**
12/07/2003	0.00	3.13	27.23	3.13	**0.00**
13/07/2003	0.00	3.24	30.47	3.24	**0.00**
14/07/2003	0.40	3.11	33.18	3.11	**0.00**
15/07/2003	6.60	2.18	28.76	2.18	**0.00**
16/07/2003	0.80	2.52	30.48	2.52	**0.00**
17/07/2003	19.60	2.44	13.32	2.44	**0.00**
18/07/2003	0.40	3.49	16.41	3.49	**0.00**
19/07/2003	5.00	3.29	14.69	3.29	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
12/06/2002	0.20	2.59	4.19	2.59	**0.00**
13/06/2002	3.40	2.11	2.91	2.11	**0.00**
14/06/2002	4.20	2.78	1.48	2.78	**0.00**
15/06/2002	0.00	2.31	3.79	2.31	**0.00**
16/06/2002	7.40	1.88	0.00	1.88	**1.73**
17/06/2002	0.20	3.09	2.89	3.09	**0.00**
18/06/2002	0.00	2.84	5.73	2.84	**0.00**
19/06/2002	0.40	2.83	8.16	2.83	**0.00**
20/06/2002	0.40	2.86	10.63	2.86	**0.00**
21/06/2002	2.00	3.40	12.02	3.40	**0.00**
22/06/2002	2.20	2.84	12.66	2.84	**0.00**
23/06/2002	1.80	2.84	13.71	2.84	**0.00**
24/06/2002	0.20	2.12	15.62	2.12	**0.00**
25/06/2002	0.00	2.93	18.55	2.93	**0.00**
26/06/2002	0.00	2.78	21.33	2.78	**0.00**
27/06/2002	0.00	3.07	24.40	3.07	**0.00**
28/06/2002	0.00	3.11	27.50	3.11	**0.00**
29/06/2002	0.60	3.03	29.93	3.03	**0.00**
30/06/2002	3.60	2.08	28.41	2.08	**0.00**
01/07/2002	0.00	2.46	30.87	2.46	**0.00**
02/07/2002	0.00	1.91	32.78	1.91	**0.00**
03/07/2002	0.40	3.34	35.73	3.34	**0.00**
04/07/2002	8.40	2.09	29.42	2.09	**0.00**
05/07/2002	2.60	2.72	29.54	2.72	**0.00**
06/07/2002	0.80	2.06	30.79	2.06	**0.00**
07/07/2002	3.20	2.25	29.85	2.25	**0.00**
08/07/2002	2.60	2.43	29.68	2.43	**0.00**
09/07/2002	3.80	2.69	28.56	2.69	**0.00**
10/07/2002	4.20	2.84	27.20	2.84	**0.00**
11/07/2002	20.20	2.35	9.35	2.35	**0.00**
12/07/2002	6.60	2.57	5.32	2.57	**0.00**
13/07/2002	0.00	3.44	8.76	3.44	**0.00**
14/07/2002	0.00	3.26	12.01	3.26	**0.00**
15/07/2002	0.00	2.23	14.25	2.23	**0.00**
16/07/2002	0.00	2.71	16.96	2.71	**0.00**
17/07/2002	0.00	2.88	19.84	2.88	**0.00**
18/07/2002	0.00	2.70	22.54	2.70	**0.00**
19/07/2002	6.00	2.41	18.95	2.41	**0.00**
20/07/2002	0.20	2.88	21.63	2.88	**0.00**
21/07/2002	0.80	3.14	23.97	3.14	**0.00**
22/07/2002	2.60	2.46	23.83	2.46	**0.00**
23/07/2002	0.00	2.37	26.20	2.37	**0.00**
24/07/2002	0.00	1.88	28.08	1.88	**0.00**
25/07/2002	0.00	3.00	31.08	3.00	**0.00**
26/07/2002	0.00	2.81	33.89	2.81	**0.00**
27/07/2002	0.00	2.90	36.79	2.90	**0.00**
28/07/2002	6.40	2.27	32.66	2.27	**0.00**
29/07/2002	4.60	2.15	30.21	2.15	**0.00**
30/07/2002	4.40	2.61	28.42	2.61	**0.00**
31/07/2002	3.80	2.26	26.88	2.26	**0.00**
01/08/2002	9.80	2.16	19.24	2.16	**0.00**
02/08/2002	7.60	1.85	13.50	1.85	**0.00**
03/08/2002	2.80	2.01	12.71	2.01	**0.00**
04/08/2002	0.80	2.43	14.34	2.43	**0.00**
05/08/2002	0.00	2.91	17.25	2.91	**0.00**
06/08/2002	3.80	2.22	15.67	2.22	**0.00**
07/08/2002	2.80	1.81	14.68	1.81	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
08/08/2002	8.40	1.52	7.80	1.52	**0.00**
09/08/2002	0.00	2.63	10.43	2.63	**0.00**
10/08/2002	0.00	2.83	13.26	2.83	**0.00**
11/08/2002	2.20	2.58	13.64	2.58	**0.00**
12/08/2002	0.00	2.63	16.27	2.63	**0.00**
13/08/2002	12.60	2.13	5.81	2.13	**0.00**
14/08/2002	0.00	1.69	7.50	1.69	**0.00**
15/08/2002	1.00	3.30	9.79	3.30	**0.00**
16/08/2002	0.00	2.84	12.64	2.84	**0.00**
17/08/2002	2.00	3.58	14.22	3.58	**0.00**
18/08/2002	0.00	1.86	16.08	1.86	**0.00**
19/08/2002	0.00	2.06	18.14	2.06	**0.00**
20/08/2002	0.60	2.82	20.36	2.82	**0.00**
21/08/2002	0.00	2.56	22.92	2.56	**0.00**
22/08/2002	0.00	2.05	24.97	2.05	**0.00**
23/08/2002	0.00	2.83	27.80	2.83	**0.00**
24/08/2002	3.20	2.08	26.68	2.08	**0.00**
25/08/2002	0.00	2.49	29.17	2.49	**0.00**
26/08/2002	0.20	2.81	31.78	2.81	**0.00**
27/08/2002	0.60	1.83	33.01	1.83	**0.00**
28/08/2002	4.00	2.12	31.12	2.12	**0.00**
29/08/2002	0.00	2.48	33.61	2.48	**0.00**
30/08/2002	3.20	2.23	32.64	2.23	**0.00**
31/08/2002	0.00	2.04	34.68	2.04	**0.00**
01/09/2002	0.00	2.90	37.58	2.90	**0.00**
02/09/2002	0.00	2.55	40.14	2.55	**0.00**
03/09/2002	0.00	1.99	41.90	1.76	**0.00**
04/09/2002	0.00	1.95	43.59	1.69	**0.00**
05/09/2002	0.00	1.93	45.23	1.64	**0.00**
06/09/2002	0.00	1.86	46.78	1.55	**0.00**
07/09/2002	0.00	2.26	48.62	1.84	**0.00**
08/09/2002	1.60	1.70	48.36	1.35	**0.00**
09/09/2002	0.20	1.82	49.61	1.45	**0.00**
10/09/2002	0.00	2.39	51.48	1.87	**0.00**
11/09/2002	0.00	2.57	53.44	1.96	**0.00**
12/09/2002	0.00	2.25	55.10	1.66	**0.00**
13/09/2002	0.00	2.27	56.74	1.64	**0.00**
14/09/2002	0.20	1.91	57.88	1.34	**0.00**
15/09/2002	0.20	1.75	58.89	1.21	**0.00**
16/09/2002	0.00	1.11	59.64	0.75	**0.00**
17/09/2002	0.00	1.14	60.40	0.76	**0.00**
18/09/2002	0.00	1.75	61.56	1.16	**0.00**
19/09/2002	0.00	1.32	62.41	0.86	**0.00**
30/12/2002	2.20	0.36	0.00	0.36	**1.84**
31/12/2002	2.80	0.31	0.00	0.31	**2.49**
01/01/2003	7.00	0.37	0.00	0.37	**6.63**
02/01/2003	1.00	0.53	0.00	0.53	**0.47**
03/01/2003	1.60	0.29	0.00	0.29	**1.31**
04/01/2003	0.20	0.02	0.00	0.02	**0.18**
05/01/2003	0.20	0.22	0.02	0.22	**0.00**
06/01/2003	0.00	0.37	0.39	0.37	**0.00**
07/01/2003	0.00	0.33	0.72	0.33	**0.00**
08/01/2003	2.40	0.23	0.00	0.23	**1.44**
09/01/2003	2.60	0.24	0.00	0.24	**2.36**
10/01/2003	0.00	0.17	0.17	0.17	**0.00**
11/01/2003	0.00	0.13	0.31	0.13	**0.00**
12/01/2003	0.20	0.87	0.97	0.87	**0.00**
13/01/2003	0.40	0.37	0.94	0.37	**0.00**
14/01/2003	0.00	0.25	1.19	0.25	**0.00**
15/01/2003	0.00	0.67	1.86	0.67	**0.00**
16/01/2003	0.20	1.04	2.70	1.04	**0.00**
17/01/2003	11.40	0.79	0.00	0.79	**7.91**
18/01/2003	8.60	0.73	0.00	0.73	**7.87**
19/01/2003	1.40	0.24	0.00	0.24	**1.16**
20/01/2003	6.60	0.51	0.00	0.51	**6.09**
21/01/2003	1.20	0.43	0.00	0.43	**0.77**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
22/01/2003	0.00	0.58	0.58	0.58	**0.00**
23/01/2003	0.20	1.05	1.43	1.05	**0.00**
24/01/2003	4.00	0.52	0.00	0.52	**2.06**
25/01/2003	7.60	0.54	0.00	0.54	**7.06**
26/01/2003	0.00	0.68	0.68	0.68	**0.00**
27/01/2003	1.00	1.18	0.86	1.18	**0.00**
28/01/2003	4.20	0.42	0.00	0.42	**2.92**
29/01/2003	0.40	0.49	0.09	0.49	**0.00**
30/01/2003	1.60	0.73	0.00	0.73	**0.78**
31/01/2003	2.00	0.76	0.00	0.76	**1.24**
01/02/2003	0.40	0.51	0.11	0.51	**0.00**
02/02/2003	2.20	0.54	0.00	0.54	**1.54**
03/02/2003	0.20	0.53	0.33	0.53	**0.00**
04/02/2003	0.80	0.49	0.02	0.49	**0.00**
05/02/2003	0.20	0.67	0.49	0.67	**0.00**
06/02/2003	2.00	0.81	0.00	0.81	**0.70**
07/02/2003	0.20	0.64	0.44	0.64	**0.00**
08/02/2003	4.00	0.54	0.00	0.54	**3.01**
09/02/2003	1.20	0.70	0.00	0.70	**0.50**
10/02/2003	6.60	1.12	0.00	1.12	**5.48**
11/02/2003	0.40	0.45	0.05	0.45	**0.00**
12/02/2003	0.20	0.24	0.09	0.24	**0.00**
13/02/2003	0.00	0.56	0.65	0.56	**0.00**
14/02/2003	0.00	0.41	1.05	0.41	**0.00**
15/02/2003	0.20	0.73	1.59	0.73	**0.00**
16/02/2003	0.00	0.77	2.36	0.77	**0.00**
17/02/2003	0.00	0.55	2.91	0.55	**0.00**
18/02/2003	0.00	0.52	3.42	0.52	**0.00**
19/02/2003	0.00	0.73	4.16	0.73	**0.00**
20/02/2003	0.60	0.44	4.00	0.44	**0.00**
21/02/2003	0.20	1.05	4.85	1.05	**0.00**
22/02/2003	0.00	1.21	6.06	1.21	**0.00**
23/02/2003	0.60	1.39	6.85	1.39	**0.00**
24/02/2003	0.20	1.16	7.81	1.16	**0.00**
25/02/2003	0.00	0.62	8.44	0.62	**0.00**
26/02/2003	2.20	0.44	6.68	0.44	**0.00**
27/02/2003	0.40	0.91	7.19	0.91	**0.00**
28/02/2003	16.80	1.26	0.00	1.26	**8.35**
01/03/2003	3.60	1.02	0.00	1.02	**2.58**
02/03/2003	2.80	1.27	0.00	1.27	**1.53**
03/03/2003	1.40	1.07	0.00	1.07	**0.33**
04/03/2003	0.80	1.13	0.33	1.13	**0.00**
05/03/2003	0.40	1.39	1.33	1.39	**0.00**
06/03/2003	0.00	1.41	2.74	1.41	**0.00**
07/03/2003	3.20	0.94	0.47	0.94	**0.00**
08/03/2003	8.80	1.35	0.00	1.35	**6.98**
09/03/2003	1.40	0.94	0.00	0.94	**0.46**
10/03/2003	10.80	1.12	0.00	1.12	**9.68**
11/03/2003	1.20	1.44	0.24	1.44	**0.00**
12/03/2003	0.20	1.28	1.32	1.28	**0.00**
13/03/2003	0.00	1.00	2.31	1.00	**0.00**
14/03/2003	0.20	1.47	3.58	1.47	**0.00**
15/03/2003	0.00	1.58	5.17	1.58	**0.00**
16/03/2003	0.00	1.66	6.83	1.66	**0.00**
17/03/2003	0.00	1.42	8.25	1.42	**0.00**
18/03/2003	0.20	1.61	9.66	1.61	**0.00**
19/03/2003	0.20	1.42	10.88	1.42	**0.00**
20/03/2003	0.00	1.39	12.26	1.39	**0.00**
21/03/2003	0.00	1.57	13.83	1.57	**0.00**
22/03/2003	0.00	1.78	15.62	1.78	**0.00**
23/03/2003	0.00	1.89	17.50	1.89	**0.00**
24/03/2003	0.00	1.54	19.04	1.54	**0.00**
25/03/2003	0.00	1.52	20.56	1.52	**0.00**
26/03/2003	0.00	1.78	22.34	1.78	**0.00**
27/03/2003	0.00	1.67	24.01	1.67	**0.00**
28/03/2003	1.00	1.16	24.16	1.16	**0.00**
29/03/2003	0.00	1.85	26.02	1.85	**0.00**
30/03/2003	0.00	1.78	27.79	1.78	**0.00**
31/03/2003	0.00	2.40	30.19	2.40	**0.00**
01/04/2003	3.40	1.87	28.66	1.87	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
02/04/2003	0.80	1.95	29.81	1.95	**0.00**
03/04/2003	0.00	1.53	31.34	1.53	**0.00**
04/04/2003	0.20	2.44	33.58	2.44	**0.00**
05/04/2003	0.00	1.82	35.40	1.82	**0.00**
06/04/2003	0.00	1.88	37.28	1.88	**0.00**
07/04/2003	0.00	1.28	38.56	1.28	**0.00**
08/04/2003	0.00	1.88	40.45	1.88	**0.00**
09/04/2003	0.00	1.94	42.16	1.71	**0.00**
20/07/2003	0.20	2.87	17.36	2.87	**0.00**
21/07/2003	6.40	3.19	14.15	3.19	**0.00**
22/07/2003	0.20	2.11	16.07	2.11	**0.00**
23/07/2003	3.80	2.47	14.73	2.47	**0.00**
24/07/2003	3.40	2.24	13.57	2.24	**0.00**
25/07/2003	0.20	2.81	16.18	2.81	**0.00**
26/07/2003	0.00	2.89	19.07	2.89	**0.00**
27/07/2003	5.00	3.12	17.20	3.12	**0.00**
28/07/2003	4.20	2.64	15.63	2.64	**0.00**
29/07/2003	2.60	2.41	15.44	2.41	**0.00**
30/07/2003	1.00	2.99	17.43	2.99	**0.00**
31/07/2003	3.40	2.92	16.96	2.92	**0.00**

(Hargreaves method)

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
04/03/2002	0.40	0.83	0.00	0.00	**0.40**
05/03/2002	0.20	1.16	0.96	1.16	**0.00**
06/03/2002	0.20	0.98	1.75	0.98	**0.00**
07/03/2002	0.00	1.05	2.79	1.05	**0.00**
08/03/2002	2.80	1.36	1.35	1.36	**0.00**
09/03/2002	10.40	0.87	0.00	0.87	**8.18**
10/03/2002	6.40	1.08	0.00	1.08	**5.32**
11/03/2002	0.00	1.36	1.36	1.36	**0.00**
12/03/2002	0.20	1.30	2.46	1.30	**0.00**
13/03/2002	0.60	1.05	2.91	1.05	**0.00**
14/03/2002	0.00	0.96	3.87	0.96	**0.00**
15/03/2002	0.40	0.94	4.40	0.94	**0.00**
16/03/2002	0.40	1.44	5.44	1.44	**0.00**
17/03/2002	1.40	1.03	5.07	1.03	**0.00**
18/03/2002	1.60	1.19	4.66	1.19	**0.00**
19/03/2002	0.20	1.32	5.78	1.32	**0.00**
20/03/2002	2.40	1.25	4.63	1.25	**0.00**
21/03/2002	0.40	1.77	6.00	1.77	**0.00**
22/03/2002	0.00	1.59	7.59	1.59	**0.00**
23/03/2002	0.00	1.00	8.59	1.00	**0.00**
24/03/2002	0.20	0.84	9.23	0.84	**0.00**
25/03/2002	0.60	1.78	10.40	1.78	**0.00**
26/03/2002	0.20	2.00	12.21	2.00	**0.00**
27/03/2002	0.00	1.84	14.05	1.84	**0.00**
28/03/2002	0.00	2.05	16.09	2.05	**0.00**
29/03/2002	0.20	2.32	18.22	2.32	**0.00**
30/03/2002	4.40	1.95	15.77	1.95	**0.00**
31/03/2002	1.00	1.55	16.32	1.55	**0.00**
01/04/2002	3.60	1.67	14.39	1.67	**0.00**
02/04/2002	2.80	1.53	13.12	1.53	**0.00**
03/04/2002	3.80	2.13	11.44	2.13	**0.00**
04/04/2002	0.00	2.10	13.54	2.10	**0.00**
05/04/2002	0.00	1.84	15.37	1.84	**0.00**
06/04/2002	0.00	1.49	16.86	1.49	**0.00**
07/04/2002	0.00	2.20	19.06	2.20	**0.00**
08/04/2002	0.20	2.52	21.38	2.52	**0.00**
09/04/2002	0.00	2.34	23.72	2.34	**0.00**
10/04/2002	0.00	2.00	25.71	2.00	**0.00**
11/04/2002	0.20	2.23	27.74	2.23	**0.00**
12/04/2002	0.40	1.96	29.30	1.96	**0.00**
13/04/2002	0.20	2.35	31.45	2.35	**0.00**
14/04/2002	1.00	1.70	32.15	1.70	**0.00**
15/04/2002	0.00	2.49	34.64	2.49	**0.00**
16/04/2002	0.40	2.13	36.37	2.13	**0.00**
17/04/2002	36.60	1.50	1.27	1.50	**0.00**
18/04/2002	1.60	2.37	2.04	2.37	**0.00**
19/04/2002	0.60	2.73	4.16	2.73	**0.00**
20/04/2002	1.60	1.59	4.15	1.59	**0.00**
21/04/2002	10.20	1.35	0.00	1.35	**4.70**
22/04/2002	0.00	2.38	2.38	2.38	**0.00**
23/04/2002	0.00	3.06	5.44	3.06	**0.00**
24/04/2002	0.80	2.42	7.06	2.42	**0.00**
25/04/2002	1.80	2.44	7.69	2.44	**0.00**
26/04/2002	9.40	1.92	0.22	1.92	**0.00**
27/04/2002	9.80	1.55	0.00	1.55	**8.03**
28/04/2002	9.40	1.72	0.00	1.72	**7.68**
29/04/2002	1.40	2.19	0.79	2.19	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
30/04/2002	5.40	2.13	0.00	2.13	**2.48**
01/05/2002	4.00	2.32	0.00	2.32	**1.68**
02/05/2002	2.80	2.62	0.00	2.62	**0.18**
03/05/2002	0.40	2.85	2.45	2.85	**0.00**
04/05/2002	0.00	3.49	5.94	3.49	**0.00**
05/05/2002	0.00	3.44	9.38	3.44	**0.00**
06/05/2002	0.00	3.03	12.40	3.03	**0.00**
07/05/2002	1.00	3.07	14.47	3.07	**0.00**
08/05/2002	0.00	2.63	17.10	2.63	**0.00**
09/05/2002	0.00	2.86	19.96	2.86	**0.00**
10/05/2002	0.20	3.50	23.26	3.50	**0.00**
11/05/2002	0.00	2.64	25.91	2.64	**0.00**
12/05/2002	0.80	2.91	28.01	2.91	**0.00**
13/05/2002	5.00	2.31	25.32	2.31	**0.00**
14/05/2002	1.20	2.81	26.93	2.81	**0.00**
15/05/2002	0.00	2.80	29.72	2.80	**0.00**
16/05/2002	0.20	3.30	32.83	3.30	**0.00**
17/05/2002	29.00	2.53	6.35	2.53	**0.00**
18/05/2002	0.20	2.87	9.03	2.87	**0.00**
19/05/2002	3.20	2.94	8.77	2.94	**0.00**
20/05/2002	4.20	2.73	7.30	2.73	**0.00**
21/05/2002	3.00	2.34	6.64	2.34	**0.00**
22/05/2002	5.80	3.03	3.87	3.03	**0.00**
23/05/2002	5.60	2.69	0.95	2.69	**0.00**
24/05/2002	6.80	2.11	0.00	2.11	**3.74**
25/05/2002	3.40	2.78	0.00	2.78	**0.62**
26/05/2002	0.40	3.17	2.77	3.17	**0.00**
27/05/2002	1.60	3.16	4.32	3.16	**0.00**
28/05/2002	8.80	2.97	0.00	2.97	**1.50**
29/05/2002	3.40	2.65	0.00	2.65	**0.75**
30/05/2002	3.20	3.05	0.00	3.05	**0.15**
31/05/2002	0.00	3.56	3.56	3.56	**0.00**
01/06/2002	1.00	4.05	6.61	4.05	**0.00**
02/06/2002	7.80	3.10	1.90	3.10	**0.00**
03/06/2002	4.20	2.96	0.66	2.96	**0.00**
04/06/2002	1.60	2.64	1.70	2.64	**0.00**
05/06/2002	0.00	3.64	5.34	3.64	**0.00**
06/06/2002	0.00	3.23	8.57	3.23	**0.00**
07/06/2002	4.00	2.44	7.00	2.44	**0.00**
08/06/2002	1.60	1.90	7.30	1.90	**0.00**
09/06/2002	9.80	2.85	0.35	2.85	**0.00**
10/06/2002	6.20	2.80	0.00	2.80	**3.05**
11/06/2002	1.00	3.22	2.22	3.22	**0.00**
20/09/2002	0.00	2.39	81.23	1.06	**0.00**
21/09/2002	0.00	2.35	82.25	1.01	**0.00**
22/09/2002	0.00	1.91	83.05	0.80	**0.00**
23/09/2002	0.00	2.09	83.91	0.86	**0.00**
24/09/2002	0.00	2.20	84.79	0.88	**0.00**
25/09/2002	0.00	2.14	85.63	0.84	**0.00**
26/09/2002	0.00	1.51	86.21	0.58	**0.00**
27/09/2002	0.00	1.63	86.82	0.61	**0.00**
28/09/2002	0.00	1.52	87.38	0.56	**0.00**
29/09/2002	0.00	1.81	88.03	0.65	**0.00**
30/09/2002	10.00	1.41	78.53	0.50	**0.00**
01/10/2002	1.00	1.23	78.10	0.57	**0.00**
02/10/2002	8.20	1.57	70.63	0.73	**0.00**
03/10/2002	0.40	1.72	71.17	0.94	**0.00**
04/10/2002	0.00	1.90	72.20	1.03	**0.00**
05/10/2002	0.20	1.84	72.98	0.98	**0.00**
06/10/2002	0.20	1.66	73.64	0.86	**0.00**
07/10/2002	0.00	1.39	74.36	0.72	**0.00**
08/10/2002	8.40	0.74	66.33	0.38	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
09/10/2002	4.40	0.73	62.37	0.44	**0.00**
10/10/2002	0.00	1.44	63.29	0.92	**0.00**
11/10/2002	29.60	0.84	34.22	0.53	**0.00**
12/10/2002	0.20	1.33	35.35	1.33	**0.00**
13/10/2002	4.40	1.11	32.06	1.11	**0.00**
14/10/2002	0.20	1.17	33.03	1.17	**0.00**
15/10/2002	10.00	0.90	23.93	0.90	**0.00**
16/10/2002	0.00	1.03	24.96	1.03	**0.00**
17/10/2002	3.00	1.00	22.96	1.00	**0.00**
18/10/2002	0.20	1.02	23.78	1.02	**0.00**
19/10/2002	0.00	1.04	24.81	1.04	**0.00**
20/10/2002	32.00	0.75	0.00	0.75	**6.43**
21/10/2002	18.20	0.92	0.00	0.92	**17.28**
22/10/2002	0.80	0.87	0.07	0.87	**0.00**
23/10/2002	0.40	0.71	0.38	0.71	**0.00**
24/10/2002	1.80	0.94	0.00	0.94	**0.48**
25/10/2002	6.80	0.77	0.00	0.77	**6.03**
26/10/2002	7.20	0.82	0.00	0.82	**6.38**
27/10/2002	3.60	0.85	0.00	0.85	**2.75**
28/10/2002	1.40	0.74	0.00	0.74	**0.66**
29/10/2002	23.80	0.52	0.00	0.52	**23.28**
30/10/2002	0.00	0.70	0.70	0.70	**0.00**
31/10/2002	0.20	0.90	1.40	0.90	**0.00**
01/11/2002	2.20	0.82	0.01	0.82	**0.00**
02/11/2002	11.00	0.94	0.00	0.94	**10.05**
03/11/2002	6.80	0.50	0.00	0.50	**6.30**
04/11/2002	0.40	0.68	0.28	0.68	**0.00**
05/11/2002	1.00	0.78	0.06	0.78	**0.00**
06/11/2002	3.80	0.75	0.00	0.75	**2.99**
07/11/2002	0.00	0.52	0.52	0.52	**0.00**
08/11/2002	14.20	0.66	0.00	0.66	**13.02**
09/11/2002	9.00	0.55	0.00	0.55	**8.45**
10/11/2002	4.60	0.58	0.00	0.58	**4.02**
11/11/2002	0.40	0.45	0.05	0.45	**0.00**
12/11/2002	0.60	0.54	0.00	0.54	**0.01**
13/11/2002	0.60	0.55	0.00	0.55	**0.05**
14/11/2002	26.40	0.41	0.00	0.41	**25.99**
15/11/2002	20.20	0.26	0.00	0.26	**19.94**
16/11/2002	0.00	0.43	0.43	0.43	**0.00**
17/11/2002	0.00	0.39	0.82	0.39	**0.00**
18/11/2002	5.60	0.52	0.00	0.52	**4.26**
19/11/2002	5.20	0.34	0.00	0.34	**4.86**
20/11/2002	1.00	0.45	0.00	0.45	**0.55**
21/11/2002	7.60	0.45	0.00	0.45	**7.15**
22/11/2002	0.60	0.44	0.00	0.44	**0.16**
23/11/2002	2.20	0.38	0.00	0.38	**1.82**
24/11/2002	2.80	0.38	0.00	0.38	**2.42**
25/11/2002	1.80	0.36	0.00	0.36	**1.44**
26/11/2002	3.40	0.34	0.00	0.34	**3.06**
27/11/2002	15.60	0.44	0.00	0.44	**15.16**
28/11/2002	0.00	0.32	0.32	0.32	**0.00**
29/11/2002	0.20	0.45	0.58	0.45	**0.00**
30/11/2002	8.60	0.44	0.00	0.44	**7.58**
01/12/2002	7.80	0.27	0.00	0.27	**7.53**
02/12/2002	2.60	0.26	0.00	0.26	**2.34**
03/12/2002	3.60	0.30	0.00	0.30	**3.30**
04/12/2002	0.20	0.37	0.17	0.37	**0.00**
05/12/2002	0.20	0.33	0.30	0.33	**0.00**
06/12/2002	0.20	0.34	0.44	0.34	**0.00**
07/12/2002	0.60	0.23	0.07	0.23	**0.00**
08/12/2002	0.00	0.16	0.23	0.16	**0.00**
09/12/2002	0.00	0.18	0.41	0.18	**0.00**
10/12/2002	0.00	0.22	0.62	0.22	**0.00**
11/12/2002	0.00	0.17	0.79	0.17	**0.00**
12/12/2002	4.20	0.18	0.00	0.18	**3.23**
13/12/2002	0.80	0.29	0.00	0.29	**0.51**
14/12/2002	0.00	0.32	0.32	0.32	**0.00**
15/12/2002	3.20	0.21	0.00	0.21	**2.67**
16/12/2002	0.00	0.29	0.29	0.29	**0.00**
17/12/2002	0.20	0.29	0.38	0.29	**0.00**
18/12/2002	0.00	0.29	0.67	0.29	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
19/12/2002	0.00	0.33	1.01	0.33	**0.00**
20/12/2002	1.60	0.24	0.00	0.24	**0.35**
21/12/2002	5.60	0.31	0.00	0.31	**5.29**
22/12/2002	0.20	0.25	0.05	0.25	**0.00**
23/12/2002	3.40	0.31	0.00	0.31	**3.03**
24/12/2002	0.60	0.27	0.00	0.27	**0.33**
25/12/2002	1.40	0.24	0.00	0.24	**1.16**
26/12/2002	1.80	0.21	0.00	0.21	**1.59**
27/12/2002	9.40	0.18	0.00	0.18	**9.22**
28/12/2002	0.20	0.29	0.09	0.29	**0.00**
29/12/2002	24.00	0.39	0.00	0.39	**23.52**
10/04/2003	0.00	1.81	49.55	1.45	**0.00**
11/04/2003	0.00	1.93	51.06	1.51	**0.00**
12/04/2003	0.00	1.86	52.49	1.43	**0.00**
13/04/2003	1.60	2.02	52.41	1.52	**0.00**
14/04/2003	0.60	2.41	53.61	1.81	**0.00**
15/04/2003	0.00	3.25	56.01	2.39	**0.00**
16/04/2003	0.00	3.57	58.55	2.54	**0.00**
17/04/2003	0.00	3.00	60.60	2.05	**0.00**
18/04/2003	0.00	2.51	62.26	1.65	**0.00**
19/04/2003	0.00	1.78	63.40	1.14	**0.00**
20/04/2003	0.00	1.74	64.49	1.10	**0.00**
21/04/2003	10.00	1.63	55.50	1.00	**0.00**
22/04/2003	0.00	2.58	57.34	1.85	**0.00**
23/04/2003	0.00	2.67	59.20	1.86	**0.00**
24/04/2003	1.80	2.33	58.98	1.57	**0.00**
25/04/2003	6.40	2.47	54.25	1.67	**0.00**
26/04/2003	3.60	2.41	52.41	1.76	**0.00**
27/04/2003	2.00	2.55	52.32	1.92	**0.00**
28/04/2003	5.60	1.83	48.10	1.37	**0.00**
29/04/2003	0.20	2.87	50.19	2.29	**0.00**
30/04/2003	1.40	2.39	50.64	1.85	**0.00**
01/05/2003	20.60	2.28	31.79	1.76	**0.00**
02/05/2003	0.60	2.69	33.89	2.69	**0.00**
03/05/2003	2.20	2.54	34.23	2.54	**0.00**
04/05/2003	24.00	1.88	12.11	1.88	**0.00**
05/05/2003	4.40	2.57	10.28	2.57	**0.00**
06/05/2003	1.20	2.96	12.04	2.96	**0.00**
07/05/2003	0.20	3.05	14.89	3.05	**0.00**
08/05/2003	0.00	2.98	17.88	2.98	**0.00**
09/05/2003	1.80	2.88	18.96	2.88	**0.00**
10/05/2003	1.00	3.06	21.01	3.06	**0.00**
11/05/2003	1.80	2.71	21.93	2.71	**0.00**
12/05/2003	3.40	2.42	20.95	2.42	**0.00**
13/05/2003	0.20	2.93	23.68	2.93	**0.00**
14/05/2003	0.00	3.26	26.94	3.26	**0.00**
15/05/2003	3.60	2.60	25.94	2.60	**0.00**
16/05/2003	9.80	2.68	18.82	2.68	**0.00**
17/05/2003	5.60	2.20	15.42	2.20	**0.00**
18/05/2003	13.40	2.68	4.70	2.68	**0.00**
19/05/2003	6.80	2.05	0.00	2.05	**0.05**
20/05/2003	1.00	2.40	1.40	2.40	**0.00**
21/05/2003	7.60	3.08	0.00	3.08	**3.12**
22/05/2003	0.40	3.30	2.90	3.30	**0.00**
23/05/2003	4.60	2.54	0.84	2.54	**0.00**
24/05/2003	0.20	2.44	3.08	2.44	**0.00**
25/05/2003	0.00	2.92	5.99	2.92	**0.00**
26/05/2003	2.20	3.31	7.10	3.31	**0.00**
27/05/2003	1.00	2.90	9.01	2.90	**0.00**
28/05/2003	3.00	2.74	8.75	2.74	**0.00**
29/05/2003	1.60	3.89	11.04	3.89	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
30/05/2003	0.00	5.29	16.34	5.29	**0.00**
31/05/2003	0.00	3.76	20.09	3.76	**0.00**
01/06/2003	0.40	3.37	23.06	3.37	**0.00**
02/06/2003	0.00	3.50	26.56	3.50	**0.00**
03/06/2003	10.80	2.52	18.28	2.52	**0.00**
04/06/2003	0.20	3.05	21.13	3.05	**0.00**
05/06/2003	2.00	3.16	22.29	3.16	**0.00**
06/06/2003	0.00	3.92	26.21	3.92	**0.00**
07/06/2003	11.40	3.03	17.85	3.03	**0.00**
08/06/2003	1.80	3.94	19.98	3.94	**0.00**
09/06/2003	4.40	3.13	18.72	3.13	**0.00**
10/06/2003	3.00	3.30	19.02	3.30	**0.00**
11/06/2003	0.20	3.53	22.34	3.53	**0.00**
12/06/2003	0.60	3.55	25.30	3.55	**0.00**
13/06/2003	0.00	3.78	29.08	3.78	**0.00**
14/06/2003	0.20	4.84	33.72	4.84	**0.00**
15/06/2003	0.00	3.91	37.63	3.91	**0.00**
16/06/2003	0.20	4.73	42.16	4.73	**0.00**
17/06/2003	0.00	3.52	45.20	3.04	**0.00**
18/06/2003	0.20	3.45	47.87	2.86	**0.00**
19/06/2003	0.00	3.55	50.71	2.84	**0.00**
20/06/2003	0.00	3.71	53.57	2.86	**0.00**
21/06/2003	0.40	4.03	56.14	2.98	**0.00**
22/06/2003	0.00	3.91	58.91	2.77	**0.00**
23/06/2003	0.00	3.48	61.27	2.36	**0.00**
24/06/2003	0.00	4.46	64.18	2.91	**0.00**
25/06/2003	0.00	5.09	67.34	3.16	**0.00**
26/06/2003	1.20	3.81	68.37	2.23	**0.00**
27/06/2003	20.80	3.24	49.43	1.86	**0.00**
28/06/2003	0.00	3.82	52.42	2.99	**0.00**
29/06/2003	2.00	4.43	53.75	3.32	**0.00**
30/06/2003	24.00	2.55	31.62	1.87	**0.00**
01/07/2003	3.20	3.28	31.70	3.28	**0.00**
02/07/2003	0.20	4.01	35.51	4.01	**0.00**
03/07/2003	0.20	2.77	38.08	2.77	**0.00**
04/07/2003	0.00	2.58	40.66	2.58	**0.00**
05/07/2003	0.00	2.96	43.27	2.61	**0.00**
06/07/2003	0.40	3.39	45.76	2.89	**0.00**
07/07/2003	4.00	3.11	44.32	2.57	**0.00**
08/07/2003	11.60	3.78	35.90	3.18	**0.00**
09/07/2003	0.00	3.57	39.46	3.57	**0.00**
10/07/2003	1.20	3.58	41.84	3.58	**0.00**
11/07/2003	0.00	3.46	44.85	3.01	**0.00**
12/07/2003	0.00	4.28	48.42	3.57	**0.00**
13/07/2003	0.00	4.74	52.19	3.77	**0.00**
14/07/2003	0.40	4.96	55.53	3.74	**0.00**
15/07/2003	6.60	3.38	51.35	2.42	**0.00**
16/07/2003	0.80	4.73	54.16	3.61	**0.00**
17/07/2003	19.60	1.97	36.00	1.44	**0.00**
18/07/2003	0.40	4.26	39.85	4.26	**0.00**
19/07/2003	5.00	3.21	38.06	3.21	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
12/06/2002	0.20	3.50	5.52	3.50	**0.00**
13/06/2002	3.40	2.55	4.67	2.55	**0.00**
14/06/2002	4.20	3.16	3.63	3.16	**0.00**
15/06/2002	0.00	2.86	6.48	2.86	**0.00**
16/06/2002	7.40	2.49	1.58	2.49	**0.00**
17/06/2002	0.20	3.24	4.62	3.24	**0.00**
18/06/2002	0.00	3.11	7.73	3.11	**0.00**
19/06/2002	0.40	3.45	10.77	3.45	**0.00**
20/06/2002	0.40	3.84	14.22	3.84	**0.00**
21/06/2002	2.00	3.98	16.20	3.98	**0.00**
22/06/2002	2.20	3.30	17.29	3.30	**0.00**
23/06/2002	1.80	3.48	18.97	3.48	**0.00**
24/06/2002	0.20	2.88	21.65	2.88	**0.00**
25/06/2002	0.00	3.44	25.10	3.44	**0.00**
26/06/2002	0.00	3.32	28.42	3.32	**0.00**
27/06/2002	0.00	3.35	31.77	3.35	**0.00**
28/06/2002	0.00	3.79	35.56	3.79	**0.00**
29/06/2002	0.60	3.92	38.88	3.92	**0.00**
30/06/2002	3.60	1.76	37.04	1.76	**0.00**
01/07/2002	0.00	2.82	39.86	2.82	**0.00**
02/07/2002	0.00	2.62	42.49	2.62	**0.00**
03/07/2002	0.40	3.63	45.22	3.13	**0.00**
04/07/2002	8.40	3.15	39.43	2.61	**0.00**
05/07/2002	2.60	3.34	40.17	3.34	**0.00**
06/07/2002	0.80	3.16	42.17	2.81	**0.00**
07/07/2002	3.20	3.10	41.65	2.68	**0.00**
08/07/2002	2.60	3.04	41.70	2.65	**0.00**
09/07/2002	3.80	3.49	40.94	3.04	**0.00**
10/07/2002	4.20	3.22	39.57	2.83	**0.00**
11/07/2002	20.20	2.84	22.21	2.84	**0.00**
12/07/2002	6.60	3.57	19.17	3.57	**0.00**
13/07/2002	0.00	4.16	23.34	4.16	**0.00**
14/07/2002	0.00	3.97	27.31	3.97	**0.00**
15/07/2002	0.00	3.46	30.77	3.46	**0.00**
16/07/2002	0.00	2.31	33.09	2.31	**0.00**
17/07/2002	0.00	3.26	36.35	3.26	**0.00**
18/07/2002	0.00	4.16	40.51	4.16	**0.00**
19/07/2002	6.00	2.95	37.11	2.60	**0.00**
20/07/2002	0.20	3.11	40.03	3.11	**0.00**
21/07/2002	0.80	3.85	42.65	3.42	**0.00**
22/07/2002	2.60	3.35	42.93	2.88	**0.00**
23/07/2002	0.00	2.72	45.26	2.33	**0.00**
24/07/2002	0.00	2.53	47.36	2.10	**0.00**
25/07/2002	0.00	3.49	50.17	2.81	**0.00**
26/07/2002	0.00	3.19	52.65	2.48	**0.00**
27/07/2002	0.00	3.46	55.24	2.59	**0.00**
28/07/2002	6.40	2.73	50.81	1.97	**0.00**
29/07/2002	4.60	2.80	48.36	2.15	**0.00**
30/07/2002	4.40	2.55	45.99	2.03	**0.00**
31/07/2002	3.80	2.48	44.22	2.04	**0.00**
01/08/2002	9.80	2.83	36.80	2.38	**0.00**
02/08/2002	7.60	1.30	30.50	1.30	**0.00**
03/08/2002	2.80	2.36	30.06	2.36	**0.00**
04/08/2002	0.80	3.88	33.14	3.88	**0.00**
05/08/2002	0.00	4.61	37.75	4.61	**0.00**
06/08/2002	3.80	3.39	37.34	3.39	**0.00**
07/08/2002	2.80	2.25	36.79	2.25	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
08/08/2002	8.40	2.06	30.45	2.06	**0.00**
09/08/2002	0.00	2.74	33.18	2.74	**0.00**
10/08/2002	0.00	3.15	36.33	3.15	**0.00**
11/08/2002	2.20	2.98	37.11	2.98	**0.00**
12/08/2002	0.00	3.54	40.65	3.54	**0.00**
13/08/2002	12.60	2.60	30.34	2.29	**0.00**
14/08/2002	0.00	1.77	32.11	1.77	**0.00**
15/08/2002	1.00	3.27	34.38	3.27	**0.00**
16/08/2002	0.00	3.39	37.77	3.39	**0.00**
17/08/2002	2.00	3.22	39.00	3.22	**0.00**
18/08/2002	0.00	2.63	41.63	2.63	**0.00**
19/08/2002	0.00	2.53	43.83	2.20	**0.00**
20/08/2002	0.60	2.78	45.58	2.35	**0.00**
21/08/2002	0.00	3.75	48.69	3.10	**0.00**
22/08/2002	0.00	3.35	51.34	2.65	**0.00**
23/08/2002	0.00	2.76	53.44	2.10	**0.00**
24/08/2002	3.20	2.05	51.76	1.52	**0.00**
25/08/2002	0.00	3.00	54.04	2.28	**0.00**
26/08/2002	0.20	3.33	56.28	2.44	**0.00**
27/08/2002	0.60	3.19	57.94	2.26	**0.00**
28/08/2002	4.00	2.24	55.49	1.55	**0.00**
29/08/2002	0.00	2.29	57.13	1.64	**0.00**
30/08/2002	3.20	2.17	55.44	1.51	**0.00**
31/08/2002	0.00	2.54	57.26	1.82	**0.00**
01/09/2002	0.00	3.16	59.47	2.21	**0.00**
02/09/2002	0.00	3.03	61.51	2.04	**0.00**
03/09/2002	0.00	3.22	63.60	2.09	**0.00**
04/09/2002	0.00	2.42	65.11	1.52	**0.00**
05/09/2002	0.00	2.13	66.41	1.30	**0.00**
06/09/2002	0.00	2.05	67.63	1.22	**0.00**
07/09/2002	0.00	2.00	68.80	1.17	**0.00**
08/09/2002	1.60	1.77	68.21	1.01	**0.00**
09/09/2002	0.20	2.43	69.40	1.40	**0.00**
10/09/2002	0.00	2.64	70.89	1.49	**0.00**
11/09/2002	0.00	2.34	72.17	1.28	**0.00**
12/09/2002	0.00	2.54	73.52	1.35	**0.00**
13/09/2002	0.00	2.58	74.85	1.33	**0.00**
14/09/2002	0.20	2.32	75.81	1.16	**0.00**
15/09/2002	0.20	2.55	76.86	1.25	**0.00**
16/09/2002	0.00	1.43	77.55	0.69	**0.00**
17/09/2002	0.00	1.78	78.39	0.84	**0.00**
18/09/2002	0.00	1.76	79.20	0.81	**0.00**
19/09/2002	0.00	2.15	80.18	0.98	**0.00**
30/12/2002	2.20	0.28	0.00	0.28	**1.92**
31/12/2002	2.80	0.22	0.00	0.22	**2.58**
01/01/2003	7.00	0.26	0.00	0.26	**6.74**
02/01/2003	1.00	0.32	0.00	0.32	**0.68**
03/01/2003	1.60	0.23	0.00	0.23	**1.37**
04/01/2003	0.20	0.30	0.10	0.30	**0.00**
05/01/2003	0.20	0.35	0.25	0.35	**0.00**
06/01/2003	0.00	0.33	0.58	0.33	**0.00**
07/01/2003	0.00	0.19	0.77	0.19	**0.00**
08/01/2003	2.40	0.29	0.00	0.29	**1.34**
09/01/2003	2.60	0.26	0.00	0.26	**2.34**
10/01/2003	0.00	0.23	0.23	0.23	**0.00**
11/01/2003	0.00	0.37	0.60	0.37	**0.00**
12/01/2003	0.20	0.42	0.82	0.42	**0.00**
13/01/2003	0.40	0.26	0.68	0.26	**0.00**
14/01/2003	0.00	0.18	0.86	0.18	**0.00**
15/01/2003	0.00	0.42	1.28	0.42	**0.00**
16/01/2003	0.20	0.46	1.54	0.46	**0.00**
17/01/2003	11.40	0.46	0.00	0.46	**9.40**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
18/01/2003	8.60	0.40	0.00	0.40	**8.20**
19/01/2003	1.40	0.40	0.00	0.40	**1.00**
20/01/2003	6.60	0.37	0.00	0.37	**6.23**
21/01/2003	1.20	0.40	0.00	0.40	**0.80**
22/01/2003	0.00	0.44	0.44	0.44	**0.00**
23/01/2003	0.20	0.58	0.82	0.58	**0.00**
24/01/2003	4.00	0.35	0.00	0.35	**2.84**
25/01/2003	7.60	0.41	0.00	0.41	**7.19**
26/01/2003	0.00	0.58	0.58	0.58	**0.00**
27/01/2003	1.00	0.63	0.21	0.63	**0.00**
28/01/2003	4.20	0.30	0.00	0.30	**3.69**
29/01/2003	0.40	0.35	0.00	0.35	**0.05**
30/01/2003	1.60	0.47	0.00	0.47	**1.13**
31/01/2003	2.00	0.51	0.00	0.51	**1.49**
01/02/2003	0.40	0.49	0.09	0.49	**0.00**
02/02/2003	2.20	0.40	0.00	0.40	**1.71**
03/02/2003	0.20	0.41	0.21	0.41	**0.00**
04/02/2003	0.80	0.45	0.00	0.45	**0.14**
05/02/2003	0.20	0.59	0.39	0.59	**0.00**
06/02/2003	2.00	0.62	0.00	0.62	**0.99**
07/02/2003	0.20	0.59	0.39	0.59	**0.00**
08/02/2003	4.00	0.44	0.00	0.44	**3.16**
09/02/2003	1.20	0.68	0.00	0.68	**0.52**
10/02/2003	6.60	0.69	0.00	0.69	**5.91**
11/02/2003	0.40	0.84	0.44	0.84	**0.00**
12/02/2003	0.20	0.85	1.09	0.85	**0.00**
13/02/2003	0.00	0.75	1.83	0.75	**0.00**
14/02/2003	0.00	0.64	2.47	0.64	**0.00**
15/02/2003	0.20	0.82	3.09	0.82	**0.00**
16/02/2003	0.00	0.57	3.66	0.57	**0.00**
17/02/2003	0.00	0.45	4.11	0.45	**0.00**
18/02/2003	0.00	0.42	4.53	0.42	**0.00**
19/02/2003	0.00	0.70	5.23	0.70	**0.00**
20/02/2003	0.60	0.67	5.30	0.67	**0.00**
21/02/2003	0.20	0.99	6.10	0.99	**0.00**
22/02/2003	0.00	0.89	6.98	0.89	**0.00**
23/02/2003	0.60	1.02	7.40	1.02	**0.00**
24/02/2003	0.20	0.94	8.15	0.94	**0.00**
25/02/2003	0.00	0.59	8.74	0.59	**0.00**
26/02/2003	2.20	0.34	6.88	0.34	**0.00**
27/02/2003	0.40	0.86	7.34	0.86	**0.00**
28/02/2003	16.80	0.98	0.00	0.98	**8.49**
01/03/2003	3.60	0.97	0.00	0.97	**2.63**
02/03/2003	2.80	1.26	0.00	1.26	**1.54**
03/03/2003	1.40	0.96	0.00	0.96	**0.44**
04/03/2003	0.80	0.98	0.18	0.98	**0.00**
05/03/2003	0.40	1.19	0.96	1.19	**0.00**
06/03/2003	0.00	1.22	2.18	1.22	**0.00**
07/03/2003	3.20	0.80	0.00	0.80	**0.22**
08/03/2003	8.80	1.18	0.00	1.18	**7.62**
09/03/2003	1.40	0.86	0.00	0.86	**0.54**
10/03/2003	10.80	1.02	0.00	1.02	**9.78**
11/03/2003	1.20	1.21	0.01	1.21	**0.00**
12/03/2003	0.20	1.24	1.05	1.24	**0.00**
13/03/2003	0.00	1.20	2.25	1.20	**0.00**
14/03/2003	0.20	1.55	3.60	1.55	**0.00**
15/03/2003	0.00	1.60	5.20	1.60	**0.00**
16/03/2003	0.00	1.85	7.05	1.85	**0.00**
17/03/2003	0.00	2.16	9.21	2.16	**0.00**
18/03/2003	0.20	2.19	11.20	2.19	**0.00**
19/03/2003	0.20	1.70	12.71	1.70	**0.00**
20/03/2003	0.00	1.67	14.38	1.67	**0.00**
21/03/2003	0.00	1.91	16.29	1.91	**0.00**
22/03/2003	0.00	1.82	18.11	1.82	**0.00**
23/03/2003	0.00	2.45	20.56	2.45	**0.00**
24/03/2003	0.00	2.08	22.64	2.08	**0.00**
25/03/2003	0.00	1.72	24.36	1.72	**0.00**
26/03/2003	0.00	2.47	26.82	2.47	**0.00**
27/03/2003	0.00	1.98	28.81	1.98	**0.00**
28/03/2003	1.00	1.85	29.66	1.85	**0.00**
29/03/2003	0.00	1.95	31.61	1.95	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
30/03/2003	0.00	1.97	33.58	1.97	**0.00**
31/03/2003	0.00	2.25	35.83	2.25	**0.00**
01/04/2003	3.40	1.70	34.13	1.70	**0.00**
02/04/2003	0.80	1.91	35.24	1.91	**0.00**
03/04/2003	0.00	1.86	37.10	1.86	**0.00**
04/04/2003	0.20	2.53	39.43	2.53	**0.00**
05/04/2003	0.00	2.17	41.60	2.17	**0.00**
06/04/2003	0.00	1.74	43.11	1.51	**0.00**
07/04/2003	0.00	1.81	44.66	1.55	**0.00**
08/04/2003	0.00	1.95	46.29	1.64	**0.00**
09/04/2003	0.00	2.21	48.10	1.81	**0.00**
20/07/2003	0.20	3.31	41.17	3.31	**0.00**
21/07/2003	6.40	3.38	37.73	2.96	**0.00**
22/07/2003	0.20	3.07	40.60	3.07	**0.00**
23/07/2003	3.80	2.92	39.37	2.57	**0.00**
24/07/2003	3.40	3.12	39.09	3.12	**0.00**
25/07/2003	0.20	3.32	42.20	3.32	**0.00**
26/07/2003	0.00	3.39	45.13	2.93	**0.00**
27/07/2003	5.00	3.67	43.18	3.05	**0.00**
28/07/2003	4.20	3.48	41.95	2.97	**0.00**
29/07/2003	2.60	2.91	41.88	2.53	**0.00**
30/07/2003	1.00	3.25	43.70	2.82	**0.00**
31/07/2003	3.40	3.34	43.13	2.83	**0.00**

Site 2 - Evapotranspiration Calculations

(Penman method)

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
04/03/2002	0.40	0.82	0.00	0.00	**0.40**
05/03/2002	0.20	1.36	1.16	1.36	**0.00**
06/03/2002	0.20	1.16	2.12	1.16	**0.00**
07/03/2002	0.00	1.12	3.24	1.12	**0.00**
08/03/2002	2.80	1.53	1.97	1.53	**0.00**
09/03/2002	10.40	1.00	0.00	1.00	**7.43**
10/03/2002	6.40	1.32	0.00	1.32	**5.08**
11/03/2002	0.00	1.55	1.55	1.55	**0.00**
12/03/2002	0.20	1.03	2.38	1.03	**0.00**
13/03/2002	0.60	1.17	2.95	1.17	**0.00**
14/03/2002	0.00	1.08	4.02	1.08	**0.00**
15/03/2002	0.40	0.89	4.51	0.89	**0.00**
16/03/2002	0.40	1.66	5.77	1.66	**0.00**
17/03/2002	1.40	1.06	5.43	1.06	**0.00**
18/03/2002	1.60	0.99	4.82	0.99	**0.00**
19/03/2002	0.20	1.12	5.74	1.12	**0.00**
20/03/2002	2.40	1.10	4.44	1.10	**0.00**
21/03/2002	0.40	1.92	5.96	1.92	**0.00**
22/03/2002	0.00	1.44	7.41	1.44	**0.00**
23/03/2002	0.00	0.96	8.37	0.96	**0.00**
24/03/2002	0.20	0.91	9.08	0.91	**0.00**
25/03/2002	0.60	1.53	10.01	1.53	**0.00**
26/03/2002	0.20	1.84	11.65	1.84	**0.00**
27/03/2002	0.00	1.98	13.63	1.98	**0.00**
28/03/2002	0.00	2.13	15.76	2.13	**0.00**
29/03/2002	0.20	1.85	17.41	1.85	**0.00**
30/03/2002	4.40	1.93	14.94	1.93	**0.00**
31/03/2002	1.00	1.59	15.53	1.59	**0.00**
01/04/2002	3.60	1.55	13.48	1.55	**0.00**
02/04/2002	2.80	1.40	12.09	1.40	**0.00**
03/04/2002	3.80	2.28	10.56	2.28	**0.00**
04/04/2002	0.00	1.86	12.42	1.86	**0.00**
05/04/2002	0.00	1.62	14.04	1.62	**0.00**
06/04/2002	0.00	1.84	15.88	1.84	**0.00**
07/04/2002	0.00	2.41	18.29	2.41	**0.00**
08/04/2002	0.20	1.94	20.03	1.94	**0.00**
09/04/2002	0.00	2.08	22.10	2.08	**0.00**
10/04/2002	0.00	1.77	23.87	1.77	**0.00**
11/04/2002	0.20	1.51	25.19	1.51	**0.00**
12/04/2002	0.40	1.79	26.58	1.79	**0.00**
13/04/2002	0.20	1.57	27.95	1.57	**0.00**
14/04/2002	1.00	2.06	29.01	2.06	**0.00**
15/04/2002	0.00	2.19	31.20	2.19	**0.00**
16/04/2002	0.40	1.95	32.75	1.95	**0.00**
17/04/2002	36.60	1.26	0.00	1.26	**2.60**
18/04/2002	1.60	2.49	0.89	2.49	**0.00**
19/04/2002	0.60	2.25	2.54	2.25	**0.00**
20/04/2002	1.60	1.35	2.29	1.35	**0.00**
21/04/2002	10.20	1.19	0.00	1.19	**6.72**
22/04/2002	0.00	2.01	2.01	2.01	**0.00**
23/04/2002	0.00	3.13	5.14	3.13	**0.00**
24/04/2002	0.80	2.12	6.46	2.12	**0.00**
25/04/2002	1.80	2.02	6.69	2.02	**0.00**
26/04/2002	9.40	2.16	0.00	2.16	**0.56**
27/04/2002	9.80	1.27	0.00	1.27	**8.53**
28/04/2002	9.40	1.77	0.00	1.77	**7.63**
29/04/2002	1.40	2.19	0.79	2.19	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
30/04/2002	5.40	2.17	0.00	2.17	**2.44**
01/05/2002	4.00	2.25	0.00	2.25	**1.75**
02/05/2002	2.80	2.53	0.00	2.53	**0.27**
03/05/2002	0.40	2.42	2.02	2.42	**0.00**
04/05/2002	0.00	3.28	5.30	3.28	**0.00**
05/05/2002	0.00	2.80	8.10	2.80	**0.00**
06/05/2002	0.00	2.32	10.42	2.32	**0.00**
07/05/2002	1.00	2.10	11.53	2.10	**0.00**
08/05/2002	0.00	2.53	14.05	2.53	**0.00**
09/05/2002	0.00	2.35	16.40	2.35	**0.00**
10/05/2002	0.20	2.15	18.35	2.15	**0.00**
11/05/2002	0.00	2.88	21.24	2.88	**0.00**
12/05/2002	0.80	2.19	22.63	2.19	**0.00**
13/05/2002	5.00	2.29	19.92	2.29	**0.00**
14/05/2002	1.20	2.35	21.07	2.35	**0.00**
15/05/2002	0.00	2.25	23.32	2.25	**0.00**
16/05/2002	0.20	2.62	25.73	2.62	**0.00**
17/05/2002	29.00	2.19	0.00	2.19	**1.08**
18/05/2002	0.20	2.59	2.39	2.59	**0.00**
19/05/2002	3.20	2.66	1.85	2.66	**0.00**
20/05/2002	4.20	2.77	0.42	2.77	**0.00**
21/05/2002	3.00	1.90	0.00	1.90	**0.67**
22/05/2002	5.80	2.76	0.00	2.76	**3.04**
23/05/2002	5.60	2.18	0.00	2.18	**3.42**
24/05/2002	6.80	1.76	0.00	1.76	**5.04**
25/05/2002	3.40	2.33	0.00	2.33	**1.07**
26/05/2002	0.40	2.19	1.79	2.19	**0.00**
27/05/2002	1.60	2.30	2.49	2.30	**0.00**
28/05/2002	8.80	2.40	0.00	2.40	**3.91**
29/05/2002	3.40	2.62	0.00	2.62	**0.78**
30/05/2002	3.20	3.18	0.00	3.18	**0.02**
31/05/2002	0.00	2.62	2.62	2.62	**0.00**
01/06/2002	1.00	3.10	4.73	3.10	**0.00**
02/06/2002	7.80	2.66	0.00	2.66	**0.42**
03/06/2002	4.20	2.90	0.00	2.90	**1.30**
04/06/2002	1.60	2.17	0.57	2.17	**0.00**
05/06/2002	0.00	3.30	3.87	3.30	**0.00**
06/06/2002	0.00	2.85	6.72	2.85	**0.00**
07/06/2002	4.00	2.61	5.34	2.61	**0.00**
08/06/2002	1.60	1.83	5.56	1.83	**0.00**
09/06/2002	9.80	2.55	0.00	2.55	**1.69**
10/06/2002	6.20	2.82	0.00	2.82	**3.38**
11/06/2002	1.00	2.80	1.80	2.80	**0.00**
21/09/2002	0.00	1.59	56.92	1.13	**0.00**
22/09/2002	0.00	1.18	57.75	0.83	**0.00**
23/09/2002	0.00	1.63	58.87	1.13	**0.00**
24/09/2002	0.20	1.32	59.57	0.90	**0.00**
25/09/2002	0.00	1.58	60.64	1.06	**0.00**
26/09/2002	0.00	1.41	61.57	0.93	**0.00**
27/09/2002	0.00	0.87	62.13	0.57	**0.00**
28/09/2002	0.00	1.33	62.99	0.85	**0.00**
29/09/2002	0.00	1.93	64.21	1.22	**0.00**
30/09/2002	8.40	1.49	56.73	0.92	**0.00**
01/10/2002	0.80	1.35	56.88	0.95	**0.00**
02/10/2002	7.60	1.71	50.48	1.20	**0.00**
03/10/2002	0.20	1.57	51.49	1.22	**0.00**
04/10/2002	0.00	1.68	52.78	1.28	**0.00**
05/10/2002	0.00	1.58	53.95	1.18	**0.00**
06/10/2002	0.20	0.90	54.41	0.66	**0.00**
07/10/2002	0.00	1.24	55.31	0.90	**0.00**
08/10/2002	10.80	0.81	45.10	0.58	**0.00**
09/10/2002	0.80	0.76	44.93	0.64	**0.00**
10/10/2002	0.00	0.92	45.70	0.77	**0.00**
11/10/2002	32.00	0.78	14.35	0.65	**0.00**
12/10/2002	0.20	1.20	15.35	1.20	**0.00**
13/10/2002	5.40	0.76	10.71	0.76	**0.00**
14/10/2002	0.00	0.75	11.46	0.75	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
15/10/2002	7.40	0.87	4.93	0.87	**0.00**
16/10/2002	0.00	1.07	6.00	1.07	**0.00**
17/10/2002	3.20	0.55	3.35	0.55	**0.00**
18/10/2002	0.20	0.75	3.89	0.75	**0.00**
19/10/2002	0.20	0.46	4.15	0.46	**0.00**
20/10/2002	21.20	0.77	0.00	0.77	**16.28**
21/10/2002	17.40	0.82	0.00	0.82	**16.58**
22/10/2002	0.80	0.99	0.19	0.99	**0.00**
23/10/2002	0.40	0.88	0.67	0.88	**0.00**
24/10/2002	1.60	1.15	0.22	1.15	**0.00**
25/10/2002	4.80	0.92	0.00	0.92	**3.66**
26/10/2002	6.40	1.26	0.00	1.26	**5.14**
27/10/2002	2.80	1.47	0.00	1.47	**1.33**
28/10/2002	0.80	0.82	0.02	0.82	**0.00**
29/10/2002	17.00	0.43	0.00	0.43	**16.55**
30/10/2002	0.20	0.50	0.30	0.50	**0.00**
31/10/2002	2.40	0.69	0.00	0.69	**1.41**
01/11/2002	3.60	1.05	0.00	1.05	**2.55**
02/11/2002	11.00	1.59	0.00	1.59	**9.41**
03/11/2002	6.00	0.57	0.00	0.57	**5.43**
04/11/2002	0.00	0.95	0.95	0.95	**0.00**
05/11/2002	0.80	1.05	1.20	1.05	**0.00**
06/11/2002	4.40	1.06	0.00	1.06	**2.14**
07/11/2002	0.20	0.67	0.47	0.67	**0.00**
08/11/2002	13.80	1.07	0.00	1.07	**12.26**
09/11/2002	7.20	0.48	0.00	0.48	**6.72**
10/11/2002	4.40	0.63	0.00	0.63	**3.77**
11/11/2002	2.00	0.56	0.00	0.56	**1.44**
12/11/2002	3.20	0.73	0.00	0.73	**2.47**
13/11/2002	1.20	0.56	0.00	0.56	**0.64**
14/11/2002	15.20	0.41	0.00	0.41	**14.79**
15/11/2002	8.00	0.31	0.00	0.31	**7.69**
16/11/2002	15.40	0.33	0.00	0.33	**15.07**
17/11/2002	1.60	0.32	0.00	0.32	**1.28**
18/11/2002	0.40	0.99	0.59	0.99	**0.00**
19/11/2002	0.60	0.51	0.51	0.51	**0.00**
20/11/2002	0.40	0.75	0.86	0.75	**0.00**
21/11/2002	0.60	0.60	0.86	0.60	**0.00**
22/11/2002	2.40	0.73	0.00	0.73	**0.81**
23/11/2002	1.00	0.62	0.00	0.62	**0.38**
24/11/2002	7.00	0.57	0.00	0.57	**6.43**
25/11/2002	5.00	0.52	0.00	0.52	**4.48**
26/11/2002	1.20	0.62	0.00	0.62	**0.58**
27/11/2002	38.00	1.02	0.00	1.02	**36.98**
28/11/2002	1.00	0.40	0.00	0.40	**0.60**
29/11/2002	0.20	0.23	0.03	0.23	**0.00**
30/11/2002	7.60	0.71	0.00	0.71	**6.86**
01/12/2002	8.00	0.48	0.00	0.48	**7.52**
02/12/2002	2.20	0.29	0.00	0.29	**1.91**
03/12/2002	2.80	0.43	0.00	0.43	**2.37**
04/12/2002	0.00	0.56	0.56	0.56	**0.00**
05/12/2002	0.20	0.36	0.72	0.36	**0.00**
06/12/2002	0.20	-0.02	0.50	-0.02	**0.00**
07/12/2002	0.60	0.18	0.08	0.18	**0.00**
08/12/2002	0.00	0.18	0.26	0.18	**0.00**
09/12/2002	0.00	0.23	0.49	0.23	**0.00**
10/12/2002	0.00	0.25	0.74	0.25	**0.00**
11/12/2002	0.00	0.20	0.95	0.20	**0.00**
12/12/2002	7.40	0.16	0.00	0.16	**6.29**
13/12/2002	0.80	-0.15	0.00	-0.15	**0.95**
14/12/2002	0.20	0.35	0.15	0.35	**0.00**
15/12/2002	3.00	0.27	0.00	0.27	**2.58**
16/12/2002	0.80	0.20	0.00	0.20	**0.60**
17/12/2002	0.20	0.07	0.00	0.07	**0.13**
18/12/2002	0.00	0.45	0.45	0.45	**0.00**
19/12/2002	0.00	0.51	0.96	0.51	**0.00**
20/12/2002	2.80	0.22	0.00	0.22	**1.62**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
21/12/2002	6.60	0.43	0.00	0.43	**6.17**
22/12/2002	0.60	0.32	0.00	0.32	**0.28**
23/12/2002	4.60	0.75	0.00	0.75	**3.85**
24/12/2002	0.60	0.40	0.00	0.40	**0.20**
25/12/2002	2.80	0.30	0.00	0.30	**2.50**
26/12/2002	6.40	0.06	0.00	0.06	**6.34**
27/12/2002	13.00	0.18	0.00	0.18	**12.82**
28/12/2002	0.40	0.26	0.00	0.26	**0.14**
29/12/2002	20.40	0.65	0.00	0.65	**19.75**
30/12/2002	2.80	0.36	0.00	0.36	**2.44**
11/04/2003	0.00	1.39	45.44	1.17	**0.00**
12/04/2003	0.00	1.35	46.56	1.12	**0.00**
13/04/2003	1.80	1.70	46.15	1.39	**0.00**
14/04/2003	0.60	2.03	47.21	1.67	**0.00**
15/04/2003	0.00	2.69	49.39	2.18	**0.00**
16/04/2003	0.00	2.95	51.70	2.31	**0.00**
17/04/2003	0.00	3.19	54.13	2.42	**0.00**
18/04/2003	0.00	2.78	56.16	2.03	**0.00**
19/04/2003	0.00	2.13	57.67	1.51	**0.00**
20/04/2003	0.00	1.73	58.87	1.20	**0.00**
21/04/2003	19.20	1.31	40.55	0.89	**0.00**
22/04/2003	0.20	2.40	42.47	2.12	**0.00**
23/04/2003	0.00	2.62	44.73	2.26	**0.00**
24/04/2003	2.60	2.32	44.08	1.94	**0.00**
25/04/2003	6.40	2.46	39.75	2.07	**0.00**
26/04/2003	3.80	2.51	38.47	2.51	**0.00**
27/04/2003	3.20	2.39	37.65	2.39	**0.00**
28/04/2003	5.20	1.51	33.96	1.51	**0.00**
29/04/2003	2.20	2.72	34.48	2.72	**0.00**
30/04/2003	3.20	2.15	33.43	2.15	**0.00**
01/05/2003	8.80	2.09	26.72	2.09	**0.00**
02/05/2003	2.60	2.73	26.84	2.73	**0.00**
03/05/2003	3.20	2.06	25.70	2.06	**0.00**
04/05/2003	26.00	1.62	1.32	1.62	**0.00**
05/05/2003	5.20	2.72	0.00	2.72	**1.16**
06/05/2003	1.60	2.69	1.09	2.69	**0.00**
07/05/2003	0.20	2.50	3.39	2.50	**0.00**
08/05/2003	0.00	2.99	6.37	2.99	**0.00**
09/05/2003	1.80	2.88	7.45	2.88	**0.00**
10/05/2003	1.80	2.78	8.43	2.78	**0.00**
11/05/2003	1.80	2.59	9.22	2.59	**0.00**
12/05/2003	4.40	2.53	7.35	2.53	**0.00**
13/05/2003	1.20	3.24	9.39	3.24	**0.00**
14/05/2003	0.00	3.04	12.43	3.04	**0.00**
15/05/2003	3.00	1.91	11.35	1.91	**0.00**
16/05/2003	7.00	2.31	6.65	2.31	**0.00**
17/05/2003	15.20	2.25	0.00	2.25	**6.30**
18/05/2003	19.80	2.50	0.00	2.50	**17.30**
19/05/2003	6.80	1.96	0.00	1.96	**4.84**
20/05/2003	3.20	1.91	0.00	1.91	**1.29**
21/05/2003	7.40	2.19	0.00	2.19	**5.21**
22/05/2003	0.60	2.50	1.90	2.50	**0.00**
23/05/2003	2.20	2.58	2.28	2.58	**0.00**
24/05/2003	1.40	2.49	3.37	2.49	**0.00**
25/05/2003	0.40	2.14	5.11	2.14	**0.00**
26/05/2003	1.40	2.29	6.00	2.29	**0.00**
27/05/2003	1.40	2.08	6.68	2.08	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
28/05/2003	1.80	2.06	6.95	2.06	**0.00**
29/05/2003	1.20	2.89	8.64	2.89	**0.00**
30/05/2003	0.00	4.84	13.48	4.84	**0.00**
31/05/2003	0.00	3.01	16.49	3.01	**0.00**
01/06/2003	0.80	3.26	18.95	3.26	**0.00**
02/06/2003	0.00	3.17	22.12	3.17	**0.00**
03/06/2003	10.80	1.89	13.21	1.89	**0.00**
04/06/2003	0.20	2.60	15.61	2.60	**0.00**
05/06/2003	0.60	2.44	17.45	2.44	**0.00**
06/06/2003	0.20	3.96	21.21	3.96	**0.00**
07/06/2003	0.60	3.27	23.87	3.27	**0.00**
08/06/2003	6.60	3.12	20.39	3.12	**0.00**
09/06/2003	5.20	2.39	17.58	2.39	**0.00**
10/06/2003	4.80	2.98	15.75	2.98	**0.00**
11/06/2003	0.20	2.67	18.23	2.67	**0.00**
12/06/2003	0.80	3.32	20.75	3.32	**0.00**
13/06/2003	0.00	2.99	23.74	2.99	**0.00**
14/06/2003	0.00	3.86	27.59	3.86	**0.00**
15/06/2003	0.00	3.44	31.03	3.44	**0.00**
16/06/2003	0.00	3.12	34.16	3.12	**0.00**
17/06/2003	0.00	2.84	37.00	2.84	**0.00**
18/06/2003	0.40	2.95	39.55	2.95	**0.00**
19/06/2003	0.00	3.00	42.55	3.00	**0.00**
20/06/2003	0.00	3.44	45.51	2.96	**0.00**
21/06/2003	0.00	2.59	47.66	2.14	**0.00**
22/06/2003	0.00	2.66	49.79	2.14	**0.00**
23/06/2003	0.00	2.76	51.95	2.16	**0.00**
24/06/2003	0.00	2.76	54.03	2.08	**0.00**
25/06/2003	0.00	4.14	57.07	3.03	**0.00**
26/06/2003	1.00	2.83	58.04	1.98	**0.00**
27/06/2003	20.20	2.95	39.88	2.03	**0.00**
28/06/2003	0.00	2.53	42.41	2.53	**0.00**
29/06/2003	0.40	3.20	44.76	2.76	**0.00**
30/06/2003	16.80	2.46	30.02	2.05	**0.00**
01/07/2003	3.40	2.19	28.81	2.19	**0.00**
02/07/2003	2.00	3.38	30.19	3.38	**0.00**
03/07/2003	0.00	2.15	32.34	2.15	**0.00**
04/07/2003	0.20	1.88	34.02	1.88	**0.00**
05/07/2003	0.00	1.98	36.00	1.98	**0.00**
06/07/2003	0.00	2.35	38.35	2.35	**0.00**
07/07/2003	0.80	2.49	40.04	2.49	**0.00**
08/07/2003	0.20	2.99	42.49	2.66	**0.00**
09/07/2003	0.00	2.53	44.67	2.18	**0.00**
10/07/2003	2.00	3.53	45.63	2.96	**0.00**
11/07/2003	0.00	3.28	48.34	2.71	**0.00**
12/07/2003	0.00	3.13	50.83	2.49	**0.00**
13/07/2003	0.80	3.24	52.52	2.49	**0.00**
14/07/2003	0.00	3.11	54.85	2.33	**0.00**
15/07/2003	8.20	2.18	48.22	1.58	**0.00**
16/07/2003	1.00	2.52	49.24	2.01	**0.00**
17/07/2003	19.60	2.44	31.55	1.92	**0.00**
18/07/2003	0.40	3.49	34.64	3.49	**0.00**
19/07/2003	6.60	3.29	31.33	3.29	**0.00**
20/07/2003	6.60	2.87	27.60	2.87	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
13/06/2002	3.40	2.11	2.91	2.11	**0.00**
14/06/2002	4.20	2.78	1.48	2.78	**0.00**
15/06/2002	0.00	2.31	3.79	2.31	**0.00**
16/06/2002	7.40	1.88	0.00	1.88	**1.73**
17/06/2002	0.20	3.09	2.89	3.09	**0.00**
18/06/2002	0.00	2.84	5.73	2.84	**0.00**
19/06/2002	0.40	2.83	8.16	2.83	**0.00**
20/06/2002	0.40	2.86	10.63	2.86	**0.00**
21/06/2002	2.00	3.40	12.02	3.40	**0.00**
22/06/2002	2.20	2.84	12.66	2.84	**0.00**
23/06/2002	1.80	2.84	13.71	2.84	**0.00**
24/06/2002	0.20	2.12	15.62	2.12	**0.00**
25/06/2002	0.00	2.93	18.55	2.93	**0.00**
26/06/2002	0.00	2.78	21.33	2.78	**0.00**
27/06/2002	0.00	3.07	24.40	3.07	**0.00**
28/06/2002	0.00	3.11	27.50	3.11	**0.00**
29/06/2002	0.60	3.03	29.93	3.03	**0.00**
30/06/2002	3.60	2.08	28.41	2.08	**0.00**
01/07/2002	0.00	2.46	30.87	2.46	**0.00**
02/07/2002	0.20	1.91	32.58	1.91	**0.00**
03/07/2002	0.60	3.34	35.33	3.34	**0.00**
04/07/2002	8.20	2.09	29.22	2.09	**0.00**
05/07/2002	2.60	2.72	29.34	2.72	**0.00**
06/07/2002	0.80	2.06	30.59	2.06	**0.00**
07/07/2002	2.40	2.25	30.45	2.25	**0.00**
08/07/2002	0.20	2.43	32.68	2.43	**0.00**
09/07/2002	1.80	2.69	33.56	2.69	**0.00**
10/07/2002	4.40	2.84	32.00	2.84	**0.00**
11/07/2002	14.20	2.35	20.15	2.35	**0.00**
12/07/2002	2.00	2.57	20.72	2.57	**0.00**
13/07/2002	0.00	3.44	24.16	3.44	**0.00**
14/07/2002	0.00	3.26	27.41	3.26	**0.00**
15/07/2002	0.00	2.23	29.65	2.23	**0.00**
16/07/2002	0.00	2.71	32.36	2.71	**0.00**
17/07/2002	0.00	2.88	35.24	2.88	**0.00**
18/07/2002	0.00	2.70	37.94	2.70	**0.00**
19/07/2002	9.00	2.41	31.35	2.41	**0.00**
20/07/2002	0.40	2.88	33.83	2.88	**0.00**
21/07/2002	0.00	3.14	36.97	3.14	**0.00**
22/07/2002	0.80	2.46	38.63	2.46	**0.00**
23/07/2002	2.60	2.37	38.40	2.37	**0.00**
24/07/2002	0.00	1.88	40.28	1.88	**0.00**
25/07/2002	0.00	3.00	42.94	2.66	**0.00**
26/07/2002	0.60	2.81	44.74	2.41	**0.00**
27/07/2002	0.00	2.90	47.17	2.42	**0.00**
28/07/2002	4.20	2.27	44.80	1.84	**0.00**
29/07/2002	3.40	2.15	43.20	1.80	**0.00**
30/07/2002	6.40	2.61	39.03	2.23	**0.00**
31/07/2002	4.00	2.26	37.29	2.26	**0.00**
01/08/2002	7.40	2.16	32.05	2.16	**0.00**
02/08/2002	8.20	1.85	25.70	1.85	**0.00**
03/08/2002	1.60	2.01	26.12	2.01	**0.00**
04/08/2002	1.60	2.43	26.95	2.43	**0.00**
05/08/2002	0.00	2.91	29.86	2.91	**0.00**
06/08/2002	2.80	2.22	29.28	2.22	**0.00**
07/08/2002	4.60	1.81	26.49	1.81	**0.00**
08/08/2002	11.40	1.52	16.61	1.52	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
09/08/2002	0.00	2.63	19.24	2.63	**0.00**
10/08/2002	0.00	2.83	22.07	2.83	**0.00**
11/08/2002	1.80	2.58	22.85	2.58	**0.00**
12/08/2002	0.00	2.63	25.48	2.63	**0.00**
13/08/2002	12.20	2.13	15.41	2.13	**0.00**
14/08/2002	0.80	1.69	16.30	1.69	**0.00**
15/08/2002	1.00	3.30	18.60	3.30	**0.00**
16/08/2002	0.00	2.84	21.44	2.84	**0.00**
17/08/2002	0.20	3.58	24.82	3.58	**0.00**
18/08/2002	0.00	1.86	26.69	1.86	**0.00**
19/08/2002	0.20	2.06	28.55	2.06	**0.00**
20/08/2002	1.80	2.82	29.57	2.82	**0.00**
21/08/2002	0.00	2.56	32.13	2.56	**0.00**
22/08/2002	9.60	2.05	24.58	2.05	**0.00**
23/08/2002	3.00	2.83	24.41	2.83	**0.00**
24/08/2002	4.60	2.08	21.89	2.08	**0.00**
25/08/2002	0.00	2.49	24.38	2.49	**0.00**
26/08/2002	0.00	2.81	27.19	2.81	**0.00**
27/08/2002	1.80	1.83	27.22	1.83	**0.00**
28/08/2002	5.40	2.12	23.93	2.12	**0.00**
29/08/2002	0.20	2.48	26.21	2.48	**0.00**
30/08/2002	1.00	2.23	27.45	2.23	**0.00**
31/08/2002	0.00	2.04	29.49	2.04	**0.00**
01/09/2002	0.00	2.90	32.39	2.90	**0.00**
02/09/2002	0.00	2.55	34.94	2.55	**0.00**
03/09/2002	0.00	1.99	36.93	1.99	**0.00**
04/09/2002	0.00	1.95	38.88	1.95	**0.00**
05/09/2002	0.20	1.93	40.61	1.93	**0.00**
06/09/2002	1.20	1.86	41.05	1.64	**0.00**
07/09/2002	4.20	2.26	38.84	1.98	**0.00**
08/09/2002	0.40	1.70	40.14	1.70	**0.00**
09/09/2002	1.60	1.82	40.15	1.61	**0.00**
10/09/2002	0.00	2.39	42.27	2.12	**0.00**
11/09/2002	0.00	2.57	44.49	2.22	**0.00**
12/09/2002	0.00	2.25	46.37	1.89	**0.00**
13/09/2002	0.20	2.27	48.03	1.86	**0.00**
14/09/2002	0.20	1.91	49.36	1.52	**0.00**
15/09/2002	0.00	1.75	50.73	1.38	**0.00**
16/09/2002	0.00	1.11	51.58	0.85	**0.00**
17/09/2002	0.00	1.14	52.45	0.87	**0.00**
18/09/2002	0.00	1.75	53.76	1.31	**0.00**
19/09/2002	0.00	1.32	54.73	0.97	**0.00**
20/09/2002	0.00	1.45	55.79	1.06	**0.00**
31/12/2002	2.40	0.31	0.00	0.31	**2.09**
01/01/2003	8.60	0.37	0.00	0.37	**8.23**
02/01/2003	2.40	0.53	0.00	0.53	**1.87**
03/01/2003	1.00	0.29	0.00	0.29	**0.71**
04/01/2003	0.00	0.02	0.02	0.02	**0.00**
05/01/2003	0.60	0.22	0.00	0.22	**0.36**
06/01/2003	0.00	0.37	0.37	0.37	**0.00**
07/01/2003	0.00	0.33	0.70	0.33	**0.00**
08/01/2003	2.40	0.23	0.00	0.23	**1.46**
09/01/2003	1.80	0.24	0.00	0.24	**1.56**
10/01/2003	0.00	0.17	0.17	0.17	**0.00**
11/01/2003	0.20	0.13	0.11	0.13	**0.00**
12/01/2003	0.40	0.87	0.57	0.87	**0.00**
13/01/2003	0.40	0.37	0.54	0.37	**0.00**
14/01/2003	0.20	0.25	0.59	0.25	**0.00**
15/01/2003	3.00	0.67	0.00	0.67	**1.74**
16/01/2003	0.40	1.04	0.64	1.04	**0.00**
17/01/2003	12.60	0.79	0.00	0.79	**11.17**
18/01/2003	7.60	0.73	0.00	0.73	**6.87**
19/01/2003	0.80	0.24	0.00	0.24	**0.56**
20/01/2003	8.20	0.51	0.00	0.51	**7.69**
21/01/2003	0.60	0.43	0.00	0.43	**0.17**
22/01/2003	0.00	0.58	0.58	0.58	**0.00**
23/01/2003	0.20	1.05	1.43	1.05	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
24/01/2003	4.20	0.52	0.00	0.52	**2.26**
25/01/2003	4.60	0.54	0.00	0.54	**4.06**
26/01/2003	0.00	0.68	0.68	0.68	**0.00**
27/01/2003	2.80	1.18	0.00	1.18	**0.94**
28/01/2003	3.00	0.42	0.00	0.42	**2.58**
29/01/2003	0.60	0.49	0.00	0.49	**0.11**
30/01/2003	2.00	0.73	0.00	0.73	**1.27**
31/01/2003	2.20	0.76	0.00	0.76	**1.44**
01/02/2003	0.20	0.51	0.31	0.51	**0.00**
02/02/2003	2.20	0.54	0.00	0.54	**1.34**
03/02/2003	0.00	0.53	0.53	0.53	**0.00**
04/02/2003	0.20	0.49	0.82	0.49	**0.00**
05/02/2003	0.20	0.67	1.29	0.67	**0.00**
06/02/2003	1.40	0.81	0.70	0.81	**0.00**
07/02/2003	0.00	0.64	1.34	0.64	**0.00**
08/02/2003	5.20	0.54	0.00	0.54	**3.32**
09/02/2003	0.60	0.70	0.10	0.70	**0.00**
10/02/2003	10.20	1.12	0.00	1.12	**8.98**
11/02/2003	0.00	0.45	0.45	0.45	**0.00**
12/02/2003	0.20	0.24	0.49	0.24	**0.00**
13/02/2003	0.20	0.56	0.85	0.56	**0.00**
14/02/2003	0.00	0.41	1.25	0.41	**0.00**
15/02/2003	0.00	0.73	1.99	0.73	**0.00**
16/02/2003	0.00	0.77	2.76	0.77	**0.00**
17/02/2003	0.00	0.55	3.31	0.55	**0.00**
18/02/2003	0.00	0.52	3.82	0.52	**0.00**
19/02/2003	0.00	0.73	4.56	0.73	**0.00**
20/02/2003	1.20	0.44	3.80	0.44	**0.00**
21/02/2003	0.20	1.05	4.65	1.05	**0.00**
22/02/2003	1.20	1.21	4.66	1.21	**0.00**
23/02/2003	1.20	1.39	4.85	1.39	**0.00**
24/02/2003	0.20	1.16	5.81	1.16	**0.00**
25/02/2003	0.00	0.62	6.44	0.62	**0.00**
26/02/2003	2.20	0.44	4.68	0.44	**0.00**
27/02/2003	0.80	0.91	4.79	0.91	**0.00**
28/02/2003	14.80	1.26	0.00	1.26	**8.75**
01/03/2003	4.80	1.02	0.00	1.02	**3.78**
02/03/2003	0.20	1.27	1.07	1.27	**0.00**
03/03/2003	0.80	1.07	1.35	1.07	**0.00**
04/03/2003	1.00	1.13	1.48	1.13	**0.00**
05/03/2003	0.20	1.39	2.67	1.39	**0.00**
06/03/2003	0.20	1.41	3.88	1.41	**0.00**
07/03/2003	7.80	0.94	0.00	0.94	**2.98**
08/03/2003	5.00	1.35	0.00	1.35	**3.65**
09/03/2003	2.60	0.94	0.00	0.94	**1.66**
10/03/2003	9.60	1.12	0.00	1.12	**8.48**
11/03/2003	2.40	1.44	0.00	1.44	**0.96**
12/03/2003	0.00	1.28	1.28	1.28	**0.00**
13/03/2003	0.00	1.00	2.28	1.00	**0.00**
14/03/2003	0.20	1.47	3.55	1.47	**0.00**
15/03/2003	0.00	1.58	5.13	1.58	**0.00**
16/03/2003	0.00	1.66	6.80	1.66	**0.00**
17/03/2003	0.00	1.42	8.21	1.42	**0.00**
18/03/2003	0.00	1.61	9.82	1.61	**0.00**
19/03/2003	0.20	1.42	11.04	1.42	**0.00**
20/03/2003	0.00	1.39	12.42	1.39	**0.00**
21/03/2003	0.00	1.57	13.99	1.57	**0.00**
22/03/2003	0.00	1.78	15.78	1.78	**0.00**
23/03/2003	0.00	1.89	17.67	1.89	**0.00**
24/03/2003	0.20	1.54	19.00	1.54	**0.00**
25/03/2003	0.00	1.52	20.52	1.52	**0.00**
26/03/2003	0.00	1.78	22.30	1.78	**0.00**
27/03/2003	0.00	1.67	23.97	1.67	**0.00**
28/03/2003	0.40	1.16	24.72	1.16	**0.00**
29/03/2003	0.20	1.85	26.38	1.85	**0.00**
30/03/2003	0.00	1.78	28.15	1.78	**0.00**
31/03/2003	0.00	2.40	30.55	2.40	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
01/04/2003	3.20	1.87	29.22	1.87	**0.00**
02/04/2003	0.40	1.95	30.77	1.95	**0.00**
03/04/2003	0.00	1.53	32.30	1.53	**0.00**
04/04/2003	0.20	2.44	34.54	2.44	**0.00**
05/04/2003	0.00	1.82	36.36	1.82	**0.00**
06/04/2003	0.00	1.88	38.24	1.88	**0.00**
07/04/2003	0.00	1.28	39.52	1.28	**0.00**
08/04/2003	0.00	1.88	41.41	1.88	**0.00**
09/04/2003	0.00	1.94	43.10	1.69	**0.00**
10/04/2003	0.00	1.37	44.27	1.17	**0.00**
21/07/2003	2.80	3.19	27.99	3.19	**0.00**
22/07/2003	0.40	2.11	29.70	2.11	**0.00**
23/07/2003	3.60	2.47	28.57	2.47	**0.00**
24/07/2003	4.00	2.24	26.81	2.24	**0.00**
25/07/2003	1.00	2.81	28.62	2.81	**0.00**
26/07/2003	0.00	2.89	31.51	2.89	**0.00**
27/07/2003	18.20	3.12	16.43	3.12	**0.00**
28/07/2003	8.00	2.64	11.07	2.64	**0.00**
29/07/2003	4.80	2.41	8.68	2.41	**0.00**
30/07/2003	3.80	2.99	7.87	2.99	**0.00**
31/07/2003	0.00	2.92	10.79	2.92	**0.00**

(Hargreaves method)

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
04/03/2002	0.40	0.83	0.00	0.00	**0.40**
05/03/2002	0.20	1.16	0.96	1.16	**0.00**
06/03/2002	0.20	0.98	1.75	0.98	**0.00**
07/03/2002	0.00	1.05	2.79	1.05	**0.00**
08/03/2002	2.80	1.36	1.35	1.36	**0.00**
09/03/2002	10.40	0.87	0.00	0.87	**8.18**
10/03/2002	6.40	1.08	0.00	1.08	**5.32**
11/03/2002	0.00	1.36	1.36	1.36	**0.00**
12/03/2002	0.20	1.30	2.46	1.30	**0.00**
13/03/2002	0.60	1.05	2.91	1.05	**0.00**
14/03/2002	0.00	0.96	3.87	0.96	**0.00**
15/03/2002	0.40	0.94	4.40	0.94	**0.00**
16/03/2002	0.40	1.44	5.44	1.44	**0.00**
17/03/2002	1.40	1.03	5.07	1.03	**0.00**
18/03/2002	1.60	1.19	4.66	1.19	**0.00**
19/03/2002	0.20	1.32	5.78	1.32	**0.00**
20/03/2002	2.40	1.25	4.63	1.25	**0.00**
21/03/2002	0.40	1.77	6.00	1.77	**0.00**
22/03/2002	0.00	1.59	7.59	1.59	**0.00**
23/03/2002	0.00	1.00	8.59	1.00	**0.00**
24/03/2002	0.20	0.84	9.23	0.84	**0.00**
25/03/2002	0.60	1.78	10.40	1.78	**0.00**
26/03/2002	0.20	2.00	12.21	2.00	**0.00**
27/03/2002	0.00	1.84	14.05	1.84	**0.00**
28/03/2002	0.00	2.05	16.09	2.05	**0.00**
29/03/2002	0.20	2.32	18.22	2.32	**0.00**
30/03/2002	4.40	1.95	15.77	1.95	**0.00**
31/03/2002	1.00	1.55	16.32	1.55	**0.00**
01/04/2002	3.60	1.67	14.39	1.67	**0.00**
02/04/2002	2.80	1.53	13.12	1.53	**0.00**
03/04/2002	3.80	2.13	11.44	2.13	**0.00**
04/04/2002	0.00	2.10	13.54	2.10	**0.00**
05/04/2002	0.00	1.84	15.37	1.84	**0.00**
06/04/2002	0.00	1.49	16.86	1.49	**0.00**
07/04/2002	0.00	2.20	19.06	2.20	**0.00**
08/04/2002	0.20	2.52	21.38	2.52	**0.00**
09/04/2002	0.00	2.34	23.72	2.34	**0.00**
10/04/2002	0.00	2.00	25.71	2.00	**0.00**
11/04/2002	0.20	2.23	27.74	2.23	**0.00**
12/04/2002	0.40	1.96	29.30	1.96	**0.00**
13/04/2002	0.20	2.35	31.45	2.35	**0.00**
14/04/2002	1.00	1.70	32.15	1.70	**0.00**
15/04/2002	0.00	2.49	34.64	2.49	**0.00**
16/04/2002	0.40	2.13	36.37	2.13	**0.00**
17/04/2002	36.60	1.50	1.27	1.50	**0.00**
18/04/2002	1.60	2.37	2.04	2.37	**0.00**
19/04/2002	0.60	2.73	4.16	2.73	**0.00**
20/04/2002	1.60	1.59	4.15	1.59	**0.00**
21/04/2002	10.20	1.35	0.00	1.35	**4.70**
22/04/2002	0.00	2.38	2.38	2.38	**0.00**
23/04/2002	0.00	3.06	5.44	3.06	**0.00**
24/04/2002	0.80	2.42	7.06	2.42	**0.00**
25/04/2002	1.80	2.44	7.69	2.44	**0.00**
26/04/2002	9.40	1.92	0.22	1.92	**0.00**
27/04/2002	9.80	1.55	0.00	1.55	**8.03**
28/04/2002	9.40	1.72	0.00	1.72	**7.68**
29/04/2002	1.40	2.19	0.79	2.19	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
30/04/2002	5.40	2.13	0.00	2.13	**2.48**
01/05/2002	4.00	2.32	0.00	2.32	**1.68**
02/05/2002	2.80	2.62	0.00	2.62	**0.18**
03/05/2002	0.40	2.85	2.45	2.85	**0.00**
04/05/2002	0.00	3.49	5.94	3.49	**0.00**
05/05/2002	0.00	3.44	9.38	3.44	**0.00**
06/05/2002	0.00	3.03	12.40	3.03	**0.00**
07/05/2002	1.00	3.07	14.47	3.07	**0.00**
08/05/2002	0.00	2.63	17.10	2.63	**0.00**
09/05/2002	0.00	2.86	19.96	2.86	**0.00**
10/05/2002	0.20	3.50	23.26	3.50	**0.00**
11/05/2002	0.00	2.64	25.91	2.64	**0.00**
12/05/2002	0.80	2.91	28.01	2.91	**0.00**
13/05/2002	5.00	2.31	25.32	2.31	**0.00**
14/05/2002	1.20	2.81	26.93	2.81	**0.00**
15/05/2002	0.00	2.80	29.72	2.80	**0.00**
16/05/2002	0.20	3.30	32.83	3.30	**0.00**
17/05/2002	29.00	2.53	6.35	2.53	**0.00**
18/05/2002	0.20	2.87	9.03	2.87	**0.00**
19/05/2002	3.20	2.94	8.77	2.94	**0.00**
20/05/2002	4.20	2.73	7.30	2.73	**0.00**
21/05/2002	3.00	2.34	6.64	2.34	**0.00**
22/05/2002	5.80	3.03	3.87	3.03	**0.00**
23/05/2002	5.60	2.69	0.95	2.69	**0.00**
24/05/2002	6.80	2.11	0.00	2.11	**3.74**
25/05/2002	3.40	2.78	0.00	2.78	**0.62**
26/05/2002	0.40	3.17	2.77	3.17	**0.00**
27/05/2002	1.60	3.16	4.32	3.16	**0.00**
28/05/2002	8.80	2.97	0.00	2.97	**1.50**
29/05/2002	3.40	2.65	0.00	2.65	**0.75**
30/05/2002	3.20	3.05	0.00	3.05	**0.15**
31/05/2002	0.00	3.56	3.56	3.56	**0.00**
01/06/2002	1.00	4.05	6.61	4.05	**0.00**
02/06/2002	7.80	3.10	1.90	3.10	**0.00**
03/06/2002	4.20	2.96	0.66	2.96	**0.00**
04/06/2002	1.60	2.64	1.70	2.64	**0.00**
05/06/2002	0.00	3.64	5.34	3.64	**0.00**
06/06/2002	0.00	3.23	8.57	3.23	**0.00**
07/06/2002	4.00	2.44	7.00	2.44	**0.00**
08/06/2002	1.60	1.90	7.30	1.90	**0.00**
09/06/2002	9.80	2.85	0.35	2.85	**0.00**
10/06/2002	6.20	2.80	0.00	2.80	**3.05**
11/06/2002	1.00	3.22	2.22	3.22	**0.00**
20/09/2002	0.00	2.39	71.37	1.33	**0.00**
21/09/2002	0.00	2.35	72.64	1.27	**0.00**
22/09/2002	0.00	1.91	73.64	1.01	**0.00**
23/09/2002	0.00	2.09	74.72	1.08	**0.00**
24/09/2002	0.20	2.20	75.63	1.11	**0.00**
25/09/2002	0.00	2.14	76.69	1.06	**0.00**
26/09/2002	0.00	1.51	77.42	0.73	**0.00**
27/09/2002	0.00	1.63	78.19	0.77	**0.00**
28/09/2002	0.00	1.52	78.89	0.70	**0.00**
29/09/2002	0.00	1.81	79.71	0.83	**0.00**
30/09/2002	8.40	1.41	71.94	0.63	**0.00**
01/10/2002	0.80	1.23	71.80	0.65	**0.00**
02/10/2002	7.60	1.57	65.04	0.84	**0.00**
03/10/2002	0.20	1.72	65.89	1.05	**0.00**
04/10/2002	0.00	1.90	67.03	1.14	**0.00**
05/10/2002	0.00	1.84	68.11	1.08	**0.00**
06/10/2002	0.20	1.66	68.86	0.95	**0.00**
07/10/2002	0.00	1.39	69.65	0.79	**0.00**
08/10/2002	10.80	0.74	59.27	0.42	**0.00**
09/10/2002	0.80	0.73	58.97	0.49	**0.00**
10/10/2002	0.00	1.44	59.94	0.98	**0.00**
11/10/2002	32.00	0.84	28.50	0.56	**0.00**
12/10/2002	0.20	1.33	29.63	1.33	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
13/10/2002	5.40	1.11	25.34	1.11	**0.00**
14/10/2002	0.00	1.17	26.51	1.17	**0.00**
15/10/2002	7.40	0.90	20.01	0.90	**0.00**
16/10/2002	0.00	1.03	21.04	1.03	**0.00**
17/10/2002	3.20	1.00	18.84	1.00	**0.00**
18/10/2002	0.20	1.02	19.66	1.02	**0.00**
19/10/2002	0.20	1.04	20.49	1.04	**0.00**
20/10/2002	21.20	0.75	0.05	0.75	**0.00**
21/10/2002	17.40	0.92	0.00	0.92	**16.43**
22/10/2002	0.80	0.87	0.07	0.87	**0.00**
23/10/2002	0.40	0.71	0.38	0.71	**0.00**
24/10/2002	1.60	0.94	0.00	0.94	**0.28**
25/10/2002	4.80	0.77	0.00	0.77	**4.03**
26/10/2002	6.40	0.82	0.00	0.82	**5.58**
27/10/2002	2.80	0.85	0.00	0.85	**1.95**
28/10/2002	0.80	0.74	0.00	0.74	**0.06**
29/10/2002	17.00	0.52	0.00	0.52	**16.48**
30/10/2002	0.20	0.70	0.50	0.70	**0.00**
31/10/2002	2.40	0.90	0.00	0.90	**1.00**
01/11/2002	3.60	0.82	0.00	0.82	**2.78**
02/11/2002	11.00	0.94	0.00	0.94	**10.06**
03/11/2002	6.00	0.50	0.00	0.50	**5.50**
04/11/2002	0.00	0.68	0.68	0.68	**0.00**
05/11/2002	0.80	0.78	0.66	0.78	**0.00**
06/11/2002	4.40	0.75	0.00	0.75	**2.99**
07/11/2002	0.20	0.52	0.32	0.52	**0.00**
08/11/2002	13.80	0.66	0.00	0.66	**12.82**
09/11/2002	7.20	0.55	0.00	0.55	**6.65**
10/11/2002	4.40	0.58	0.00	0.58	**3.82**
11/11/2002	2.00	0.45	0.00	0.45	**1.55**
12/11/2002	3.20	0.54	0.00	0.54	**2.66**
13/11/2002	1.20	0.55	0.00	0.55	**0.65**
14/11/2002	15.20	0.41	0.00	0.41	**14.79**
15/11/2002	8.00	0.26	0.00	0.26	**7.74**
16/11/2002	15.40	0.43	0.00	0.43	**14.97**
17/11/2002	1.60	0.39	0.00	0.39	**1.21**
18/11/2002	0.40	0.52	0.12	0.52	**0.00**
19/11/2002	0.60	0.34	0.00	0.34	**0.13**
20/11/2002	0.40	0.45	0.05	0.45	**0.00**
21/11/2002	0.60	0.45	0.00	0.45	**0.11**
22/11/2002	2.40	0.44	0.00	0.44	**1.96**
23/11/2002	1.00	0.38	0.00	0.38	**0.62**
24/11/2002	7.00	0.38	0.00	0.38	**6.62**
25/11/2002	5.00	0.36	0.00	0.36	**4.64**
26/11/2002	1.20	0.34	0.00	0.34	**0.86**
27/11/2002	38.00	0.44	0.00	0.44	**37.56**
28/11/2002	1.00	0.32	0.00	0.32	**0.68**
29/11/2002	0.20	0.45	0.25	0.45	**0.00**
30/11/2002	7.60	0.44	0.00	0.44	**6.91**
01/12/2002	8.00	0.27	0.00	0.27	**7.73**
02/12/2002	2.20	0.26	0.00	0.26	**1.94**
03/12/2002	2.80	0.30	0.00	0.30	**2.50**
04/12/2002	0.00	0.37	0.37	0.37	**0.00**
05/12/2002	0.20	0.33	0.50	0.33	**0.00**
06/12/2002	0.20	0.34	0.64	0.34	**0.00**
07/12/2002	0.60	0.23	0.27	0.23	**0.00**
08/12/2002	0.00	0.16	0.43	0.16	**0.00**
09/12/2002	0.00	0.18	0.61	0.18	**0.00**
10/12/2002	0.00	0.22	0.82	0.22	**0.00**
11/12/2002	0.00	0.17	0.99	0.17	**0.00**
12/12/2002	7.40	0.18	0.00	0.18	**6.23**
13/12/2002	0.80	0.29	0.00	0.29	**0.51**
14/12/2002	0.20	0.32	0.12	0.32	**0.00**
15/12/2002	3.00	0.21	0.00	0.21	**2.67**
16/12/2002	0.80	0.29	0.00	0.29	**0.51**
17/12/2002	0.20	0.29	0.09	0.29	**0.00**
18/12/2002	0.00	0.29	0.38	0.29	**0.00**
19/12/2002	0.00	0.33	0.71	0.33	**0.00**
20/12/2002	2.80	0.24	0.00	0.24	**1.85**
21/12/2002	6.60	0.31	0.00	0.31	**6.29**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
22/12/2002	0.60	0.25	0.00	0.25	**0.35**
23/12/2002	4.60	0.31	0.00	0.31	**4.29**
24/12/2002	0.60	0.27	0.00	0.27	**0.33**
25/12/2002	2.80	0.24	0.00	0.24	**2.56**
26/12/2002	6.40	0.21	0.00	0.21	**6.19**
27/12/2002	13.00	0.18	0.00	0.18	**12.82**
28/12/2002	0.40	0.29	0.00	0.29	**0.11**
29/12/2002	20.40	0.39	0.00	0.39	**20.01**
10/04/2003	0.00	1.81	50.39	1.43	**0.00**
11/04/2003	0.00	1.93	51.88	1.49	**0.00**
12/04/2003	0.00	1.86	53.29	1.41	**0.00**
13/04/2003	1.80	2.02	52.99	1.50	**0.00**
14/04/2003	0.60	2.41	54.18	1.79	**0.00**
15/04/2003	0.00	3.25	56.56	2.37	**0.00**
16/04/2003	0.00	3.57	59.08	2.52	**0.00**
17/04/2003	0.00	3.00	61.11	2.03	**0.00**
18/04/2003	0.00	2.51	62.75	1.64	**0.00**
19/04/2003	0.00	1.78	63.88	1.13	**0.00**
20/04/2003	0.00	1.74	64.97	1.09	**0.00**
21/04/2003	19.20	1.63	46.77	1.00	**0.00**
22/04/2003	0.20	2.58	48.66	2.10	**0.00**
23/04/2003	0.00	2.67	50.78	2.12	**0.00**
24/04/2003	2.60	2.33	49.97	1.79	**0.00**
25/04/2003	6.40	2.47	45.49	1.92	**0.00**
26/04/2003	3.80	2.41	43.68	1.99	**0.00**
27/04/2003	3.20	2.55	42.64	2.16	**0.00**
28/04/2003	5.20	1.83	39.01	1.57	**0.00**
29/04/2003	2.20	2.87	39.68	2.87	**0.00**
30/04/2003	3.20	2.39	38.87	2.39	**0.00**
01/05/2003	8.80	2.28	32.35	2.28	**0.00**
02/05/2003	2.60	2.69	32.44	2.69	**0.00**
03/05/2003	3.20	2.54	31.78	2.54	**0.00**
04/05/2003	26.00	1.88	7.67	1.88	**0.00**
05/05/2003	5.20	2.57	5.03	2.57	**0.00**
06/05/2003	1.60	2.96	6.40	2.96	**0.00**
07/05/2003	0.20	3.05	9.25	3.05	**0.00**
08/05/2003	0.00	2.98	12.23	2.98	**0.00**
09/05/2003	1.80	2.88	13.31	2.88	**0.00**
10/05/2003	1.80	3.06	14.57	3.06	**0.00**
11/05/2003	1.80	2.71	15.48	2.71	**0.00**
12/05/2003	4.40	2.42	13.50	2.42	**0.00**
13/05/2003	1.20	2.93	15.23	2.93	**0.00**
14/05/2003	0.00	3.26	18.49	3.26	**0.00**
15/05/2003	3.00	2.60	18.10	2.60	**0.00**
16/05/2003	7.00	2.68	13.77	2.68	**0.00**
17/05/2003	15.20	2.20	0.77	2.20	**0.00**
18/05/2003	19.80	2.68	0.00	2.68	**16.34**
19/05/2003	6.80	2.05	0.00	2.05	**4.75**
20/05/2003	3.20	2.40	0.00	2.40	**0.80**
21/05/2003	7.40	3.08	0.00	3.08	**4.32**
22/05/2003	0.60	3.30	2.70	3.30	**0.00**
23/05/2003	2.20	2.54	3.04	2.54	**0.00**
24/05/2003	1.40	2.44	4.08	2.44	**0.00**
25/05/2003	0.40	2.92	6.59	2.92	**0.00**
26/05/2003	1.40	3.31	8.50	3.31	**0.00**
27/05/2003	1.40	2.90	10.01	2.90	**0.00**
28/05/2003	1.80	2.74	10.95	2.74	**0.00**
29/05/2003	1.20	3.89	13.64	3.89	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
30/05/2003	0.00	5.29	18.94	5.29	**0.00**
31/05/2003	0.00	3.76	22.69	3.76	**0.00**
01/06/2003	0.80	3.37	25.26	3.37	**0.00**
02/06/2003	0.00	3.50	28.76	3.50	**0.00**
03/06/2003	10.80	2.52	20.48	2.52	**0.00**
04/06/2003	0.20	3.05	23.33	3.05	**0.00**
05/06/2003	0.60	3.16	25.89	3.16	**0.00**
06/06/2003	0.20	3.92	29.61	3.92	**0.00**
07/06/2003	0.60	3.03	32.05	3.03	**0.00**
08/06/2003	6.60	3.94	29.38	3.94	**0.00**
09/06/2003	5.20	3.13	27.32	3.13	**0.00**
10/06/2003	4.80	3.30	25.82	3.30	**0.00**
11/06/2003	0.20	3.53	29.14	3.53	**0.00**
12/06/2003	0.80	3.55	31.90	3.55	**0.00**
13/06/2003	0.00	3.78	35.68	3.78	**0.00**
14/06/2003	0.00	4.84	40.52	4.84	**0.00**
15/06/2003	0.00	3.91	43.97	3.45	**0.00**
16/06/2003	0.00	4.73	47.97	4.00	**0.00**
17/06/2003	0.00	3.52	50.78	2.81	**0.00**
18/06/2003	0.40	3.45	53.04	2.65	**0.00**
19/06/2003	0.00	3.55	55.67	2.64	**0.00**
20/06/2003	0.00	3.71	58.33	2.65	**0.00**
21/06/2003	0.00	4.03	61.09	2.76	**0.00**
22/06/2003	0.00	3.91	63.65	2.56	**0.00**
23/06/2003	0.00	3.48	65.82	2.18	**0.00**
24/06/2003	0.00	4.46	68.51	2.68	**0.00**
25/06/2003	0.00	5.09	71.42	2.91	**0.00**
26/06/2003	1.00	3.81	72.48	2.06	**0.00**
27/06/2003	20.20	3.24	53.99	1.71	**0.00**
28/06/2003	0.00	3.82	56.79	2.80	**0.00**
29/06/2003	0.40	4.43	59.50	3.11	**0.00**
30/06/2003	16.80	2.55	44.41	1.71	**0.00**
01/07/2003	3.40	3.28	43.76	2.76	**0.00**
02/07/2003	2.00	4.01	45.16	3.40	**0.00**
03/07/2003	0.00	2.77	47.47	2.31	**0.00**
04/07/2003	0.20	2.58	49.34	2.08	**0.00**
05/07/2003	0.00	2.96	51.66	2.32	**0.00**
06/07/2003	0.00	3.39	54.24	2.57	**0.00**
07/07/2003	0.80	3.11	55.71	2.27	**0.00**
08/07/2003	0.20	3.78	58.21	2.70	**0.00**
09/07/2003	0.00	3.57	60.66	2.45	**0.00**
10/07/2003	2.00	3.58	61.01	2.36	**0.00**
11/07/2003	0.00	3.46	63.28	2.27	**0.00**
12/07/2003	0.00	4.28	65.98	2.70	**0.00**
13/07/2003	0.80	4.74	68.02	2.85	**0.00**
14/07/2003	0.00	4.96	70.89	2.87	**0.00**
15/07/2003	8.20	3.38	64.53	1.84	**0.00**
16/07/2003	1.00	4.73	66.45	2.92	**0.00**
17/07/2003	19.60	1.97	48.02	1.17	**0.00**
18/07/2003	0.40	4.26	51.03	3.41	**0.00**
19/07/2003	6.60	3.21	46.88	2.46	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
12/06/2002	0.20	3.50	5.52	3.50	**0.00**
13/06/2002	3.40	2.55	4.67	2.55	**0.00**
14/06/2002	4.20	3.16	3.63	3.16	**0.00**
15/06/2002	0.00	2.86	6.48	2.86	**0.00**
16/06/2002	7.40	2.49	1.58	2.49	**0.00**
17/06/2002	0.20	3.24	4.62	3.24	**0.00**
18/06/2002	0.00	3.11	7.73	3.11	**0.00**
19/06/2002	0.40	3.45	10.77	3.45	**0.00**
20/06/2002	0.40	3.84	14.22	3.84	**0.00**
21/06/2002	2.00	3.98	16.20	3.98	**0.00**
22/06/2002	2.20	3.30	17.29	3.30	**0.00**
23/06/2002	1.80	3.48	18.97	3.48	**0.00**
24/06/2002	0.20	2.88	21.65	2.88	**0.00**
25/06/2002	0.00	3.44	25.10	3.44	**0.00**
26/06/2002	0.00	3.32	28.42	3.32	**0.00**
27/06/2002	0.00	3.35	31.77	3.35	**0.00**
28/06/2002	0.00	3.79	35.56	3.79	**0.00**
29/06/2002	0.60	3.92	38.88	3.92	**0.00**
30/06/2002	3.60	1.76	37.04	1.76	**0.00**
01/07/2002	0.00	2.82	39.86	2.82	**0.00**
02/07/2002	0.20	2.62	42.29	2.62	**0.00**
03/07/2002	0.60	3.63	44.82	3.14	**0.00**
04/07/2002	8.20	3.15	39.25	2.63	**0.00**
05/07/2002	2.60	3.34	39.99	3.34	**0.00**
06/07/2002	0.80	3.16	42.35	3.16	**0.00**
07/07/2002	2.40	3.10	42.63	2.68	**0.00**
08/07/2002	0.20	3.04	45.04	2.61	**0.00**
09/07/2002	1.80	3.49	46.15	2.91	**0.00**
10/07/2002	4.40	3.22	44.39	2.64	**0.00**
11/07/2002	14.20	2.84	32.58	2.39	**0.00**
12/07/2002	2.00	3.57	34.14	3.57	**0.00**
13/07/2002	0.00	4.16	38.31	4.16	**0.00**
14/07/2002	0.00	3.97	42.28	3.97	**0.00**
15/07/2002	0.00	3.46	45.27	2.99	**0.00**
16/07/2002	0.00	2.31	47.19	1.92	**0.00**
17/07/2002	0.00	3.26	49.83	2.64	**0.00**
18/07/2002	0.00	4.16	53.08	3.25	**0.00**
19/07/2002	9.00	2.95	46.27	2.19	**0.00**
20/07/2002	0.40	3.11	48.42	2.55	**0.00**
21/07/2002	0.00	3.85	51.48	3.06	**0.00**
22/07/2002	0.80	3.35	53.23	2.55	**0.00**
23/07/2002	2.60	2.72	52.65	2.02	**0.00**
24/07/2002	0.00	2.53	54.54	1.89	**0.00**
25/07/2002	0.00	3.49	57.08	2.54	**0.00**
26/07/2002	0.60	3.19	58.71	2.23	**0.00**
27/07/2002	0.00	3.46	61.07	2.36	**0.00**
28/07/2002	4.20	2.73	58.66	1.79	**0.00**
29/07/2002	3.40	2.80	57.16	1.91	**0.00**
30/07/2002	6.40	2.55	52.54	1.78	**0.00**
31/07/2002	4.00	2.48	50.40	1.86	**0.00**
01/08/2002	7.40	2.83	45.19	2.19	**0.00**
02/08/2002	8.20	1.30	38.07	1.08	**0.00**
03/08/2002	1.60	2.36	38.82	2.36	**0.00**
04/08/2002	1.60	3.88	41.11	3.88	**0.00**
05/08/2002	0.00	4.61	45.14	4.04	**0.00**
06/08/2002	2.80	3.39	45.16	2.82	**0.00**
07/08/2002	4.60	2.25	42.43	1.87	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
08/08/2002	11.40	2.06	32.81	1.78	**0.00**
09/08/2002	0.00	2.74	35.54	2.74	**0.00**
10/08/2002	0.00	3.15	38.69	3.15	**0.00**
11/08/2002	1.80	2.98	39.87	2.98	**0.00**
12/08/2002	0.00	3.54	43.41	3.54	**0.00**
13/08/2002	12.20	2.60	33.42	2.21	**0.00**
14/08/2002	0.80	1.77	34.39	1.77	**0.00**
15/08/2002	1.00	3.27	36.66	3.27	**0.00**
16/08/2002	0.00	3.39	40.05	3.39	**0.00**
17/08/2002	0.20	3.22	42.72	2.86	**0.00**
18/08/2002	0.00	2.63	44.98	2.26	**0.00**
19/08/2002	0.20	2.53	46.88	2.11	**0.00**
20/08/2002	1.80	2.78	47.34	2.26	**0.00**
21/08/2002	0.00	3.75	50.37	3.03	**0.00**
22/08/2002	9.60	3.35	43.36	2.59	**0.00**
23/08/2002	3.00	2.76	42.71	2.35	**0.00**
24/08/2002	4.60	2.05	39.88	1.76	**0.00**
25/08/2002	0.00	3.00	42.88	3.00	**0.00**
26/08/2002	0.00	3.33	45.73	2.86	**0.00**
27/08/2002	1.80	3.19	46.57	2.63	**0.00**
28/08/2002	5.40	2.24	43.00	1.83	**0.00**
29/08/2002	0.20	2.29	44.75	1.96	**0.00**
30/08/2002	1.00	2.17	45.57	1.81	**0.00**
31/08/2002	0.00	2.54	47.67	2.10	**0.00**
01/09/2002	0.00	3.16	50.21	2.54	**0.00**
02/09/2002	0.00	3.03	52.56	2.35	**0.00**
03/09/2002	0.00	3.22	54.97	2.41	**0.00**
04/09/2002	0.00	2.42	56.72	1.75	**0.00**
05/09/2002	0.20	2.13	58.02	1.50	**0.00**
06/09/2002	1.20	2.05	58.23	1.41	**0.00**
07/09/2002	4.20	2.00	55.40	1.38	**0.00**
08/09/2002	0.40	1.77	56.27	1.27	**0.00**
09/09/2002	1.60	2.43	56.39	1.72	**0.00**
10/09/2002	0.00	2.64	58.26	1.87	**0.00**
11/09/2002	0.00	2.34	59.87	1.60	**0.00**
12/09/2002	0.00	2.54	61.56	1.70	**0.00**
13/09/2002	0.20	2.58	63.04	1.68	**0.00**
14/09/2002	0.20	2.32	64.31	1.47	**0.00**
15/09/2002	0.00	2.55	65.88	1.58	**0.00**
16/09/2002	0.00	1.43	66.75	0.86	**0.00**
17/09/2002	0.00	1.78	67.80	1.05	**0.00**
18/09/2002	0.00	1.76	68.82	1.02	**0.00**
19/09/2002	0.00	2.15	70.04	1.22	**0.00**
30/12/2002	2.80	0.28	0.00	0.28	**2.52**
31/12/2002	2.40	0.22	0.00	0.22	**2.18**
01/01/2003	8.60	0.26	0.00	0.26	**8.34**
02/01/2003	2.40	0.32	0.00	0.32	**2.08**
03/01/2003	1.00	0.23	0.00	0.23	**0.77**
04/01/2003	0.00	0.30	0.30	0.30	**0.00**
05/01/2003	0.60	0.35	0.05	0.35	**0.00**
06/01/2003	0.00	0.33	0.38	0.33	**0.00**
07/01/2003	0.00	0.19	0.57	0.19	**0.00**
08/01/2003	2.40	0.29	0.00	0.29	**1.54**
09/01/2003	1.80	0.26	0.00	0.26	**1.54**
10/01/2003	0.00	0.23	0.23	0.23	**0.00**
11/01/2003	0.20	0.37	0.40	0.37	**0.00**
12/01/2003	0.40	0.42	0.42	0.42	**0.00**
13/01/2003	0.40	0.26	0.28	0.26	**0.00**
14/01/2003	0.20	0.18	0.26	0.18	**0.00**
15/01/2003	3.00	0.42	0.00	0.42	**2.32**
16/01/2003	0.40	0.46	0.06	0.46	**0.00**
17/01/2003	12.60	0.46	0.00	0.46	**12.08**
18/01/2003	7.60	0.40	0.00	0.40	**7.20**
19/01/2003	0.80	0.40	0.00	0.40	**0.40**
20/01/2003	8.20	0.37	0.00	0.37	**7.83**
21/01/2003	0.60	0.40	0.00	0.40	**0.20**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
22/01/2003	0.00	0.44	0.44	0.44	**0.00**
23/01/2003	0.20	0.58	0.82	0.58	**0.00**
24/01/2003	4.20	0.35	0.00	0.35	**3.04**
25/01/2003	4.60	0.41	0.00	0.41	**4.19**
26/01/2003	0.00	0.58	0.58	0.58	**0.00**
27/01/2003	2.80	0.63	0.00	0.63	**1.59**
28/01/2003	3.00	0.30	0.00	0.30	**2.70**
29/01/2003	0.60	0.35	0.00	0.35	**0.25**
30/01/2003	2.00	0.47	0.00	0.47	**1.53**
31/01/2003	2.20	0.51	0.00	0.51	**1.69**
01/02/2003	0.20	0.49	0.29	0.49	**0.00**
02/02/2003	2.20	0.40	0.00	0.40	**1.51**
03/02/2003	0.00	0.41	0.41	0.41	**0.00**
04/02/2003	0.20	0.45	0.66	0.45	**0.00**
05/02/2003	0.20	0.59	1.05	0.59	**0.00**
06/02/2003	1.40	0.62	0.27	0.62	**0.00**
07/02/2003	0.00	0.59	0.86	0.59	**0.00**
08/02/2003	5.20	0.44	0.00	0.44	**3.89**
09/02/2003	0.60	0.68	0.08	0.68	**0.00**
10/02/2003	10.20	0.69	0.00	0.69	**9.43**
11/02/2003	0.00	0.84	0.84	0.84	**0.00**
12/02/2003	0.20	0.85	1.49	0.85	**0.00**
13/02/2003	0.20	0.75	2.03	0.75	**0.00**
14/02/2003	0.00	0.64	2.67	0.64	**0.00**
15/02/2003	0.00	0.82	3.49	0.82	**0.00**
16/02/2003	0.00	0.57	4.06	0.57	**0.00**
17/02/2003	0.00	0.45	4.51	0.45	**0.00**
18/02/2003	0.00	0.42	4.93	0.42	**0.00**
19/02/2003	0.00	0.70	5.63	0.70	**0.00**
20/02/2003	1.20	0.67	5.10	0.67	**0.00**
21/02/2003	0.20	0.99	5.90	0.99	**0.00**
22/02/2003	1.20	0.89	5.58	0.89	**0.00**
23/02/2003	1.20	1.02	5.40	1.02	**0.00**
24/02/2003	0.20	0.94	6.15	0.94	**0.00**
25/02/2003	0.00	0.59	6.74	0.59	**0.00**
26/02/2003	2.20	0.34	4.88	0.34	**0.00**
27/02/2003	0.80	0.86	4.94	0.86	**0.00**
28/02/2003	14.80	0.98	0.00	0.98	**8.89**
01/03/2003	4.80	0.97	0.00	0.97	**3.83**
02/03/2003	0.20	1.26	1.06	1.26	**0.00**
03/03/2003	0.80	0.96	1.22	0.96	**0.00**
04/03/2003	1.00	0.98	1.19	0.98	**0.00**
05/03/2003	0.20	1.19	2.18	1.19	**0.00**
06/03/2003	0.20	1.22	3.20	1.22	**0.00**
07/03/2003	7.80	0.80	0.00	0.80	**3.80**
08/03/2003	5.00	1.18	0.00	1.18	**3.82**
09/03/2003	2.60	0.86	0.00	0.86	**1.74**
10/03/2003	9.60	1.02	0.00	1.02	**8.58**
11/03/2003	2.40	1.21	0.00	1.21	**1.19**
12/03/2003	0.00	1.24	1.24	1.24	**0.00**
13/03/2003	0.00	1.20	2.44	1.20	**0.00**
14/03/2003	0.20	1.55	3.79	1.55	**0.00**
15/03/2003	0.00	1.60	5.39	1.60	**0.00**
16/03/2003	0.00	1.85	7.24	1.85	**0.00**
17/03/2003	0.00	2.16	9.40	2.16	**0.00**
18/03/2003	0.00	2.19	11.59	2.19	**0.00**
19/03/2003	0.20	1.70	13.10	1.70	**0.00**
20/03/2003	0.00	1.67	14.77	1.67	**0.00**
21/03/2003	0.00	1.91	16.68	1.91	**0.00**
22/03/2003	0.00	1.82	18.50	1.82	**0.00**
23/03/2003	0.00	2.45	20.95	2.45	**0.00**
24/03/2003	0.20	2.08	22.83	2.08	**0.00**
25/03/2003	0.00	1.72	24.55	1.72	**0.00**
26/03/2003	0.00	2.47	27.01	2.47	**0.00**
27/03/2003	0.00	1.98	29.00	1.98	**0.00**
28/03/2003	0.40	1.85	30.45	1.85	**0.00**
29/03/2003	0.20	1.95	32.20	1.95	**0.00**
30/03/2003	0.00	1.97	34.17	1.97	**0.00**
31/03/2003	0.00	2.25	36.42	2.25	**0.00**
01/04/2003	3.20	1.70	34.92	1.70	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
02/04/2003	0.40	1.91	36.43	1.91	**0.00**
03/04/2003	0.00	1.86	38.29	1.86	**0.00**
04/04/2003	0.20	2.53	40.62	2.53	**0.00**
05/04/2003	0.00	2.17	42.53	1.91	**0.00**
06/04/2003	0.00	1.74	44.03	1.49	**0.00**
07/04/2003	0.00	1.81	45.55	1.53	**0.00**
08/04/2003	0.00	1.95	47.17	1.62	**0.00**
09/04/2003	0.00	2.21	48.96	1.79	**0.00**
20/07/2003	6.60	3.31	42.97	2.69	**0.00**
21/07/2003	2.80	3.38	43.06	2.89	**0.00**
22/07/2003	0.40	3.07	45.29	2.62	**0.00**
23/07/2003	3.60	2.92	44.11	2.42	**0.00**
24/07/2003	4.00	3.12	42.74	2.63	**0.00**
25/07/2003	1.00	3.32	44.58	2.85	**0.00**
26/07/2003	0.00	3.39	47.42	2.84	**0.00**
27/07/2003	18.20	3.67	32.18	2.96	**0.00**
28/07/2003	8.00	3.48	27.66	3.48	**0.00**
29/07/2003	4.80	2.91	25.77	2.91	**0.00**
30/07/2003	3.80	3.25	25.22	3.25	**0.00**
31/07/2003	0.00	3.34	28.56	3.34	**0.00**

Site 3 - Evapotranspiration Calculations

(Hargreaves method)

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
01/01/2003	7.00	0.26	0.00	0.00	**7.00**
02/01/2003	1.00	0.32	0.00	0.32	**0.68**
03/01/2003	1.60	0.23	0.00	0.23	**1.37**
04/01/2003	0.20	0.30	0.10	0.30	**0.00**
05/01/2003	0.20	0.35	0.25	0.35	**0.00**
06/01/2003	0.00	0.33	0.58	0.33	**0.00**
07/01/2003	0.00	0.19	0.77	0.19	**0.00**
08/01/2003	2.40	0.29	0.00	0.29	**1.34**
09/01/2003	2.60	0.26	0.00	0.26	**2.34**
10/01/2003	0.00	0.23	0.23	0.23	**0.00**
11/01/2003	0.00	0.37	0.60	0.37	**0.00**
12/01/2003	0.20	0.42	0.82	0.42	**0.00**
13/01/2003	0.40	0.26	0.68	0.26	**0.00**
14/01/2003	0.00	0.18	0.86	0.18	**0.00**
15/01/2003	0.00	0.42	1.28	0.42	**0.00**
16/01/2003	0.20	0.46	1.54	0.46	**0.00**
17/01/2003	11.40	0.46	0.00	0.46	**9.40**
18/01/2003	8.60	0.40	0.00	0.40	**8.20**
19/01/2003	1.40	0.40	0.00	0.40	**1.00**
20/01/2003	6.60	0.37	0.00	0.37	**6.23**
21/01/2003	1.20	0.40	0.00	0.40	**0.80**
22/01/2003	0.00	0.44	0.44	0.44	**0.00**
23/01/2003	0.20	0.58	0.82	0.58	**0.00**
24/01/2003	4.00	0.35	0.00	0.35	**2.84**
25/01/2003	7.60	0.41	0.00	0.41	**7.19**
26/01/2003	0.00	0.58	0.58	0.58	**0.00**
27/01/2003	1.00	0.63	0.21	0.63	**0.00**
28/01/2003	4.20	0.30	0.00	0.30	**3.69**
29/01/2003	0.40	0.35	0.00	0.35	**0.05**
30/01/2003	1.60	0.47	0.00	0.47	**1.13**
31/01/2003	2.00	0.51	0.00	0.51	**1.49**
01/02/2003	0.40	0.49	0.09	0.49	**0.00**
02/02/2003	2.20	0.40	0.00	0.40	**1.71**
03/02/2003	0.20	0.41	0.21	0.41	**0.00**
04/02/2003	0.80	0.45	0.00	0.45	**0.14**
05/02/2003	0.20	0.59	0.39	0.59	**0.00**
06/02/2003	2.00	0.62	0.00	0.62	**0.99**
07/02/2003	0.20	0.59	0.39	0.59	**0.00**
08/02/2003	4.00	0.44	0.00	0.44	**3.16**
09/02/2003	1.20	0.68	0.00	0.68	**0.52**
10/02/2003	6.60	0.69	0.00	0.69	**5.91**
11/02/2003	0.40	0.84	0.44	0.84	**0.00**
12/02/2003	0.20	0.85	1.09	0.85	**0.00**
13/02/2003	0.00	0.75	1.83	0.75	**0.00**
14/02/2003	0.00	0.64	2.47	0.64	**0.00**
15/02/2003	0.20	0.82	3.09	0.82	**0.00**
16/02/2003	0.00	0.57	3.66	0.57	**0.00**
17/02/2003	0.00	0.45	4.11	0.45	**0.00**
18/02/2003	0.00	0.42	4.53	0.42	**0.00**
19/02/2003	0.00	0.70	5.23	0.70	**0.00**
20/02/2003	0.60	0.67	5.30	0.67	**0.00**
21/02/2003	0.20	0.99	6.10	0.99	**0.00**
22/02/2003	0.00	0.89	6.98	0.89	**0.00**
23/02/2003	0.60	1.02	7.40	1.02	**0.00**
24/02/2003	0.20	0.94	8.15	0.94	**0.00**
25/02/2003	0.00	0.59	8.74	0.59	**0.00**
26/02/2003	2.20	0.34	6.88	0.34	**0.00**
27/02/2003	0.40	0.86	7.34	0.86	**0.00**
28/02/2003	16.80	0.98	0.00	0.98	**8.49**
01/03/2003	3.60	0.97	0.00	0.97	**2.63**
02/03/2003	2.80	1.26	0.00	1.26	**1.54**
03/03/2003	1.40	0.96	0.00	0.96	**0.44**
04/03/2003	0.80	0.98	0.18	0.98	**0.00**
05/03/2003	0.40	1.19	0.96	1.19	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
06/03/2003	0.00	1.22	2.18	1.22	**0.00**
07/03/2003	3.20	0.80	0.00	0.80	**0.22**
08/03/2003	8.80	1.18	0.00	1.18	**7.62**
09/03/2003	1.40	0.86	0.00	0.86	**0.54**
10/03/2003	10.80	1.02	0.00	1.02	**9.78**
11/03/2003	1.20	1.21	0.01	1.21	**0.00**
12/03/2003	0.20	1.24	1.05	1.24	**0.00**
13/03/2003	0.00	1.20	2.25	1.20	**0.00**
14/03/2003	0.20	1.55	3.60	1.55	**0.00**
15/03/2003	0.00	1.60	5.20	1.60	**0.00**
16/03/2003	0.00	1.85	7.05	1.85	**0.00**
17/03/2003	0.00	2.16	9.21	2.16	**0.00**
18/03/2003	0.20	2.19	11.20	2.19	**0.00**
19/03/2003	0.20	1.70	12.71	1.70	**0.00**
20/03/2003	0.00	1.67	14.38	1.67	**0.00**
21/03/2003	0.00	1.91	16.29	1.91	**0.00**
22/03/2003	0.00	1.82	18.11	1.82	**0.00**
23/03/2003	0.00	2.45	20.56	2.45	**0.00**
24/03/2003	0.00	2.08	22.64	2.08	**0.00**
25/03/2003	0.00	1.72	24.36	1.72	**0.00**
26/03/2003	0.00	2.47	26.82	2.47	**0.00**
27/03/2003	0.00	1.98	28.81	1.98	**0.00**
28/03/2003	1.00	1.85	29.66	1.85	**0.00**
29/03/2003	0.00	1.95	31.61	1.95	**0.00**
30/03/2003	0.00	1.97	33.58	1.97	**0.00**
31/03/2003	0.00	2.25	35.83	2.25	**0.00**
01/04/2003	3.40	1.70	34.13	1.70	**0.00**
02/04/2003	0.80	1.91	35.24	1.91	**0.00**
03/04/2003	0.00	1.86	37.10	1.86	**0.00**
04/04/2003	0.20	2.53	39.43	2.53	**0.00**
05/04/2003	0.00	2.17	41.60	2.17	**0.00**
06/04/2003	0.00	1.74	43.11	1.51	**0.00**
07/04/2003	0.00	1.81	44.66	1.55	**0.00**
08/04/2003	0.00	1.95	46.29	1.64	**0.00**
09/04/2003	0.00	2.21	48.10	1.81	**0.00**
10/04/2003	0.00	1.81	49.55	1.45	**0.00**
11/04/2003	0.00	1.93	51.06	1.51	**0.00**
12/04/2003	0.00	1.86	52.49	1.43	**0.00**
13/04/2003	1.60	2.02	52.41	1.52	**0.00**
14/04/2003	0.60	2.41	53.61	1.81	**0.00**
15/04/2003	0.00	3.25	56.01	2.39	**0.00**
16/04/2003	0.00	3.57	58.55	2.54	**0.00**
17/04/2003	0.00	3.00	60.60	2.05	**0.00**
18/04/2003	0.00	2.51	62.26	1.65	**0.00**
19/04/2003	0.00	1.78	63.40	1.14	**0.00**
20/04/2003	0.00	1.74	64.49	1.10	**0.00**
21/04/2003	10.00	1.63	55.50	1.00	**0.00**
22/04/2003	0.00	2.58	57.34	1.85	**0.00**
23/04/2003	0.00	2.67	59.20	1.86	**0.00**
24/04/2003	1.80	2.33	58.98	1.57	**0.00**
25/04/2003	6.40	2.47	54.25	1.67	**0.00**
26/04/2003	3.60	2.41	52.41	1.76	**0.00**
27/04/2003	2.00	2.55	52.32	1.92	**0.00**
28/04/2003	5.60	1.83	48.10	1.37	**0.00**
29/04/2003	0.20	2.87	50.19	2.29	**0.00**
30/04/2003	1.40	2.39	50.64	1.85	**0.00**
01/05/2003	20.60	2.28	31.79	1.76	**0.00**
02/05/2003	0.60	2.69	33.89	2.69	**0.00**
03/05/2003	2.20	2.54	34.23	2.54	**0.00**
04/05/2003	24.00	1.88	12.11	1.88	**0.00**
05/05/2003	4.40	2.57	10.28	2.57	**0.00**
06/05/2003	1.20	2.96	12.04	2.96	**0.00**
07/05/2003	0.20	3.05	14.89	3.05	**0.00**
08/05/2003	0.00	2.98	17.88	2.98	**0.00**
09/05/2003	1.80	2.88	18.96	2.88	**0.00**
10/05/2003	1.00	3.06	21.01	3.06	**0.00**
11/05/2003	1.80	2.71	21.93	2.71	**0.00**
12/05/2003	3.40	2.42	20.95	2.42	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
13/05/2003	0.20	2.93	23.68	2.93	**0.00**
14/05/2003	0.00	3.26	26.94	3.26	**0.00**
15/05/2003	3.60	2.60	25.94	2.60	**0.00**
16/05/2003	9.80	2.68	18.82	2.68	**0.00**
17/05/2003	5.60	2.20	15.42	2.20	**0.00**
18/05/2003	13.40	2.68	4.70	2.68	**0.00**
19/05/2003	6.80	2.05	0.00	2.05	**0.05**
20/05/2003	1.00	2.40	1.40	2.40	**0.00**
21/05/2003	7.60	3.08	0.00	3.08	**3.12**
22/05/2003	0.40	3.30	2.90	3.30	**0.00**
23/05/2003	4.60	2.54	0.84	2.54	**0.00**
24/05/2003	0.20	2.44	3.08	2.44	**0.00**
25/05/2003	0.00	2.92	5.99	2.92	**0.00**
26/05/2003	2.20	3.31	7.10	3.31	**0.00**
27/05/2003	1.00	2.90	9.01	2.90	**0.00**
28/05/2003	3.00	2.74	8.75	2.74	**0.00**
29/05/2003	1.60	3.89	11.04	3.89	**0.00**
30/05/2003	0.00	5.29	16.34	5.29	**0.00**
31/05/2003	0.00	3.76	20.09	3.76	**0.00**
01/06/2003	0.40	3.37	23.06	3.37	**0.00**
02/06/2003	0.00	3.50	26.56	3.50	**0.00**
03/06/2003	10.80	2.52	18.28	2.52	**0.00**
04/06/2003	0.20	3.05	21.13	3.05	**0.00**
05/06/2003	2.00	3.16	22.29	3.16	**0.00**
06/06/2003	0.00	3.92	26.21	3.92	**0.00**
07/06/2003	11.40	3.03	17.85	3.03	**0.00**
08/06/2003	1.80	3.94	19.98	3.94	**0.00**
09/06/2003	4.40	3.13	18.72	3.13	**0.00**
10/06/2003	3.00	3.30	19.02	3.30	**0.00**
11/06/2003	0.20	3.53	22.34	3.53	**0.00**
12/06/2003	0.60	3.55	25.30	3.55	**0.00**
13/06/2003	0.00	3.78	29.08	3.78	**0.00**
14/06/2003	0.20	4.84	33.72	4.84	**0.00**
15/06/2003	0.00	3.91	37.63	3.91	**0.00**
16/06/2003	0.20	4.73	42.16	4.73	**0.00**
17/06/2003	0.00	3.52	45.20	3.04	**0.00**
18/06/2003	0.20	3.45	47.87	2.86	**0.00**
19/06/2003	0.00	3.55	50.71	2.84	**0.00**
20/06/2003	0.00	3.71	53.57	2.86	**0.00**
21/06/2003	0.40	4.03	56.14	2.98	**0.00**
22/06/2003	0.00	3.91	58.91	2.77	**0.00**
23/06/2003	0.00	3.48	61.27	2.36	**0.00**
24/06/2003	0.00	4.46	64.18	2.91	**0.00**
25/06/2003	0.00	5.09	67.34	3.16	**0.00**
26/06/2003	1.20	3.81	68.37	2.23	**0.00**
27/06/2003	20.80	3.24	49.43	1.86	**0.00**
28/06/2003	0.00	3.82	52.42	2.99	**0.00**
29/06/2003	2.00	4.43	53.75	3.32	**0.00**
30/06/2003	24.00	2.55	31.62	1.87	**0.00**
01/07/2003	3.20	3.28	31.70	3.28	**0.00**
02/07/2003	0.20	4.01	35.51	4.01	**0.00**
03/07/2003	0.20	2.77	38.08	2.77	**0.00**
04/07/2003	0.00	2.58	40.66	2.58	**0.00**
05/07/2003	0.00	2.96	43.27	2.61	**0.00**
06/07/2003	0.40	3.39	45.76	2.89	**0.00**
07/07/2003	4.00	3.11	44.32	2.57	**0.00**
08/07/2003	11.60	3.78	35.90	3.18	**0.00**
09/07/2003	0.00	3.57	39.46	3.57	**0.00**
10/07/2003	1.20	3.58	41.84	3.58	**0.00**
11/07/2003	0.00	3.46	44.85	3.01	**0.00**
12/07/2003	0.00	4.28	48.42	3.57	**0.00**
13/07/2003	0.00	4.74	52.19	3.77	**0.00**
14/07/2003	0.40	4.96	55.53	3.74	**0.00**
15/07/2003	6.60	3.38	51.35	2.42	**0.00**
16/07/2003	0.80	4.73	54.16	3.61	**0.00**
17/07/2003	19.60	1.97	36.00	1.44	**0.00**
18/07/2003	0.40	4.26	39.85	4.26	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
19/07/2003	5.00	3.21	38.06	3.21	**0.00**
20/07/2003	0.20	3.31	41.17	3.31	**0.00**
21/07/2003	6.40	3.38	37.73	2.96	**0.00**
22/07/2003	0.20	3.07	40.60	3.07	**0.00**
23/07/2003	3.80	2.92	39.37	2.57	**0.00**
24/07/2003	3.40	3.12	39.09	3.12	**0.00**
25/07/2003	0.20	3.32	42.20	3.32	**0.00**
26/07/2003	0.00	3.39	45.13	2.93	**0.00**
27/07/2003	5.00	3.67	43.18	3.05	**0.00**
28/07/2003	4.20	3.48	41.95	2.97	**0.00**
29/07/2003	2.60	2.91	41.88	2.53	**0.00**
30/07/2003	1.00	3.25	43.70	2.82	**0.00**
31/07/2003	3.40	3.34	43.13	2.83	**0.00**
01/08/2003	0.00	3.01	45.70	2.57	**0.00**
02/08/2003	0.20	3.95	48.76	3.26	**0.00**
03/08/2003	0.20	3.66	51.45	2.89	**0.00**
04/08/2003	0.00	4.55	54.92	3.46	**0.00**
05/08/2003	0.20	4.98	58.32	3.60	**0.00**
06/08/2003	0.20	3.99	60.85	2.73	**0.00**
07/08/2003	0.00	5.07	64.18	3.33	**0.00**
08/08/2003	0.20	5.27	67.25	3.27	**0.00**
09/08/2003	0.00	3.61	69.37	2.12	**0.00**
10/08/2003	0.00	3.75	71.47	2.11	**0.00**
11/08/2003	0.00	4.34	73.82	2.34	**0.00**
12/08/2003	0.00	4.43	76.09	2.27	**0.00**
13/08/2003	0.00	3.43	77.76	1.67	**0.00**
14/08/2003	0.20	3.87	79.38	1.82	**0.00**
15/08/2003	0.00	3.55	80.98	1.60	**0.00**
16/08/2003	0.00	4.17	82.79	1.81	**0.00**
17/08/2003	1.40	3.42	82.81	1.42	**0.00**
18/08/2003	0.20	3.31	83.98	1.37	**0.00**
19/08/2003	0.00	2.62	85.02	1.05	**0.00**
20/08/2003	0.00	2.82	86.12	1.09	**0.00**
21/08/2003	0.00	3.15	87.30	1.19	**0.00**
22/08/2003	3.40	2.71	84.89	0.98	**0.00**
23/08/2003	0.00	3.09	86.09	1.21	**0.00**
24/08/2003	0.00	3.16	87.28	1.19	**0.00**
25/08/2003	0.20	2.36	87.94	0.86	**0.00**
26/08/2003	0.00	2.23	88.73	0.79	**0.00**
27/08/2003	0.20	2.94	89.56	1.02	**0.00**
28/08/2003	0.60	2.56	89.82	0.87	**0.00**
29/08/2003	0.40	2.54	90.27	0.85	**0.00**
30/08/2003	0.00	2.65	91.15	0.88	**0.00**
31/08/2003	0.20	2.29	91.68	0.73	**0.00**
01/09/2003	0.00	2.97	92.62	0.94	**0.00**
02/09/2003	0.00	2.28	93.31	0.69	**0.00**
03/09/2003	0.00	2.64	94.10	0.78	**0.00**
04/09/2003	0.00	2.63	94.85	0.76	**0.00**
05/09/2003	0.60	2.20	94.87	0.62	**0.00**
06/09/2003	0.40	2.76	95.24	0.77	**0.00**
07/09/2003	4.20	2.58	91.75	0.71	**0.00**
08/09/2003	0.20	2.69	92.39	0.84	**0.00**
09/09/2003	4.00	2.12	89.04	0.65	**0.00**
10/09/2003	0.40	1.65	89.21	0.57	**0.00**
11/09/2003	0.60	2.67	89.52	0.91	**0.00**
12/09/2003	0.00	2.42	90.34	0.82	**0.00**
13/09/2003	0.00	1.96	90.99	0.65	**0.00**
14/09/2003	0.00	2.50	91.79	0.81	**0.00**
15/09/2003	0.00	2.66	92.63	0.83	**0.00**
16/09/2003	0.20	3.07	93.36	0.93	**0.00**
17/09/2003	0.00	2.73	94.17	0.81	**0.00**
18/09/2003	0.80	2.01	93.95	0.58	**0.00**
19/09/2003	5.20	1.71	89.24	0.50	**0.00**
20/09/2003	16.80	1.64	73.00	0.56	**0.00**
21/09/2003	2.80	2.64	71.58	1.38	**0.00**
22/09/2003	7.60	1.88	64.99	1.01	**0.00**
23/09/2003	0.00	1.65	66.00	1.01	**0.00**
24/09/2003	0.00	1.82	67.09	1.09	**0.00**
25/09/2003	0.00	1.94	68.23	1.14	**0.00**
26/09/2003	1.40	1.57	67.73	0.90	**0.00**
27/09/2003	0.00	1.61	68.67	0.93	**0.00**
28/09/2003	0.00	1.82	69.70	1.04	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
29/09/2003	2.80	1.21	67.58	0.68	**0.00**
30/09/2003	9.60	1.45	58.83	0.84	**0.00**
01/10/2003	0.20	1.74	59.81	1.19	**0.00**
02/10/2003	0.00	1.77	60.99	1.18	**0.00**
03/10/2003	0.20	1.38	61.70	0.91	**0.00**
04/10/2003	0.20	1.36	62.38	0.88	**0.00**
05/10/2003	4.00	1.37	59.26	0.88	**0.00**
06/10/2003	0.00	1.06	59.97	0.71	**0.00**
07/10/2003	5.40	0.99	55.23	0.66	**0.00**
08/10/2003	1.00	1.44	55.27	1.04	**0.00**
09/10/2003	0.40	1.42	55.89	1.02	**0.00**
10/10/2003	0.40	1.41	56.49	1.00	**0.00**
11/10/2003	0.00	1.45	57.51	1.02	**0.00**
12/10/2003	3.20	0.82	54.88	0.57	**0.00**
13/10/2003	5.80	1.16	49.92	0.84	**0.00**
14/10/2003	0.00	1.27	50.91	0.99	**0.00**
15/10/2003	0.00	1.36	51.95	1.04	**0.00**
16/10/2003	0.00	1.39	53.00	1.05	**0.00**
17/10/2003	0.00	1.38	54.03	1.03	**0.00**
18/10/2003	0.20	1.13	54.66	0.83	**0.00**
19/10/2003	0.60	0.90	54.72	0.66	**0.00**
20/10/2003	0.40	0.89	54.96	0.64	**0.00**
21/10/2003	0.40	0.85	55.18	0.62	**0.00**
22/10/2003	11.00	0.55	44.58	0.39	**0.00**
23/10/2003	0.00	1.01	45.42	0.84	**0.00**
24/10/2003	0.20	0.91	45.98	0.76	**0.00**
25/10/2003	0.40	0.88	46.30	0.72	**0.00**
26/10/2003	0.20	0.94	46.87	0.77	**0.00**
27/10/2003	0.00	1.00	47.69	0.81	**0.00**
28/10/2003	3.60	0.74	44.68	0.59	**0.00**
29/10/2003	1.60	0.72	43.68	0.60	**0.00**
30/10/2003	32.60	0.70	11.68	0.60	**0.00**
31/10/2003	15.80	0.59	0.00	0.59	**3.53**
01/11/2003	9.40	0.74	0.00	0.74	**8.66**
02/11/2003	1.40	0.65	0.00	0.65	**0.75**
03/11/2003	2.60	0.72	0.00	0.72	**1.88**
04/11/2003	0.40	0.84	0.44	0.84	**0.00**
05/11/2003	3.60	0.53	0.00	0.53	**2.64**
06/11/2003	0.00	0.88	0.88	0.88	**0.00**
07/11/2003	0.00	0.87	1.75	0.87	**0.00**
08/11/2003	0.00	0.42	2.17	0.42	**0.00**
09/11/2003	2.20	0.71	0.68	0.71	**0.00**
10/11/2003	0.20	0.62	1.10	0.62	**0.00**
11/11/2003	25.20	0.44	0.00	0.44	**23.66**
12/11/2003	8.00	0.64	0.00	0.64	**7.36**
13/11/2003	23.80	0.60	0.00	0.60	**23.20**
14/11/2003	3.60	0.37	0.00	0.37	**3.23**
15/11/2003	0.20	0.47	0.27	0.47	**0.00**
16/11/2003	0.00	0.55	0.82	0.55	**0.00**
17/11/2003	2.60	0.58	0.00	0.58	**1.20**
18/11/2003	0.00	0.34	0.34	0.34	**0.00**
19/11/2003	14.80	0.41	0.00	0.41	**14.06**
20/11/2003	9.80	0.59	0.00	0.59	**9.21**
21/11/2003	0.20	0.49	0.29	0.49	**0.00**
22/11/2003	0.20	0.47	0.56	0.47	**0.00**
23/11/2003	0.20	0.48	0.85	0.48	**0.00**
24/11/2003	0.40	0.48	0.93	0.48	**0.00**
25/11/2003	7.00	0.37	0.00	0.37	**5.70**
26/11/2003	1.20	0.36	0.00	0.36	**0.84**
27/11/2003	0.20	0.41	0.21	0.41	**0.00**
28/11/2003	1.40	0.53	0.00	0.53	**0.66**
29/11/2003	18.00	0.46	0.00	0.46	**17.54**
30/11/2003	0.20	0.42	0.22	0.42	**0.00**
01/12/2003	1.60	0.41	0.00	0.41	**0.97**
02/12/2003	11.20	0.40	0.00	0.40	**10.80**
03/12/2003	0.20	0.25	0.05	0.25	**0.00**
04/12/2003	0.00	0.44	0.49	0.44	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
05/12/2003	0.20	0.41	0.70	0.41	**0.00**
06/12/2003	0.20	0.43	0.93	0.43	**0.00**
07/12/2003	0.00	0.38	1.31	0.38	**0.00**
08/12/2003	0.80	0.41	0.92	0.41	**0.00**
09/12/2003	2.20	0.29	0.00	0.29	**0.98**
10/12/2003	6.20	0.23	0.00	0.23	**5.97**
11/12/2003	8.20	0.43	0.00	0.43	**7.77**
12/12/2003	11.60	0.50	0.00	0.50	**11.10**
13/12/2003	1.40	0.41	0.00	0.41	**0.99**
14/12/2003	0.00	0.35	0.35	0.35	**0.00**
15/12/2003	0.00	0.31	0.66	0.31	**0.00**
16/12/2003	0.00	0.30	0.96	0.30	**0.00**
17/12/2003	0.00	0.33	1.29	0.33	**0.00**
18/12/2003	0.00	0.33	1.62	0.33	**0.00**
19/12/2003	0.60	0.24	1.27	0.24	**0.00**
20/12/2003	10.20	0.34	0.00	0.34	**8.59**
21/12/2003	0.40	0.28	0.00	0.28	**0.12**
22/12/2003	0.60	0.29	0.00	0.29	**0.31**
23/12/2003	0.80	0.32	0.00	0.32	**0.48**
24/12/2003	0.00	0.23	0.23	0.23	**0.00**
25/12/2003	10.00	0.24	0.00	0.24	**9.53**
26/12/2003	17.40	0.39	0.00	0.39	**17.01**
27/12/2003	0.20	0.30	0.10	0.30	**0.00**
28/12/2003	0.20	0.26	0.16	0.26	**0.00**
29/12/2003	1.60	0.33	0.00	0.33	**1.11**
30/12/2003	2.60	0.31	0.00	0.31	**2.29**
31/12/2003	14.40	0.38	0.00	0.38	**14.02**
01/01/2004	0.40	0.30	0.00	0.30	**0.10**
02/01/2004	5.20	0.22	0.00	0.22	**4.98**
03/01/2004	5.20	0.41	0.00	0.41	**4.79**
04/01/2004	0.60	0.35	0.00	0.35	**0.25**
05/01/2004	2.80	0.32	0.00	0.32	**2.48**
06/01/2004	3.20	0.36	0.00	0.36	**2.84**
07/01/2004	11.40	0.33	0.00	0.33	**11.07**
08/01/2004	20.00	0.32	0.00	0.32	**19.68**
09/01/2004	3.80	0.33	0.00	0.33	**3.47**
10/01/2004	2.80	0.41	0.00	0.41	**2.39**
11/01/2004	6.80	0.42	0.00	0.42	**6.38**
12/01/2004	7.20	0.39	0.00	0.39	**6.81**
13/01/2004	0.40	0.34	0.00	0.34	**0.06**
14/01/2004	3.20	0.28	0.00	0.28	**2.92**
15/01/2004	15.60	0.44	0.00	0.44	**15.16**
16/01/2004	0.80	0.32	0.00	0.32	**0.48**
17/01/2004	0.20	0.37	0.17	0.37	**0.00**
18/01/2004	0.20	0.47	0.44	0.47	**0.00**
19/01/2004	0.60	0.38	0.22	0.38	**0.00**
20/01/2004	0.20	0.24	0.26	0.24	**0.00**
21/01/2004	0.00	0.28	0.54	0.28	**0.00**
22/01/2004	4.00	0.60	0.00	0.60	**2.86**
23/01/2004	8.40	0.52	0.00	0.52	**7.88**
24/01/2004	1.20	0.46	0.00	0.46	**0.74**
25/01/2004	0.20	0.46	0.26	0.46	**0.00**
26/01/2004	7.20	0.43	0.00	0.43	**6.50**
27/01/2004	2.20	0.37	0.00	0.37	**1.83**
28/01/2004	1.40	0.53	0.00	0.53	**0.87**
29/01/2004	0.00	0.42	0.42	0.42	**0.00**
30/01/2004	7.20	0.61	0.00	0.61	**6.17**
31/01/2004	14.00	0.62	0.00	0.62	**13.38**
01/02/2004	2.60	0.53	0.00	0.53	**2.07**
02/02/2004	7.20	0.61	0.00	0.61	**6.59**
03/02/2004	13.00	0.68	0.00	0.68	**12.32**
04/02/2004	13.00	0.67	0.00	0.67	**12.33**
05/02/2004	0.00	0.62	0.62	0.62	**0.00**
06/02/2004	12.80	0.48	0.00	0.48	**11.70**
07/02/2004	0.40	0.59	0.19	0.59	**0.00**
08/02/2004	0.00	0.70	0.89	0.70	**0.00**
09/02/2004	0.00	0.78	1.67	0.78	**0.00**
10/02/2004	0.00	0.67	2.34	0.67	**0.00**
11/02/2004	0.00	0.93	3.27	0.93	**0.00**
12/02/2004	0.20	0.98	4.05	0.98	**0.00**
13/02/2004	0.00	0.86	4.91	0.86	**0.00**
14/02/2004	0.00	0.83	5.74	0.83	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
15/02/2004	0.00	0.89	6.63	0.89	**0.00**
16/02/2004	0.60	0.80	6.84	0.80	**0.00**
17/02/2004	0.00	1.01	7.85	1.01	**0.00**
18/02/2004	0.00	0.90	8.75	0.90	**0.00**
19/02/2004	0.00	0.86	9.60	0.86	**0.00**
20/02/2004	0.00	0.67	10.27	0.67	**0.00**
21/02/2004	0.00	0.65	10.92	0.65	**0.00**
22/02/2004	0.00	0.74	11.66	0.74	**0.00**
23/02/2004	0.00	0.89	12.55	0.89	**0.00**
24/02/2004	0.20	0.78	13.13	0.78	**0.00**
25/02/2004	0.00	0.67	13.80	0.67	**0.00**
26/02/2004	0.60	0.63	13.83	0.63	**0.00**
27/02/2004	0.00	0.72	14.55	0.72	**0.00**
28/02/2004	0.00	0.90	15.45	0.90	**0.00**
29/02/2004	0.00	0.99	16.44	0.99	**0.00**
01/03/2004	0.00	1.07	17.50	1.07	**0.00**
02/03/2004	0.00	1.11	18.61	1.11	**0.00**
03/03/2004	11.00	1.12	8.73	1.12	**0.00**
04/03/2004	0.40	1.36	9.69	1.36	**0.00**
05/03/2004	0.00	1.31	11.00	1.31	**0.00**
06/03/2004	0.60	1.31	11.71	1.31	**0.00**
07/03/2004	0.00	1.29	13.00	1.29	**0.00**
08/03/2004	0.00	1.24	14.24	1.24	**0.00**
09/03/2004	0.00	1.26	15.50	1.26	**0.00**
10/03/2004	0.00	1.07	16.57	1.07	**0.00**
11/03/2004	15.80	0.51	1.28	0.51	**0.00**
12/03/2004	20.40	1.21	0.00	1.21	**17.92**
13/03/2004	3.60	1.35	0.00	1.35	**2.25**
14/03/2004	6.60	1.50	0.00	1.50	**5.10**
15/03/2004	2.40	1.57	0.00	1.57	**0.83**
16/03/2004	2.00	1.12	0.00	1.12	**0.88**
17/03/2004	0.00	1.64	1.64	1.64	**0.00**
18/03/2004	5.60	1.27	0.00	1.27	**2.69**
	640.40	183.67	4412.64	133.79	**414.93**

Site 4 - Evapotranspiration Calculations

(Hargreaves method)

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
01/01/2003	7.00	0.26	0.00	0.00	**7.00**
02/01/2003	1.00	0.32	0.00	0.32	**0.68**
03/01/2003	1.60	0.23	0.00	0.23	**1.37**
04/01/2003	0.20	0.30	0.10	0.30	**0.00**
05/01/2003	0.20	0.35	0.25	0.35	**0.00**
06/01/2003	0.00	0.33	0.58	0.33	**0.00**
07/01/2003	0.00	0.19	0.77	0.19	**0.00**
08/01/2003	2.40	0.29	0.00	0.29	**1.34**
09/01/2003	2.60	0.26	0.00	0.26	**2.34**
10/01/2003	0.00	0.23	0.23	0.23	**0.00**
11/01/2003	0.00	0.37	0.60	0.37	**0.00**
12/01/2003	0.20	0.42	0.82	0.42	**0.00**
13/01/2003	0.40	0.26	0.68	0.26	**0.00**
14/01/2003	0.00	0.18	0.86	0.18	**0.00**
15/01/2003	0.00	0.42	1.28	0.42	**0.00**
16/01/2003	0.20	0.46	1.54	0.46	**0.00**
17/01/2003	11.40	0.46	0.00	0.46	**9.40**
18/01/2003	8.60	0.40	0.00	0.40	**8.20**
19/01/2003	1.40	0.40	0.00	0.40	**1.00**
20/01/2003	6.60	0.37	0.00	0.37	**6.23**
21/01/2003	1.20	0.40	0.00	0.40	**0.80**
22/01/2003	0.00	0.44	0.44	0.44	**0.00**
23/01/2003	0.20	0.58	0.82	0.58	**0.00**
24/01/2003	4.00	0.35	0.00	0.35	**2.84**
25/01/2003	7.60	0.41	0.00	0.41	**7.19**
26/01/2003	0.00	0.58	0.58	0.58	**0.00**
27/01/2003	1.00	0.63	0.21	0.63	**0.00**
28/01/2003	4.20	0.30	0.00	0.30	**3.69**
29/01/2003	0.40	0.35	0.00	0.35	**0.05**
30/01/2003	1.60	0.47	0.00	0.47	**1.13**
31/01/2003	2.00	0.51	0.00	0.51	**1.49**
01/02/2003	0.40	0.49	0.09	0.49	**0.00**
02/02/2003	2.20	0.40	0.00	0.40	**1.71**
03/02/2003	0.20	0.41	0.21	0.41	**0.00**
04/02/2003	0.80	0.45	0.00	0.45	**0.14**
05/02/2003	0.20	0.59	0.39	0.59	**0.00**
06/02/2003	2.00	0.62	0.00	0.62	**0.99**
07/02/2003	0.20	0.59	0.39	0.59	**0.00**
08/02/2003	4.00	0.44	0.00	0.44	**3.16**
09/02/2003	1.20	0.68	0.00	0.68	**0.52**
10/02/2003	6.60	0.69	0.00	0.69	**5.91**
11/02/2003	0.40	0.84	0.44	0.84	**0.00**
12/02/2003	0.20	0.85	1.09	0.85	**0.00**
13/02/2003	0.00	0.75	1.83	0.75	**0.00**
14/02/2003	0.00	0.64	2.47	0.64	**0.00**
15/02/2003	0.20	0.82	3.09	0.82	**0.00**
16/02/2003	0.00	0.57	3.66	0.57	**0.00**
17/02/2003	0.00	0.45	4.11	0.45	**0.00**
18/02/2003	0.00	0.42	4.53	0.42	**0.00**
19/02/2003	0.00	0.70	5.23	0.70	**0.00**
20/02/2003	0.60	0.67	5.30	0.67	**0.00**
21/02/2003	0.20	0.99	6.10	0.99	**0.00**
22/02/2003	0.00	0.89	6.98	0.89	**0.00**
23/02/2003	0.60	1.02	7.40	1.02	**0.00**
24/02/2003	0.20	0.94	8.15	0.94	**0.00**
25/02/2003	0.00	0.59	8.74	0.59	**0.00**
26/02/2003	2.20	0.34	6.88	0.34	**0.00**
27/02/2003	0.40	0.86	7.34	0.86	**0.00**
28/02/2003	16.80	0.98	0.00	0.98	**8.49**
01/03/2003	3.60	0.97	0.00	0.97	**2.63**
02/03/2003	2.80	1.26	0.00	1.26	**1.54**
03/03/2003	1.40	0.96	0.00	0.96	**0.44**
04/03/2003	0.80	0.98	0.18	0.98	**0.00**
05/03/2003	0.40	1.19	0.96	1.19	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
06/03/2003	0.00	1.22	2.18	1.22	**0.00**
07/03/2003	3.20	0.80	0.00	0.80	**0.22**
08/03/2003	8.80	1.18	0.00	1.18	**7.62**
09/03/2003	1.40	0.86	0.00	0.86	**0.54**
10/03/2003	10.80	1.02	0.00	1.02	**9.78**
11/03/2003	1.20	1.21	0.01	1.21	**0.00**
12/03/2003	0.20	1.24	1.05	1.24	**0.00**
13/03/2003	0.00	1.20	2.25	1.20	**0.00**
14/03/2003	0.20	1.55	3.60	1.55	**0.00**
15/03/2003	0.00	1.60	5.20	1.60	**0.00**
16/03/2003	0.00	1.85	7.05	1.85	**0.00**
17/03/2003	0.00	2.16	9.21	2.16	**0.00**
18/03/2003	0.20	2.19	11.20	2.19	**0.00**
19/03/2003	0.20	1.70	12.71	1.70	**0.00**
20/03/2003	0.00	1.67	14.38	1.67	**0.00**
21/03/2003	0.00	1.91	16.29	1.91	**0.00**
22/03/2003	0.00	1.82	18.11	1.82	**0.00**
23/03/2003	0.00	2.45	20.56	2.45	**0.00**
24/03/2003	0.00	2.08	22.64	2.08	**0.00**
25/03/2003	0.00	1.72	24.36	1.72	**0.00**
26/03/2003	0.00	2.47	26.82	2.47	**0.00**
27/03/2003	0.00	1.98	28.81	1.98	**0.00**
28/03/2003	1.00	1.85	29.66	1.85	**0.00**
29/03/2003	0.00	1.95	31.61	1.95	**0.00**
30/03/2003	0.00	1.97	33.58	1.97	**0.00**
31/03/2003	0.00	2.25	35.83	2.25	**0.00**
01/04/2003	3.40	1.70	34.13	1.70	**0.00**
02/04/2003	0.80	1.91	35.24	1.91	**0.00**
03/04/2003	0.00	1.86	37.10	1.86	**0.00**
04/04/2003	0.20	2.53	39.43	2.53	**0.00**
05/04/2003	0.00	2.17	41.60	2.17	**0.00**
06/04/2003	0.00	1.74	43.11	1.51	**0.00**
07/04/2003	0.00	1.81	44.66	1.55	**0.00**
08/04/2003	0.00	1.95	46.29	1.64	**0.00**
09/04/2003	0.00	2.21	48.10	1.81	**0.00**
10/04/2003	0.00	1.81	49.55	1.45	**0.00**
11/04/2003	0.00	1.93	51.06	1.51	**0.00**
12/04/2003	0.00	1.86	52.49	1.43	**0.00**
13/04/2003	1.60	2.02	52.41	1.52	**0.00**
14/04/2003	0.60	2.41	53.61	1.81	**0.00**
15/04/2003	0.00	3.25	56.01	2.39	**0.00**
16/04/2003	0.00	3.57	58.55	2.54	**0.00**
17/04/2003	0.00	3.00	60.60	2.05	**0.00**
18/04/2003	0.00	2.51	62.26	1.65	**0.00**
19/04/2003	0.00	1.78	63.40	1.14	**0.00**
20/04/2003	0.00	1.74	64.49	1.10	**0.00**
21/04/2003	10.00	1.63	55.50	1.00	**0.00**
22/04/2003	0.00	2.58	57.34	1.85	**0.00**
23/04/2003	0.00	2.67	59.20	1.86	**0.00**
24/04/2003	1.80	2.33	58.98	1.57	**0.00**
25/04/2003	6.40	2.47	54.25	1.67	**0.00**
26/04/2003	3.60	2.41	52.41	1.76	**0.00**
27/04/2003	2.00	2.55	52.32	1.92	**0.00**
28/04/2003	5.60	1.83	48.10	1.37	**0.00**
29/04/2003	0.20	2.87	50.19	2.29	**0.00**
30/04/2003	1.40	2.39	50.64	1.85	**0.00**
01/05/2003	20.60	2.28	31.79	1.76	**0.00**
02/05/2003	0.60	2.69	33.89	2.69	**0.00**
03/05/2003	2.20	2.54	34.23	2.54	**0.00**
04/05/2003	24.00	1.88	12.11	1.88	**0.00**
05/05/2003	4.40	2.57	10.28	2.57	**0.00**
06/05/2003	1.20	2.96	12.04	2.96	**0.00**
07/05/2003	0.20	3.05	14.89	3.05	**0.00**
08/05/2003	0.00	2.98	17.88	2.98	**0.00**
09/05/2003	1.80	2.88	18.96	2.88	**0.00**
10/05/2003	1.00	3.06	21.01	3.06	**0.00**
11/05/2003	1.80	2.71	21.93	2.71	**0.00**
12/05/2003	3.40	2.42	20.95	2.42	**0.00**
13/05/2003	0.20	2.93	23.68	2.93	**0.00**
14/05/2003	0.00	3.26	26.94	3.26	**0.00**
15/05/2003	3.60	2.60	25.94	2.60	**0.00**
16/05/2003	9.80	2.68	18.82	2.68	**0.00**
17/05/2003	5.60	2.20	15.42	2.20	**0.00**
18/05/2003	13.40	2.68	4.70	2.68	**0.00**
19/05/2003	6.80	2.05	0.00	2.05	**0.05**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
20/05/2003	1.00	2.40	1.40	2.40	**0.00**
21/05/2003	7.60	3.08	0.00	3.08	**3.12**
22/05/2003	0.40	3.30	2.90	3.30	**0.00**
23/05/2003	4.60	2.54	0.84	2.54	**0.00**
24/05/2003	0.20	2.44	3.08	2.44	**0.00**
25/05/2003	0.00	2.92	5.99	2.92	**0.00**
26/05/2003	2.20	3.31	7.10	3.31	**0.00**
27/05/2003	1.00	2.90	9.01	2.90	**0.00**
28/05/2003	3.00	2.74	8.75	2.74	**0.00**
29/05/2003	1.60	3.89	11.04	3.89	**0.00**
30/05/2003	0.00	5.29	16.34	5.29	**0.00**
31/05/2003	0.00	3.76	20.09	3.76	**0.00**
01/06/2003	0.40	3.37	23.06	3.37	**0.00**
02/06/2003	0.00	3.50	26.56	3.50	**0.00**
03/06/2003	10.80	2.52	18.28	2.52	**0.00**
04/06/2003	0.20	3.05	21.13	3.05	**0.00**
05/06/2003	2.00	3.16	22.29	3.16	**0.00**
06/06/2003	0.00	3.92	26.21	3.92	**0.00**
07/06/2003	11.40	3.03	17.85	3.03	**0.00**
08/06/2003	1.80	3.94	19.98	3.94	**0.00**
09/06/2003	4.40	3.13	18.72	3.13	**0.00**
10/06/2003	3.00	3.30	19.02	3.30	**0.00**
11/06/2003	0.20	3.53	22.34	3.53	**0.00**
12/06/2003	0.60	3.55	25.30	3.55	**0.00**
13/06/2003	0.00	3.78	29.08	3.78	**0.00**
14/06/2003	0.20	4.84	33.72	4.84	**0.00**
15/06/2003	0.00	3.91	37.63	3.91	**0.00**
16/06/2003	0.20	4.73	42.16	4.73	**0.00**
17/06/2003	0.00	3.52	45.20	3.04	**0.00**
18/06/2003	0.20	3.45	47.87	2.86	**0.00**
19/06/2003	0.00	3.55	50.71	2.84	**0.00**
20/06/2003	0.00	3.71	53.57	2.86	**0.00**
21/06/2003	0.40	4.03	56.14	2.98	**0.00**
22/06/2003	0.00	3.91	58.91	2.77	**0.00**
23/06/2003	0.00	3.48	61.27	2.36	**0.00**
24/06/2003	0.00	4.46	64.18	2.91	**0.00**
25/06/2003	0.00	5.09	67.34	3.16	**0.00**
26/06/2003	1.20	3.81	68.37	2.23	**0.00**
27/06/2003	20.80	3.24	49.43	1.86	**0.00**
28/06/2003	0.00	3.82	52.42	2.99	**0.00**
29/06/2003	2.00	4.43	53.75	3.32	**0.00**
30/06/2003	24.00	2.55	31.62	1.87	**0.00**
01/07/2003	3.20	3.28	31.70	3.28	**0.00**
02/07/2003	0.20	4.01	35.51	4.01	**0.00**
03/07/2003	0.20	2.77	38.08	2.77	**0.00**
04/07/2003	0.00	2.58	40.66	2.58	**0.00**
05/07/2003	0.00	2.96	43.27	2.61	**0.00**
06/07/2003	0.40	3.39	45.76	2.89	**0.00**
07/07/2003	4.00	3.11	44.32	2.57	**0.00**
08/07/2003	11.60	3.78	35.90	3.18	**0.00**
09/07/2003	0.00	3.57	39.46	3.57	**0.00**
10/07/2003	1.20	3.58	41.84	3.58	**0.00**
11/07/2003	0.00	3.46	44.85	3.01	**0.00**
12/07/2003	0.00	4.28	48.42	3.57	**0.00**
13/07/2003	0.00	4.74	52.19	3.77	**0.00**
14/07/2003	0.40	4.96	55.53	3.74	**0.00**
15/07/2003	6.60	3.38	51.35	2.42	**0.00**
16/07/2003	0.80	4.73	54.16	3.61	**0.00**
17/07/2003	19.60	1.97	36.00	1.44	**0.00**
18/07/2003	0.40	4.26	39.85	4.26	**0.00**
19/07/2003	5.00	3.21	38.06	3.21	**0.00**
20/07/2003	0.20	3.31	41.17	3.31	**0.00**
21/07/2003	6.40	3.38	37.73	2.96	**0.00**
22/07/2003	0.20	3.07	40.60	3.07	**0.00**
23/07/2003	3.80	2.92	39.37	2.57	**0.00**
24/07/2003	3.40	3.12	39.09	3.12	**0.00**
25/07/2003	0.20	3.32	42.20	3.32	**0.00**
26/07/2003	0.00	3.39	45.13	2.93	**0.00**
27/07/2003	5.00	3.67	43.18	3.05	**0.00**
28/07/2003	4.20	3.48	41.95	2.97	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
29/07/2003	2.60	2.91	41.88	2.53	**0.00**
30/07/2003	1.00	3.25	43.70	2.82	**0.00**
31/07/2003	3.40	3.34	43.13	2.83	**0.00**
01/08/2003	0.00	3.01	45.70	2.57	**0.00**
02/08/2003	0.20	3.95	48.76	3.26	**0.00**
03/08/2003	0.20	3.66	51.45	2.89	**0.00**
04/08/2003	0.00	4.55	54.92	3.46	**0.00**
05/08/2003	0.20	4.98	58.32	3.60	**0.00**
06/08/2003	0.20	3.99	60.85	2.73	**0.00**
07/08/2003	0.00	5.07	64.18	3.33	**0.00**
08/08/2003	0.20	5.27	67.25	3.27	**0.00**
09/08/2003	0.00	3.61	69.37	2.12	**0.00**
10/08/2003	0.00	3.75	71.47	2.11	**0.00**
11/08/2003	0.00	4.34	73.82	2.34	**0.00**
12/08/2003	0.00	4.43	76.09	2.27	**0.00**
13/08/2003	0.00	3.43	77.76	1.67	**0.00**
14/08/2003	0.20	3.87	79.38	1.82	**0.00**
15/08/2003	0.00	3.55	80.98	1.60	**0.00**
16/08/2003	0.00	4.17	82.79	1.81	**0.00**
17/08/2003	1.40	3.42	82.81	1.42	**0.00**
18/08/2003	0.20	3.31	83.98	1.37	**0.00**
19/08/2003	0.00	2.62	85.02	1.05	**0.00**
20/08/2003	0.00	2.82	86.12	1.09	**0.00**
21/08/2003	0.00	3.15	87.30	1.19	**0.00**
22/08/2003	3.40	2.71	84.89	0.98	**0.00**
23/08/2003	0.00	3.09	86.09	1.21	**0.00**
24/08/2003	0.00	3.16	87.28	1.19	**0.00**
25/08/2003	0.20	2.36	87.94	0.86	**0.00**
26/08/2003	0.00	2.23	88.73	0.79	**0.00**
27/08/2003	0.20	2.94	89.56	1.02	**0.00**
28/08/2003	0.60	2.56	89.82	0.87	**0.00**
29/08/2003	0.40	2.54	90.27	0.85	**0.00**
30/08/2003	0.00	2.65	91.15	0.88	**0.00**
31/08/2003	0.20	2.29	91.68	0.73	**0.00**
01/09/2003	0.00	2.97	92.62	0.94	**0.00**
02/09/2003	0.00	2.28	93.31	0.69	**0.00**
03/09/2003	0.00	2.64	94.10	0.78	**0.00**
04/09/2003	0.00	2.63	94.85	0.76	**0.00**
05/09/2003	0.60	2.20	94.87	0.62	**0.00**
06/09/2003	0.40	2.76	95.24	0.77	**0.00**
07/09/2003	4.20	2.58	91.75	0.71	**0.00**
08/09/2003	0.20	2.69	92.39	0.84	**0.00**
09/09/2003	4.00	2.12	89.04	0.65	**0.00**
10/09/2003	0.40	1.65	89.21	0.57	**0.00**
11/09/2003	0.60	2.67	89.52	0.91	**0.00**
12/09/2003	0.00	2.42	90.34	0.82	**0.00**
13/09/2003	0.00	1.96	90.99	0.65	**0.00**
14/09/2003	0.00	2.50	91.79	0.81	**0.00**
15/09/2003	0.00	2.66	92.63	0.83	**0.00**
16/09/2003	0.20	3.07	93.36	0.93	**0.00**
17/09/2003	0.00	2.73	94.17	0.81	**0.00**
18/09/2003	0.80	2.01	93.95	0.58	**0.00**
19/09/2003	5.20	1.71	89.24	0.50	**0.00**
20/09/2003	16.80	1.64	73.00	0.56	**0.00**
21/09/2003	2.80	2.64	71.58	1.38	**0.00**
22/09/2003	7.60	1.88	64.99	1.01	**0.00**
23/09/2003	0.00	1.65	66.00	1.01	**0.00**
24/09/2003	0.00	1.82	67.09	1.09	**0.00**
25/09/2003	0.00	1.94	68.23	1.14	**0.00**
26/09/2003	1.40	1.57	67.73	0.90	**0.00**
27/09/2003	0.00	1.61	68.67	0.93	**0.00**
28/09/2003	0.00	1.82	69.70	1.04	**0.00**
29/09/2003	2.80	1.21	67.58	0.68	**0.00**
30/09/2003	9.60	1.45	58.83	0.84	**0.00**
01/10/2003	0.20	1.74	59.81	1.19	**0.00**
02/10/2003	0.00	1.77	60.99	1.18	**0.00**
03/10/2003	0.20	1.38	61.70	0.91	**0.00**
04/10/2003	0.20	1.36	62.38	0.88	**0.00**
05/10/2003	4.00	1.37	59.26	0.88	**0.00**
06/10/2003	0.00	1.06	59.97	0.71	**0.00**
07/10/2003	5.40	0.99	55.23	0.66	**0.00**
08/10/2003	1.00	1.44	55.27	1.04	**0.00**
09/10/2003	0.40	1.42	55.89	1.02	**0.00**
10/10/2003	0.40	1.41	56.49	1.00	**0.00**
11/10/2003	0.00	1.45	57.51	1.02	**0.00**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
12/10/2003	3.20	0.82	54.88	0.57	**0.00**
13/10/2003	5.80	1.16	49.92	0.84	**0.00**
14/10/2003	0.00	1.27	50.91	0.99	**0.00**
15/10/2003	0.00	1.36	51.95	1.04	**0.00**
16/10/2003	0.00	1.39	53.00	1.05	**0.00**
17/10/2003	0.00	1.38	54.03	1.03	**0.00**
18/10/2003	0.20	1.13	54.66	0.83	**0.00**
19/10/2003	0.60	0.90	54.72	0.66	**0.00**
20/10/2003	0.40	0.89	54.96	0.64	**0.00**
21/10/2003	0.40	0.85	55.18	0.62	**0.00**
22/10/2003	11.00	0.55	44.58	0.39	**0.00**
23/10/2003	0.00	1.01	45.42	0.84	**0.00**
24/10/2003	0.20	0.91	45.98	0.76	**0.00**
25/10/2003	0.40	0.88	46.30	0.72	**0.00**
26/10/2003	0.20	0.94	46.87	0.77	**0.00**
27/10/2003	0.00	1.00	47.69	0.81	**0.00**
28/10/2003	3.60	0.74	44.68	0.59	**0.00**
29/10/2003	1.60	0.72	43.68	0.60	**0.00**
30/10/2003	32.60	0.70	11.68	0.60	**0.00**
31/10/2003	15.80	0.59	0.00	0.59	**3.53**
01/11/2003	9.40	0.74	0.00	0.74	**8.66**
02/11/2003	1.40	0.65	0.00	0.65	**0.75**
03/11/2003	2.60	0.72	0.00	0.72	**1.88**
04/11/2003	0.40	0.84	0.44	0.84	**0.00**
05/11/2003	3.60	0.53	0.00	0.53	**2.64**
06/11/2003	0.00	0.88	0.88	0.88	**0.00**
07/11/2003	0.00	0.87	1.75	0.87	**0.00**
08/11/2003	0.00	0.42	2.17	0.42	**0.00**
09/11/2003	2.20	0.71	0.68	0.71	**0.00**
10/11/2003	0.20	0.62	1.10	0.62	**0.00**
11/11/2003	25.20	0.44	0.00	0.44	**23.66**
12/11/2003	8.00	0.64	0.00	0.64	**7.36**
13/11/2003	23.80	0.60	0.00	0.60	**23.20**
14/11/2003	3.60	0.37	0.00	0.37	**3.23**
15/11/2003	0.20	0.47	0.27	0.47	**0.00**
16/11/2003	0.00	0.55	0.82	0.55	**0.00**
17/11/2003	0.20	0.58	1.20	0.58	**0.00**
18/11/2003	0.00	0.34	1.53	0.34	**0.00**
19/11/2003	27.00	0.41	0.00	0.41	**25.06**
20/11/2003	17.20	0.59	0.00	0.59	**16.61**
21/11/2003	0.40	0.49	0.09	0.49	**0.00**
22/11/2003	0.40	0.47	0.16	0.47	**0.00**
23/11/2003	0.40	0.48	0.25	0.48	**0.00**
24/11/2003	1.20	0.48	0.00	0.48	**0.47**
25/11/2003	13.80	0.37	0.00	0.37	**13.43**
26/11/2003	1.80	0.36	0.00	0.36	**1.44**
27/11/2003	0.60	0.41	0.00	0.41	**0.19**
28/11/2003	2.20	0.53	0.00	0.53	**1.67**
29/11/2003	32.60	0.46	0.00	0.46	**32.14**
30/11/2003	0.20	0.42	0.22	0.42	**0.00**
01/12/2003	6.20	0.41	0.00	0.41	**5.57**
02/12/2003	31.00	0.40	0.00	0.40	**30.60**
03/12/2003	0.40	0.25	0.00	0.25	**0.15**
04/12/2003	0.00	0.44	0.44	0.44	**0.00**
05/12/2003	0.20	0.41	0.66	0.41	**0.00**
06/12/2003	1.00	0.43	0.09	0.43	**0.00**
07/12/2003	0.00	0.38	0.47	0.38	**0.00**
08/12/2003	3.00	0.41	0.00	0.41	**2.13**
09/12/2003	4.20	0.29	0.00	0.29	**3.91**
10/12/2003	9.60	0.23	0.00	0.23	**9.37**
11/12/2003	16.20	0.43	0.00	0.43	**15.77**
12/12/2003	26.40	0.50	0.00	0.50	**25.90**
13/12/2003	5.20	0.41	0.00	0.41	**4.79**
14/12/2003	0.00	0.35	0.35	0.35	**0.00**
15/12/2003	0.00	0.31	0.66	0.31	**0.00**
16/12/2003	0.00	0.30	0.96	0.30	**0.00**
17/12/2003	0.00	0.33	1.29	0.33	**0.00**
18/12/2003	0.00	0.33	1.62	0.33	**0.00**
19/12/2003	0.80	0.24	1.07	0.24	**0.00**
20/12/2003	16.60	0.34	0.00	0.34	**15.19**
21/12/2003	1.40	0.28	0.00	0.28	**1.12**
22/12/2003	1.60	0.29	0.00	0.29	**1.31**
23/12/2003	2.60	0.32	0.00	0.32	**2.28**

DATE	meas. RF mm/d	calc. Eto (mm/d)	calc. SMD (mm)	Et actual	Eff RF mm/d
24/12/2003	0.00	0.23	0.23	0.23	**0.00**
25/12/2003	18.20	0.24	0.00	0.24	**17.73**
26/12/2003	34.40	0.39	0.00	0.39	**34.01**
27/12/2003	0.20	0.30	0.10	0.30	**0.00**
28/12/2003	0.20	0.26	0.16	0.26	**0.00**
29/12/2003	4.00	0.33	0.00	0.33	**3.51**
30/12/2003	6.60	0.31	0.00	0.31	**6.29**
31/12/2003	26.60	0.38	0.00	0.38	**26.22**
01/01/2004	1.00	0.30	0.00	0.30	**0.70**
02/01/2004	9.80	0.22	0.00	0.22	**9.58**
03/01/2004	10.20	0.41	0.00	0.41	**9.79**
04/01/2004	1.60	0.35	0.00	0.35	**1.25**
05/01/2004	4.80	0.32	0.00	0.32	**4.48**
06/01/2004	6.00	0.36	0.00	0.36	**5.64**
07/01/2004	18.60	0.33	0.00	0.33	**18.27**
08/01/2004	30.80	0.32	0.00	0.32	**30.48**
09/01/2004	8.00	0.33	0.00	0.33	**7.67**
10/01/2004	6.80	0.41	0.00	0.41	**6.39**
11/01/2004	14.20	0.42	0.00	0.42	**13.78**
12/01/2004	9.20	0.39	0.00	0.39	**8.81**
13/01/2004	1.40	0.34	0.00	0.34	**1.06**
14/01/2004	4.40	0.28	0.00	0.28	**4.12**
15/01/2004	30.60	0.44	0.00	0.44	**30.16**
16/01/2004	4.80	0.32	0.00	0.32	**4.48**
17/01/2004	0.80	0.37	0.00	0.37	**0.43**
18/01/2004	0.20	0.47	0.27	0.47	**0.00**
19/01/2004	0.80	0.38	0.00	0.38	**0.15**
20/01/2004	0.80	0.24	0.00	0.24	**0.56**
21/01/2004	0.00	0.28	0.28	0.28	**0.00**
22/01/2004	6.60	0.60	0.00	0.60	**5.72**
23/01/2004	13.00	0.52	0.00	0.52	**12.48**
24/01/2004	2.40	0.46	0.00	0.46	**1.94**
25/01/2004	0.20	0.46	0.26	0.46	**0.00**
26/01/2004	21.40	0.43	0.00	0.43	**20.70**
27/01/2004	7.20	0.37	0.00	0.37	**6.83**
28/01/2004	3.00	0.53	0.00	0.53	**2.47**
29/01/2004	0.00	0.42	0.42	0.42	**0.00**
30/01/2004	13.20	0.61	0.00	0.61	**12.17**
31/01/2004	27.40	0.62	0.00	0.62	**26.78**
01/02/2004	3.80	0.53	0.00	0.53	**3.27**
02/02/2004	9.60	0.61	0.00	0.61	**8.99**
03/02/2004	10.40	0.68	0.00	0.68	**9.72**
04/02/2004	11.00	0.67	0.00	0.67	**10.33**
05/02/2004	0.00	0.62	0.62	0.62	**0.00**
06/02/2004	9.20	0.48	0.00	0.48	**8.10**
07/02/2004	0.40	0.59	0.19	0.59	**0.00**
08/02/2004	0.00	0.70	0.89	0.70	**0.00**
09/02/2004	0.00	0.78	1.67	0.78	**0.00**
10/02/2004	0.00	0.67	2.34	0.67	**0.00**
11/02/2004	0.00	0.93	3.27	0.93	**0.00**
12/02/2004	0.00	0.98	4.25	0.98	**0.00**
13/02/2004	0.40	0.86	4.71	0.86	**0.00**
14/02/2004	0.00	0.83	5.54	0.83	**0.00**
15/02/2004	0.20	0.89	6.23	0.89	**0.00**
16/02/2004	0.80	0.80	6.24	0.80	**0.00**
17/02/2004	0.00	1.01	7.25	1.01	**0.00**
18/02/2004	0.20	0.90	7.95	0.90	**0.00**
19/02/2004	0.00	0.86	8.80	0.86	**0.00**
20/02/2004	0.20	0.67	9.27	0.67	**0.00**
21/02/2004	0.00	0.65	9.92	0.65	**0.00**
22/02/2004	0.00	0.74	10.66	0.74	**0.00**
23/02/2004	0.00	0.89	11.55	0.89	**0.00**
24/02/2004	1.20	0.78	11.13	0.78	**0.00**
25/02/2004	0.00	0.67	11.80	0.67	**0.00**
26/02/2004	0.80	0.63	11.63	0.63	**0.00**
27/02/2004	0.00	0.72	12.35	0.72	**0.00**
28/02/2004	0.00	0.90	13.25	0.90	**0.00**
29/02/2004	0.00	0.99	14.24	0.99	**0.00**
01/03/2004	0.20	1.07	15.10	1.07	**0.00**
02/03/2004	0.00	1.11	16.21	1.11	**0.00**
03/03/2004	13.40	1.12	3.93	1.12	**0.00**
04/03/2004	0.20	1.36	5.09	1.36	**0.00**
05/03/2004	0.00	1.31	6.40	1.31	**0.00**
06/03/2004	0.20	1.31	7.51	1.31	**0.00**
07/03/2004	0.00	1.29	8.80	1.29	**0.00**
08/03/2004	0.00	1.24	10.04	1.24	**0.00**
09/03/2004	0.20	1.26	11.10	1.26	**0.00**
10/03/2004	0.00	1.07	12.17	1.07	**0.00**
11/03/2004	30.60	0.51	0.00	0.51	**17.92**
12/03/2004	5.40	1.21	0.00	1.21	**4.19**
13/03/2004	3.80	1.35	0.00	1.35	**2.45**
14/03/2004	7.80	1.50	0.00	1.50	**6.30**
15/03/2004	3.60	1.57	0.00	1.57	**2.03**
16/03/2004	2.20	1.12	0.00	1.12	**1.08**
17/03/2004	1.20	1.64	0.44	1.64	**0.00**
18/03/2004	6.00	1.27	0.00	1.27	**4.29**