Environmental Protection Division

Water Stewardship Division

Ministry of Environment

Water Quality Assessment and Objectives for the Englishman River Community Watershed

Technical Report

Approved By: ____________________________ Date: ________________

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1.0 INTRODUCTION

The Ministry of Environment (MOE) on Vancouver Island is conducting a program to assess water quality in priority watersheds. The purpose of this program is to accumulate the baseline data necessary to assess both the current state of water quality and longer term trends, and to establish ambient water quality objectives on a watershed specific basis. Water quality objectives provide goals that need to be met to ensure protection of designated water uses. The implementation of water quality objectives into planning initiatives can help protect watershed values, mitigate impacts of land-use activities on source area watersheds, and protect water quality in the context of both acute and chronic impacts to human and aquatic ecosystem health. Water quality objectives provide direction for resource managers, serve as a guide for issuing permits, licenses, and orders by MOE, and establish benchmarks for assessing the Ministry's performance in protecting water quality. Water quality objectives and attainment monitoring results are reported out both to local stakeholders and on a province wide basis through forums such as State of the Environment reporting.

Vancouver Island's topography is such that the many watersheds of the MOE's Vancouver Island Region are generally small (<500 km^2). As a result the stream response times can be relatively short and opportunities for dilution or settling are often minimal. Rather than developing water quality objectives for each of these watersheds on an individual basis, an ecoregion approach has been implemented. The ecoregion areas are based on the ecosections developed by Demarchi (1996). However, for ease of communication with a wide range of stakeholders the term "ecoregion" has been adopted by Vancouver Island MOE regional staff. Thus, Vancouver Island has been split into six terrestrial ecoregions, based on similar climate, geology, soils, hydrology etc. (Figure 1).

Fundamental baseline water quality should be similar in all streams and all lakes throughout each ecoregion. However, the underlying physical, chemical and biological differences between streams and lakes must be recognized. Representative lake and stream watersheds within each ecoregion are selected (initially stream focused) and a three year monitoring program is implemented to collect water quality and quantity data, as well as biological data. Standard base monitoring programs have been established for use in streams and lakes, to maximize data comparability between watersheds and among ecoregions, regardless of location. Water quality objectives will be developed for each of the representative lake and stream watersheds based on the data, and these objectives will also be applied on an interim basis to the remaining lake and stream watersheds within that ecoregion. Over time, other priority watersheds within each ecoregion will be monitored for one year to verify the validity of the objectives developed for each ecoregion and to determine whether the objectives are being met for individual watersheds.

Figure 1. Map of Vancouver Island Ecoregions.

Partnerships formed between the MOE and local municipalities and stewardship groups are a key component of the water quality network. Water quality sampling conducted by the public works departments of local municipalities and stewardship groups has enabled the Ministry to significantly increase the number of watersheds studied and the sampling regime within these watersheds. These partnerships have allowed the Ministry to study watersheds over a greater geographic range and in more ecoregions across Vancouver Island, and have resulted in strong relationships with local government and interest groups, provided valuable input and local support and, ultimately, resulted in a more effective monitoring program.

The Englishman River community watershed provides a significant source of drinking water to the local community and has important fisheries values, with chinook, chum, coho, sockeye and pink salmon, cutthroat and rainbow trout, and steelhead all present at some point during the year (FISS, 2006). Anthropogenic land uses within the watershed include timber harvesting, agriculture, rural residential, urban residential (in the lower watershed), light industrial development, and recreation. These activities, as well as natural erosion and the presence of wildlife, all potentially affect water quality in the Englishman River.

This report examines the existing water quality of the Englishman River and recommends water quality objectives for this watershed based on potential impacts and water quality parameters of concern. The Englishman River was designated as a community watershed in 1995, as defined under the *Forest Practices Code of British Columbia Act* ("the drainage area above the downstream point of diversion and which are licensed under the *Water Act* for waterworks purposes"). This designation was grandparented and continued under the *Forest and Range Practices Act* (FRPA) in 2004 and infers a level of protection. As the majority of the Englishman River community watershed is on private land, the FRPA does not apply to most of the watershed. However, the MOE uses other tools, such as water quality objectives, and legislation, such as the *Private Managed Forest Land Act* and the *Drinking Water Protection Act*, to ensure that water quality within these watersheds is protected and managed in a consistent manner.

2.0 WATERSHED PROFILE AND HYDROLOGY

2.1 BASIN PROFILE

The Englishman River is a fourth-order stream 39 km in length, entering Georgia Strait near the community of Parksville, BC (Figure 2). The community watershed portion of the Englishman River watershed is approximately 31,890 ha in area, comprising 98% of the total Englishman River watershed, and ranges from approximately 1,800 m elevation at Mount Arrowsmith in the upper watershed to near sea level at the City of Parksville water intake (located about 1 km from the confluence of Georgia Strait). There are seven named lakes within the watershed (Table 1) (FISS, 2006).

Figure 2. Englishman River Community Watershed.

Table 1. Summary of named lakes located within the Englishman River watershed.

Name of Lake	Elevation (m)	Area (ha)	Fish species present
Fishtail Lake	1,003	15.5	Rainbow trout
Hidden Lake	1,091	15.8	Rainbow trout
Arrowsmith Lake	813	35.5	Brown trout, rainbow trout
Rowbotham Lake	970	21.3	Cutthroat trout, rainbow trout
Marshall Lake	817	<10	unknown
Shelton Lake	548	36	Rainbow trout
Healy Lake	531	33.8	Rainbow trout

The lower portion of the watershed (below 100 m elevation) lies within the Coastal Douglas-fir biogeoclimatic zone (moist maritime, CDFmm), progressing through Coastal Western Hemlock (eastern very dry maritime, CWHxm1) above 100 m, Mountain Hemlock (windward moist montane, MHmm1) above 1,000 m elevation, and Alpine Tundra (ATunp) in small areas above 1,300 m. The Englishman River falls within the Nanaimo Lowland (NAL) ecoregion (see Figure 1) established for Vancouver Island by MOE staff.

2.2 HYDROLOGY AND PRECIPITATION

The nearest climate station to the watershed for which climate normal data are available is the Nanaimo A station (elevation 28 m) (Environment Canada Climate Station 1025370), located approximately 44 km south-east of Parksville. Average daily temperatures between 1971 and 2000 ranged from 2.9°C in January to 18.0°C in August. Average total annual precipitation between 1971 and 2000 was 1,163 mm, with only 81 mm (water equivalent) (7%) of this falling as snow (Figure 3). Temperatures at higher elevations in the watershed would be cooler than recorded at sea level. A larger portion of the annual total precipitation occurred as snowfall in the higher-elevation terrain of the watershed. Most of the precipitation (909 mm, or 78%) fell between October and March.

Water Survey Canada (WSC) has periodically operated a hydrometric station on the Englishman River for at total of 37 years between 1913 and the present downstream from Highway 19A. However, for this report, only the data from 1913 to 2002 were available. Minimum, maximum and average daily flows for this period are shown in Figure 4. Peak flows measured between 1913 and 2004 were approximately 393 m^3/s, while minimum flows were approximately 0.085 m^3/s (Figure 4).

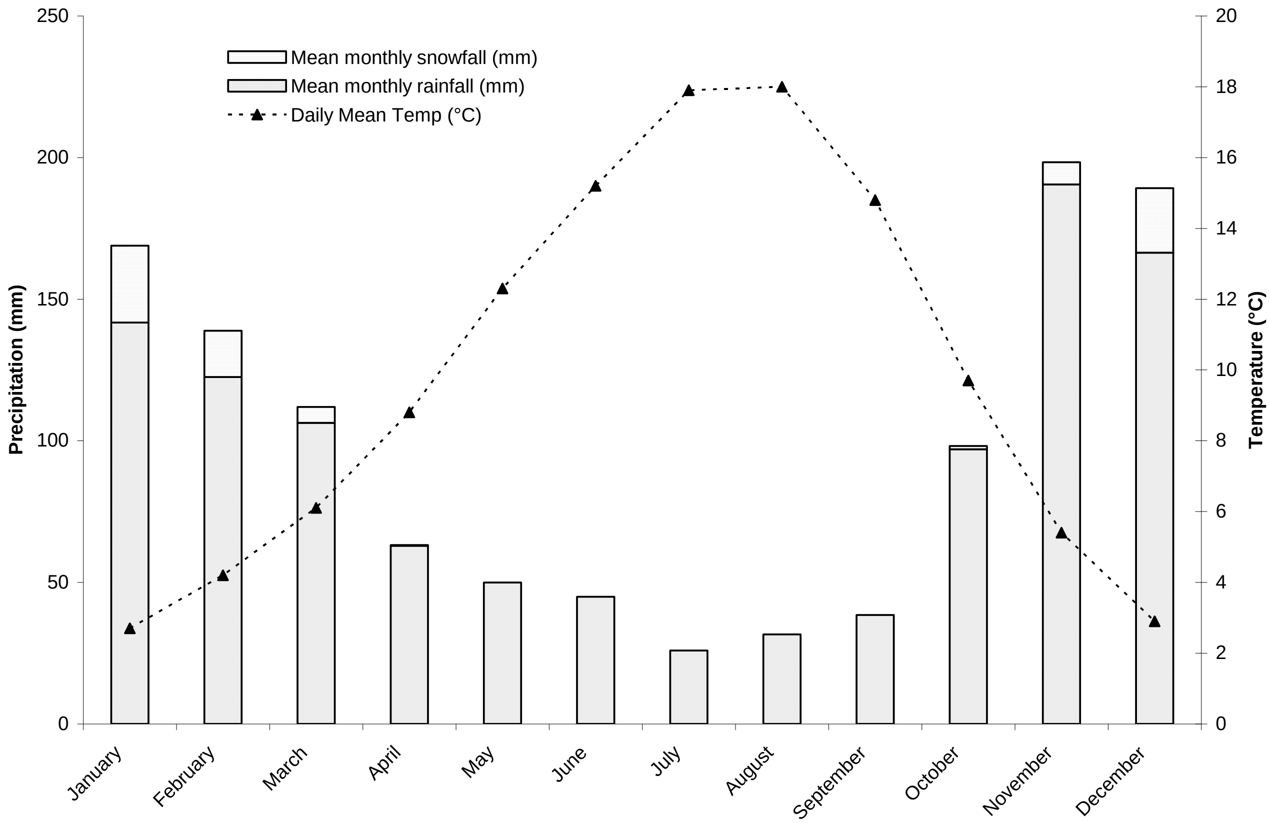

Figure 3. Climate data (1971 – 2000) for Nanaimo (Environment Canada Climate Station 1025370).

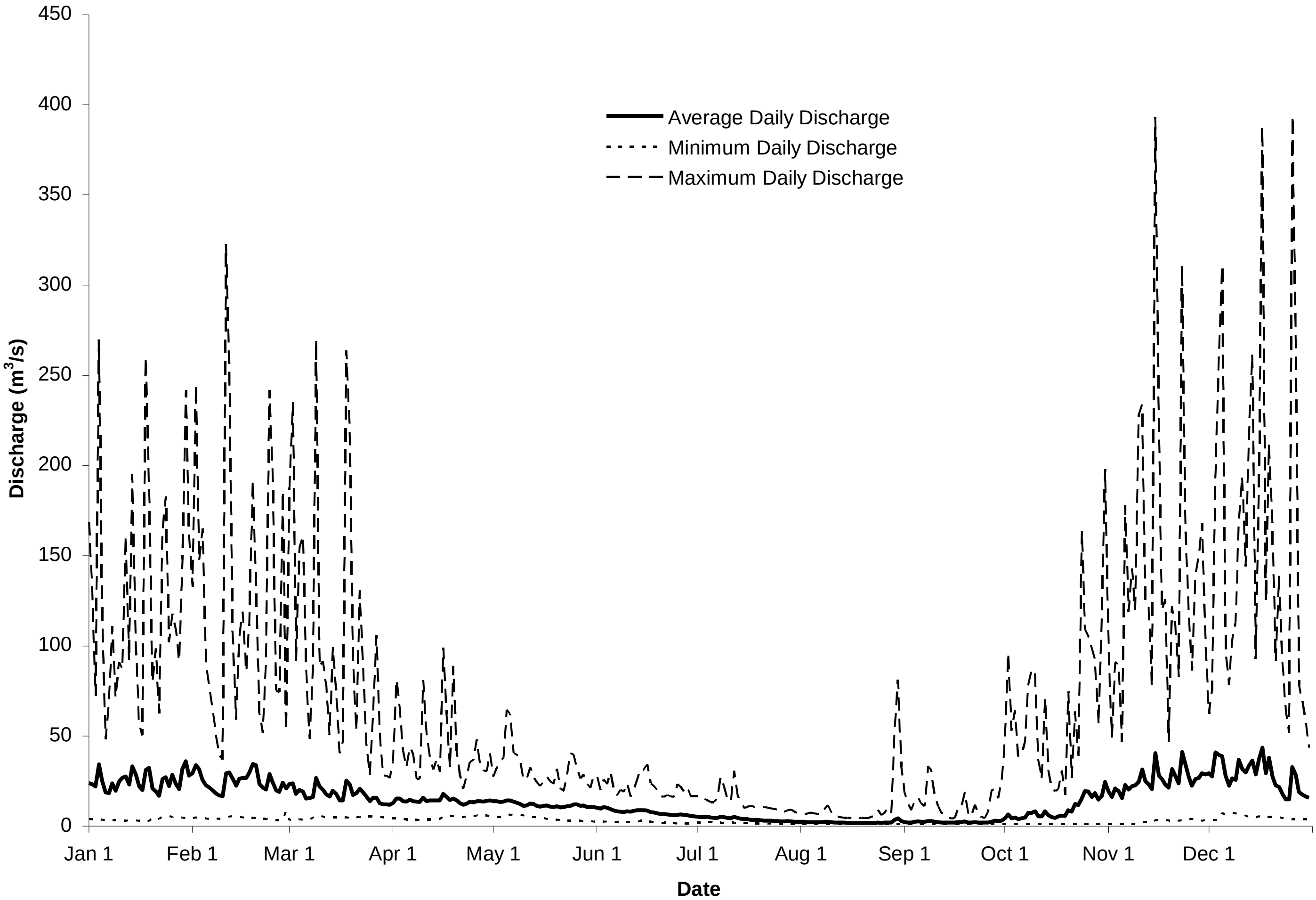

Figure 4. Minimum, maximum and average daily discharge data for Englishman River near Parksville (Water Survey Canada Station 08HB002) between 1913 and 2002 (Water Survey Canada, 2005).

3.0 WATER USES

3.1 WATER LICENSES

Twenty-four water licenses have been issued for the Englishman River (Table 2), allowing for the withdrawal of 9,796 dam^3/year (cubic decameters/year, where 1 dam^3 = 1,000 m^3) of water and the storage of 9,005 dam^3/year of water. The majority of the water is licensed for use in waterworks and domestic use. There have also been three water licenses issued for Morison Creek and one water license for Shelly Creek, primarily for irrigation purposes.

Table 2. Summary of licensed water withdrawals from within the Englishman River community watershed.

Use	No. Licensed Withdrawals	Total Volume (dam^3/year)	Principal Licensee
Englishman River			
Conservation – Use of Water	2	1,875.3	Department of Fisheries and Oceans
Domestic	13	11.6	Various
Enterprise	2	19.9	Various
Irrigation	1	3.7	Various
Storage	1	9,004.6	Regional District of Nanaimo, City of Parksville and Town of Qualicum Beach
Water Delivery	1	5.0	BC Water Service
Waterworks – Local Authority	3	879.4	City of Parksville
Waterworks – Local Authority	1	7,001.0	Regional District of Nanaimo, City of Parksville and Town of Qualicum Beach
Morison Creek			
Irrigation	2	49.3	Various
Storage	1	12.3	Various
Shelly Creek			
Irrigation	1	18.5	Various

3.2 FISHERIES

The Englishman River has high fisheries values and species present include chinook (*Oncorhynchus tshawytscha*), pink (*O. gorbuscha*), coho (*O. kisutch*), sockeye (*O. nerka*) and chum (*O. keta*) salmon, as well as cutthroat trout (*O. clarkii*), rainbow trout (*O. mykiss*), and steelhead (*O. mykiss*) (FISS, 2006). All seven named lakes within the watershed contain salmonid species (see Table 2).

The Englishman River is stocked on an annual basis with anadromous cutthroat trout smolts from the Big Qualicum fish hatchery, with a total of 24,374 smolts between 2000 and 2005. As part of the Englishman River Watershed Recovery Plan, over $1M has been invested since 2001 on numerous habitat enhancement and restoration projects (M. Deacon pers. comm., 2009), to improve water quality and increase salmonid populations, especially coho and steelhead. Partners include the Mid-Vancouver Island Habitat Enhancement Society, the BC Conservation Foundation, Weyerhaeuser, Island Timberlands, TimberWest, BC Ministry of Environment, Fisheries and Oceans Canada, the Community Fisheries Development Centre, the Regional District of Nanaimo, The Nature Trust of BC and others.

3.3 RECREATION

There are no BC Forest Service recreation sites located in the Englishman River watershed. A provincial park (the Englishman River Falls Provincial Park) is located within the watershed, with an area of 97 ha and providing 105 campsites. A regional park (Englishman River Regional Park: a Conservation Area) is also located within the watershed, with an area of 207 ha and includes a trail system frequented by hikers, bikers, and people on horseback (Lanarc & LGL, 2008). The regional park is managed by the Regional District of Nanaimo but owned by the Province of BC, the Nature Trust of BC, Ducks Unlimited and the Nature Conservancy of Canada. Logging roads are present throughout the watershed, but access to logging roads on private land (the majority of the watershed, see Section 4.0) is controlled by a manned gate and no overnight camping is allowed. The river is known to be utilized by fisherman throughout the year and by swimmers during the summer. While no in-depth studies have been conducted to determine the recreational use of the Englishman River watershed, it is likely that impacts from these activities are minimal in the upper portion of the watershed and managed in that portion of the watershed lying within the Provincial Park.

3.4 FLORA AND FAUNA

The Englishman River watershed provides habitat to a wide variety of both animal and plant species. Animal species include blacktail deer (*Odocoileus hemionus columbianus*), black bear (*Ursus americanus*), cougar (*Puma concolor*), and numerous other small mammals and birds. The endangered Vancouver Island marmot (*Marmota vancouverensis*) has been found in the sub-alpine portions of both Mount Moriarty and near Labor Day Lake east of P Mountain (CDC, 2005). Another species of concern, the anguinae sub-species of ermine (*Mustela erminea anguinae*), has been observed in the lower portion of the watershed (CDC, 2005).

A number of rare plant species are also found within the Englishman River watershed. Species on the BC Conservation Data Centre (CDC) red list (composed of species legally considered endangered or threatened) include *Rubus nivalis* (snow bramble) and *Allium crenulatum* (Olympic onion) (CDC, 2005). Blue-listed plant species (considered species of concern) include *Senecio macounii* (Macoun's groundsel), *Viola howellii* (Howell's violet), *Glyderia occidentalis* (western mannagrass), *Nothochelone nemorosa* (woodland penstemon), *Draba lonchocarpa* var. *vestita* (lance-fruited draba), and *Aster paucicapitatus* (Olympic mountain aster) (CDC, 2005).

3.5 DESIGNATED WATER USES

Designated water uses are those identified for protection in a specific watershed or waterbody. Water quality objectives are designed for the substances or conditions of concern in a watershed so that attainment of the objectives will protect the most sensitive designated uses.

The preceding discussion demonstrates that water uses to be protected should include drinking water, recreation, irrigation, wildlife and aquatic life.

4.0 INFLUENCES ON WATER QUALITY

The Englishman River community watershed is located primarily on private land owned and managed by timber groups. Island Timberlands Limited Partnership owns and manages the majority (approximately 69%) of the watershed (primarily in the South Englishman, Upper Englishman and upper Center Creek sub-basins). TimberWest Forest Corp. owns and manages 18% of the total watershed, primarily in the lower Center Creek and upper Morison Creek sub-basins. There is a significant amount of rural residential development in the lower portions of Morison Creek, Shelly Creek and the lower Englishman River sub-basins. As well, there is some urban development along the lower 1 km of the Englishman River, at and just downstream from the water intake. The rural and urban development represents approximately 10% of the overall watershed area, with the provincial park representing 1.4% of the total area and Crown Lands and right of ways representing the final 1.6% of the overall watershed area.

There are no permitted waste discharges within the watershed. Recreational use is generally limited to use of trail systems and seasonal activities such as hunting, and there are no sanctioned camping areas within the watershed outside of the Provincial Park. Therefore, the primary concerns with regard to potential anthropogenic impacts on water quality in the Englishman River are associated with urban and rural residential development (including fecal contamination from livestock and domestic animals), light industrial development, forestry and road-building, agriculture, and recreational activities.

Another potential contributing factor to impacts on water quality in the lower Englishman River is an exposed clay bank located approximately 150 meters downstream of the South Fork confluence (Gaboury, 2005). This clay bank, which is approximately 300 m in length and 30 m in height, contributes fine sediment to the river through constant weathering, in particular, freezing and thawing cycles, and erosion by the river at the toe causing sloughing of materials into the river.

4.1 LAND OWNERSHIP

As there are a number of rural residences within the watershed, potential sources of contamination associated with households (such as septic fields), as well as fecal material from domestic animals, may affect water quality in the Englishman River watershed.

Considerable agricultural development has occurred within the Morison Creek and Shelly Creek sub-basins, primarily hobby farms with horses, and forage crops including corn and grasses (Bocking and Gaboury, 2001). Agricultural activities such as tilling of peat bogs in the Morison Creek watershed have resulted in major sediment loadings to this tributary (Rosenau and Angelo, 2003).

Urbanization, particularly in the lower watershed, can impact water quality in many ways, including road runoff, stormwater, nutrients from lawn fertilizers, proliferation of impervious surfaces and increased sediment loadings from land disturbance.

Run off from light industrial development, especially in the lower watershed, may also impact water quality. As part of the Englishman River Watershed Recovery Plan, the Mid-Vancouver Island Habitat Enhancement Society (a local stewardship group) worked on a project to encourage automotive and marine-related businesses in the City of Parksville to minimize impacts on water quality. This was done by promoting the reduction of storm water run-off on the lower portion of the Englishman River by eliminating as many pollutants as possible from the target businesses, and educating the public about the sensitivity of the aquatic system. The Society has continued with other educations programs such as Salmon Friendly Lawns (encouraging reduced use of pesticides and fertilizers and water conservation), teaching rain garden construction, and storm drain awareness (painting salmon on streets near storm drains). They also conduct some flow monitoring and water quality monitoring on the Englishman River and in the estuary.

Finally, there are two highway crossings in the lower Englishman River watershed: the Inland Island Highway (Highway 19) crosses the river just upstream of Parksville; and the Old Island Highway (Highway 19A), a major highway and local thoroughfare with high traffic volume, crosses the Englishman River just upstream from the City of Parksville intake. Runoff from the highway can also impact the lower portion of the Englishman River with increased sediment loads and contaminants such as polycyclic aromatic hydrocarbons from vehicles.

4.2 LICENSED WATER WITHDRAWALS

There is a maximum licensed water withdrawal from the Englishman River community watershed of 9,796 dam^3/year. Assuming water was withdrawn from the Englishman River at a constant rate throughout the year (an unlikely scenario), the average withdrawal rate would be 0.311 m^3/s. As average daily flows between 1913 and 2004 ranged from 0.085 m^3/s during the mid-summer to 393 m^3/s during spring freshet (see Figure 4), water withdrawals could potentially impact downstream flows in the Englishman River during summer low-flow periods.

4.3 FOREST HARVESTING AND FOREST ROADS

Forestry activities can impact water quality both directly and indirectly in several ways. The removal of trees can decrease water retention times within the watershed and result in a more rapid response to precipitation events and earlier and higher spring freshets. The improper construction of roads can change drainage patterns, destabilize slopes, and introduce high concentrations of sediment to streams.

The Englishman River watershed consists primarily of private lands managed by Island Timberlands LP (22,488 ha) and TimberWest Forest Corp. (5,656 ha). The most recent watershed assessment project (WAP) for Island Timberlands was completed in 2002 (Horel and Pollard, 2002), and statistics are available for the TimberWest Forest Corp. portion of the watershed to January 2006 (D. Iannidinardo pers. comm., 2006). The following information is summarized from those sources.

In the area managed by TimberWest Forest Corp., the weighted equivalent clearcut area (ECA), as of 2006, was 4% overall. Within this area, there were 141 km of roads, resulting in a road density of 2.5 km/km^2, and 48 stream crossings, resulting in 0.8 stream crossings/ km^2. The road density was high, while the stream crossing density was low within the TimberWest Forest Corp. management area, and while these data were not available for the area managed by Island Timberlands LP, they were likely similar.

In the area managed by Island Timberlands LP, the ECA, as of 2002, was 10% overall, with values as high as 22% for individual sub-basins. By 2001, 81% of the first rotation was harvested, the majority of which was during the 1960's and 1970's.

Most streamside roadways within the watershed have a vegetated buffer between them and the river, reducing runoff and therefore decreasing the amount of turbidity and suspended solids entering the river. However, the high density of roads within the watershed suggests that, in some areas, runoff from these roads has the potential to impact turbidity levels within the river. Potential impacts from these roads will decrease as roads are deactivated and reclaimed.

Almost all alluvial reaches (representing 19% of the total stream channel length in the watershed) have experienced impacts such as channel widening, sediment aggradation, increased sediment loading and loss of functioning large woody debris (Horel and Pollard, 2002) due to historical harvesting practices. These can, in turn, contribute to increased turbidity levels especially during periods of high precipitation. As the riparian areas of these alluvial reaches recover, the potential for impacts will decrease.

While the relatively low ECA in both the Island Timberlands and TimberWest management areas suggests there is a low potential for peak flow increases, it is likely the cumulative effect of the large number of small-scale disturbances associated with road construction and forest harvesting is impacting water quality to a certain degree, especially with respect to turbidity levels during rain events. Improvements in harvesting practices over the past 20 years, coupled with increased legislation and enforcement (for example, the *Water Act* and the *Private Managed Forest Land Act*), suggests that the potential for impacts to water quality will decrease as hydrologic recovery continues.

4.4 RECREATION

Recreational activities can affect water quality in a number of ways. Erosion associated with 4-wheel drive vehicles, all-terrain vehicles and mountain bikes, direct contamination of water from vehicle fuel, and fecal contamination from human and domestic animal wastes (e.g., dogs or horses) are typical examples of potential effects. As no in-depth studies have been conducted on recreation within the Englishman River watershed, the relative impacts of recreational activities cannot be discussed. However, with the ease of access in the lower watershed, presence of a large provincial park and a regional park within the watershed boundaries, and proximity to population centres, it is possible recreational impacts occur within the watershed. Management of the regional park includes gates and barriers which help prevent vehicle access (Lanarc & LGL, 2008) and potential associated impacts.

4.5 WILDLIFE

Wildlife can influence water quality because warm-blooded animals can carry pathogens such as *Giardia lamblia*, which causes giardiasis or "beaver fever", and *Cryptosporidium* oocysts which cause the gastrointestinal disease, cryptosporidiosis (Health Canada, 2004). In addition, warm-blooded animals excrete fecal coliforms and *Escherichia coli* in their feces, and can cause elevated levels of these indicators in water. Fecal contamination of water by animals is generally considered to be less of a concern to human health than contamination by humans because there is less risk of inter-species transfer of pathogens. However, without specific source tracking methods, it is impossible to determine the origins of coliforms.

The Englishman River watershed contains valuable wildlife habitat, and provides a home for a wide variety of warm-blooded species including blacktail deer, black bear, wolf, cougar, red squirrels, eagles, hawks, owls, grouse and numerous other species of small birds. Therefore, the risk of contamination from endemic wildlife exists.

4.6 MINING

Mining activities can impact water quality by introducing high concentrations of metals and other contaminants (e.g., sulphate) to waterbodies. The leaching of waste rock or adit discharges can also contribute to acidification of the water. Mining activities generally include road construction and land-clearing, which can change water movement patterns and result in increased turbidity levels.

There are two mineral prospects shown in the BC Provincial Mineral Inventory (MINFILE, 2005). One is the Okay Mountain showing, which consists of an ash-rich coal seam containing high concentrations of sulphur, calcium, titanium, nickel and copper. The other is the Hey-Bert showing, which contains high copper concentrations.

5.0 STUDY DETAILS

Five water quality monitoring locations were established within the Englishman River community watershed (see Figure 2): Environmental Monitoring System (EMS) site E248835, on Morison Creek just upstream from its confluence with the Englishman River (selected to monitor potential impacts from agricultural activities and timber harvesting in the upper watershed); site E248834, the Englishman River just upstream from its confluence with Morison Creek (representing a small amount of timber harvesting, but primarily unimpacted); site E248836, the South Englishman River just upstream from its confluence with the Englishman River (representing potential impacts solely from timber harvesting); site E252010, the Englishman River just upstream from Allsbrook Canyon (a potential new location for the City of Parksville water intake); and site 0121580, the Englishman River at Highway 19A (just upstream from the City of Parksville water intake). The project consisted of four phases: collecting water quality data, gathering information on water use, determining land use activities that may influence water quality, and establishing water quality objectives.

Water quality data were collected from 2002 to 2005. Drinking water is one of the designated water uses in the Englishman River and so water quality variables relevant to the protection of raw drinking water supplies were included. Based on current knowledge of potential anthropogenic impacts to the sub-watersheds (generally associated with agriculture and forestry), natural features (clay bank, wildlife), and the lack of discharge licenses to any of the watersheds, the following water quality variables were included:

- Physical: pH, true color, specific conductivity, turbidity, non-filterable residue (total suspended solids)
- Carbon: dissolved organic carbon
- Nutrients: total phosphorus, orthophosphate, nitrate, nitrite.
- Bacteriological: fecal coliforms and *E. coli*
- Total and dissolved metals concentrations

To represent the worst case scenario, water samples were collected at each of the sites on a weekly basis for five consecutive weeks during the summer low flow and fall high flow periods from 2002 to 2004, and usually on a monthly basis for the remainder of the year between 2002 and 2005 (Table 3). Additional sampling was conducted at the Englishman River at Highway 19A as part of pre-2002 sampling programs.

Table 3. Summary of monitoring schedule for water quality samples collected at Englishman River water quality monitoring sites.

Site Number	Site Name	Sampling Schedule*
E248836	South Englishman River U/S from Englishman River	Monthly, August 2002 – August 2005, 5-in-30 samples summer and fall
E248835	Morison Creek U/S from Englishman River	Monthly, August 2002 – June 2005, 5-in-30 samples summer and fall
E248834	Englishman River U/S from Morison Creek	Monthly, August 2002 – June 2005, 5-in-30 samples summer and fall
E252010	Englishman River U/S from Allsbrook Canyon	Monthly, May 2003 – June 2005, 5-in-30 samples summer and fall
0121580	Englishman River at Highway 19A	3 samples early 1996; 1 sample in May 1998; 2 samples May – December 1999; 1 sample in November 2000 and November 2001; Monthly, April 2002 – October 2005, 5-in-30 samples summer and fall, 2002 – 2005. Continuous monitoring May 2003-March 2005

***5-in-30 sampling represents a minimum of five weekly samples collected within a 30-day period.**

Grab samples were collected at the water surface using plastic bottles provided by the lab conducting the analyses. Water samples were collected in strict accordance with Resource Inventory Standards Committee (RISC) standards (BC MOE, 2003), by trained personnel. Water chemistry analyses were conducted by Maxxam Analytics Inc. in Burnaby, British Columbia. Bacteriological analyses were conducted by Cantest Laboratories in Burnaby, British Columbia. Summary statistics were calculated on all available data, and 90th percentiles were calculated using data from a minimum of 5 weekly samples in 30 consecutive days for each site. Data are summarized in Appendix I.

An automated water quality/quantity monitoring station was also installed at Site 0121580 (at Highway 19A near the City of Parksville intake) to measure and log water temperature, turbidity, specific conductivity and water level. Here, a McVan analyte SDI-12 turbidity sensor was installed within the stream flow and polled every 15 minutes by a FWS-12 datalogger. The station has operated from May 2003 to the present. For the purposes of this report, only data up to June 2005 will be reviewed.

5.1 QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance and quality control was verified by collecting duplicate and blank samples. Duplicate co-located samples were collected by filling two sample bottles in as close to the same time period as possible (one right after the other) at a monitoring location, and then calculating the percent difference between the laboratory results reported for the various samples. The maximum acceptable percentage difference between duplicate samples is 25%. However, this interpretation only holds true if the results are at least 10 times the detectable limits for a given parameter, as the accuracy of a result close to the detectable limit shows more variability than results well above detectable limits. As well, some parameters (notably bacteriological indicators) are not homogeneous throughout the water column and therefore we expect to see a higher degree of variability between replicate samples. For blanks, the Guidelines for Interpreting Water Quality Data (RISC, 1997) state that contamination has occurred when 5% or more of the blanks show any levels above the method detection limit. If the blanks are within the guidelines, the data are to be considered clean and the real sample data are to be treated as uncontaminated.

6.0 WATER QUALITY ASSESSMENT AND OBJECTIVES

There are two sets of guidelines that are commonly used to determine the suitability of drinking water. The British Columbia source water quality guidelines (available at http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html) are used to assess water at the point of diversion of the natural stream into a waterworks system. The Guidelines for Canadian Drinking Water Quality (Health Canada, 2006) are national guidelines that apply to drinking water at the point of consumption, after treatment processes that may include particle removal and bacterial disinfection. In the case of Parksville, treatment consists of disinfection with chlorine is applied. The Ministry of Health requires water purveyors to disinfect all surface water as a minimum prior to drinking (*Drinking Water Protection Act* – Drinking Water Protection Regulation, 2005). In addition, the Vancouver Island Health Authority now requires all new water systems to provide *Cryptosporidium* control.

Seven sets of duplicate samples were collected during the sampling program (Appendix II). In 77% of the instances (127 of 165 variables monitored), relative percent mean differences were found to be within acceptable limits as discussed above. For the remaining samples, concentrations were almost invariably less than ten times the detection limits, and therefore the guidelines for interpreting acceptability do not apply. Three blank samples were also analyzed. All variables were at or below detection limits, except for one instance of elevated total aluminum and one sample where UV absorbance rates were elevated. The cause for elevated UV absorbance rates in the one blank sample collected October 11, 2005 is not known, but may be a result of a sample being filled as a duplicate instead of a blank. The cause for slightly elevated total aluminum in one blank sample collected November 9, 2004 is not known but was nearly two orders of magnitude lower that the elevated aluminum observed in the regular samples and thus likely did not significantly affect the sample results. Based on these samples, the data can be considered to be within acceptable limits for data quality.

6.1 pH

pH measures the concentration of hydrogen ions (H^+) in water. The concentration of hydrogen ions in water can range over 14 orders of magnitude, so pH is defined on a logarithmic scale between 0 and 14. A pH between 0 and 7 is acidic (the lower the number, the more acidic the water) and a pH between 7 and 14 is alkaline (the higher the number, the more basic the water). The aesthetic objective for drinking water is a pH between 6.5 and 8.5 (McKean and Nagpal, 1991). Corrosion of metal plumbing may occur at both low and high pH outside of this range, while scaling or encrustation of metal pipes may occur at high pH. The effectiveness of chlorine as a disinfectant is also reduced outside of this range. pH in the Englishman River watershed was generally near-neutral, with average values ranging from 7.3 at Highway 19A to 7.5 pH units in Morison Creek (Table 4). All pH values were well within the drinking water guideline, suggesting that pH is not presently a concern within the Englishman River watershed. Therefore, no water quality objective is proposed for pH in the Englishman River.

Table 4. Summary of pH data (reported in pH units) collected at the five Englishman River water quality monitoring sites.

Site Number	Site Name	Minimum	Maximum	Average	Number of samples
E248835	Morison Ck U/S Englishman R.	6.9	8.0	7.5	34
E248834	Englishman R U/S Morison Ck	6.8	7.7	7.4	34
E248836	South Englishman R.	6.7	8.0	7.4	34
E252010	Englishman R. U/S Allsbrook Canyon	6.8	7.8	7.4	25
0121580	Englishman R. at Highway 19A	6.6	7.8	7.3	75

6.2 TEMPERATURE

Temperature is considered in drinking water for aesthetic reasons. The aesthetic guideline is 15°C and temperatures above this level are considered to be too warm to be aesthetically pleasing (Oliver and Fidler, 2001). For the protection of aquatic life, the allowable change in temperature is +/-1°C from naturally occurring levels. The optimum temperature ranges for steelhead and salmonids are based on specific life history stages such as incubation, rearing, migration and spawning. For steelhead, which are present in the Englishman River, the optimum temperature ranges are: 10 – 12°C for incubation; 16 – 18°C for rearing; and 10 – 15.5°C for spawning (Oliver and Fidler, 2001). Each salmon species also has its own optimum temperature range. Chum salmon, which are present in the Englishman River, are the most sensitive salmonid to warmer temperatures (12-14°C for rearing); however, the juveniles are not present in the river during the summer months. Steelhead and coho, which have similar temperature thresholds, are the species in the watershed for the longest periods of time, including the summer.

Water temperature was measured at the automated station located at Highway 19A near the City of Parksville water intake. Water temperatures varied seasonally, with maximum temperatures occurring in late July through the end of August. Water temperatures measured by the automated station ranged from near 0°C in the winter months to a maximum of 21.5°C in July 2004 (Figure 5).

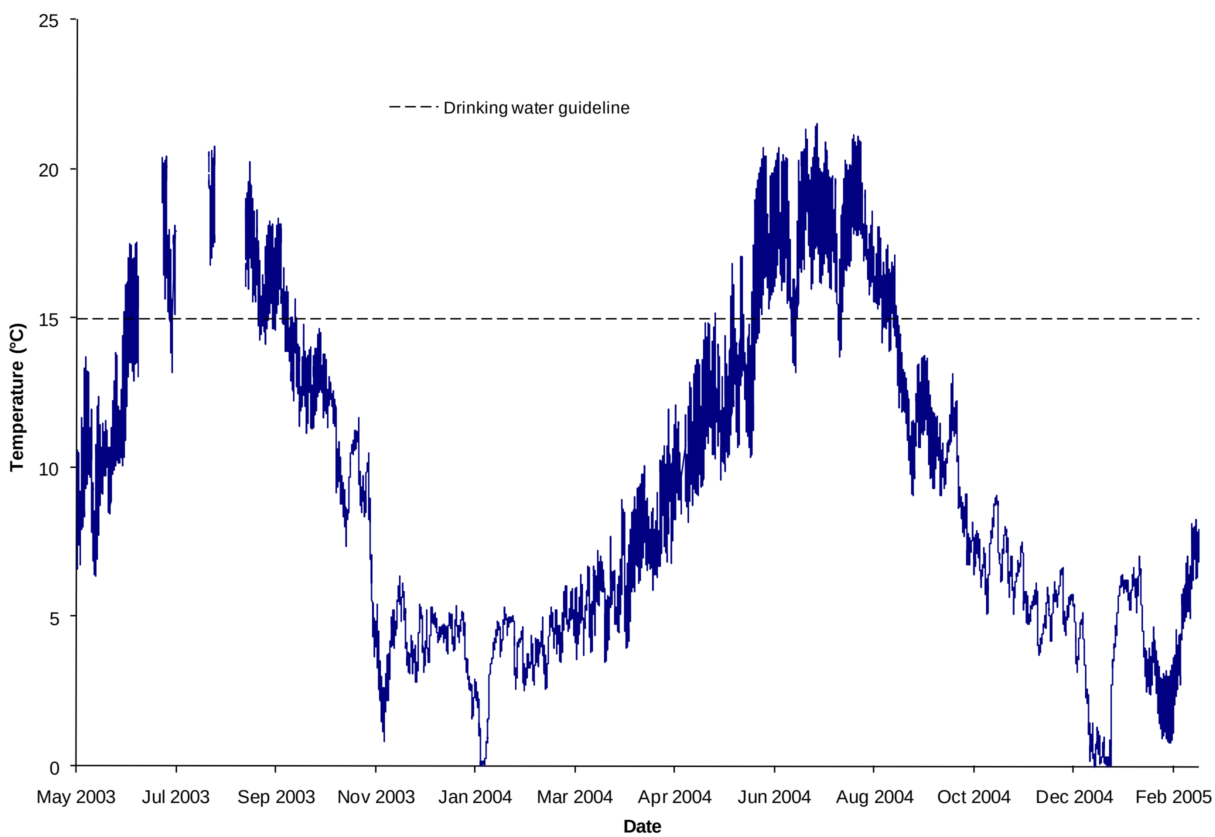

Figure 5. Automated water temperature data collected from the Englishman River at Highway 19A between May 2003 and March 2005. Due to equipment malfunction, data gaps exist for the summer of 2003.

Water temperatures remained consistently below the aquatic life guidelines for the incubation and spawning period for salmonids. However, maximum summer water temperatures exceed the guideline (optimum maximum temperature plus a change of 1 degree Celsius) for both coho (17°C) and steelhead (19°C) rearing. While adult steelhead typically return to the ocean after spawning, most juveniles spend one to two years in freshwater maturing into smolts before entering the ocean. Some salmon species, including coho, also utilize freshwater for up to three years before entering the ocean. Water temperatures were only collected at one location (at Highway 19A), and values measured here are likely considerably higher than those occurring upstream. This is due to the fact that the lower portion of the Englishman River is generally wide and shallow, with little riparian cover, allowing considerable solar infiltration. We recommend monitoring water temperatures upstream with temperature loggers at high-value rearing locations. ***Due to the high summer temperatures and the high values of the Englishman River as fisheries habitat, a short-term (within five years) water quality objective is proposed to protect juvenile salmonids, in particular coho (the most sensitive species at this time). The average weekly temperature at any location in the river should not exceed 17°C at any time during the year.*** While maximum temperatures in the lower portion of the river may exceed the guideline, as long as refuges remain with average temperatures below the guideline, juveniles should be able to retreat to these areas during periods of elevated temperatures.

The aesthetic drinking water guideline (a maximum of 15°C) was exceeded by a considerable margin each year in the lower watershed. Many watersheds on the east coast of Vancouver Island, as well as throughout the Southern Interior, typically have elevated summer water temperatures. It is therefore likely that higher summer temperatures are, for the most part, a natural occurrence. However, it is possible that activities such as forest harvesting, agriculture or urban development, activities that have the potential to decrease stream shading if removal of vegetation occurs in riparian areas, and climate change, could exacerbate peak summer water temperature to the point where this guideline is occasionally exceeded.

In the Englishman River system, releases of water from the Arrowsmith dam could augment low summer flows and decrease maximum temperatures, which would be beneficial both for aquatic life and for drinking water aesthetics. ***Therefore, a long-term (within five to ten years) objective is also proposed for drinking water purposes whereby by the average weekly temperature should not exceed 15°C at the intake (Highway 19A site) at any time during the year.*** Another possible management strategy to meet this long term objective might involve moving the water intake higher upstream in the Englishman River, where maximum temperatures would likely be lower. This option is currently under consideration.

6.3 CONDUCTIVITY

Conductivity refers to the ability of a substance to conduct an electric current. The conductivity of a water sample gives an indication of the amount of dissolved ions in the water. The more ions dissolved in a solution, the greater the electrical conductivity. As temperature affects the conductivity of water (a 1ºC increase in temperature results in approximately a 2% increase in conductivity), specific conductivity is used (rather than simply conductivity) to compensate for temperature. Coastal systems, with high annual rainfall values and typically short water retention times, generally have low specific conductivity (<80 µS/cm), while interior watersheds generally have higher values. Increased flows resulting from precipitation events or snowmelt tend to dilute the ions, resulting in decreased specific conductivity levels with increased flow levels. Therefore, water level and specific conductivity tend to be inversely related. However, in situations such as landslides, where high levels of dissolved and suspended solids are introduced to the stream, specific conductivity levels tend to increase. As such, significant changes in specific conductivity can be used as an indicator of potential impacts.

Specific conductivity values measured in the Englishman River are summarized in Table 5. At the automated station, values ranged from 21 microsiemans/centimeter (µS/cm) to 139 µS/cm, with an average of 66 µS/cm. Values were correlated with flows, with the highest conductivity occurring during low summer flows (when dilution was lowest) and conductivity values dropping during the winter (when dilution from rainfall was highest) (Figure 6). Specific conductivity was highest in the South Englishman River, suggesting

Table 5. Summary of specific conductivity (µS/cm) data collected at the five Englishman River water quality monitoring sites.

Site Number	Site Name	Minimum	Maximum	Average	Number of samples
E248835	Morison Ck U/S Englishman R.	32	108	68.6	34
E248834	Englishman R U/S Morison Ck	31	124	68.8	34
E248836	South Englishman R.	23	304	112	34
E252010	Englishman R. U/S Allsbrook Canyon	30	109	66.5	25
0121580	Englishman R. at Highway 19A	31	131	69.3	71

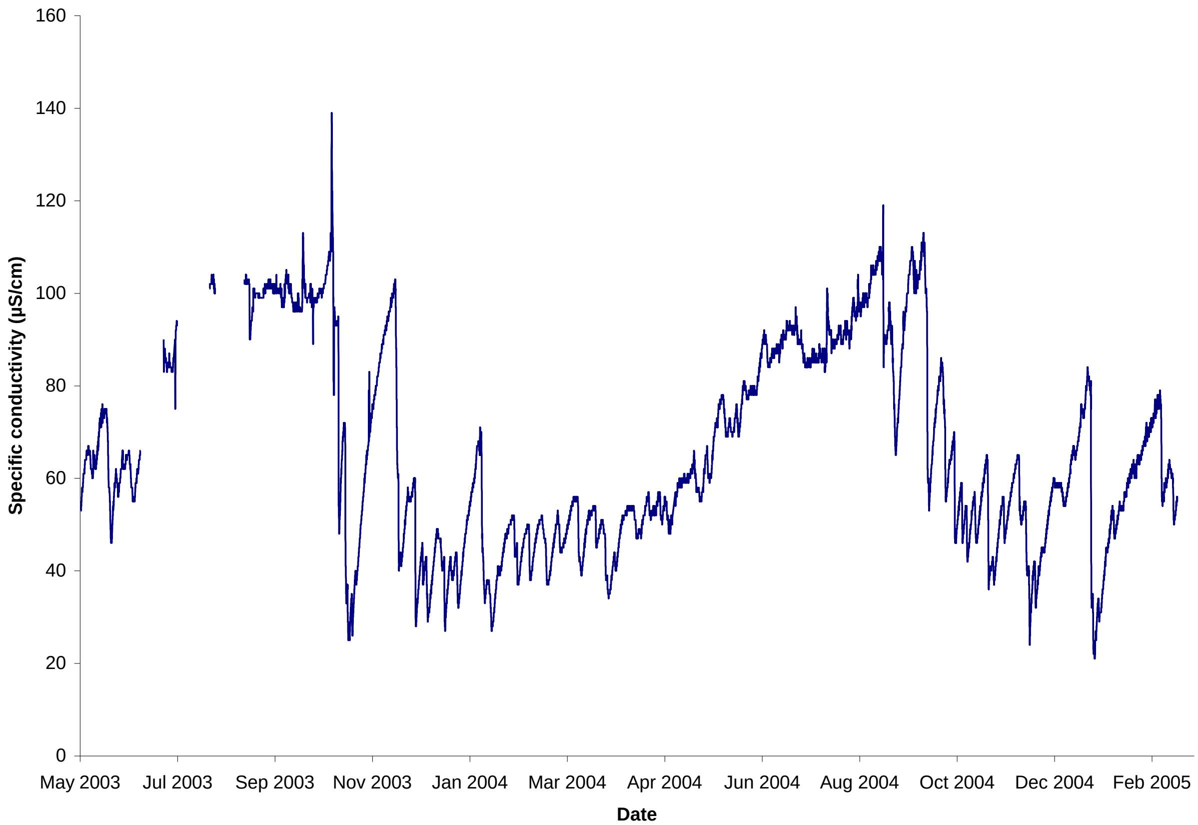

Figure 6. Specific conductivity measured in Englishman River at Highway 19A between May 2003 and March 2005. Due to equipment malfunction, data gaps exist for the summer of 2003.

that this portion of the watershed has higher concentrations of dissolved solids than either the mainstem of the Englishman River or Morison Creek. As there is no BC Water Quality Guideline for specific conductivity and the average specific conductivity observed was typical of coastal systems, no objective is proposed for specific conductivity in the Englishman River watershed.

6.4 TURBIDITY

Turbidity is a measure of the clarity or cloudiness of water, and is measured by the amount of light scattered by the particles in the water as nephelometric turbidity units (NTU). Elevated turbidity levels can decrease the efficiency of disinfection, allowing coliforms to enter the water system. As well, there are aesthetic concerns with cloudy water, and particulate matter can clog water filters and leave a film on plumbing fixtures. The guideline for drinking water that does not receive treatment to remove turbidity is an induced turbidity over background of 1 NTU when background is not more than 5 NTU and a maximum change from background of 5 NTU (during turbid flow periods) (Caux *et al*., 1997). In general, it is considered that turbidity values greater than 2 NTU will compromise disinfection efficiency (VIHA pers. comm., 2006).

Turbidity values measured at the five monitoring locations are summarized in Table 6. In general, turbidity levels were low at all sites, with average values typically at or below 1.0 NTU. While the range of turbidity values measured at most of the sites was similar, mean turbidity values at the site in the Englishman River upstream from Morison Creek and in the South Englishman River were considerably lower than at the other sites. As the Englishman River upstream from Morison Creek represents the relatively unimpacted (ambient) condition of the river, we would expect that turbidity values seen here would be representative of the natural conditions. As average turbidity at this site was < 1 NTU and the maximum value was < 5 NTU, BC Water Quality Guidelines for drinking water in the watershed specify a maximum of 5 NTU and an induced (caused by athropogenic activities) maximum turbidity of 2 NTU. It appears that a significant portion of the turbidity in the watershed originates in Morison Creek and turbidity values increase in a downstream direction, with the highest individual values measured at the Highway 19A site and the highest average value in Morison Creek. Contributions to increases in turbidity in the lower watershed likely include natural concerns (the clay bank discussed in Section 4.0) and those triggered by human activities (agriculture, timber harvesting and urban run-off). Turbidity values were highest during the winter (between January and March), coinciding with increased rainfall events.

Table 6. Summary of turbidity (NTU) data for discrete water samples collected at the five Englishman River water quality monitoring sites.

Site Number	Site Name	Minimum	Maximum	Average	Number of samples
E248835	Morison Ck U/S Englishman R.	0.13	4.61	1.84	34
E248834	Englishman R U/S Morison Ck	0.13	4.27	0.50	34
E248836	South Englishman R.	0.13	1.57	0.45	34
E252010	Englishman R. U/S Allsbrook Canyon	0.24	5.37	1.0	25
0121580	Englishman R. at Highway 19A	0.25	10.5	1.0	70

Turbidity values measured at the Englishman River upstream from the Morison Creek site were compared with values measured on the same day at the Allsbrook Canyon site and the Highway 19A site to determine the degree to which turbidity changed in a downstream direction. Between the Englishman River upstream of Morison Creek and the Allsbrook Canyon sites there was an average increase of 0.5 NTU (n=25), possibly influenced by inputs from Morison Creek that get diluted at the confluence of the creek with the Englishman River. This is supported by the observed average change of -0.9 NTU (n=25) between Morison Creek upstream of Englishman River and the Allsbrook Canyon site. Between the Englishman River upstream from Morison Creek and Highway 19A sites changes ranged from a decrease of 2 NTU to an increase of 2.9 NTU, with an overall average increase of 0.2 NTU (n=34). The average change between the Allsbrook Canyon site and the Highway 19A site was -0.2 NTU (n=25). Therefore, it appears that in general, on a given day, turbidity values increase moderately between the Englishman River upstream from Morison Creek site to the Allsbrook Canyon site, and then decrease slightly to the Highway 19A site, resulting in Highway 19A values on a given day being higher than values at the site upstream of Morrison Creek.

A summary of continuous turbidity data collected at the automated water quality monitoring station at the Highway 19A site between May 2003 and March 2005 is given in Table 7. The distribution of data shows that about 73% of values were below 1 NTU, over 89% of values were below 5 NTU, and that about 10.9% of the time, or about 1,600 of the 14,860 hours when turbidity was measured over the course of the study, turbidity values exceeded the drinking water guideline of 5 NTU. Turbidity is notoriously difficult to measure accurately with automated equipment due to the wide variety of factors that can affect measurements, including fish and other aquatic organisms, algae and air bubbles. In this study, values greater than 500 NTU (1.5% of values, or 833 samples) were likely affected by such factors, which were exacerbated by the location of the deployment tube.

Table 7. Summary of automated turbidity data measured at Englishman River at Highway 19A station between May 2003 and March 2005.

	Number	Percentage	Cumulative %
Number Turbidity <=1 NTU	43443	73.1%	73.1%
Number Turbidity >1, <=5 NTU	9558	16.1%	89.1%
Number Turbidity >5, <=10	2068	3.5%	92.6%
Number Turbidity >10, <=50	2625	4.4%	97.0%
Number Turbidity >50	1761	3.0%	100.0%
Totals:	**59455**	**100**	

It is important to consider not only the total amount of time the criterion was exceeded, but also how long each exceedance lasted. For example, high turbidity levels for five consecutive hours are more likely to impact drinking water quality than five one-hour events separated by a few hours of low-turbidity water. The Englishman River has relatively frequent turbidity events between the months of April and June characterized by sudden, rapid increases in turbidity that tend to be of short duration (Figure 7).

Table 8 shows a summary of the intensity and duration of turbidity events occurring at the automated station between 2003 and 2005. A turbidity event, for the sake of this summary, is defined as a number of consecutive turbidity values measured at 15-minute intervals exceeding the 5 NTU threshold. The recovery time is the length of time that has passed since the previous turbidity event (i.e., since the turbidity last exceeded 5 NTU). For the sake of brevity and ease of reading, Table 8 includes only the longest-duration events (i.e., events over 10 hours in length). The remainder of the summary is included as

Appendix III, arranged in chronological order. The longest turbidity event was 157 hours in length, with a maximum value of 346 NTU. While most turbidity events (over 70% of all events) occurred between April and June, most of the events with the longest duration 57% of events over 10 hours in duration) occurred between October and December.

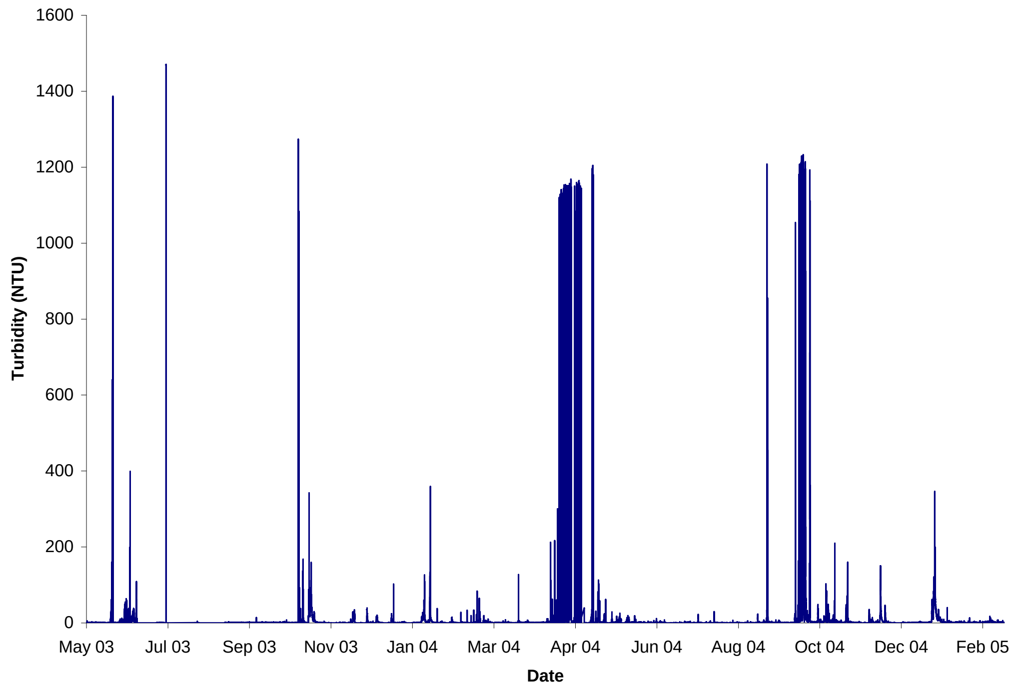

Figure 7. Turbidity levels in the Englishman River between May 2003 and March 2005 as measured on 15-minute intervals by the automated water quality monitoring station near the Highway 19A. Due to equipment malfunction, data gaps exist for the summer of 2003.

Appendix IV shows a comparison of laboratory results compared with the automated data collected at the same time. In those instances where laboratory samples were not collected on the 15-minute interval, automated data from immediately before and immediately after the lab sample was collected is shown. This table shows that in 27 of 29 instances, turbidity values reported by the laboratory and by the automated equipment were within 2 NTU, which is an acceptable level, while the remaining values differed by between 2. 7 NTU and 7.6 NTU. However, most of the samples were collected when turbidity was very low (< 1 NTU), and are therefore not indicative of the occasional turbidity events that occur in this watershed. Future monitoring should focus on collecting water samples following significant rain events, in order to try and capture these occasional elevated turbidity levels. In the event of a significant turbidity event (i.e., turbidity values exceeding 5 NTU for a period of at least 24 hours), grab-samples should be collected at other monitoring sites within the system to determine the origin of the problem.

Turbidity at the Englishman River site upstream of Morison Creek (representative of natural conditions) was maintained at a constant level (< 1 NTU for 90% of the grab sample data) with only minor fluctuations during rain storm events (to a maximum value of < 5 NTU). ***Therefore, to protect drinking water quality in the Englishman River, it is recommended that from October to December (when turbid flows can occur), turbidity measured at the City of Parksville water intake (Highway 19A site) should not exceed 5 NTU; during the remainder of the year (clear flow periods), turbidity measured at the City of Parksville water intake (Highway 19A site) should not exceed 2 NTU (1 NTU above ambient levels, as measured upstream from Morison Creek).*** It should be noted that turbidity values above 2 NTU are considered likely to affect disinfection in a chlorine-only system. An alternative to the average objective of 2 NTU would be to treat the raw water prior to chlorination to remove some of the turbidity and increase chlorine efficiency.

Table 8. Summary of turbidity events exceeding 10 hours in duration reported by automated turbidity meter at MOE station between 2003 and 2005.

Start Date	Start Time	Recovery Time (hrs)	Duration of event (h)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
08/06/2003	5:45	1	10.25	18.6	4.6	10.6	3.0
24/04/2004	16:45	0.25	11.25	1151	0	864.5	404.3
01/03/2005	13:30	2	11.75	11.9	4.8	8.6	2.1
08/06/2003	20:15	0.25	13	30.5	4.4	17.2	6.0
18/11/2003	1:00	30	13.25	28.8	4	16.0	7.5
05/12/2003	19:15	0.25	13.25	20.2	5	11.5	4.8
17/10/2004	11:30	0.25	13.25	32.1	3.8	13.4	6.3
29/01/2004	21:15	255	13.5	14.8	4.5	9.9	2.8
04/12/2004	10:15	17.5	13.5	13.9	5	7.0	1.7
12/10/2004	0:00	0.25	13.75	1207.3	4.8	252.4	232.9
03/05/2004	11:00	0.25	14.25	1150.2	4.2	696.1	429.0
02/05/2004	19:15	0.25	14.5	1158.8	0.6	851.7	331.9
02/11/2004	0:15	0.25	14.5	48.5	5	16.0	8.9
08/10/2004	12:45	276.25	16	1054.4	3.7	28.9	130.3
14/12/2004	2:30	45.25	16.75	46.2	5	10.2	5.9
12/10/2003	2:30	0.25	17.25	167.4	4.5	30.7	30.3
02/06/2003	14:45	0.25	17.5	48.8	0.5	15.7	10.0
09/06/2003	9:15	0.25	18.5	37.8	4.5	24.3	7.3
25/10/2004	10:45	0.25	19	48.5	4	14.2	10.1
15/11/2004	3:45	1.75	19	48.1	3.9	17.3	9.4
16/12/2003	7:45	239.5	19.5	24.1	4.5	12.0	5.5
28/11/2003	8:30	208.25	19.75	38.8	4.9	18.1	10.6
18/10/2004	14:15	0.25	20.75	17.4	2.9	9.0	2.0
18/11/2003	17:30	0.25	21.75	34.2	4.7	14.6	5.6
16/05/2004	20:45	0.25	21.75	112.7	4.8	27.6	19.9
20/10/2003	7:45	2.75	22.5	29.6	5	14.5	7.2
22/04/2004	15:30	0.25	34.75	1153.8	1.8	787.9	354.4
13/01/2004	15:45	0.5	35	359.2	4.8	18.7	33.5
10/12/2004	6:30	0.25	45	150.2	4.8	34.1	38.3
25/04/2004	4:00	0.25	45.75	1168.5	0.9	822.2	397.5
15/10/2004	13:45	0.25	45.75	1214.4	3.1	249.2	362.9
08/01/2004	1:00	1	59.5	126	4.7	14.9	11.6
12/10/2004	13:45	0.25	72	1232.3	3.1	293.8	359.9
16/10/2003	12:45	0.25	84.5	342.1	0	36.2	28.6
17/01/2005	7:30	801	157	346.1	4.3	31.3	30.1

6.5 TOTAL SUSPENDED SOLIDS

Total suspended solids (TSS), or non-filterable residue (NFR) include all of the undissolved particulate matter in a sample. This value should be closely correlated with the turbidity value, however, unlike turbidity it is not measured by optics. Instead, a quantity of the sample is filtered, and the residue is dried and weighed so that a weight of residue per volume is determined. No guideline has been established for drinking water sources at this time. For the protection of aquatic life, the maximum concentration allowed is an induced TSS concentration over background of 25 mg/L at any one time in 24 hours when background is less than or equal to 25 mg/L (clear flows) and an induced TSS concentration of 5 mg/L over background concentrations at any one time for a duration of 30 days (clear flows). Initially, less frequent monitoring may be appropriate to determine the need for more extensive monitoring (Caux *et al.* 1997).

Concentrations of TSS at all sites ranged from below detectable limits (<1 mg/L) to 51 mg/L (at Englishman River upstream of Morison Creek) (Appendix 1). To determine average background values relative to impacted sites, a minimum of five weekly samples within 30 days were collected on five occasions (three for summer and two for fall) for all sites, with the exception of the Allsbrook Canyon site (added in 2003) which only had three (two summer and one fall) (Table 9). The fall period, from October to December, tends to have elevated TSS values largely driven by rainstorm events. As the fall 2003 samples captured the first fall flush period and provided useful information for determination of a TSS objective, these data were also included but are based on 4 instead of 5 weekly samples in 30 days. Summer average 5 in 30 day values for all sites were considerably lower than the corresponding fall averages, ranging from 1.1 mg/L in the South Englishman River to 1. 7 mg/L in Morison Creek. Throughout most of the year monthly TSS values at all sites are either below detection limits (1 mg/L) or just slightly higher. The fall sampling period tends to see an increase in TSS with average values ranging from 7.0 mg/L in the South Fork Englishman to 14.0 mg/L at the Allsbrook Canyon site. Comparing TSS concentrations in a downstream direction from the Englishman River upstream from Morison Creek to the Allsbrook Canyon site showed changes ranging from a decrease of 2 mg/L to an increase of 32 mg/L, while changes from the Allsbrook Canyon site to the Highway 19A site ranged from a decrease of 20 mg/L TSS to an increase of 16 mg/L.

Table 9. Summary of summer and fall mean TSS values (based on five weekly samples collected within 30 days (mg/L)) for all sampling sites on Englishman River

Site Number	Site name	Number of samples	Min	Max	Summer Mean 2002	Fall Mean 2002	Summer Mean 2003	Fall Mean 2003*	Summer Mean 2004	Fall Mean 2004	Summer Mean	Fall Mean
E248835	Morison Ck U/S Englishman R.	57	< 1	32	1.4	3.0	1.0	9.0	2.6	12.0	1.7	8.0
E248834	Englishman R U/S Morison Ck	58	< 1	51	1.0	12.6	1.8	6.5	1.0	6.2	1.3	8.4
E248836	South Englishman R.	59	< 1	40	1.0	4.8	1.2	6.5	1.0	9.8	1.1	7.0
E252010	Englishman R. U/S Allsbrook Canyon	40	< 1	54			1.0	8.3	1.6	19.8	1.3	14.0
121580	Englishman R. at Highway 19A	92	< 1	57	1.0	16.4	1.8	12.3	1.0	12.6	1.3	13.8

*based on 4 weekly samples in 30 days

In general, TSS concentrations showed trends similar to those shown by turbidity, with increases between the Englishman River site upstream from Morison Creek to the Allsbrook Canyon site, and then slight decreases to the Highway 19A site. These increases were occasionally greater than 25 mg/L above upstream levels, and for this reason a water quality objective for TSS is proposed. The objective is meant to apply to situations which both identify natural concerns (the clay bank) and those that are not natural but may have been triggered by human activities (agriculture, timber harvesting and urban run-off). During the monitoring period there has been little or no activity in the upper watershed, and as such the total suspended solids have been maintained at a constant low level with elevated fluctuations only occurring during rain storm events during the months October to December. This suggests that the data collected from the Englishman River upstream of Morison Creek actually reflects background levels. ***Therefore it is recommended that TSS measured the Highway 19A site during the months October to December (when turbid flows can occur) should not exceed 33mg/L at any time and the mean of five weekly samples in 30-days during this period should not exceed 13 mg/L. It is also recommended that during the remainder of the year (clear flow period) TSS measured at the Highway 19A site should not exceed 26 mg/L***

at any time and the mean of five weekly samples in 30 days (primarily during August to September) should not exceed 6 mg/L. Means of five weekly samples in 30 days were chosen (rather than maximum values of 30 samples in a 30 day period, as recommended in the guideline) considering the practicality of and resources available for monitoring, as well as local hydrology and the fact that Vancouver Island streams have clear flows for most of the year.

6.6 COLOUR AND TOTAL ORGANIC CARBON

Colour in water is caused by dissolved and particulate organic and inorganic matter. True colour is a measure of the dissolved colour in water after the particulate matter has been removed, while apparent colour is a measure of the dissolved and particulate matter in water. Colour can affect the aesthetic acceptability of drinking water, and the aesthetic water quality guideline is a maximum of 15 true colour units (TCU) (Moore and Caux, 1997). Colour is also an indicator of the amount of organic matter in water. When organic matter is chlorinated it can produce disinfection by-products (DBPs) such as trihalomethanes, which may pose a risk to human health.

Colour was only measured at the Highway 19A site, and on only six occasions. Colour ranged from below detection limits (< 5 TCU) to 20 TCU, with an average of 13 TCU for 6 samples collected (Appendix I). As colour has not been measured elsewhere in the watershed, the origin of the occasional elevated colour values is not known. However, it appears that colour may be an occasional aesthetic concern. ***Thus, the following objective is proposed: true colour should not exceed 15 TCU at the Highway 19A site.*** Colour should be monitored elsewhere in the watershed to determine the source of the occasional higher levels and to establish colour levels relative to upstream sites; the recommended objective should be re-evaluated when additional data are available.

Elevated total organic carbon (TOC) levels (above 4.0 mg/L) can result in higher levels of DBPs in finished drinking water if chlorination is used to disinfect the water (Moore, 1998). As the City of Parksville uses chlorine to disinfect their drinking water, TOC concentrations should be monitored. However, during the study period TOC was only measured four times (ranged from 2.1 to 3.7 mg/L) and only at the Highway 19A site.

Instead, dissolved organic carbon (DOC) values were measured. TOC consists of two fractions: DOC and particulate organic carbon, with the majority generally as DOC. DOC values for the Englishman River ranged from 1.0 to 2.8 at Englishman River upstream of Morison Creek, from 2.0 to 7.7 mg/L at Morison Creek upstream Englishman River, and from 0.6 to 6.8 mg/L at the Englishman River at Highway 19A (Appendix 1). It appears as though the elevated DOC in Morison Creek is being diluted while it converges with the Englishman, similar to the trend observed with turbidity. Given the fact that turbidity, NFR and color are all elevated during rainstorm events, ***a water quality objective for total organic carbon is proposed. It is recommended that maximum TOC values should not exceed 4.0 mg/L at the City of Parksville intake (Highway 19A site).***

6.7 NUTRIENTS (NITRATE, NITRITE AND PHOSPHORUS)

The concentrations of nitrogen (including nitrate and nitrite) and phosphorus are important parameters, since they tend to be the limiting nutrients in biological systems. Productivity is therefore directly proportional to the availability of these parameters. Nitrogen is usually the limiting nutrient in terrestrial systems, while phosphorus tends to be the limiting factor in freshwater aquatic systems. In watersheds where drinking water is a priority, it is desirable that nutrient levels in surface water remain low to avoid algal blooms and foul tasting water. Similarly, to protect aquatic life, nutrient levels should not be too high or the resulting plant and algal growth can deplete oxygen levels when it dies and begins to decompose, as well as during periods of low productivity when plants consume oxygen (i.e., at night and during the winter under ice cover).

The guideline for the maximum concentration for nitrate in drinking water is 10 mg/L as nitrogen and the guideline for nitrite is a maximum of 1 mg/L as nitrogen. When both nitrate and nitrite are present, their combined concentration must not exceed 10 mg /L as N. For the protection of freshwater aquatic life, the nitrate guidelines are a maximum concentration of 31.3 mg/L and an average concentration of 3 mg/L. Nitrite concentrations are dependent on chloride; in low chloride waters (i.e., less than 2 mg/L) the maximum concentration of nitrite is 0.06 mg/L and the average concentration is 0.02 mg/L. Allowable concentrations of nitrite increase with ambient concentrations of chloride (Meays, 2009). There are no BC guidelines for phosphorus in streams.

Nitrogen concentrations were measured in terms of dissolved nitrite (NO_2) and dissolved nitrate (NO_3). Dissolved nitrate concentrations (Table 10) were highest in Morison Creek upstream from the Englishman River, with a maximum concentration of 0.54 mg/L and an average concentration of 0.13 mg/L, and lowest at the Allsbrook Canyon site, with a maximum concentration of 0.08 mg/L and an average concentration of 0.02 mg/L. Concentrations of total nitrite (Table 11) were consistently low at all of the five monitoring locations, with maximum concentrations less than 0.01 mg/L and average concentrations near the detection limit of 0.002 mg/L. All values of both nitrate and nitrite species were well below the existing aquatic life guidelines (Appendix I). As concentrations of nitrogen are generally low in the Englishman River, no objective is proposed for this parameter.

Table 10. Summary of total nitrate (mg/L) data collected at the five Englishman River water quality monitoring sites.

Site Number	Site Name	Minimum	Maximum	Average	Number of samples
E248835	Morison Ck U/S Englishman R.	0.001	0.541	0.131	31
E248834	Englishman R U/S Morison Ck	0.001	0.194	0.031	31
E248836	South Englishman R.	0.001	0.288	0.051	30
E252010	Englishman R. U/S Allsbrook Canyon	0.001	0.076	0.023	23
0121580	Englishman R. at Highway 19A	0.001	0.151	0.034	65

Table 11. Summary of total nitrite (mg/L) data collected at the five Englishman River water quality monitoring sites.

Site Number	Site Name	Minimum	Maximum	Average	Number of samples
E248835	Morison Ck U/S Englishman R.	< 0.002	0.007	0.003	33
E248834	Englishman R U/S Morison Ck	0.001	0.006	0.002	33
E248836	South Englishman R.	0.001	0.007	0.002	32
E252010	Englishman R. U/S Allsbrook Canyon	0.001	0.006	0.002	25
0121580	Englishman R. at Highway 19A	0.001	0.009	0.003	71

Total phosphorus concentrations ranged from below detectable limits (< 0.002 mg/L) at all sites to a maximum of 0.126 mg/L at the Morison Creek site (Table 12). As with nitrogen, phosphorus concentrations were considerably higher in Morison Creek than at the other locations, and showed peaks during the spring and fall. Limited phosphorous data suggest that higher spring values may coincide with tilling of soil and fertilizer applications at that time, while fall values coincide with fall flush rainfall events. It is recommended that 5 weekly samples in 30 days total phosphorous data be collected in April (spring planting), August-September (summer low flow) and October-November (fall flush) to confirm these trends. While no objective for phosphorous is proposed at this time, the need for an objective should be re-evaluated after the next attainment monitoring period. MOE is working towards developing an interim phosphorous objective for Vancouver Island streams that will be available for use during future attainment periods.

Table 12. Summary of total phosphorus data collected at the five Englishman River water quality monitoring sites.

Site Number	Site Name	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	Number of samples
E248835	Morison Ck U/S Englishman R.	< 0.002	0.126	0.023	34
E248834	Englishman R U/S Morison Ck	< 0.002	0.024	0.004	34
E248836	South Englishman R.	< 0.002	0.010	0.003	34
E252010	Englishman R. U/S Allsbrook Canyon	< 0.002	0.027	0.004	25
0121580	Englishman R. at Highway 19A	< 0.002	0.016	0.005	48

6.1 METALS

Total metals concentrations were measured on 35 occasions in the Englishman River (Appendix I). The concentrations of most metals were below detection limits, and well below guidelines for drinking water and aquatic life. One exception to this was for aluminum; while aluminum met the drinking water guideline at the intake (at Highway 19A) on all sample dates, the maximum concentration of dissolved aluminum measured at each of the sites exceeded the aquatic life guideline of 0.1 mg/L on at least one occasion, with a maximum value of 0.347 mg/L measured in Morison Creek upstream from the Englishman River. In addition, the mean of five weekly samples collected in a 30 day period for dissolved aluminum also exceeded the aquatic life guideline of 0.05 mg/L on numerous occasions during the fall (Table 13). While the 2003 fall sample period only had 4 samples collected within a 30 day period, this data set captured the first fall flush period and as such were included for the determination of an aluminum objective.

Table 13. Summary of dissolved aluminum data collected at the five Englishman River water quality monitoring sites, showing means calculated when a minimum of five weekly samples were collected within a 30-day period (mg/L). Boldfaced values exceed the BC Water Quality Guidelines for dissolved aluminum of 0.05 mg/L.

Site Number	Site name	Summer 2002	Fall 2002	Summer 2003	Fall 2003*	Summer 2004	Fall 2004	Summer Mean	Fall Mean
E248835	Morison Ck U/S Englishman R.	0.005	0.041	0.003	**0.053**	0.004	**0.052**	0.004	0.049
E248834	Englishman R U/S Morison Ck	0.008	0.032	0.004	0.030	0.005	**0.056**	0.006	0.039
E248836	South Englishman R.	0.006	**0.053**	0.004	**0.059**	0.005	**0.062**	0.005	**0.058**
E252010	Englishman R. U/S Allsbrook Canyon	no data	no data	0.004	0.048	0.006	**0.054**	0.005	**0.051**
121580	Englishman R. at Highway 19A	0.005	0.041	0.003	**0.053**	0.004	**0.052**	0.004	0.049

*based on 4 weekly samples in 30 days

Dissolved aluminum in the Englishman River upstream of Morison Creek, where little or no activity occurred during the monitoring period, exceeded the maximum aquatic life guideline once (0.11 mg/L in October 2004), but approached it (0.078-0.091 mg/L) at least once during each fall sample period. These elevated values are almost certainly a result of the natural geology of the area. The dissolved aluminum values there have been maintained at a constant level with elevated fluctuations only occurring during rain storm events during the months October to December. This suggests that the data collected from the Englishman River upstream of Morison Creek actually reflect background levels. When combined with soil disturbances from forestry and agriculture, these naturally high values may lead to values elevated above acceptable levels and thus be a cause for concern. At Englishman River upstream of Morrison Creek, 95% of all observed values were below the maximum guideline of 0.1 mg/L, and 95% of the 5 sample in 30 day means were at or below 0.05 mg/L. The latter data indicates that the 5 sample in 30 day mean naturally tends to be slightly higher than the recommended guideline at times. For these reasons, ***it is recommended that, at any location in the river, dissolved aluminum should not exceed a maximum of 0.1 mg/L at any one time and the mean of 5 weekly samples in 30 days should not exceed 0.06 mg/L.***

Metal speciation determines the biologically available portion of the total metal concentration. Only a portion of the total metals level is in a form which can be toxic to aquatic life. Naturally occurring organics in the watershed can bind substantial proportions of the metals which are present, forming metal complexes which are not biologically available. The relationship will vary both seasonally and depending upon the metal (e.g.,copper has the highest affinity for binding sites in humic materials). Levels of organics as measured by DOC vary from ecoregion to ecoregion. To aid in future development of metals objectives, DOC has been included in the Englishman River monitoring program. As increasing water hardness can decrease the toxicity of copper and some other metals to some organisms, hardness has also been included in the Englishman River monitoring program.

6.2 COLIFORM BACTERIA

Coliform bacteria are present in large numbers in the feces of warm-blooded animals, and although rarely pathogenic themselves, they are used as indicators of fecal contamination in water. Fecal coliforms and *E. coli* are quite specific to the feces of warm-blooded animals, whereas total coliforms have many non-fecal sources (e.g.,soils, plants), and thus are less indicative of fecal contamination. Coliforms generally do not survive long in cold, fresh water (Brettar and Höfle, 1992), but can survive for prolonged periods in stream sediment, soils or fecal material, when associated with particulate matter, or in warmer water (Howell *et al.*, 1996; Tiedemann *et al.*, 1987). Disturbance of these sediments can therefore result in coliforms appearing in overlying water for extended periods (Jawson *et al.*, 1982; Stephenson and Rychert, 1982). The inclusion of a small piece of fecal matter in a sample can result in extremely high concentrations (>1,000 CFU/100 mL), which can skew the overall results for a particular site. It is therefore important to consider the range of values, as well as the standard deviation, to determine if numbers are consistently high or if one value artificially inflated the mean. For this reason, the 90th percentile is generally used to determine if the water quality guideline is exceeded, as extreme values would have less effect on the data. The drinking water guideline for raw waters receiving disinfection as the only form of treatment is that the 90th percentile of at least five weekly samples collected in a 30-day period should not exceed 10 CFU/100 mL for both fecal coliforms and *E. coli* (Warrington, 1988).

In general, fecal coliform concentrations were lowest in the Englishman River upstream from Morison Creek and in the South Englishman River, and highest in Morison Creek and at Highway 19A. In those instances when at least five samples were collected within a 30-day period, a 90th percentile value was calculated, and these are summarized in For the South Englishman River, summer values were elevated (mean 90th percentile summer concentration of 33 CFU /100 mL) compared to the Englishman River upstream from Morison Creek (background), likely due to an active fish ladder that may attract wildlife at that time of year. Fall values were lower (fall mean 90th percentile was 40 CFU/100mL) than background. As the South Englishman is impacted by forestry only, fall bacteriological levels here will also be considered background. The mean of 90th percentile fecal coliform values from both sites for the fall was 54 CFU /100mL.

Table 14. Summary of 90th percentile values for fecal coliforms (CFU/100mL) at Englishman River sites, calculated when a minimum of five weekly samples were collected within a 30-day period.

Site Number	Site name	Summer 2002	Fall 2002	Summer 2003	Fall 2003*	Summer 2004	Fall 2004	Summer Mean	Fall Mean
E248835	Morison Ck U/S Englishman R.	28	94	144	1542	no data	602	86	746
E248834	Englishman R U/S Morison Ck	4	41	8	45	no data	118*	6	68
E248836	South Englishman R.	33	41	34	33	no data	47	33	40
E252010	Englishman R. U/S Allsbrook Canyon	no data	no data	31	not enough samples	no data	164	31	164
121580	Englishman R. at Parksville intake	24	24	27042	217	no data	632	13533	291

*based on 4 weekly samples in 30 days

As with fecal coliforms, *E. coli* concentrations were lowest in the Englishman River upstream from Morison Creek and in the South Englishman River, and highest in Morison Creek and at Highway 19A. A summary of 90^{th} percentile values for each site is given in Table 15. At the Highway 19A site on one sample date in the summer of 2003, as with fecal coliforms, there was one greatly elevated *E. coli* value of over 27, 000 CFU/100mL, likely due to a piece of fecal material in the sample. The drinking water guidelines for *E. coli* were exceeded in 22 of 27 instances when the requisite sampling frequency was met for this parameter (this includes the data based on only 4 samples in 30 days that capture the fall flush event). At the Englishman River upstream from Morison Creek site (considered background), the average of the three summer 90^{th} percentile values was 5 CFU/100 mL, while the average of the three fall 90^{th} percentile values was 57CFU/100 mL. As with fecal coliforms, fall *E. coli* levels at the South Englishman Site were also considered background, and the mean of 90^{th} percentile *E. coli* values from both sites for the fall was 41CFU /100mL.

. At the Highway 19A site, one value of over 45,000 CFU/100mL greatly skewed the 90^{th} percentile value for the summer 2003 sample period as well as the mean of summer 90^{th} percentile values, and was not consistent with any other values. As this was likely due to a piece a fecal matter in the sample it was considered valuable to leave in the dataset. Such a value likely represents the real possibility of fecal contamination occurring from recreational use in the populated areas of the watershed. The drinking water guidelines were exceeded 20 of the 22 times where the sampling frequency was sufficient to determine guideline compliance. While the 2003 fall sample period only had 4 samples collected within a 30 day period, this data set captured the first fall flush period and was included for the determination of an objective. For the Englishman River upstream from Morison Creek (which lies upstream of the majority of potential impacts on water quality and therefore was considered the ambient or natural conditions of the river), the average of the two summer 90^{th} percentile values was 6 CFU/100 mL, while the average of the three fall 90^{th} percentile values was 68 CFU/100 mL. Though exceeding the drinking water guidelines, these elevated fall flush values in areas of no impact are considered natural and have been observed in other Vancouver Island watersheds. For example, in the untouched watershed of McKelvie Creek, an objective of 60 CFU/100ml (90^{th} percentile for 5 samples in 30 days) was recommended to reflect natural variability within the watershed (Epps, 2007).

For the South Englishman River, summer values were elevated (mean 90^{th} percentile summer concentration of 33 CFU /100 mL) compared to the Englishman River upstream from Morison Creek (background), likely due to an active fish ladder that may attract wildlife at that time of year. Fall values were lower (fall mean 90^{th} percentile was 40 CFU/100mL) than background. As the South Englishman is impacted by forestry only, fall bacteriological levels here will also be considered background. The mean of 90^{th} percentile fecal coliform values from both sites for the fall was 54 CFU /100mL.

Table 14. Summary of 90th percentile values for fecal coliforms (CFU/100mL) at Englishman River sites, calculated when a minimum of five weekly samples were collected within a 30-day period.

Site Number	Site name	Summer 2002	Fall 2002	Summer 2003	Fall 2003*	Summer 2004	Fall 2004	Summer Mean	Fall Mean
E248835	Morison Ck U/S Englishman R.	28	94	144	1542	no data	602	86	746
E248834	Englishman R U/S Morison Ck	4	41	8	45	no data	118*	6	68
E248836	South Englishman R.	33	41	34	33	no data	47	33	40
E252010	Englishman R. U/S Allsbrook Canyon	no data	no data	31	not enough samples	no data	164	31	164
121580	Englishman R. at Parksville intake	24	24	27042	217	no data	632	13533	291

*based on 4 weekly samples in 30 days

As with fecal coliforms, *E. coli* concentrations were lowest in the Englishman River upstream from Morison Creek and in the South Englishman River, and highest in Morison Creek and at Highway 19A. A summary of 90^{th} percentile values for each site is given in Table 15. At the Highway 19A site on one sample date in the summer of 2003, as with fecal coliforms, there was one greatly elevated *E. coli* value of over 27, 000 CFU/100mL, likely due to a piece of fecal material in the sample. The drinking water guidelines for *E.*

coli were exceeded in 22 of 27 instances when the requisite sampling frequency was met for this parameter (this includes the data based on only 4 samples in 30 days that capture the fall flush event). At the Englishman River upstream from Morison Creek site (considered background), the average of the three summer 90th percentile values was 5 CFU/100 mL, while the average of the three fall 90th percentile values was 57CFU/100 mL. As with fecal coliforms, fall *E. coli* levels at the South Englishman Site were also considered background, and the mean of 90th percentile *E. coli* values from both sites for the fall was 41CFU /100mL.

Table 15. Summary of 90th percentile values for *E. coli* (CFU/100mL) at Englishman River sites, calculated when a minimum of five weekly samples were collected within a 30-day period .

Site Number	Site name	Summer 2002	Fall 2002	Summer 2003	Fall 2003*	Summer 2004	Fall 2004	Summer Mean	Fall Mean
E248835	Morison Ck U/S Englishman R.	20	34	15	324	121	572	52	310
E248834	Englishman R U/S Morison Ck	3	19	4	31	6	120*	5	57
E248836	South Englishman R.	23	16	10	17	4	40	12	24
E252010	Englishman R. U/S Allsbrook Canyon	no data	no data	9	not enough samples	11	164	10	164
121580	Englishman R. at Parksville intake	14	23	16218	81	57	634	5430	246

*based on 4 weekly samples in 30 days

While drinking water guidelines only apply at the Highway 19A site as it is near the intake where drinking water is withdrawn, the Highway 19A site actually had the second highest concentrations of both fecal coliforms and *E. coli* after the site at Morison Creek upstream of the Englishman. The fact that coliform concentrations are highest in the populated portions of the watershed (i.e. Morison Creek) and, at times, increase in a downstream direction to the Highway 19A site, suggests that a significant portion of the coliforms come from anthropogenic sources. In addition, decaying salmon carcasses were observed at the Highway 19A site during the fall sampling period and may have been an attraction for wildlife in the area. Fall values were generally higher than summer values.

Therefore, a seasonally adjusted water quality objective is proposed for both fecal coliforms and E. coli ***in the Englishman River. The objective is that the 90th percentile of a minimum of five weekly samples collected within a 30-day period from October-November (to capture the first fall flush) must not exceed 54 CFU/100 mL for fecal coliforms and/or must not exceed 41 CFU/100 mL for*** **E. coli.** These are based on the mean of the fall 90th percentile values for both the Englishman River upstream of Morison Creek and the South Englishman River site so that the variability of 90th percentile values between seasons is retained. ***For the remainder of the year, the 90th percentile of a minimum of five weekly samples collected within a 30-day period (sampling should occur during July-September, to capture the low flow event) must not exceed 10 CFU/100 mL at the City of Parksville drinking water intake (Highway 19A site) for fecal coliforms and/or*** **E. coli.** While this proposed objective is higher than the provincial guideline it does represent the natural variability within the watershed with respect to bacteriological values (as measured at the Englishman River upstream from Morison Creek site). This highlights the need for water purveyors to provide adequate treatment prior to consumption. Meeting these objectives will provide protection from most pathogens but not from parasites such as *Cryptosporidium* or *Giardia*. Sampling for these pathogens falls under the auspices of the water purveyor, in this case the Arrowsmith Water Service.

7.0 MONITORING RECOMMENDATIONS

Although most recommended objectives apply specifically to the Englishman River at Highway 19A, attainment monitoring should include monitoring at all five water quality monitoring sites. This will ensure water quality is protected throughout the watershed and help determine the source of exceedences, should they occur.

In order to capture the periods where water quality concerns are most likely to occur (i.e., freshet and summer low-flow) we recommend that a minimum of five weekly samples be collected within a 30-day period between August and September, as well as between October and November. Samples collected during the winter months should coincide with rain events whenever possible. In this way, the two critical periods (minimum dilution and maximum turbidity) will be monitored. Samples should be analyzed for general water chemistry (including TSS, turbidity, colour, DOC, TOC and nutrients (specifically nitrate, nitrite and total phosphorous)), dissolved metals, as well as bacteriology (including fecal coliforms and *E. coli*) and field measurements of temperature should be taken. At least one of the samples collected during the both the high-flow and low-flow period should also be analyzed for total metals concentrations (low level analysis) and hardness. For nutrients only, a minimum of five weekly samples should also be collected within a 30-day period between April and May (see section 7.7).

7.1 BIOLOGICAL MONITORING

Objectives development has traditionally focused on physical, chemical and bacteriological parameters. Biological data has been underutilized due to the highly specialized interpretation required and the difficulty in applying the data quantitatively. Notwithstanding this problem, with few exceptions, the most sensitive use of our water bodies is aquatic life. Therefore biological objectives need to be incorporated into the overall objectives development program.

In streams, benthic invertebrates have been accepted as a very important assessment tool. Considerable progress has been made in the development of benthic invertebrate indices, which can be incorporated into impact assessments and water quality objectives. On Vancouver Island, benthic sampling has been conducted at a limited number of sites over the past three years. The dataset at present is too limited to be able to make a sound judgment as to the state of the ecosystem health. To be able to apply and test the benthic invertebrate approach, Vancouver Island regional staff will be collecting more data at a broad range of both reference and test sites. Once all the data has been compiled and analyzed, biological objectives and/or indices will be developed for those watersheds where water quality objectives have already been developed.

8.0 SUMMARY OF PROPOSED WATER QUALITY OBJECTIVES AND MONITORING SCHEDULE

Table 16. Summary of proposed water quality objectives for the Englishman River Community Watershed. All objectives apply to the site Englishman River at Highway 19A, unless stated otherwise.

Parameter	Objective Value
Fecal Coliform Bacteria	≤10 CFU/100 mL (90th percentile) Dec-Sept ≤54 CFU/100 mL (90th percentile) Oct-Nov (based on a minimum 5 weekly samples collected over a 30-day period)
***E. coli* Bacteria**	≤10 CFU/100 mL (90th percentile) Dec-Sept ≤41 CFU/100 mL (90th percentile) Oct-Nov (based on a minimum 5 weekly samples collected over a 30-day period)
Turbidity	October to December: 5 NTU maximum January to September: 2 NTU maximum
True Colour	15 TCU maximum
Total Organic Carbon	4.0 mg/L maximum
Temperature	Short Term, at any location in the river - ≤17^{o}C average weekly temperature Long Term, at Highway 19A site - ≤ 15 ^{o}C average weekly temperature
Non-Filterable Residue (TSS)	October to December: 33 mg/L maximum in a 24-hour period 13mg/L average (based on a minimum of five weekly samples collected over a 30-day period) January to September: 26 mg/L maximum in a 24-hour period 6 mg/L average (based on a minimum of five weekly samples collected over a 30-day period)
Dissolved Aluminum (mg/L)	At any location in the river: 0.05 mg/L average (based on a minimum 5 weekly samples collected over a 30-day period) 0.10 mg/L maximum

Designated water uses: drinking water, aquatic life, irrigation, recreation and wildlife

Table 17. Proposed schedule for future water quality and benthic invertebrate monitoring in the Englishman River.

Frequency and timing	Characteristic to be measured	Sites
August – September (low-flow season): once per week for five consecutive weeks	Temperature, TSS, turbidity, TOC, DOC, colour, nutrients (nitrate, nitrite, total phosphorous), dissolved metals, fecal coliforms and *E. coli*	all
October - November (high-flow fall flush season): once per week for five consecutive weeks	Temperature, TSS, turbidity, TOC, DOC, colour, nutrients (nitrate, nitrite, total phosphorous), dissolved metals, fecal coliforms and *E. coli*	all
At least once during each summer and fall 5 weekly samples in 30 day sample period	Total metals, hardness	all
April-May (spring planting) (once per week for five consecutive weeks)	Nutrients (nitrate, nitrite, total phosphorous)	Englishman River upstream Morison Creek (E248835) and Morison Creek upstream Englishman River (E248834) only
Once every five years in September	Benthic invertebrate sampling	all
Continuous	Turbidity, temp, DO, conductivity	Englishman River at Highway 19A (0121580) only

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APPENDIX I. SUMMARY OF WATER QUALITY DATA

Table 18. Summary of general water chemistry at Site E248834, Englishman River Upstream from Morison Creek.

	Minimum	Maximum	Average	Std Dev	Number of Samples
Fecal coliforms (CFU/100mL)	< 1	140	10.8	24.9	42
E. coli (CFU/100mL)	< 1	140	8.2	22.4	48
Streptococci (CFU/100mL)	16	48	33.7	11.9	6
Carbon Dissolved Organic (mg/L)	1	2.8	1.7	0.6	11
Nitrate (NO3) Dissolved (mg/L)	0.001	0.194	0.031	0.041	31
Nitrate + Nitrite Diss. (mg/L)	0.001	0.197	0.031	0.040	34
Nitrogen - Nitrite Diss. (mg/L)	0.001	0.006	0.002	0.001	33
Ortho-Phosphate Dissolved (mg/L)	< 0.001	0.009	0.002	0.002	33
pH (pH units)	6.8	7.7	7.4	0.2	34
Phosphorus Tot. Dissolved (mg/L)	< 0.002	0.013	0.003	0.002	34
P--T (mg/L)	< 0.002	0.024	0.004	0.005	34
Residue Non-filterable (mg/L)	< 1	51	4.2	10.0	58
Specific Conductance (μS/cm)	31	124	68.8	22.6	34
Turbidity (NTU)	0.13	4.27	0.50	0.76	34
UV Absorbance 250nm (AU/cm)	0.03	0.04	0.035	0.007	2
UV Absorbance 254nm (AU/cm)	0.03	0.04	0.035	0.007	2
UV Absorbance 310nm (AU/cm)	0.01	0.01	0.01	0	2
UV Absorbance 340nm (AU/cm)	< 0.01	< 0.01	< 0.01	0	2
UV Absorbance 360nm (AU/cm)	< 0.01	< 0.01	< 0.01	0	2
UV Absorbance 365nm (AU/cm)	< 0.01	< 0.01	< 0.01	0	2
Ag-D (mg/L)	< 0.0001	0.0001	0.0001	0	30
Ag-T (mg/L)	< 0.0001	0.0001	0.0001	0	30
Al-D (mg/L)	0.0024	0.11	0.0227	0.0301	30
Al-T (mg/L)	0.0035	0.521	0.0694	0.1316	30
As-D (mg/L)	< 0.0001	0.0004	0.0001	0	30
As-T (mg/L)	< 0.0001	0.0003	0.0001	0	30
Ba-D (mg/L)	0.0025	0.0082	0.0050	0.0013	30
Ba-T (mg/L)	0.0034	0.0123	0.0057	0.0017	30
Be-D (mg/L)	< 0.0001	0.0001	0.0001	0	30
Be-T (mg/L)	< 0.0001	0.0001	0.0001	0	30
Bi-D (mg/L)	< 0.0001	0.0001	0.0001	0	30
Bi-T (mg/L)	< 0.0001	0.0001	0.0001	0	30
Cd-D (mg/L)	< 0.0001	0.0001	0.0001	0	30
Cd-T (mg/L)	< 0.0001	0.0001	0.0001	0	30
Co-D (mg/L)	< 0.0001	0.0001	0.0001	0	30
Co-T (mg/L)	< 0.0001	0.0005	0.0001	0.0001	30
Cr-D (mg/L)	< 0.0002	0.0004	0.0002	0	30
Cr-T (mg/L)	< 0.0002	0.0007	0.0002	0.0001	30
Cu-D (mg/L)	< 0.0001	0.0023	0.0007	0.0004	30
Cu-T (mg/L)	< 0.0001	0.0031	0.0009	0.0007	30
Li-D (mg/L)	< 0.0001	0.0044	0.0023	0.0013	30
Li-T (mg/L)	< 0.0001	0.0044	0.0026	0.0012	30

	Minimum	Maximum	Average	Std Dev	Number of Samples
Mn-D (mg/L)	0.0001	0.0026	0.0008	0.0006	30
Mn-T (mg/L)	0.0001	0.0313	0.0025	0.0060	30
Mo-D (mg/L)	< 0.0001	0.0001	0.0001	0	30
Mo-T (mg/L)	< 0.0001	0.0001	0.0001	0	30
Pb-D (mg/L)	< 0.0001	0.0002	0.0001	0	30
Pb-T (mg/L)	< 0.0001	0.0002	0.0001	0	30
Sb-D (mg/L)	< 0.0001	0.0001	0.0001	0	30
Sb-T (mg/L)	< 0.0001	0.0001	0.0001	0	30
Se-D (mg/L)	< 0.0002	0.0003	0.0002	0	30
Se-T (mg/L)	< 0.0002	0.0003	0.0002	0	30
Sn-D (mg/L)	< 0.0001	0.0002	0.0001	0	30
Sn-T (mg/L)	< 0.0001	0.0001	0.0001	0	30
Sr-D (mg/L)	0.01	0.0593	0.0357	0.0126	30
Sr-T (mg/L)	0.0136	0.0607	0.0375	0.0125	30
Tl-D (mg/L)	< 0.0001	0.0001	0.0001	0	30
Tl-T (mg/L)	< 0.0001	0.0001	0.0001	0	30
U--D (mg/L)	< 0.000001	0.000001	0.000001	0	30
U--T (mg/L)	< 0.000001	0.000001	0.000001	0	30
V--D (mg/L)	0.0001	0.0012	0.0004	0.0002	30
V--T (mg/L)	0.0002	0.0022	0.0005	0.0004	30
Zn-D (mg/L)	< 0.0001	0.0565	0.0038	0.0111	30
Zn-T (mg/L)	< 0.0001	0.0128	0.0020	0.0036	30

Table 19. Summary of general water chemistry at Site E248835, Morison Creek Upstream from Englishman River.

	Minimum	Maximum	Average	Std Dev	Number of Samples
Fecal coliforms (CFU/100mL)	< 1	2200	105.8	352.9	43
E. coli (CFU/100mL)	< 1	820	52.9	134.3	49
Streptococci (CFU/100mL)	380	2400	821.7	780.6	6
Carbon Dissolved Organic (mg/L)	2	7.7	5.3	1.9	11
Nitrate (NO3) Dissolved (mg/L)	0.001	0.541	0.131	0.108	31
Nitrate + Nitrite Diss. (mg/L)	< 0.002	0.545	0.133	0.105	34
Nitrogen - Nitrite Diss. (mg/L)	< 0.002	0.007	0.003	0.001	33
Ortho-Phosphate Dissolved (mg/L)	0.001	0.015	0.008	0.004	33
pH (pH units)	6.9	8	7.5	0.3	34
Phosphorus Tot. Dissolved (mg/L)	< 0.002	0.022	0.013	0.005	34
P--T (mg/L)	< 0.002	0.126	0.023	0.021	34
Residue Non-filterable (mg/L)	< 1	32	3.6	6.0	57
Specific Conductance (μS/cm)	32	108	68.6	24.2	34
Turbidity (NTU)	0.13	4.61	1.84	1.36	34
UV Absorbance 250nm (AU/cm)	0.09	0.2	0.15	0.08	2
UV Absorbance 254nm (AU/cm)	0.09	0.19	0.14	0.07	2
UV Absorbance 310nm (AU/cm)	0.03	0.08	0.06	0.04	2
UV Absorbance 340nm (AU/cm)	0.02	0.05	0.04	0.02	2
UV Absorbance 360nm (AU/cm)	< 0.01	0.03	0.02	0.01	2
UV Absorbance 365nm (AU/cm)	< 0.01	0.03	0.02	0.01	2
Ag-D (mg/L)	< 0.0001	0.0001	0.0001	0	29
Ag-T (mg/L)	< 0.0001	0.0001	0.0001	0	29
Al-D (mg/L)	0.0049	0.347	0.0668	0.0972	29
Al-T (mg/L)	0.0102	1.25	0.1508	0.2748	29
As-D (mg/L)	< 0.0001	0.0004	0.0002	0.0001	29
As-T (mg/L)	< 0.0001	0.0004	0.0003	0.0001	29
Ba-D (mg/L)	0.0037	0.0104	0.0068	0.0017	29
Ba-T (mg/L)	0.0048	0.0126	0.0077	0.0019	29
Be-D (mg/L)	< 0.0001	0.0001	0.0001	0	29
Be-T (mg/L)	< 0.0001	0.0001	0.0001	0	29
Bi-D (mg/L)	< 0.0001	0.0001	0.0001	0	29
Bi-T (mg/L)	< 0.0001	0.0001	0.0001	0	29
Cd-D (mg/L)	< 0.0001	0.0001	0.0001	0	29
Cd-T (mg/L)	< 0.0001	0.0001	0.0001	0	29
Co-D (mg/L)	< 0.0001	0.0001	0.0001	0	29
Co-T (mg/L)	< 0.0001	0.0004	0.0001	0	29
Cr-D (mg/L)	< 0.0002	0.0006	0.0003	0.0001	29
Cr-T (mg/L)	< 0.0002	0.0016	0.0003	0.0003	29
Cu-D (mg/L)	0.0004	0.0045	0.0012	0.0008	29
Cu-T (mg/L)	0.0006	0.005	0.0015	0.0010	29
Li-D (mg/L)	< 0.0001	0.0022	0.0004	0.0004	29
Li-T (mg/L)	< 0.0001	0.0022	0.0005	0.0004	29
Mn-D (mg/L)	0.0004	0.0053	0.0016	0.0010	29
Mn-T (mg/L)	0.0018	0.0253	0.0047	0.0049	29

	Minimum	Maximum	Average	Std Dev	Number of Samples
Mo-D (mg/L)	< 0.0001	0.0001	0.0001	0	29
Mo-T (mg/L)	< 0.0001	0.0002	0.0001	0	29
Pb-D (mg/L)	< 0.0001	0.0001	0.0001	0	29
Pb-T (mg/L)	< 0.0001	0.0007	0.0001	0.0001	29
Sb-D (mg/L)	< 0.0001	0.0001	0.0001	0	29
Sb-T (mg/L)	< 0.0001	0.0001	0.0001	0	29
Se-D (mg/L)	< 0.0002	0.0002	0.0002	0	29
Se-T (mg/L)	< 0.0002	0.0005	0.00021	0	29
Sn-D (mg/L)	< 0.0001	0.0001	0.0001	0	29
Sn-T (mg/L)	< 0.0001	0.0002	0.0001	0	29
Sr-D (mg/L)	0.0182	0.0509	0.0393	0.0102	29
Sr-T (mg/L)	0.0217	0.052	0.0403	0.0097	29
Tl-D (mg/L)	< 0.0001	0.0001	0.0001	0	29
Tl-T (mg/L)	< 0.0001	0.0001	0.0001	0	29
U--D (mg/L)	< 0.000001	0.000001	0.000001	0	29
U--T (mg/L)	< 0.000001	0.0001	0.00001	0.00003	29
V--D (mg/L)	0.0002	0.0019	0.0009	0.0004	29
V--T (mg/L)	0.0003	0.004	0.0011	0.0008	29
Zn-D (mg/L)	< 0.0001	0.0059	0.0011	0.0013	29
Zn-T (mg/L)	< 0.0001	0.0211	0.0022	0.0041	29

Table 20. Summary of general water chemistry at Site E248836, Englishman River at South Fork.

	Minimum	Maximum	Average	Std Dev	Number of Samples
Fecal coliforms (CFU/100mL)	< 1	65	14.6	16.7	44
E. coli (CFU/100mL)	< 1	49	8.3	11.1	50
Streptococci (CFU/100mL)	41	380	164.3	119.8	6
Carbon Dissolved Organic (mg/L)	1.1	4.1	2.4	0.9	11
Nitrate (NO3) Dissolved (mg/L)	0.001	0.288	0.051	0.071	30
Nitrate + Nitrite Diss. (mg/L)	0.001	0.29	0.053	0.069	34
Nitrogen - Nitrite Diss. (mg/L)	0.001	0.007	0.002	0.001	32
Ortho-Phosphate Dissolved (mg/L)	< 0.001	0.007	0.003	0.002	33
pH (pH units)	6.7	8	7.4	0.4	34
Phosphorus Tot. Dissolved (mg/L)	< 0.002	0.008	0.003	0.002	33
P--T (mg/L)	< 0.002	0.01	0.003	0.002	34
Residue Non-filterable (mg/L)	< 1	40	2.6	6.1	59
Specific Conductance (μS/cm)	23	304	111.5	85.0	34
Turbidity (NTU)	0.13	1.57	0.45	0.36	34
UV Absorbance 250nm (AU/cm)	0.04	0.05	0.05	0.01	2
UV Absorbance 254nm (AU/cm)	0.04	0.05	0.05	0.01	2
UV Absorbance 310nm (AU/cm)	0.01	0.02	0.02	0.01	2
UV Absorbance 340nm (AU/cm)	< 0.01	< 0.01	< 0.01	0	2
UV Absorbance 360nm (AU/cm)	< 0.01	< 0.01	< 0.01	0	2
UV Absorbance 365nm (AU/cm)	< 0.01	< 0.01	< 0.01	0	2
Ag-D (mg/L)	< 0.0001	0.0001	0.0001	0	33
Ag-T (mg/L)	< 0.0001	0.0001	0.0001	0	33
Al-D (mg/L)	0.001	0.143	0.033	0.042	33
Al-T (mg/L)	0.0017	0.414	0.054	0.088	33
As-D (mg/L)	< 0.0001	0.0004	0.0002	0	33
As-T (mg/L)	0.0001	0.0006	0.0003	0.0001	33
Ba-D (mg/L)	0.0038	0.0314	0.0149	0.0087	33
Ba-T (mg/L)	0.0048	0.0311	0.0157	0.0087	33
Be-D (mg/L)	< 0.0001	0.0001	0.0001	0	33
Be-T (mg/L)	< 0.0001	0.0001	0.0001	0	33
Bi-D (mg/L)	< 0.0001	0.0001	0.0001	0	33
Bi-T (mg/L)	< 0.0001	0.0001	0.0001	0	33
Cd-D (mg/L)	< 0.0001	0.0001	0.0001	0	33
Cd-T (mg/L)	< 0.0001	0.0001	0.0001	0	33
Co-D (mg/L)	< 0.0001	0.0001	0.0001	0	33
Co-T (mg/L)	< 0.0001	0.0002	0.0001	0	33
Cr-D (mg/L)	< 0.0002	0.0007	0.0002	0	33
Cr-T (mg/L)	< 0.0002	0.001	0.0002	0.0001	33
Cu-D (mg/L)	< 0.0001	0.0017	0.0006	0.0003	33
Cu-T (mg/L)	< 0.0001	0.0016	0.0007	0.0003	33
Li-D (mg/L)	< 0.0001	0.0027	0.0008	0.0005	33
Li-T (mg/L)	< 0.0001	0.0028	0.0009	0.0005	33
Mn-D (mg/L)	0.0002	0.0043	0.0010	0.0010	33
Mn-T (mg/L)	0.0003	0.009	0.0018	0.0023	33

	Minimum	Maximum	Average	Std Dev	Number of Samples
Mo-D (mg/L)	< 0.0001	0.0002	0.0001	0	33
Mo-T (mg/L)	< 0.0001	0.0002	0.0001	0	33
Pb-D (mg/L)	< 0.0001	0.0002	0.0001	0	33
Pb-T (mg/L)	< 0.0001	0.0005	0.0001	0	33
Sb-D (mg/L)	< 0.0001	0.0001	0.0001	0	33
Sb-T (mg/L)	< 0.0001	0.0001	0.0001	0	33
Se-D (mg/L)	< 0.0002	0.0004	0.0002	0	33
Se-T (mg/L)	< 0.0002	0.0004	0.0002	0	33
Sn-D (mg/L)	< 0.0001	0.0001	0.0001	0	33
Sn-T (mg/L)	< 0.0001	0.0001	0.0001	0	33
Sr-D (mg/L)	0.0127	0.229	0.0833	0.0571	33
Sr-T (mg/L)	0.0152	0.222	0.0855	0.0580	33
Tl-D (mg/L)	< 0.0001	0.0001	0.0001	0	33
Tl-T (mg/L)	< 0.0001	0.0001	0.0001	0	33
U--D (mg/L)	< 0.000001	0.000001	0.000001	0	33
U--T (mg/L)	< 0.000001	0.000001	0.000001	0	33
V--D (mg/L)	< 0.0001	0.0012	0.0004	0.0003	33
V--T (mg/L)	< 0.0001	0.0014	0.0005	0.0003	33
Zn-D (mg/L)	< 0.0001	0.0046	0.0011	0.0011	33
Zn-T (mg/L)	< 0.0001	0.008	0.0014	0.0019	33

Table 21. Summary of general water chemistry at Site E252010, Englishman River upstream from Allsbrook Canyon.

	Minimum	Maximum	Average	Std Dev	Number of Samples
Fecal coliforms (CFU/100mL)	< 1	580	41.5	117.8	26
E. coli (CFU/100mL)	< 1	210	16.1	41.2	32
Streptococci (CFU/100mL)	5	65	31.5	21.7	6
Carbon Dissolved Organic (mg/L)	1	2.4	1.7	0.7	3
Nitrate (NO3) Dissolved (mg/L)	0.001	0.076	0.023	0.024	23
Nitrate + Nitrite Diss. (mg/L)	0.001	0.078	0.025	0.026	25
Nitrogen - Nitrite Diss. (mg/L)	0.001	0.006	0.002	0.001	25
Ortho-Phosphate Dissolved (mg/L)	< 0.001	0.007	0.002	0.001	25
pH (pH units)	6.8	7.8	7.4	0.2	25
Phosphorus Tot. Dissolved (mg/L)	< 0.002	0.006	0.003	0.001	25
P--T (mg/L)	< 0.002	0.027	0.004	0.005	25
Residue Non-filterable (mg/L)	< 1	54	4.3	9.8	40
Specific Conductance (μS/cm)	30	109	66.5	23.4	25
Turbidity (NTU)	0.24	5.37	1.0	1.3	25
UV Absorbance 250nm (AU/cm)	0.03	0.04	0.04	0.01	2
UV Absorbance 254nm (AU/cm)	0.03	0.04	0.04	0.01	2
UV Absorbance 310nm (AU/cm)	< 0.01	0.01	0.01	0	2
UV Absorbance 340nm (AU/cm)	< 0.01	< 0.01	< 0.01	0	2
UV Absorbance 360nm (AU/cm)	< 0.01	< 0.01	< 0.01	0	2
UV Absorbance 365nm (AU/cm)	< 0.01	< 0.01	< 0.01	0	2
Ag-D (mg/L)	< 0.0001	0.0001	0.0001	0	19
Ag-T (mg/L)	< 0.0001	0.0001	0.0001	0	19
Al-D (mg/L)	0.0022	0.114	0.0297	0.0346	19
Al-T (mg/L)	0.0079	0.446	0.0809	0.1223	19
As-D (mg/L)	< 0.0001	0.0002	0.0001	0	19
As-T (mg/L)	< 0.0001	0.0003	0.0001	0	19
Ba-D (mg/L)	0.0033	0.0079	0.0053	0.0012	19
Ba-T (mg/L)	0.0039	0.0077	0.0060	0.0010	19
Be-D (mg/L)	< 0.0001	0.0001	0.0001	0	19
Be-T (mg/L)	< 0.0001	0.0001	0.0001	0	19
Bi-D (mg/L)	< 0.0001	0.0001	0.0001	0	19
Bi-T (mg/L)	< 0.0001	0.0001	0.0001	0	19
Cd-D (mg/L)	< 0.0001	0.0001	0.0001	0	19
Cd-T (mg/L)	< 0.0001	0.0001	0.0001	0	19
Co-D (mg/L)	< 0.0001	0.0001	0.0001	0	19
Co-T (mg/L)	< 0.0001	0.0003	0.0001	0	19
Cr-D (mg/L)	< 0.0002	0.0003	0.0002	0	19
Cr-T (mg/L)	< 0.0002	0.0012	0.0003	0.0002	19
Cu-D (mg/L)	0.0004	0.0019	0.0008	0.0004	19
Cu-T (mg/L)	0.0005	0.002	0.0010	0.0004	19
Li-D (mg/L)	0.0004	0.0034	0.0021	0.0009	19
Li-T (mg/L)	0.0008	0.0033	0.0022	0.0010	19
Mn-D (mg/L)	0.0009	0.0062	0.0027	0.0015	19
Mn-T (mg/L)	0.0013	0.0115	0.0048	0.0029	19

	Minimum	Maximum	Average	Std Dev	Number of Samples
Mo-D (mg/L)	< 0.0001	0.0001	0.0001	0	19
Mo-T (mg/L)	< 0.0001	0.0001	0.0001	0	19
Pb-D (mg/L)	< 0.0001	0.0001	0.0001	0	19
Pb-T (mg/L)	< 0.0001	0.0001	0.0001	0	19
Sb-D (mg/L)	< 0.0001	0.0001	0.0001	0	19
Sb-T (mg/L)	< 0.0001	0.0001	0.0001	0	19
Se-D (mg/L)	< 0.0002	0.0004	0.0002	0	19
Se-T (mg/L)	< 0.0002	0.0005	0.0002	0	19
Sn-D (mg/L)	< 0.0001	0.0001	0.0001	0	19
Sn-T (mg/L)	< 0.0001	0.0002	0.0001	0	19
Sr-D (mg/L)	0.013	0.0488	0.0353	0.0117	19
Sr-T (mg/L)	0.0156	0.0505	0.0374	0.0123	19
Tl-D (mg/L)	< 0.0001	0.0001	0.0001	0	19
Tl-T (mg/L)	< 0.0001	0.0001	0.0001	0	19
U--D (mg/L)	< 0.000001	0.000001	0.000001	0	19
U--T (mg/L)	< 0.000001	0.000001	0.000001	0	19
V--D (mg/L)	0.0002	0.0007	0.0004	0.0001	19
V--T (mg/L)	0.0003	0.0015	0.0006	0.0003	19
Zn-D (mg/L)	0.0001	0.0009	0.0004	0.0002	19
Zn-T (mg/L)	0.0002	0.0017	0.0007	0.0004	19

Table 22. Summary of general water chemistry at Site 0121580, Englishman River at Highway 19A.

	Minimum	Maximum	Average	Std Dev	Number of Samples
Fecal coliforms (CFU/100mL)	< 1	45000	648.2	5227.7	74
E. coli (CFU/100mL)	< 1	27000	394.9	3115.5	75
Streptococci (CFU/100mL)	41	78	55.0	13.5	6
Carbon Dissolved Organic (mg/L)	0.6	6.8	2.4	1.3	61
Carbon Total Inorganic (mg/L)	3	4.5	3.9	0.7	4
Carbon Total Organic (mg/L)	2.1	3.7	2.7	0.7	4
Color True (Col.unit)	< 5	20	13.3	5.2	6
Hardness Total (D) (mg/L)	11.8	40	24.4	9.4	35
Hardness Total (T) (mg/L)	13.2	23.2	18.8	4.6	5
Nitrate (NO3) Dissolved (mg/L)	0.001	0.151	0.034	0.031	65
Nitrate + Nitrite Diss. (mg/L)	0.001	0.153	0.034	0.032	75
Nitrogen - Nitrite Diss. (mg/L)	0.001	0.009	0.003	0.002	71
Ortho-Phosphate Dissolved (mg/L)	0.001	0.033	0.003	0.004	74
pH (pH units)	6.6	7.8	7.3	0.3	75
Phosphorus Tot. Dissolved (mg/L)	< 0.002	0.014	0.003	0.002	69
P--T (mg/L)	< 0.002	0.016	0.005	0.004	48
Residue Non-filterable (mg/L)	< 1	57	4.0	9.6	92
Specific Conductance (µS/cm)	31	131	69.3	25.4	71
Turbidity (NTU)	0.25	10.5	1.0	1.5	70
UV Absorbance 250nm (AU/cm)	< 0.01	0.58	0.10	0.12	44
UV Absorbance 254nm (AU/cm)	< 0.01	0.6	0.10	0.12	44
UV Absorbance 310nm (AU/cm)	< 0.01	0.62	0.05	0.11	44
UV Absorbance 340nm (AU/cm)	< 0.01	0.64	0.04	0.11	44
UV Absorbance 360nm (AU/cm)	< 0.01	0.65	0.04	0.11	44
UV Absorbance 365nm (AU/cm)	< 0.01	0.66	0.04	0.11	44
Ag-D (mg/L)	< 0.0001	0.0001	0.0001	0	37
Ag-T (mg/L)	< 0.0001	0.0001	0.0001	0	39
Al-D (mg/L)	0.0018	0.14	0.0327	0.0359	41
Al-T (mg/L)	0.0059	0.57	0.0890	0.1382	43
As-D (mg/L)	< 0.0001	0.0004	0.0001	0.0001	37
As-T (mg/L)	< 0.0001	0.0004	0.0002	0.0001	39
Ba-D (mg/L)	0.0029	0.0083	0.0053	0.0014	43
Ba-T (mg/L)	0.003	0.0118	0.0059	0.0020	43
B--D (mg/L)	< 0.004	0.011	0.0083	0.0022	8
Be-D (mg/L)	< 0.0001	0.0001	0.0001	0	37
Be-T (mg/L)	< 0.0001	0.0005	0.0001	0	39
Bi-D (mg/L)	< 0.0001	0.0001	0.0001	0	37
Bi-T (mg/L)	< 0.0001	0.0005	0.0001	0	39
B--T (mg/L)	0.004	0.01	0.0073	0.0019	6
Ca-D (mg/L)	3.72	13.4	7.9351	3.3081	35
Ca-T (mg/L)	3.85	7.5	5.5656	1.4631	9
Cd-D (mg/L)	< 0.0001	0.0002	0.0001	0	37
Cd-T (mg/L)	< 0.0001	0.0002	0.0001	0	39
Co-D (mg/L)	< 0.0001	0.0001	0.0001	0	37

	Minimum	Maximum	Average	Std Dev	Number of Samples
Co-T (mg/L)	< 0.0001	0.0007	0.0001	0.0001	39
Cr-D (mg/L)	< 0.0002	0.003	0.0004	0.0006	41
Cr-T (mg/L)	< 0.0002	0.002	0.0004	0.0005	43
C--T (mg/L)	5.8	7.4	6.6	0.7	4
Cu-D (mg/L)	< 0.0001	0.005	0.0009	0.0010	42
Cu-T (mg/L)	< 0.0001	0.0042	0.0010	0.0008	43
Fe-D (mg/L)	0.026	0.106	0.058	0.027	8
Fe-T (mg/L)	0.04	0.21	0.12	0.06	10
K--D (mg/L)	< 0.1	0.5	0.3	0.2	8
K--T (mg/L)	< 0.1	2	0.5	0.8	5
Li-D (mg/L)	0.0004	0.0029	0.0018	0.0008	37
Li-T (mg/L)	0.0004	0.0033	0.0018	0.0008	39
Mg-D (mg/L)	0.6	1.75	1.07	0.33	37
Mg-T (mg/L)	0.62	1.227	0.85	0.22	9
Mn-D (mg/L)	0.0003	0.044	0.0042	0.0065	43
Mn-T (mg/L)	0.0017	0.0487	0.0062	0.0076	43
Mo-D (mg/L)	< 0.0001	0.007	0.0006	0.0015	41
Mo-T (mg/L)	< 0.0001	0.004	0.0005	0.0011	43
Na-D (mg/L)	1.4	3.7	2.2	0.9	8
Na-T (mg/L)	1.4	3.8	2.3	0.9	5
Pb-D (mg/L)	< 0.0001	0.0036	0.0002	0.0006	37
Pb-T (mg/L)	< 0.0001	0.0036	0.0002	0.0006	39
Sb-D (mg/L)	< 0.0001	0.0001	0.0001	0	37
Sb-T (mg/L)	< 0.0001	0.0001	0.0001	0	39
S--D (mg/L)	0.51	0.76	0.64	0.18	2
Se-D (mg/L)	< 0.0002	0.0003	0.0002	0	37
Se-T (mg/L)	0.0001	0.0003	0.0002	0	38
Si-D (mg/L)	1.83	3.25	2.49	0.48	8
Si-T (mg/L)	1.94	3.26	2.46	0.43	9
Sn-D (mg/L)	< 0.0001	0.0001	0.0001	0	37
Sn-T (mg/L)	< 0.0001	0.0002	0.0001	0	38
Sr-D (mg/L)	0.0133	0.0585	0.0338	0.0125	43
Sr-T (mg/L)	0.015	0.062	0.035	0.013	43
S--T (mg/L)	0.48	0.7	0.59	0.16	2
Ti-D (mg/L)	< 0.002	0.003	0.003	0.000	8
Ti-T (mg/L)	< 0.002	0.008	0.005	0.002	8
Tl-D (mg/L)	< 0.0001	0.0001	0.0001	0	37
Tl-T (mg/L)	< 0.0001	0.0001	0.0001	0	39
U--D (mg/L)	< 0.000001	0.000001	0.000001	0	37
U--T (mg/L)	< 0.000001	0.0001	0.000004	0.00002	39
V--D (mg/L)	0.0002	0.0007	0.0004	0.0001	37
V--T (mg/L)	0.0002	0.0024	0.0006	0.0005	39
Zn-D (mg/L)	< 0.0001	0.0049	0.0010	0.0012	37
Zn-T (mg/L)	< 0.0001	0.0197	0.0016	0.0033	38

APPENDIX II. SUMMARY OF QA/QC DATA

Table 23. Relative percent differences between duplicate samples collected at Site E248836 on November 15, 2004.

Parameter	Sample #1	Sample #2	Relative % Difference*
Coli:Fec (CFU/100mL)	50	58	14.8%
E Coli (CFU/100mL)	49	49	0.0%

*Bold numbers denote exceedences of acceptable relative percent difference limits

Table 24. Relative percent differences between duplicate samples collected at Site E248836 on December 07, 2004.

Parameter	Sample #1	Sample #2	Relative % Difference*
Nitrate (NO3) Dissolved (mg/L)	0.086	0.03	**96.6%**
Nitrate + Nitrite Diss. (mg/L)	0.088	0.032	**93.3%**
Nitrogen - Nitrite Diss. (mg/L)	0.002	0.002	0.0%
Ortho-Phosphate Dissolved (mg/L)	0.004	0.003	**28.6%**
P--T (mg/L)	0.004	< 0.002	**66.7%**
Phosphorus Tot. Dissolved (mg/L)	0.003	< 0.002	**40.0%**
Residue Non-filterable (mg/L)	< 1	< 1	0.0%
Specific Conductance (μS/cm)	49	35	**33.3%**
Turbidity (NTU)	0.64	0.54	16.9%
pH (pH units)	7.2	7.1	1.4%

*Bold numbers denote exceedences of acceptable relative percent difference limits

Table 25. Relative percent differences between duplicate samples collected at Site E248836 on October 25, 2004.

Parameter	Sample #1	Sample #2	Relative % Difference*
Coli:Fec (CFU/100mL)	43	41	4.8%
E Coli (CFU/100mL)	31	41	**27.8%**
Residue Non-filterable (mg/L)	< 1	1	0.0%
Ag-D (mg/L)	< 0.0001	< 0.0001	0.0%
Ag-T (mg/L)	< 0.0001	< 0.0001	0.0%
Al-D (mg/L)	0.0442	0.0204	**73.7%**
Al-T (mg/L)	0.0494	0.0437	12.2%
As-D (mg/L)	0.0002	0.0002	0.0%
As-T (mg/L)	0.0003	0.0002	**40.0%**
Ba-D (mg/L)	0.0071	0.0099	**32.9%**
Ba-T (mg/L)	0.0067	0.0099	**38.6%**
Be-D (mg/L)	< 0.0001	< 0.0001	0.0%
Be-T (mg/L)	0.0001	0.0001	0.0%
Bi-D (mg/L)	< 0.0001	< 0.0001	0.0%
Bi-T (mg/L)	0.0001	< 0.0001	0.0%
Cd-D (mg/L)	< 0.0001	< 0.0001	0.0%
Cd-T (mg/L)	< 0.0001	< 0.0001	0.0%
Co-D (mg/L)	0.0001	0.0001	0.0%
Co-T (mg/L)	0.0001	0.0001	0.0%
Cr-D (mg/L)	< 0.0002	< 0.0002	0.0%
Cr-T (mg/L)	< 0.0002	< 0.0002	0.0%
Cu-D (mg/L)	0.0006	0.0009	**40.0%**
Cu-T (mg/L)	0.0006	0.0009	**40.0%**
Li-D (mg/L)	0.0008	0.0008	0.0%
Li-T (mg/L)	0.0009	0.0009	0.0%
Mn-D (mg/L)	0.0002	0.0004	**66.7%**
Mn-T (mg/L)	0.0009	0.0009	0.0%
Mo-D (mg/L)	< 0.0001	0.0001	0.0%
Mo-T (mg/L)	< 0.0001	0.0001	0.0%
Pb-D (mg/L)	0.0001	0.0001	0.0%
Pb-T (mg/L)	0.0001	0.0001	0.0%
Sb-D (mg/L)	0.0001	0.0001	0.0%
Sb-T (mg/L)	0.0001	0.0001	0.0%
Se-D (mg/L)	< 0.0002	< 0.0002	0.0%
Se-T (mg/L)	< 0.0002	< 0.0002	0.0%
Sn-D (mg/L)	0.0001	0.0001	0.0%
Sn-T (mg/L)	0.0001	0.0001	0.0%
Sr-D (mg/L)	0.0334	0.0472	**34.2%**
Sr-T (mg/L)	0.0307	0.0476	**43.2%**
Tl-D (mg/L)	< 0.0001	< 0.0001	0.0%
Tl-T (mg/L)	< 0.0001	< 0.0001	0.0%
U--D (mg/L)	0.000001	0.000001	0.0%
U--T (mg/L)	0.000001	0.000001	0.0%
V--D (mg/L)	0.0003	0.0005	**50.0%**
V--T (mg/L)	0.0003	0.0006	**66.7%**
Zn-D (mg/L)	0.0005	0.0004	22.2%
Zn-T (mg/L)	0.0006	0.0005	18.2%

*Bold numbers denote exceedences of acceptable relative percent difference limits

Table 26. Relative percent differences between duplicate samples collected at Site 0121580 on November 09, 2004.

Parameter	Sample #1	Sample #2	Relative % Difference*
Carbon Dissolved Organic (mg/L)	7.6	6.8	11.1%
Coli:Fec (CFU/100mL)	14	19	**30.3%**
E Coli (CFU/100mL)	1	2	**66.7%**
Nitrate (NO3) Dissolved (mg/L)	< 0.054	< 0.053	1.9%
Nitrate + Nitrite Diss. (mg/L)	0.056	0.055	1.8%
Nitrogen - Nitrite Diss. (mg/L)	< 0.002	< 0.002	0.0%
Ortho-Phosphate Dissolved (mg/L)	0.007	0.004	**54.5%**
Phosphorus Tot. Dissolved (mg/L)	< 0.002	< 0.002	0.0%
Residue Non-filterable (mg/L)	1	2	**66.7%**
Specific Conductance (μS/cm)	54	51	5.7%
Turbidity (NTU)	1.02	1.24	19.5%
UV Absorbance 250nm (AU/cm)	0.11	0.12	8.7%
UV Absorbance 254nm (AU/cm)	0.11	0.11	0.0%
UV Absorbance 310nm (AU/cm)	0.04	0.05	22.2%
UV Absorbance 340nm (AU/cm)	0.03	0.03	0.0%
UV Absorbance 360nm (AU/cm)	0.02	0.02	0.0%
UV Absorbance 365nm (AU/cm)	0.02	0.02	0.0%
pH (pH units)	7.1	6.9	2.9%
Ag-T (mg/L)	0.0001	0.0001	0.0%
Al-T (mg/L)	0.0947	0.0956	0.9%
As-T (mg/L)	0.0002	0.0002	0.0%
B--T (mg/L)	0.0079	0.0076	3.9%
Ba-T (mg/L)	0.0047	0.0047	0.0%
Be-T (mg/L)	0.0001	0.0001	0.0%
Bi-T (mg/L)	< 0.0001	0.0001	0.0%
Ca-D (mg/L)	6	5.9	1.7%
Cd-T (mg/L)	0.0001	0.0001	0.0%
Co-T (mg/L)	0.0001	0.0001	0.0%
Cr-T (mg/L)	0.0002	0.0002	0.0%
Cu-T (mg/L)	0.0009	0.0011	20.0%
Fe-T (mg/L)	0.0969	0.0983	1.4%
Li-T (mg/L)	0.0013	0.0014	7.4%
Mg-D (mg/L)	0.79	0.79	0.0%
Mn-T (mg/L)	0.0045	0.0039	14.3%
Mo-T (mg/L)	0.0001	0.0001	0.0%
Pb-T (mg/L)	0.0001	0.0001	0.0%
Sb-T (mg/L)	0.0001	0.0001	0.0%
Se-T (mg/L)	0.0001	< 0.0001	0.0%
Sr-T (mg/L)	0.0247	0.0246	0.4%
Tl-T (mg/L)	0.0001	0.0001	0.0%
U--T (mg/L)	0.000001	0.000001	0.0%
V--T (mg/L)	0.0005	0.0005	0.0%
Zn-T (mg/L)	0.0004	0.0008	**66.7%**

*Bold numbers denote exceedences of acceptable relative percent difference limits

Table 27. Relative percent differences between duplicate samples collected at Site 0121580 on March 21, 2005.

Parameter	Sample #1	Sample #2	Relative % Difference*
Ca-D (mg/L)	5.2	5.18	0.4%
Carbon Dissolved Organic (mg/L)	3.5	3.5	0.0%
Coli:Fec (CFU/100mL)	40	44	9.5%
E Coli (CFU/100mL)	31	35	12.1%
Hardness Total (D) (mg/L)	17	16	6.1%
Mg-D (mg/L)	0.88	0.86	2.3%
Nitrate (NO3) Dissolved (mg/L)	0.1	0.09	10.5%
Nitrate + Nitrite Diss. (mg/L)	0.1	0.09	10.5%
Nitrogen - Nitrite Diss. (mg/L)	0.002	0.003	**40.0%**
Ortho-Phosphate Dissolved (mg/L)	0.003	0.003	0.0%
Phosphorus Tot. Dissolved (mg/L)	0.007	0.008	13.3%
Residue Non-filterable (mg/L)	3	3	0.0%
Specific Conductance (μS/cm)	49	51	4.0%
Turbidity (NTU)	2.3	2	14.0%
UV Absorbance 250nm (AU/cm)	0.16	0.16	0.0%
UV Absorbance 254nm (AU/cm)	0.16	0.16	0.0%
UV Absorbance 310nm (AU/cm)	0.08	0.08	0.0%
UV Absorbance 340nm (AU/cm)	0.05	0.05	0.0%
UV Absorbance 360nm (AU/cm)	0.04	0.04	0.0%
UV Absorbance 365nm (AU/cm)	0.03	0.03	0.0%
pH (pH units)	6.8	7.4	8.5%

*Bold numbers denote exceedences of acceptable relative percent difference limits

Table 28. Relative percent differences between duplicate samples collected at Site 0121580 on July 26, 2005**.**

Parameter	Sample #1	Sample #2	Relative % Difference*
Ca-D (mg/L)	13.2	13.4	1.5%
Carbon Dissolved Organic (mg/L)	0.8	0.8	0.0%
Coli:Fec (CFU/100mL)	38	45	16.9%
E Coli (CFU/100mL)	82	87	5.9%
Hardness Total (D) (mg/L)	40	40	0.0%
Mg-D (mg/L)	1.69	1.65	2.4%
Nitrate (NO3) Dissolved (mg/L)	< 0.02	< 0.02	0.0%
Nitrate + Nitrite Diss. (mg/L)	0.017	0.018	5.7%
Nitrogen - Nitrite Diss. (mg/L)	< 0.002	< 0.002	0.0%
Ortho-Phosphate Dissolved (mg/L)	0.005	0.006	18.2%
Phosphorus Tot. Dissolved (mg/L)	< 0.002	0.004	**66.7%**
Residue Non-filterable (mg/L)	< 1	< 1	0.0%
Specific Conductance (μS/cm)	107	109	1.9%
Turbidity (NTU)	0.4	0.3	**28.6%**
UV Absorbance 250nm (AU/cm)	0.03	0.02	**40.0%**
UV Absorbance 254nm (AU/cm)	0.03	0.02	**40.0%**
UV Absorbance 310nm (AU/cm)	0.01	< 0.01	0.0%
UV Absorbance 340nm (AU/cm)	< 0.01	< 0.01	0.0%
UV Absorbance 360nm (AU/cm)	< 0.01	< 0.01	0.0%
UV Absorbance 365nm (AU/cm)	< 0.01	< 0.01	0.0%
pH (pH units)	7.6	7.4	2.7%

*Bold numbers denote exceedences of acceptable relative percent difference limits

Table 29. Relative percent differences between duplicate samples collected at Site 0121580 on October 11, 2005.

Parameter	Sample #1	Sample #2	Relative % Difference*
Ca-D (mg/L)	11.2	11.2	0.0%
Carbon Dissolved Organic (mg/L)	1.3	1.7	**26.7%**
Coli:Fec (CFU/100mL)	13	20	**42.4%**
E Coli (CFU/100mL)	14	12	15.4%
Hardness Total (D) (mg/L)	33	33	0.0%
Mg-D (mg/L)	1.16	1.16	0.0%
Nitrate (NO3) Dissolved (mg/L)	< 0.007	< 0.01	**35.3%**
Nitrate + Nitrite Diss. (mg/L)	0.009	0.012	**28.6%**
Nitrogen - Nitrite Diss. (mg/L)	< 0.002	< 0.002	0.0%
Ortho-Phosphate Dissolved (mg/L)	0.003	0.003	0.0%
Phosphorus Tot. Dissolved (mg/L)	< 0.002	< 0.002	0.0%
Residue Non-filterable (mg/L)	1	1	0.0%
Specific Conductance (μS/cm)	93	93	0.0%
Turbidity (NTU)	0.7	0.7	0.0%
UV Absorbance 250nm (AU/cm)	0.54	1	**59.7%**
UV Absorbance 254nm (AU/cm)	0.5	0.96	**63.0%**
UV Absorbance 310nm (AU/cm)	0.41	0.66	**46.7%**
UV Absorbance 340nm (AU/cm)	0.41	0.57	**32.7%**
UV Absorbance 360nm (AU/cm)	0.35	0.55	**44.4%**
UV Absorbance 365nm (AU/cm)	0.37	0.54	**37.4%**
pH (pH units)	7.6	7.3	4.0%

*Bold numbers denote exceedences of acceptable relative percent difference limits

Table 30. Analysis of results for blank samples collected at Site 0121580 on November 9, 2004.

Parameter	Blank*
Ag-T (mg/L)	< 0.0001
Al-T (mg/L)	**0.0015**
As-T (mg/L)	< 0.0001
B--T (mg/L)	< 0.0001
Ba-T (mg/L)	< 0.0001
Be-T (mg/L)	< 0.0001
Bi-T (mg/L)	< 0.0001
Ca-D (mg/L)	< 0.05
Carbon Dissolved Organic (mg/L)	< 0.5
Cd-T (mg/L)	0.0001
Co-T (mg/L)	< 0.0001
Coli:Fec (CFU/100mL)	< 1
Cr-T (mg/L)	< 0.0001
Cu-T (mg/L)	0.0001
E Coli (CFU/100mL)	< 1
Fe-T (mg/L)	0.006
Li-T (mg/L)	< 0.0002
Mg-D (mg/L)	< 0.05
Mn-T (mg/L)	< 0.0001
Mo-T (mg/L)	< 0.0001
Nitrate + Nitrite Diss. (mg/L)	< 0.002
Nitrogen - Nitrite Diss. (mg/L)	< 0.002
Ortho-Phosphate Dissolved (mg/L)	0.003
Pb-T (mg/L)	< 0.0001
Phosphorus Tot. Dissolved (mg/L)	< 0.002
Residue Non-filterable (mg/L)	< 1
Sb-T (mg/L)	< 0.0001
Se-T (mg/L)	< 0.0001
Specific Conductance (μS/cm)	1
Sr-T (mg/L)	< 0.0001
Tl-T (mg/L)	< 0.0001
Turbidity (NTU)	0.1
U--T (mg/L)	< 0.000001
UV Absorbance 250nm (AU/cm)	0.01
UV Absorbance 254nm (AU/cm)	0.01
UV Absorbance 310nm (AU/cm)	< 0.01
UV Absorbance 340nm (AU/cm)	< 0.01
UV Absorbance 360nm (AU/cm)	< 0.01
UV Absorbance 365nm (AU/cm)	< 0.01
V--T (mg/L)	0.0001
Zn-T (mg/L)	< 0.0001
pH (pH units)	6

*Bold numbers represent detection limit exceedences.

Table 31. Analysis of results for blank samples collected at Site 0121580 on March 21, 2005.

Parameter	Blank*
Ca-D (mg/L)	< 0.05
Carbon Dissolved Organic (mg/L)	< 0.5
Coli:Fec (CFU/100mL)	< 1
E Coli (CFU/100mL)	< 1
Mg-D (mg/L)	< 0.05
Nitrate (NO3) Dissolved (mg/L)	< 0.02
Nitrate + Nitrite Diss. (mg/L)	< 0.002
Nitrogen - Nitrite Diss. (mg/L)	< 0.002
Ortho-Phosphate Dissolved (mg/L)	< 0.001
Phosphorus Tot. Dissolved (mg/L)	< 0.002
Specific Conductance (μS/cm)	2
Turbidity (NTU)	< 0.1
UV Absorbance 250nm (AU/cm)	< 0.01
UV Absorbance 254nm (AU/cm)	< 0.01
UV Absorbance 310nm (AU/cm)	< 0.01
UV Absorbance 340nm (AU/cm)	< 0.01
UV Absorbance 360nm (AU/cm)	< 0.01
UV Absorbance 365nm (AU/cm)	< 0.01
pH (pH units)	7.5

*Bold numbers represent detection limit exceedences.

Table 32. Analysis of results for blank samples collected at Site 0121580 on October 11, 2005.

Parameter	Blank*
Ca-D (mg/L)	< 0.05
Carbon Dissolved Organic (mg/L)	< 0.5
Coli:Fec (CFU/100mL)	< 1
E Coli (CFU/100mL)	< 1
Mg-D (mg/L)	< 0.05
Nitrate + Nitrite Diss. (mg/L)	< 0.002
Nitrogen - Nitrite Diss. (mg/L)	< 0.002
Ortho-Phosphate Dissolved (mg/L)	< 0.001
Phosphorus Tot. Dissolved (mg/L)	< 0.002
Residue Non-filterable (mg/L)	< 1
Specific Conductance (μS/cm)	1
Turbidity (NTU)	< 0.1
UV Absorbance 250nm (AU/cm)	**0.65**
UV Absorbance 254nm (AU/cm)	**0.63**
UV Absorbance 310nm (AU/cm)	**0.58**
UV Absorbance 340nm (AU/cm)	**0.58**
UV Absorbance 360nm (AU/cm)	**0.55**
UV Absorbance 365nm (AU/cm)	**0.63**
pH (pH units)	6.3

***Bold numbers represent detection limit exceedences.**

APPENDIX III.

Table 33. Summary of turbidity events >0.5 hours in duration measured at the automated station.

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
23/05/2003	15:45	411.25	0.75	5.3	1.2	3.9	2.3
23/05/2003	17:00	0.75	0.5	5.7	0.6	3.2	3.6
23/05/2003	17:45	0.5	0.75	10	4.5	7.8	2.9
23/05/2003	19:00	0.75	0.75	9.8	4	7.5	3.1
23/05/2003	20:00	0.5	0.5	15.5	1.4	8.5	10.0
23/05/2003	20:45	0.5	1	12.3	4.9	8.3	3.0
23/05/2003	22:30	1	1.5	16.1	1.2	7.4	4.9
24/05/2003	0:00	0.25	0.5	10.3	0.4	5.4	7.0
24/05/2003	0:30	0.25	0.75	24.4	1.2	16.5	13.2
24/05/2003	1:45	0.75	0.5	8.7	0.9	4.8	5.5
24/05/2003	2:30	0.5	0.5	10.4	0.6	5.5	6.9
24/05/2003	3:00	0.25	0.5	31.4	1.7	16.6	21.0
24/05/2003	4:15	1	0.75	28.1	4.8	17.7	11.8
24/05/2003	5:00	0.25	1	20.8	3.6	12.2	9.0
24/05/2003	7:15	1.5	0.5	6.8	0.9	3.9	4.2
24/05/2003	7:45	0.25	0.5	29.1	4.7	16.9	17.3
24/05/2003	9:15	1.25	1.25	61.3	2	26.6	26.8
24/05/2003	10:30	0.25	0.75	24	1.1	13.2	11.5
24/05/2003	11:15	0.25	1.25	53.4	1.9	28.5	22.9
24/05/2003	12:30	0.25	0.5	44	1.8	22.9	29.8
24/05/2003	15:45	3	1	160.2	0.7	44.6	77.2
24/05/2003	17:45	1.25	0.5	6.7	1.4	4.1	3.7
24/05/2003	18:15	0.25	0.5	60.9	3.6	32.3	40.5
25/05/2003	0:30	6	0.5	9.1	1.4	5.3	5.4
25/05/2003	1:00	0.25	0.5	6.4	1	3.7	3.8
25/05/2003	1:30	0.25	0.5	7.1	3.8	5.5	2.3
25/05/2003	2:15	0.5	1.25	46	1.9	20.7	19.1
25/05/2003	3:45	0.5	0.75	640.1	1.3	301.8	321.1
25/05/2003	4:30	0.25	0.75	262.6	4	108.0	136.5
25/05/2003	5:15	0.25	0.75	35	1.7	14.8	17.7
25/05/2003	6:15	0.5	0.5	7.2	0.9	4.1	4.5
25/05/2003	7:00	0.5	0.75	121.7	0.9	43.0	68.2
25/05/2003	8:00	0.5	0.5	264.7	2.1	133.4	185.7
25/05/2003	9:00	0.75	1.25	1375.7	0.6	1098.9	614.0
25/05/2003	12:30	2.5	1	80.3	0.5	39.9	33.7
25/05/2003	13:30	0.25	0.5	1386.5	1.2	693.9	979.6
25/05/2003	14:00	0.25	0.75	72.6	0.6	26.5	40.1
25/05/2003	15:45	1.25	0.5	12.5	1.2	6.9	8.0
25/05/2003	16:15	0.25	0.5	45.2	1	23.1	31.3
25/05/2003	17:00	0.5	0.5	11.5	0.7	6.1	7.6
30/05/2003	11:15	114	0.5	5.9	1.2	3.6	3.3
30/05/2003	17:45	6.25	0.5	6.1	0.3	3.2	4.1
30/05/2003	18:30	0.5	0.5	9.8	3.7	6.8	4.3

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
30/05/2003	20:15	1.5	0.75	8.4	0.8	5.8	4.3
30/05/2003	21:15	0.5	0.5	8.7	1.8	5.3	4.9
31/05/2003	11:15	13.75	0.75	9.4	1	5.8	4.3
31/05/2003	12:15	0.5	0.5	7.1	0.8	4.0	4.5
31/05/2003	13:15	0.75	0.75	6.5	3.4	5.3	1.6
31/05/2003	14:15	0.5	0.5	5.9	4.3	5.1	1.1
31/05/2003	14:45	0.25	0.5	6.5	4.7	5.6	1.3
31/05/2003	15:15	0.25	0.5	5.4	2.7	4.1	1.9
31/05/2003	16:45	1.25	0.75	5.8	2	4.5	2.2
31/05/2003	17:45	0.5	0.5	6.1	1.8	4.0	3.0
31/05/2003	18:30	0.5	1	7.6	2.3	5.5	2.3
31/05/2003	19:45	0.5	0.75	8.7	3.2	5.7	2.8
31/05/2003	20:45	0.5	1.5	8.4	4.8	7.1	1.5
31/05/2003	22:30	0.5	0.5	9.7	3.7	6.7	4.2
31/05/2003	23:00	0.25	0.5	7.5	4.5	6.0	2.1
31/05/2003	23:45	0.5	0.5	6.4	4.2	5.3	1.6
01/06/2003	0:15	0.25	1.25	10.5	2.8	6.2	2.8
01/06/2003	1:30	0.25	0.75	6.1	5	5.4	0.6
01/06/2003	2:15	0.25	1	5.6	3.3	4.9	1.1
01/06/2003	3:15	0.25	1	12.3	3.3	8.8	4.1
01/06/2003	4:30	0.5	1	6.1	4.9	5.4	0.5
01/06/2003	6:30	1.25	0.5	6	4.2	5.1	1.3
01/06/2003	8:15	1.5	0.5	5.4	2.5	4.0	2.1
01/06/2003	9:45	1.25	0.75	6.8	4.3	5.9	1.4
01/06/2003	10:30	0.25	0.75	6.4	5	5.9	0.8
01/06/2003	11:15	0.25	0.5	5.9	4.5	5.2	1.0
01/06/2003	12:00	0.5	0.75	5.9	4.8	5.3	0.6
01/06/2003	12:45	0.25	0.5	6.7	3.6	5.2	2.2
01/06/2003	14:45	1.75	0.5	6.7	4.7	5.7	1.4
01/06/2003	15:30	0.5	0.5	5.1	4.2	4.7	0.6
01/06/2003	16:15	0.5	0.5	5.9	3	4.5	2.1
01/06/2003	20:30	4	0.5	6.5	0.7	3.6	4.1
01/06/2003	21:15	0.5	0.75	5.2	1.3	3.9	2.2
01/06/2003	22:15	0.5	1.5	7.2	4	6.0	1.2
01/06/2003	23:45	0.25	1.5	7.5	2.2	5.9	2.0
02/06/2003	1:15	0.25	2.5	8	4.8	6.6	0.9
02/06/2003	4:15	0.75	0.5	6.1	4.2	5.2	1.3
02/06/2003	4:45	0.25	0.75	6.1	4.5	5.3	0.8
02/06/2003	5:30	0.25	1.5	7	4.2	5.9	1.1
02/06/2003	7:45	1	0.75	6.2	4.7	5.5	0.8
02/06/2003	8:30	0.25	1	7.4	5	6.2	1.0
02/06/2003	9:30	0.25	5.25	9.6	4.6	7.9	1.1
02/06/2003	14:45	0.25	17.5	48.8	0.5	15.7	10.0
03/06/2003	8:15	0.25	0.75	23.4	0.4	15.0	12.7
03/06/2003	9:00	0.25	2.25	20.4	5	11.1	5.3
03/06/2003	11:30	0.5	1.25	34.4	0.7	17.4	12.7
03/06/2003	12:45	0.25	2	54.6	3.6	19.0	16.7
03/06/2003	14:45	0.25	0.5	5.1	2.9	4.0	1.6
03/06/2003	15:30	0.5	3.75	24.2	5	14.9	6.4
03/06/2003	19:15	0.25	1.5	34.3	0.3	18.2	13.0

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
03/06/2003	21:00	0.5	5	40.9	0.3	16.7	9.0
04/06/2003	2:00	0.25	0.5	36.8	1.8	19.3	24.7
04/06/2003	2:30	0.25	2.75	35.5	4.2	24.4	10.0
04/06/2003	5:15	0.25	3.75	63.7	3.1	28.6	15.2
04/06/2003	9:00	0.25	2.25	32.1	2.5	19.2	9.2
04/06/2003	11:15	0.25	5.75	59.2	2.5	25.4	13.5
04/06/2003	17:15	0.5	0.5	5.1	3.9	4.5	0.8
04/06/2003	19:00	1.5	0.5	14.5	2.2	8.4	8.7
04/06/2003	19:30	0.25	3.75	18.8	5	9.7	4.6
04/06/2003	23:15	0.25	2.75	18.3	3.1	10.1	3.8
05/06/2003	2:00	0.25	0.5	10.3	4.9	7.6	3.8
05/06/2003	2:30	0.25	2.75	16.6	1.2	9.2	4.3
05/06/2003	5:15	0.25	0.5	7.2	2.6	4.9	3.3
05/06/2003	6:00	0.5	1.5	33.6	3.4	14.1	10.4
05/06/2003	7:30	0.25	0.75	9.7	3.6	7.0	3.1
05/06/2003	8:15	0.25	0.75	9.7	3.7	6.7	3.0
05/06/2003	9:00	0.25	0.5	9.8	3.9	6.9	4.2
05/06/2003	9:30	0.25	1.5	19	4.4	9.9	5.6
05/06/2003	11:15	0.5	1.25	11	4.2	7.5	2.7
05/06/2003	12:30	0.25	1.5	19.2	1.6	12.1	6.5
05/06/2003	14:15	0.5	1	11.5	1	6.5	4.3
05/06/2003	15:15	0.25	1.25	36.2	1.5	13.8	13.3
05/06/2003	16:45	0.5	0.75	7	4.1	5.8	1.5
05/06/2003	17:30	0.25	0.5	5.7	3.8	4.8	1.3
05/06/2003	19:00	1.25	0.5	9	3.7	6.4	3.7
05/06/2003	19:45	0.5	0.75	27.3	0.7	12.0	13.8
05/06/2003	20:30	0.25	1	8.6	2	6.0	2.9
05/06/2003	21:45	0.5	3.25	12.4	3.9	7.0	2.3
06/06/2003	1:30	0.75	0.5	7	0.7	3.9	4.5
06/06/2003	2:30	0.75	1.75	37.7	4.6	16.5	12.9
06/06/2003	4:15	0.25	1.5	9.2	3.9	6.3	1.9
06/06/2003	6:00	0.5	0.75	18.8	0.5	8.5	9.4
06/06/2003	6:45	0.25	0.5	9.3	0.5	4.9	6.2
06/06/2003	7:15	0.25	0.5	28.2	2.8	15.5	18.0
06/06/2003	7:45	0.25	0.75	7.3	2.1	4.9	2.6
06/06/2003	8:30	0.25	0.5	6.4	5	5.7	1.0
06/06/2003	9:00	0.25	0.5	10.9	4.3	7.6	4.7
06/06/2003	9:30	0.25	0.5	8	3.5	5.8	3.2
06/06/2003	10:30	0.75	1.25	15.2	3.7	10.0	4.6
06/06/2003	11:45	0.25	1.5	37.8	4.2	12.6	12.7
06/06/2003	13:15	0.25	0.5	11.4	2.5	7.0	6.3
06/06/2003	14:00	0.5	0.5	6.8	1	3.9	4.1
06/06/2003	14:30	0.25	2.5	10.6	1.7	7.1	2.5
06/06/2003	17:15	0.5	1.25	14.5	4.5	9.1	3.8
06/06/2003	18:30	0.25	0.5	5.2	4.7	5.0	0.4
06/06/2003	20:00	1.25	0.5	26.3	4.5	15.4	15.4
06/06/2003	21:15	1	0.5	5.5	3.6	4.6	1.3
06/06/2003	21:45	0.25	0.5	7.6	4.2	5.9	2.4
06/06/2003	23:30	1.5	0.5	5.1	1.5	3.3	2.5
07/06/2003	1:30	1.75	0.5	124.3	3.1	63.7	85.7

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
07/06/2003	2:00	0.25	0.75	199.8	0.7	68.6	113.6
07/06/2003	2:45	0.25	0.75	68.6	0.7	26.3	36.9
07/06/2003	3:30	0.25	0.5	52.7	1.3	27.0	36.3
07/06/2003	4:00	0.25	0.5	398.9	0.6	199.8	281.6
07/06/2003	13:30	9.25	0.5	5.1	2	3.6	2.2
07/06/2003	14:45	1	0.75	5.4	2.5	4.4	1.6
07/06/2003	17:15	2	0.5	6.8	3	4.9	2.7
07/06/2003	17:45	0.25	0.75	6.5	4.7	5.8	1.0
07/06/2003	19:45	1.5	0.75	8.1	4.7	6.4	1.7
07/06/2003	20:45	0.5	0.5	8.1	4.7	6.4	2.4
07/06/2003	21:15	0.25	0.5	7.2	4.3	5.8	2.1
07/06/2003	21:45	0.25	1	9.1	1.2	6.4	3.5
07/06/2003	22:45	0.25	2	9.7	3.9	7.8	1.8
08/06/2003	1:00	0.5	0.5	7.1	2.1	4.6	3.5
08/06/2003	1:30	0.25	0.5	7.3	2.3	4.8	3.5
08/06/2003	2:00	0.25	0.75	9.5	4.8	6.8	2.4
08/06/2003	2:45	0.25	2.25	10.8	4.7	7.9	2.1
08/06/2003	5:45	1	10.25	18.6	4.6	10.6	3.0
08/06/2003	16:00	0.25	3.5	15	4.8	11.0	3.6
08/06/2003	19:30	0.25	0.75	15	4.5	10.2	5.3
08/06/2003	20:15	0.25	13	30.5	4.4	17.2	6.0
09/06/2003	9:15	0.25	18.5	37.8	4.5	24.3	7.3
10/06/2003	10:45	7.25	0.75	10.6	2.5	6.3	4.1
10/06/2003	11:30	0.25	0.5	6.1	1.6	3.9	3.2
10/06/2003	12:00	0.25	0.5	9.5	2.7	6.1	4.8
11/06/2003	13:15	25	1.25	15.6	0.1	7.5	5.7
11/06/2003	14:45	0.5	0.5	27.2	0.4	13.8	19.0
11/06/2003	15:30	0.5	0.5	6.7	0.1	3.4	4.7
11/06/2003	16:15	0.5	1	25.2	0.3	15.3	10.7
11/06/2003	17:15	0.25	1	62.7	3	19.8	28.7
11/06/2003	18:30	0.5	0.5	108.8	0.1	54.5	76.9
11/06/2003	19:00	0.25	0.5	12	0.4	6.2	8.2
11/06/2003	20:00	0.75	0.75	47.1	4	18.9	24.4
11/06/2003	20:45	0.25	0.5	8.1	1.7	4.9	4.5
11/06/2003	21:45	0.75	0.5	9.8	1.4	5.6	5.9
11/06/2003	23:00	1	0.5	15.5	1.4	8.5	10.0
12/06/2003	5:15	6	1	11.8	2	6.5	4.0
12/06/2003	6:15	0.25	0.5	6.1	3.9	5.0	1.6
12/06/2003	6:45	0.25	0.5	8	4.3	6.2	2.6
12/06/2003	7:15	0.25	0.5	6.7	0.4	3.6	4.5
03/07/2003	14:15	145.25	2.5	1470.7	2.9	1322.4	463.6
08/09/2003	3:00	680.5	0.5	14.2	0.9	7.6	9.4
30/09/2003	9:30	532.5	0.5	7.7	0.6	4.2	5.0
08/10/2003	19:30	201.5	7	1273.6	3.3	60.4	238.5
09/10/2003	2:30	0.25	1.25	26.7	3.9	13.5	9.1
09/10/2003	3:45	0.25	1.25	37.1	4	14.5	13.2
09/10/2003	6:00	1.25	2	14.7	2.3	9.2	4.1
09/10/2003	8:00	0.25	0.5	6.2	3	4.6	2.3
09/10/2003	9:00	0.75	1.25	1083.6	4.2	268.2	459.3
09/10/2003	10:30	0.5	0.5	217.4	1.9	109.7	152.4

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
09/10/2003	11:00	0.25	1.25	18.1	1.8	8.7	5.9
09/10/2003	12:15	0.25	0.75	74.5	3.7	28.0	40.3
09/10/2003	13:15	0.5	1	10.3	1.8	6.7	3.6
09/10/2003	15:30	1.5	0.75	15.9	4.5	8.7	6.3
09/10/2003	16:45	0.75	1	14.8	2.4	8.0	5.2
09/10/2003	18:30	1	1	9.9	5	7.4	2.6
09/10/2003	19:30	0.25	0.75	5.5	4.3	5.0	0.6
09/10/2003	20:15	0.25	1	92.7	4	26.8	44.0
09/10/2003	21:15	0.25	2.5	39.9	3.3	21.2	13.9
10/10/2003	0:15	0.75	0.5	5.8	4.9	5.4	0.6
10/10/2003	0:45	0.25	1	8.3	4.4	6.7	1.7
10/10/2003	1:45	0.25	0.5	6.4	4	5.2	1.7
10/10/2003	10:00	8	0.5	13.9	2.7	8.3	7.9
10/10/2003	12:15	2	0.5	7.6	3.8	5.7	2.7
10/10/2003	13:00	0.5	0.5	5.6	4.7	5.2	0.6
10/10/2003	13:30	0.25	0.75	7.5	4.7	5.9	1.4
10/10/2003	15:45	1.75	1	37.4	4.8	21.4	18.3
12/10/2003	1:00	32.5	1.5	11.3	5	7.4	2.8
12/10/2003	2:30	0.25	17.25	167.4	4.5	30.7	30.3
12/10/2003	20:00	0.5	0.5	5.1	5	5.1	0.1
13/10/2003	7:30	11.25	0.5	5.7	2.3	4.0	2.4
16/10/2003	7:15	70	5.5	18.4	4.3	12.8	3.6
16/10/2003	12:45	0.25	84.5	342.1	0	36.2	28.6
20/10/2003	1:45	0.75	0.5	5.4	4.7	5.1	0.5
20/10/2003	3:00	1	0.5	5.4	4.8	5.1	0.4
20/10/2003	4:45	1.5	0.5	5.1	3.9	4.5	0.8
20/10/2003	7:45	2.75	22.5	29.6	5	14.5	7.2
21/10/2003	6:15	0.25	1.25	5.4	4.8	5.1	0.2
21/10/2003	8:30	1.25	0.5	5.8	4.7	5.3	0.8
16/11/2003	14:45	630	2	10.1	5	7.6	1.9
16/11/2003	18:45	2.25	0.5	5.3	4.7	5.0	0.4
18/11/2003	1:00	30	13.25	28.8	4	16.0	7.5
18/11/2003	14:15	0.25	0.75	10.1	5	7.1	2.7
18/11/2003	15:00	0.25	1.25	11.6	4.9	8.3	3.0
18/11/2003	16:15	0.25	0.5	5.3	4.8	5.1	0.4
18/11/2003	16:45	0.25	0.75	10.1	4.5	7.3	2.8
18/11/2003	17:30	0.25	21.75	34.2	4.7	14.6	5.6
28/11/2003	8:30	208.25	19.75	38.8	4.9	18.1	10.6
29/11/2003	4:30	0.5	0.5	5.3	4.3	4.8	0.7
05/12/2003	11:30	150.75	4.5	17	4.7	7.3	3.2
05/12/2003	16:15	0.5	0.75	5.6	4.9	5.2	0.4
05/12/2003	17:00	0.25	0.5	5.7	4.8	5.3	0.6
05/12/2003	18:30	1.25	0.75	5.4	4.8	5.2	0.3
05/12/2003	19:15	0.25	13.25	20.2	5	11.5	4.8
16/12/2003	7:45	239.5	19.5	24.1	4.5	12.0	5.5
17/12/2003	3:15	0.25	0.5	6.1	5	5.6	0.8
17/12/2003	3:45	0.25	0.5	5.1	5	5.1	0.1
18/12/2003	5:15	25.25	0.5	102.1	0.9	51.5	71.6
07/01/2004	17:15	491.75	4	16.2	5	10.3	3.8
07/01/2004	21:15	0.25	3	6.3	4.8	5.7	0.4

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
08/01/2004	1:00	1	59.5	126	4.7	14.9	11.6
10/01/2004	12:30	0.25	0.5	5.1	4.4	4.8	0.5
10/01/2004	13:30	0.75	0.5	6	4.4	5.2	1.1
12/01/2004	19:30	53.75	0.5	7.9	1.5	4.7	4.5
13/01/2004	15:00	19.25	0.5	5.2	4.2	4.7	0.7
13/01/2004	15:45	0.5	35	359.2	4.8	18.7	33.5
15/01/2004	2:45	0.25	0.5	5.3	5	5.2	0.2
15/01/2004	3:45	0.75	0.5	5.1	4.7	4.9	0.3
15/01/2004	4:15	0.25	1.25	8.1	4.7	6.4	1.5
15/01/2004	11:15	6	0.5	5.1	3.7	4.4	1.0
19/01/2004	6:00	90.5	0.5	37.5	0	18.8	26.5
29/01/2004	21:15	255	13.5	14.8	4.5	9.9	2.8
05/02/2004	18:45	152.25	0.5	27.6	0.1	13.9	19.4
10/02/2004	7:15	108.25	0.5	33	0.1	16.6	23.3
13/02/2004	5:45	70.25	0.5	18.9	0.1	9.5	13.3
15/02/2004	6:15	48.25	0.5	33.6	0.2	16.9	23.6
17/02/2004	4:45	46.25	0.5	22	2.8	12.4	13.6
17/02/2004	17:00	12	0.5	83.4	0.7	42.1	58.5
17/02/2004	21:45	4.5	0.5	6.5	0.6	3.6	4.2
19/02/2004	7:30	33.5	0.5	64.3	0.1	32.2	45.4
19/02/2004	18:00	10.25	0.5	24.4	2.4	13.4	15.6
19/02/2004	19:45	1.5	0.5	28.8	0	14.4	20.4
19/02/2004	22:15	2.25	0.5	12.2	0.3	6.3	8.4
22/02/2004	4:15	53.75	0.5	5.9	0	3.0	4.2
22/02/2004	16:00	11.5	1.5	19	3.2	11.3	5.8
23/02/2004	21:45	28.5	1.25	6.7	2.3	5.1	1.7
24/02/2004	9:45	11	0.75	5.9	4.8	5.3	0.6
25/02/2004	21:00	32.5	1	10.1	1.7	6.3	3.5
09/03/2004	12:30	302.75	1	7.9	4.3	6.2	1.7
18/03/2004	22:45	225.5	0.5	5.6	0.6	3.1	3.5
19/03/2004	4:00	5	0.5	126.8	0.6	63.7	89.2
19/03/2004	17:45	13.5	0.5	5.6	0.6	3.1	3.5
25/03/2004	18:45	144.75	0.5	7.1	5	6.1	1.5
25/03/2004	19:45	0.75	2.5	6.6	4.8	5.7	0.6
25/03/2004	22:30	0.5	2	7	5	5.8	0.7
26/03/2004	0:45	0.5	0.5	5.1	4.8	5.0	0.2
09/04/2004	2:45	337.75	0.5	10.5	5	7.8	3.9
09/04/2004	18:00	15	0.5	10.6	0.9	5.8	6.9
09/04/2004	22:30	4.25	0.5	5.9	2	4.0	2.8
11/04/2004	13:45	39	0.5	5.1	0	2.6	3.6
11/04/2004	17:30	3.5	0.5	14.1	2	8.1	8.6
11/04/2004	18:00	0.25	0.75	212	3.6	74.6	119.0
11/04/2004	19:00	0.5	0.5	5.8	3.9	4.9	1.3
11/04/2004	20:15	1	0.5	112	1.7	56.9	78.0
11/04/2004	23:30	3	0.5	5.3	0.6	3.0	3.3
12/04/2004	3:00	3.25	0.5	48.4	1.5	25.0	33.2
12/04/2004	4:45	1.5	0.5	20	0.2	10.1	14.0
12/04/2004	9:45	4.75	0.5	7.4	0.6	4.0	4.8
13/04/2004	1:45	15.75	0.5	62.3	0.2	31.3	43.9
13/04/2004	11:45	9.75	0.5	6.8	0.6	3.7	4.4

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
13/04/2004	18:45	6.75	0.5	19.8	0	9.9	14.0
14/04/2004	16:30	21.5	0.5	35.5	0.2	17.9	25.0
14/04/2004	17:15	0.5	0.75	56.2	1.2	26.7	27.7
14/04/2004	18:00	0.25	0.5	6.1	0.8	3.5	3.7
14/04/2004	19:15	1	0.5	19.7	0.7	10.2	13.4
14/04/2004	20:00	0.5	0.5	15.1	1	8.1	10.0
14/04/2004	20:30	0.25	0.5	17	1.2	9.1	11.2
14/04/2004	21:00	0.25	0.75	216.8	0.9	79.6	119.3
14/04/2004	22:30	1	0.5	9.9	0.5	5.2	6.6
14/04/2004	23:30	0.75	0.5	27.7	2.1	14.9	18.1
15/04/2004	0:00	0.25	0.75	27.5	1.8	11.5	13.9
15/04/2004	2:15	1.75	0.5	6	1.3	3.7	3.3
15/04/2004	2:45	0.25	0.5	5.3	1.5	3.4	2.7
15/04/2004	3:15	0.25	0.5	5.4	0.4	2.9	3.5
15/04/2004	4:00	0.5	0.75	35.7	0.3	21.8	18.9
15/04/2004	5:00	0.5	0.75	57	1.4	30.1	27.8
15/04/2004	6:30	1	0.5	6.1	0.9	3.5	3.7
15/04/2004	7:00	0.25	0.5	18.4	1.3	9.9	12.1
15/04/2004	7:30	0.25	0.5	5.1	0.7	2.9	3.1
15/04/2004	8:00	0.25	0.5	50.6	1.7	26.2	34.6
15/04/2004	9:45	1.5	0.5	5.6	0.4	3.0	3.7
15/04/2004	10:45	0.75	0.5	56.7	2	29.4	38.7
15/04/2004	11:15	0.25	0.5	7.8	2.4	5.1	3.8
15/04/2004	11:45	0.25	0.5	20.7	4	12.4	11.8
15/04/2004	13:15	1.25	0.75	19.7	0.3	9.8	9.7
15/04/2004	14:15	0.5	0.5	19.1	0.4	9.8	13.2
15/04/2004	15:00	0.5	0.5	12.3	4.7	8.5	5.4
15/04/2004	16:00	0.75	0.5	9	0.7	4.9	5.9
15/04/2004	17:45	1.5	0.5	22.4	0.6	11.5	15.4
15/04/2004	19:00	1	0.5	35.6	3.8	19.7	22.5
15/04/2004	20:15	1	0.5	6.1	1	3.6	3.6
15/04/2004	21:00	0.5	0.5	29.8	3.7	16.8	18.5
15/04/2004	22:30	1.25	0.5	27.3	0.9	14.1	18.7
15/04/2004	23:00	0.25	0.5	6.8	0.7	3.8	4.3
15/04/2004	23:45	0.5	0.5	29.7	1	15.4	20.3
16/04/2004	2:15	2.25	0.5	5.7	0.5	3.1	3.7
16/04/2004	2:45	0.25	0.75	59.8	0.4	23.3	32.0
16/04/2004	4:30	1.25	0.75	7.5	0.3	4.5	3.8
16/04/2004	6:15	1.25	0.5	18.6	1.9	10.3	11.8
16/04/2004	7:00	0.5	0.5	5.6	4	4.8	1.1
16/04/2004	8:15	1	0.5	10.4	1.2	5.8	6.5
16/04/2004	10:30	2	0.5	26.6	0.3	13.5	18.6
16/04/2004	11:30	0.75	0.5	20.3	0.9	10.6	13.7
16/04/2004	12:45	1	0.5	7	1.2	4.1	4.1
16/04/2004	13:30	0.5	1	52.2	2.6	26.9	26.3
16/04/2004	14:45	0.5	0.5	9.5	1.8	5.7	5.4
16/04/2004	15:30	0.5	0.5	7.3	0.5	3.9	4.8
16/04/2004	18:00	2.25	0.75	46.6	1.6	17.8	25.0
16/04/2004	18:45	0.25	0.5	8.2	0.7	4.5	5.3
16/04/2004	19:45	0.75	0.5	7.8	0.8	4.3	4.9

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
16/04/2004	21:15	1.25	0.5	41.1	1.5	21.3	28.0
16/04/2004	23:15	1.75	0.75	300.2	0.2	122.4	157.5
17/04/2004	0:15	0.5	0.5	7.2	0.1	3.7	5.0
17/04/2004	1:00	0.5	0.5	5.4	0.4	2.9	3.5
17/04/2004	2:00	0.75	0.75	38.6	2	15.4	20.2
17/04/2004	3:45	1.25	0.75	28.1	0.8	11.5	14.6
17/04/2004	4:30	0.25	0.5	13.1	0.5	6.8	8.9
17/04/2004	5:30	0.75	0.5	24	1.5	12.8	15.9
17/04/2004	6:30	0.75	1	119.4	0.4	41.6	55.0
17/04/2004	7:45	0.5	0.75	7	0.6	4.6	3.5
17/04/2004	8:30	0.25	0.75	49.8	0.4	25.5	24.7
17/04/2004	9:30	0.5	0.5	24.8	3.9	14.4	14.8
17/04/2004	10:00	0.25	1.25	92.2	1.2	23.8	38.4
17/04/2004	13:45	2.75	0.5	31	1.9	16.5	20.6
17/04/2004	14:15	0.25	0.75	8.7	0.3	5.2	4.4
17/04/2004	15:00	0.25	0.75	19.2	1.2	9.0	9.2
17/04/2004	16:00	0.5	0.5	110.4	0.5	55.5	77.7
17/04/2004	16:30	0.25	0.5	7.8	0.4	4.1	5.2
17/04/2004	17:00	0.25	0.5	11.7	3.6	7.7	5.7
17/04/2004	17:30	0.25	0.5	41.6	1.5	21.6	28.4
17/04/2004	18:30	0.75	1	21.4	0.4	9.9	8.8
17/04/2004	19:30	0.25	0.75	29.6	1.9	12.3	15.1
17/04/2004	20:15	0.25	0.75	9.3	1.3	5.4	4.0
17/04/2004	21:15	0.5	0.75	47.4	0.7	19.4	24.7
17/04/2004	22:00	0.25	0.75	6.8	0.9	4.3	3.0
17/04/2004	22:45	0.25	0.5	7.9	1.5	4.7	4.5
17/04/2004	23:30	0.5	0.75	39.2	3.4	16.3	19.9
18/04/2004	1:30	1.5	0.75	47.1	3.1	18.6	24.7
18/04/2004	2:30	0.5	2	1120.6	0.4	570.0	587.7
18/04/2004	4:45	0.5	0.5	57.7	0.3	29.0	40.6
18/04/2004	5:45	0.75	0.75	55.9	0.4	21.4	30.1
18/04/2004	6:30	0.25	1	76.9	2.9	23.9	35.5
18/04/2004	8:00	0.75	0.75	1118.4	0.6	391.7	629.9
18/04/2004	9:00	0.5	0.5	43.3	0.4	21.9	30.3
18/04/2004	9:45	0.5	0.75	510.1	4.8	288.2	258.2
18/04/2004	10:45	0.5	1.25	73.1	0.2	20.2	29.9
18/04/2004	12:00	0.25	0.5	122.2	1.2	61.7	85.6
18/04/2004	13:00	0.75	0.75	56.8	0.3	29.7	28.3
18/04/2004	13:45	0.25	1	90.9	2	27.9	42.1
18/04/2004	14:45	0.25	0.75	53.7	2.8	29.9	25.6
18/04/2004	15:30	0.25	1.25	59.2	0.1	26.5	24.2
18/04/2004	16:45	0.25	1.25	106.4	2.7	27.7	44.1
18/04/2004	18:45	1	3	1128.4	0.8	307.3	495.6
18/04/2004	21:45	0.25	1.5	1126.2	1	395.4	566.2
18/04/2004	23:15	0.25	0.5	56.8	0.1	28.5	40.1
18/04/2004	23:45	0.25	2.5	80.2	0.6	33.0	30.9
19/04/2004	2:15	0.25	1.5	362.7	2.6	127.3	142.1
19/04/2004	4:00	0.5	2.5	1119.2	4.7	604.0	547.4
19/04/2004	6:45	0.5	0.5	1117.7	2.7	560.2	788.4
19/04/2004	8:15	1.25	1.5	146.7	0.3	44.5	58.2

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
19/04/2004	9:45	0.25	0.75	103.5	5	63.2	51.6
19/04/2004	10:30	0.25	2	1133.1	0.2	197.8	384.3
19/04/2004	12:30	0.25	6.25	1140.9	1.3	713.3	409.9
19/04/2004	19:00	0.5	3.25	1135.8	1.5	510.0	516.7
19/04/2004	22:15	0.25	2.5	1130.6	2.2	470.2	552.7
20/04/2004	0:45	0.25	1	201.1	1.9	62.5	93.8
20/04/2004	2:15	0.75	2.5	1126.8	0.7	605.9	532.8
20/04/2004	4:45	0.25	1.25	1124.3	0.9	466.9	600.7
20/04/2004	6:00	0.25	1	43.3	0.8	15.1	19.2
20/04/2004	7:00	0.25	0.75	83.2	2.7	50.0	42.0
20/04/2004	8:00	0.5	1.75	175.9	1	80.4	70.6
20/04/2004	9:45	0.25	3.75	1127.4	4.4	150.8	289.5
20/04/2004	13:30	0.25	2.75	1129.2	1.6	132.2	331.5
20/04/2004	16:15	0.25	1.5	44.8	4.5	14.1	15.3
20/04/2004	17:45	0.25	0.75	55.2	1.5	21.2	29.5
20/04/2004	18:30	0.25	0.75	371.2	0.7	167.6	188.0
20/04/2004	19:15	0.25	8.25	1128.9	3.5	638.0	504.6
21/04/2004	3:30	0.25	4.5	1121.6	1.7	518.3	483.9
21/04/2004	8:00	0.25	2.25	1123.7	1.2	649.1	563.7
21/04/2004	10:30	0.5	1.5	1134.4	0.5	626.7	560.7
21/04/2004	12:15	0.5	9.75	1152.8	0.8	591.8	438.9
21/04/2004	22:00	0.25	9.25	1137.3	4.3	790.1	374.6
22/04/2004	7:15	0.25	8.25	1147.8	1.4	766.8	417.0
22/04/2004	15:30	0.25	34.75	1153.8	1.8	787.9	354.4
24/04/2004	2:30	0.5	1.75	1112.8	0.4	496.1	577.4
24/04/2004	4:15	0.25	4.5	1128.8	0.6	471.7	542.1
24/04/2004	9:00	0.5	1.25	19.7	2.3	11.7	6.7
24/04/2004	10:45	0.75	1.25	1136.9	1.2	234.3	504.6
24/04/2004	12:15	0.5	1	1140.5	4.7	298.1	561.7
24/04/2004	13:15	0.25	1.75	1147.3	0.4	754.2	536.7
24/04/2004	15:00	0.25	1.75	1109	0.6	642.3	457.0
24/04/2004	16:45	0.25	11.25	1151	0	864.5	404.3
25/04/2004	4:00	0.25	45.75	1168.5	0.9	822.2	397.5
28/04/2004	9:45	32.25	0.5	5.4	0	2.7	3.8
29/04/2004	2:00	16	0.5	7.2	1.1	4.2	4.3
29/04/2004	4:30	2.25	0.5	5.3	0.4	2.9	3.5
29/04/2004	5:30	0.75	0.5	14.6	0	7.3	10.3
29/04/2004	8:30	2.75	0.5	5.1	0	2.6	3.6
29/04/2004	9:15	0.5	0.5	14.1	4.1	9.1	7.1
29/04/2004	10:45	1.25	0.5	1084.9	0	542.5	767.1
29/04/2004	13:00	2	0.5	1150.6	0	575.3	813.6
29/04/2004	22:15	9	0.5	21	0	10.5	14.8
30/04/2004	1:15	2.75	0.5	5.6	2.9	4.3	1.9
30/04/2004	3:15	1.75	0.5	5.7	0.1	2.9	4.0
30/04/2004	13:15	9.75	0.5	9.9	0	5.0	7.0
30/04/2004	15:00	1.5	0.5	16.1	1.1	8.6	10.6
30/04/2004	21:00	5.75	0.5	1159.4	0	579.7	819.8
01/05/2004	1:00	3.75	0.75	12.3	0.9	6.6	5.7
01/05/2004	1:45	0.25	0.5	9.7	0	4.9	6.9
01/05/2004	2:30	0.5	0.75	1149.4	0	411.7	640.3

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
01/05/2004	3:45	0.75	0.75	20.5	0.1	10.8	10.2
01/05/2004	6:00	1.75	1.5	1144.5	0.1	894.9	460.2
01/05/2004	7:30	0.25	0.5	597.5	0.4	299.0	422.2
01/05/2004	8:00	0.25	0.5	76.6	0.3	38.5	54.0
01/05/2004	8:30	0.25	0.5	107.6	0.1	53.9	76.0
01/05/2004	9:45	1	0.5	1148.3	0.7	574.5	811.5
01/05/2004	11:00	1	0.5	117.1	0.1	58.6	82.7
01/05/2004	11:45	0.5	1	1123.6	0.1	762.1	530.2
01/05/2004	13:45	1.25	0.5	110.5	0.2	55.4	78.0
01/05/2004	14:45	0.75	1	1119.9	0.2	839.5	559.5
01/05/2004	16:00	0.5	0.5	18.3	0.1	9.2	12.9
01/05/2004	16:30	0.25	0.5	13.2	1.8	7.5	8.1
01/05/2004	17:00	0.25	0.5	133.7	0.8	67.3	94.0
01/05/2004	18:45	1.5	0.5	42.7	0	21.4	30.2
01/05/2004	19:45	0.75	0.5	22.1	0.4	11.3	15.3
01/05/2004	20:45	0.75	0.5	1155.2	0	577.6	816.8
01/05/2004	22:15	1.25	0.5	29	0.4	14.7	20.2
02/05/2004	0:30	2	1.25	1101.6	0.3	800.4	480.3
02/05/2004	1:45	0.25	0.5	66.2	0.6	33.4	46.4
02/05/2004	2:30	0.5	0.5	10.1	0.3	5.2	6.9
02/05/2004	3:15	0.5	0.5	10	0.9	5.5	6.4
02/05/2004	3:45	0.25	0.5	6.3	3.8	5.1	1.8
02/05/2004	4:15	0.25	1	21	0.5	10.6	8.8
02/05/2004	5:30	0.5	0.75	914.6	3.6	308.3	525.1
02/05/2004	6:45	0.75	1.5	1114.5	0.5	749.4	565.6
02/05/2004	8:15	0.25	3	1143.6	0.9	473.2	391.4
02/05/2004	11:30	0.5	1.5	877.2	1.2	529.0	414.2
02/05/2004	13:00	0.25	6.25	1164.3	1.2	813.2	375.5
02/05/2004	19:15	0.25	14.5	1158.8	0.6	851.7	331.9
03/05/2004	9:45	0.25	1.25	502.9	0	178.3	203.1
03/05/2004	11:00	0.25	14.25	1150.2	4.2	696.1	429.0
04/05/2004	1:15	0.25	3.5	1139.8	0.2	669.1	514.1
04/05/2004	5:00	0.5	7	1143.9	1	938.4	291.5
04/05/2004	12:00	0.25	1.5	920.7	2.5	682.8	358.4
04/05/2004	13:30	0.25	0.75	39.5	0.4	18.2	19.8
11/05/2004	8:30	113.25	0.5	5.6	3.1	4.4	1.8
11/05/2004	10:00	1.25	0.5	5.2	4	4.6	0.8
11/05/2004	10:45	0.5	0.5	7.5	1.3	4.4	4.4
11/05/2004	11:45	0.75	1.5	9.9	0.4	7.0	3.6
11/05/2004	13:45	0.75	1	14.8	0	10.6	7.1
11/05/2004	15:30	1	0.5	6.4	0.6	3.5	4.1
11/05/2004	16:00	0.25	0.5	7.3	0	3.7	5.2
11/05/2004	16:30	0.25	0.75	12.6	0	8.0	7.0
11/05/2004	17:30	0.5	0.75	9.4	0.1	4.9	4.7
11/05/2004	18:45	0.75	0.75	14.1	0	8.6	7.6
11/05/2004	19:30	0.25	0.5	15.9	3.1	9.5	9.1
11/05/2004	20:45	1	0.5	7.5	0.5	4.0	4.9
11/05/2004	21:15	0.25	0.5	11.2	0.3	5.8	7.7
11/05/2004	21:45	0.25	0.75	13.4	0.3	8.1	6.9
11/05/2004	23:00	0.75	1	15.8	1	10.4	6.5

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
12/05/2004	0:00	0.25	2.25	22.5	0.7	11.9	6.8
12/05/2004	2:15	0.25	3.75	36	3.7	14.6	7.9
12/05/2004	6:00	0.25	0.5	6.5	3.1	4.8	2.4
12/05/2004	6:45	0.5	1.75	1176	2.8	445.5	547.4
12/05/2004	8:30	0.25	0.75	1061.5	0.2	368.0	601.0
12/05/2004	9:15	0.25	0.5	1181	1.7	591.4	833.9
12/05/2004	9:45	0.25	0.75	1120.3	0.6	392.6	630.9
12/05/2004	10:30	0.25	1.25	1106.6	3.6	331.5	445.7
12/05/2004	11:45	0.25	0.5	1196.2	2.1	599.2	844.4
12/05/2004	12:15	0.25	2.25	1051.8	0.3	282.5	386.0
12/05/2004	14:30	0.25	4.25	1060.7	0	401.7	436.3
12/05/2004	18:45	0.25	1.75	1141.9	0.3	435.7	460.0
12/05/2004	20:30	0.25	2	1204.4	1	491.1	548.3
12/05/2004	22:30	0.25	1.5	1051.8	0.4	304.3	403.7
13/05/2004	0:00	0.25	1.25	1058.7	5	385.2	436.6
13/05/2004	1:15	0.25	5.25	1180.4	0	308.4	458.8
15/05/2004	1:00	42.75	0.5	31.1	0.4	15.8	21.7
15/05/2004	1:30	0.25	0.5	9.9	0.1	5.0	6.9
15/05/2004	2:00	0.25	0.5	12.2	0.9	6.6	8.0
15/05/2004	23:45	21.5	0.75	5.4	0.9	3.9	2.6
16/05/2004	4:45	4.5	0.5	11.5	1.6	6.6	7.0
16/05/2004	9:00	4	0.5	9.5	3.4	6.5	4.3
16/05/2004	10:45	1.5	1	13.4	2.4	7.3	4.6
16/05/2004	12:00	0.5	0.5	8.7	2.7	5.7	4.2
16/05/2004	13:30	1.25	0.75	7.8	5	6.1	1.5
16/05/2004	14:30	0.5	4.5	81.6	5	13.8	21.3
16/05/2004	19:00	0.25	1.75	12	4.8	7.8	2.6
16/05/2004	20:45	0.25	21.75	112.7	4.8	27.6	19.9
17/05/2004	18:30	0.25	0.5	53.4	3.6	28.5	35.2
17/05/2004	19:00	0.25	3	55.8	4.3	20.2	14.2
17/05/2004	22:00	0.25	1	58.4	2.3	21.7	25.2
20/05/2004	19:45	69	0.5	7.3	1.8	4.6	3.9
20/05/2004	23:45	3.75	1	6.3	4.4	5.7	0.9
21/05/2004	1:15	0.75	2.25	9.7	4.1	7.0	1.7
21/05/2004	3:30	0.25	0.75	9	4.3	6.5	2.4
21/05/2004	4:15	0.25	0.75	14.4	4.8	9.0	4.9
21/05/2004	5:00	0.25	1.5	18.3	3.2	8.9	5.7
21/05/2004	7:00	0.75	0.5	14.7	4.2	9.5	7.4
21/05/2004	7:30	0.25	1.25	23.8	1.8	17.2	9.0
21/05/2004	9:00	0.5	2.25	16.6	0.4	8.9	4.5
21/05/2004	11:15	0.25	0.5	5.7	2.7	4.2	2.1
21/05/2004	12:45	1.25	0.5	9.4	3.7	6.6	4.0
21/05/2004	13:45	0.75	1.25	9.1	4.5	7.2	1.9
21/05/2004	15:00	0.25	0.5	7.9	2.6	5.3	3.7
21/05/2004	15:45	0.5	0.5	10.6	1.8	6.2	6.2
21/05/2004	16:15	0.25	1	9	3.5	7.5	2.6
21/05/2004	19:00	2	1.5	13.7	0.3	7.8	5.0
21/05/2004	20:30	0.25	0.75	7.8	1.7	4.9	3.1
22/05/2004	1:00	4	0.5	6.3	2	4.2	3.0
22/05/2004	1:30	0.25	0.5	6.7	3.1	4.9	2.5

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
22/05/2004	2:00	0.25	0.5	5.4	4.2	4.8	0.8
22/05/2004	2:30	0.25	0.5	5.2	1.3	3.3	2.8
22/05/2004	3:00	0.25	0.5	19.1	4	11.6	10.7
22/05/2004	3:45	0.5	0.75	5.2	2.3	4.2	1.6
22/05/2004	5:00	0.75	2	18.4	4.7	10.8	4.9
22/05/2004	7:00	0.25	0.5	11.9	3.2	7.6	6.2
22/05/2004	8:30	1.25	1	61.4	0.2	27.8	28.0
26/05/2004	21:00	107.75	0.75	9.9	2.2	6.0	3.9
26/05/2004	21:45	0.25	1.5	28.6	3.1	13.3	9.3
27/05/2004	1:00	2	0.5	6.1	0.1	3.1	4.2
27/05/2004	1:45	0.5	0.5	10.9	0.1	5.5	7.6
30/05/2004	11:45	81.75	0.5	17.7	2.9	10.3	10.5
31/05/2004	1:30	13.5	0.5	5.1	4.8	5.0	0.2
31/05/2004	3:30	1.75	0.5	5.3	2.6	4.0	1.9
31/05/2004	4:15	0.5	0.5	7.5	0.6	4.1	4.9
31/05/2004	7:45	3.25	0.5	5.1	4.2	4.7	0.6
31/05/2004	8:15	0.25	0.5	6.9	4.5	5.7	1.7
31/05/2004	10:15	1.75	0.5	5.1	2.1	3.6	2.1
31/05/2004	11:15	0.75	0.75	6.2	2.2	4.8	2.3
31/05/2004	13:00	1.25	0.5	8.6	0.2	4.4	5.9
31/05/2004	14:30	1.25	0.5	6.1	2	4.1	2.9
31/05/2004	18:00	3.25	0.5	6.4	2.1	4.3	3.0
31/05/2004	21:30	3.25	0.5	8.4	2.5	5.5	4.2
01/06/2004	6:00	8.25	0.5	6.9	0.2	3.6	4.7
01/06/2004	6:30	0.25	0.75	7.9	3.4	5.8	2.3
01/06/2004	7:15	0.25	0.5	12.5	4	8.3	6.0
01/06/2004	8:45	1.25	0.5	8.8	4	6.4	3.4
01/06/2004	9:45	0.75	0.5	8.4	2.8	5.6	4.0
01/06/2004	10:15	0.25	0.5	16.7	3.7	10.2	9.2
01/06/2004	11:30	1	0.5	7.2	1	4.1	4.4
01/06/2004	13:15	1.5	0.75	7.5	0.7	5.1	3.8
01/06/2004	15:30	1.75	0.5	7.2	2	4.6	3.7
01/06/2004	16:15	0.5	0.5	7.2	1	4.1	4.4
01/06/2004	17:00	0.5	1	11.2	2.1	6.3	3.7
01/06/2004	18:15	0.5	1	6.7	2.3	5.2	2.0
01/06/2004	19:15	0.25	1	17.7	2.9	10.2	6.2
01/06/2004	20:15	0.25	0.75	15.6	4.7	11.8	6.2
01/06/2004	21:00	0.25	1.25	25.6	4.8	11.7	8.2
01/06/2004	22:15	0.25	0.75	7.6	3.4	6.0	2.3
01/06/2004	23:00	0.25	0.5	6.5	1.3	3.9	3.7
02/06/2004	3:00	3.75	0.5	5.7	2.9	4.3	2.0
02/06/2004	4:30	1.25	0.75	8.2	2.2	5.4	3.0
02/06/2004	7:15	2.25	0.5	5.4	1.9	3.7	2.5
02/06/2004	12:00	4.5	0.5	7	1.9	4.5	3.6
02/06/2004	12:45	0.5	0.5	5.5	2.3	3.9	2.3
02/06/2004	14:30	1.5	0.5	9.7	1	5.4	6.2
02/06/2004	15:15	0.5	1.5	10.9	2.8	7.3	3.2
02/06/2004	16:45	0.25	0.5	7.9	5	6.5	2.1
06/06/2004	19:00	98	0.5	5.3	1.2	3.3	2.9
06/06/2004	20:45	1.5	0.75	8.3	1.5	6.0	3.9

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
06/06/2004	23:15	2	0.5	13.4	3.6	8.5	6.9
07/06/2004	1:45	2.25	0.5	6.4	3.6	5.0	2.0
07/06/2004	2:45	0.75	0.5	5.2	3.6	4.4	1.1
07/06/2004	4:30	1.5	0.5	11.6	1.4	6.5	7.2
07/06/2004	7:45	3	0.5	10.1	1.1	5.6	6.4
07/06/2004	8:30	0.5	0.5	5.1	4	4.6	0.8
07/06/2004	10:00	1.25	0.5	13	0.1	6.6	9.1
07/06/2004	11:15	1	0.5	6.9	2.2	4.6	3.3
07/06/2004	11:45	0.25	0.5	5.5	1	3.3	3.2
07/06/2004	12:30	0.5	0.5	6.7	1.7	4.2	3.5
07/06/2004	13:00	0.25	0.5	5.3	2.1	3.7	2.3
07/06/2004	14:45	1.5	0.5	5.6	0.3	3.0	3.7
07/06/2004	16:00	1	0.5	18.8	1.5	10.2	12.2
07/06/2004	22:45	6.5	0.5	6	0.1	3.1	4.2
08/06/2004	0:45	1.75	0.5	7.8	0.1	4.0	5.4
08/06/2004	2:15	1.25	0.5	12.2	2.9	7.6	6.6
08/06/2004	7:30	5	0.75	8.9	1.2	5.6	4.0
08/06/2004	8:30	0.5	1	13	1.7	8.1	4.7
08/06/2004	10:15	1	0.5	6.2	0.1	3.2	4.3
08/06/2004	10:45	0.25	0.5	5.3	0.7	3.0	3.3
08/06/2004	11:30	0.5	0.75	14.8	0	7.7	7.4
08/06/2004	13:00	1	0.5	10.6	4	7.3	4.7
08/06/2004	14:00	0.75	0.5	9.5	1.7	5.6	5.5
12/06/2004	17:45	99.5	0.5	18.5	0	9.3	13.1
13/06/2004	14:15	20.25	0.5	8.8	0.1	4.5	6.2
26/06/2004	20:30	318	0.5	6.2	1	3.6	3.7
28/06/2004	16:15	43.5	0.5	5.7	0	2.9	4.0
28/06/2004	16:45	0.25	0.75	11.7	0.3	5.8	5.7
28/06/2004	18:00	0.75	0.5	10.4	0	5.2	7.4
28/06/2004	18:30	0.25	0.5	5.1	4.7	4.9	0.3
01/07/2004	14:45	68	0.5	5.4	0.9	3.2	3.2
04/07/2004	14:45	71.75	0.5	7.3	0.1	3.7	5.1
29/07/2004	11:00	596	0.75	5.9	0	3.7	3.2
29/07/2004	12:00	0.5	2	21.9	4.5	11.7	6.0
07/08/2004	11:15	213.5	0.5	5.4	2	3.7	2.4
10/08/2004	4:00	64.5	0.5	7.3	3.2	5.3	2.9
10/08/2004	4:30	0.25	0.75	6.8	4.6	5.7	1.1
10/08/2004	5:15	0.25	1	29.5	3.1	12.7	11.6
23/08/2004	23:00	327.25	0.5	6.5	0.1	3.3	4.5
03/09/2004	20:00	260.75	0.5	5.4	0	2.7	3.8
11/09/2004	6:00	177.75	3.5	22.8	2.8	10.2	4.6
15/09/2004	17:45	104.5	0.5	5.2	0.6	2.9	3.3
15/09/2004	18:30	0.5	0.75	7.6	2.6	5.4	2.6
17/09/2004	21:15	50.25	0.75	13.1	1.7	8.0	5.8
17/09/2004	22:00	0.25	0.5	6	1	3.5	3.5
17/09/2004	22:30	0.25	0.75	10.9	1.9	6.1	4.5
17/09/2004	23:15	0.25	0.5	8.3	1.8	5.1	4.6
17/09/2004	23:45	0.25	0.5	6.8	1.2	4.0	4.0
18/09/2004	1:15	1.25	1.25	43.3	1	19.3	18.2
18/09/2004	2:45	0.5	0.5	76.7	3.6	40.2	51.7

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
18/09/2004	3:30	0.5	0.5	1207.7	1.4	604.6	853.0
18/09/2004	6:15	2.5	0.5	5.6	3.8	4.7	1.3
18/09/2004	6:45	0.25	0.5	19.5	4.8	12.2	10.4
18/09/2004	7:30	0.5	1.25	25.9	4.4	11.6	9.2
18/09/2004	9:00	0.5	0.5	10.8	4.8	7.8	4.2
18/09/2004	9:30	0.25	0.75	27.5	3.6	15.2	12.0
18/09/2004	10:30	0.5	6.5	855.5	3.4	63.2	184.0
18/09/2004	17:30	0.75	0.5	8.7	4.8	6.8	2.8
18/09/2004	21:15	3.5	0.5	16.9	2.8	9.9	10.0
24/09/2004	17:30	140	0.5	7.6	0.2	3.9	5.2
26/09/2004	20:45	51	0.5	7	1.9	4.5	3.6
26/09/2004	23:00	2	0.5	5.1	0.3	2.7	3.4
27/09/2004	0:15	1	0.5	6	0.3	3.2	4.0
08/10/2004	12:45	276.25	16	1054.4	3.7	28.9	130.3
09/10/2004	5:15	0.75	0.75	15	5	8.9	5.4
09/10/2004	6:00	0.25	0.75	31.9	4.3	18.2	13.8
09/10/2004	7:00	0.5	0.5	11.9	2.1	7.0	6.9
09/10/2004	7:30	0.25	0.5	7.7	3.2	5.5	3.2
09/10/2004	8:45	1	0.5	5.6	3.1	4.4	1.8
09/10/2004	10:00	1	0.5	13.6	1.8	7.7	8.3
09/10/2004	13:45	3.5	0.5	5.1	4.3	4.7	0.6
09/10/2004	16:30	2.5	0.5	6.8	3.9	5.4	2.1
09/10/2004	17:00	0.25	0.5	6.2	4.6	5.4	1.1
09/10/2004	17:30	0.25	0.5	9.2	3.9	6.6	3.7
09/10/2004	18:15	0.5	1	9.4	4.4	6.2	2.2
09/10/2004	21:30	2.5	0.5	6.2	5	5.6	0.8
09/10/2004	22:45	1	0.5	7.2	4.2	5.7	2.1
10/10/2004	0:00	1	0.5	8.2	4.2	6.2	2.8
10/10/2004	0:45	0.5	0.75	6.6	4.6	5.6	1.0
10/10/2004	2:30	1.25	0.75	11.9	2	6.9	5.0
10/10/2004	3:15	0.25	0.75	7	4.7	6.0	1.2
10/10/2004	4:00	0.25	0.5	5.7	4	4.9	1.2
10/10/2004	4:30	0.25	0.5	10.3	4.5	7.4	4.1
10/10/2004	6:00	1.25	0.5	6.1	2.1	4.1	2.8
10/10/2004	16:45	10.5	0.5	5.7	3.4	4.6	1.6
10/10/2004	19:30	2.5	1	23.4	3.6	10.2	9.1
10/10/2004	20:30	0.25	5.25	46.8	3.3	17.4	9.7
11/10/2004	1:45	0.25	9.25	162.9	4.3	29.2	32.1
11/10/2004	11:00	0.25	1	8.1	3.1	6.0	2.1
11/10/2004	12:00	0.25	1	14.7	3	8.2	4.9
11/10/2004	13:00	0.25	1.5	16.4	4	8.8	4.4
11/10/2004	16:45	2.5	0.75	895.8	4.5	304.9	511.8
11/10/2004	17:30	0.25	6.5	1181	3.2	278.7	379.7
12/10/2004	0:00	0.25	13.75	1207.3	4.8	252.4	232.9
12/10/2004	13:45	0.25	72	1232.3	3.1	293.8	359.9
15/10/2004	13:45	0.25	45.75	1214.4	3.1	249.2	362.9
17/10/2004	11:30	0.25	13.25	32.1	3.8	13.4	6.3
18/10/2004	0:45	0.25	4.5	16.6	3.1	11.0	3.0
18/10/2004	5:15	0.25	2.25	21.6	4.7	10.8	5.7
18/10/2004	9:30	2.25	0.5	5.7	4.2	5.0	1.1

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
18/10/2004	11:30	1.75	0.5	5.4	1.9	3.7	2.5
18/10/2004	13:45	2	0.5	7.2	3.7	5.5	2.5
18/10/2004	14:15	0.25	20.75	17.4	2.9	9.0	2.0
19/10/2004	11:00	0.25	0.75	156.8	4.1	56.5	86.9
19/10/2004	11:45	0.25	10	1192.2	5	187.5	287.9
25/10/2004	10:15	132.75	0.5	5.7	4.5	5.1	0.8
25/10/2004	10:45	0.25	19	48.5	4	14.2	10.1
26/10/2004	6:00	0.5	0.5	5.1	4.5	4.8	0.4
26/10/2004	7:30	1.25	0.5	6.4	4.9	5.7	1.1
26/10/2004	8:00	0.25	0.75	5.8	4.2	5.0	0.8
26/10/2004	8:45	0.25	1	6.9	4.7	5.8	0.9
26/10/2004	14:45	5.25	0.5	5.3	4.1	4.7	0.8
26/10/2004	19:30	4.5	0.5	5.4	3.9	4.7	1.1
27/10/2004	2:15	6.5	0.5	9	4.5	6.8	3.2
27/10/2004	17:15	14.75	1.5	9.2	3.1	7.1	2.2
30/10/2004	1:00	54.5	6.75	17.8	4.9	8.5	3.5
30/10/2004	7:45	0.25	1	6.8	4.8	5.5	0.9
30/10/2004	11:45	3.25	1	6.7	4	5.5	1.1
30/10/2004	12:45	0.25	1.25	8.3	4.3	6.3	1.5
30/10/2004	14:00	0.25	0.75	7.7	4	5.8	1.9
30/10/2004	14:45	0.25	4.25	12.2	5	7.4	2.4
30/10/2004	19:00	0.25	1.25	7	4.6	5.7	0.9
30/10/2004	20:15	0.25	1.75	7.8	4.3	6.6	1.2
30/10/2004	22:00	0.25	0.5	8	4.7	6.4	2.3
30/10/2004	22:30	0.25	0.75	5.4	4.3	4.9	0.6
31/10/2004	0:15	1.25	0.5	5.4	3.5	4.5	1.3
31/10/2004	0:45	0.25	2	7.2	3.8	5.7	1.0
31/10/2004	2:45	0.25	1.75	7.6	4.3	6.4	1.1
31/10/2004	4:30	0.25	2	9.6	4	6.7	1.7
31/10/2004	7:00	0.75	0.75	8.3	4.7	6.3	1.8
31/10/2004	7:45	0.25	2.5	9.5	4.7	6.6	1.5
31/10/2004	10:30	0.5	10	102.6	4.6	31.7	22.1
31/10/2004	20:30	0.25	5.25	83.8	3.2	58.7	25.9
01/11/2004	7:30	6	0.5	7.3	2.1	4.7	3.7
01/11/2004	16:00	8.25	0.5	5.2	2.4	3.8	2.0
01/11/2004	17:45	1.5	0.5	5.7	1.8	3.8	2.8
01/11/2004	21:00	3	0.5	5.2	5	5.1	0.1
01/11/2004	21:30	0.25	0.5	7	2.8	4.9	3.0
01/11/2004	22:00	0.25	0.5	6.1	3.1	4.6	2.1
01/11/2004	23:30	1.25	0.75	8.3	4.2	6.0	2.1
02/11/2004	0:15	0.25	14.5	48.5	5	16.0	8.9
02/11/2004	15:30	1	0.5	5.2	4.9	5.1	0.2
02/11/2004	22:00	6.25	0.5	25	3	14.0	15.6
03/11/2004	1:30	3.25	0.5	9.5	3.1	6.3	4.5
04/11/2004	3:00	25.25	0.5	5.7	4.5	5.1	0.8
04/11/2004	5:00	1.75	0.75	7.7	2.9	5.2	2.4
05/11/2004	1:00	19.5	1.5	7.5	4.4	6.3	1.1
05/11/2004	2:30	0.25	0.5	7	2.5	4.8	3.2
05/11/2004	6:15	3.5	0.5	7.4	3.8	5.6	2.5
05/11/2004	7:00	0.5	0.75	10	2.3	6.7	4.0

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
05/11/2004	17:45	10.25	0.5	5.9	4.5	5.2	1.0
05/11/2004	18:15	0.25	0.75	6.3	5	5.8	0.7
05/11/2004	19:00	0.25	1.5	10	3.4	7.9	2.4
05/11/2004	20:30	0.25	2.25	20.9	3.1	14.6	5.2
06/11/2004	6:15	7.75	0.75	8.4	1	5.7	4.1
06/11/2004	18:00	11.25	0.5	5.6	4.7	5.2	0.6
06/11/2004	19:00	0.75	1.25	43.8	2.1	15.5	16.8
06/11/2004	22:30	2.5	1.5	58.8	1.7	24.3	19.3
07/11/2004	2:30	2.75	0.75	209.4	2.1	76.3	115.5
07/11/2004	3:15	0.25	0.75	11.4	2.5	6.5	4.5
07/11/2004	15:00	11.25	0.5	6.1	2.5	4.3	2.5
08/11/2004	4:00	12.75	0.5	8.7	1.8	5.3	4.9
08/11/2004	4:30	0.25	0.5	5.8	3	4.4	2.0
08/11/2004	23:15	18.5	0.5	6	1	3.5	3.5
08/11/2004	23:45	0.25	0.5	5.2	1.2	3.2	2.8
11/11/2004	18:15	66.25	0.5	7.4	0.8	4.1	4.7
15/11/2004	1:45	79.25	0.5	5.7	2.3	4.0	2.4
15/11/2004	3:45	1.75	19	48.1	3.9	17.3	9.4
15/11/2004	22:45	0.25	2	13.1	4.7	7.7	3.3
16/11/2004	0:45	0.25	0.5	7.5	4.8	6.2	1.9
16/11/2004	1:30	0.5	0.5	11.8	4.2	8.0	5.4
16/11/2004	2:15	0.5	0.75	5.7	3.9	5.1	1.0
16/11/2004	3:00	0.25	0.5	31.2	4.2	17.7	19.1
16/11/2004	3:30	0.25	1.25	7.6	3.9	6.1	1.4
16/11/2004	4:45	0.25	2.25	71	4	27.7	24.2
16/11/2004	7:00	0.25	1	19.4	3.1	10.2	7.4
16/11/2004	8:00	0.25	0.5	8	3.6	5.8	3.1
16/11/2004	8:45	0.5	1	29.9	4	15.2	11.9
16/11/2004	10:00	0.5	0.5	6.2	3	4.6	2.3
16/11/2004	10:30	0.25	0.75	7.4	2.8	5.8	2.6
16/11/2004	11:30	0.5	0.75	8.5	4.2	7.0	2.4
16/11/2004	12:15	0.25	0.75	160	4.7	60.6	86.3
16/11/2004	13:00	0.25	0.75	8	2.6	5.5	2.7
16/11/2004	14:00	0.5	0.5	5.4	3.6	4.5	1.3
16/11/2004	22:30	8.25	0.5	11.9	2.6	7.3	6.6
17/11/2004	0:30	1.75	0.5	5.7	2.5	4.1	2.3
17/11/2004	1:15	0.5	0.5	8.7	2.5	5.6	4.4
17/11/2004	1:45	0.25	0.5	5.4	2.8	4.1	1.8
02/12/2004	6:00	362.75	0.5	5.1	0.9	3.0	3.0
02/12/2004	6:45	0.5	0.5	10.6	0	5.3	7.5
02/12/2004	7:15	0.25	0.75	35.1	0.5	14.6	18.1
02/12/2004	8:00	0.25	0.5	8.3	3.7	6.0	3.3
02/12/2004	8:30	0.25	1	18.6	2.2	11.8	7.5
02/12/2004	9:45	0.5	0.5	11.3	0	5.7	8.0
02/12/2004	10:15	0.25	0.75	18.5	0	11.5	10.0
02/12/2004	11:00	0.25	0.5	6	1.9	4.0	2.9
02/12/2004	12:00	0.75	0.75	28.5	3.9	15.3	12.4
02/12/2004	13:15	0.75	1.25	23.3	0	11.6	9.2
03/12/2004	16:30	26.25	0.5	9.2	0	4.6	6.5
04/12/2004	10:15	17.5	13.5	13.9	5	7.0	1.7

Start Date	Start Time	Recovery Time (hrs)	Duration of event (hrs)	Max turb (NTU)	Min turb (NTU)	Avg. turb (NTU)	St.Dev.
04/12/2004	23:45	0.25	0.5	5.2	5	5.1	0.1
05/12/2004	2:45	2.75	0.75	5.7	5	5.3	0.4
08/12/2004	19:30	88.25	0.5	7.8	4.2	6.0	2.5
10/12/2004	4:45	33	0.75	5.5	4	5.0	0.8
10/12/2004	5:30	0.25	0.5	5.1	4.9	5.0	0.1
10/12/2004	6:00	0.25	0.5	5.2	4.4	4.8	0.6
10/12/2004	6:30	0.25	45	150.2	4.8	34.1	38.3
12/12/2004	5:00	1.75	0.5	5.2	4.5	4.9	0.5
14/12/2004	2:30	45.25	16.75	46.2	5	10.2	5.9
14/12/2004	19:15	0.25	0.5	5.3	4.8	5.1	0.4
14/12/2004	20:00	0.5	0.5	6	4.7	5.4	0.9
14/12/2004	22:00	1.75	0.5	6.7	4.6	5.7	1.5
17/01/2005	7:30	801	157	346.1	4.3	31.3	30.1
23/01/2005	21:15	1	0.75	6.1	4.7	5.3	0.7
23/01/2005	22:30	0.75	1	5.3	4.7	5.1	0.3
24/01/2005	0:15	1	0.5	5.6	4.2	4.9	1.0
24/01/2005	7:30	7	0.5	5.6	4.6	5.1	0.7
24/01/2005	20:00	12.25	0.75	5.6	2.8	4.5	1.5
24/01/2005	22:45	2.25	0.75	9.4	2.5	6.1	3.5
26/01/2005	9:15	34	0.75	9.2	4.4	6.3	2.5
28/01/2005	21:00	59.25	1	40	4.7	14.1	17.3
30/01/2005	7:45	34	0.5	5.1	4.7	4.9	0.3
30/01/2005	10:00	2	0.75	6.2	3.4	5.2	1.6
10/02/2005	6:45	260.25	0.5	5.1	0.4	2.8	3.3
14/02/2005	7:00	96	0.75	13.1	1.8	7.1	5.7
21/02/2005	22:45	183.25	1	5.7	3.8	5.1	0.9
22/02/2005	0:00	0.5	0.5	5.6	3.6	4.6	1.4
28/02/2005	22:30	166.25	1.75	6.1	4.7	5.6	0.5
01/03/2005	5:45	5.75	0.75	17	1.7	8.8	7.7
01/03/2005	8:00	1.75	3.75	13.6	4.7	8.7	3.2
01/03/2005	13:30	2	11.75	11.9	4.8	8.6	2.1
02/03/2005	3:15	2.25	0.5	5.1	4.3	4.7	0.6
02/03/2005	22:30	19	0.5	7	1.8	4.4	3.7
06/03/2005	18:15	91.5	0.5	6	0.7	3.4	3.7
06/03/2005	20:15	1.75	0.5	6.8	0.5	3.7	4.5
06/03/2005	21:30	1	0.5	5.9	0.8	3.4	3.6
07/03/2005	6:00	8.25	0.5	7.6	1.2	4.4	4.5
10/03/2005	18:00	83.75	0.5	5.9	0	3.0	4.2

APPENDIX IV.

Table 34. Comparison of turbidity values reported by laboratory analyses and automated turbidity probe.

Sample date / time	Laboratory Result (NTU)	Automated Sensor Result (NTU)	Difference (Automated - Laboratory) (NTU)
12/05/2003 9:10	0.34	0.6	0.26
02/06/2003 15:15	0.46	8.1	**7.64**
04/09/2003 12:15	0.37	0.6	0.23
01/10/2003 14:00	0.4	0	-0.4
04/11/2003 9:15	0.28	0	-0.28
13/01/2004 9:25	2.25	2.0 / 1.5	-0.25 / -0.75
04/02/2004 9:45	0.81	2	1.19
11/03/2004 9:25	0.35	0.2 / 0.3	-0.15 / -0.05
07/04/2004 12:10	0.37	0.3 / 0.9	-0.07 / 0.53
06/05/2004 16:00	0.26	0.1	-0.16
02/06/2004 10:15	0.62	1	0.38
08/07/2004 10:20	0.39	0	-0.39
03/08/2004 12:20	3.17	0.5	**-2.67**
31/08/2004 9:03	0.48	0.1 / 0	-0.38 / -0.48
05/10/2004 9:45	0.67	0.2	-0.47
03/11/2004 10:10	1.32	2.0 / 2.4	0.68 / 1.08
09/11/2004 11:54	1.24	0.9	-0.34
23/11/2004 10:50	0.73	0.1 / 0.2	-0.63 / -0.53
07/12/2004 9:20	1.29	1.5	0.21
07/12/2004 10:20	1.11	1.5 / 1.1	-0.39 / -0.01
20/12/2004 10:20	1.06	0.3	-0.76
04/01/2005 10:15	0.84	0.2	-0.64
05/01/2005 11:40	1.88	0.1	-1.78
18/01/2005 9:45	10.5	11	0.5
01/02/2005 11:15	1.1	0.5	-0.6
01/02/2005 14:00	1.21	0.6	-0.61
15/02/2005 9:55	1.2	0.7	-0.5
01/03/2005 10:15	6.7	8.3	1.6
04/03/2005 13:05	0.9	0.7	-0.2