Final Report

EFFECTS OF HIGHWAY CONSTRUCTION IN SEDGEFIELD LAKES AND KINGS MILL CONTINUED

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16. Abstract

This report summarizes the results of a project to document the effects of the construction of the I40 bypass around Greensboro on the water quality of tributaries to residential lakes in the Sedgefield Lakes (SELCO) and King's Mill communities. This report also includes data from two past projects to provide a comprehensive characterization of the water quality. Two unnamed tributaries draining to SELCO, referred to as Tilly and Ellery for this study, were monitored at two locations downstream of the highway corridor and one tributary draining to a lake in the King's Mill community was monitored upstream and downstream of the highway corridor. At each monitoring site, discharge was continuously monitored and flow-proportional samples were collected. Samples were analyzed for total suspended solids, total solids, and turbidity. A recording raingage was also maintained in the Sedgefield Lakes watershed and in-situ measurements of temperature, dissolved oxygen (DO), conductivity, and pH were made periodically at each site.

Monitoring data at all sites documented elevated sediment export and turbidity levels during the construction period as compared to the pre- and post-construction periods. The greatest increase in sediment export and turbidity occurred at the upstream site on the Tilly tributary. For this site, which was located just downstream of the highway corridor, about 32% of the sediment export during the entire construction period was associated with two tropical storm systems that occurred in September 2004. At this time the highway was particularly susceptible to erosion because more than 20 ft of fill had recently been added to bring the road surface to near grade and vegetation had not yet been established on the sideslopes. Increases in sediment export and turbidity at the other 4 downstream sites during highway construction were less pronounced. Mean turbidity levels during construction at all sites downstream of highway construction were greater than 50 NTU. Post-construction mean turbidity levels were much less than during construction, but were still greater than pre-construction at both Tilly sites and the upstream Ellery site. Post-construction turbidity levels on the King's Mill tributary downstream of the highway were not significantly different from upstream. Limited monitoring of temperature, specific conductance, DO, and pH for all six sites showed that highway construction had little, if any, detectable effect on these parameters.

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DISCLAIMER

The contents of this report reflect the views of the author(s) and not necessarily the views of the University. The author(s) are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of either the North Carolina Department of Transportation or the Federal Highway Administration at the time of publication. This report does not constitute a standard, specification, or regulation.

SUMMARY

This report summarizes the results of the current project as well as HWY 2004-26 and HWY 2007-17 projects, which were all designed to document the effects of highway construction on the water quality of three tributaries to lakes in the Sedgefield Lakes (SELCO) and King's Mill residential areas. Two monitoring stations were established and maintained on each tributary to continuously record discharge and collect flow-proportional samples. In Sedgefield Lakes, the upstream monitoring sites, referred to as Tilly-up and Ellery-up, were located just downstream of the highway corridor, while the downstream sites, Tilly-down and Ellery-down were located just upstream of the Lake. For King's Mill, the sites were located just upstream (King's Mill-up) and downstream (King's Mill-down) of the highway corridor. All samples collected at the sites were analyzed for total suspended solids (TSS), total solids (TS), and turbidity and selected samples were also analyzed for nitrogen and phosphorus forms. In-situ measurements of temperature, specific conductance, dissolved oxygen (DO), and pH were made occasionally. A recording raingage was also maintained in the Sedgefield Lakes watershed.

Despite an array of erosion and sediment control measures installed and continuous monitoring by NC DOT personnel and local residents, sediment export from the highway corridor at the Tilly-up site increased from 0.01 to 7.91 tons/ac-yr when comparing the pre to during construction periods, while average turbidity of samples went from 25 to 1,570 NTU. About 32% of the total sediment export from the highway corridor occurred during two tropical storms that hit the Greensboro area in September, 2004. Following these events, additional sediment basins with skimmer outlets and coir fiber baffles, flocculation logs, and sediment traps were installed. Following completion of highway construction sediment export and turbidity decreased to 0.44 tons/ac-yr and 135 NTU, respectively.

Sediment export in the much larger Tilly-down watershed increased from 0.07 tons/ac-yr prior to construction to 2.89 tons/ac-yr during the construction period and then decreased to 0.21 tons/ac-yr post construction. The much smaller increase in sediment export during construction was likely due to the fact that the highway corridor encompassed only 15.8% of the Tilly-down watershed and that a greater section of the highway was, due to topography, built closer to the pre-existing grade thereby making it less vulnerable to erosion. Mean turbidity levels in samples increased from 54 NTU pre-construction to 887 NTU during construction decreasing to 93 NTU post construction.

Sediment export from the Ellery-up drainage area increased from 0.04 tons/ac-yr before construction to 4.72 tons/ac-yr during construction and decreased to 0.38 tons/ac-yr post-construction. The increase during construction was less than half that of Tilly-up even though the highway corridor encompassed more than 25% of both drainage areas. The main difference was that construction in the Ellery-up area was at an earlier phase at the time of the tropical storms of September, 2004; thus, the highway corridor was less vulnerable to erosion. Mean turbidity of samples were 29 NTU; 1,607 NTU; and 81 NTU for pre-, during-, and post-construction, respectively.

At Ellery-down, the sediment export rate increased from 0.20 tons/ac-yr before to 1.23 tons/ac-yr during the construction period and decreased to 0.17 tons/ac-yr post-construction. Mean turbidity levels in samples were 140 NTU, 466 NTU, and 72 NTU for pre-, during-, and post-construction periods, respectively. The increases during construction can be attributed to a combination of the highway construction, the Hilltop Road widening, and residential

construction upstream. All of these construction projects were completed by the start of the post-construction period when the sediment export and mean turbidity were actually less than the corresponding pre-construction levels.

At King's Mill, sediment export upstream of the highway corridor during and post construction was 0.08 tons/ac-yr, while downstream it was 1.54 tons/ac-yr and 0.17 tons/ac-yr. Estimated sediment export for the highway corridor itself was 11.0 tons/ac-yr and 0.79 tons/ac-yr during and post construction, respectively. Average turbidity of samples collected at the downstream monitoring site was 589 NTU and 39 NTU during and post construction, respectively. Post-construction mean turbidities of upstream and downstream samples were not significantly different.

Limited monitoring of temperature, specific conductance, DO, and pH for all six sites showed that highway construction had little, if any, effect on these parameters. Similarly, the few samples analyzed for nitrogen and phosphorus indicated levels sufficient to produce aquatic growth in downstream impoundments, although the effect of highway construction on these levels could not be determined as these samples were collected after the start of construction.

The mean turbidity of water samples collected from SELCO Lake, which was immediately downstream of Tilly-down and Ellery-down, was 14 NTU, 32 NTU, and 16 NTU for pre-, during-, and post-construction periods, respectively. Post-construction mean turbidity was not significantly different from pre-construction turbidity indicating that the lake clarity returned to pre-construction conditions relatively quickly.

While erosions and sediment control regulations and technologies have changed, data from this project provide an estimate of sediment export from highway construction under similar conditions of 11-18 tons/ac-yr. Limited post-construction monitoring (~1 yr) suggested that sediment export from similar completed highways range from 0.79 to 1.24 tons/ac-yr.

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INTRODUCTION

North Carolina has one of the strongest sediment and erosion control programs for construction sites in the U.S. in terms of its comprehensiveness, financing and staffing levels (Paterson et al., 1993). The program requires anyone who intends to disturb one acre or more of land to have an erosion and sediment control plan detailing the area to be disturbed and measures used to control sediment export from the site throughout the life of the project. Despite this ambitious program, sediment remains the primary pollutant affecting the quality of North Carolina's surface waters. Construction-related activities were cited by the state as a major source of degradation to lakes (NC DENR, 1992). Further, Burby et al. (1990) reported that one-third or more of urban construction sites in the state release sediment to neighboring property and nearby streams.

While road and highways make up a significant proportion of urban construction, it is unknown what the contribution of highway construction is to the overall sediment export resulting from urban development. In fact, few studies have documented the effects of highway construction on the water quality of receiving streams. An extensive review conducted by Wheeler et al. (2005) included only two studies (Weber and Reed, 1976; Barton, 1977) and both of these were more than 30 years old and included only very limited surface water monitoring. However, related studies of various erosion and sediment control measures have been conducted. For example, the use of polyacrylamide (PAM) for erosion control has also been well documented and its use throughout a site has been shown to greatly reduce erosion and improve vegetative cover (McLaughlin and Brown, 2006; Hayes et al., 2005). The effectiveness of sediment basins with various baffles has been documented (Thaxton and McLaughlin, 2005).

One of the few comprehensive field studies of a NC construction site was conducted by Line and White (2001). Their study monitored sediment export and evaluated the efficiencies of standard sediment traps on 2 residential construction sites over a nearly 2-yr. period of actual construction and rainfall activity. Results documented that 59 and 69% of incoming sediment from Piedmont and Coastal Plain construction sites was retained in the two traps. In addition, the study reported that 13.1 tons/ac-yr of sediment was exported from a Piedmont residential construction site during the clearing and major grading phase of construction in spite of an approved erosion and sediment control plan. This study underscores the difficulty of controlling sediment export from most construction sites.

The NC Department of Transportation manages its own erosion and sediment control program within its Roadside Environmental Unit. Erosion and sediment control plans are developed for every construction project and field personnel of the Roadside unit regularly inspect projects to ensure compliance with the provisions of the law. As stated in the above paragraph even when sites are following an approved erosion and sediment control plan some sediment may still leave a construction site and enter nearby waters. The effect of this sediment on the waters is dependent of the amount of sediment exported, the size and quality of the waters, and aquatic life in the waters. This study was designed to evaluate through water quality monitoring the effectiveness of the sediment control efforts on the I40 Greensboro bypass in the Sedgefield Lakes and King's Mill communities.

METHODOLOGY AND PROCEDURES

The Sedgefield Lakes and King's Mill monitoring stations were maintained at the same locations (fig. 1 and fig. 2) as the previous project (HWY2004-26). The drainage areas to each monitoring station are shown in Table 1. These areas were computed from topographical and highway maps, which are subject to some error particularly in urban areas where stormdrains can be installed in such a way as to change the surface drainage area. The portion of each area encompassed by the highway corridor is also shown. For example, of the 18.6 acres draining to the Ellery-up monitoring site, 4.8 acres are the highway corridor. For King's Mill, the highway corridor is entirely contained within the area between the sites, which is why this area is subdivided and shown separately. The area of highway corridor is also subject to uncertainty because it was also determined by topographic maps, which may have been altered by grading for the road. The area was determined by assuming the highway corridor was 350 ft wide throughout the length of the project.

Table 1. Drainage Area to the Monitoring Stations.

Site	Drainage Area	Highway Corridor	
	ac	ac	%
Ellery-up	18.6	4.8	25.8
Ellery-down	147	24.1	16.4
Tilly-up	28.5	10.8	37.9
Tilly-down	132	20.9	15.8
King's Mill-up	96	0	0.0
King's Mill-down	183	24.7	13.5
Between Kings Mill-up & down	87	24.7	28.4

All 6 samplers were programmed to collect samples on a flow-proportional basis, which has been shown to be the most representative means of sample collection. Flow or discharge monitoring was accomplished via the use of weirs (fig. 3) or stage-discharge rating tables referenced to a permanent stream staff gage (fig. 4 and 5). The frequency of sampling was continually evaluated to insure that enough samples were collected to adequately characterize the stream flow, while making sure the capacity of the sampler was adequate to sample all the discharge during the 2-week period (before the sampler became full). An equal volume of sample was taken from each bottle that was collected during the approximately 2-week monitoring period and placed in a laboratory container for analysis. All samples were analyzed for total suspended solids (TSS), total solids (TS), and turbidity. Selected samples will also be analyzed for total Kjeldahl nitrogen (TKN), nitrate nitrogen (NO_3-N), ammonia nitrogen (NH_3-N), and total phosphorus (TP) by the NC State University Biological and Agricultural Engineering Departmental laboratory. Samples were analyzed using standard methods (Eaton et al., 1995). Selected samples were analyzed for TSS by two labs to assess the repeatability of the results.

In-situ monitoring of pH, dissolved oxygen (DO), conductivity, and temperature was conducted using a YSI multi-parameter meter. Due to various equipment repairs and low flow conditions, some of the planned measurements were not conducted. The meter was calibrated for field use before each use. Typically the probe was placed in an area of flowing water near the sampling point and allowed to equilibrate before the readings were made. At each site the probe settled to or near the bottom of the column of water where the measurement was made.

Effective quality assurance and control procedures are essential to ensure the utility of monitoring data (U.S. DOT, 1996). The biweekly samples were analyzed for TSS, TS, and turbidity only. These samples often remained in the samplers without preservative for extended periods of time (2+ weeks), which does not meet the recommended storage requirements for regulatory compliance (Eaton et al., 1995). Microbial degradation of some solids, particularly those of organic origin, can occur in the absence of preservation; however, the focus of this project is on soil particles as sediment, which under most conditions, do not degrade, hence preservation is only necessary in unusual cases. Further, Harmel et al. (2006) in a study of uncertainty associated with streamflow from small watersheds reported that the concentration of TSS was not affected by preservation and storage procedures for a series of combinations including up to 192 hours of storage without preservation. The TSS was mostly made up of inert soil particles, which are rarely degraded by an extended period in water at ambient temperatures.

RESULTS

The unique partnership between the developer (NC DOT) and the residents of the Sedgefield Lakes (SELCO) and King's Mill communities, begun during earlier projects, continued during this last phase of the monitoring project. At quarterly meetings summaries of monitoring data were presented and citizens' observations of runoff and sediment movement were voiced. A willingness to address citizens' concerns led to continued cooperation by all parties. Maintenance and enhancement of standard erosion and sediment control measures such as sediment traps, silt fence, and check dams were continued throughout the highway corridor. The NC DOT personnel inspected the corridor after every rain event of greater than 0.25 inches and brought any problems encountered to the attention of their contractor(s).

Monitoring results are presented by site in the following section. The extent, general topography, and land use of the drainage area to the monitoring stations were determined from maps and observation. Activities, construction phase, sediment control practices, and other hydrologic factors occurring on the construction sites were recorded when observed during the biweekly visits to the monitoring sites.

The interpretation of the results was limited by the relatively short pre- and post-construction monitoring durations. Generally, at least 1.5 years of monitoring data is needed to adequately characterize hydrology and pollutant export from nonpoint sources such as construction sites. Both the pre- and post-construction periods were less than this and were not truly periods of stability as some, albeit relatively minor, construction activities were occurring during these periods. In addition to providing a comparison with data collected during construction, adequate pre-construction monitoring was needed to estimate the sediment export from nonhighway areas in the monitored drainage areas. As a surrogate, the sediment export rate from the King's Mill-up monitoring station was used as the export rate for nonhighway areas in all three drainage areas to compute the estimated contribution from the highway corridor. The King's Mill-up data was generated from the same climatic conditions (concurrent monitoring); however, even though the land use in all areas was mostly single family residential, the hydrologic characteristics such as imperviousness, topography, and soils may not have been the same in the three monitored drainage areas.

Tilly-up Site

A summary of construction stage and activities for the Tilly-up and Tilly-down sites is included in Table 2, while a summary of monitoring data for Tilly-up only is in Table 3. The data are separated into pre-, during-, and post-construction periods. The pre-construction period ended about the time when grubbing and earth moving activities were starting in the highway corridor. The pre-construction period was relatively short (0.38 years) and did not include any large storm events (see data in Appendix); therefore, the long term pre-construction sediment dynamics and hydrology could not be fully characterized, but relatively low runoff and sediment export was indicated by the limited data. The during-construction period continued to the end of all major construction activities and most minor activities (1/3/08). Some final activities occurred between 1/3/08 and the opening of the road to traffic on 2/21/08, but these should not have had a significant affect on sediment export.

The rainfall, runoff, and TSS load (columns 4-6 of Table 3) were summed for each period, while the TSS concentrations and turbidity of samples (columns 7 and 8) were averaged. The pre-construction period sediment export rate was 0.01 tons/ac-yr, while the during-construction sediment export rate was 7.91 tons/ac-yr. The pre-construction period was relatively short with relatively low accumulation and intensity storms; thus, erosion and sediment export was minimal. The during-construction period encompassed several large storms including two tropical storms. About 32% of the total sediment export for the entire 3.49-year period can be attributed to back to back tropical storms which occurred in September, 2004. The magnitude of sediment export during this period is also illustrated by the height of the two bars in September, 2004 on figure 6. Neither of these events exceeded the 10-yr, 24-hr rainfall accumulation (5.2 inches) for Guilford County; however, the two combined would have. It should also be noted that the peak discharge rate for this storm exceeded the capacity of the stream channel and consequently the monitoring weir; hence, the monitoring data is subject to considerable uncertainty. The volume of sediment deposition in and around the monitoring site also created difficult monitoring conditions as the deposited sediment may have inundated the sampler intake.

The increased sediment export can almost totally be attributed to the highway construction as the rest of the drainage area to the Tilly-up site appeared to remain stable. With this in mind and the fact that the area of the highway corridor was 10.8 acres (37.9% of the total drainage area), the estimated sediment export from the highway alone during construction was computed as 20.6 tons/ac-yr. This export rate is about twice as high as the export (10.1 tons/ac-yr) measured over the duration of construction of a residential development in Wake County (Line et al., 2002). The increased sediment export was likely caused by a combination of factors including the steep banks of the highway fill slopes and the two tropical storms. Mean sediment (TSS) concentrations and turbidity of samples also increased (columns 7 and 8) during the construction period. The mean TSS concentration here (2,223 mg/L) was less than that measured on the Wake County construction site (3,491 mg/L) reported by Line et al. (2002). The mean turbidity (1,570 NTU) was much greater than the NC receiving water standard of 50 NTU. Only 7 of the 80 samples collected during construction had a turbidity of less than 50 NTU, while 8 of 10 and 7 of 20 collected pre- and post-construction were less than 50 NTU.

Table 2. Construction Stage and Activities at the Tilly-up and Tilly-down Monitoring Sites.

Date	Activity/construction stage
1/16/04	Monitoring begins
6/3/04-6/23/04	Grubbing, significant grading occurring
7/10/04-7/24/04	Culvert under highway installed, fill being added
8/15/04	Silt curtain installed in lake
8/17/04	Moved sampling station downstream ~200ft
8/17/04	Straw applied to banks of road
9/5/04-9/25/04	Tropical storms dump >8 in of rain
10/15/04	Skimmer basins and other sediment control practices added
11/22/04	Corridor cleared all the way to railroad crossing
4/18/05	NCSU spread PAM around banks & road at Tilly-up
7/14/05-2/15/06	Construction of development (Cavanough), site cleared
11/20/06	Permanent culvert from road installed, basin reworked, part of the roadbank unvegetated
12/1/06	Stream restoration work begins
2/1/07	Stream restoration construction complete
2/15/07	Planting of stream restoration complete
4/25/07	Add fill to bring roadbed up to final grade
8/17/07	Road surface/pavement about half finished
1/3/08	Highway construction complete, erosion control fabric over all soil
2/21/08	Highway opens for traffic
5/10/08	Access roads, connectors, etc. completed and stabilized

Sediment (TSS) concentration and turbidity decreased considerably in the post-construction period (Table 3); however, not quite to the levels of the pre-construction period. A t-test on the log-transformed data indicated that both the mean TSS concentration and the turbidity were significantly different from pre- as compared to post-construction. The continued growth of vegetation and the diminishing of previously deposited sediment in the drainageways should cause these levels to decrease with time. In fact, from June to December the mean TSS and turbidity levels were 109 mg/L and 61 NTU, which was about 50% less than the previous 6 months. Further, 5 of the 11 samples collected during this time had a turbidity of less than 50 NTU.

Table 3. Summary of Rain, Runoff, and Sediment Data for the Tilly-up Site.

Begin	End	Dur. yr	Rain in	Runoff gal	TSS tons	TSS mg/L	TS mg/L	Turb NTU
Pre-Construction								
2/5/04	6/23/04	0.38	9.26	1,005,000	0.16	33	133	25
Sed export to station= 0.01 tons/ac-yr								
During-Construction								
6/24/04	1/3/08	3.49	120	58,775,000	786	2,223	3,131	1,570
Sed export to station= 7.91 tons/ac-yr								
Est. sediment export from highway= 20.6 tons/ac-yr								
Post-Construction								
1/4/08	12/18/08	0.96	38	14,618,000	12.1	213	326	135
Sed. export to station= 0.44 tons/ac-yr								
Est. sediment export from highway= 1.02 tons/ac-yr								

Table 4 contains temperature, conductivity, DO, and pH data measured in-situ during trips to the watershed. Because of the relatively small number of data points, making definitive statements about the data is not warranted; however, comparing the data with those collected from an urban stream draining a residential area of Charlotte, NC as reported by USGS (1999) could be useful. The specific conductance at the Tilly-up site was much less than the Charlotte streams, while the temperature and pH were similar. The very small discharge of the stream could be subject to large changes in physical parameters as a result of only a small amount of stressor. The change in water temperature from pre- to during- to post-construction probably reflects seasonal differences (half the during-construction measurements were made during summer) rather than any effect of the highway. The reason for the consistent drop in DO is unknown, but it occurred at every site indicating either a problem with the calibration of the DO meter or a seasonal effect, except that it occurred at every site indicating a possible measurement timing/seasonal effect or a problem with the instrumentation.

Table 4. Summary of Physical Monitoring Data for the Tilly-up Site.

Begin	End	Count	Temperature C	Cond[1]	DO mg/L	pH
Pre-Construction						
2/5/04	6/23/04	2	15.8	0.15	10.3	7.4
During-Construction						
6/24/04	1/3/08	11	17.3	0.14	6.0	6.6
Post-Construction						
1/4/08	12/18/08	5	13.2	0.17	2.3	6.5
USGS (1999)[2]			15.2	0.64	na	6.8

[1] Specific conductance with units of milliS/cm
[2] Study of residential urban stream in Charlotte, NC

Tilly-down Site

A summary of monitoring data for the Tilly-down station is shown in Table 5. The pre-construction period includes data collected by the residents of the watershed along with the data collected in this study. Samples collected by the residents were equally-spaced in time for selected storm events during the period shown. No discharge data was collected and some storms were not sampled due to battery failure and equipment malfunction; thus, runoff/discharge and sediment (TSS) loading could not be calculated.

Like the Tilly-up station, sediment concentration and export increased during construction and then decreased post-construction, although the increase and decrease were not as great as those for the Tilly-up site. The less dramatic increase could be attributed to the fact that a smaller portion (15.8%) of the drainage area to Tilly-down was disturbed by the highway construction. Construction of a residential subdivision in the upper part of the drainage area likely added sediment to the site during 2005. For this reason, an estimate of sediment export from the highway corridor itself cannot be made with reasonable certainty. However, if the same method as was used for Tilly-up is employed, the estimated export from the corridor would be 17.8 tons/ac-yr, which would be conservative as some of this export likely came from the residential construction. Overall the average TSS concentration and turbidity of samples also increased during the construction period compared to the pre-construction period and then decreased in the post-construction period. Like Tilly-up, the post-construction mean TSS concentration was significantly greater than pre-construction using a t test on the log-transformed data; however, unlike Tilly-up the turbidity levels were not significantly different. In addition, TSS (133 mg/L) and turbidity (86 NTU) levels from June to December were similar to the previous 6 months. This indicates that there may be a larger store of previously deposited sediment in the drainageways or that there is another source of sediment contributing to Tilly-down.

Table 5. Summary of Monitoring Data for the Tilly-down Station.

Begin	End	Dur. yr	Rain in	Runoff gal	TSS tons	TSS[1] mg/L	TS[1] mg/L	Turb[1] NTU
Pre-Construction								
9/16/02	3/4/03	0.46	na	na	na	24[2]	na	31[2]
2/5/04	6/23/04	0.38	9.26	18,057,000	3.75	58	207	54
Sed export= 0.07 tons/ac-yr								
During-Construction								
6/24/04	1/3/08	3.49	120	211,320,000	1,240	1,037	1,269	887
Sed export= 2.89 tons/ac-yr								
Post-Construction								
1/4/08	12/18/08	0.96	38	56,834,000	26.7	127	244	93
Sed export= 0.21 tons/ac-yr								

[1] These are the mean values for the period.
[2] Mean of 14 storm event samples collected by homeowners.

Table 6 contains temperature, conductivity, DO, and pH data measured in-situ during trips to the sampling site. Like Tilly-up, the specific conductance was less than the average of several Charlotte streams (USGS, 1999), while the temperature and pH were similar. The changes in temperature, conductance, and pH are relatively small and shown no consistent trend indicating that there was no effect of highway construction evident. The reason for the decrease in DO from pre- to post-construction is unknown, but may be related to measurement timing and instrument problems as the decrease occurred for all sites. Small streams can have highly variable DO especially during nonstorm flow.

Table 6. Summary of Physical Monitoring Data for the Tilly-down.

Begin	End	Count	Temp C	Cond[1]	DO mg/L	pH
Pre-construction						
2/5/04	6/23/04	2	15.2	0.23	8.0	7.4
During-construction						
6/24/04	1/3/08	11	15.8	0.15	6.2	6.6
Post-construction						
1/4/08	12/18/08	5	12.9	0.17	2.9	6.7

[1] Specific conductance with units of milliS/cm

A summary of nitrogen, phosphorus, and sediment concentrations in selected samples is shown in Table 7. In general, TP concentrations greater than 0.05 mg/L and organic nitrogen (TKN) concentrations greater than 0.3 mg/L are considered adequate for excess or nuisance algal growth; hence, the nitrogen and phosphorus concentrations are sufficient for algae blooms. However, because there were no pre-construction or upstream data, there is no way to determine if the highway construction had any effect on nutrient levels. The nitrogen and phosphorus levels do not appear to be excessive for urban streams (compared to NURP data) with the possible exception of TP.

Table 7. Nutrient and Sediment Concentration Data for Tilly Tributary.

	Tilly-up					Tilly-down				
Date	TKN mg/L	NH_3-N mg/L	NO_3-N mg/L	TP mg/L	TSS mg/L	TKN mg/L	NH_3-N mg/L	NO_3-N mg/L	TP mg/L	TSS mg/L
Mean	0.75	0.00	0.21	0.45	1210	1.26	0.00	0.29	0.47	745
Count	3	3	3	3	3	3	3	3	3	3
NURP[1]	1.51	0.26	0.48	0.26	na					

[1] Mean event mean concentration from suburban areas (Claytor and Schueler, 1996).

Ellery-up Site

Construction phase and activities for the Ellery-up and Ellery-down drainage areas are shown in Table 8. A summary of monitoring data for the Ellery-up station is shown in Table 9. The data are divided into a pre-construction period, which was prior to clearing and grubbing the highway corridor, and the during construction period, which included the grading and construction of the highway and a post-construction period. The post-construction period began when the road surface was finished, but landscaping type activity was still occurring until the opening of the road for traffic in February, 2008.

Table 8. Construction Phase and Activities in the Ellery-up and Ellery-down Drainage Areas.

Date	Activity/construction stage
1/16/04	Monitoring begins
4/6/04	Tree clearing occurring
7/10/04	Foundation for highway overpass over Hilltop Road starting
7/14/04	Construction on Hilltop road
8/15/04	Silt curtain installed in lake
8/20/04	Grubbing and earthwork begins
9/3/04	Culvert under highway being installed
9/15/04	Sediment control practices installed
7/1/05	Highway corridor ~halfway filled to final grade
8/2/05	Culverts under Hilltop road being installed
9/15/05	Installation of Hilltop road culverts done, land for development cleared & grubbing occurring
4/8/06	Hilltop Road completed, mostly stabilized
5/5/06	Residential development under way
9/7/06	Highway filled up to about grade, slopes stabilized
11/9/06	Hilltop Apartments development on Ellery complete, site stable
2/22/07	Slope drain reinstalled after failure, permanent storm drain installed
5/15/07	Paving of road surface occurring
10/25/07	Road surface done, median stable (matted), shoulders mostly seeded
11/15/07	Highway construction is basically complete
2/21/08	Highway is opened for traffic
5/15/08	Completely done stabilizing access roads, connectors, etc.

Sediment export at the monitoring station increased from 0.04 tons/ac-yr during pre-construction to 4.72 tons/ac-yr during construction and then decreased to 0.38 tons/ac-yr following construction. The variability in sediment export during the construction period is illustrated in figure 7. The sediment export rate from the highway corridor itself was estimated at 18.0 tons/ac-yr using the method outlined earlier. While this export rate was less than Tilly-up it was greater than was measured from the residential site reported in Line et al. (2002). The TSS concentration and turbidity of samples also increased during the construction period and decreased during the post-construction period. The mean TSS and turbidity during post-construction were still significantly greater (according to a t test on log-transformed data) than pre-construction. The TSS and turbidity levels have been decreasing during the post-construction period as from June to December they were 124 mg/L and 65 NTU, respectively. Turbidity and TSS levels should continue to decrease as vegetation grows and previously deposited sediment is flushed out of the drainageways.

Table 8. Summary of Monitoring Data for the Ellery-up Station.

Begin	End	Dur. yr	Rain in	Runoff gal	TSS tons	TSS mg/L	TS mg/L	Turb NTU
Pre-construction								
2/5/04	8/20/04	0.54	17.4	2,099,250	0.40	36	187	29
Sediment export to station= 0.04 tons/ac-yr								
During-construction								
8/21/04	11/14/07	3.2	107	24,071,000	281	2,535	2,839	1,607
Sediment export to station= 4.72 tons/ac-yr								
Est. sediment export from highway= 18.0 tons/ac-yr								
Post-construction								
11/15/07	12/18/08	1.1	41.9	11,747,000	7.83	146	269	81
Sediment export to station= 0.38 tons/ac-yr								
Est. sediment export from highway= 1.24 tons/ac-yr								

Table 10 contains the mean temperature, conductivity, DO, and pH data measured in-situ during trips to the watershed. Like the Tilly sites, the specific conductance was less than the Charlotte site (Table 3) while the temperature and pH were similar. Comparing the periods, the water temperature was similar for pre- and during-construction, but then decreases significantly for the post-construction period. This decrease may be related to the water being piped under the road (shaded), although there are not enough data points to say with much certainty. While both mean conductance and pH, were similar for all 3 periods, the DO increased from pre- to during-construction and then decreased in the post-construction period. The reason for the low DO during the post-construction period is unknown, but may be related to low flow conditions (drought) in general, piping of the stream reducing turbulence, timing of the measurements occurring during low flow, and/or simply random natural variability.

Table 10. Summary of Physical Monitoring Data for the Ellery-up.

Begin	End	Count	Temperature C	Cond[1]	DO mg/L	pH
Pre-construction						
2/5/04	8/20/04	2	16.7	0.18	3.2	7.2
During-construction						
8/21/08	11/14/07	9	15.0	0.21	5.3	6.5
Post-construction						
11/15/07	12/18/08	5	12.6	0.22	1.3	6.6

[1] Specific conductance with units of milliS/cm

Ellery-down Site

A summary of monitoring data for the Ellery-down station is shown in Table 11. The data are divided into a pre-, during-, and post-construction periods. Data in the first pre-construction period shown was collected by the residents as described above in the Tilly-down section. The construction period also encompassed the widening of Hilltop Road by the City of Greensboro and the construction of a residential housing development just upstream of Hilltop Road. The residential development and the widening of Hilltop road encompassed about 6 acres of disturbed land, whereas the area of the highway corridor within the drainage area was about 24 acres.

The mean TSS and turbidity of samples collected by the residents of the Sedgefield Lakes community is shown in row one for reference. Their samples were collected by automated samplers during selected storm events on a timed basis and thus were not flow-proportional, but they still serve to provide a measure of the TSS and turbidity levels of the pre-construction period. These samples were collected at the same location as those during this study. The mean TSS and turbidity levels increased from pre- to during-construction and then decreased considerably in the post-construction period to the levels less than the pre-construction period. Given the size of the drainage area, it is likely other construction activities in the watershed may have accounted for elevated TSS and turbidity levels during the pre-construction period. The sediment export rate during the pre- and post-construction periods were similar indicating that the decreases in concentration may be from dilution. Sediment export rate increased from 0.20 during pre-construction to 1.35 tons/ac-yr during the construction period and then decreased to 0.17 tons/ac-yr during post-construction. The increase cannot totally be attributed to the highway construction as a significant portion of the drainage area was disturbed by the residential development and the Hilltop Road widening.

Table 11. Summary of Monitoring Data for the Ellery-down Station.

Begin	End	Dur. yr	Rain in	Runoff gal	TSS kg	TSS[1] mg/L	TS[1] mg/L	Turb[1] NTU
Pre-Construction								
9/16/02	2/4/04	1.5	na	na	na	32[2]	na	37[2]
2/5/04	8/20/04	0.54	17.41	22,512,000	14,520	172	362	140
Sed export to station= 0.20 tons/ac-yr								
During-Construction								
8/21/04	11/14/07	3.20	107.4	148,261,000	527,160	563	776	466
Sed export to station = 1.23 tons/ac-yr								
Post-Construction								
11/15/07	12/18/08	1.10	41.9	60,499,000	24,570	84	198	72
Sed export to station = 0.17 tons/ac-yr								

[1] These are the mean values for the period.
[2] Mean of samples collected by homeowners from 16 storm events.

Table 12 contains the mean temperature, conductivity, DO, and pH data measured in-situ during trips to the watershed. Like the Tilly sites, the specific conductance was less than the Charlotte site (Table 3) while the pH and temperature were similar. The differences between periods does not appear to be significant given the number of data points, except for DO. The relatively low level of DO in the post-construction period is similar to Ellery-up. Since a low percentage of the stream channel was piped in this watershed, low values suggest that something else caused the decrease, but what is unknown.

Table 12. Summary of Physical Monitoring Data for the Ellery-down.

Begin	End	Count	Temperature C	Cond.	DO mg/L	pH
Pre-construction						
2/5/04	8/20/04	2	23.2	0.23	5.6	7.4
During-construction						
8/21/04	11/14/07	9	15.8	0.18	6.6	6.8
Post-construction						
11/15/07	12/18/08	5	14.2	0.18	2.4	6.7

Selected samples were analyzed for nutrients during the project, with the results shown Table 13. Like the samples from Tilly-down, nitrogen and phosphorus levels are generally sufficient for the nuisance growth of aquatic vegetation; however, there is no way of determining if the highway construction had any effect on these levels.

Table 13. Nutrient and Sediment Concentration Data for Ellery Tributary.

	Ellery-up					Ellery-down				
	TKN mg/L	NH_3-N mg/L	NO_3-N mg/L	TP mg/L	TSS mg/L	TKN mg/L	NH_3-N mg/L	NO_3-N mg/L	TP mg/L	TSS mg/L
Mean	0.95	0.00	0.08	0.50	1010	1.97	0.00	0.32	0.35	251
Count	3	3	3	3	3	1	1	1	1	1

King's Mill-up and Down Sites

Table 14 contains descriptions of construction activities/stages as observed during visits to monitoring sites. Monitoring data for the King's Mill upstream and downstream sites are shown in Table 15. The numbers in the 'Between sites' and 'Highway corridor' sections were computed from monitoring data. The 6/5/04 to 11/14/07 row of data corresponds to the during-construction period whereas the 11/15/07 to 12/18/08 row corresponds to post-construction. Rainfall for the two sites was recorded at the Tilly-up site, which was less than 3 miles away.

For the upstream site, during- and post-construction data were similar. This was expected as there was little change in the land use activities in the drainage area to this site. The relatively small differences shown reflect natural and/or random variability in monitoring data from nonpoint sources. For the downstream site, discharge increased from the during- to post-construction period. This was expected given that the during-construction period started before most of the land was cleared of trees and the increase in impervious surface with the highway construction. The increase in discharge from upstream to downstream may, from a purely runoff standpoint, seem startling, but it is important to realize a tributary stream entered the monitored stream between the two sites and this tributary appeared to be fed by a good source of ground water, which increased the discharge to the downstream site. Hence, the increase in discharge was likely not all surface runoff.

Table 14. Construction Phase and Activities for the King's Mill Up and Down Drainage Areas.

Date	Activity/construction stage
6/04	Monitoring begins
8/04	Clearing trees, but no grubbing yet
9/04	Temporary crossing being installed
11/04	Tributary rerouted, grubbing, earthwork, some fill added around Groometown road
12/04	Box culvert being installed
7/05	Box culvert installation complete, water through it, not much fill
6/05	Large sediment/stormwater basin installed
10/05	Filled to point where construction of overpass over Groometown road can begin
1/06	Highway filled to where construction of overpass over Kings Mill road can begin
4/07	Road bed stabilized, median and shoulders not stable yet
11/07	Construction is basically completed
2/08	Highway is opened for traffic
5/08	Completely done stabilizing access road, connectors, etc.

Annual sediment (TSS) load (column 6) at the downstream site was considerably greater than upstream even after a large decrease from during- to post-construction. In fact, the post-construction sediment load was more than 4 times greater than at the upstream site. This load should continue to decrease as the vegetation becomes more established in the highway corridor. The mean TSS and turbidity at the downstream site were much greater than the upstream during construction, but then decreased to about the same level as the upstream during the post-construction period. Both the upstream and downstream turbidity levels were less than the state receiving water standard of 50 NTU (NC DENR, 1997) during the post-construction period. In fact, during the post-construction period there was no statistically significant difference (0.05 level) between upstream and downstream TSS or turbidity levels according to a paired t-test for means. Thus, the increased sediment load was caused by increased discharge. Like sediment loads, the sediment (TSS) export rate at the downstream site was greater than the upstream site, especially during construction, but decrease significantly during post-construction.

The differences between downstream and upstream sediment load and export are shown in the next section. The sediment export was computed by subtracting upstream sediment load from downstream and dividing by the area between the sites (87 acres). However, only 22.6 acres (assumes 320ft wide and 3072ft long corridor) of this area is highway corridor. To estimated sediment export from the highway corridor itself, the upstream sediment export rate of 0.08 tons/ac-yr was applied to the nonhighway land between the monitoring stations (64.4 acres), which was then subtracted from the total sediment yield from between the stations and divided by 22.6 acres to yield the sediment export from the highway corridor (Table 15). The 12 tons/ac-yr during construction is similar to sediment export rate monitored from a residential construction site during clearing and rough grading (13.1 tons/ac-yr) in Wake County (Line and White, 2007). The export rate decreased considerably during the post-construction period, although it was still greater than the upstream site.

Table 15. Summary of Monitoring Data for the King's Mill Sites.

Begin	End	Dur. yr	Rain in/yr	Discharge in/yr	TSS kg/yr	TSS mg/L	TS mg/L	Turb NTU	TSS Export T/ac-yr
Upstream site									
6/5/04	11/14/07	3.45	34.2	10.2	7,370	72	184	42	0.08
11/15/07	12/18/08	1.09	38.5	10.3	7,050	56	209	36	0.08
Downstream site									
6/5/04	11/14/07	3.45	34.2	15.9	254,830	845	979	589	1.54
11/15/07	12/18/08	1.09	38.5	22.1	31,503	68	172	39	0.17
Between sites									
6/5/04	11/14/07	na	na	na	247,460	na	na	na	3.17
11/15/07	12/18/08	na	na	na	24,453	na	na	na	0.28
Highway corridor only									
6/5/04	11/14/07	na	na	na	na	na	na	na	11.0[1]
11/15/07	12/18/08	na	na	na	na	na	na	na	0.79[1]

[1] Computed estimate based on areal extent of highway corridor.

Table 16 contains the mean temperature, conductivity, DO, and pH data measured in-situ during trips to King's Mill. Like the Sedgefield sites, the specific conductance of both sites was much less than the Charlotte site (Table 4) while the temperature and pH were similar. The slight increases in temperature, DO, and pH from upstream to downstream during both the pre- and post-construction periods were likely not significant given the relatively small number of data and measurement uncertainty. The considerable drop in DO from during- to post-construction cannot be explained, but seems to be consistent for every site indicating that it may be due to seasonal effects or a problem with the calibration of the YSI instrument. A problem with the instrument likely would not affect the comparison between upstream and downstream stations, which is the main objective of the monitoring.

Table 16. Summary of Physical Monitoring Data for the King's Mill Sites.

Begin	End	Count	Temperature C	Cond	DO mg/L	pH
Upstream site						
6/5/04	11/14/07	12	16.4	0.188	5.9	6.9
11/15/07	12/18/08	5	12.2	0.203	1.9	6.9
Downstream site						
6/5/04	11/14/07	11	17.7	0.202	7.3	7.5
11/15/07	12/18/08	5	12.5	0.220	2.2	7.2
USGS (1999)[2]			15.2	0.64	na	6.8

[1] Specific conductance with units of milliS/cm
[2] Study of residential urban stream in Charlotte, NC

Several samples were analyzed for nitrogen forms, total P, and sediment during the project (Table 17). With so little data no definitive statements can be made; however, the data suggests that nitrogen forms were not significantly changed by highway construction, but that TP and TSS concentrations increased downstream. The TSS data is in agreement with samples collected at other times and the TP increase is consistent with many studies showing that increased sediment concentrations often correspond with increased TP concentrations in storm discharge.

Table 17. Nutrient and Sediment Concentration Data for King's Mill Tributary.

	King's Mill-up					King's Mill-down				
Date	TKN mg/L	NH_3-N mg/L	NO_3-N mg/L	TP mg/L	TSS mg/L	TKN mg/L	NH_3-N mg/L	NO_3-N mg/L	TP mg/L	TSS mg/L
Mean	1.04	0.00	0.54	0.39	67	0.91	0.00	0.75	0.60	656
Count	2	2	2	2	2	3	3	3	3	3

All Sites Combined

Table 18 contains monitoring data for all sites to facilitate comparisons between sites. Except for the Ellery-down site, the mean pre-construction TSS concentration and turbidity were less than 100 mg/L and 55 NTU, respectively. For King's Mill, all of the data from the upstream monitoring station was considered pre-construction because there was no construction in the drainage area during project. The pre-construction sediment export from all of the sites ranged from 0.01 to 0.20 tons/ac-yr with a mean of 0.08 tons/ac-yr. This is similar to the 0.16 tons/ac-yr sediment export from a small undeveloped, Piedmont NC watershed reported by Line and White (2007). These data confirm the use of the 0.08 tons/ac-yr sediment export rate to estimate the contributions from all areas where no development/construction was occurring in the monitored watersheds.

Table 18. Monitoring Data for All Sites.

Site	Period yr	TSS mg/L	Turb NTU	Sediment Export tons/ac-yr	Highway Estimate tons/ac-yr
Ellery-up					
pre-construction	0.54	36	29	0.04	na
during-construction	3.20	2,535	1,607	4.72	18.0
post-construction	1.10	146	81	0.38	1.24
Ellery-down					
pre-construction	0.54	172	140	0.20	na
during-construction	3.20	563	466	1.23	na
post-construction	1.10	84	72	0.17	na
Tilly-up					
pre-construction	0.38	33	25	0.01	na
during-construction	3.49	2,223	1,570	7.91	20.6
post-construction	0.96	213	135	0.44	1.02
Tilly-down					
pre-construction	0.38	58	54	0.07	na
during-construction	3.49	1,037	887	2.89	na
post-construction	0.96	127	93	0.21	na
King's Mill-up					
during-construction	3.45	72	42	0.08	na
post-construction	1.09	56	36	0.08	na
King's Mill-down					
during-construction	3.45	845	589	1.54	11.0
post-construction	1.09	68	39	0.17	0.79

During construction, the TSS and turbidity levels increased dramatically at downstream sites. Sediment export rates also increased at all affected sites during the construction period. For the Tilly-up, Ellery-up, and King's Mill sites the sediment export rate for the highway corridor itself could be estimated with reasonable confidence given that a significant proportion of the drainage area to these sites was highway corridor and the other land use appeared to be stable. The export rates from these sections of highway corridor ranged from 11.0 to 20.6 tons/ac-yr. The 20.6 tons/ac-yr represents the worst case scenario of tropical storm rainfall occurring on a large fill section of highway (Tilly-up) at a time when the construction site was most vulnerable. In addition, highway construction was delayed in the Tilly-up drainage area for the construction of a railroad bridge, which caused the highway corridor to be unstable for longer. Hence, the 12-18 tons/ac-yr sediment export rate is likely more representative of highway construction projects like this. Sediment export from a residential development in Piedmont NC during clearing and major grading was 13.1 tons/ac-yr as reported by Line and White (2007), which is similar to the export rates from these two sites.

The TSS and turbidity levels and sediment export rates decreased dramatically during the post-construction monitoring period at stations downstream of highway construction. However, only at the Ellery-down was the post-construction levels and rate equal to or less than those of the pre-construction period. This was expected as often construction sites are not stable until after at least one growing season. The highway corridor in the Tilly-up drainage areas was the last to be stabilized and likely was not representative of completed highways; therefore, after deleting this station, the range of TSS export rates for the completed highway was 0.79-1.24 tons/ac-yr. These export rates are similar to those (0.24-1.19 tons/ac-yr) reported by Wu et al. (1998) for three stable highway sites in the Charlotte, NC area.

SELCO Lake Monitoring

The monitoring of the SELCO lake, which was just downstream of Tilly-down and Ellery-down, was funded and conducted, in part, by the residents of the area. Even though these data were not funded by this project, they are included to add perspective to the stream monitoring data. Grab samples of lake water were collected and analyzed in the same manner as the stream samples. Samples were collected before, during, and following construction at various intervals (fig. 8). Residents quit collecting samples from about December, 2002 to September, 2003 because the lake was drained and from March, 2006 to May, 2007, because they said the lake was continually very turbid. The post-construction samples were collected by NCSU staff during visits to the samplers to recover stream samples; thus, these are from the same location and use the same technique, while most of the others were collected by residents and several locations around the lake. The main purpose of the post-construction samples was to document if and how quickly the lake returned to pre-construction conditions. A quick scan of the figure indicates that by about July, 2007 the lake was back to its pre-construction turbidity levels. The turbidity levels remained relatively low even though considerable rainfall occurred. Summary statistics of the turbidity data are shown in Table 19.

Table 19. SELCO Lake Monitoring Data.

	Count	Mean NTU	Median NTU
Pre-construction (9/14/02-6/4/04)	29	14	11
During-construction (6/5/04-1/3/08)	29	32	25
Post-construction (1/4/08-12/18/08)	19	16	10
(5/08-12/08)	7	8	7

As shown, the pre- and post-construction mean and median turbidities are similar. In fact, a t test assuming unequal variances suggested that the pre- and post-construction turbidities were not significantly different at the 0.05 level of significance, while those collected during construction were different. Further, the mean turbidity of samples collected from 5/08-12/08 was much less than those collected over the entire post-construction period, thereby indicating improving turbidity. Thus, it appears that the lake turbidity returned rather quickly to pre-construction levels following construction. However, these data must be used with caution because it is unknown the extent of construction in other parts of the lake's drainage area during these periods. Two residential developments and a local road widening occurred during the construction of the highway and construction in other parts of the lake's watershed was likely occurring even during the pre-construction period. The fact that the mean turbidity of samples from Ellery-down during pre-construction was greater than post-construction is indicative of other land disturbing activities occurring during the pre-construction period.

In addition to turbidity, another concern was sediment accumulation in the lake. Unlike turbidity, sediment accumulation is a permanent impairment unless the sediment is removed. The NC DOT used geotechnical methods to map the lake bottom during the pre- and post-construction periods. The NC DOT estimated that 63,558 ft^3 (1800 m^3) of sediment had been deposited in the lake since the start of highway construction to December 19, 2007. During this period monitoring at Ellery-down and Tilly-down documented that 55,507 ft^3 (1572 m^3) of sediment (assuming a bulk density of sediment equal to 1.1 g/cm^3) had passed the monitoring stations. Given that other tributaries may have contributed sediment to the lake, organic matter is likely mixed in with the sediment in the lake, and the bulk density of the stream sediment was not measured, the relatively close agreement of the two estimates tends to confirm their validity.

SUMMARY AND CONCLUSIONS

Rainfall and discharge were monitored continuously for more than three years at four sites in the Sedgefield Lakes area and two sites in the King's Mill area. Flow proportional samples were collected at each site and analyzed for TSS, TS, and turbidity. In-situ measurements of temperature, conductance, pH, and DO were made at various times. Two of the Sedgefield Lakes monitoring sites, Tilly-up and Ellery-up, were located immediately downstream of the new highway and two of the sites, Tilly-down and Ellery-down, were near the downstream end of the tributaries just upstream of the SELCO Lake. The King's Mill sites were just upstream and downstream of the new highway corridor on the unnamed tributary draining the King's Pond residential area.

Sediment export rate at the Tilly-up site increased from 0.01 tons/ac-yr during the 4.6 month pre-construction period to 7.91 tons/ac-yr during construction and then dropped to 1.02 tons/ac-yr in the post construction period. The estimated sediment export rate from the highway corridor itself was 20.6 tons/ac-yr during- and 1.02 tons/ac-yr post-construction. Average turbidity levels in samples increased from 25 NTU before highway construction to 1,570 NTU during construction and then fell to 153 NTU post-construction. About 32% of the sediment export to the station during-construction occurred during two tropical storm systems that hit the Greensboro area in September, 2004. Additional sediment control measures were installed following these events, which seemed to reduce sediment export from the highway corridor. The Tilly-up data represents the worst case scenario for highway construction in that, there was a large fill section with high and steep banks, tropical storm rainfall occurred at a time when the highway was most vulnerable, and this section of the highway took a long time to complete due to delays associated with building a railroad bridge.

Sediment export rate in the much larger Tilly-down watershed increased from 0.07 tons/ac-yr prior to construction to 2.8 tons/ac-yr during the construction and then decreased to 0.21 tons/ac-yr in the post-construction period. The much smaller increase was likely due to the fact that the highway corridor encompassed only 15.8% of the Tilly-down watershed and that a portion of the highway in the drainage area was closer to on-grade. Mean turbidity levels in samples increased from 54 NTU pre-construction to 887 NTU during construction falling to 93 NTU post-construction.

The sediment export rate at the Ellery-up site increased from 0.04 tons/ac-yr before construction to 4.72 tons/ac-yr during construction. This increase was less than that of Tilly-up even though the highway corridor encompassed more than 25% of both drainage areas. The main difference was that construction in the Ellery-up area was at an earlier phase during the tropical storms of September, 2004; thus, the corridor was less vulnerable to erosion. The estimated sediment export rate from the highway corridor itself was 18.0 tons/ac-yr during- and 1.24 tons/ac-yr post-construction. Corresponding decreases in TSS concentration and turbidity also occurred from during- to post-construction.

At Ellery-down, the sediment export rate increased from 0.20 tons/ac-yr before to 1.23 tons/ac-yr during the construction period and decreased to 0.17 tons/ac-yr post construction. . Mean turbidity levels in samples increased from 140 NTU before to 504 NTU during construction and then decreased to 72 NTU post-construction. The increases can be attributed to a combination of the highway construction, the Hilltop Road widening, and residential construction upstream. The post-construction TSS and turbidity levels and sediment export rate were less than those of the pre-construction period indicating that the highway corridor stabilized quickly.

At the King's Mill stations there was no pre-construction monitoring, but sediment export upstream of the highway corridor was 0.1 tons/ac-yr, while downstream it was 1.54 tons/ac-yr during construction. Much of this increase could be attributed to the highway construction. The estimated sediment export from the highway corridor itself was computed as 11.0 tons/ac-yr during and 0.79 tons/ac-yr post-construction. The mean turbidity of upstream samples was 42 NTU, while downstream it was 589 NTU during construction and 36 NTU upstream and 39 NTU downstream post construction. There was no statistically significant difference between upstream and downstream turbidities during the post-construction period.

Limited monitoring of temperature, specific conductance, DO, and pH for all six sites documented levels similar to or better than an urban stream in Charlotte, NC (USGS, 1999). The highway construction had little, if any, detectable effect on these parameters. There was not enough samples analyzed for nitrogen and phosphorus to compare pre- to during-construction, but the few data collected indicate that the levels of nitrogen and phosphorus in discharge were sufficient to support nuisance aquatic growth in downstream impoundments, although this could not be attributed to highway construction activities.

The mean turbidity of samples collected from SELCO Lake, which is just downstream of Tilly-down and Ellery-down, during the post-construction period (16 NTU) was not statistically different from those collected during the pre-construction period (14 NTU). Hence, the lake appeared to recover its clarity relatively quickly in the post-construction period. In fact, beginning just 4 months into the post-construction period, the mean turbidity for the rest of the post-construction period was 8 NTU. Sediment accumulation in the lake during construction was measured by geotechnical methods and was found to be in relatively close agreement with the combined sediment export measured at Tilly-down and Ellery-down.

Interaction and cooperation between NC DOT and the residents of the area helped reduce sediment movement from the highway corridor. Area residents' observations of runoff and sediment movement helped NC DOT focus efforts on potential trouble spots, thereby leading to improved erosion and sediment control.

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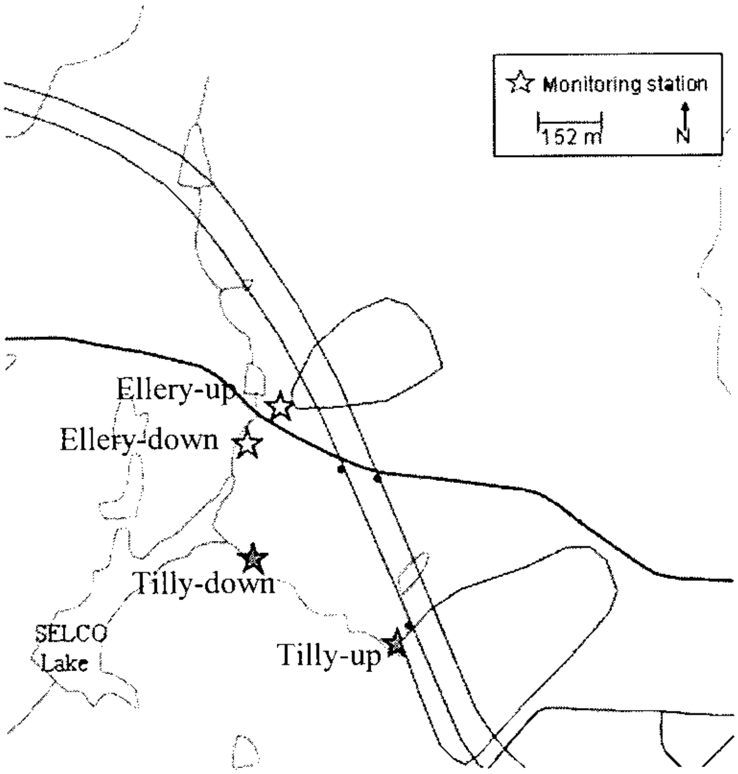

Figure 1. SELCO Lake monitoring sites.

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Figure 2. King's Mill monitoring sites.

Figure 3. Tilly-up weir (left) and Tilly-down monitoring site (right).

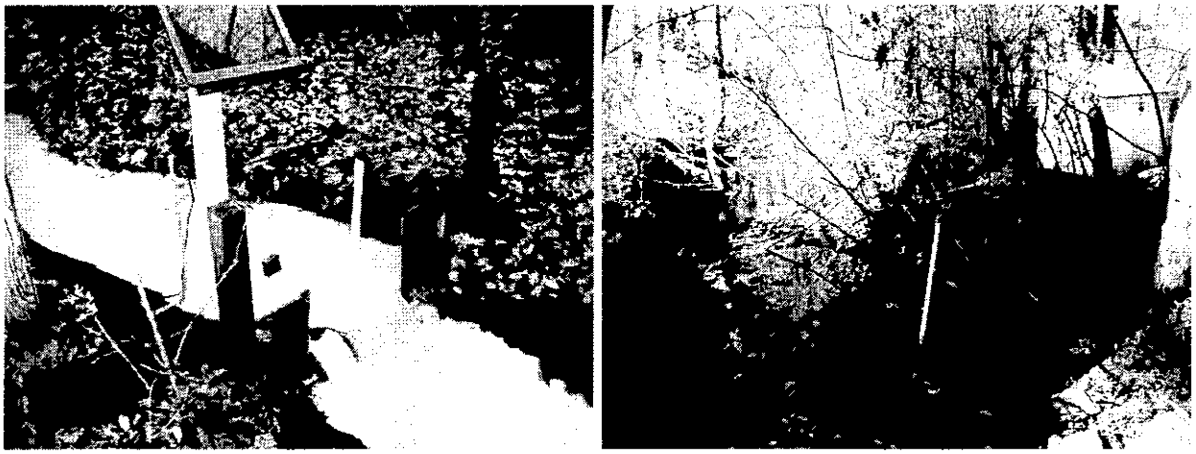

Figure 4. Ellery-up (left) and Ellery-down (right) monitoring sites.

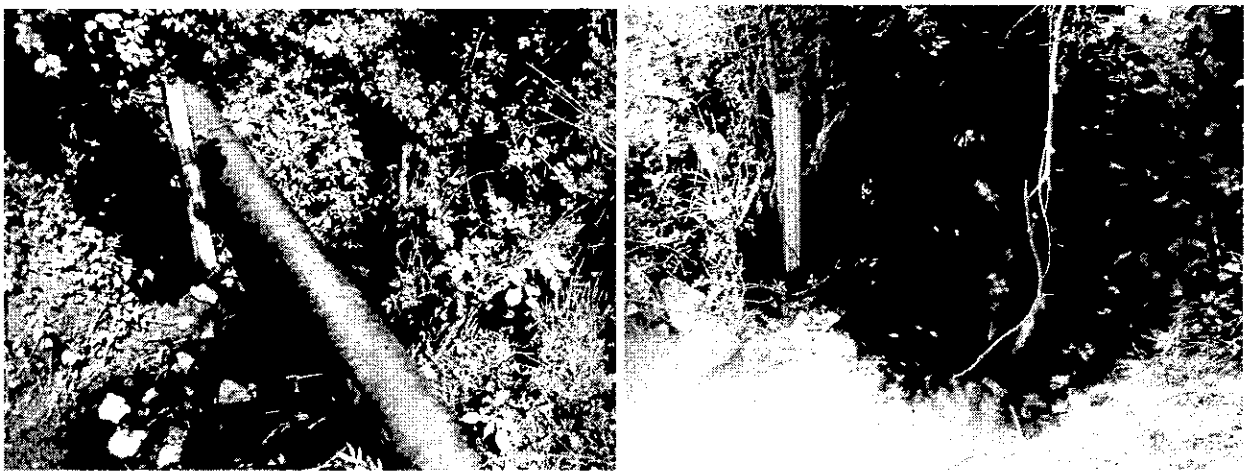

Figure 5. King's Mill up (left) and down (right) monitoring sites.

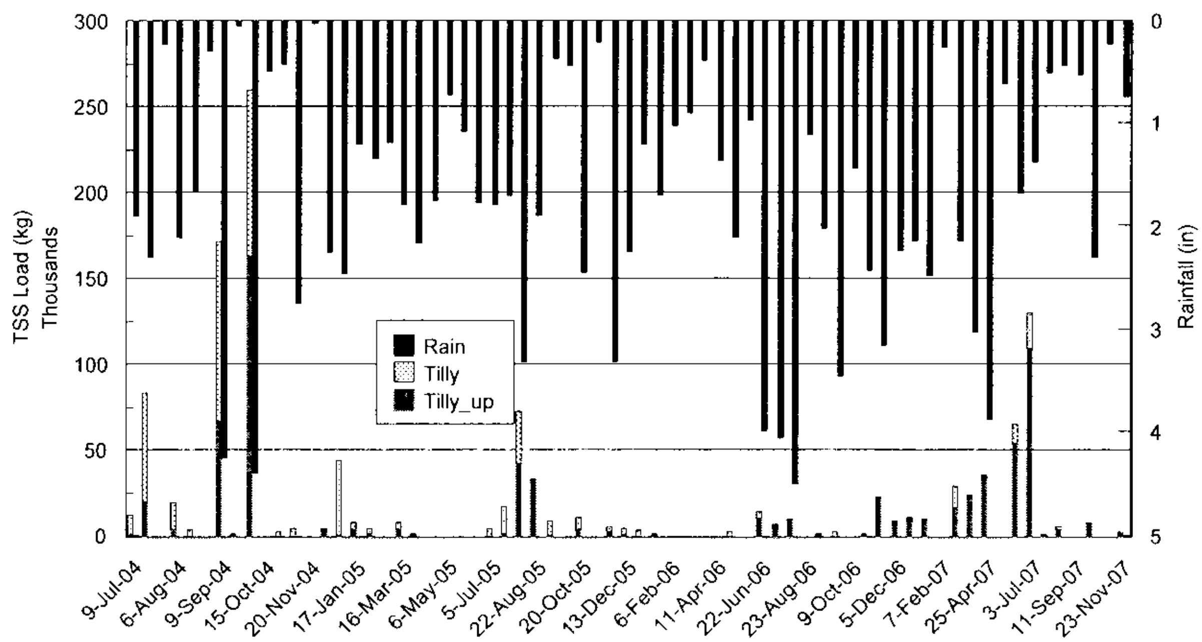

Figure 6. Sediment export at Tilly-up and Tilly-down during construction.

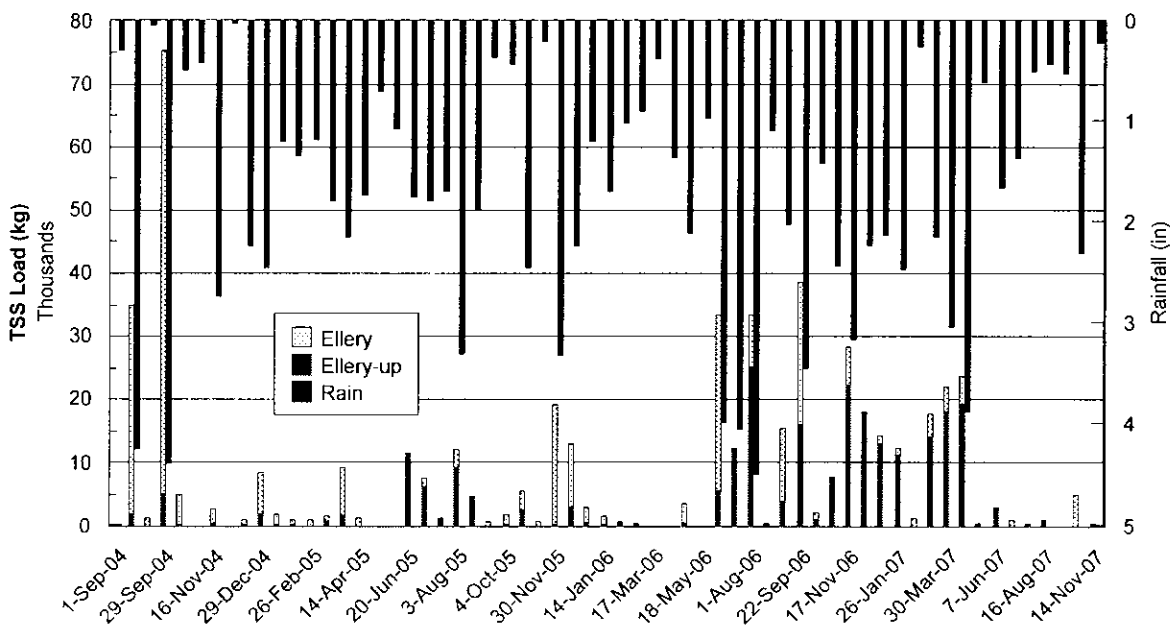

Figure 7. Sediment export at Ellery-up and Ellery-down during construction.

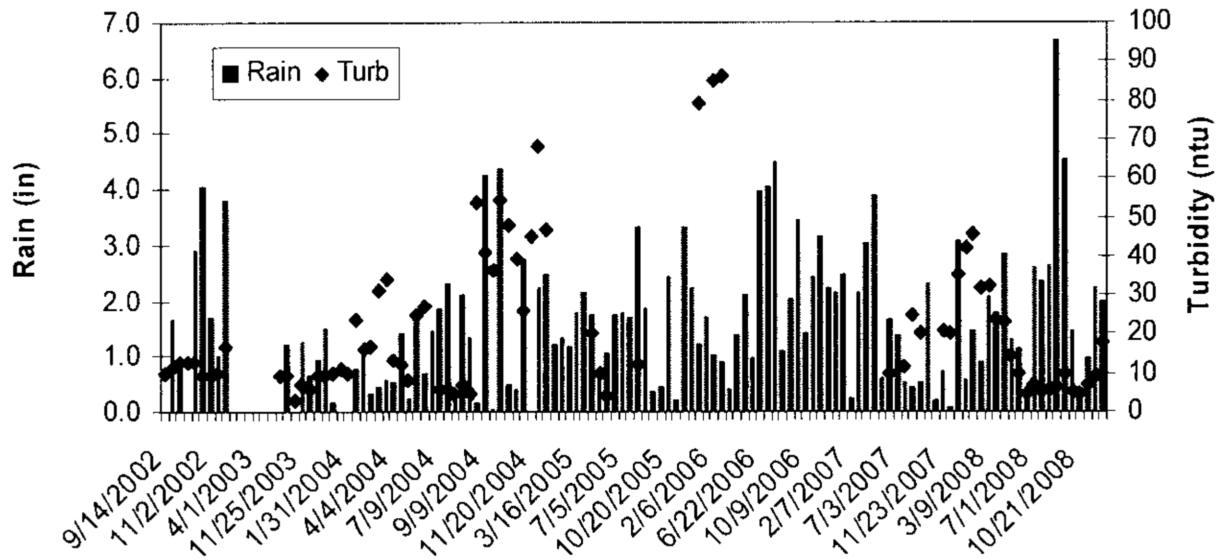

Figure 8. Turbidity of SELCO lake samples

APPENDIX

The date shown is the day samples were collected; thus it represents the last day of the monitoring period (i.e. the rainfall for 2/21/04 occurred from 2/5/04 to 2/21/04).

Exhibit 1. Monitoring Data for the Tilly-up Site.

Date	Rain In	Discharge gal	TS mg/L	TSS mg/L	TS kg	TSS kg	Turb NTU	Temp C	Cond	DO mg/L	pH
5-Feb-04	0.75	166,002	190	52	119	33	9				
21-Feb-04	1.06	138,210	110	6	58	3	13				
29-Feb-04	0.31	68,489	100	7	26	2	14				
14-Mar-04	0.45	55,000	105	10	22	2	10				
21-Mar-04	0.55	11,330	85	15	4	1	12				
4-Apr-04	0.53	6,950	165	43	4	1	30	9.6	0.13	10.3	7.4
18-Apr-04	1.43	83,945	140	81	44	26	67				
30-Apr-04	0.25	65,000	135	23	33	6	17				
21-May-04	1.78	187,776	160	28	114	20	19				
4-Jun-04	0.68	54,996	136	38	28	8	na	22.1	0.17	NA	7.3
23-Jun-04	1.47	167,810	135	64	86	41	54				
9-Jul-04	1.88	135,623	1,010	712	518	365	457	27.5	0.16	7.6	na
19-Jul-04	2.30	308,382	17,772	17,570	20,743	20,508	6,963				
24-Jul-04	0.22	10,305	6,306	6,115	246	239	na				
6-Aug-04	2.10	82,174	16,250	14,780	5,054	4,597	9,550				
20-Aug-04	1.65	19,760	9,000	7,498	673	561	na	22.9	0.19	4.9	6.9
3-Sep-04	0.29	5,787	1,750	216	38	5	536				
9-Sep-04	4.25	1,022,000	17,376	na	67,215	67,215	10,000				
16-Sep-04	0.05	114.107	6,357	na	2,746	1,647	2,770				
29-Sep-04	4.39	2.838.588	15,260	na	163,954	163,954	8,740				
15-Oct-04	0.49	273,800	157	24	162	24	16				
31-Oct-04	0.42	86,400	257	94	84	31	91				
16-Nov-04	2.74	720.000	377	216	1,027	589	219				
20-Nov-04	0.02	61,000	147	43	34	10	56				
7-Dec-04	2.24	1,040,183	947	905	3,728	3,563	855				
29-Dec-04	2.45	1,327,317	420	240	2,110	1,206	259				
17-Jan-05	1.20	858,500	1,661	1,510	5,397	4,907	789	12.5	0.227	7.0	6.6
9-Feb-05	1.34	1,373,000	580	434	3,014	2,255	379	10.1	0.090	7.6	6.4
26-Feb-05	1.18	529,000	180	56	360	112	67				
16-Mar-05	1.78	1,144,000	1,217	1,048	5,270	4,538	860				
30-Mar-05	2.15	1,321,000	423	122	2,115	610	221				
14-Apr-05	1.74	738,000	140	115	391	321	55	14.3	0.093	4.4	7.2
6-May-05	0.71	1,171,000	187	40	829	177	16				
31-May-05	1.07	1,020,000	156	24	602	93	11				
20-Jun-05	1.76	632,000	197	77	470	184	72				
5-Jul-05	1.78	332,000	790	648	993	814	558	21.1	0.132	4.9	5.6
22-Jul-05	1.70	531,000	1,570	1,175	3,155	2,362	1142				
3-Aug-05	3.30	1,086,000	10,300	10,490	42,338	42,729	4870				
22-Aug-05	1.88	661,000	16,540	na	41,381	33,105	8120	21.7	0.132	5.0	na

Date	Rain In	Discharge gal	TS mg/L	TSS mg/L	TS kg	TSS kg	Turb NTU	Temp C	Cond	DO mg/L	pH
13-Sep-05	0.37	177,500	1,910	1,740	1,283	1,169	990				
4-Oct-05	0.43	67,500	203	81	52	21	57				
20-Oct-05	2.44	424,760	3,468	3,090	5,576	4,968	2824				
6-Nov-05	0.21	285,690	283	119	306	129	87				
30-Nov-05	3.31	943,748	1,282	1,055	4,578	3,769	1140				
13-Dec-05	2.24	947,547	647	460	2,319	1,650	497				
24-Dec-05	1.20	951,780	293	199	1,057	716	179				
14-Jan-06	1.70	887,529	ns	na	1,025	765	na				
6-Feb-06	1.02	1,266,000	200	57	958	273	74				
25-Feb-06	0.90	721,444	na	na	549	156	na				
17-Mar-06	0.39	317,000	na	na	266	87	na				
11-Apr-06	1.36	342,900	na	na	391	192	na	16.7	0.135	na	6.7
6-May-06	2.10	625,700	500	331	1,184	783	291				
18-May-06	0.97	237,200	203	57	183	51	80				
22-Jun-06	3.98	2,215,000	1,523	1,343	12,771	11,258	1156				
12-Jul-06	4.05	1,473,000	1,228	1,060	6,848	5,910	829				
1-Aug-06	4.50	1,775,400	1,698	1,520	11,413	10,214	853				
23-Aug-06	1.10	420,000	190	38	302	60	19				
6-Sep-06	2.02	735,000	na	na	1,253	721	na				
22-Sep-06	3.44	1,171,000	170	51	753	226	42				
9-Oct-06	1.42	721,074	155	27	423	74	43	18.7	0.180	4.4	7.1
4-Nov-06	2.42	1,134,400	500	260	2,147	1,116	362				
17-Nov-06	3.15	1,726,500	3,670	3,567	23,983	23,307	2835	14.4	0.165	7.0	7.2
5-Dec-06	2.23	1,743,000	1,362	1,239	8,983	8,173	958				
3-Jan-07	2.13	979,730	2,773	2,700	10,284	10,012	1976				
26-Jan-07	2.47	1,433,000	2,013	1,940	10,920	10,522	1166				
7-Feb-07	0.25	511,000	353	196	683	379	134				
26-Feb-07	2.14	1,396,300	3,392	3,278	17,927	17,323	2245	10.4	0.090	7.6	na
30-Mar-07	3.03	2,362,000	2,492	2,500	22,279	22,350	1664				
25-Apr-07	3.87	3,260,000	2,752	2,820	33,957	34,796	1560				
12-May-07	0.61	507,600	180	34	346	65	34				
7-Jun-07	1.67	635,800	8,312	9,333	20,003	22,461	2572				
3-Jul-07	1.37	1,565,000	18,564	18,564	109,964	109,964	8500				
27-Jul-07	0.51	501,850	820	616	1,558	1,170	355				
16-Aug-07	0.44	304,000	6,075	5,770	6,990	5,311	4950				
11-Sep-07	0.52	580,529	374	185	822	407	156				
28-Oct-07	2.30	1,325,500	1,723	1,548	8,644	7,766	1360				
14-Nov-07	0.22	416,000	181	36	285	56	62				
23-Nov-07	0.74	268,875	2,160	2,176	2,198	2,214	225				
14-Dec-07	0.07	260,500	400	238	394	235	146				
3-Jan-08	3.09	795,000	1,024	1,000	3,083	3,009	538				
24-Jan-08	0.55	287,200	534	330	580	359	41	7.9	0.174	na	6.7
12-Feb-08	1.45	833,500	627	476	1,977	1,502	298				
26-Feb-08	0.87	333,350	618	542	779	684	582				
9-Mar-08	2.06	670,500	987	784	2,504	1,990	516				
1-Apr-08	1.80	934,000	424	277	1,500	980	191				
23-Apr-08	2.85	1,101,500	371	276	1,547	1,151	166	14.3	0.135	3.7	6.5

9-May-08	1.28	540,150	171	57	349	117	33				
31-May-08	1.15	490,650	266	106	494	197	64				
13-Jun-08	0.30	289,440	172	42	189	46	31				
1-Jul-08	2.60	456,500	220	111	380	192	58				
10-Jul-08	2.36	427,500	242	233	391	378	145				
7-Aug-08	2.63	916,500	209	197	726	685	70	19.4	0.000	2.4	6.5
27-Aug-08	6.66	1,470,000	254	169	1,412	942	94				
25-Sep-08	4.53	1,946,000	151	52	1,111	383	38				
7-Oct-08	1.44	689,000	209	32	546	83	19				
21-Oct-08	0.31	408,000	165	14	254	22	11	13.4	0.188	2.2	6.5
9-Nov-08	0.98	863,200	118	27	387	88	21				
5-Dec-08	2.21	1,151,200	175	149	764	649	84				
18-Dec-08	2.00	809,600	278	168	853	515	95	11.2	0.186	0.7	na

*due to very high concentration of sediment only TS analysis was conducted, TSS was assumed to equal TS, which at these high levels has been shown to be a reasonable assumption.

Exhibit 2. Monitoring Data for the Tilly-down Site.

Date	Rain In	Discharge gal	TS mg/L	TSS mg/L	TS Kg	TSS kg	Turb NTU	Temp C	Cond	DO mg/L	pH
5-Feb-04	0.75	2,460,000	200	57	1,862	531	70				
21-Feb-04	1.06	6,245,000	155	19	3,664	449	28				
29-Feb-04	0.31	2,110,000	170	25	1,358	200	30				
14-Mar-04	0.45	1,128,000	150	21	640	90	17				
21-Mar-04	0.55	483,389	175	14	320	26	23				
4-Apr-04	0.53	190,084	225	30	162	22	24	9.9	0.203	10.5	7.5
18-Apr-04	1.43	4,341,000	248	110	4,067	1,807	98				
30-Apr-04	0.25	140,480	150	25	80	13	22				
21-May-04	1.78	271,700	220	51	226	52	42				
4-Jun-04	0.68	71,440	375	219	101	59	189	20.5	0.257	5.42	7.4
23-Jun-04	1.47	616,347	208	63	484	147	54				
9-Jul-04	1.88	1,451,000	2530	2236	13,895	12,280	2,130	24.3	0.188	4.46	na
19-Jul-04	2.30	2,428,000	9748	9090	89,584	83,537	6,280				
24-Jul-04	0.22	356,000	293	188	395	253	137				
6-Aug-04	2.10	1,515,000	3568	3347	20,460	19,193	2,019				
20-Aug-04	1.65	1,060,000	1027	828	4,120	3,322	620	22.2	0.2	7.8	6.8
3-Sep-04	0.29	626,000	210	54	498	128	78				
9-Sep-04	4.25	8,400,000	5389	na	171,322	171,322	10,000				
16-Sep-04	0.01	700,000	na	na	na	1,909	na				
29-Sep-04	4.39	9,335,000	7367	7367	260,286	260,286	6,640				
15-Oct-04	0.49	2,869,000	180	94	1,955	1,021	78				
31-Oct-04	0.42	674,798	1075	884	2,746	2,258	348				
16-Nov-04	2.74	4,230,000	517	332	8,277	5,316	293				
20-Nov-04	0.02	103,000	140	28	55	11	30				
7-Dec-04	2.24	6,908,000	330	198	8,628	5,177	184				
29-Dec-04	2.45	9,469,000	1380	1240	49,459	44,442	830				
17-Jan-05	1.20	4,724,000	600	428	10,728	7,653	266	12.8	0.196	7.7	5.8
9-Feb-05	1.34	5,141,000	369	225	7,171	4,378	na	10.1	0.130	7.0	6.6
26-Feb-05	1.18	2,000,000	155	40	1,173	303	na				
16-Mar-05	1.78	3,546,000	737	112	9,889	7,787	115				
30-Mar-05	2.15	5,845,000	150	58	3,318	1,283	80				
14-Apr-05	1.74	3,808,000	257	57	3,704	822	81	14.5	0.128	3.4	7.4
6-May-05	0.71	2,387,000	153	89	1,382	804	86				
31-May-05	1.07	1,860,000	ns	109	na	765	na				
20-Jun-05	1.76	919,000	333	180	1,159	626	154				
5-Jul-05	1.78	748,800	1860	1650	5,272	4,676	1,120	22.1	0.137	5.5	5.5
22-Jul-05	1.70	1,035,000	4787	4530	18,752	17,746	3,140				
3-Aug-05	3.30	2,980,000	6360	6450	71,736	72,751	2,970				
22-Aug-05	1.88	1,116,000	3007	2670	12,700	11,278	1,740	21.4	0.125	4.9	na
13-Sep-05	0.37	595,912	4353	4230	9,819	9,541	2,510				
4-Oct-05	0.43	104,000	640	440	252	173	309				
20-Oct-05	2.44	1,765,000	1873	1735	12,515	11,591	1,314				
6-Nov-05	0.21	339,200	188	42	242	54	45				
30-Nov-05	3.31	2,676,500	750	546	7,598	5,531	503				
13-Dec-05	2.24	5,943,900	362	236	8,137	5,315	228				
24-Dec-05	1.20	5,213,300	ns	na	na	4,251	na				

Date	Rain In	Discharge gal	TS mg/L	TSS mg/L	TS kg	TSS kg	Turb NTU	Temp C	Cond	DO mg/L	pH
25-Feb-06	0.90	1,084,000	232	88	951	361	67				
17-Mar-06	0.39	838,400	270	134	857	425	82				
11-Apr-06	1.36	1,083,000	207	86	847	353	58	14.6	0.152	na	7.1
6-May-06	2.10	2,295,200	400	254	3,475	2,210	203				
18-May-06	0.97	522,900	172	62	340	123	70				
22-Jun-06	3.98	6,397,000	682	608	16,505	14,721	405				
12-Jul-06	4.05	4,401,000	545	432	9,078	7,196	311				
1-Aug-06	4.50	4,506,000	590	560	10,063	9,551	270				
23-Aug-06	1.10	821,000	175	25	544	78	35				
6-Sep-06	2.02	1,741,000	377	276	2,482	1,818	220				
22-Sep-06	3.44	4,476,000	273	172	4,631	2,910	146				
9-Oct-06	1.42	855,672	167	70	540	227	56	20.0	0.108	6.0	7.2
4-Nov-06	2.42	2,004,360	260	112	1,972	850	133				
17-Nov-06	3.15	6,191,700	893	672	20,936	15,749	643	12.3	0.100	6.9	7.3
5-Dec-06	2.23	8,632,000	380	274	12,415	8,952	272				
3-Jan-07	2.13	5,671,000	682	528	14,632	11,333	416				
26-Jan-07	2.47	6,434,000	455	332	11,080	8,085	281				
7-Feb-07	0.25	815,700	427	232	1,317	716	172				
26-Feb-07	2.14	6,832,000	1264	1131	32,686	29,253	731	10.3	0.123	8.7	5.6
30-Mar-07	3.03	9,787,000	740	636	27,412	23,560	479				
25-Apr-07	3.87	8,245,000	1236	1125	38,572	35,108	765				
12-May-07	0.61	662,630	na	na	96	85	na				
7-Jun-07	1.67	980,000	4728	4800	17,538	17,805	3,856				
3-Jul-07	1.37	2,890,628	na	na	na	130,570	na				
27-Jul-07	0.51	1,176,000	276	105	1,229	1,402	59				
16-Aug-07	0.44	865,000	1963	1872	6,425	6,129	1,825				
11-Sep-07	0.52	624,900	263	85	622	422	53				
28-Oct-07	2.30	2,916,100	833	728	9,189	8,035	728				
14-Nov-07	0.22	881,920	150	24	501	80	16				
23-Nov-07	0.74	972,400	715	620	2,632	2,282	180				
14-Dec-07	0.07	891,200	189	31	637	263	28				
3-Jan-08	3.09	4,528,000	424	303	7,274	5,184	286				
24-Jan-08	0.55	1,072,500	362	160	1,470	650	181	5.4	0.216	na	6.9
12-Feb-08	1.45	2,110,000	322	246	2,573	1,965	196				
26-Feb-08	0.87	908,400	289	68	993	234	117				
9-Mar-08	2.06	3,307,000	324	182	4,061	2,278	147				
1-Apr-08	1.80	3,439,320	151	64	1,967	833	51				
23-Apr-08	2.85	8,991,000	185	102	6,283	3,471	57	15.0	0.173	3.3	6.8
9-May-08	1.28	2,837,000	165	79	1,768	848	40				
31-May-08	1.15	1,017,700	206	48	794	185	31				
13-Jun-08	0.30	314,500	178	68	212	81	17				
1-Jul-08	2.60	841,700	377	266	1,201	847	185				
10-Jul-08	2.36	1,701,600	242	184	1,556	1,185	104				
7-Aug-08	2.63	1,645,200	614	524	3,822	3,263	337	22.6	0.000	4.6	6.8
27-Aug-08	6.66	12,000,000	303	122	13,766	5,541	86				
25-Sep-08	4.53	6,960,000	122	33	3,202	878	36				
7-Oct-08	1.44	1,632,400	176	76	1,089	470	45				

21-Oct-08	0.31	666,300	226	55	570	138	37	11.9	0.210	2.4	6.4
9-Nov-08	0.98	1,279,000	105	26	506	126	27				
5-Dec-08	2.21	3,126,000	105	51	1,238	599	29				
18-Dec-08	2.00	2,984,000	180	57	2,033	648	46	9.7	0.184	1.0	na

Exhibit 3. Monitoring Data for the Ellery-up Site.

Date	Rain in	Discharge gal	TS mg/L	TSS mg/L	TS kg	TSS kg	Turb NTU	Tem C	Cond	DO mg/L	pH
5-Feb-04	0.75	98,200	120	2	45	1	5				
21-Feb-04	1.06	129,000	240	24	117	12	28				
29-Feb-04	0.31	41,000	345	14	54	2	21				
14-Mar-04	0.45	158,470	170	5	102	3	14				
21-Mar-04	0.55	150,000	153	10	87	5	na				
4-Apr-04	0.53	173,395	135	14	89	9	13	8.2	0.18	7.2	7.4
18-Apr-04	1.43	190,500	280	172	202	124	101				
30-Apr-04	0.25	70,000	130	7	34	2	8				
21-May-04	1.78	157,000	120	10	71	6	12				
4-Jun-04	0.68	80,600	135	4	41	1	12	17.6	0.16	1.8	7.4
23-Jun-04	1.47	107,360	170	40	69	16	8				
9-Jul-04	1.88	142,620	197	58	106	31	52	20.4	0.18	1.7	na
19-Jul-04	2.30	182,240	184	49	127	34	na				
24-Jul-04	0.22	25,028	150	29	14	3	32				
6-Aug-04	2.10	239,229	220	102	199	92	59				
20-Aug-04	1.65	154,607	243	44	142	26	42	20.7	0.19	2.1	6.8
1-Sep-04	0.29	34,782	140	40	18	5	46				
9-Sep-04	4.25	529,000	7630	1025	15,277	2,052	2820				
16-Sep-04	0.01	30,800	760	400	89	47	235				
29-Sep-04	4.39	581,487	2367	2367	5,209	5,209	1005				
15-Oct-04	0.49	99,922	1400	1400	529	529	520				
31-Oct-04	0.42	28,467	280	34	30	4	32				
16-Nov-04	2.74	325,575	583	576	718	710	332				
20-Nov-04	0.02	26,532	226	18	23	2	11				
7-Dec-04	2.24	507,300	507	294	974	565	264				
29-Dec-04	2.45	510,500	1273	1055	2,460	2,039	822				
17-Jan-05	1.20	251,424	na	na	606	502	na	13.3	0.2	3.5	6.0
9-Feb-05	1.34	349,000	613	384	810	507	291	9.7	0.2	7.8	6.0
26-Feb-05	1.18	409,000	253	70	392	108	70				
16-Mar-05	1.78	572,000	663	440	1,435	953	385				
30-Mar-05	2.15	583,000	1070	900	2,361	1,986	618				
14-Apr-05	1.74	304,000	500	155	575	178	269	15.4	0.2	3.6	7.1
6-May-05	0.71	112,000	233	74	99	31	60				
31-May-05	1.07	272,000	276	95	284	98	58				
20-Jun-05	1.76	143,000	21973	21070	11,893	11,404	9720				
5-Jul-05	1.78	106,000	na	na	na	6,399	na	20.0	0.3	5.8	5.7
22-Jul-05	1.70	32,000	11357	10830	1,376	1,312	5750				
3-Aug-05	3.30	294,000	8657	8560	9,633	9,525	1530				
22-Aug-05	1.88	123,200	10590	10040	4,938	4,682	3610	20.1	0.3	5.3	na
13-Sep-05	0.37	87,020	303	105	100	35	90				
4-Oct-05	0.43	96,333	1663	1480	606	540	976				
20-Oct-05	2.44	325,027	2438	2175	3,000	2,676	1998				
6-Nov-05	0.21	57,740	342	133	75	29	126				
30-Nov-05	3.31	590,000	388	192	867	429	170				
13-Dec-05	2.24	509,000	2353	1700	4,534	3,275	1950				
24-Dec-05	1.20	300,000	na	na	na	741	na				

Date	Rain In	Discharge gal	TS mg/L	TSS mg/L	TS kg	TSS kg	Turb NTU	Temp C	Cond	DO mg/L	pH
25-Feb-06	0.90	241,742	230	77	210	71	72				
17-Mar-06	0.39	85,000	229	68	74	22	58				
11-Apr-06	1.36	273,000	190	33	196	34	38	16.7	0.1	na	6.7
6-May-06	2.10	284,500	945	790	1,018	851	615				
18-May-06	0.97	193,207	183	40	134	29	50				
22-Jun-06	3.98	638,540	2495	2413	6,030	5,833	1708				
12-Jul-06	4.05	526,070	6225	6200	12,395	12,345	4655				
1-Aug-06	4.50	413,600	16083	16267	25,178	25,465	10080				
23-Aug-06	1.10	180,000	447	236	304	161	142				
6-Sep-06	2.02	122,910	9717	9160	4,520	4,261	8110				
22-Sep-06	3.44	777,300	5848	5590	17,206	16,446	4520				
9-Oct-06	1.42	275,400	1370	1113	1,428	1,160	1102	16.7	0.3	3.8	7.1
4-Nov-06	2.42	387,200	5733	5258	8,402	7,706	4780				
17-Nov-06	3.15	856,300	6642	6960	21,526	22,558	4755	12.9	0.2	5.8	7.0
5-Dec-06	2.23	736,200	5693	6471	15,865	18,033	4080				
3-Jan-07	2.13	1,293,000	2735	2727	13,385	13,347	2172				
26-Jan-07	2.47	1,125,140	na	na	na	11,615	na				
7-Feb-07	0.25	299,600	298	137	338	155	93				
26-Feb-07	2.14	991,500	3902	3867	14,642	14,511	2715	10.7	0.2	6.9	6.4
30-Mar-07	3.03	1,476,000	3344	3280	18,682	18,324	2095				
25-Apr-07	3.87	1,717,000	2960	2988	19,237	19,415	1840				
12-May-07	0.61	225,000	392	207	334	176	168				
7-Jun-07	1.67	368,500	2320	2136	3,236	2,979	1648				
3-Jul-07	1.37	168,500	480	274	306	175	118				
27-Jul-07	0.51	246,800	544	372	508	347	280				
16-Aug-07	0.44	234,000	2052	1128	1,817	999	1070				
11-Sep-07	0.52	135,780	277	163	142	84	195				
28-Oct-07	2.30	561,700	220	100	468	213	49				
14-Nov-07	0.22	299,600	325	181	369	206	91				
23-Nov-07	0.74	136,800	na	na	na	89	na				
14-Dec-07	0.07	95,760	na	na	na	62	na				
3-Jan-08	3.09	1,115,000	462	312	1,951	1,317	176				
24-Jan-08	0.55	150,600	336	124	191	71	74	5.5	0.2	na	6.8
12-Feb-08	1.45	326,940	482	348	597	431	219				
26-Feb-08	0.87	228,100	267	93	230	80	53				
9-Mar-08	2.06	1,789,000	300	166	2,031	1,124	109				
1-Apr-08	1.80	934,250	178	88	629	311	48				
23-Apr-08	2.85	1,044,000	272	188	1,076	743	91	14.6	0.2	2.1	6.6
9-May-08	1.28	468,200	168	68	297	121	41				
31-May-08	1.15	242,530	268	128	246	118	68				
13-Jun-08	0.30	37,112	176	9	25	1	8				
1-Jul-08	2.60	288,470	335	158	366	172	111				
10-Jul-08	2.36	388,700	245	118	360	173	84				
7-Aug-08	2.63	450,000	263	139	448	236	63	19.3	0.2	1.2	6.4
27-Aug-08	6.66	1,185,200	295	236	1,325	1,059	101				
25-Sep-08	4.53	1,262,000	145	61	691	293	35				
7-Oct-08	1.44	468,200	143	39	254	69	29				

21-Oct-08	0.31	280,000	177	42	188	45	23	12.6	0.24	1.3	6.5
9-Nov-08	0.98	142,040	na	na	na	25					
5-Dec-08	2.21	374,000	na	na	na	161					
18-Dec-08	2.00	340,000	334	313	430	403	133	10.8	0.21	0.73	na

Exhibit 4. Monitoring Data for the Ellery-down Site.

Date	Rain in	Discharge Gal	TS mg/L	TSS mg/L	TS kg	TSS kg	Turb NTU	Temp C	Cond	DO mg/L	pH
5-Feb-04	0.75	1,965,000	270	16	2,008	119	9				
21-Feb-04	1.06	4,194,000	215	70	3,413	1,111	50				
29-Feb-04	0.31	1,140,500	230	34	993	147	na				
14-Mar-04	0.45	3,211,000	205	16	2,491	194	20				
21-Mar-04	0.55	1,714,000	290	21	1,881	136	16				
4-Apr-04	0.53	971,932	305	102	1,122	375	61	9.6	0.29	7.9	7.9
18-Apr-04	1.43	1,746,640	258	106	1,702	697	70				
30-Apr-04	0.25	242,310	124	26	114	24	NA				
21-May-04	1.78	344,608	130	32	170	42	20				
4-Jun-04	0.68	271,471	185	14	190	14	26	27.7	0.13	5.9	7.4
23-Jun-04	1.47	464,878	225	88	396	155	76				
9-Jul-04	1.88	381,736	900	536	1,300	774	596	26.3	0.24	4.2	na
19-Jul-04	2.30	989,158	965	715	3,613	2,675	429				
24-Jul-04	0.22	187,033	383	234	271	166	176				
6-Aug-04	2.10	768,500	614	424	1,785	1,234	na				
20-Aug-04	1.65	284,263	493	324	530	349	275	29.3	0.2	4.6	6.8
1-Sep-04	0.29	158,121	420	264	251	158	na				
9-Sep-04	4.25	2,518,000	1,501	1194	14,301	11,380	890				
16-Sep-04	0.01	546,365	600	376	1,241	778	282				
29-Sep-04	4.39	3,657,997	1,952	1952	27,020	27,020	1095				
15-Oct-04	0.49	532,613	1,333	1333	2,687	2,687	548				
31-Oct-04	0.42	301,073	263	90	300	103	78				
16-Nov-04	2.74	1,426,136	450	236	2,429	1,274	229				
20-Nov-04	0.02	2,995,000	450	236	5,101	2,675	229				
7-Dec-04	2.24	576,000	240	40	523	87	75				
29-Dec-04	2.45	2,516,400	346	114	3,296	1,086	134				
17-Jan-05	1.20	4,627,000	697	487	12,207	8,529	450				
9-Feb-05	1.34	1,934,000	413	240	3,023	1,757	209	13.1	0.2	5.3	5.9
26-Feb-05	1.18	1,539,000	393	158	2,289	920	143	10.6	0.2	9.1	6.4
16-Mar-05	1.78	903,000	547	304	1,870	1,039	357				
30-Mar-05	2.15	4,120,000	773	596	12,054	9,294	397				
14-Apr-05	1.74	1,014,000	na	na	na	1,366	na	14.5	0.1	3.4	7.4
6-May-05	0.71	617,000	203	60	474	140	57				
31-May-05	1.07	344,000	na	na	na	237	na				
20-Jun-05	1.76	287,000	na	na	na	7,867	na				
5-Jul-05	1.78	248,000	na	na	na	7,548	na	25.4	0.2	5.9	6.3
22-Jul-05	1.70	368,000	363	204	506	284	139				
3-Aug-05	3.30	1,350,000	777	528	3,969	2,698	453				
22-Aug-05	1.88	618,000	2,183	1880	5,107	4,398	1050	23.0	0.3	6.6	na
13-Sep-05	0.37	253,000	993	730	951	699	745				
4-Oct-05	0.43	602,000	na	na	na	6,043	na				
20-Oct-05	2.44	1,409,000	na	na	na	14,144	na				
6-Nov-05	0.21	201,700	na	na	na	2,025	na				
30-Nov-05	3.31	3,016,000	2,033	1690	23,212	19,292	1402				
13-Dec-05	2.24	5,028,500	1,086	676	20,667	12,866	752				

Date	Rain In	Discharge gal	TS mg/L	TSS mg/L	TS kg	TSS kg	Turb NTU	Temp C	Cond	DO mg/L	pH
6-Feb-06	1.02	1,145,400	448	144	1,944	624	202				
25-Feb-06	0.90	857,340	292	121	946	394	99				
17-Mar-06	0.39	543,000	292	77	599	158	81				
11-Apr-06	1.36	750,400	225	68	639	193	71	14.6	0.2	na	7.1
6-May-06	2.10	1,802,700	710	504	4,844	3,439	420				
18-May-06	0.97	486,400	315	135	580	248	139				
22-Jun-06	3.98	4,235,120	2,525	2082	40,476	33,371	1692				
12-Jul-06	4.05	4,300,000	1,023	732	16,655	11,914	751				
1-Aug-06	4.50	4,000,000	na	na	na	33,371	na				
23-Aug-06	1.10	642,400	348	154	847	374	97				
6-Sep-06	2.02	1,911,300	2,245	2153	16,241	15,578	1920				
22-Sep-06	3.44	5,151,000	na	na	na	38,507	na				
9-Oct-06	1.42	869,700	813	624	2,677	2,054	562	17.9	0.1	6.3	7.4
4-Nov-06	2.42	2,982,200	813	528	9,181	5,960	493				
17-Nov-06	3.15	4,961,300	1,718	1514	32,268	28,436	1246	12.1	0.1	8.9	7.4
5-Dec-06	2.23	6,148,700	895	628	20,829	14,615	622				
3-Jan-07	2.13	5,175,000	955	728	18,706	14,260	686				
26-Jan-07	2.47	6,305,000	753	524	17,978	12,505	513				
7-Feb-07	0.25	1,019,400	592	360	2,283	1,389	344				
26-Feb-07	2.14	5,106,000	1,123	924	21,710	17,857	778	11.0	0.1	7.4	6.4
30-Mar-07	3.03	6,959,000	1,036	835	27,288	22,001	718				
25-Apr-07	3.87	8,328,000	1,000	757	31,521	23,866	662				
12-May-07	0.61	883,300	348	152	1,163	508	127				
7-Jun-07	1.67	1,489,400	420	280	2,368	1,578	196				
3-Jul-07	1.37	1,034,000	468	280	1,832	1,096	171				
27-Jul-07	0.51	643,400	288	108	701	395	79				
16-Aug-07	0.44	710,400	na	na	na	1,065	na				
11-Sep-07	0.52	208,650	503	156	397	123	68				
28-Oct-07	2.30	5,877,000	283	226	6,284	5,027	243				
14-Nov-07	0.22	1,502,000	195	52	1,109	296	74				
23-Nov-07	0.74	563,650	205	81	437	174	76				
14-Dec-07	0.07	1,800,000	202	39	1,378	267	24				
3-Jan-08	3.09	4,404,000	184	68	3,062	1,360	86				
24-Jan-08	0.55	1,610,000	229	55	1,395	400	71	6.7	0.2	na	6.7
12-Feb-08	1.45	2,618,200	200	98	1,982	1,165	79				
26-Feb-08	0.87	1,321,400	207	48	1,034	288	54				
9-Mar-08	2.06	3,164,200	213	82	2,555	1,178	99				
1-Apr-08	1.80	2,801,000	147	51	1,555	649	65				
23-Apr-08	2.85	6,633,000	226	119	5,678	3,578	106	16.1	0.2	2.8	6.8
9-May-08	1.28	2,707,200	185	69	1,892	848	108				
31-May-08	1.15	1,020,000	200	43	772	199	35				
13-Jun-08	0.30	329,700	191	43	238	64	31				
1-Jul-08	2.60	1,185,400	255	212	1,146	1,143	125				
10-Jul-08	2.36	1,955,100	174	114	1,286	1,015	77				
7-Aug-08	2.63	2,771,700	237	112	2,486	1,410	74	24.6	0.1	4.2	6.9
27-Aug-08	6.66	5,622,100	212	168	4,518	4,290	140				
25-Sep-08	4.53	7,430,000	148	57	4,153	1,912	46				

7-Oct-08	1.44	468,200	143	39	254	69	29				
21-Oct-08	0.31	280,000	177	42	188	45	23	12.6	0.235	1.3	6.5
9-Nov-08	0.98	142,040	na	na	na	25	na				
5-Dec-08	2.21	374,000	na	na	na	161	na				
18-Dec-08	2.00	340,000	334	313	430	403	133	10.8	0.213	0.73	

Exhibit 5. Monitoring Data for the King's Mill-up Site.

Date	Rain In	Discharge gal	TS mg/L	TSS mg/L	TS kg	TSS kg	Turb NTU	Temp C	Cond	DO mg/L	pH
5-Jun-04	0.68	457768	400	216	693	374	87	19.5	0.2	5.2	7.2
23-Jun-04	1.47	420240	315	236	501	375	93				
9-Jul-04	1.88	653,462	127	91	314	225	17	24.4	0.22	6.3	na
19-Jul-04	2.30	1,078,359	232	121	945	492	54				
24-Jul-04	0.22	168,921	120	43	77	27	43				
6-Aug-04	2.10	556,087	147	51	309	107	21				
20-Aug-04	1.65	273,144	147	45	152	47	29	21.7	0.23	5.6	7.5
1-Sep-04	0.29	106,854	133	81	54	33	47				
9-Sep-04	4.25	4,054,000	197	156	3,023	2,386	61				
16-Sep-04	0.01	241,820	187	22	171	20	38				
29-Sep-04	4.39	5,088,682	233	69	4,488	1,329	35				
15-Oct-04	0.49	1,662,000	157	24	984	148	16				
31-Oct-04	0.42	928,000	146	18	513	63	17				
20-Nov-04	2.74	2,583,996	210	53	2,054	518	29				
7-Dec-04	2.24	2,453,000	160	106	1,486	984	46				
29-Dec-04	2.45	3,425,000	173	91	2,243	1,180	48				
17-Jan-05	1.20	1,744,890	210	98	1,387	647	38	12.5	0.23	5.8	6.4
9-Feb-05	1.34	1,420,000	na	na	976	396	na	10.2	0.17	9.0	6.8
26-Feb-05	1.18	830,000	180	46	565	145	32				
16-Mar-05	1.78	2,067,000	173	55	1,353	430	42				
30-Mar-05	2.15	3,519,000	183	90	2,437	1,199	59				
14-Apr-05	1.74	1,233,000	143	23	667	107	18	12.1	0.17	3.9	7.1
6-May-05	0.71	729,000	143	27	395	75	18				
31-May-05	1.07	489,000	193	47	357	87	30				
20-Jun-05	1.76	660,000	220	116	550	290	59				
5-Jul-05	1.78	993,600	237	138	890	519	72	21.1	0.23	3.4	5.6
22-Jul-05	1.70	641,000	227	81	550	197	48				
3-Aug-05	3.30	1,405,000	150	95	798	505	50				
22-Aug-05	1.88	844,000	173	74	554	236	45	21.2	0.19	5.1	na
13-Sep-05	0.37	331,000	180	42	226	53	25				
4-Oct-05	0.43	106,000	na	na	na	33	na				
20-Oct-05	2.44	523,000	212	99	419	196	64				
6-Nov-05	0.21	110,000	na	na	na	34	na				
30-Nov-05	3.31	1,600,000	na	na	na	497	na				
13-Dec-05	2.24	2,846,000	142	52	1,526	560	41				
24-Dec-05	1.20	1,884,000	113	40	808	285	32				
14-Jan-06	1.70	1,109,000	193	65	812	273	65				
6-Feb-06	1.02	525,378	145	25	288	50	24				
25-Feb-06	0.90	410,270	138	13	215	20	17				
14-Mar-06	0.39	218,000	nes	86	252	71	na				
11-Apr-06	1.36	649,700	na	na	377	115	na	14.2	0.18	na	7.0
6-May-06	2.10	1,161,800	na	na	421	239	na				
18-May-06	0.97	738208	na	na	396	131	na				
22-Jun-06	3.98	2,155,000	245	152	1,998	1,240	75				
12-Jul-06	4.05	1,979,200	202	81	1,511	607	47				
1-Aug-06	4.50	2,654,000	118	62	1,189	623	13				

Date	Rain In	Discharge gal	TS mg/L	TSS mg/L	TS kg	TSS kg	Turb NTU	Temp C	Cond	DO mg/L	pH
22-Sep-06	3.44	2,462,700	103	27	963	252	75				
9-Oct-06	1.42	527,370	130	44	259	88	35	18.1	0.13	4.9	7.5
4-Nov-06	2.42	1,804,500	162	37	1,104	253	26				
17-Nov-06	3.15	4,548,000	132	42	2,267	723	26	12.4	0.14	6.4	7.1
5-Dec-06	2.23	3,021,900	147	39	1,678	446	33				
3-Jan-07	2.13	1,379,877	193	30	1,010	157	24				
26-Jan-07	2.47	1,574,013	172	39	1,023	232	42				
7-Feb-07	0.25	195,000	190	15	140	11	20				
26-Feb-07	2.14	2,333,000	205	69	1,810	609	56	8.9	0.16	9.4	na
30-Mar-07	3.03	3,195,000	196	63	2,370	762	53				
25-Apr-07	3.87	3,506,000	228	77	3,026	1,022	51				
12-May-07	0.61	339,300	252	122	324	157	35				
7-Jun-07	1.67	466,700	204	47	360	83	39				
3-Jul-07	1.37	1,354,000	252	124	1,291	635	56				
27-Jul-07	0.51	329,500	204	83	254	104	50				
16-Aug-07	0.44	86,460	170	87	56	28	59				
11-Sep-07	0.52	2,980	na	na	na	1	na				
28-Oct-07	2.30	2,883,000	115	35	1,255	384	23				
14-Nov-07	0.22	226,000	187	64	160	55	54				
23-Nov-07	0.74	168,000	198	87	126	55	46				
14-Dec-07	0.07	297,000	191	18	215	20	10				
3-Jan-08	3.09	2,751,000	156	57	1,624	594	28				
24-Jan-08	0.55	475,330	164	35	295	63	27	4.6	0.19	na	6.9
12-Feb-08	1.45	1,370,000	729	42	3,780	218	26				
26-Feb-08	0.87	420,300	178	54	283	86	36				
9-Mar-08	2.06	1,759,000	191	63	1,272	419	42				
1-Apr-08	1.80	945,800	180	56	644	200	34				
23-Apr-08	2.85	2,482,400	140	64	1,315	601	35	14.8	0.22	2.0	6.9
9-May-08	1.28	1,159,000	151	45	661	197	30				
31-May-08	1.15	816,857	195	29	604	90	16				
13-Jun-08	0.30	157,300	195	57	116	34	43				
1-Jul-08	2.60	390,600	254	76	1,291	386	57				
7-Aug-08	2.63	677,470	178	90	458	230	40	21.0	0.19	2.3	7.1
27-Aug-08	6.66	3,293,000	123	78	1,534	972	35				
25-Sep-08	4.53	4,416,000	128	50	2,134	836	38				
7-Oct-08	1.44	1,353,000	157	56	804	287	33				
21-Oct-08	0.31	334,600	182	30	230	38	20	11.3	0.21	2.3	6.6
9-Nov-08	0.98	415,750	115	47	182	74	27				
5-Dec-08	2.21	1,960,000	178	121	1,324	900	74				
18-Dec-08	2.00	2,785,000	231	131	2,433	1,384	63	9.2	0.20	0.8	

Exhibit 6. Monitoring Data for the King's Mill-down Site.

Date	Rain In	Discharge gal	TS mg/L	TSS mg/L	TS kg	TSS kg	Turb NTU	Temp C	Cond	DO mg/L	pH
5-Jun-04	0.68	1,202,280	250	178	1,138	810	84	21.4	0.22	5.0	7.2
23-Jun-04	1.47	506,750	340	200	652	384	112				
9-Jul-04	1.88	1,725,000	195	133	1,273	865	82	24.1	0.24	4.9	na
19-Jul-04	2.30	3,654,627	335	278	4,634	3,839	106				
24-Jul-04	0.22	182,140	143	78	99	54	71				
6-Aug-04	2.10	1,112,174	216	74	909	312	na				
20-Aug-04	1.65	1,390,950	167	74	879	390	54	23.5	0.21	5.2	7.6
1-Sep-04	0.29	269,583	210	104	214	106	82				
9-Sep-04	4.25	5,755,000	398	314	8,670	6,840	180				
16-Sep-04	0.01	682,000	177	45	456	116	na				
29-Sep-04	4.39	9,472,500	395	265	14,162	9,483	181				
15-Oct-04	0.49	1,717,000	180	94	1,170	611	78				
31-Oct-04	0.42	1,132,000	217	36	930	154	34				
20-Nov-04	2.74	3,952,000	233	87	3,485	1,301	82				
7-Dec-04	2.24	6,656,500	430	240	10,834	6,047	196				
29-Dec-04	2.45	7,334,000	750	510	20,819	14,157	446				
17-Jan-05	1.20	3,736,358	536	318	7,580	4,497	218	14.4	0.22	13.0	7.5
9-Feb-05	1.34	4,166,000	306	90	4,825	1,419	107	10.0	0.2	6.8	6.9
26-Feb-05	1.18	2,217,000	236	44	1,980	369	61				
16-Mar-05	1.78	6,372,000	407	196	9,816	4,727	184				
30-Mar-05	2.15	7,721,000	200	29	5,845	847	54				
14-Apr-05	1.74	2,519,000	223	81	2,126	772	86	14.0	0.1	4.7	7.9
6-May-05	0.71	1,709,000	203	68	1,313	440	55				
31-May-05	1.07	1,622,000	na	na	na	457	na				
20-Jun-05	1.76	2,188,000	833	640	6,901	5,300	437				
5-Jul-05	1.78	2,070,000	na	na	na	2,395	na	23.2	0.3	6.5	7.4
22-Jul-05	1.70	1,876,000	5,113	4,660	36,308	33,089	2,170				
3-Aug-05	3.30	4,394,000	3,710	3,900	61,702	64,862	1,835				
22-Aug-05	1.88	2,721,000	3,923	3,570	40,406	36,767	1,860	26.9	0.3	6.0	na
13-Sep-05	0.37	1,040,000	2,657	2,310	10,458	9,093	1,450				
4-Oct-05	0.43	1,245,000	517	464	2,435	2,187	223				
20-Oct-05	2.44	3,051,000	1,718	2,105	19,843	24,309	1,110				
6-Nov-05	0.21	1,739,000	1,723	1,536	11,343	10,110	1,278				
30-Nov-05	3.31	7,950,800	2,448	2,225	73,680	66,959	1,816				
13-Dec-05	2.24	7,745,000	853	644	25,015	18,879	597				
24-Dec-05	1.20	5,144,000	na	na	na	8,976	na				
14-Jan-06	1.70	4,851,000	440	278	8,079	5,104	252				
6-Feb-06	1.02	2,614,700	297	82	2,936	812	121				
25-Feb-06	0.90	2,353,230	na	na	na	1,648	na				
14-Mar-06	0.39	1,492,600	552	424	3,117	2,395	261				
11-Apr-06	1.36	4,152,800	563	420	8,855	6,602	278	15.5	0.2	na	7.6
6-May-06	2.10	4,720,900	872	680	15,575	12,151	684				
18-May-06	0.97	1,431,000	423	288	2,293	1,560	216				
22-Jun-06	3.98	7,000,000	293	170	7,772	4,504	112				
12-Jul-06	4.05	6,888,000	2,327	2,282	60,659	59,489	1,596				

Date	Rain In	Discharge gal	TS mg/L	TSS mg/L	TS kg	TSS kg	Turb NTU	Temp C	Cond	DO mg/L	pH
6-Sep-06	2.02	2,935,500	1,340	1,553	14,889	17,259	1,206				
22-Sep-06	3.44	6,445,340	1,432	1,267	34,926	30,901	1,148				
9-Oct-06	1.42	2,363,440	3,010	2,630	26,926	23,527	2,375	18.0	0.2	8.4	7.9
4-Nov-06	2.42	4,861,200	1,020	760	18,768	13,984	788				
17-Nov-06	3.15	8,883,300	1,555	1,400	52,284	47,073	1,186	11.9	0.2	9.7	7.8
5-Dec-06	2.23	10,351,400	980	772	38,396	30,256	792				
3-Jan-07	2.13	6,234,000	813	652	19,191	15,384	606				
26-Jan-07	2.47	8,118,000	638	444	19,614	13,643	467				
7-Feb-07	0.25	869,300	185	105	609	347	73				
26-Feb-07	2.14	7,230,000	882	729	24,127	19,938	752	9.0	0.2	10.4	na
30-Mar-07	3.03	11,222,000	1,076	895	45,703	38,015	798				
25-Apr-07	3.87	13,161,000	812	740	40,449	36,863	381				
12-May-07	0.61	1,414,400	196	44	1,049	236	47				
7-Jun-07	1.67	2,211,700	456	310	3,817	2,595	217				
3-Jul-07	1.37	4,991,000	na	na	na	38.295	na				
27-Jul-07	0.51	1,885,000	2,916	2,886	20,805	20,589	1,476				
16-Aug-07	0.44	1,104,600	530	415	2,216	1,737	509				
11-Sep-07	0.52	917,800	na	na	na	721	na				
28-Oct-07	2.30	9,203,000	257	198	8,970	6,897	162				
14-Nov-07	0.22	705,400	182	27	487	73	17				
23-Nov-07	0.74	900,200	155	114	528	388	33				
14-Dec-07	0.07	1,315,000	178	13	885	63	12				
3-Jan-08	3.09	8,524,900	178	76	5,743	2,452	60				
24-Jan-08	0.55	2,665,500	162	25	1,637	252	33	5.1	0.2	na	6.9
12-Feb-08	1.45	4,991.000	118	34	2,225	642	23				
26-Feb-08	0.87	2,693,400	162	37	1,654	377	35				
9-Mar-08	2.06	5,657,100	196	70	4,187	1,499	65				
1-Apr-08	1.80	4,624,600	118	41	2,062	718	31				
23-Apr-08	2.85	9,209,500	187	89	6,507	3,102	50	14.5	0.2	2.5	7.4
9-May-08	1.28	4,560,000	175	69	3,027	1,191	50				
31-May-08	1.15	1,717,000	200	47	1,300	305	37				
13-Jun-08	0.30	707,400	206	104	552	278	58				
1-Jul-08	2.60	8,401,649	na	na	na	4,044	na				
7-Aug-08	2.63	2,526,800	206	168	1,970	1,610	85	23.1	0.2	2.7	7.6
27-Aug-08	6.66	21,736,260	na	na	na	8,199	na				
25-Sep-08	4.53	14,676,832	na	na	na	5,536	na				
7-Oct-08	1.44	4,173,000	229	128	3,621	2,022	52				
21-Oct-08	0.31	787,400	189	12	564	36	6	10.5	0.236	2.5	7.1
9-Nov-08	0.98	1,884,000	75	16	538	114	14				
5-Dec-08	2.21	4,903,000	85	39	1,570	724	25				
18-Dec-08	2.00	5,182,000	158	36	3,108	706	33	9.3	0.197	1.1	na