Burnt Mill Creek Water Quality Summary 2007

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Abstract

Burnt Mill Creek drains a 4,288 acre watershed which is extensively urbanized (36% impervious surface coverage) into Smith Creek. Six locations were sampled in 2007. This creek has very poor water quality, with large algal blooms, extensive periods of substandard dissolved oxygen, and major issues with high fecal coliform counts, with all six sites exceeding the human contact standard > 25% of occasions sampled. Restoration efforts are continuing in a joint effort by the City of Wilmington, NCSU, and UNCW funded through the US EPA. Sediment metals concentrations were below harmful levels except for lead at the Princess Place site. However, sediment polychlorinated aromatic hydrocarbon (PAH) concentrations exceeded known levels harmful to aquatic biota at all five of the six sampling sites.

The effectiveness of Ann McCrary wet detention pond and the Kerr Avenue wetland as pollution control devices was poor during 2007. Several water quality parameters indicated a subsequent worsening of the creek from where it exited the detention pond to the downstream Wallace Park and Princess Place sampling stations.

Introduction

In 1997 the City of Wilmington contracted with the Aquatic Ecology Laboratory at the UNC Wilmington Center for Marine Sciences to begin citywide water quality sampling. Since 1then the Burnt Mill Creek watershed (Fig. 4.1) has been sampled just upstream of Ann McCrary Pond on Randall Parkway (BMC-AP1), and about 40 m downstream of the pond outfall (BMC-AP3). Ann McCrary Pond is a large (28.8 acres) regional wet detention pond draining 1,785 acres, with an apartment complex at the upper end near BMC-AP1. The pond itself periodically hosts a thick growth of submersed aquatic vegetation, with *Hydrilla verticillata, Egeria densa, Alternanthera philoxeroides, Ceratophyllum demersum* and *Valliseneria americana* having been common at times. There have been efforts to control this growth, including addition of triploid grass carp as grazers. The ability of this detention pond to reduce suspended sediments and fecal coliform bacteria, and its failure to reduce nutrient concentrations, was detailed in a scientific journal article (Mallin et al. 2002). Numerous waterfowl utilize this pond as well.

In 2005 sampling began on the inflow (BMC-KA1) and outflow (BMC-KA3) channels of the Kerr Avenue constructed wetland (Fig. 4.1). This sampling began as a part of a larger project (through North Carolina State University funded by the EPA 319 Program) to provide stream restoration to Burnt Mill Creek. Construction of the 0.7 acre Kerr Avenue Wetland was funded by the N.C. Wetlands Restoration Program, now known as the Ecosystem Enhancement Program. Wetland construction was completed in November 2000 and the first aquatic macrophyte planting (sponsored by Cape Fear River Watch) occurred later that month (various rushes, sedge, pickerelweed, lizard's tail, water tupelo, wax myrtle, black gum, pond pine, bald cypress, etc.). Since then there have been many supplemental plantings as well as tree donations. The vegetation coverage is presently so dense that macrophytes from this site have been transplanted into other wetland restoration sites. The wetland has a forebay to collect sediment, and the system is designed to retain and treat the first 0.5 inches of a rainfall event before an overflow channel is utilized. This Best Management Practice (BMP) lies in the headwaters of Burnt Mill Creek, which is on the State 303(d) list for poor biological condition. Another station is located along the main stem of the creek in the Wallace Park area (BMC-WP) and an older station is also on the creek at the bridge at Princess Place (BMC-PP - Fig. 4.1). Recent water quality results of these continuing studies have been published previously (Mallin et al. 2006a; Mallin et al. 2007).

Results from 2007

Kerr Avenue Wetland: This represents the third year of statistically comparative data useful for assessing the efficacy of this wetland as a pollutant removal device. Results of the seven sampling trips showed that turbidity and suspended solids both appeared to have higher concentrations leaving the wetland compared with entering it, with the turbidity difference being statistically significant (Table 4.1). There were no differences in nutrient concentrations entering or leaving the wetland; however, inorganic nutrients were low entering the wetland, probably due to the drought and less runoff. There was no significant difference in BOD5 entering or leaving the wetland. Fecal coliform bacteria were high both entering and exiting the wetland, with no statistical difference entering or leaving the pond. The presence of a number of dumpsters surrounding the site, and consequent small mammals foraging and defecating, may be a localized source of fecal coliform bacteria, BOD and organic nutrients.

Ann McCrary Pond: Turbidity and suspended solids concentrations entering and leaving this large regional pond were low to moderate, with incoming nutrients low due to the drought and less runoff (Table 4.1). Fecal coliform concentrations entering Ann McCrary Pond at BMC-AP1 were very high, however (Table 4.1), possibly a result of pet waste runoff from the apartment complex and runoff from urban upstream areas. Five of seven samples collected in 2007 at BMC-AP1 had counts exceeding 200 CFU/100 mL; and four of seven samples from BMC-AP3 exceeded the standard. The high variability among counts prevented the apparent reduction through the pond from being statistically significant. There was a major algal bloom at BMC-AP1 in August (chlorophyll *a* 287 μg/L) and a minor bloom in September (24 μg/L). At BMC AP-3 there were major algal blooms June through September (chlorophyll *a* $\geq$ 30 μg/L) and a minor

bloom of 25 μg/L in April 2007. The pond hosted more algal blooms than usual during 2007. The efficiency of Ann McCrary Pond as a pollutant removal device was poor in 2007, with no pollutant significantly reduced during passage through the pond. As in previous years, it is likely that inputs of nutrients have entered the pond from a suburban drainage stream midway down the pond across from our former BMC-AP2 site (Fig. 4.1), short circuiting the ability of the pond to remove nutrients. Also, intensive waterfowl use of the pond, particularly at a tributary near the outfall, may have contributed to phosphorus loading in the pond and along its shoreline. However, as mentioned the concentrations of nutrients entering the pond were not high to begin with. There was no significant decrease in conductivity through the pond. Dissolved oxygen significantly increased through the pond, probably because of in-pond photosynthesis and aeration by passage over the final dam at the outfall. There was a significant increase in pH, probably due to utilization of CO_2 during photosynthesis in the pond.

Lower Burnt Mill Creek: Both the Wallace Park (BMC-WP) and the Princess Place location (BMC-PP) experienced several water quality problems during the sampling period. Dissolved oxygen was substandard (between 2.0 and 5.0 mg/L) three of seven times at BMC-WP and four of seven times at BMC-PP. No problems were seen with turbidity or suspended solids. Nutrients were unremarkable at either site. One major algal bloom (chlorophyll *a* of 452 μg/L) occurred at Wallace Park with two minor blooms of 28 and 25 μg/L occurring in June and September, respectively. Two excessively high algal blooms of 588 and 140 μg/L as chlorophyll *a* occurred at Princess Place in May and June. BOD5 increased from the previous year, likely a response to the algal blooms. Conductivity was much higher than the previous year, probably due to the prolonged drought and lack of runoff.

An important issue, from a public health perspective, was the excessive fecal coliform counts, which maintained geometric means (1820 CFU/100 mL at BMC-WP and 1890 CFU/100 mL at BMC-PP) well in excess of the State standard for human contact waters (200 CFU/100 mL). Fecal coliform counts were greater than 200 CFU/100 mL in six of seven months at Wallace Park and seven of seven months at Princess Place, a deterioration from the previous year. It is notable that fecal coliform bacteria increased along the passage from BMC-AP3 to the Wallace Park location, while dissolved oxygen decreased (Table 4.1). BOD5 analyses were performed at Wallace Park, with median concentrations (2.2 mg/L) higher than rural streams but typical of urban streams in the Wilmington area (Mallin et al. 2006b).

Table 4.1. Mean and (standard deviation) of water quality parameters in upper Burnt Mill Creek, Jan. – Sep. 2007. Fecal coliforms as geometric mean; N/P as median.

Parameter	KA-1	KA-3	BMC-AP1	BMC-AP3
DO (mg/L)	6.5 (2.2)	5.5 (2.5)	6.4 (2.1)	9.5 (1.3)**
Cond. (μS/cm)	254 (175)	296 (116)	237 (78)	231 (44)
pH	7.4 (0.4)	7.3 (0.3)	7.3 (0.2)	8.1 (0.4)**
Turbidity (NTU)	8 (7)	22 (12)*	14(10	10 (3)
TSS (mg/L)	9 (6)	33 (30)	44 (41)	10 (5)
Nitrate (mg/L)	0.129 (0.130)	0.047 (0.094)	0.044 (0.055)	0.037 (0.035)
Ammonium (mg/L)	0.044 (0.049)	0.022 (0.027)	0.030 (0.016)	0.032 (0.036)
TN (mg/L)	0.923 (0.494)	0.651 (0.510)	1.010 (0.486)	0.774 (0.364)
OrthoPhos. (mg/L)	0.016 (0.010)	0.031 (0.048)	0.010 (0.000)	0.010 (0.000)
TP (mg/L)	0.079 (0.073)	0.237 (0.241)	0.157 (0.114)	0.059 (0.015)
N/P molar ratio	22	4	11	11
Chlor. *a* (μg/L)	22.7 (43.7)	11.4 (8.9)	51.8 (103.7)	35.3 (31.3)
Fec. col. (/100 mL)	2626	2727	1159	422
BOD5	1.6 (0.8)	2.2 (1.3)	NA	NA

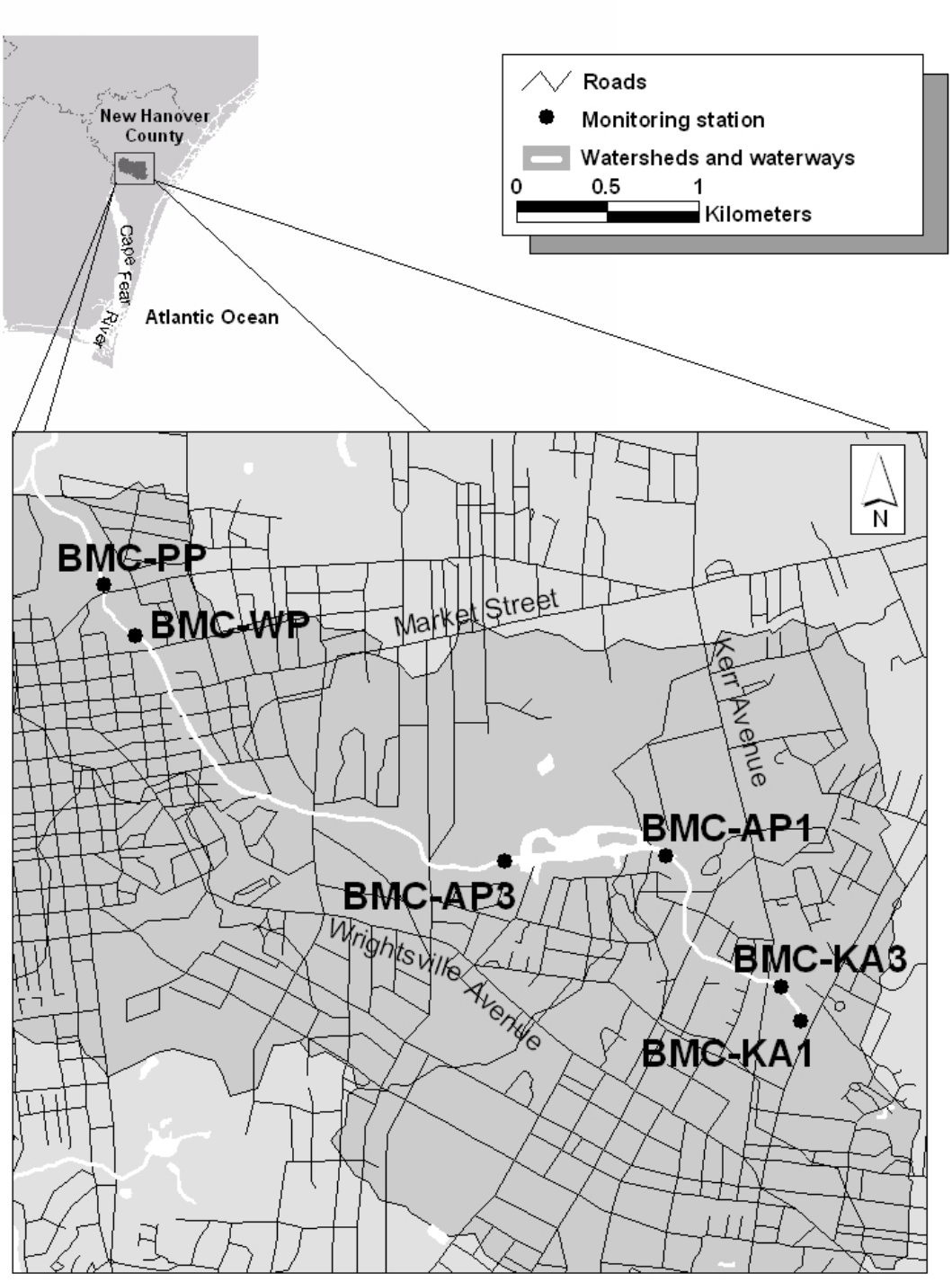
* Indicates statistically significant difference between inflow and outflow at $p<0.05$
NA = not analyzed. Italics indicate near-significant difference ($p < 0.10$).

Table 4.2. Mean and (standard deviation) of water quality parameters in lower Burnt Mill Creek, Jan. – Sep. 2007. Fecal coliforms as geometric mean; N/P as median.

Parameter	BMC-WP	BMC-PP
DO (mg/L)	6.0 (2.5)	5.1 (2.4)
Cond. (μS/cm)	2779 (3296)	4128 (4495)
pH	7.4 (0.1)	7.3 (0.1)
Turbidity (NTU)	8 (3)	9 (5)
TSS (mg/L)	12 (9)	7 (3)
Nitrate (mg/L)	0.114 (0.078)	0.130 (0.170)
Ammonium (mg/L)	0.071 (0.051)	0.083 (0.071)
TN (mg/L)	1.721 (1.379)	0.936 (0.379)
OrthoPhos. (mg/L)	0.023 (0.026)	0.027 (0.023)
TP (mg/L)	0.174 (0.133)	0.111 (0.156)
N/P molar ratio	19	18
Chlor. *a* (μg/L)	113.3 (214.6)	81.2 (163.6)
Fec. col. (/100 mL)	1820	1890
BOD5	3.1 (2.5)	NA

NA = not analyzed

Figure 4.1. Burnt Mill Creek watershed and sampling sites.



Sediment Metals and PAH Concentrations

As part of the stream restoration effort funded through NCSU and the EPA 319 program, we collected sediment samples on one occasion throughout Burnt Mill Creek for analysis of sediment metals and polycyclic aromatic hydrocarbons (PAHs). The State of North Carolina has no official guidelines for sediment concentrations of metals and organic pollutants in reference to protection of invertebrates, fish and wildlife. However, academic researchers (Long et al. 1995) have produced guidelines (Appendix D) based on extensive field and laboratory testing that are used by the US Environmental Protection Agency in their National Coastal Condition Report II (US EPA 2004).

Table 4.3. Guideline values for sediment metals and organic pollutant concentrations (ppm, or μg/g, dry wt.) potentially harmful to aquatic life (Long et al. 1995; U.S. EPA 2004). ERL = (Effects range low). Concentrations below the ERL are those in which harmful effects on aquatic communities are rarely observed. ERM = (Effects range median). Concentrations above the ERM are those in which harmful effects would frequently occur. Concentrations between the ERL and ERM are those in which harmful effects occasionally occur.

Metal	ERL	ERM
Arsenic (As)	8.2	70.0
Cadmium (Cd)	1.2	9.6
Chromium (Cr)	81.0	370.0
Copper (Cu)	34.0	270.0
Lead (Pb)	46.7	218.0
Mercury (Hg)	0.15	0.71
Nickel (Ni)	20.9	51.6
Silver (Ag)	1.0	3.7
Zinc (Zn)	150.0	410.0
Total PCBs	0.0227	0.1800
Total PAHs	4.02	44.80
Total DDT	0.0016	0.0461

Polycyclic aromatic hydrocarbons (PAHs) are organic compounds with a fused ring structure. PAHs with two to five rings are of considerable environmental concern. They are compounds of crude and refined petroleum products and coal and are also produced by incomplete combustion of organic materials. They are characteristic of urban runoff as they derive from tire wear, automobile oil and exhaust particles, and leaching of asphalt roads. Other sources include domestic and industrial waste discharge, atmospheric deposition, and spilled fossil fuels. They are carcinogenic to humans, and bioconcentrate in aquatic animals. In these organisms they form carcinogenic and mutagenic intermediaries and cause tumors in fish (US EPA 2000).

Most of the stations had sediment metals concentrations that were well below levels considered potentially toxic to benthic organisms. One exception was lead, which exceeded the ERL (Table 4.3) at the Princess Place station (BMC-PP) and approached harmful levels at the Wallace Park station BMC-WP (Table 4.4). Otherwise, sediment metals concentrations were lower than during 2006, and similar to levels in 2005. All of the PAH sediment samples exceeded the ERM except for Station AP3, below Ann McCrary Pond, where PAHs were below the detection limit (Table 4.4). This sediment PAH concentration distribution in general was similar to those of 2005 and 2006 (Mallin et al. 2006a; Mallin et al. 2007). Compared with sediment samples taken in 1999 at BC-PP, there was a decrease in copper, chromium, lead, and zinc in 2005-2007 (Mallin et al. 1999). This may have been a result of burial of contaminated sediments by further sedimentation, or flushing from subsequent storm-induced flooding.

Table 4.4. Concentrations of sediment metals and polycyclic aromatic hydrocarbons (PAHs) in Burnt Mill Creek, 2007 (as mg/kg = ppm). Concentrations in bold type exceed the level at which harmful effects to benthic organisms may occur, and italicized concentrations are near potentially harmful levels (see Table 4.3 for more detail).

Parameter	KA1	KA3	AP1	AP3	WP	PP
Antimony	0.105	<0.032	0.093	<0.031	<0.034	0.084
Arsenic	<0.097	<0.101	<0.114	<0.099	<0.109	<0.113
Beryllium	0.055	0.021	<0.054	0.028	0.152	0.065
Cadmium	0.190	0.048	0.114	0.129	0.464	0.329
Chromium	3.140	0.828	2.530	1.650	6.600	3.430
Copper	3.26	1.03	12.00	0.75	5.29	6.36
Lead	0.95	1.52	3.46	<0.06	*34.20*	**60.00**
Mercury	<0.002	<0.002	<0.003	<0.002	0.023	0.004
Nickel	1.840	0.379	0.701	0.926	3.240	1.360
Selenium	0.085	<0.063	<0.070	0.091	<0.070	<0.070
Silver	<0.060	<0.063	<0.070	<0.060	<0.070	<0.080
Thallium	<0.012	<0.013	<0.014	<0.012	<0.014	<0.014
Zinc	41.70	9.67	32.70	28.30	45.90	60.50
Total PAH	**5,026**	**9,978**	**13,334**	BDL	**1,141**	**13,582**
TN	25	76	609	121	328	528
TP	763	119	43	57	413	187
TOC	19.6	14.4	30.9	11.9	47.5	40.9

BDL = below detection limit

References

Long, E.R., D.D. McDonald, S.L. Smith and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. *Environmental Management* 19:81-97.

Mallin, M.A., S.H. Ensign, D.C. Parsons and J.F. Merritt. 1999. *Environmental Quality of Wilmington and New Hanover County Watersheds, 1998-1999.* CMSR Report No. 99-02. Center for Marine Science Research, University of North Carolina at Wilmington, Wilmington, N.C.

Mallin, M.A., S.H. Ensign, T.L. Wheeler and D.B. Mayes. 2002. Pollutant removal efficacy of three wet detention ponds. *Journal of Environmental Quality* 31:654-660.

Mallin, M.A., L.B. Cahoon, M.H. Posey, V.L. Johnson, D.C. Parsons, T.D. Alphin, B.R. Toothman, M.L. Ortwine and J.F. Merritt. 2006a. *Environmental Quality of Wilmington and New Hanover County Watersheds, 2004-2005*. CMS Report 06-01, Center for Marine Science, University of North Carolina at Wilmington, Wilmington, N.C.

Mallin, M.A., V.L. Johnson, S.H. Ensign and T.A. MacPherson. 2006b. Factors contributing to hypoxia in rivers, lakes and streams. *Limnology and Oceanography* 51:690-701.

Mallin, M.A., L.B. Cahoon, T.D. Alphin, M.H. Posey, B.A. Rosov, D.C. Parsons, R.M. Harrington and J.F. Merritt. 2007. *Environmental Quality of Wilmington and New Hanover County Watersheds, 2005-2006*. CMS Report 07-01, Center for Marine Science, University of North Carolina at Wilmington, Wilmington, N.C.

US EPA 200. Guidance for assessing chemical contaminant data for use In fish advisories, Volume 2: Risk assessment and fish consumption limits. EPA-823-B-00-008. United States Environmental Protection Agency, Office of Research and Development, Office of Water, Washington, D.C.

US EPA. 2004. National Coastal Condition Report II. EPA-620/R-03/002. United States Environmental Protection Agency, Office of Research and Development, Office of Water, Washington, D.C.