Total Maximum Daily Loads (TMDLs) Analysis for Buntings Branch, Delaware

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EXECUTIVE SUMMARY

Section 303(d) of the Clean Water Act requires States to identify water quality impaired waterways and develop Total Maximum Daily Loads (TMDLs) for the pollutants that impair the waterways. The Delaware Department of Natural Resources and Environmental Control (DNREC) has identified that the water quality of Buntings Branch (4.6 miles of 11.1 miles segment DE070-001) was impaired because of its elevated nutrient levels and low dissolved oxygen concentrations (1) (2). This segment had been placed on the State's 1996, 1998, and 2002 303(d) lists and targeted for development of TMDLs.

Buntings Branch Watershed is located just north of DE-MD state line. The stream flows southeastward through Selbyville and crosses the state line into Maryland's Bishopville Prong. It is the headwater of Bishopville Prong. The drainage area of Buntings Branch Watershed within Delaware is 6300 acres and is about 58% of the total drainage area of the Bishopville Prong. There are no active point sources discharging nutrients into Buntings Branch, Therefore, all pollutants are coming from nonpoint sources.

In April 2002, Maryland Department of the Environment (MDE) developed total maximum daily loads for nitrogen and phosphorous for Bishopville Prong along with TMDLs for four other tidal tributaries in Northern Coastal Bays System, Worcester County, Maryland (3). The nonpoint source load generated from Buntings Branch Watershed was accounted for in the Bishopville Prong TMDL analysis. For an average annual flow condition, Bishopville Prong TMDL required that nonpoint source loads be reduced by 31% for nitrogen and 19% for phosphorous from all contributing areas including Buntings Branch Watershed. For an average summer low flow condition, Bishopville Prong TMDL required that nonpoint source nitrogen be reduced by 31% with no specific requirement for nonpoint source phosphorous load reduction.

Taking into consideration of this watershed's unique geographical location and the existing TMDLs established by Maryland MDE for this area, Delaware DNREC plans to apply and implement Maryland's existing TMDL to the Buntings Branch in Delaware if its independent monitoring and modeling study shows that the reduction rates specified by Maryland MDE is sufficient to meet State of Delaware's water quality standards and nutrient target values.

To check the sufficiency of the MDE's prescribed load reduction rates, DNREC developed water quality model for Buntings Branch using U.S. EPA's Enhanced Stream Water Quality Model (Qual2E) as a framework. Water quality data collected during 2000 – 2002 was used to calibrate the model. Load reduction rates of 31% for nitrogen and 19% for phosphorous established by Maryland MDE were then applied to the Buntings Branch using the calibrated model. Under both average and summer low flow conditions, water quality standard of 5.5 mg/l for dissolved oxygen was met at all reaches. Total nitrogen concentrations were under 3 mg/l and total phosphorous concentrations were below 0.1 mg/l. This modeling study showed that the load reduction rates established by Maryland MDE were adequate to meet State of Delaware's water quality standards and nutrient targets in Buntings Branch. Therefore, the same load reduction rates will be applied and implemented for Buntings Branch Watershed in Delaware.

Under annual-average flow condition, this TMDL results in reducing total nitrogen load during the baseline period of 2000-2002 from 213 lb/day (96 kg/day) to 146 lb/day (66 kg/day). Corresponding reduction of total phosphorous load will be from 6 lb/day (3 kg/day) to 5 lb/day (2 kg/day).

1.0 INTRODUCTION

Background

Section 303(d) of the Clean Water Act (CWA) as amended by the Water Quality Act of 1987, requires States to identify water quality limited waters to develop Total Maximum Daily Loads (TMDLs) for pollutants of concern. The Delaware Department of Natural Resources and Environmental Control has identified 4.6 miles of Buntings Branch (from headwaters to the MD-DE State line, segment DE070-001) as a water quality limited water, placed it on the State's 1996, 1998, and 2002 303(d) lists, and targeted for TMDL development. The redline showing the impaired segment listed on 303(d) list is presented in Figure 1 -1. Table 1-1 is the excerpt for Buntings Branch from 1998 303(d) List.

Table 1-1 Excerpt from 303(d) List of 1998 for Buntings Branch (2)

WATERBODY ID (TOTAL SIZE)	WATERSHED NAME	SEGMENT	DESCRIPTION	SIZE AFFECTED	POLLUTANT(S) AND/OR STRESSOR(S)	PROBABLE SOURCE(S)
DE070-001 (11.1 miles)	Buntings Branch	Buntings Branch	From the headwaters to the MD-DE State line	4.6 miles	Nutrients and DO	PS, NPS

The Buntings Branch Watershed is located just north of the DE-MD state line and is the headwater of Maryland's Bishopville Prong. The drainage area of Buntings Branch Watershed within Delaware is 6300 acres and is about 58% of the total drainage area of the Bishopville Prong. There are no active point sources discharging nutrients into Buntings Branch. Therefore, all pollutants are coming from nonpoint sources.

In April 2002, the Maryland Department of the Environment (MDE) developed TMDLs for nitrogen and phosphorous for Bishopville Prong along with four other tidal tributaries in Northern Coastal Bay System, Worcester County, Maryland (3). The nonpoint source load generated from Buntings Branch Watershed was accounted for in the Bishopville Prong TMDL analysis. For an average annual flow condition, Bishopville Prong TMDL required that nonpoint source loads be reduced by 31% for nitrogen and 19% for phosphorous from all contributing areas including Buntings Branch Watershed. For an average summer low flow condition, Bishopville Prong TMDL required that nonpoint source nitrogen be reduced by 31% with no specific requirement for nonpoint source phosphorous load.

Taking into consideration of this watershed's unique geographical location and the existing TMDL study for this area, Delaware DNREC plans to apply and implement the existing TMDL reduction rates developed by MDE to Buntings Branch as long as its independent monitoring and modeling analysis shows that State Delaware's water quality standards and nutrient targets are met.

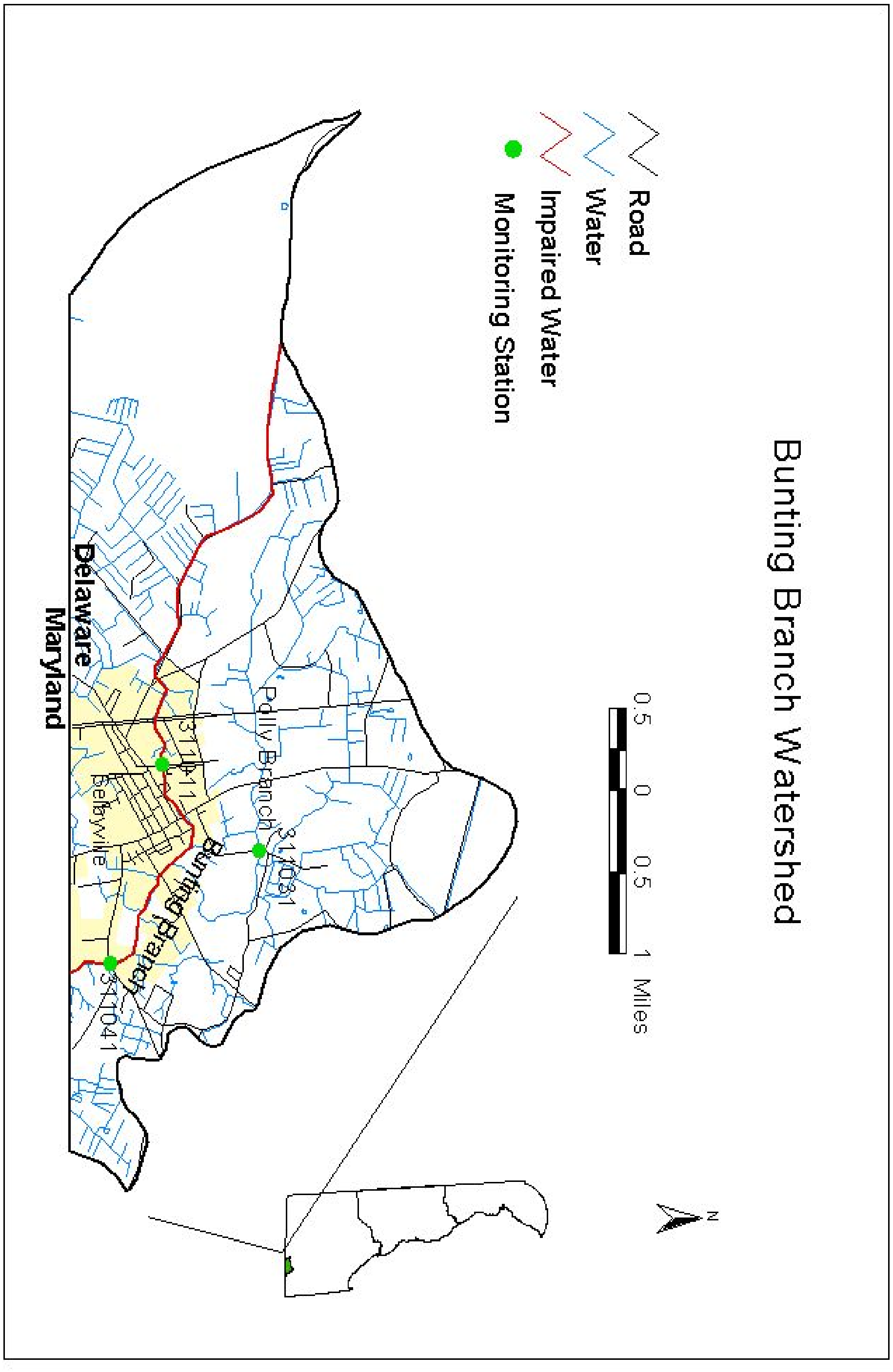

Figure 1 -1 Bunting Branch Watershed Map

To check the adequacy of the MDE's prescribed load reduction rates, DNREC has developed a water quality model for Buntings Branch using U.S. EPA's Enhanced Stream Water Quality Model (Qual2E) as a framework. Water quality data collected during 2000 – 2002 was used to calibrate the model. Load reduction rates of 31% for nitrogen and 19% for phosphorous developed by Maryland MDE were then applied to the Buntings Branch using the calibrated model. The results of the model simulation after applying the reduction rates were compared against water quality standards and nutrient targets.

This analysis documents Buntings Branch Qual2E model development and calibration. Load reduction simulation under both average condition and summer low flow condition are evaluated. Finally, the TMDL load reductions based on the simulation results are calculated and provided in this document.

Buntings Branch Watershed

Buntings Branch watershed is located in the south central section of Sussex County just north of the Delaware-Maryland state line. The stream flows southeastward through Selbyville and crosses the Delaware-Maryland state line (Figure 1 -1). About ¾ of a mile below the Maryland state line, it enters Bishopville Prong, a tributary of St. Martins River. Buntings Branch is the headwater of Bishopville Prong. Delaware portion of the Buntings Branch Watershed, as defined in The State of Delaware's Watershed Assessment Reports (305(b)), is bounded by the natural divides on the three sides of east, north and west, and by state line on the southern side of the watershed. It has a drainage area of 6300 acres (about 10 square miles), and covers about 58% of the total drainage area of Bishopville Prong.

The land use within the watershed is dominated by agriculture, wetlands, and a small town. There are no major water impoundments in this watershed. Selbyville is the only incorporated town. The primary land uses outside of Selbyville are agriculture and wetlands. The watershed is extensively ditched. Cypress Swamp, a unique natural feature, is located in the headwater of Sandy Branch a tributary of Buntings Branch (1). This wetland area is about one third of the whole drainage area of Buntings Branch.

The detailed land use information for this watershed is based on 1997 Delaware Office of Planning land cover data. Figure 1-2 shows the geographic distribution of different land uses in the Buntings Branch Watershed. The land use activity in the watershed consists of 2,696 acres of agriculture (43% of the watershed); 2,175 acres of wetland (34% of the watershed); 863 acres of residential, commercial and industrial area (14% of the watershed); and 564 acres of forest (9% of the watershed). The summary of relative distribution of land use coverage is presented in the pie chart in Figure 1-3.

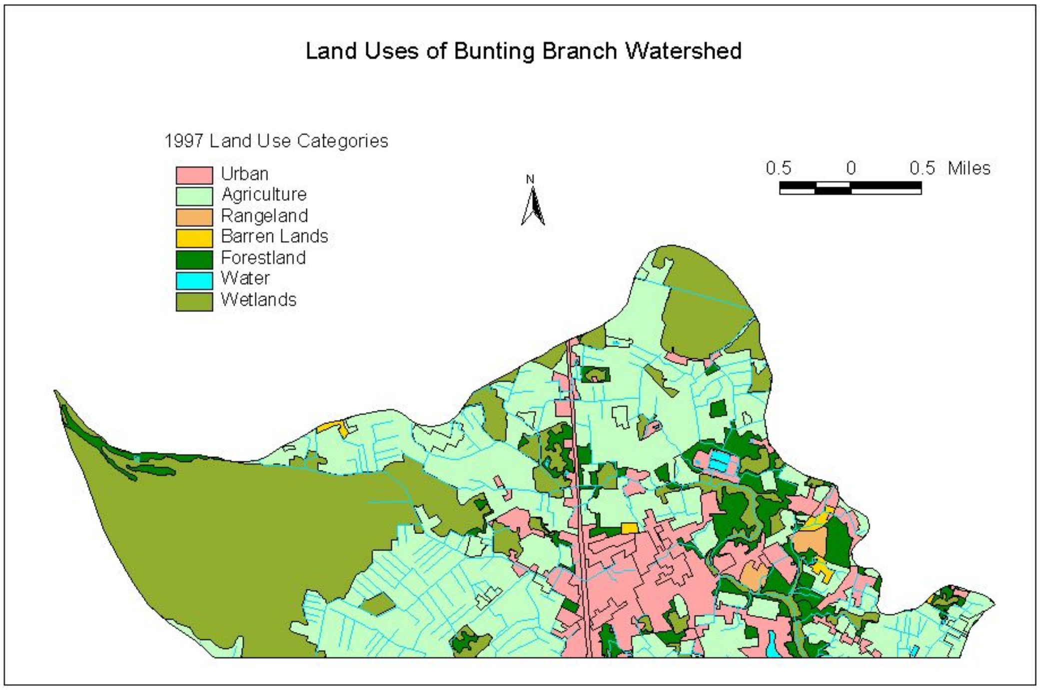

Figure 1-2 Land Use in the Bunting Branch Watershed

Soil types in the watershed include predominantly Pocomoke-Woodstown-Fallsington association described by the Natural Resources Conservation Service as "very poorly drained and poorly drained soils that have a moderately permeable subsoil of sandy loam or sandy clay loam, and excessively drained soils that have rapidly permeable sandy subsoil" (1).

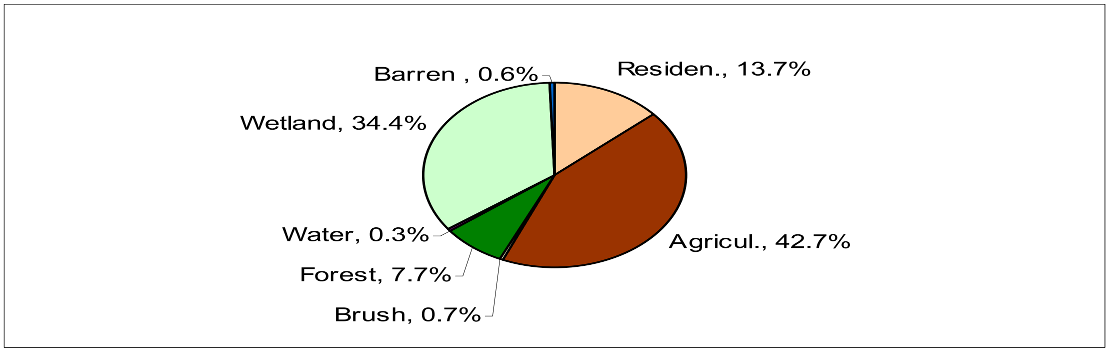

Figure 1 – 3 Landuse Percentage in Buntings Branch Watershed

Designated Uses

The purpose of establishing TMDLs is to reduce the pollutants to levels that result in meeting water quality standards and support designated uses of the streams. Section 3 of the State of Delaware Surface Water Quality Standards, as amended, July 11, 2004, specifies the following designated uses for the waters of the Buntings Branch (4):

- Primary Contact Recreation
- Secondary Contact Recreation
- Fish, Aquatic Life, and Wildlife
- Agricultural Water Supply

Applicable Water Quality Standards and Nutrient Guidelines

To protect the designated uses, the following sections of the State Delaware Surface Water Quality Standards, amended July 2004, provide specific narrative and numeric criteria concerning the waters in Buntings Branch (4):

Section 4 Criteria to Protect Designated Uses
Section 5 Antidegradation and ERES Waters Policies

Based on the above sections, the following is a brief summary of pertinent water quality standards that are applicable to the waters of Buntings Branch:

a. Dissolved Oxygen (D.O.):
- Daily average shall not be less than 5.5 mg/l
- Instantaneous minimum shall not be less than 4.0 mg/l

b. Nutrients:
- It shall be the policy of this Department to minimize nutrient input to surface waters from point and human induced non-point sources. The types of, and need for, nutrient controls shall be established on a site-specific basis.

The standards are a State regulation and the basis for preparing 305(b) Reports, 303(d) Lists, and establishing TMDLs.

In the absence of national numeric nutrient criteria, DNREC has used target thresholds of 3.0 mg/l for total nitrogen and 0.2 mg/l for total phosphorus as indicators of excessive nutrient levels in the streams. The target levels have been used as the guideline for the 305(b) assessment reports and the 303(d) listing of impaired waters, and are generally accepted by the scientific community to be an indication of over enriched waters.

Stream Water Quality Conditions and Water Quality Impairment

To support the model development for Buntings Branch, the Department has conducted intensive water quality monitoring at three locations during 2000 - 2002 (see Table 1-2 and Figure 1-1). At each station, grab samples were collected four times a year and were analyzed for a suite of 24 water quality parameters (5). Monitoring data collected during 2000-2002 is presented in Figures 1- 4 and 1-5 for water temperature, dissolved oxygen, BOD_5, Chlorophyll-*a*, total nitrogen, and total phosphorous.

Table 1-2 Buntings Branch Water Quality Monitoring Stations

Monitoring Location	Storet No.
1. Buntings Branch at Railroad Bridge (upper stream)	311011
2. Polly Branch at Rt. 386 Bridge (tributary)	311031
3. Buntings Branch at Rt. 54 (lower stream)	311041

The monitoring data showed that occasional dissolved oxygen violations occurred in all three monitoring sites, with concentrations below 5.5 mg/l during summer months (Figure 1-4). Concentrations of BOD and chlorophyll-*a* were relatively low in the stream, a typical headwater and nonpoint source influenced stream. Nutrient levels were relatively high in the range of 0.5 to 7.0 mg/l for total nitrogen and 0.05 to 0.25 mg/l for total phosphorous. They exceeded State's nutrient threshold levels of 3.0 mg/l for total nitrogen and 0.2 mg/l for total phosphorous (Figure 1-5). A data summary presented in Table 1-3 is the average concentrations of monitoring data collected during the period of 2000 - 2002.

Based on the monitoring data, Delaware's 2002 305(b) Reports (1) showed that elevated nutrient levels and low DO concentrations impaired Buntings Branch and its designated uses were not fully supported for fish and aquatic life.

Table 1-3. Average Water Quality Conditions at Three Monitoring Locations of Buntings Branch Watershed during 2000-2002

Monitoring Station	Water Temp C	Field DO mg/l	CBOD5 mg/l	Chlor-a ug/l	Org_N mg/l	NH3_N MG/L	NO2_N mg/l	NO3_N mg/l	TotalN mg/l	Org_P mg/l	DOrthP mg/l	TPhos mg/l
311011	18.0	6.8	2.4	12.5	1.69	0.13	0.28	2.49	4.58	0.09	0.02	0.11
311031	13.5	6.9	2.5	18.1	1.97	2.72	0.24	2.18	7.11	0.14	0.01	0.15
311041	17.3	7.1	2.6	7.8	1.06	0.20	0.22	1.94	3.42	0.09	0.03	0.12

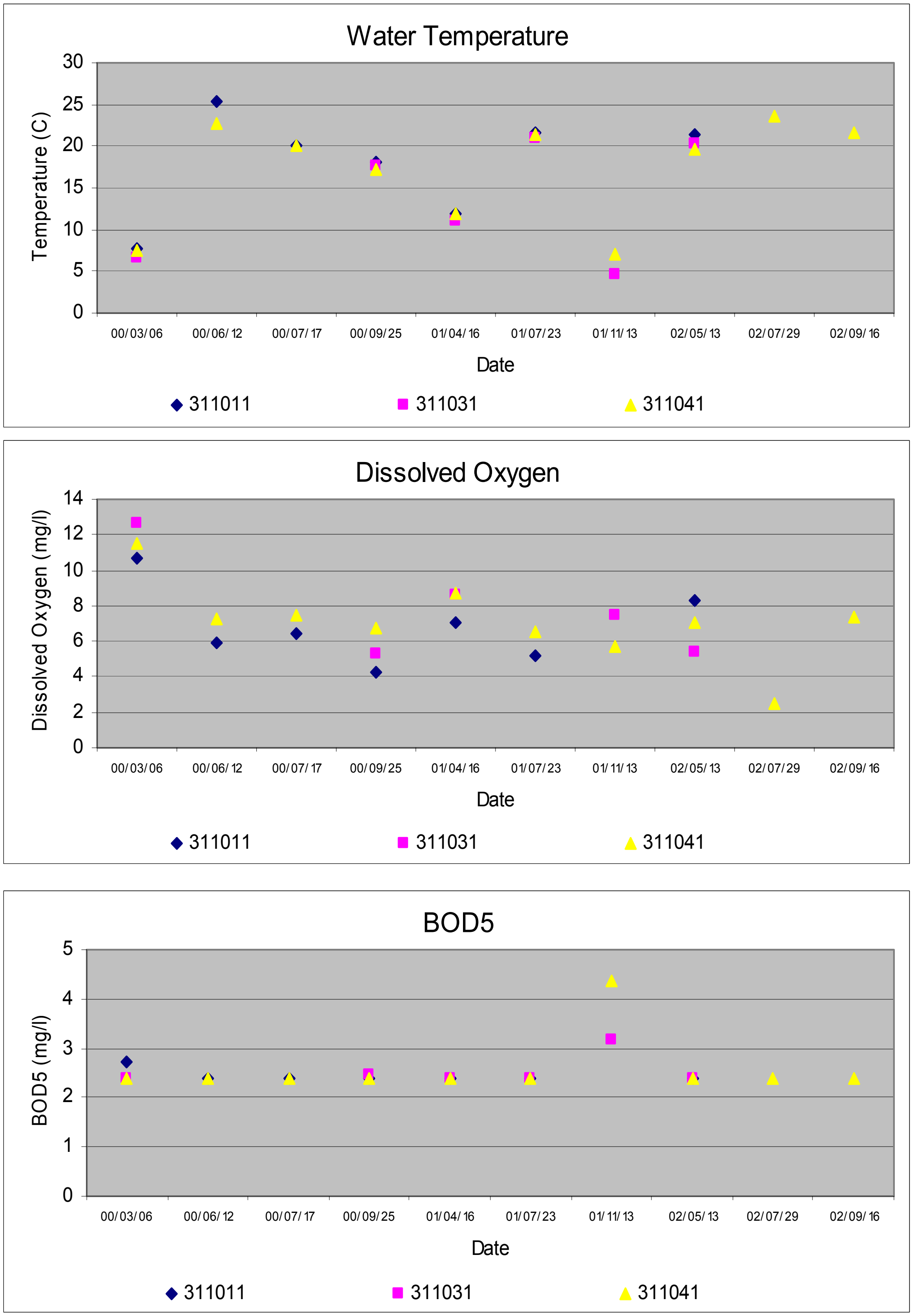

Figure 1-4 Observed Water Temperature, Dissolved Oxygen, and BOD_5 at Three Monitoring Locations of Buntings Branch Watershed

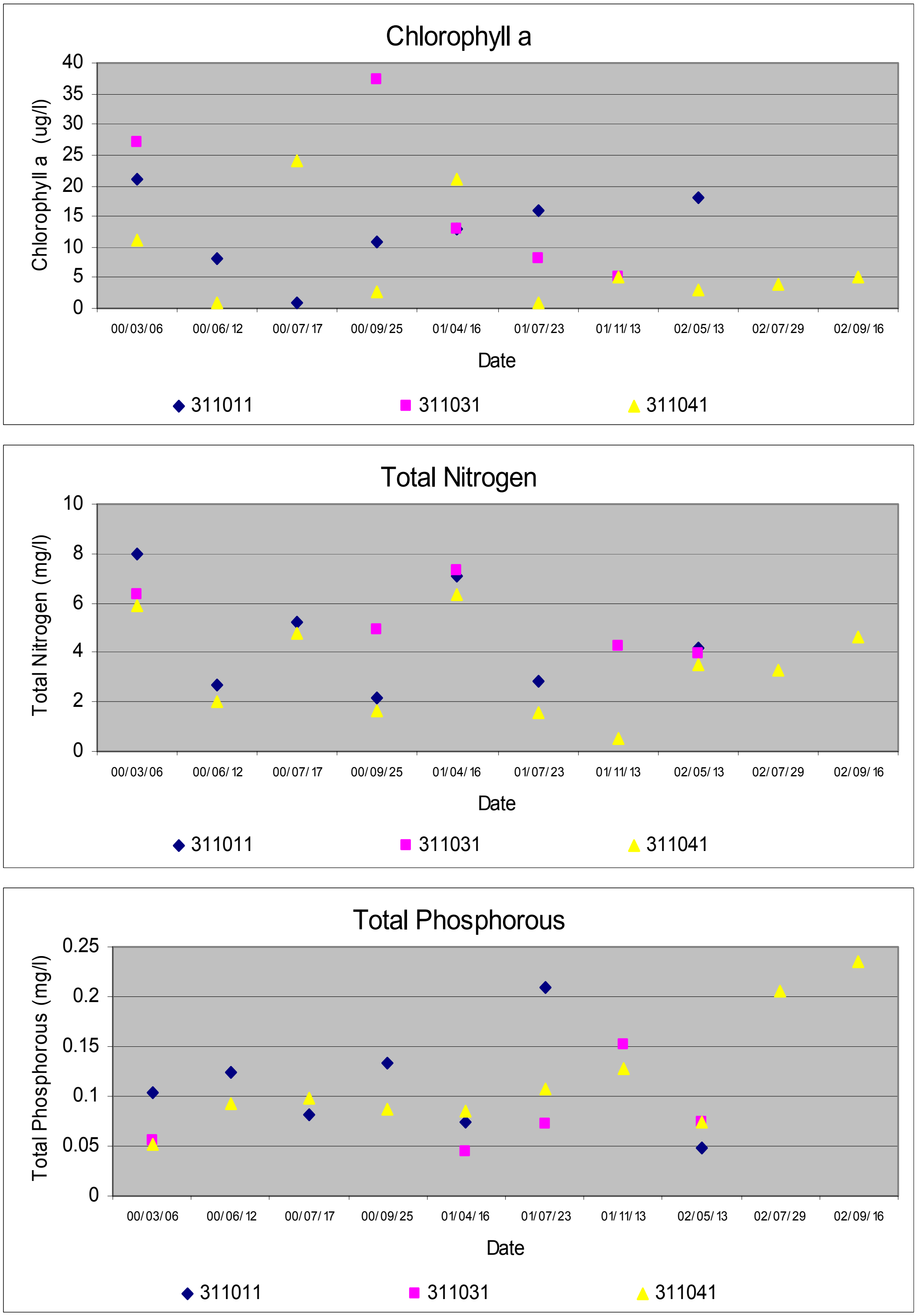

Figure 1-5 Observed Chlorophyll-*a*, Total Nitrogen, and Total Phosphorous at Three Monitoring Locations of Buntings Branch Watershed

Sources of Pollution

There are no active point sources discharging nutrients in the watershed. The Mountaire Farm facility (NPDES permit ID 0050326) is the only point source in the watershed and is permitted to discharge cooling water and storm water into Buntings Branch's tributary -Sandy Branch. However, the discharge outfall for cooling water and storm water has not had any discharge since 1998 and there is no plan to discharge from the outfall in the future.

All the sources of pollutants considered in this analysis are nonpoint sources such as surface runoffs from agricultural and other land use activities, septic tanks, and groundwater discharges loaded with nutrients in the watershed.

2.0 BUNTINGS BRANCH WATER QUALITY MODEL

The Enhanced Stream Water Quality Model (Qual2E)

The Enhanced Stream Water Quality Model (Qual2E) is chosen as the framework for modeling Buntings Branch water quality and TMDL development. Qual2E is supported by the U.S. EPA and has been widely used for studying the impact of conventional pollutants on streams. Windows based version (ver.3.21) of this model is used in this study.

Buntings Branch is a small stream. It has long-term average annual flow less than 10 cubic feet per second (cfs). The width of the stream increases from about 2 feet at its headwater to 15 feet at its lower reaches, while its depth is more uniformly distributed from its headwater to the lower reaches at approximately 6 inches. Water quality concerns for Buntings Branch include elevated nutrient levels and low dissolved oxygen concentrations during summer.

The Qual2E model is suitable for simulating the hydrological and water quality components of a small stream. It is a simple one-dimensional model, but consists of the basic stream transport and mixing processes. The kinetic processes employed in Qual2E address nutrient cycles, algal growth, and dissolved oxygen dynamics. Comparing to other available models, Qual2E is the one best suited for Buntings Branch's condition. Therefore, Qual2E was selected as the tool to develop the Buntings Branch water quality model and conduct TMDL analysis.

The Qual2E consists of 13 types of input data groups. Below is a brief summary of the input data groups. A detailed discussion is available in the model's user manual (6). Data inputs for the Buntings Branch Qual2E Model are discussed in a later section of this chapter.

- Type 1, 1A, and 1B data groups define program control, global algal, nutrient, and light parameters, and temperature correction factors.
- Type 2 data identifies the stream reach system by listing reach names and lengths.
- Type 3 data gives flow augmentation information.
- Type 4 data identifies each type of computational element in each reach.
- Type 5 data describes the hydraulic characteristics of the system.
- Type 6, 6A, and 6B data provide reach varied coefficients and rates related to kinetic processes of BOD, DO, nutrient and algae.
- Type 7 and 7A data define the initial conditions of the system.
- Type 8 and 8A data provide incremental inflow values and their concentrations.
- Type 9 data defines stream junction name and order if tributaries are simulated.
- Type 10 and 10A data define headwater conditions.
- Type 11 and 11A data define point load or tributary conditions.
- Type 12 data provides dam reaeration information.

- Type 13 data defines downstream condition.

Buntings Branch Qual2E Model Input Data

The Buntings Branch Qual2E Model is set up as a one dimensional, steady state model. It simulates average instream water quality condition including dissolved oxygen, BOD, algae as chlorophyll-*a*, various forms of nitrogen, as well as organic and dissolved phosphorous. Water temperature and diurnal changes of algae are not simulated. The model is defined by various input data as described in the previous section. The major input data groups for the Buntings Branch Qual2E Model are summarized below.

<u>Model Segmentation</u>

The Buntings Branch Qual2E consists of three model reaches starting from its headwater at Sandy Branch to the state line and covers 4.2 kilometers (2.6 miles). Figure 2-1 displays these reaches on the watershed map. Due to the structure of Qual2E, each reach is further divided into a number of computational elements (CE) which must have the same length across the entire model domain. A length of 0.3 kilometer was assigned to Buntings Branch Qual2E's computational elements. A summary of reach length and the number of computational elements is presented in Table 2-1.

<u>Hydraulic Characteristics</u>

The Buntings Branch Qual2E used functional representation, rather than geometric representation, to describe its stream hydraulic characteristics with the assumption of rectangular channel cross-section. Functional representation of hydraulic characteristics of the stream reaches were determined by using the following discharge coefficient equations:

$$\bar{u} = aQ^{b}$$
$$A_x = Q / \bar{u}$$
$$d = \alpha Q^{\beta}$$

where $\bar{u}$ - mean velocity of stream reach (m/s)
d – depth of stream reach (m)
a, b, **"**, and **$** - empirical discharge coefficient constants

Field measurements of stream channel width, depth, and velocity were conducted at the same time when water quality sample were collected at the monitoring sites during 2000-2002. The average width, depth, and velocity for each site were calculated from the field measurements, and the results are presented in Table 2–2. It can be seen that Sandy Branch/Upper Buntings Branch and Polly Branch have narrower channels, flow slower than lower reaches, and possess channel depths that do not change very much along the stream from headwater to the lower reaches of Buntings Branch.

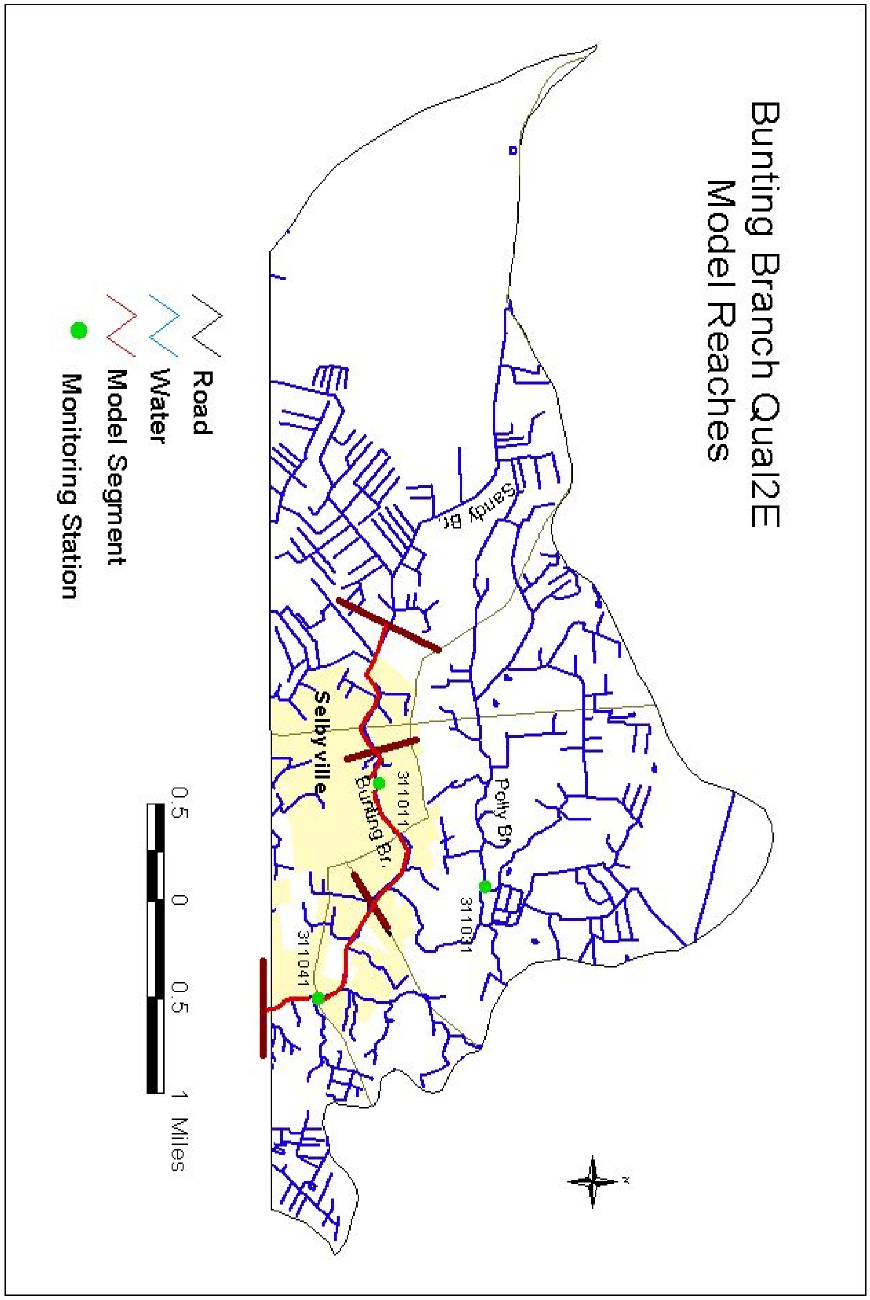

Figure 2 -1 Bunting Branch Qual2E Model Reaches

Table 2-1 Buntings Branch Qual2E Reaches

Reach Number	Description	Reach Length (km)	Number of Computational Elements in the Reach
1	Headwater starts from Sandy Branch	1.2	4
2	Middle reach goes through Selbyville	1.5	5
3	Lower reach ends at the state line	1.5	5

Table 2-2 Average Channel Widths, Depths and Velocities of Buntings Branch

Station	Number of Measurement	Stream Segment	Average Width (ft)	Average Depth (ft)	Average Velocity (ft/s)
311011	7	From Sandy Branch to upper Buntings Branch represented by model reaches #1 and #2	3.6	0.5	0.7
311031	3	Polly Branch, a major tributary	3.0	0.6	0.8
311041	8	Lower Buntings Branch represented by model reach #3	9.1	0.6	1.0

The field measurements were used to estimate discharge coefficient constants. First, channel depths and velocities, which were estimated from the data collected at each sample location, were plotted against their corresponding stream flow measurements. Next, regressions for depth vs. flow and velocity vs. flow were performed separately for each sample location. From the regression plots, the discharge coefficient constants *a, b,* ***″***, and ***$*** for each sample location were calculated. Then the discharge function at each sample site was formed and assigned to represent the hydraulic characteristics of the stream reach. Table 2-3 summarized the estimated discharge coefficient constants and the discharge functions.

Table 2-3 Discharge Coefficient Constants for Buntings Branch Qual2E Reaches

Reach	Stream Segment Name	Station	Mean Velocity (m/s)	Depth (m)
			u = a Q ^b	d = α Q ^β
1	Upper Buntings Branch	311011	u = 0.783 Q ^ 0.380	d = 0.411 Q ^ 0.315
2	Middle Buntings Branch	311011	u = 0.783 Q ^ 0.380	d = 0.411 Q ^ 0.315
3	Lower Buntings Branch	311041	u = 0.421 Q ^ 0.192	d = 0.547 Q ^ 0.516

Stream Flows

Two types of flows were considered for development of the Buntings Branch model and analysis of its TMDLs, average flow and summer low flow. Average flow was the result of averaging daily mean flows over the period of 2000 - 2002; summer low flow was the lowest monthly flows of July, August, and September over the period of 2000 - 2002. The average flow was used in model scenario runs to simulate the average condition of a typical year in Buntings Branch, while the summer low flow was used in model scenario runs to simulate the critical condition possibly occurring in summer low flow and warm weather situations at Buntings Branch.

There is no USGS gauging station in the Buntings Branch Watershed. Daily flows recorded at the Stockley gauging station (USGS 01484500) were used to estimate daily flows in Buntings Branch using the ratio of flow to drainage area. The Stockley gauge data was considered reasonable for estimating the flows of the Buntings Branch Watershed due to its similar geology, topography, and proximity to the watershed. The average daily flow at Stockley during 2000 -2002 was 8.4 cubic feet per second, and summer lowest flow was 2.4 cubic feet per second with a drainage area of 5.24 square miles (7). Table 2-4 lists Buntings Branch's sub-watershed drainage areas as well as the estimated average and summer flows.

Table 2-4. Average Flows and Summer Low Flows of Buntings Branch

Description of Drainage Area	Drainage Area		Daily Average Flow over calendar year '00 - '02		Lowest Summer Monthly Average Flow over '00 - '02	
	acre	square mile	cfs	m3/s	cfs	m3/s
Sandy Branch, a headwater	418.00	0.65	1.05	0.03	0.30	0.01
Reach 1 incremental	407.00	0.64	1.02	0.03	0.29	0.01
Reach 2 incremental	475.00	0.74	1.19	0.03	0.34	0.01
Reach 3 incremental	877.00	1.37	2.20	0.06	0.63	0.02
Polly Branch, a tributary to Buntings	2302.00	3.60	5.76	0.16	1.66	0.05
Buntings Branch Watershed (total)	4479.00*	7.00	11.22	0.32	3.23	0.09

* Drainage area used in the flow calculation was less than the area given in Chapter 1. The reason was that a part of the swamp area located near the headwater and the area bordered with Maryland were not accounted for in the model flow calculation since these areas were not drained directly to the modeled segments.

System Parameters

The physical, chemical, and biological processes simulated by Qual2E are represented by a set of equations that contain many system parameters. Some are global constant, some are spatial variables, and some are temperature dependent. Detail descriptions of these parameters and associated processes are available in the Qual2E user's manual. Global constants and reach variable coefficients used in the Buntings Branch Qual2E calibration are listed in Table 2-5 and Table 2-6.

Table 2-5 Global Constants of the Buntings Branch Qual2E

Parameter	Description	Unit	Value
"$_0$	Ratio of chlorophyll-a to algal biomass	ug-Chl *a* / mg A	50
"$_1$	Fraction of algal biomass that is Nitrogen	mg-N / mg A	0.08
"$_2$	Fraction of algal biomass that is Phosphorus	mg-p / mg A	0.012
"$_3$	O_2 production per unit of algal growth	mg-O / mg A	1.4
"$_4$	O_2 uptake per unit of algae respired	mg-O / mg A	2
"$_5$	O_2 uptake per unit of NH_3 oxidation	mg-O / mg N	3.43
"$_6$	O_2 uptake per unit of $N0_2$ oxidation	mg-O / mg N	1.12
:$_{max}$	maximum algal growth rate	day-l	2.5
D	Algal respiration rate	day-l	0.1
K_L	Half- saturation constant for light (Option 1)	langleys/min	0.01
K_N	Half- saturation constant for nitrogen	mg-N/L	0.1
K_p	Half- saturation constant for phosphorus	mg-P/L	0.005
λ1	Linear algal self-shading coefficient	(1/m) / (ug Chl-*a*/L)	0
λ2	Nonlinear algal self- shading coefficient	(1/m) / (ug Chl-*a*/L)**2/3	0
P_N	Algal preference factor for ammonia	-	0.9

Table 2-6 Reach Varied Coefficients of the Buntings Branch Qual2E

Parameter	Description	Unit	Range
λ0	Non-algal light extinction coefficient	1/m	0.01
F$_1$	Algal settling rate	m/day	0 - 0.9
F$_2$	Benthos source rate for phosphorous	mg-p / m2-day	0
F$_3$	Benthos source rate for ammonia nitrogen	mg-N / ft2-day	0
F$_4$	Organic nitrogen settling rate	day-l	0.13
F$_5$	Organic phosphorus settling rate	day-l	0.1
K_1	Carbonaceous deoxygeneration rate constant	day-l	3.5
K_2	Reaeration rate constant	day-l	Calc internally (option 6)
K_3	Rate of loss of BOD due to settling	day-l	0.5
K_4	Benthic oxygen uptake	mg-O / m2-day	1.5
β1	Rate constant for the biological oxidation of NH3 to NO2	day -1	1.3
β2	Rate constant for the biological oxidation of N02 to N03	day-l	2
β3	Rate constant for the hydrolysis of organic-N to ammonia	day-l	0.1
β4	Rate constant for the decay of organic-P to dissolved-P	day-l	0.8-0.9

Boundary Conditions

Qual2E uses different data groups to define model boundary conditions. It uses the headwater data group to define most upstream boundary conditions of a model domain. Downstream boundary condition can be defined by the user, or computed internally. The point source data group defines the condition of point source discharge from facilities or small tributaries that input to the simulated stream segments.

The headwater conditions and tributary conditions of the Buntings Branch Qual2E Model were defined by monitoring data collected at station 311031 (on Polly Branch). The monitoring data were averaged over the entire period of 2000 – 2002 and over the summer months (July, August and September) during 2000 – 2002. Average concentrations over the entire period of 2000 -2002 were used with average flows, and average concentrations of the summer months were used with summer low flows.

Option of internally calculation of the downstream boundary conditions was selected for the Buntings Branch Qual2E Model.

Incremental Inflow Conditions

The incremental inflow data group defines the condition of uniformly distributed flow over the entire length of the reach. The uniformly distributed flow could be groundwater inflow and/or distributed surface runoff that can be assumed constant over time.

Incremental inflow concentrations of the Buntings Branch Qual2E Model were estimated based on consideration of surface runoff concentrations for different land uses.

Surface runoff concentrations from different types of land use, as listed in Table 2-7, were developed by HydroQual, Inc. considering literature values and specific studies including the land use study in Delaware (8). Downward adjustments on phosphorous concentrations of surface runoff were made considering that concentrations of the Buntings Branch Qual2E Model incremental inflow made up a large portion of groundwater flow and a small portion of distributed surface runoff, were much lower than the concentrations in a surface runoff. In general, phosphorous concentrations in groundwater tend to be much lower than the concentrations in surface runoff. Furthermore, instream water samples collected from Buntings Branch showed that phosphorous concentrations were much lower than the surface runoff concentrations listed in Table 2-7, supporting the downward adjustment.

The fractions of different land uses were calculated using 1997 land use and land cover data. For a sub-watershed that flows directly into the modeled segment in the distributed form, its land use data was broken down into seven major types, see Table 2-7, and the fraction of each land use type area to its total sub-watershed area was estimated. Considering the percentage of each land use type in a reach and assigning appropriate runoff concentrations for the specific land use type, a reach-wide incremental inflow concentration is calculated as shown in Table 2-8.

Table 2-7 Surface Runoff Concentrations for Each Land Use Type (8)

System	Units	Urban or Built-up Land	Agricultural Land	Rangeland	Forest Land	Water	Wetland	Barren Land
NH3	mg/l	0.110	0.290	0.120	0.120	0.120	0.120	0.120
NO3	mg/l	0.390	1.540	0.350	0.350	0.350	0.350	0.350
PO4	mg/l	0.150	0.310	0.130	0.130	0.130	0.130	0.130
Phyto	mg/l	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CBOD	mg/l	10.000	10.000	2.000	2.000	2.000	2.000	2.000
DO	mg/l	6.000	5.000	6.000	6.000	6.000	4.000	6.000
OrgN	mg/l	0.910	1.310	1.140	1.140	1.140	1.140	1.140
OrgP	mg/l	0.380	0.350	0.130	0.130	0.130	0.130	0.130

Table 2-8 Incremental Inflow Concentrations of the Bunting Branch Qual2E

Concentration	NH3	NO3	PO4	CHL-*a*	DO	OrgN	OrgP	BOD5
Unit	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l	mg/l
Reach 1	0.254	1.308	0.018	0.000	5.202	1.229	0.108	3.490
Reach 2	0.166	0.748	0.018	0.000	5.688	1.036	0.108	5.236
Reach 3	0.206	0.977	0.018	0.000	5.481	1.170	0.108	3.388

Unanalyzed Constituents

Each of these boundary data groups and incremental inflow data group consist of a set of specific constituent concentrations including dissolved oxygen, BOD, chlorophyll-*a*, organic nitrogen, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, organic phosphorous, dissolved phosphorous, and water temperature. They are required in the model input file. However, organic nitrogen, nitrite nitrogen, nitrate nitrogen, and organic phosphorous were not directly analyzed from the water quality samples. Their values, therefore, were calculated according to the following relationships:

Organic Nitrogen = (TKN) - (Ammonia Nitrogen)
Nitrite Nitrogen = 0.1* (Nitrite Nitrogen + Nitrate Nitrogen)
Nitrate Nitrogen = 0.9* (Nitrite Nitrogen + Nitrate Nitrogen)
Organic Phosphorous = (Total Phosphorous) - (Dissolved Phosphorous)

Input data for Buntings Branch Qual2E Model calibration is presented in Appendix A.

3.0 MODEL CALIBRATION AND SCENARIO ANALYSIS

Model Calibration / Baseline Condition

The Buntings Branch Qual2E Model was calibrated to reproduce average water quality conditions observed during 2000-2002. Average annual flows and water quality concentrations were used in the model's calibration. The input and output data for the Buntings Branch Qual2E Model calibration is presented in Appendix A.

Figure 3-1 displays the model calibration results for several water quality constituents including nutrient species, dissolved oxygen, biochemical oxygen demand, phytoplankton chlorophyll-*a*, and water temperature under average condition during 2000 - 2002. Model calibration results are presented as lines while observed data at the monitoring sites (311011 and 311041) are summarized and shown as symbols with mean, maximum, and minimum values.

The calibration results show that dissolved oxygen and temperature predictions are very close to the observed values and that nitrogen, phosphorous, and chlorophyll-*a* have been reproduced reasonably well. This calibrated model for average condition during 2000 – 2002 constitutes the baseline condition for the Buntings Branch.

Application of the MDE's Prescribed Nonpoint Source Reductions

The nonpoint source loads are considered implicitly in Qual2E model. They are used in the model through user-defined boundary conditions including headwater conditions, tributary inflow conditions, and incremental inflow conditions. Water Quality concentrations used to define these boundary conditions for the Buntings Branch Qual2E Model were discussed in Chapter 2 of this report.

As it was stated earlier, Maryland Department of the Environment in its April 2002 TMDL calls for nonpoint source reduction of 31% for nitrogen and 19% for phosphorous. To evaluate the efficiency of these load reductions in achieving State of Delaware's water quality standards and nutrient targets, this analysis was performed. For this analysis, load reduction rates from nonpoint sources were applied to baseline scenario. The nitrogen and phosphorous concentrations at headwater, tributary inflow, and incremental inflow were reduced at the rates of 31% and 19%, respectively. In addition, the rate of sediment oxygen demand was reduced by 31% considering the impact of reduced nutrient input from nonpoint sources.

Results of the dissolved oxygen, total nitrogen and total phosphorus concentrations for this scenario are presented in Figure 3-2 as red line. The blue lines represent the baseline conditions. It is apparent that the dissolved oxygen levels meet State of Delaware's standard of 5.5 mg/l of the daily average, while the nutrient concentrations meet State Delaware's thresholds of 3 mg/l for total nitrogen and 0.2 mg/l for total phosphorous.

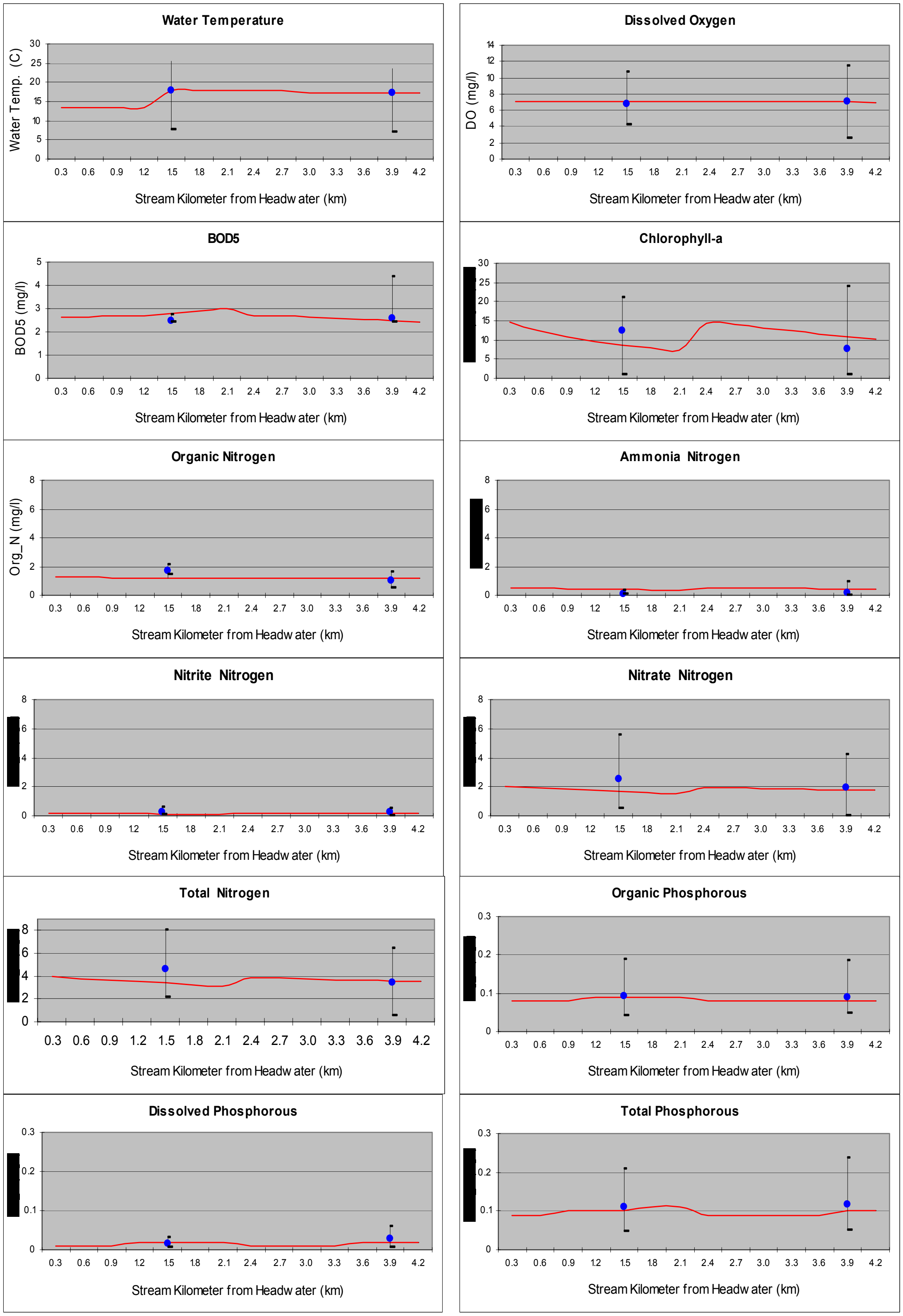

Figure 3-1 Calibration Results of Water Temperature, DO, BOD5, Chlorophyll-*a*, Org_N, NH3_N, NO2_N, NO3_N, TN, Org_P, Dis_P, and TP

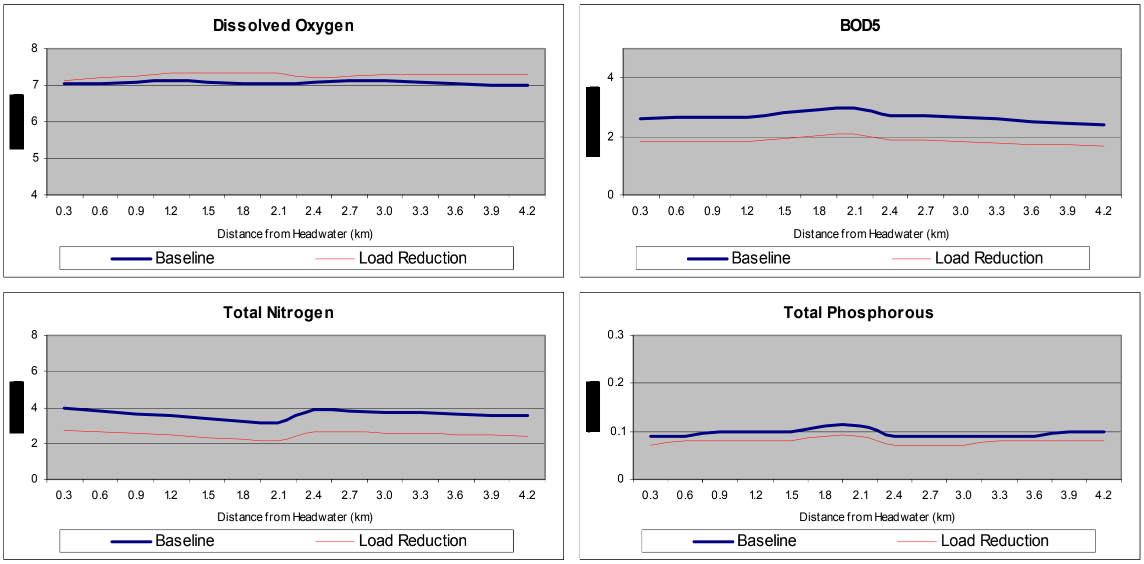

Figure 3-2 Results of Load Reduction on Baseline Scenario for Dissolved Oxygen, BOD5, Total Nitrogen, and Total Phosphorous

Baseline Condition During Summer

Low flows coupled with warm temperatures are observed during the months of July, August, and September in Buntings Branch. Monitoring data showed that violation of the dissolved oxygen standard happened more frequently during summer months than other months of the year.

The water quality conditions in the summer were simulated to form the critical baseline conditions during summer time. Water quality data collected during July, August, and September were considered summer month samples and were averaged over the period of 2000-2002. The averaged summer concentrations were used to define the headwater conditions and tributary input conditions of the model. The average summer concentrations were coupled with the summer low flows to simulate the summer critical condition. The results are presented in Figure 3-3 as blue lines.

Application of the MDE's Prescribed Load Reductions to Summer Condition

The same load reduction rates previously discussed were applied to the summer condition. The nitrogen and phosphorous concentrations at the headwater, tributary inflow, and incremental inflow were reduced at the rates of 31% and 19%, respectively. In addition, the rate of sediment oxygen demand was reduced by 31% considering the impact of reduced nutrient input from nonpoint sources.

Results of the load reduction over the summer condition are presented for dissolved oxygen, total nitrogen and total phosphorus in Figure 3-3 as red line and are compared to summer baseline condition. As it can be seen, implementing MDE's prescribed nonpoint source reductions would achieve State of Delaware's water quality standards and nutrient targets in Buntings Branch, hence will be adopted for this watershed.

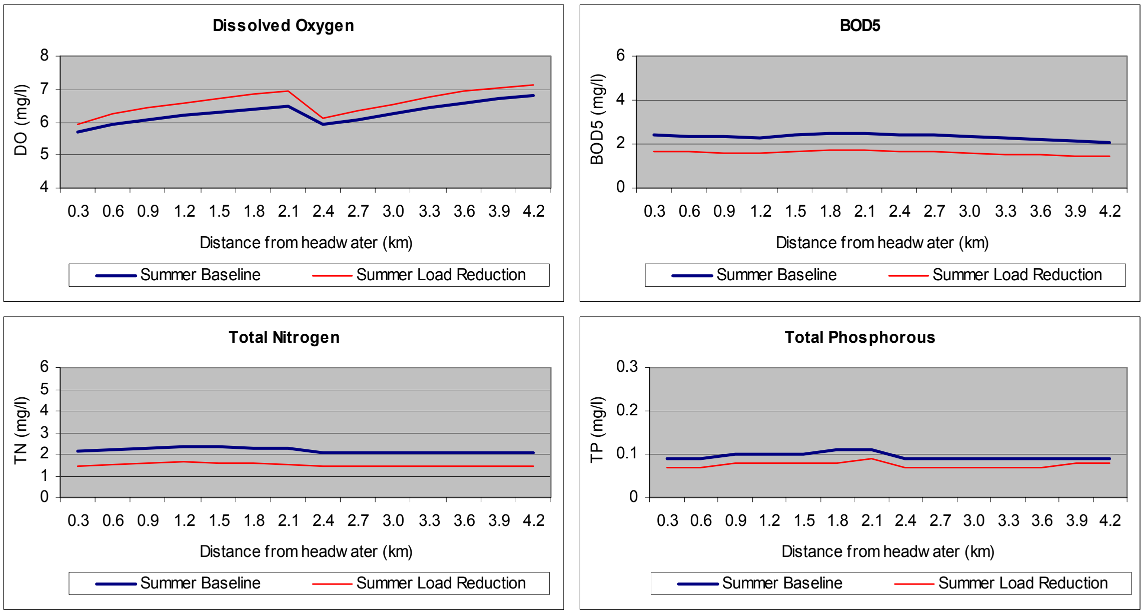

Figure 3-3 Results of Load Reduction on Summer Critical Scenario for Dissolved Oxygen, BOD5, Total Nitrogen, and Total Phosphorous

4.0 TOTAL MAXIMUM DAILY LOADS AND THEIR ALLOCATIONS

Buntings Branch TMDLs Designed to Achieve Applicable Water Quality Standards

As was stated in Chapter 1, the applicable State of Delaware water quality standard for dissolved oxygen is 5.5 mg/l for freshwater streams, and the TMDL nutrient targets are 3.0 mg/l for total nitrogen and 0.2 mg/l for total phosphorous. The results of load reduction scenarios, as discussed in Chapter 3, show that under summer critical condition as well as average condition, the dissolved oxygen standard and nutrient targets are met along all simulated reaches of Buntings Branch. Therefore, it can be concluded that the nonpoint source load reduction rates of 31% and 19% for nitrogen and phosphorous respectively are sufficient to achieve water quality standards in impaired segments of the Buntings Branch..

Load Allocations for Nonpoint Sources

As discussed previously, there are no active point sources discharging nutrients within the Buntings Branch Watershed. Hence, the TMDLs for Buntings Branch only contain load allocations for nonpoint sources. The baseline loads and TMDLs for Buntings Branch are calculated using scenario results discussed in Chapter 3. The baseline loads were estimated from the model results of the baseline scenario. The TMDL loads were estimated from the model results of the load reduction scenario that applied reduction rates of 31% nitrogen and 19% phosphorous. Table 4-1 presents the load allocations for total nitrogen and total phosphorous. Under average condition, total nitrogen should be reduced from the baseline of 213 pounds per day to the level of 146 pounds per day, and total phosphorous should be reduced from the baseline of 6 pounds per day to the level of 5 pounds per day.

Table 4-1 Load Allocation of the Buntings Branch TMDLs

Bunting Branch Condition	Flow (m3/s)	TN Load (kg/d)		TP Load (kg/d)		TN Load (lb/day)		TP Load (lb/day)	
		Baseline	TMDL	Baseline	TMDL	Baseline	TMDL	Baseline	TMDL
Annual Average	0.317	96.4	66.3	2.7	2.2	213	146	6	5

Consideration of the Impact of Background Pollutants

The Buntings Branch TMDLs for nutrients were estimated using the results of a calibrated water quality model. The model was developed using data collected in the field to represent model input for headwater conditions, tributary inflow conditions, and incremental inflow conditions. The data collected in the field also reflected background pollutant conditions. Therefore, the impact of background pollutants is accounted in the model.

Consideration of Critical Environmental Conditions

Low stream flow during summer months coupled with high water temperature constitute a critical condition for Buntings Branch and has been recognized and simulated in this analysis. A scenario that incorporated summer low flow with high water temperature was considered. Headwater conditions and tributary inflow conditions were defined using data collected during summer months (July, August, and September). Details of the model inputs and results of the model run are discussed in chapter 3 and showed that implementing MDE's prescribed nonpoint source reduction would result in achieving water quality standards and nutrient targets. Therefore, the critical condition of Buntings Branch was considered in this analysis.

Consideration of Seasonal Variations

Seasonal variations are considered in the Buntings Branch Qual2E Model as the model was calibrated to the average flow and water quality conditions. The data used to define the model input were collected during 2000-2003 at different months (see Surface Water Monitoring Program FY2000), which reflected the seasonal variations in the model. In addition, the model was also run under summer low flow condition to simulate the impact of low flow coupled with high temperatures. Therefore, seasonal variations have been considered for this analysis.

Consideration of Margin of Safety

EPA's technical guidance allows consideration of a margin of safety as implicit or as explicit. An implicit margin of safety is the conservative assumptions are considered for model development and TMDL establishment. An explicit margin of safety is a specified percentage of assimilative capacity is kept unassigned to account for uncertainties, lack of sufficient data, or future growth.

An implicit margin of safety has been considered for the Buntings Branch analysis. The Buntings Branch Qual2E was calibrated using conservative assumptions regarding reaction rates, pollutant loads, and other environmental conditions. Consideration of these conservative assumptions contributes to the implicit margin of safety.

TMDL Implementation / Public Participation

Delaware DNREC will implement the requirements of this TMDL through cooperation with the State of Maryland and development of a Pollution Control Strategy. As with all Pollution Control Strategies, Delaware will engage stakeholders through extensive public education and review process.

REFERENCES

1. "State of Delaware 1996 Watershed Assessment Report (305(b))", Department of Natural Resources and Environmental Control, April 1, 1996.

2. "Final Determination for the State of Delaware 1998 Clean Water Act Section 303(d) List of Waters Needing TMDLs", Department of Natural Resources and Environmental Control, 1998.

3. "Total Maximum Daily Loads of Nitrogen and Phosphorous for Five Tidal Tributaries in Northern Coastal Bays System Worcester County, Maryland, Final", Maryland Department of Environment, April 17, 2002.

4. "State of Delaware Surface Water Quality Standards, as amended July 11, 2004," Department of Natural Resources and Environmental Control.

5. "State of Delaware Surface Water Quality Monitoring Program FY2000", Department of Natural Resources and Environmental Control, May 3, 1999.

6. "Linfield C. Brown and Thomas O. Barnwell, Jr., The Enhanced Stream Water Quality Models Qual2E and Qual2E-UNCAS: Documentation and User Manual, EPA/600/3-87/007, May 1987, Environmental Research laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Athens, Georgia, 30613.

7. "Water Resource Data, Maryland, Delaware, and Washington, D.C., Water Year 2002, Volume 1. Surface-Water Data", U.S. Geological Survey.

8. "A model for the Murderkill River Watershed", HydroQual Inc., February 2001

Appendix A – Input and Output Data for Buntings Branch Qual2E Model Calibration (Run Qal2e100)

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                                     * * * QUAL-2E  STREAM QUALITY ROUTING MODEL * * *
                                                  Version 3.21  -  Feb. 1995

 $$$ (PROBLEM TITLES) $$$

CARD TYPE                             QUAL-2E PROGRAM TITLES
TITLE01             Qal2E100 is the new calibration run that is based on Qal2E080,
TITLE02             10/1/04
TITLE03  NO         CONSERVATIVE MINERAL I
TITLE04  NO         CONSERVATIVE MINERAL II
TITLE05  NO         CONSERVATIVE MINERAL III
TITLE06  NO         TEMPERATURE
TITLE07  YES        5-DAY BIOCHEMICAL OXYGEN DEMAND
TITLE08  YES        ALGAE AS CHL-A IN UG/L
TITLE09  YES        PHOSPHORUS CYCLE AS P IN MG/L
TITLE10               (ORGANIC-P; DISSOLVED-P)
TITLE11  YES        NITROGEN CYCLE AS N IN MG/L
TITLE12               (ORGANIC-N; AMMONIA-N; NITRITE-N;' NITRATE-N)
TITLE13  YES        DISSOLVED OXYGEN IN MG/L
TITLE14  NO         FECAL COLIFORM IN NO./100 ML
TITLE15  NO         ARBITRARY NON-CONSERVATIVE
ENDTITLE

 $$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE                                    CARD TYPE
LIST DATA INPUT            0.00000                                          0.00000
WRITE OPTIONAL SUMMARY     0.00000                                          0.00000
NO FLOW AUGMENTATION       0.00000                                          0.00000
STEADY STATE               0.00000                                          0.00000
NO TRAP CHANNELS           0.00000                                          0.00000
NO PRINT LCD/SOLAR DATA    0.00000                                          0.00000
NO PLOT DO AND BOD DATA    0.00000                                          0.00000
FIXED DNSTM CONC (YES=1)=  0.00000          5D-ULT BOD CONV K COEF  =   0.23000
INPUT METRIC           =   1.00000          OUTPUT METRIC           =   1.00000
NUMBER OF REACHES      =   3.00000          NUMBER OF JUNCTIONS     =   0.00000
NUM OF HEADWATERS      =   1.00000          NUMBER OF POINT LOADS   =   1.00000
TIME STEP (HOURS)      =   0.00000          LNTH. COMP. ELEMENT (DX)=   0.30000
MAXIMUM ROUTE TIME (HRS)= 100.00000         TIME INC. FOR RPT2 (HRS)=   0.00000
LATITUDE OF BASIN (DEG) =  38.50000         LONGITUDE OF BASIN (DEG)=  75.60000
STANDARD MARIDIAN (DEG) =  75.00000         DAY OF YEAR START TIME  = 213.00000
EVAP. COEF.,(AE)       =   0.00001          EVAP. COEF.,(BE)        =   0.00001
ELEV. OF BASIN (ELEV)  =  30.00000          DUST ATTENUATION COEF.  =   0.10000
ENDATA1                    0.00000                                          0.00000

 $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

CARD TYPE                                          CARD TYPE
O UPTAKE BY NH3 OXID(MG O/MG N)=    3.4300         O UPTAKE BY NO2 OXID(MG O/MG N)=    1.1200
O PROD  BY ALGAE (MG O/MG A)   =    1.4000         O UPTAKE BY ALGAE (MG O/MG A)  =    2.0000
N CONTENT OF ALGAE (MG N/MG A) =    0.0800         P CONTENT OF ALGAE (MG O/MG A) =    0.0120
ALG MAX SPEC GROWTH RATE(1/DAY)=    2.5000         ALGAE RESPIRATION RATE (1/DAY) =    0.1000
N HALF SATURATION CONST (MG/L) =    0.1000         P HALF SATURATION CONST (MG/L) =    0.0010
LIN ALG SHADE CO (1/M-UGCHA/L) =    0.0000         NLIN SHADE (1/M-(UGCHA/L)**2/3)=    0.0000
LIGHT FUNCTION OPTION (LFNOPT) =    1.0000         LIGHT SAT'N COEF (LANGLEYS/MIN)=    0.0100
DAILY AVERAGING OPTION (LAVOPT)=    2.0000         LIGHT AVERAGING FACTOR (AFACT) =    0.9500
NUMBER OF DAYLIGHT HOURS (DLH) =   14.0000         TOTAL DAILY SOLR RAD (LANGLEYS)=  380.0000
ALGY GROWTH CALC OPTION(LGROPT)=    2.0000         ALGAL PREF FOR NH3-N (PREFN)   =    0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)=    0.0000         NITRIFICATION INHIBITION COEF  =   10.0000
ENDATA1A                            0.0000                                             0.0000

 $$$ DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

CARD TYPE     RATE CODE     THETA VALUE

THETA( 1)      BOD DECA       1.047     DFLT
THETA( 2)      BOD SETT       1.024     DFLT
THETA( 3)      OXY TRAN       1.024     DFLT
THETA( 4)      SOD RATE       1.060     DFLT
THETA( 5)      ORGN DEC       1.047     DFLT
THETA( 6)      ORGN SET       1.024     DFLT
THETA( 7)      NH3 DECA       1.083     DFLT
THETA( 8)      NH3 SRCE       1.074     DFLT
THETA( 9)      NO2 DECA       1.047     DFLT
THETA(10)      PORG DEC       1.047     DFLT
THETA(11)      PORG SET       1.024     DFLT
THETA(12)      DISP SRC       1.074     DFLT
THETA(13)      ALG GROW       1.047     DFLT
THETA(14)      ALG RESP       1.047     DFLT
THETA(15)      ALG SETT       1.024     DFLT
THETA(16)      COLI DEC       1.047     DFLT
THETA(17)      ANC DECA       1.000     DFLT
THETA(18)      ANC SETT       1.024     DFLT
THETA(19)      ANC SRCE       1.000     DFLT
ENDATA1B

 $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE            REACH ORDER AND IDENT              R. MI/KM             R. MI/KM
STREAM REACH     1.0  RCH=   Upper Bunting   FROM          4.2     TO           3.0
STREAM REACH     2.0  RCH=     Mid Bunting   FROM          3.0     TO           1.5
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STREAM REACH	3.0	RCH=	Lower Bunting	FROM	1.5	TO	0.0
ENDATA2	0.0				0.0		0.0

$$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE	REACH	AVAIL HDWS	TARGET	ORDER OF AVAIL SOURCES					
ENDATA3	0.	0.	0.0	0.	0.	0.	0.	0.	0.

$$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE	REACH	ELEMENTS/REACH	COMPUTATIONAL FLAGS
FLAG FIELD	1.	4.	1.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	2.	5.	2.2.2.6.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	3.	5.	2.2.2.2.5.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
ENDATA4	0.	0.	0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

$$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEF-DSPN	COEFQV	EXPOQV	COEFQH	EXPOQH	CMANN
HYDRAULICS	1.	60.00	0.783	0.380	0.411	0.315	0.055
HYDRAULICS	2.	60.00	0.783	0.380	0.411	0.315	0.055
HYDRAULICS	3.	60.00	0.421	0.191	0.547	0.516	0.055
ENDATA5	0.	0.00	0.000	0.000	0.000	0.000	0.000

$$$ DATA TYPE 5A (STEADY STATE TEMPERATURE AND CLIMATOLOGY DATA) $$$

CARD TYPE	REACH	ELEVATION	DUST COEF	CLOUD COVER	DRY BULB TEMP	WET BULB TEMP	ATM PRESSURE	WIND	SOLAR RAD ATTENUATION
TEMP/LCD	1.	9.14	0.10	0.00	25.00	15.00	1002.00	0.00	1.00
TEMP/LCD	2.	9.14	0.10	0.00	25.00	15.00	1002.00	0.00	1.00
TEMP/LCD	3.	9.14	0.10	0.00	25.00	15.00	1002.00	0.00	1.00
ENDATA5A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	SOD RATE	K2OPT	K2	COEQK2 OR TSIV COEF OR FOR OPT 8	EXPQK2 OR SLOPE FOR OPT 8
REACT COEF	1.	3.50	0.50	1.500	6.	0.00	0.000	0.00000
REACT COEF	2.	3.50	0.50	1.500	6.	0.00	0.000	0.00000
REACT COEF	3.	3.50	0.50	1.500	6.	0.00	0.000	0.00000
ENDATA6	0.	0.00	0.00	0.000	0.	0.00	0.000	0.00000

$$$ DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	CKNH2	SETNH2	CKNH3	SNH3	CKNO2	CKPORG	SETPORG	SPO4
N AND P COEF	1.	0.10	0.13	1.30	0.00	2.00	0.80	0.10	0.00
N AND P COEF	2.	0.10	0.13	1.30	0.00	2.00	0.80	0.10	0.00
N AND P COEF	3.	0.10	0.13	1.30	0.00	2.00	0.90	0.10	0.00
ENDATA6A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	EXCOEF	CK5 CKCOLI	CKANC	SETANC	SRCANC
ALG/OTHER COEF	1.	50.00	0.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	2.	50.00	0.00	0.01	0.00	0.00	0.00	0.00
ALG/OTHER COEF	3.	50.00	0.90	0.01	0.00	0.00	0.00	0.00
ENDATA6B	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	13.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	2.	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-1	3.	17.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA7	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-2	2.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INITIAL COND-2	3.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENDATA7A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.029	18.00	5.20	3.49	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	2.	0.034	18.00	5.69	5.24	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	3.	0.062	18.00	5.48	3.39	0.00	0.00	0.00	0.00	0.00
ENDATA8	0.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS) $$$

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INCR INFLOW-2	1.	0.00	1.23	0.25	0.00	1.31	0.11	0.02
INCR INFLOW-2	2.	0.00	1.04	0.17	0.00	0.75	0.11	0.02
INCR INFLOW-2	3.	0.00	1.17	0.21	0.00	0.98	0.11	0.02
ENDATA8A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT	UPSTRM	JUNCTION	TRIB
ENDATA9	0.	0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWTR ORDER	NAME	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
HEADWTR-1	1.	Upper Bunting	0.03	13.50	7.08	2.54	0.00	0.00	0.00
ENDATA10	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS,
COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	HDWTR ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
HEADWTR-2	1.	0.00	0.00	18.08	1.25	0.63	0.24	2.18	0.07	0.01
ENDATA10A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

CARD TYPE	POINT LOAD ORDER	NAME	EFF	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
POINTLD-1	1.	trib of Poll	0.00	0.16	13.50	7.08	2.54	0.00	0.00	0.00
ENDATA11	0.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS,
COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	POINT LOAD ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	N03-N	ORG-P	DIS-P
POINTLD-2	1.	0.00	0.00	18.08	1.25	0.63	0.24	2.18	0.07	0.01
ENDATA11A	0.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$$$ DATA TYPE 12 (DAM CHARACTERISTICS) $$$

	DAM	RCH	ELE	ADAM	BDAM	FDAM	HDAM
ENDATA12	0.	0.	0.	0.00	0.00	0.00	0.00

$$$ DATA TYPE 13 (DOWNSTREAM BOUNDARY CONDITIONS-1) $$$

CARD TYPE	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
ENDATA13	DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED							

$$$ DATA TYPE 13A (DOWNSTREAM BOUNDARY CONDITIONS-2) $$$

CARD TYPE	CHL-A	ORG-N	NH3-N	NO2-N	NH3-N	ORG-P	DIS-P
ENDATA13A	DOWNSTREAM BOUNDARY CONCENTRATIONS ARE UNCONSTRAINED						

STEADY STATE ALGAE/NUTRIENT/DISSOLVED OXYGEN SIMULATION; CONVERGENCE SUMMARY:

VARIABLE	ITERATION	NUMBER OF NONCONVERGENT ELEMENTS
ALGAE GROWTH RATE	1	14
ALGAE GROWTH RATE	2	14
ALGAE GROWTH RATE	3	14
ALGAE GROWTH RATE	4	14
ALGAE GROWTH RATE	5	14
ALGAE GROWTH RATE	6	14
ALGAE GROWTH RATE	7	0
ALGAE GROWTH RATE	8	0

SUMMARY OF CONDITIONS FOR ALGAL GROWTH RATE SIMULATION:

1. LIGHT AVERAGING OPTION. LAVOPT= 2

   METHOD: MEAN SOLAR RADIATION DURING DAYLIGHT HOURS

   SOURCE OF SOLAR VALUES: DATA TYPE 1A
   DAILY NET SOLAR RADIATION: 1400.300 BTU/FT-2 (380.000 LANGLEYS)
   NUMBER OF DAYLIGHT HOURS: 0.0
   PHOTOSYNTHETIC ACTIVE FRACTION OF SOLAR RADIATION (TFACT): N/A
   MEAN SOLAR RADIATION ADJUSTMENT FACTOR (AFACT): 0.950

2. LIGHT FUNCTION OPTION: LFNOPT= 1

   HALF SATURATION METHOD, WITH HALF SATURATION COEF = 0.010 LANGLEYS/MIN

3. GROWTH ATTENUATION OPTION FOR NUTRIENTS. LGROPT= 2

   MINIMUM OF NITROGEN, PHOSPHORUS: FL*MIN(FN,FP)

DISSOLVED OXYGEN IN MG/L ITERATION 8

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	7.04	7.05	7.09	7.14																
2	7.09	7.06	7.05	7.08	7.12															
3	7.11	7.07	7.04	7.01	6.99															

5-DAY BIOCHEMICAL OXYGEN DEMAND ITERATION 8

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	2.61	2.65	2.66	2.66																
2	2.80	2.91	2.98	2.70	2.69															
3	2.64	2.58	2.52	2.47	2.42															

ORGANIC NITROGEN AS N IN MG/L ITERATION 8

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.24	1.24	1.23	1.23																
2	1.21	1.19	1.17	1.22	1.21															
3	1.21	1.20	1.20	1.20	1.19															

AMMONIA AS N IN MG/L ITERATION 8

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.55	0.50	0.46	0.43																
2	0.40	0.37	0.35	0.53	0.51															
3	0.50	0.48	0.46	0.45	0.44															

NITRITE AS N IN MG/L ITERATION 8

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.20	0.17	0.14	0.13																
2	0.12	0.11	0.10	0.19	0.19															
3	0.18	0.18	0.17	0.17	0.16															

NITRATE AS N IN MG/L ITERATION 8

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	2.01	1.90	1.82	1.76																
2	1.66	1.57	1.51	1.93	1.90															
3	1.86	1.82	1.79	1.76	1.73															

ORGANIC PHOSPHORUS AS P IN MG/L ITERATION 8

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.08	0.08	0.08	0.09																
2	0.09	0.09	0.09	0.08	0.08															
3	0.08	0.08	0.08	0.08	0.08															

DISSOLVED PHOSPHORUS AS P IN MG/L ITERATION 8

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.01	0.01	0.01	0.02																
2	0.02	0.02	0.02	0.01	0.01															
3	0.01	0.01	0.02	0.02	0.02															

ALGAE AS CHL-A IN UG/L ITERATION 8

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	14.73	12.47	10.84	9.61																
2	8.73	8.01	7.48	14.29	14.01															
3	13.13	12.30	11.56	10.89	10.29															

ALGAE GROWTH RATES IN PER DAY ARE ITERATION 8

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.92	0.93	0.94	0.94																
2	1.17	1.17	1.17	1.14	1.15															
3	1.11	1.12	1.12	1.13	1.13															

PHOTOSYNTHESIS-RESPIRATION RATIOS ARE ITERATION 8

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	8.72	8.81	8.87	8.91																
2	8.94	8.97	8.99	8.78	8.81															
3	8.84	8.88	8.90	8.93	8.95															

***** STEADY STATE SIMULATION *****

** HYDRAULICS SUMMARY **

ELE ORD	RCH NUM	ELE NUM	BEGIN LOC KILO	END LOC KILO	FLOW CMS	POINT SRCE CMS	INCR FLOW CMS	VEL MPS	TRVL TIME DAY	DEPTH M	WIDTH M	VOLUME K-CU-M	BOTTOM AREA K-SQ-M	X-SECT AREA SQ-M	DSPRSN COEF SQ-M/S
1	1	1	4.20	3.90	0.04	0.00	0.01	0.223	0.016	0.146	1.131	0.05	0.43	0.16	0.46
2	1	2	3.90	3.60	0.04	0.00	0.01	0.239	0.015	0.154	1.195	0.06	0.45	0.18	0.52
3	1	3	3.60	3.30	0.05	0.00	0.01	0.253	0.014	0.162	1.252	0.06	0.47	0.20	0.57
4	1	4	3.30	3.00	0.06	0.00	0.01	0.266	0.013	0.168	1.303	0.07	0.49	0.22	0.62
5	2	1	3.00	2.70	0.07	0.00	0.01	0.278	0.013	0.174	1.347	0.07	0.51	0.23	0.67
6	2	2	2.70	2.40	0.07	0.00	0.01	0.288	0.012	0.180	1.388	0.07	0.52	0.25	0.71
7	2	3	2.40	2.10	0.08	0.00	0.01	0.298	0.012	0.185	1.427	0.08	0.54	0.26	0.75
8	2	4	2.10	1.80	0.25	0.16	0.01	0.461	0.008	0.265	2.029	0.16	0.77	0.54	1.58
9	2	5	1.80	1.50	0.26	0.00	0.01	0.466	0.007	0.268	2.046	0.16	0.77	0.55	1.61
10	3	1	1.50	1.20	0.27	0.00	0.01	0.327	0.011	0.277	2.953	0.25	1.05	0.82	1.16
11	3	2	1.20	0.90	0.28	0.00	0.01	0.330	0.011	0.284	2.993	0.25	1.07	0.85	1.19
12	3	3	0.90	0.60	0.29	0.00	0.01	0.333	0.010	0.290	3.031	0.26	1.08	0.88	1.23
13	3	4	0.60	0.30	0.30	0.00	0.01	0.335	0.010	0.296	3.068	0.27	1.10	0.91	1.26
14	3	5	0.30	0.00	0.32	0.00	0.01	0.338	0.010	0.303	3.104	0.28	1.11	0.94	1.29

***** STEADY STATE SIMULATION *****

** REACTION COEFFICIENT SUMMARY **

RCH NUM	ELE NUM	DO SAT MG/L	K2 OPT	OXYGN REAIR 1/DAY	BOD DECAY 1/DAY	BOD SETT 1/DAY	SOD RATE G/M2D	ORGN DECAY 1/DAY	ORGN SETT 1/DAY	NH3 DECAY 1/DAY	NH3 SRCE MG/M2D	NO2 DECAY 1/DAY	ORGP DECAY 1/DAY	ORGP SETT 1/DAY	DISP SRCE MG/M2D	COLI DECAY 1/DAY	ANC DECAY 1/DAY	ANC SETT 1/DAY	ANC SRCE MG/M2D
1	1	10.44	6	12.76	2.60	0.43	1.03	0.07	0.11	0.77	0.00	1.48	0.59	0.09	0.00	0.00	0.00	0.00	0.00
1	2	10.44	6	12.71	2.60	0.43	1.03	0.07	0.11	0.77	0.00	1.48	0.59	0.09	0.00	0.00	0.00	0.00	0.00
1	3	10.44	6	12.63	2.60	0.43	1.03	0.07	0.11	0.77	0.00	1.48	0.59	0.09	0.00	0.00	0.00	0.00	0.00
1	4	10.44	6	12.56	2.60	0.43	1.03	0.07	0.11	0.77	0.00	1.48	0.59	0.09	0.00	0.00	0.00	0.00	0.00
2	1	9.49	6	13.91	3.19	0.48	1.33	0.09	0.12	1.11	0.00	1.82	0.73	0.10	0.00	0.00	0.00	0.00	0.00
2	2	9.49	6	13.86	3.19	0.48	1.33	0.09	0.12	1.11	0.00	1.82	0.73	0.10	0.00	0.00	0.00	0.00	0.00
2	3	9.49	6	13.81	3.19	0.48	1.33	0.09	0.12	1.11	0.00	1.82	0.73	0.10	0.00	0.00	0.00	0.00	0.00
2	4	9.49	6	13.48	3.19	0.48	1.33	0.09	0.12	1.11	0.00	1.82	0.73	0.10	0.00	0.00	0.00	0.00	0.00
2	5	9.49	6	13.18	3.19	0.48	1.33	0.09	0.12	1.11	0.00	1.82	0.73	0.10	0.00	0.00	0.00	0.00	0.00
3	1	9.63	6	10.82	3.09	0.47	1.28	0.09	0.12	1.05	0.00	1.77	0.79	0.09	0.00	0.00	0.00	0.00	0.00
3	2	9.63	6	8.59	3.09	0.47	1.28	0.09	0.12	1.05	0.00	1.77	0.79	0.09	0.00	0.00	0.00	0.00	0.00
3	3	9.63	6	8.40	3.09	0.47	1.28	0.09	0.12	1.05	0.00	1.77	0.79	0.09	0.00	0.00	0.00	0.00	0.00
3	4	9.63	6	8.23	3.09	0.47	1.28	0.09	0.12	1.05	0.00	1.77	0.79	0.09	0.00	0.00	0.00	0.00	0.00
3	5	9.63	6	8.06	3.09	0.47	1.28	0.09	0.12	1.05	0.00	1.77	0.79	0.09	0.00	0.00	0.00	0.00	0.00

***** STEADY STATE SIMULATION *****

** WATER QUALITY VARIABLES **

RCH NUM	ELE NUM	TEMP DEG-C	CM-1	CM-2	CM-3	DO MG/L	BOD MG/L	ORGN MG/L	NH3N MG/L	NO2N MG/L	NO3N MG/L	SUM-N MG/L	ORGP MG/L	DIS-P MG/L	SUM-P MG/L	COLI #/100ML	ANC	CHLA UG/L
1	1	13.50	0.00	0.00	0.00	7.04	2.61	1.24	0.55	0.20	2.01	4.00	0.08	0.01	0.09	0.00	0.00	14.73
1	2	13.50	0.00	0.00	0.00	7.05	2.65	1.24	0.50	0.17	1.90	3.80	0.08	0.01	0.09	0.00	0.00	12.47
1	3	13.50	0.00	0.00	0.00	7.09	2.66	1.23	0.46	0.14	1.82	3.66	0.08	0.01	0.10	0.00	0.00	10.84
1	4	13.50	0.00	0.00	0.00	7.14	2.66	1.23	0.43	0.13	1.76	3.55	0.09	0.02	0.10	0.00	0.00	9.61
2	1	18.00	0.00	0.00	0.00	7.09	2.80	1.21	0.40	0.12	1.66	3.38	0.09	0.02	0.10	0.00	0.00	8.73
2	2	18.00	0.00	0.00	0.00	7.06	2.91	1.19	0.37	0.11	1.57	3.25	0.09	0.02	0.11	0.00	0.00	8.01
2	3	18.00	0.00	0.00	0.00	7.05	2.98	1.17	0.35	0.10	1.51	3.14	0.09	0.02	0.11	0.00	0.00	7.48
2	4	18.00	0.00	0.00	0.00	7.08	2.70	1.22	0.53	0.19	1.93	3.86	0.08	0.01	0.09	0.00	0.00	14.29
2	5	18.00	0.00	0.00	0.00	7.12	2.69	1.21	0.51	0.19	1.90	3.81	0.08	0.01	0.09	0.00	0.00	14.01
3	1	17.28	0.00	0.00	0.00	7.11	2.64	1.21	0.50	0.18	1.86	3.74	0.08	0.01	0.09	0.00	0.00	13.13
3	2	17.28	0.00	0.00	0.00	7.07	2.58	1.20	0.48	0.18	1.82	3.68	0.08	0.01	0.09	0.00	0.00	12.30
3	3	17.28	0.00	0.00	0.00	7.04	2.52	1.20	0.46	0.17	1.79	3.62	0.08	0.02	0.09	0.00	0.00	11.56
3	4	17.28	0.00	0.00	0.00	7.01	2.47	1.20	0.45	0.17	1.76	3.57	0.08	0.02	0.10	0.00	0.00	10.89
3	5	17.28	0.00	0.00	0.00	6.99	2.42	1.19	0.44	0.16	1.73	3.52	0.08	0.02	0.10	0.00	0.00	10.29

***** STEADY STATE SIMULATION *****

** ALGAE DATA **

ELE ORD	RCH NUM	ELE NUM	CHLA UG/L	ALGY GRWTH 1/DAY	ALGY RESP 1/DAY	ALGY SETT M/DAY	A P/R RATIO *	NET P-R MG/L-D	NH3 PREF *	NH3-N FRACT N-UPTKE *	LIGHT EXTCO 1/M	ALGAE GROWTH RATE ATTEN FACTORS LIGHT *	NITRGN *	PHSPRS *
1	1	1	14.73	0.92	0.07	0.00	8.72	0.34	0.90	0.71	0.01	0.54	0.96	0.92
2	1	2	12.47	0.93	0.07	0.00	8.81	0.29	0.90	0.70	0.01	0.54	0.96	0.93
3	1	3	10.84	0.94	0.07	0.00	8.87	0.25	0.90	0.69	0.01	0.54	0.96	0.94
4	1	4	9.61	0.94	0.07	0.00	8.91	0.23	0.90	0.69	0.01	0.54	0.96	0.94
5	2	1	8.73	1.17	0.09	0.00	8.94	0.25	0.90	0.68	0.01	0.54	0.95	0.94
6	2	2	8.01	1.17	0.09	0.00	8.97	0.23	0.90	0.68	0.01	0.54	0.95	0.95
7	2	3	7.48	1.17	0.09	0.00	8.99	0.22	0.90	0.68	0.01	0.54	0.95	0.95
8	2	4	14.29	1.14	0.09	0.00	8.78	0.41	0.90	0.71	0.01	0.54	0.96	0.93
9	2	5	14.01	1.15	0.09	0.00	8.81	0.40	0.90	0.71	0.01	0.54	0.96	0.93
10	3	1	13.13	1.11	0.09	0.84	8.84	0.36	0.90	0.71	0.01	0.54	0.96	0.93
11	3	2	12.30	1.12	0.09	0.84	8.88	0.34	0.90	0.70	0.01	0.54	0.96	0.94
12	3	3	11.56	1.12	0.09	0.84	8.90	0.32	0.90	0.70	0.01	0.54	0.96	0.94
13	3	4	10.89	1.13	0.09	0.84	8.93	0.30	0.90	0.70	0.01	0.54	0.96	0.94
14	3	5	10.29	1.13	0.09	0.84	8.95	0.29	0.90	0.69	0.01	0.54	0.96	0.94

***** STEADY STATE SIMULATION *****

** DISSOLVED OXYGEN DATA **

									COMPONENTS OF DISSOLVED OXYGEN MASS BALANCE (MG/L-DAY)						
ELE ORD	RCH NUM	ELE NUM	TEMP DEG-C	DO SAT MG/L	DO MG/L	DO DEF MG/L	DAM INPUT MG/L	NIT INHIB FACT	F-FNCTN INPUT	OXYGN REAIR	C-BOD	SOD	NET P-R	NH3-N	NO2-N
1	1	1	13.50	10.44	7.04	3.40	0.00	1.00	431.80	43.37	-6.78	-7.05	0.34	-1.46	-0.33
2	1	2	13.50	10.44	7.05	3.39	0.00	1.00	58.60	43.05	-6.87	-6.67	0.29	-1.32	-0.28
3	1	3	13.50	10.44	7.09	3.35	0.00	1.00	53.34	42.32	-6.90	-6.36	0.25	-1.22	-0.24
4	1	4	13.50	10.44	7.14	3.30	0.00	1.00	49.16	41.51	-6.91	-6.10	0.23	-1.15	-0.21
5	2	1	18.00	9.49	7.09	2.39	0.00	1.00	47.03	33.31	-8.95	-7.66	0.25	-1.52	-0.24
6	2	2	18.00	9.49	7.06	2.42	0.00	1.00	44.24	33.55	-9.28	-7.43	0.23	-1.42	-0.22
7	2	3	18.00	9.49	7.05	2.44	0.00	1.00	41.85	33.64	-9.51	-7.22	0.22	-1.35	-0.21
8	2	4	18.00	9.49	7.08	2.40	0.00	1.00	637.88	32.38	-8.62	-5.03	0.41	-2.00	-0.39
9	2	5	18.00	9.49	7.12	2.36	0.00	1.00	20.16	31.14	-8.60	-4.99	0.40	-1.95	-0.39
10	3	1	17.28	9.63	7.11	2.52	0.00	1.00	24.00	27.26	-8.16	-4.62	0.36	-1.78	-0.36
11	3	2	17.28	9.63	7.07	2.56	0.00	1.00	23.13	21.98	-7.97	-4.51	0.34	-1.72	-0.35
12	3	3	17.28	9.63	7.04	2.59	0.00	1.00	22.33	21.78	-7.79	-4.41	0.32	-1.66	-0.34
13	3	4	17.28	9.63	7.01	2.62	0.00	1.00	21.59	21.55	-7.63	-4.32	0.30	-1.61	-0.33
14	3	5	17.28	9.63	6.99	2.64	0.00	1.00	20.91	21.30	-7.47	-4.23	0.29	-1.56	-0.32