Total Maximum Daily Loads of Carbonaceous Biochemical Oxygen Demand (CBOD) and Nitrogenous Biochemical Oxygen Demand (NBOD) for Georges Creek in Allegany and Garrett Counties

APPENDIX - A

INPRG Model Desription:

INPRG which is an abbreviation for "Input Program" is a steady state, mathematical model developed by Maryland Department of the Environment (MDE) for simulating conventional pollutants in free-flowing streams. This program prepares input data and runs a free-flowing stream model based upon the Streeter Phelps equations. The program is written in FORTRAN IV. This program reads raw data for tributary drainage area planimeter readings, station elevations, gaging station flow, velocity data, and stream temperature values. It computes a 90th percentile (design) stream temperature, plots regression between flow and stream velocity, and computes elevation differences between stations. The program can independently perform statistical analysis of data sets to obtain average values and predict levels of confidence. It also computes reaeration values for the stream reaches using Tsivoglou's formula. It adjusts all reaction rates in the model to the stream design temperature. The model is also capable of independently computing oxygen production, photosynthesis, and respiration values based upon chlorophyll-a concentrations in the stream or estuary.

INPRG Input Data:

This program requires input data for tributary drainage area planimeter readings, station elevations, and segment lengths to calculate tributary flows, stream velocities and reaeration rates. The INPRG model input values for drainage areas, station elevations, and stream lengths for each INPRG model station were prepared using GIS information and are shown in Table A1 and Figure A1.

STATION	TRIBUTARY	D.A. Mi^2	STATION ELEV. Ft.	STREAM LENGTH Ft.	STREAM LENGTH Meters
1	SAND SPRING RUN	5.938	1850	6583	2006
2	WINEBRENNER RUN	3.816	1741	13865	4225
3	NEFF RUN	14.029	1689	17405	5304
4	GEORGES CREEK	13.522	1580	9582	2920
5	GEORGES CREEK	6.658	1480	10042	3060
6	BUTCHER RUN	10.333	1220	5743	1750
7	MILL RUN	6.813	1120	11082	3377
8	TRIBUTARY (LESS GEORGES CREEK WWTP)	9.212	980	5920	1804
9	NORTH BRANCH CONFLUENCE	2.079	902	-	-

Table A1: INPRG Model Input Data

INPRG calculates tributary stream flows for each station by multiplying the corresponding tributary drainage area by the inputted stream flow runoff rate. The stream flow runoff rate is determined by selecting a representative reference stream gaging station near the study stream. US Geological Survey (USGS) gaging station 01599000 on Georges Creek near Franklin, Maryland was used.

Modeling Points
Georges Creek Watershed

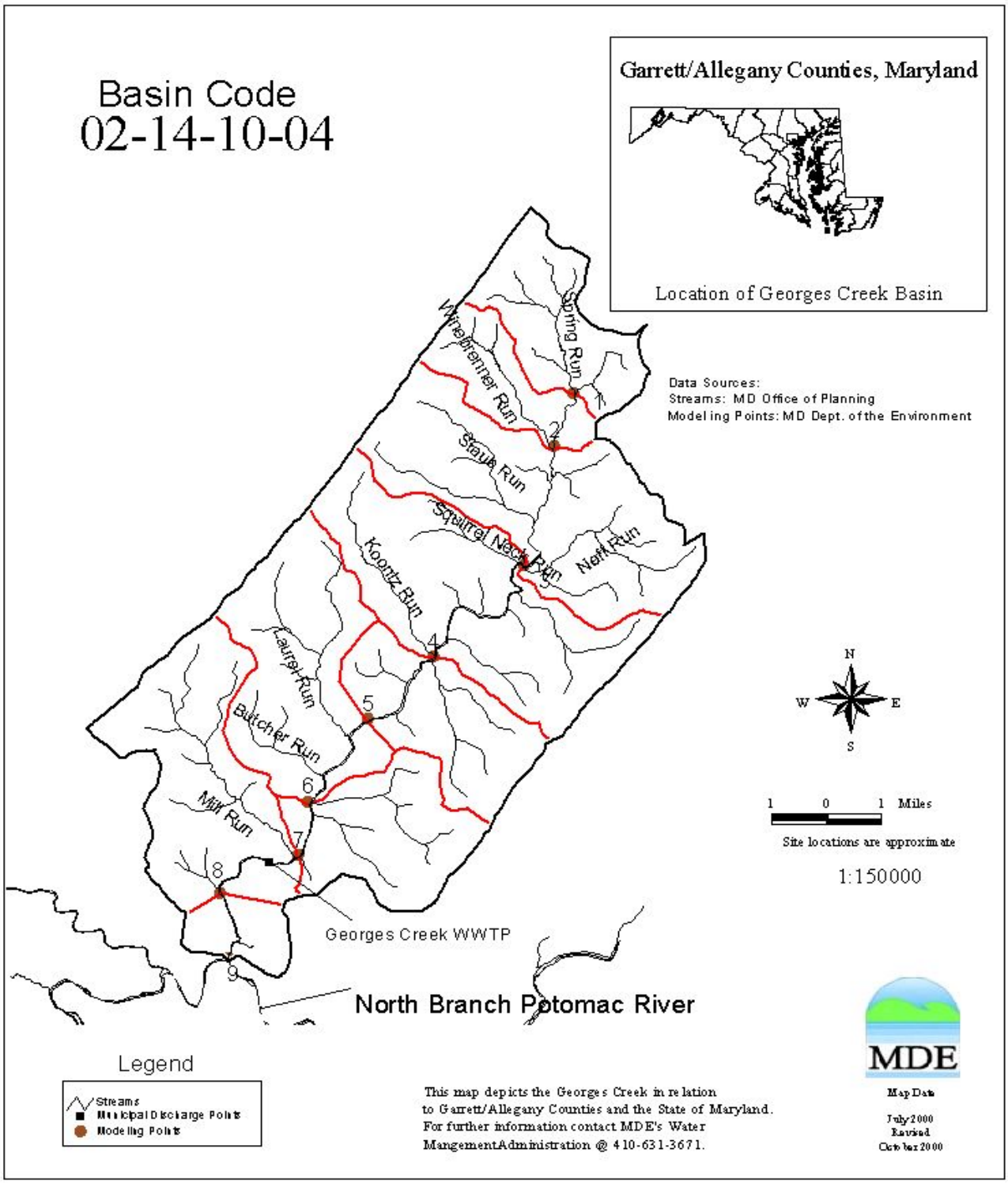

Figure A1: Georges Creek INPRG Stream Model Stations

Water Quality Input Data:

Input data from a total of sixteen water quality-sampling sites in Georges Creek, seven of which are located in the Georges Creek mainstem and nine on the tributaries were examined. The Maryland Department of Environment collected the water chemistry data in July, August and October 1999 in support of TMDL development. The locations of the water quality stream data measurements are shown in Figure A2.

Water Quality Stations
Georges Creek Watershed

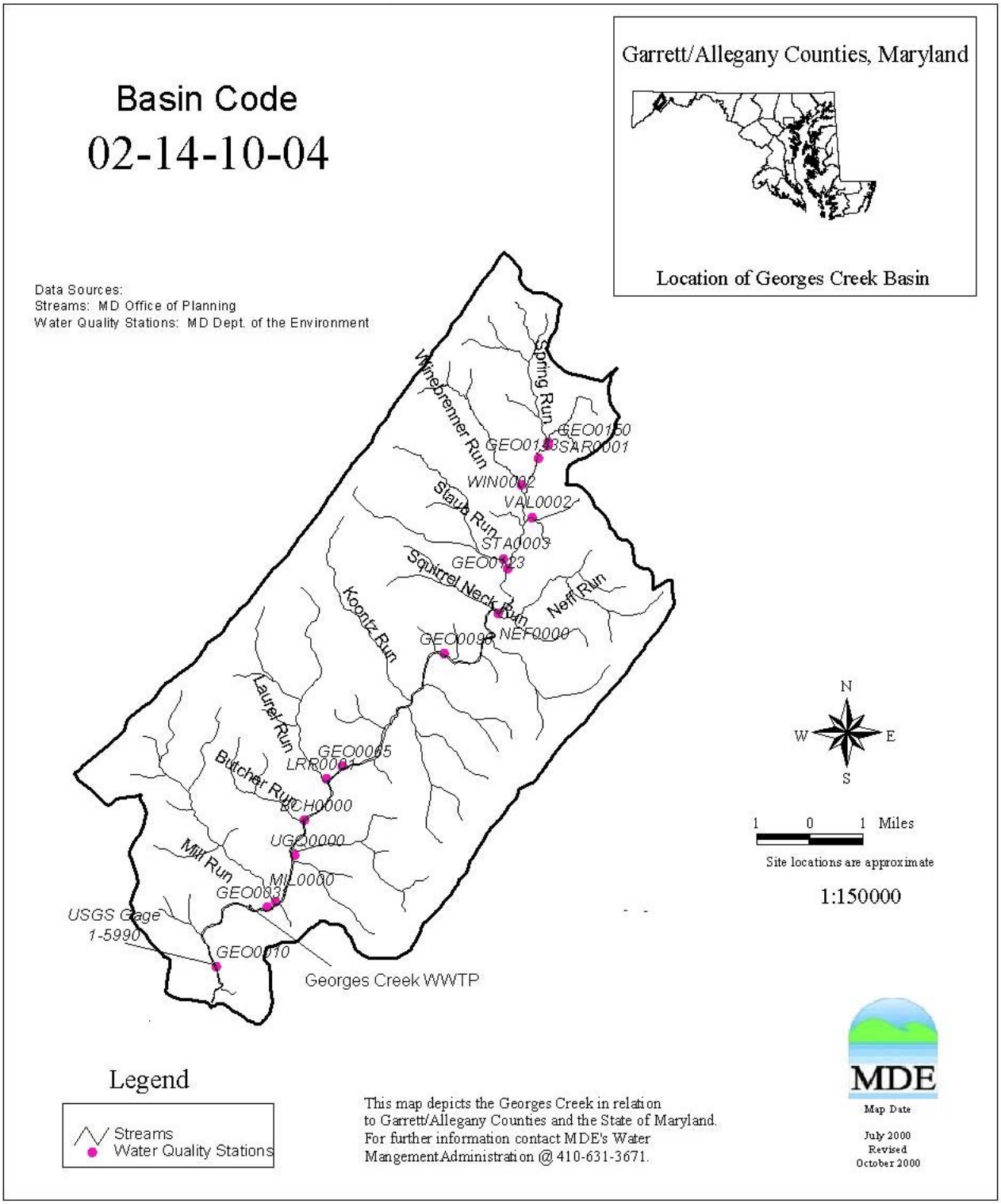

Figure A2: Georges Creek Watershed Water Quality Stations

INPRG CBOD, NBOD and Dissolved Oxygen Calibration:

Once the INPRG model input data was analyzed and prepared, calibration runs were made for Carbonaceous Biochemical Oxygen Demand (CBOD), Nitrogenous Biochemical Oxygen Demand (NBOD) and dissolved oxygen (DO). Calibration of the model for CBOD, NBOD and dissolved oxygen were achieved through adjustment of the carbonaceous deoxygenating rate (k_c) and the nitrogenous deoxygenating rate (k_n). The July, August and October 1999 averaged water quality data were used for the calibration runs. The observed water quality and model predictions are shown in Table A2, and Figures A3 through A5.

MODEL STATION	RIVER Mile.	7/14, 8/19 & 10/5 1999 CBOD mg/l	MODEL CBOD mg/l	7/14, 8/19 & 10/5 1999 NBOD mg/l	MODEL NBOD mg/l	7/14, 8/19 & 10/5 1999 DO mg/l	MODEL DO mg/l
1	14.7	1.5	1.37	2.80	2.53	8.35	8.00
2	13.5	1.5	1.04	2.53	1.80	10.50	7.80
4	7.7	1.5	1.16	0.78	0.81	9.20	8.11
5	5.9	1.5	1.17	0.78	0.77	9.20	8.16
7	3.0	1.5	1.24	0.92	0.79	9.30	8.25
9	0.0	1.5	2.40	0.92	0.90	9.30	8.32

Table A2: Georges Creek CBOD, NBOD , DO and Model Predictions

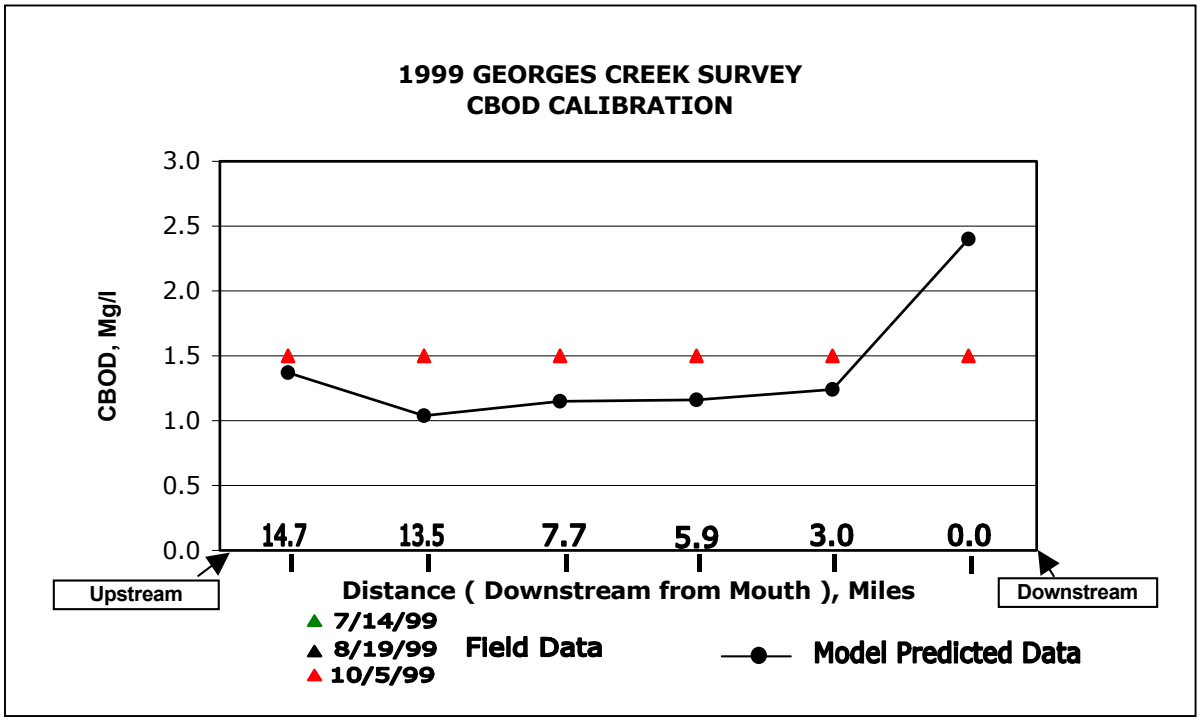

Figure A3: Georges Creek CBOD and Model Predictions

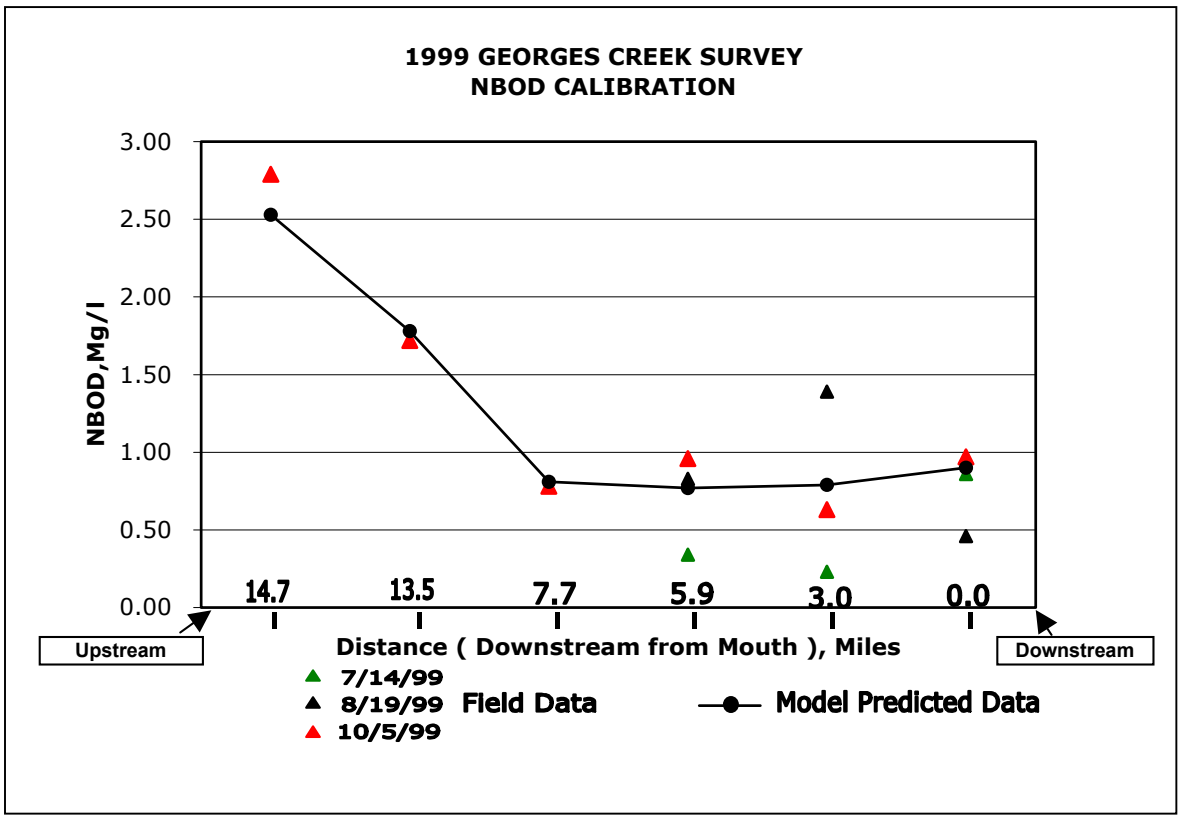

Figure A4: Georges Creek NBOD and Model Predictions

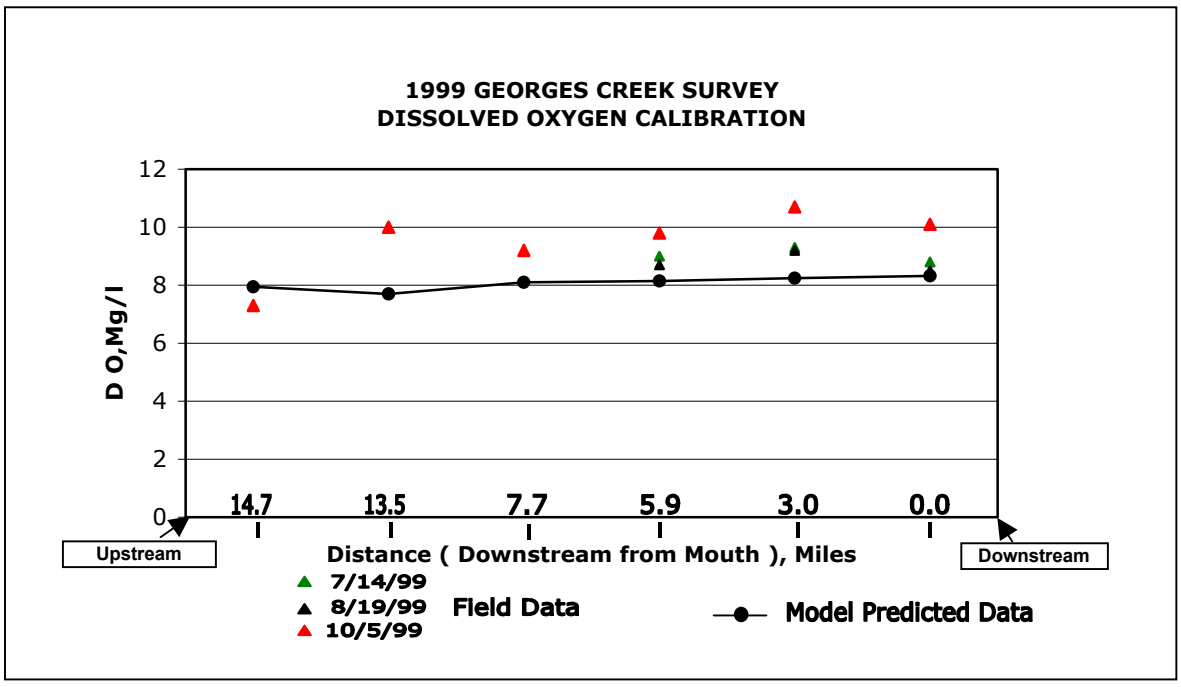

Figure A5: Georges Creek Dissolved Oxygen and Model Predictions

Application of INPRG Model:

Once the INPRG model was calibrated, input data were assembled to simulate summer 7Q10 low-flow and average stream flow conditions. The following sections discuss the development of the summer condition INPRG input data sets.

Estimation of Summer Stream Temperature:

The INPRG program determines a 90th percentile stream temperature by developing a frequency distribution of the stream temperature input. A 90th percentile stream temperature of 23.1 degrees Celsius was determined from the temperature data shown in Table A4.

Station	Year	Month	Day	Water temp
GEO0010	99	7	14	19.5
GEO0031	99	7	14	19.2
MIL0000	99	7	14	17.8
UGQ0000	99	7	14	18.5
BCH0000	99	7	14	19.7
LRR0001	99	7	14	17.8
GEO0065	99	7	14	18.3
GEO0096	99	7	14	18.2
NEF0000	99	7	14	18.2
GEO0010	99	8	19	24.0
GEO0031	99	8	19	22.3
MIL0000	99	8	19	20.4
UGQ0000	99	8	19	25.0
BCH0000	99	8	19	22.6
LRR0001	99	8	19	19.0
GEO0065	99	8	19	19.3
GEO0096	99	8	19	18.7
NEF0000	99	8	19	19.3
GEO0010	99	10	5	12.4
GEO0031	99	10	5	11.7
MIL0000	99	10	5	11.2
UGQ0000	99	10	5	11.1
BCH0000	99	10	5	15.0
LRR0001	99	10	5	12.8
GEO0065	99	10	5	12.3
GEO0096	99	10	5	12.7
NEF0000	99	10	5	14.0

Table A4: Georges Creek Stream Temperatures in Degrees Celsius

All of the model reaction rates (k_2, k_c and k_n) were adjusted by INPRG to the 90th percentile stream temperature of 23.1 degrees Celsius.

Estimation of Summer Stream Water Quality:

Georges Creek background and tributary summer condition water quality shown in Table A5 below was used as INPRG input data. The input data were estimated from the water quality data shown in Tables A15 through A27 of the water quality data section of this Appendix.

STATION	TRIBUTARY	MODEL CALIBRATION AVG. 7/14, 8/19 & 10/5 1999		
		CBOD Mg/l	NBOD Mg/l	DO Mg/l
1	GEORGES CREEK	1.5	2.80	8.35
2	WINEBRENNER RUN	1.5	2.53	10.5
3	SAND SPRING RUN	1.5	0.64	9.4
4	NEFF RUN	1.5	0.78	9.2
5	NEFF RUN	1.5	0.78	9.2
6	LAUREL RUN	1.5	0.92	9.5
7	UNNAMED TRIB	1.5	0.92	9.3
8	WWTP DATA	6.0	1.43	7.0
9	UNNAMED TRIB	1.5	0.92	9.3

Table A5: INPRG Model Water Quality Input Data

Estimation of 7-Day, 10-Year Low-flow:

The USGS gaging station 01599000 located on Georges Creek near Franklin, Maryland was used to estimate the Georges Creek 7Q10 low-flow. Listed below are USGS gaging station 01599000 statistics.

Station Name:	Georges Creek near Franklin, Maryland
Station Number:	01599000
Latitude (dd.mm.ss)	39.29.38
Longitude (dd.mm.ss)	79.02.42
Drainage area (square miles)	72.4
7Q10 Flow (cfs)	4.68

7Q10 low-flow runoff rate = 4.68 ÷ 72.4 = 0.06464 cfs/sq. mile.

The above calculated 7Q10 low-flow runoff rate of 0.06464 cfs/sq. mile was input into the INPRG program which computes the 7Q10 flow for each modeling segment using the drainage area for the model segment.

Estimation of Average High Stream Flow Conditions:

The USGS gaging station 01599000 located on Georges Creek near Franklin, Maryland was used to estimate the Georges Creek average high-flow. Listed below are USGS gaging station 01599000 statistics.

Station Name:	Georges Creek near Franklin, Maryland
Station Number:	01599000
Latitude (dd.mm.ss)	39.29.38
Longitude (dd.mm.ss)	79.02.42
Drainage area (square miles)	72.4
Average discharge (50 years), cfs	81.20

High-flow runoff rate = 81.2 ÷ 72.4 = 1.12 cfs/sq. mile.

The calculated high-flow runoff rate of 1.12 cfs/sq. mile was input into the INPRG program, which computes the high flow for each modeling segment using the drainage area for the model segment. Listed below in Table A6 are the flows in each modeling segment.

03/25, 04/08 & 04/27 1999 GEORGES CREEK STREAM FLOW STATISTICS	
MODELING SEGMENT	STREAM FLOW - CFS
1	6.66
2	4.28
3	15.73
4	15.17
5	**7.47**
6	**11.59**
7	**7.64**
8	**26.86**
9	**2.33**

Table A6: USGS Gaging Station 01599000 Stream Flow Statistics

Determination of Expected Tier II Target Dissolved Oxygen Minimum

As noted in the main body of this document, it is anticipated that Georges Creek will receive a Tier II protection, which will result in raising the dissolved oxygen minimum standards. The following analysis provides a conceptual framework for determining the required minimum target dissolved oxygen. The summer 1999 observed data shown in Table A7 below was used to compute the average values for DO (9.2 mg/l), temperature (19.9 ^{0}C) and DO saturation (98.3 %). At the current stream DO minimum standard of 5.0 mg/l, DO saturation is 55%.

Observed DO saturation for the summer months (%)	= 98
Current DO standard saturation (%)	= 55
Difference between observed and current standard saturation (%)	= 43
25% of difference (%)	= 10.75
DO saturation goal (%)	= 98 - 10.75
	= 87.25 %

Station	Sample Dates	Observed Values		
		DO (mg/l)	Temperature (^{O}C)	D.O. Saturation (%)
GEO0010	7/14/1999	9.5	19.5	100
	8/19/1999	10.5	24.0	125
GEO0031	7/14/1999	8.8	19.2	83
	8/19/1999	8.5	22.3	95
GEO0065	7/14/1999	9.3	18.3	95
	8/19/1999	9.2	19.3	98
GEO0096	7/14/1999	9.0	18.2	95
	8/19/1999	8.7	18.7	96
AVERAGE		9.2	19.9	98.3

Table A7: INPRG Model Results for Scenario One

Using Figure A8 nomogram (adapted from Reid 1961), the expected minimum dissolved oxygen at 90th percentile design temperature of 23.10 and 87.25 % saturation was calculated. A line segment drawn from 23.10 on the water temperature scale through the 87.25% on the saturation scale intersects the dissolved oxygen scale at 7.5 mg/L. This 7.5 mg/L reflects the minimum DO that will be maintained for Georges Creek under the State's Antidegradation Policy regulation and is the basis for the TMDLs.

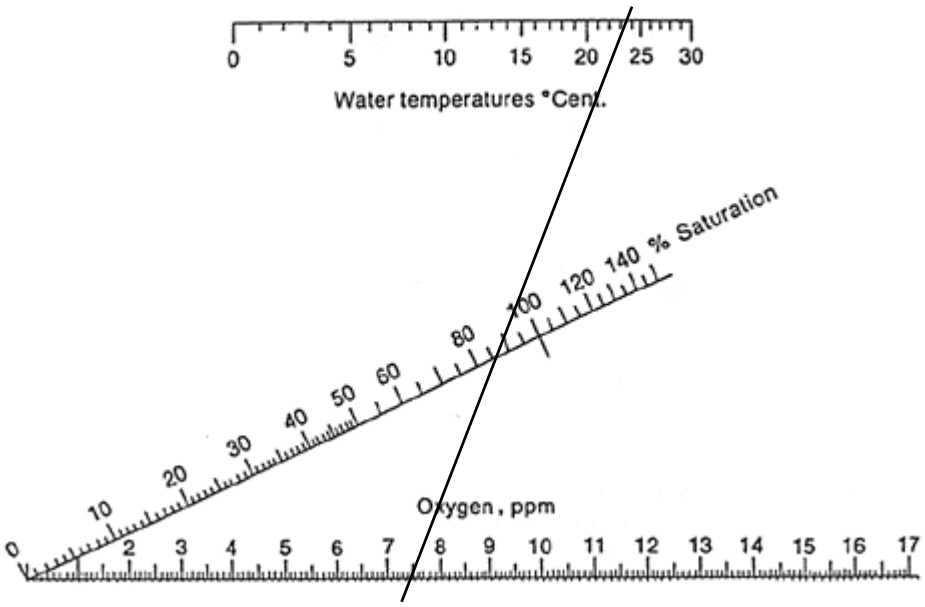

Figure A8: Nomogram (adapted from Reid 1961) showing expected dissolved oxygen minimum standard

INPRG Results for TMDL Scenarios:

The following sections present the INPRG model results for the three TMDL scenarios presented in the main document.

Scenario One:

Station	River Miles From Headwaters	Upstream Just Before mixing			Downstream Just After Mixing		
		CBOD mg/l	NBOD mg/l	D.O. mg/l	CBOD mg/l	NBOD mg/l	D.O. mg/l
1	14.7	1.50	2.80	8.35	1.37	2.53	7.99
2	13.5	1.42	2.53	8.97	1.04	1.80	7.79
3	10.9	1.31	1.12	8.74	1.09	0.91	8.03
4	7.7	1.24	0.86	8.46	1.16	0.81	8.11
5	5.9	1.21	0.80	8.27	1.17	0.77	8.16
6	4.0	1.23	0.99	8.41	1.20	0.96	8.23
7	3.0	1.24	0.96	8.35	1.18	0.91	8.25
8	1.0	13.97	34.21	7.59	13.67	33.40	8.03
9	0	13.38	32.64	8.06	13.26	32.30	8.15

Table A7: INPRG Model Results for Scenario One

Scenario one assumed existing 7Q10 low-flow nonpoint source loads in addition to the facility effluent concentrations shown in Table A8 below.

FACILITY	FACILITY FLOW gpd	BOD_5 mg/l	TKN Mg/l	DO mg/l
GEORGES CREEK WWTP	600,000	30	25	6.0

Table A8: Scenario One Assumed Facility Effluent Concentrations

Scenario Two:

Station	River Miles From Headwaters	Upstream Just Before mixing			Downstream Just After Mixing		
		CBOD mg/l	NBOD mg/l	D.O. mg/l	CBOD mg/l	NBOD mg/l	D.O. mg/l
1	14.7	6.75	5.98	8.20	6.52	5.76	7.98
2	13.5	4.56	3.89	8.96	4.06	3.42	7.82
3	10.9	2.55	1.78	8.52	2.38	1.65	8.05
4	7.7	2.06	1.15	8.14	2.01	1.12	8.12
5	5.9	1.93	1.00	8.15	1.91	0.98	8.16
6	4.0	1.83	1.05	8.30	1.81	1.04	8.23
7	3.0	1.78	1.02	8.27	1.75	1.00	8.26
8	1.0	14.37	34.43	7.60	14.26	34.12	8.19
9	0	13.96	33.34	8.20	13.91	33.21	8.26

Table A9: INPRG Model Results for Scenario Two

Scenario two assumed average high-flow nonpoint source loads in addition to the facility effluent and Combined Sewer Overflows (CSO) concentrations shown in Table A10 below.

FACILITY	FACILITY FLOW gpd	BOD_5 mg/l	TKN Mg/l	DO mg/l
GEORGES CREEK WWTP	600,000	30	25	6.0
CSOs	250,000	97	25	5.0

Table A10: Scenario Two Assumed Facility Effluent and CSOs Concentrations

Scenario Three:

Station	River Miles From Headwaters	Upstream Just Before mixing			Downstream Just After Mixing		
		CBOD mg/l	NBOD mg/l	D.O. mg/l	CBOD mg/l	NBOD mg/l	D.O. mg/l
1	14.7	2.25	4.21	8.20	2.05	3.81	7.95
2	13.5	2.13	3.80	8.95	1.56	2.71	7.61
3	10.9	1.97	2.98	8.43	1.64	2.43	7.96
4	7.7	1.86	2.10	8.08	1.75	1.96	8.08
5	5.9	1.82	1.89	8.12	1.75	1.82	8.15
6	4.0	1.85	2.13	8.29	1.81	2.07	8.22
7	3.0	1.86	2.07	8.26	1.76	1.95	8.24
8	1.0	18.68	45.08	7.46	18.29	44.06	7.95
9	0	17.94	43.15	7.97	17.78	42.72	8.10

Table A11: INPRG Model Results for Scenario Three

Scenario three assumed existing 7Q10 low-flow nonpoint source loads increased by 50% in addition to the facility effluent concentrations and flow shown in Table A12 below.

FACILITY	FACILITY FLOW gpd	BOD_5 mg/l	TKN Mg/l	DO mg/l
GEORGES CREEK WWTP	900,000	30	25	6.0

Table A12: Scenario Three Assumed Facility Effluent Concentrations

List of Equations for INPRG Model:

The following equations are used in the INPRG Mathematical Model for Freshwater Streams:

1. Equations for Conversion of BOD to CBOD and Total Potassium Nitrogen (TKN) to NBOD:

   As per guidelines of the Surface Discharge Permits Division, the following equations are used to convert BOD and TKN to CBOD and NBOD, respectively:

   CBOD = 1.5 * BOD

   NBOD = 4.6 * TKN

List of Equations for INPRG Model, Continued:

2. Equations To Estimate Decay of CBOD and NBOD Matter:

   The following equations are used in the INPRG to characterize decay of the CBOD and NBOD matter with first order kinetics:

   k_c at temperature (T) = $k_{c20} * \{1.047^{(T-20)}\}$

   k_n at temperature (T) = $k_{n20} * \{1.08^{(T-20)}\}$

   $L_{ct} = L_{co} * e^{-(k_c * t)}$ and $L_{nt} = L_{no} * e^{-(k_n * t)}$

   Where: T is 90th Percentile Stream Temperature for Summer period, ° C
   k_{c20} is Standard CBOD Decay rate at 20° C, per day
   k_{n20} is Standard NBOD Decay rate at 20° C, per day
   k_c temperature corrected CBOD Decay Rate, per day
   k_n temperature corrected NBOD Decay Rate, per day
   t is time of travel, days
   L_{co} is initial ultimate CBOD concentration, mg/l
   L_{ct} is ultimate CBOD concentration at downstream after time of travel (t), mg/l
   L_{no} is initial NBOD concentration, mg/l
   L_{nt} is NBOD concentration at downstream after time of travel (t), mg/l

Reaeration Rates:

The reaeration rates (k_a) are estimated using Tsivoglou's Formula. Refer to U.S. EPA Publication "Rates, Constants and Kinetics Formulations in Surface Water Quality Modeling, 2nd Edition, EPA/600/3-85/040, June 1985" for this formula.

$k_a = \{0.054 * (\in H \div t)\} * \{1.022^{(T-25)}\}$

Where: k_a is reaeration rate at temperature (T), per day
$\in H$ is difference of elevations at two modeling points of a segment, ft.

List of Equations for INPRG Model, Continued:

3. Equation for Dissolved Oxygen Sag Prediction:

   The following equation for dissolved oxygen deficit is based on the Streeter-Phelps equation:

   $$D = [\{kc * (Lct - Lco) \div (k\mathbf{a} - kc)\} * \{e^{-(kc * t)} - e^{-(k\mathbf{a} * t)}\}] + [\{kn * (Lnt - Lno) \div (k\mathbf{a} - kn)\} * \{e^{-(kn * t)} - e^{-(k\mathbf{a} * t)}\}] - [\{P - R - (S \div d)\} * t]$$

   Where: D is dissolved oxygen deficit, mg/l

   P is algal photosynthetic oxygen production rate, mg/l- day

   R is algal respiration (dissolved oxygen consumption) rate, mg/l- day

   S is sediment oxygen demand rate, gm/m^2- day

   d is stream depth, meters

4. Equation for Saturation Dissolved Oxygen:

   The INPRG program estimates the dissolved oxygen saturation (C_S) in mg/l at each modeling point using the following formula:

   $$C_S = \{(14.62 - 0.3893 * T) + (0.006969 * T^2) - (5.897 * 10^{-5} * T^3)\} * \{1 - (6.97 * 10^{-6} * \in H)\}$$

5. Equation for Dissolved Oxygen:

   The INPRG program uses the following formula to estimate dissolved oxygen at each modeling point:

   $$C = C_S - D$$

   Where: C is dissolved oxygen after time of travel (t), mg/l

Water Quality Data

BCH0000 - Butcher Run, Mouth @ Abandoned Rd Remnant Bridge

DATE	FLOWS (CFS)	CH_AA (UG/L)	BOD5 (MG/L)	DO (MG/L)	TN (MG/L)	TKN(NH_3+ON) (MG/L)	TP (MG/L)	TSS (MG/L)	TEMP (0^C)
03/25/1999	4.91	0.299	1.0	11.3	2.364	0.263	0.013	12	9
04/08/1999	1.83	3.738	1.0	10.2	1.212	0.202	0.012	10	13
04/27/1999	3.63	0.897	1.0	9.8	1.382	0.122	0.014	10	15
07/14/1999	0.05	1.196	1.0	7.1	0.397	0.312	0.019	12	20
08/19/1999	0.01	0.299	2.0	**4.2**	0.373	0.232	0.016	8	23
10/05/1999	0.05	0.598	1.0	8.5	0.576	0.267	0.019	7	15
Average	1.75	1.171	1.2	8.5	1.051	0.233	0.016	9	16
Maximum	4.91	3.738	2.0	11.3	2.364	0.312	0.019	12	23
Minimum	0.01	0.299	1.0	4.2	0.373	0.122	0.012	7	9
JULY - OCTOBER									
Average	0.04	0.698	1.3	6.6	0.449	0.270	0.018	9	19
90th PERCENTILE	0.05	1.077	1.8	8.2	0.540	0.303	0.019	11	22
10th PERCENTILE	0.02	0.359	1.0	4.8	0.378	0.239	0.017	7	16
High Flow Avg.	*3.37*	*2.02*	*1.0*	*10.75*	*1.79*	*0.23*	*0.01*	*10.50*	*11*

Table A13: Water Quality Station BCH0000

GEO0010 - Georges Creek, @ USGS Gage 1-59900

DATE	FLOWS (CFS)	CH_AA (UG/L)	BOD5 (MG/L)	DO (MG/L)	TN (MG/L)	TKN(NH_3+ON) (MG/L)	TP (MG/L)	TSS (MG/L)	TEMP (0^C)
03/25/1999	253.5		1.0	13.2	1.354	0.264	0.017	9	2
04/08/1999	73.30		1.0	10.5	0.833	0.173	0.013	11	13
04/27/1999	133.0		3.0	10.0	1.420	0.580	0.098	17	14
07/14/1999	7.72	30.203	1.0	9.5	1.444	0.294	0.018	15	20
08/19/1999	4.08	8.373	1.0	10.5	2.481	0.411	0.044	8	24
10/05/1999	9.65		1.0	10.3	1.691	0.201	0.042	10	12
Average	80.21	19.288	1.3	10.7	1.537	0.321	0.039	12	14
Maximum	253.5	30.203	3.0	13.2	2.481	0.580	0.098	17	24
Minimum	4.08	8.373	1.0	9.5	0.833	0.173	0.013	8	2
JULY - OCTOBER									
Average	7.15	19.288	1.0	10.1	1.872	0.302	0.034	11	19
90th PERCENTILE	9.26	28.020	1.0	10.5	2.323	0.387	0.043	14	23
10th PERCENTILE	4.81	10.556	1.0	9.7	1.493	0.220	0.022	8	14
High Flow Avg.	*163*		*1.0*	*11.85*	*1.09*	*0.22*	*0.01*	*10.00*	*7*

16: Water Quality Station GEO0010

Table A14: Water Quality Station GEO0010

GEO0031 - Georges Creek, Reynolds Rd @ Bridge, Upstream of WWTP

DATE	FLOWS (CFS)	CH_AA (UG/L)	BOD5 (MG/L)	DO (MG/L)	TN (MG/L)	TKN(NH_3+ON) (MG/L)	TP (MG/L)	TSS (MG/L)	TEMP (0^C)
03/25/1999			1.0	12.7	1.239	0.179	0.012	8	5
04/08/1999			1.0	10.4	0.779	0.160	0.008	10	12
04/27/1999			1.0	10.2	0.818	0.109	0.010	10	14
07/14/1999			1.0	8.8	0.524	0.188	0.010	11	19
08/19/1999		0.299	1.0	8.5	0.270	0.101	0.005	10	22
10/05/1999			1.0	10.1	0.591	0.211	0.009	9	12
Average		0.299	1.0	10.1	0.704	0.158	0.009	9	14
Maximum		0.299	1.0	12.7	1.239	0.211	0.012	11	22
Minimum		299	.0	5	.270	101	.005	8	5
JULY - OCTOBER									
Average		0.299	.0	9.1	0.462	0.167	.008	10	18
90th PERCENTILE		0.299	.0	9.8	0.578	0.207	.010	10	22
10th PERCENTILE		0.299	.0	8.6	0.321	0.118	.006	9	13
High Flow Avg.			*1.0*	*11.55*	*1.01*	*0.17*		*8.85*	*9*

Table A15: Water Quality Station GEO0031

GEO0065 - Georges Creek, Bridge Crossing on Old Rt 36, Near Power Lines

DATE	FLOWS (CFS)	CH_AA (UG/L)	BOD5 (MG/L)	DO (MG/L)	TN (MG/L)	TKN(NH_3+ON) (MG/L)	TP (MG/L)	TSS (MG/L)	TEMP (0^C)
03/25/1999	162.2		1.0	11.8	1.327	0.217	0.007	5	8
04/08/1999	50.08		1.0	11.2	0.845	0.175	0.007	7	9
04/27/1999	74.47		1.0	10.8	0.842	0.132	0.009	6	11
07/14/1999	3.13	0.897	1.0	9.3	0.666	0.051	0.002	3	18
08/19/1999	2.40	0.598	1.0	9.2	0.666	0.302	0.004	4	19
10/05/1999	3.77		1.0	10.7	0.566	0.137	0.004	4	12
Average	49.34	0.748	1.0	10.5	0.819	0.169	0.006	5	13
Maximum	162.2	0.897	1.0	11.8	1.327	0.302	0.009	7	19
Minimum	2.40	0.598	1.0	9.2	0.566	0.051	0.002	3	8
JULY - OCTOBER									
Average	3.10	0.748	1.0	9.7	0.633	0.164	0.004	4	17
90th PERCENTILE	3.64	0.867	1.0	10.4	0.666	0.269	0.004	4	19
10th PERCENTILE	2.55	0.628	1.0	9.2	0.586	0.068	0.003	3	14
High Flow Avg.	*106*		*1.0*	*11.50*	*1.09*	*0.20*	*0.01*	*5.90*	*8*

Table A16: Water Quality Station GEO0065

GEO0096 - Georges Creek 2nd Bridge Crossing Rt 36 S of Midland

DATE	FLOWS (CFS)	CH_AA (UG/L)	BOD5 (MG/L)	DO (MG/L)	TN (MG/L)	TKN(NH_3+ON) (MG/L)	TP (MG/L)	TSS (MG/L)	TEMP (0^C)
03/25/1999			1.0	11.7	1.210	0.150	0.007	5	8
04/08/1999			1.0	11.1	0.680	0.088	0.006	6	9
04/27/1999			1.0	10.7	0.742	0.081	0.006	6	11
07/14/1999	0.38		1.0	9.0	0.266	0.074	0.003	6	18
08/19/1999	0.12		1.0	8.7	0.406	0.181	0.002	4	19
10/05/1999			1.0	9.8	0.496	0.208	0.002	2	13
Average	0.25		1.0	10.2	0.633	0.130	0.004	5	13
Maximum	0.38		1.0	11.7	1.210	0.208	0.007	6	19
Minimum	0.12		1.0	8.7	0.266	0.074	0.002	2	8
JULY - OCTOBER									
Average	0.25		1.0	9.2	0.389	0.155	0.002	4	17
90th PERCENTILE	0.36		1.0	9.6	0.478	0.203	0.003	5	19
10th PERCENTILE	0.15		1.0	8.8	0.294	0.096	0.002	3	14
High Flow Avg.			*1.0*	*11.40*	*0.95*	*0.12*	*0.01*	*5.4*	*8*

Table A17: Water Quality Station GEO0096

GEO0143 - Georges Creek , South of I-68 @ Power Lines

DATE	FLOWS (CFS)	CH_AA (UG/L)	BOD5 (MG/L)	DO (MG/L)	TN (MG/L)	TKN(NH_3+ON) (MG/L)	TP (MG/L)	TSS (MG/L)	TEMP (0^C)
03/25/1999			2.0	11.2	1.813	0.533	0.085	7	8
04/08/1999		0.299	1.0	11.0	0.726	0.116	0.008	2	7
04/27/1999	8.09		1.0	11.6	0.896	0.045	0.006	3	8
07/14/1999									
08/19/1999									
10/05/1999	0.20	0.598	1.0	9.4	0.907	0.373	0.058	6	14
Average	4.15	0.449	1.3	10.8	1.086	0.267	0.039	4	9
Maximum	8.09	0.598	2.0	11.6	1.813	0.533	0.085	7	14
Minimum	0.20	0.299	1.0	9.4	0.726	0.045	0.006	2	7
JULY - OCTOBER									
Average	0.20	0.598	1.0	9.4	0.907	0.373	0.058	6	14
90th PERCENTILE	0.20	0.598	1.0	9.4	0.907	0.373	0.058	6	14
10th PERCENTILE	0.20	0.598	1.0	9.4	0.907	0.373	0.058	6	14
High Flow Avg.		*0.30*	*1.5*	*11.10*	*1.27*	*0.32*	*0.05*	*4.45*	*7*

Table A18: Water Quality Station GEO0143

GEO0150 - Georges Creek, Above Sand Spring Run

DATE	FLOWS (CFS)	CH_AA (UG/L)	BOD5 (MG/L)	DO (MG/L)	TN (MG/L)	TKN(NH_3+ON) (MG/L)	TP (MG/L)	TSS (MG/L)	TEMP (0^C)
03/25/1999	5.60	0.598	15.0	9.3	6.201	4.371	0.399	12	8
04/08/1999	0.26		1.0	7.8	0.778	0.565	0.093	3	7
04/27/1999	0.49		1.0	11.1	0.915	0.127	0.011	2	9
07/14/1999									
08/19/1999									
10/05/1999	0.01	0.897	1.0	7.3	1.443	1.071	0.246	5	13
Average	1.59	0.748	4.5	8.9	2.334	1.533	0.187	6	9
Maximum	5.60	0.897	15.0	11.1	6.201	4.371	0.399	12	13
Minimum	0.01	0.598	1.0	7.3	0.778	0.127	0.011	2	7
JULY - OCTOBER									
Average	0.01	0.897	1.0	7.3	1.443	1.071	0.246	5	13
90^{th} PERCENTILE	0.01	0.897	1.0	7.3	1.443	1.071	0.246	5	13
10^{th} PERCENTILE	0.01	0.897	1.0	7.3	1.443	1.071	0.246	5	13
High Flow Avg.	*2.93*	*0.60*	*8.0*	*8.55*	*3.49*	*2.47*	*0.25*	*7.65*	*7*

Table A19: Water Quality Station GEO0150

LRR0001 - Laurel Run, Between 1st & 2nd Bridge Crossing on Laurel Run Rd

DATE	FLOWS (CFS)	CH_AA (UG/L)	BOD5 (MG/L)	DO (MG/L)	TN (MG/L)	TKN(NH_3+ON) (MG/L)	TP (MG/L)	TSS (MG/L)	TEMP (0^C)
03/25/1999	24.49		1.0	12.0	0.889	0.495	0.005	2	7
04/08/1999	9.28		1.0	11.1	0.526	0.077	0.004	2	9
04/27/1999	14.39		1.0	10.6	0.594	0.321	0.004	3	12
07/14/1999	0.53	1.794	1.0	8.9	0.482	0.135	0.009	9	18
08/19/1999	0.09	1.794	1.0	9.1	0.442	0.346	0.010	11	19
10/05/1999	0.45		1.0	10.4	0.436	0.128	0.005	2	13
Average	8.20	1.794	1.0	10.4	0.562	0.250	0.006	5	13
Maximum	24.49	1.794	1.0	12.0	0.889	0.495	0.010	11	19
Minimum	0.09	1.794	1.0	8.9	0.436	0.077	0.004	2	7
JULY - OCTOBER									
Average	0.36	1.794	1.0	9.5	0.454	0.203	0.008	8	17
90^{th} PERCENTILE	0.51	1.794	1.0	10.1	0.474	0.304	0.009	11	19
10^{th} PERCENTILE	0.16	1.794	1.0	8.9	0.437	0.130	0.005	4	14
High Flow Avg.	*16.9*		*1.0*	*11.55*	*0.71*	*0.29*	*0.00*	*2.4*	*8*

Table A20: Water Quality Station LRR0001

MIL0000 - Mill Run, Mouth @ Reynolds Rd

DATE	FLOWS (CFS)	CH_AA (UG/L)	BOD5 (MG/L)	DO (MG/L)	TN (MG/L)	TKN(NH_3+ON) (MG/L)	TP (MG/L)	TSS (MG/L)	TEMP (0^C)
03/25/1999	29.32		1.0	12.4	0.908	0.148	0.006	9	6
04/08/1999	9.38		1.0	10.6	0.514	0.136	0.005	9	13
04/27/1999	14.53		1.0	10.2	0.698	0.079	0.006	10	14
07/14/1999	0.76		1.0	9.1	0.729	0.496	0.015	31	18
08/19/1999	0.31		1.0	9.0	0.423	0.259	0.012	23	20
10/05/1999	0.60		1.0	10.2	0.522	0.297	0.024	29	11
Average	9.15		1.0	10.3	0.632	0.236	0.012	18	14
Maximum	29.32		1.0	12.4	0.908	0.496	0.024	31	20
Minimum	0.31		1.0	9.0	0.423	0.079	0.005	9	6
JULY - OCTOBER									
Average	0.56		1.0	9.4	0.558	0.351	0.017	27	16
90th PERCENTILE	0.72		1.0	10.0	0.687	0.456	0.022	30	20
10th PERCENTILE	0.37		1.0	9.0	0.443	0.267	0.013	24	13
High Flow Avg.	*19.4*		*1.0*	*11.50*	*0.71*	*0.14*	*0.01*	*8.90*	*9*

Table A21: Water Quality Station MIL0000

NEF0000 - Neff Run, Rt 936 Bridge Crossing

DATE	FLOWS (CFS)	CH_AA (UG/L)	BOD5 (MG/L)	DO (MG/L)	TN (MG/L)	TKN(NH_3+ON) (MG/L)	TP (MG/L)	TSS (MG/L)	TEMP (0^C)
03/25/1999	24.48		1.0	11.5	1.456	0.216	0.006	4	7
04/08/1999	1.62		1.0	11.1	0.876	0.061	0.004	3	8
04/27/1999	9.60		1.0	10.7	0.906	0.063	0.005	4	11
07/14/1999	0.13	0.299	1.0	9.2	0.326	0.075	0.005	3	18
08/19/1999	0.05	0.897	1.0	8.3	0.305	0.205	0.004	2	19
10/05/1999	1.23	0.897	1.0	10.1	0.526	0.215	0.005	2	14
Average	6.18	0.698	1.0	10.2	0.732	0.139	0.005	3	13
Maximum	24.48	0.897	1.0	11.5	1.456	0.216	0.006	4	19
Minimum	0.05	0.299	1.0	8.3	0.305	0.061	0.004	2	7
JULY - OCTOBER									
Average	0.47	0.698	1.0	9.2	0.386	0.165	0.005	3	17
90th PERCENTILE	1.01	0.897	1.0	9.9	0.486	0.213	0.005	3	19
10th PERCENTILE	0.07	0.419	1.0	8.5	0.309	0.101	0.004	2	15
High Flow Avg.	*13.0*		*1.0*	*11.30*	*1.17*	*0.14*	*0.01*	*3.70*	*8*

Table A22: Water Quality Station NEF0000

SAR0001 - Sand Spring Run, @ the Mouth

DATE	FLOWS (CFS)	CH_AA (UG/L)	BOD5 (MG/L)	DO (MG/L)	TN (MG/L)	TKN(NH_3+ON) (MG/L)	TP (MG/L)	TSS (MG/L)	TEMP (0^C)
03/25/1999			1.0	11.6	1.363	0.183	0.008	6	7
04/08/1999	4.49		1.0	11.2	0.744	0.095	0.004	2	7
04/27/1999	8.40		1.0	9.0	0.727	0.463	0.080	2	8
07/14/1999									
08/19/1999									
10/05/1999	0.14		1.0	9.4	0.456	0.144	0.016	2	12
Average	4.34		1.0	10.3	0.823	0.221	0.027	3	8
Maximum	8.40		1.0	11.6	1.363	0.463	0.080	6	12
Minimum	0.14		1.0	9.0	0.456	0.095	0.004	2	7
JULY - OCTOBER									
Average	0.14		1.0	9.4	0.456	0.144	0.016	2	12
90^{th} PERCENTILE	0.14		1.0	9.4	0.456	0.144	0.016	2	12
10^{th} PERCENTILE	0.14		1.0	9.4	0.456	0.144	0.016	2	12
High Flow Avg.	*4.5*		*1.0*	*11.40*	*1.05*	*0.14*	*0.01*	*4.20*	*7*

Table A23: Water Quality Station SAR0001

UGQ0000 - Unnamed Tributary, Mouth @ Reynolds Rd

DATE	FLOWS (CFS)	CH_AA (UG/L)	BOD5 (MG/L)	DO (MG/L)	TN (MG/L)	TKN(NH_3+ON) (MG/L)	TP (MG/L)	TSS (MG/L)	TEMP (0^C)
03/25/1999	4.14		1.0	12.3	1.757	0.287	0.007	6	7
04/08/1999	1.11		1.0	10.6	0.806	0.117	0.004	6	12
04/27/1999	3.13		1.0	10.1	1.217	0.097	0.005	7	14
07/14/1999	0.12		1.0	9.0	0.337	0.105	0.005	16	19
08/19/1999	0.06		1.0	8.6	0.312	0.124	0.007	16	25
10/05/1999	0.11	1.495	1.0	10.3	0.517	0.200	0.035	53	11
Average	1.44	1.495	1.0	10.2	0.824	0.155	0.010	17	14
Maximum	4.14	1.495	1.0	12.3	1.757	0.287	0.035	53	25
Minimum	0.06	1.495	1.0	8.6	0.312	0.097	0.004	6	7
JULY - OCTOBER									
Average	0.10	1.495	1.0	9.3	0.388	0.143	0.016	28	18
90^{th} PERCENTILE	0.12	1.495	1.0	10.0	0.481	0.184	0.029	46	24
10^{th} PERCENTILE	0.07	1.495	1.0	8.7	0.317	0.109	0.006	16	13
High Flow Avg.	*2.63*		*1.0*	*11.45*	*1.28*	*0.20*	*0.01*	*5.90*	*9*

Table A24: Water Quality Station UGQ0000

WIN0002 - Winebrenner Run, Bridge Crossing on Morgan Rd

DATE	FLOWS (CFS)	CH_AA (UG/L)	BOD5 (MG/L)	DO (MG/L)	TN (MG/L)	TKN(NH_3+ON) (MG/L)	TP (MG/L)	TSS (MG/L)	TEMP (0^C)
03/25/1999			1.0	11.3	0.958	0.186	0.005	7	8
04/08/1999	3.60		1.0	11.2	0.681	0.226	0.003	5	7
04/27/1999	7.22		1.0	10.8	0.722	0.178	0.004	5	9
07/14/1999									
08/19/1999									
10/05/1999	0.36	0.498	1.0	10.5	1.075	0.554	0.023	31	11
Average	3.73	0.498	1.0	11.0	0.859	0.286	0.009	12	9
Maximum	7.22	0.498	1.0	11.3	1.075	0.554	0.023	31	11
Minimum	0.36	0.498	1.0	10.5	0.681	0.178	0.003	5	7
JULY - OCTOBER									
Average	0.36	0.498	1.0	10.5	1.075	0.554	0.023	31	11
90th PERCENTILE	0.36	0.498	1.0	10.5	1.075	0.554	0.023	31	11
10th PERCENTILE	0.36	0.498	1.0	10.5	1.075	0.554	0.023	31	11
High Flow Avg.	*3.60*						*0.00*	*6.05*	*7*

Table A25: Water Quality Station WIN0002

Discharge Permits Limits

For Georges Creek Wastewater Treatment Plant (Expired January 31, 2000)

Effluent Limitations, Outfall 001 (1)

The quality of the effluent discharged by the facility shall be limited at all times as shown below.

Effluent Characteristics	Monthly Loading Rate kg/d (lbs/d)	Weekly Loading Rate kg/d (lbs/d)	Monthly Average mg/l	Weekly Average mg/l
BOD_5	68 (150)	100 (230)	30	45
TSS	68 (150)	100 (230)	30	45
Total Phosphorus as P	4.5 (10)	6.8 (15)	2.0	3.0

Effluent Characteristics	Maximum	Minimum
Fecal Coliforms	200 MPN/100 ml monthly log mean value	Not applicable
Total Residual Chlorine	Dechlorination is required to reduce the total residual chlorine to a nondetectable level.	
Dissolved Oxygen	Not applicable	5.0 mg/l at anytime.
pH	8.5	6.5

(1) Refer to 94-DP-2048 for additional discharge permit conditions.

Georges Creek WWTP Performance Records

MONTHS	FLOW (MGD)		BOD5 (Mg/l)		TSS (Mg/l)		TKN (Mg/l)		pH MIN		FC MAX 200 MPN PER 100 ml	DO MIN (Mg/l)	TRC MAX
	AVG	MAX	AVG	MAX	AVG	MAX	AVG	MAX	MIN	MAX			
Jan-99	0.539	0.765	12	16	17	24	-	-	6.6	7.8	9.5	7	N/A
FEB	0.563	0.792	11	14	17	25	-	-	6.5	7.4	15.8	7.5	N/A
MAR	0.775	0.810	12	14	18	29	-	-	6.5	7.4	9.8	7.6	N/A
APR	0.760	0.806	10	13	14	22	-	-	6.5	7.5	9.5	7.1	N/A
MAY	0.668	0.801	7	8	11	13	-	-	6.5	7.3	4.8	7.2	N/A
JUN	0.566	0.750	8	9	16	20	-	-	6.5	7.4	8.71	7	N/A
JUL	0.505	0.680	4	7	7	10	-	-	6.5	7.6	3.2	7	N/A
AUG	0.516	0.662	4	5	12	15	-	-	6.6	7.3	17.4	7	N/A
SEP	0.623	0.789	5	8	9	14	-	-	6.6	7.4	7.59	6.9	N/A
OCT	0.509	0.728	4	5	12	17	-	-	6.6	7.2	5.0	7	N/A
NOV	0.533	0.721	4	6	12	16	-	-	6.6	7.4	1.9	7	N/A
DEC	0.575	0.752	11	22	6	26	-	-	6.5	7.3	4.0	7.4	N/A
SUMR AVG.	0.565	0.735	5.33	7.0	11.2	14.8	-	-	6.55	7.36	7.78	7.02	-
YRLY AVG.	0.594	0.755	8.0	11	13	19	-	-	6.5	7.4	8.1	7.14	-