

# Great Swamp Watershed Association

FINAL REPORT

## **WATER QUALITY IN GREAT BROOK** **Quarterly Monitoring Results**

**January 2008 - December 2010**

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# **WATER QUALITY IN GREAT BROOK**

## **Quarterly Monitoring Results, January 2008 - December 2010**

During the 3-year period of 2008 - 2010, the Great Swamp Watershed Association (GSWA), under its Adopt-a-Stream program<sup>1</sup>, performed quarterly monitoring of water quality at several sites on Great Brook and two of its tributaries. Great Brook is formed from several smaller streams originating in Morris and Harding Townships, New Jersey. The brook passes through urban, suburban and rural areas, eventually flowing into the Great Swamp National Wildlife Refuge, where it merges with Loantaka and Primrose Brooks and finally joins the Passaic River. This report documents the results obtained during this program. An interim report was submitted to the NJDEP in July 2009 and covered the first 18 months of the program (January 2008 – June 2009)<sup>2</sup>.

### **1. Background**

From 1999 to 2008, the Ten Towns Great Swamp Watershed Management Committee (TTC) conducted water quality monitoring of the five major streams entering the Great Swamp National Wildlife Refuge (Refuge). GSWA Stream Team staff and volunteers participated in some phases of this work. The monitoring focused on key nitrogen and phosphorus nutrients and total suspended solids (TSS). Beginning in 2006, some additional parameters, including total dissolved solids (TDS), were included in the measurements. During the TTC program, Great Brook was sampled at a single site (designated GB1) where the stream crosses Woodland Road in Green Village, a short distance upstream from the stream's entry into the Refuge. Reports prepared by the TTC's consultants were issued<sup>3,4</sup> in 2002, 2007; and 2009. Overall, the results for Great Brook showed it to be somewhat impaired, principally under storm flow conditions,

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<sup>1</sup> GSWA's Adopt-a-Stream program, initiated with the support of local corporations, is aimed at measuring and improving the water quality of streams forming the headwaters of the Passaic River in Morris and Somerset Counties, NJ.

<sup>2</sup> Water Quality in Great Brook – Quarterly Monitoring Results – January 2008-June 2009, prepared by Great Swamp Watershed Association, July 2009.

<sup>3</sup> Great Swamp Watershed Water Quality Monitoring Report, Ten Towns Great Swamp Watershed Management Committee, prepared by F. X. Browne, June 2002.

Great Swamp Watershed Water Quality Monitoring Report, Ten Towns Great Swamp Watershed Management Committee, prepared by Princeton Hydro, LLC, March 2007.

<sup>4</sup> Great Brook data for 2006 – 2008 is included in The Loantaka Brook Watershed Report, Ten Towns Great Swamp Watershed Management Committee, prepared by Princeton Hydro, LLC, July 2009.

with respect to the New Jersey Surface Water Quality Standards (NJSWQS), though to a lesser extent than two of the other watershed streams, Loantaka Brook and Black Brook.

## **2. GSWA's 2008-2010 Great Brook Monitoring Program**

To develop a more extensive characterization of the stream's water quality, six sites distributed along Great Brook and its tributaries were initially selected for our Adopt-a-Stream program. A map showing the locations of the monitoring sites is provided in Figure 1. Four of the sites, designated in upstream to downstream order GB5, GB4, GB3 and GB1, are on the main stem of Great Brook upstream from the Refuge. A site designated CMA is located in GSWA's Conservation Management Area on Silver Brook (a.k.a. Catfish Brook), one of Great Brook's headwaters tributaries. Another tributary, Bayne Brook, was monitored at the HLT site on Harding Land Trust property where the brook passes under Wexford Lane. The two tributaries merge and join Great Brook at a point approximately midway between the GB4 and GB3 sites. For the final year of the program, 2010, two changes were made in the locations of the monitored sites. To enable easier access to Silver Brook, it was decided to use a site, designated CMA2, located approximately 50 yards upstream from the previously-used CMA site. The CMA2 site is also situated upstream from where two mosquito ditches drain into the main stem of Silver Brook. In addition, monitoring of Bayne Brook at the HLT site was discontinued, and a new site, GBNWR, located within the Refuge at Pleasant Plains Road, was monitored to include the downstream reaches of Great Brook shortly before it flows into the Passaic River. By the time the brook reaches GBNWR, it has merged with two other watershed streams, Loantaka Brook and Primrose Brook. Figure 2 contains an aerial photo of the area, marked with the site locations, and a table with their geographic coordinates. The sampling and analytical procedures were modeled on those followed in our 2005–2007 monitoring<sup>5</sup> of Loantaka Brook. All monitoring activities follow the requirements of a NJDEP-approved Quality Assurance Project Plan<sup>6</sup>.

Samples, collected quarterly, were submitted to Environmental Compliance Monitoring, Inc. (ECM) in Hillsborough, NJ for analysis. ECM is a NJDEP-certified laboratory. The concentrations of total Kjeldahl nitrogen, nitrate, nitrite, soluble reactive phosphate, total phosphorus, TSS, TDS, sodium, and chloride, were determined. Copies of the laboratory data packages from July 2009 through December 2010 can be found in Attachments 1 through 6 (Laboratory data packages from January 2008 through June 2009 were submitted with the July 2009 report<sup>2</sup>.)

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<sup>5</sup> Water Quality in Loantaka Brook, 2005–2007 Monitoring Results, Roger Edwards and Kelley Curran, GSWA Stream Team, May 2008.

<sup>6</sup> Long-Term Monitoring QA Project Plan, prepared by Great Swamp Watershed Association, Revised December 2008.

Supplementing the lab analyses, a Horiba U-10 water quality meter was leased for each sampling event and used for taking in-situ measurements of temperature, pH, dissolved oxygen (DO), turbidity and conductivity. An estimate of TDS also was derived from the conductivity readings.

In most cases, sampling was performed under base-flow conditions, meaning that no significant precipitation had occurred for at least 48 hours prior to each collection. However, the sampling round of November 4, 2010 was carried out during a rainstorm. In addition, some runoff from snow melting occurred on the days immediately prior to the February 4, 2009 and February 17, 2010 collections. Reference will be made to these events in Section 3. On all except one sampling date, measurements of stream flow rates were made at some of the sites using the Volunteer Stream Monitoring Partnership protocol.

Copies of the chain-of-custody reports, field sampling data sheets, and meter calibration logs can be found in Attachments 7, 8 and 9, respectively. (The same documents for the first half of the project were submitted with the July 2009 report<sup>2</sup>.)

### **3. Results**

Tables A1 to A3 summarize the laboratory results for nitrogen and phosphorus-bearing nutrients, TSS, TDS, sodium, and chloride concentrations. The total nitrogen “as N” data were obtained by summing the quantities in the three preceding columns. In addition, the table includes the measured stream flow volumes, frequently taken at GB3, GB4 and GB5, and occasionally at other sites. Tables B1 to B3 include the meter measurements made at each site, together with estimates of DO percentage of saturation and TDS derived from the conductivity values. These TDS estimates were made using a linear best-fit correlation between the Horiba conductivity readings and the corresponding laboratory TDS results obtained by GSWA over a four-year period. Although primary emphasis is given to the laboratory TDS values, meter measurements offer a convenient low-cost method of estimating TDS and our experience indicates that the results, with some exceptions, fall within about 20% of the laboratory numbers. For comparison purposes, the rightmost column of these tables repeats the laboratory TDS data.

On 11 of the 12 monitoring dates, no precipitation had occurred during the preceding 48 hours and sampling was considered to have taken place under base-flow conditions. On the 12<sup>th</sup> date, November 4, 2010, sampling was carried out during a rain storm, resulting in considerable runoff into the streams, as indicated by the high flow volumes recorded on that date.

### **3.1 Nitrogen and Phosphorus Nutrients**

Figure 3 graphically summarizes the 2008 -2010 results for total nitrogen concentrations at the different sampling sites<sup>7</sup>. Nitrogen levels were usually found to be greater at the upstream sites GB4 and GB5 than at the other sites, at least under normal base-flow conditions, which might be a result of the proximity of those sites to the more-developed part of Morris Township. There is no New Jersey Surface Water Quality Standard (NJSWQS) for total nitrogen, but a human-health-based standard of 10 mg/l is specified for the nitrate-N contribution to total-N. Figure 4 displays the nitrate results, all of which are well within that standard.

The applicable NJSWQS for total phosphorus-P concentration is 0.1 mg/l. On the 11 base-flow monitoring dates, most samples met this standard (see Figure 5) but there were 7 exceedances among the 65 samples. None of these exceedances occurred at GB1, a result consistent with the previous TTC monitoring at the same site. Three of the seven base-flow exceedances occurred on August 12, 2010. The flow volume was very low that day, a condition which sometimes leads to increased concentration of phosphorus compounds and other solutes (see Section 3.3). The total-P concentration at the downstream GSNWR site was especially high that day, but upstream from that site, Great Brook is joined by Loantaka Brook and Primrose Brook, the first of which is likely to have contributed additional phosphorus to the stream.

Under the storm-flow conditions of 11/04/2010, 4 out of the 5 samples taken on that date showed total phosphorus exceedances. Higher phosphorus levels are frequently seen during storms as a result of increased surface runoff, bank erosion and sediment disturbance, all of which can lead to release of soil-bound phosphorus.

### **3.2 Total Suspended Solids**

The concentration of TSS met the NJSWQS of 40 mg/l in almost all samples (Figure 6). There were three exceptions, two of which occurred among the 11/04/2010 storm samples. As in the case of total-P, higher TSS levels under storm conditions are frequently found, and are also attributable to erosion and water turbulence.

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<sup>7</sup> In Figures 3 through 8, the CMA, Silver Brook tributary data include the sampling results from both the CMA (2008 – 2009) site and the nearby CMA2 (2010) site.

### 3.3 Total Dissolved Solids, Sodium and Chloride

Laboratory measurements of TDS, sodium and chloride concentrations are listed in Tables A1 to A3, and Figures 7 and 8 provide graphical representations of the TDS and chloride data, illustrating the marked seasonal variation that can be seen in these parameters. Especially evident are the high surges in both parameters on February 4, 2009 and February 17, 2010. The data show that on those two February dates, the combined sodium and chloride concentrations contributed a much higher proportion (typically 70% to 90%) of the TDS than on all the other monitoring dates (35% to 45%). These results are consistent with the effects of road salt runoff, which we have observed in other local streams, particularly Loantaka Brook<sup>5</sup>. We were unable to measure stream flow on 02/17/10, but flow volumes on 02/04/09 were somewhat higher than those usually measured, consistent with recent snowmelt runoff during the days immediately preceding the sampling. The lack of a similar surge in these parameters on February 12, 2008 indicates that on that occasion no recent runoff carrying road salt had taken place.

The NJSWQS for TDS of 500 mg/l was exceeded at all six sites on 02/04/2009, and at five of the six sites sampled on 02/17/2010. Similarly, exceedances of the chloride chronic toxicity standard of 230 mg/l occurred at the same 11 sites, and at one site, GB5, the more stringent acute toxicity standard of 860 mg/l was exceeded on both these sampling dates.

Tables A1 to A3 and Figures 7 and 8 also show that on almost all the sampling dates, TDS and chloride levels at GB4 and GB5 were consistently higher than at the other sites. Although the NJ standards were only exceeded at these sites on the February 2009 and 2010 dates, the frequently-occurring TDS values of 450 mg/l or more on other dates were uncomfortably close to the NJ standard. These upstream sites are located in a more urbanized region of Morris Township near the southern border of Morristown; in this area there is a greater density of roads and parking lots receiving deicing agents during winter than is the case further downstream. Cleaner water draining into the stream dilutes the contaminants at the downstream sites.

Also evident in Figures 7 and 8 is the tendency for TDS and chloride levels at the more vulnerable upstream sites, GB4 and GB5, to decrease gradually through the spring, summer and fall months. Although road salt is used only in winter, it can be retained in soils, slowly leaching into shallow groundwater and seeping into the stream throughout the year. Sometimes, however, during times of very low stream flow, a slight rise in these concentrations can occur, as seen in November 2008 and August 2010; during drought periods, enhanced evaporation and reduced stream flushing can cause such increases.

One of the two tributaries monitored, Bayne Brook, originates in New Vernon and flows through terrain having a relatively low density of roads and housing; the degree to which this stream was impacted by contamination from road salt was comparatively small. On the other tributary, Silver Brook, the monitoring sites CMA and CMA2 are located a short distance downstream from two major highways (US 202 and I 287) and medium density housing; significant increases in TDS and chloride levels were evident during the two February road salt events.

### **3.4 Horiba U-10 Meter Measurements**

Tables B1 to B3 show that several pH values fell outside the range of 6.5 to 8.5 specified by the NJSWQS. The NJ standard for dissolved oxygen, a minimum of 5 mg/l, was met in all cases. The “any time” maximum NJ standard for turbidity is 50 NTU, which was met in all 44 of the base-flow field measurements of this parameter that were recorded. Three out of the five storm-flow turbidity readings exceeded this standard. A more comprehensive characterization of turbidity would require continuous measurements to evaluate it against the 30-day average maximum standard of 15 NTU.

The Horiba meter also provides values of electrical conductivity, from which TDS concentrations can be estimated. Although the TDS values obtained by chemical analysis are considered the most reliable data for characterizing our streams and for comparing with NJ standards, it is useful to have a low-cost procedure for rapidly estimating TDS in the field. The values of TDS derived from conductivity, listed in Tables B1 to B3, were obtained using the following relationship

$$\text{TDS (in mg/l)} = 57 + 0.52 \times \text{Conductivity (in microSiemens/cm)}$$

This equation was developed empirically, using the best linear fit of data gathered by GSWA over a four-year period of measuring conductivity in our watershed streams. In almost all cases, the conductivity-derived TDS values are within 20% of the laboratory numbers. For comparison purposes, the more-accurate TDS values derived from laboratory measurements are duplicated in Tables B1 to B3.

#### 4. Other relevant data

The TTC monitoring program mentioned earlier included sampling Great Brook at GB1 from 1999 to 2008. The concentrations of nitrogen and phosphorus-bearing nutrients, and TSS, were included in reports issued by the TTC consultants<sup>3,4</sup>. Our 2008-2010 data for the same suite of parameters, as summarized in Tables A1 to A3 for the GB1 site, are generally similar to the TTC results. With respect to total phosphorus, out of 45 GB1 base flow samples taken over an approximately 9-year period, the TTC reported no NJSWQS exceedances in nitrate or TSS levels, and just 1 total-P exceedance. Under storm flow conditions, a substantial number of the TTC samples exceeded the total-P and TSS standards. In general, the water quality at the GB1 site was found to be measurably higher than that of nearby Loantaka Brook, but not as high as the neighboring stream to the west, Primrose Brook.

In 2006, Princeton Hydro, TTC's consultant at that time, began measuring some additional parameters, including TDS. Between September 2006 and August 2008, 24 base flow samples were analyzed<sup>4</sup>. Usually TDS was found to fall in the 200 to 300 mg/l range, like most of our 2008-2010 results at GB1. Some were higher, notably in December 2007 and February 2008, likely influenced by road salting practices, similarly to our TDS data for February 2009 and February 2010.

USGS has reported comprehensive monitoring<sup>8</sup> at a Great Brook site, in collaboration with NJDEP. The site is located in the Refuge near the end of Woodland Road in Green Village, and is about half a mile downstream from our GB1 site. The site is designated 01378770 by USGS, and is one of NJDEP's Ambient Network sites, AN0219. Monitoring was carried out from November 2008 to August 2010. Loantaka Brook flows into Great Brook at a point upstream from this site, but downstream from our GB1. The reported data shows that in most of the 8 quarterly samples, total-P concentrations exceed the NJ standard, a result which probably is at least partially attributable to phosphorus entering from Loantaka Brook.

In recent years studies of macro invertebrate communities in Great Swamp watershed streams have been performed annually by Dr. Leland Pollock of Drew University, a consultant for the TTC. In his studies<sup>9</sup> samples have been assessed at 17 sites on six watershed streams, including 4 Great Brook sites. Throughout 10 years of monitoring, these studies have shown Great Brook to fall in the "Poor" category, though over the 10 years of study there is a small but perceptible improving trend in the macro invertebrate quality index at several of the brook's sites. In a separate TTC macro invertebrate assessment<sup>4</sup> conducted in 2007- 2008, Princeton Hydro rated Great Brook as "Moderately Impaired" at the GB1 site. As in the case of water quality

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<sup>8</sup> USGS Water Data Report 2009. <http://wdr.water.usgs.gov/wy2009/pdfs/01378770.2009.pdf>  
USGS Water Data Report 2010. <http://wdr.water.usgs.gov/wy2010/pdfs/01378770.2010.pdf>

<sup>9</sup> Results of these studies covering the period 2000 – 2009 are available at <http://www.tentowns.org/10t/macro09.htm>



determined through chemical monitoring, the biological indices were found to be higher in Great Brook than in Loantaka Brook, but not as high as in Primrose Brook.

NJDEP conducts macro invertebrate surveys at 5-year intervals at its Ambient Biomonitoring Network sites. In its 2008 report<sup>10</sup> results for 2003 sampling indicated a “Moderately Impaired” condition at 2 of its 3 Great Brook sites, and “Nonimpaired” at its 3<sup>rd</sup> site, located on the Silver Brook tributary, about half a mile upstream from our CMA sites.

## 5. Summary

Under its Adopt-a-Stream program, GSWA has completed quarterly monitoring of water quality in Great Brook over the period 2008 to 2010, with several sites located on the stream’s main stem and on two of its headwaters tributaries being sampled. The principal findings of this study are as follows:

- No exceedances of NJSWQS were found for the concentrations of nitrogen and phosphorus compounds, and TSS, at the GB1 site, located just prior to the brook’s entry into the Refuge. These results are consistent with findings at the same site, under base flow conditions, reported by the Ten Towns Committee during its 1999-2008 study.
- In most cases, samples taken at the other Great Brook sites and the two tributaries also met the NJSWQS for nutrients and TSS, but there were some exceptions, with the total phosphorus standard being exceeded in about 10% of the base flow samples. Under the storm flow conditions prevailing on only one of the quarterly sampling dates, a higher incidence of exceedances was found in both total-P and TSS at sites upstream from GB1.
- The concentrations of total dissolved solids showed large surges on two out of the three February sampling dates. Winter surges of TDS can occur with snow melt or storm water transporting road salt into streams and the observation of similar surges of sodium and chloride concentrations is strongly consistent with this origin. NJ quality standards for TDS were exceeded at almost all the sampling sites on both these occasions, and the chloride levels failed the NJ chronic toxicity standard at the same sites, as well as the more stringent acute toxicity standard at one site. Numerical values of these parameters were consistently higher all year round in the upper reaches of the main stem (GB4 and GB5) than at the other sites. These two sites are located in a more urbanized district of Morris Township, and close to two of the watershed’s major highways; this section of Great Brook is therefore especially vulnerable to contamination from road salting practices. The effects of this pollution are present to some degree throughout the year,

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<sup>10</sup> NJDEP Ambient Biomonitoring Network, Northeast Water Region, Round 3 Benthic Macroinvertebrate Data, February, 2008

since deicing materials retained in soils leach slowly into shallow groundwater seeping into the stream.

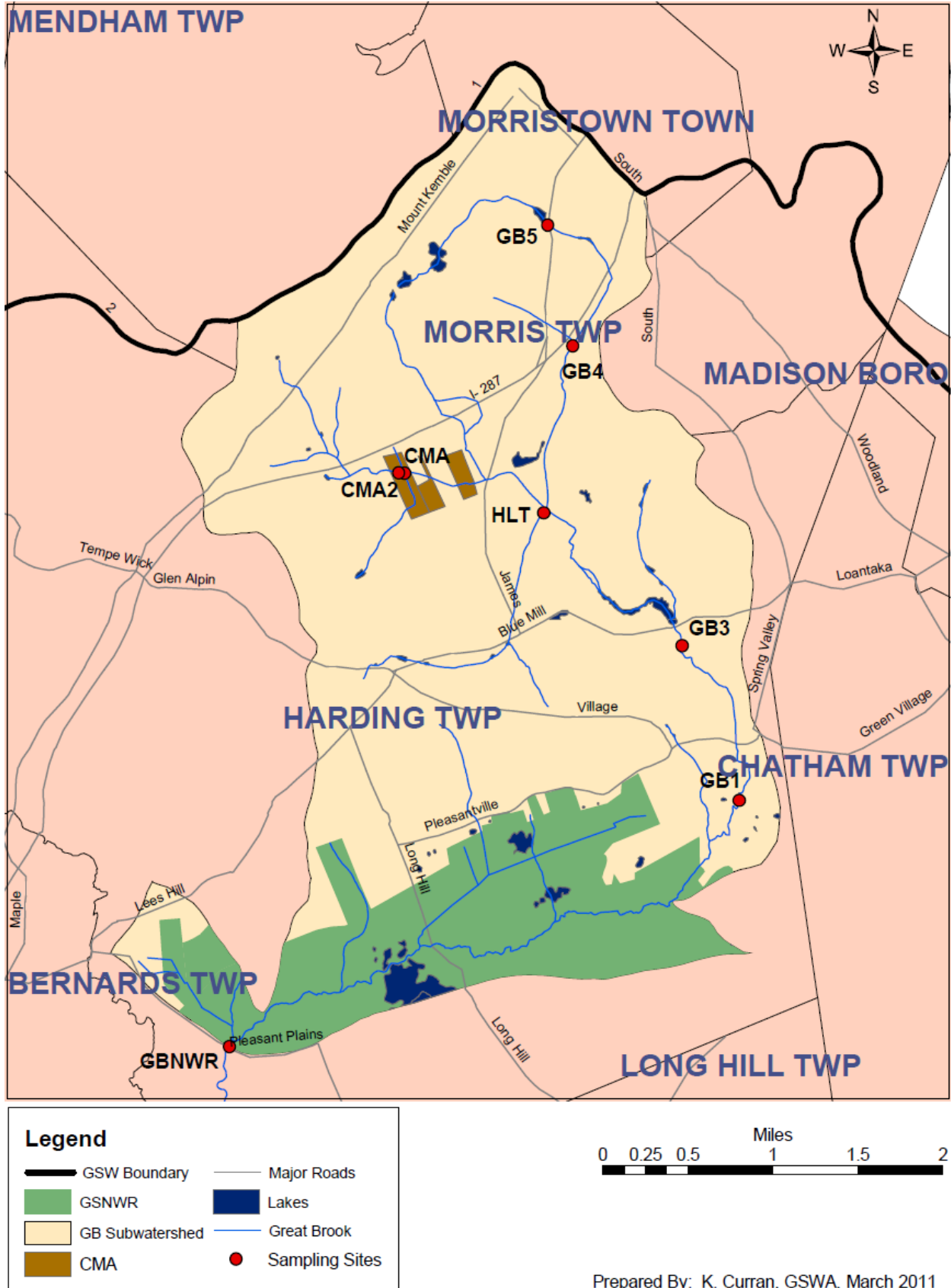
- A comparison between the results of our Great Brook and our 2005–2007 Loantaka Brook studies is appropriate. Both streams flow through similar terrain, originating in developed parts of Morris Township, flowing through more rural areas and preserved land in Harding and Chatham Townships to Green Village, eventually merging into a single stream within the Refuge. They would be expected to have similar water quality properties, but for the fact that Loantaka Brook is partially fed by a sewage treatment plant that influences its water quality for much of its length, contributing nitrogen and phosphorus-bearing nutrients as well as dissolved solids to the stream. Previous monitoring studies by TTC at the GB1 site have concluded that Great Brook’s water quality is higher than that of Loantaka Brook, though not as high as the more westerly situated Primrose Brook and Upper Passaic River. Our present study confirms this view for most sections of the streams. However, in the case of total dissolved solids and their primary constituents (sodium and chloride), our results are remarkably similar in the headwaters of Great Brook and Loantaka Brook, where both streams are highly vulnerable to contamination from winter roads deicing practices.

## **Acknowledgements**

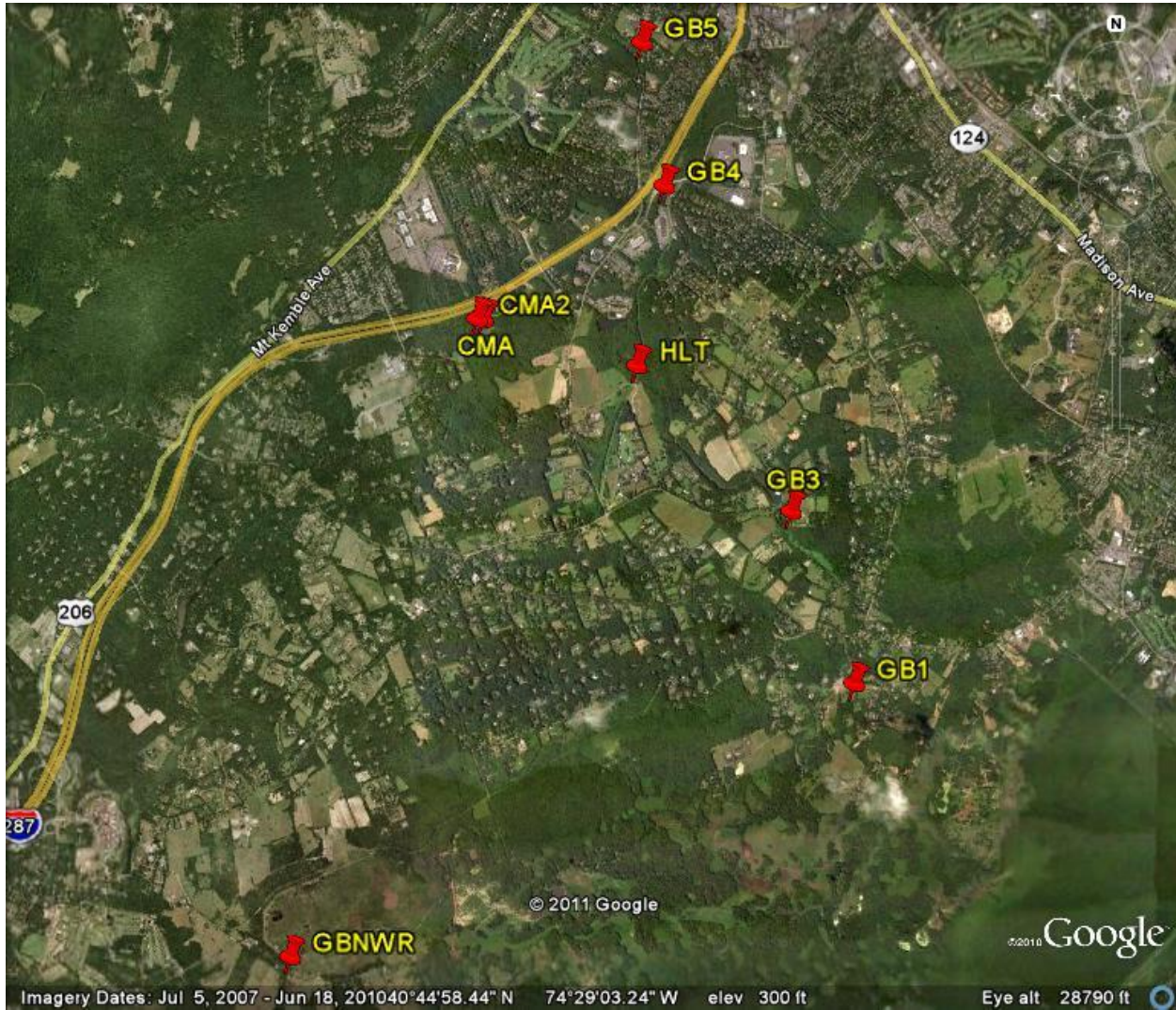
This work was carried out with the support of members of GSWA’s Corporate Council through the Association’s Adopt-a-Stream program. Thanks are due to Stream Team volunteers Dick Barrett, Wes Boyce, Laura Costello, Ellen Drury, Terry Dyben, Gene Fox, Adam Osborn, and Katherine Perri for their enthusiastic participation in this work. We also appreciate valued comments and suggestions from other members of GSWA’s Stream Team and its Science and Technology Committee during the course of this work.

**NOTE:** Attachments 1 to 9, mentioned in the text, are not included in the web version of this report. Any enquiries regarding these attachments may be directed to Laura Kelm at [lkelm@greatswamp.org](mailto:lkelm@greatswamp.org)

**Figure 1 ADOPT-GREAT-BROOK MONITORING SITES**



**Figure 2 AERIAL PHOTO SHOWING GREAT BROOK MONITORING SITES**



**Geographic Coordinates for Sampling Sites on Great Brook**

Source: Google Earth software

<b>SITE</b>	<b>LOCATION</b>	<b>LATITUDE</b>	<b>LONGITUDE</b>
GB1	Woodland Road	40°44'4.83"N	74°27'30.41"W
GB3	Dickson's Mill Rd	40°44'52.38"N	74°27'53.40"W
GB4	Laura Lane	40°46'22.06"N	74°28'39.67"W
GB5	Footes Pond James St	40°47'1.63"N	74°28'47.87"W
GBNWR	In Refuge @ Pleasant Plains Rd. Bridge	40°42'49.35"N	74°30'56.07"W
CMA	GSWA's Conservation Mgt. Area	40°45'45.33"N	74°29'45.61"W
CMA2	GSWA's Conservation Mgt. Area	40°45'45.45"N	74°29'47.85"W
HLT	Harding Land Trust property/Wexford Ln.	40°45'32.57"N	74°28'49.67"W

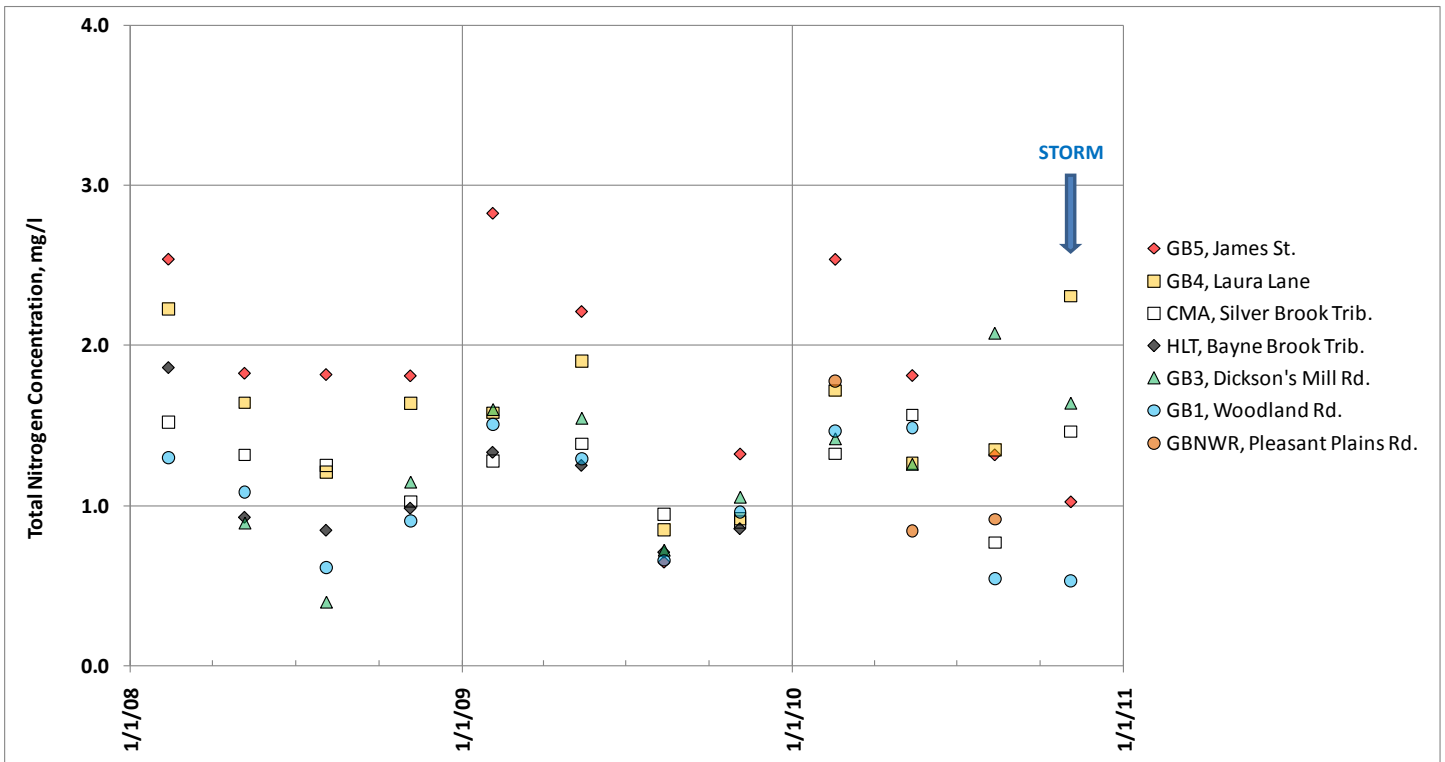


Figure 3. Total Nitrogen Concentration, Great Brook, 2008 - 2010  
There is currently no NJ Surface Water Quality Standard for Total Nitrogen.

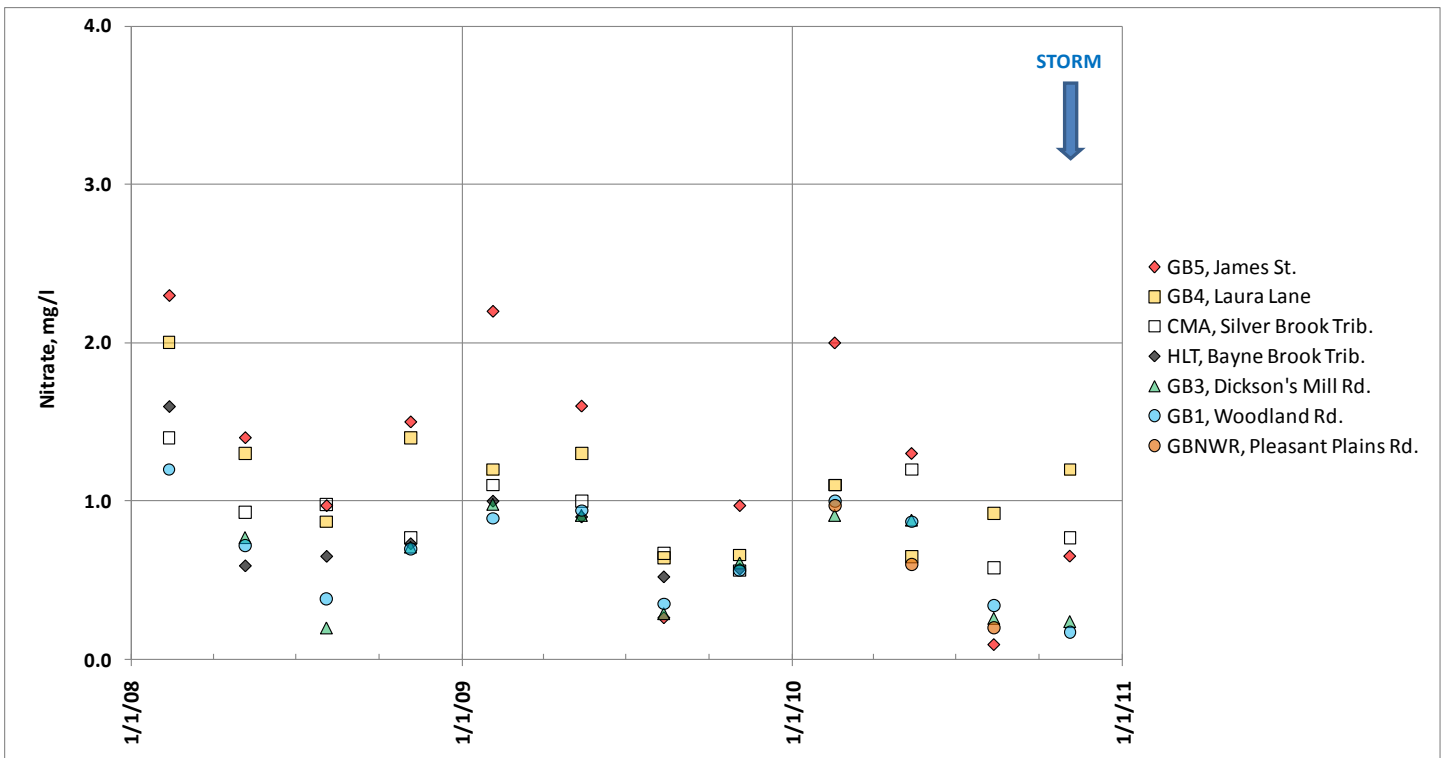


Figure 4. Total Nitrate Concentration, Great Brook, 2008 - 2010  
The NJ Surface Water Quality Standard for Nitrate is 10 mg/l, based on a human health criterion.

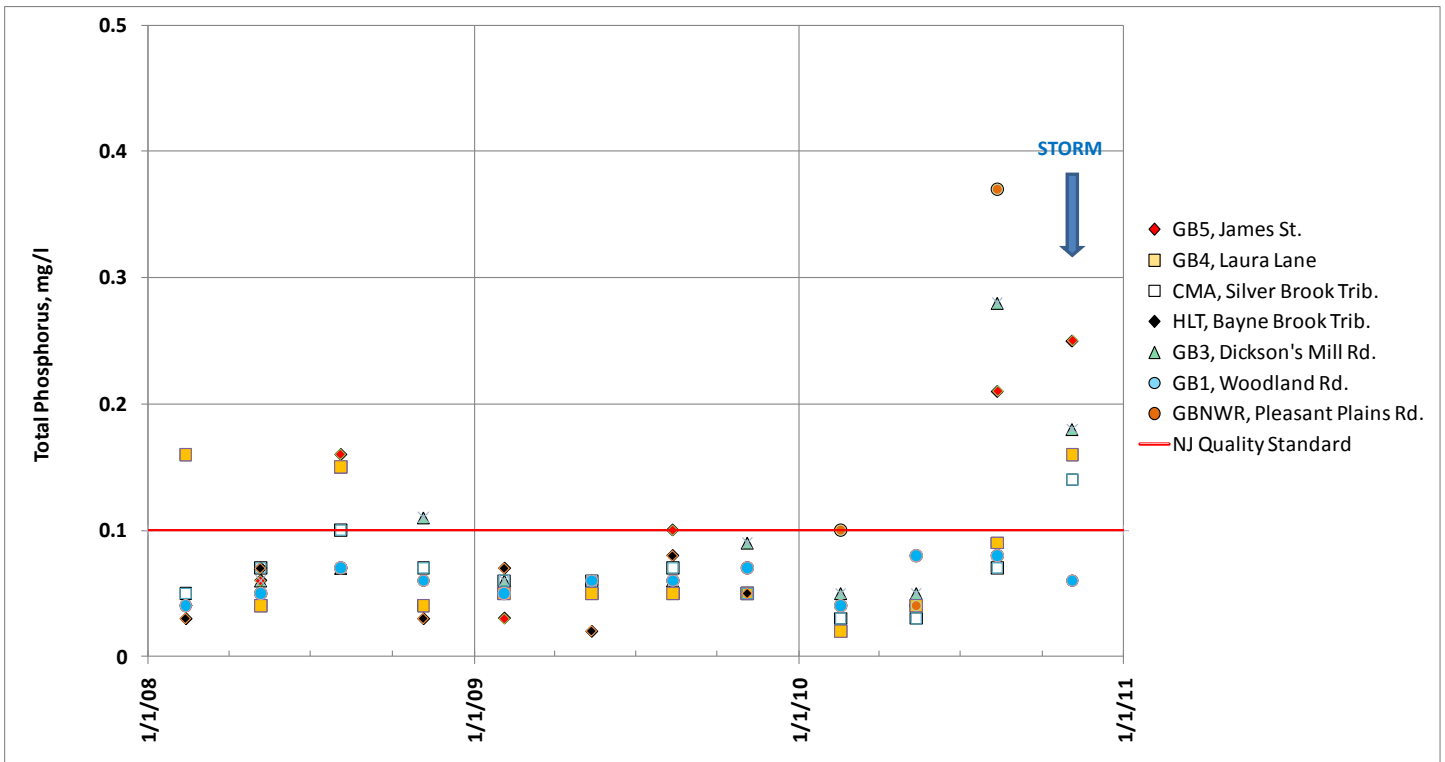


Figure 5. Total Phosphorus Concentration, Great Brook, 2008 - 2010

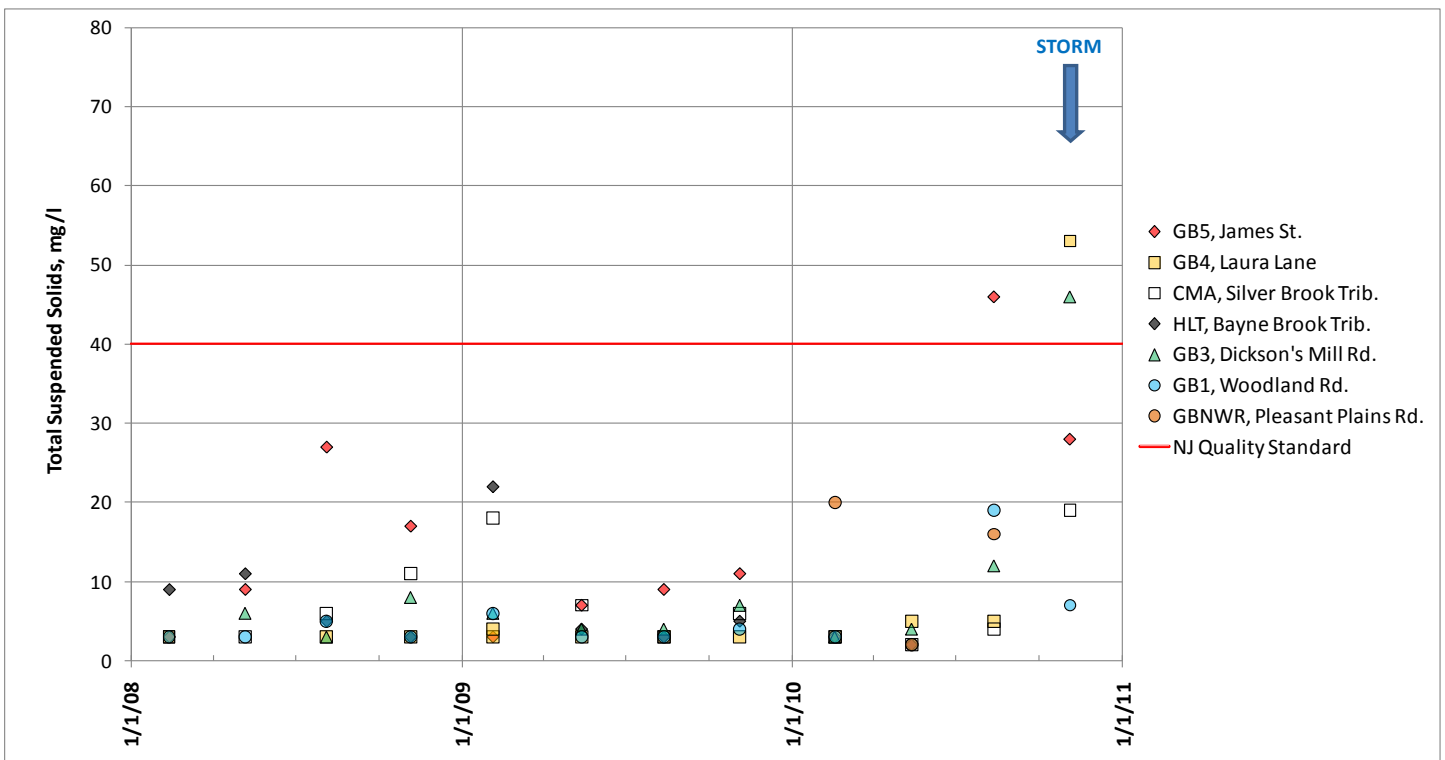


Figure 6. Total Suspended Solids Concentration, Great Brook, 2008 - 2010

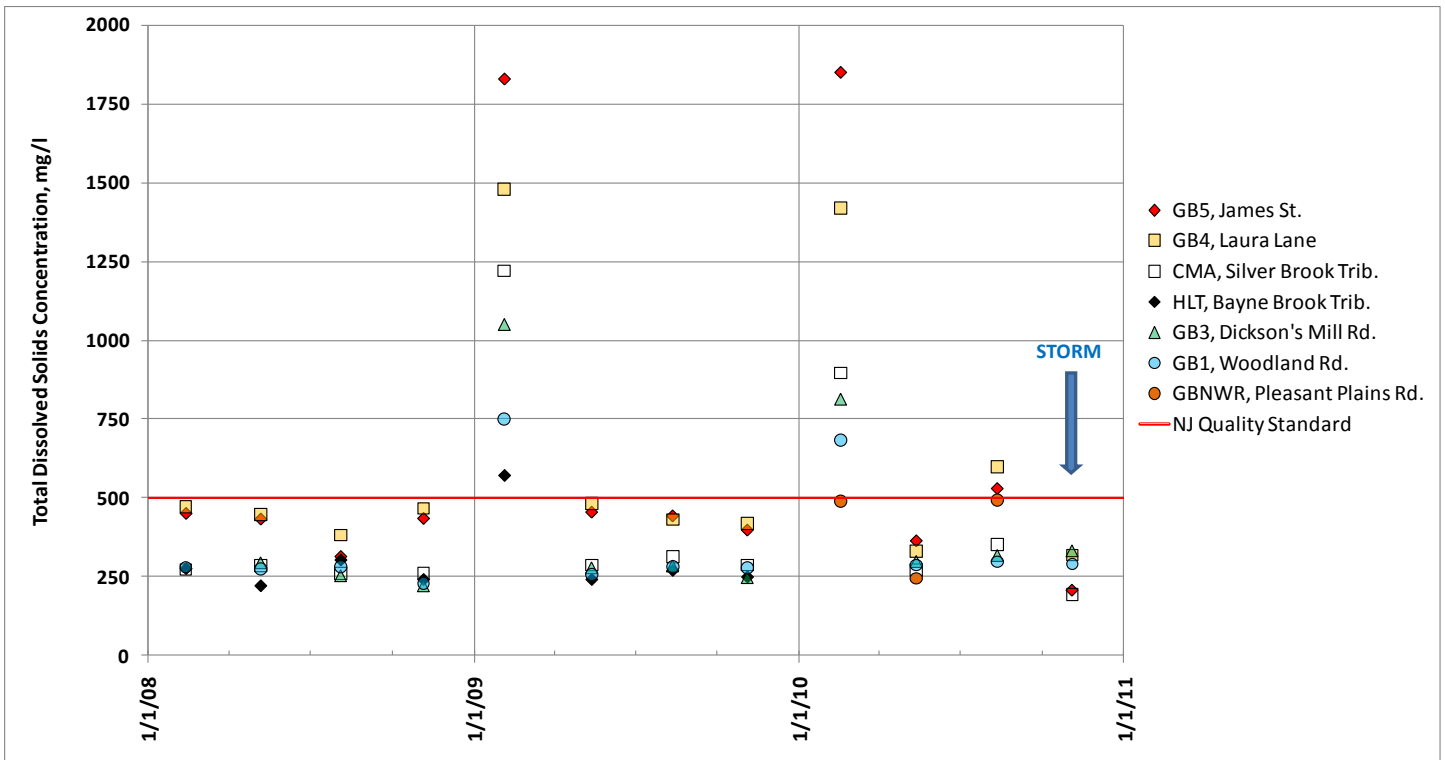


Figure 7. Total Dissolved Solids Concentration, Great Brook, 2008 - 2010

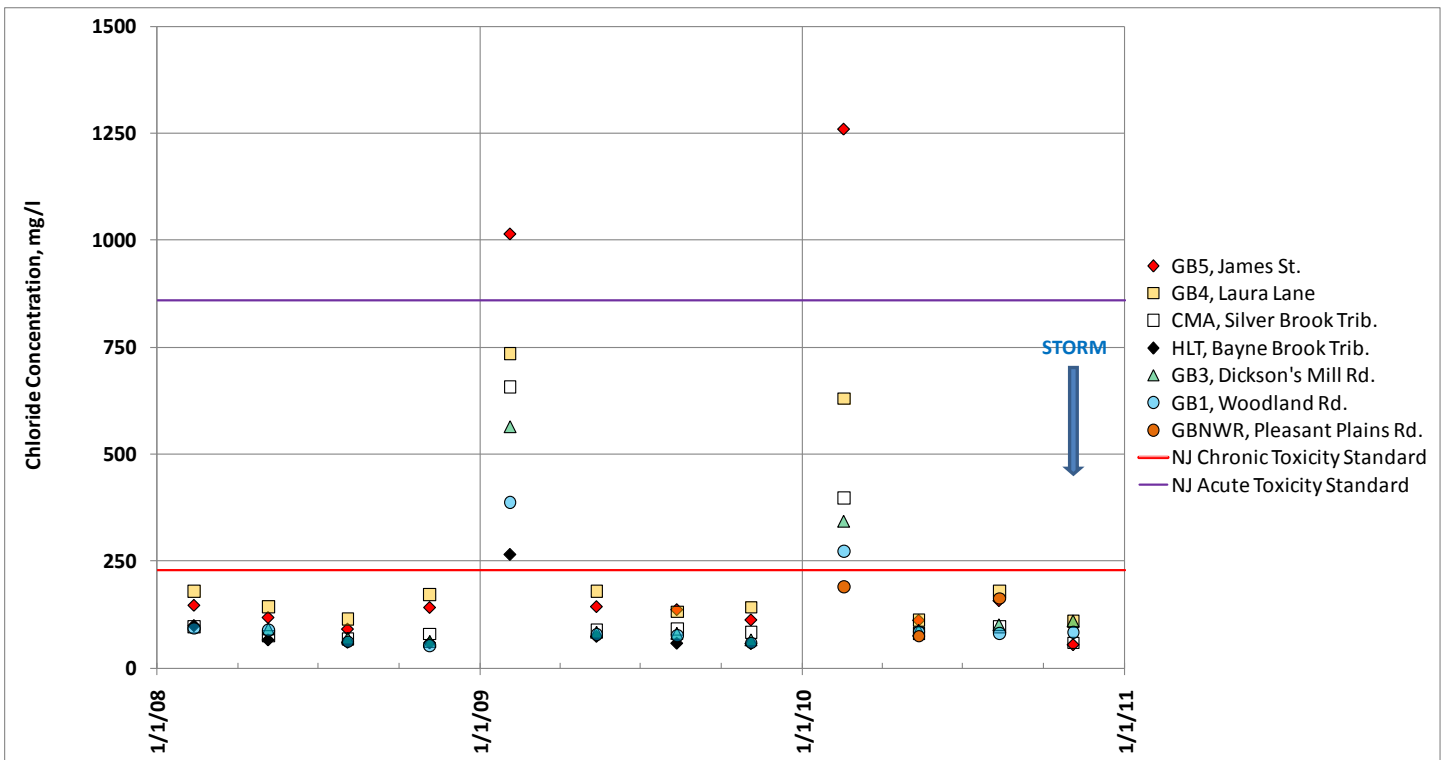


Figure 8. Chloride Concentration, Great Brook, 2008 - 2010

## A1. Lab Results: N- and P- Nutrients, TSS, TDS, Na & Cl, Great Brook, 2008

Sampling Site	Sampling Date	Flow Volume <sup>1</sup> cf/s	Water Temp. ° C	Results of Lab Analysis <sup>2</sup> , Concentrations in milligrams/liter									
				Total Kjeldahl Nitrogen			Total Nitrogen	Soluble Phosphate	Reactive Phosphorus	Total Suspended Solids	Total Dissolved Solids	Major TDS Components	
				"as N"	Nitrate "as N"	Nitrite "as N"	"as N"	"as P"	"as P"	Solids	Solids	Sodium	Chloride
GB5 below Foote's Pond (nr James St)	02/12/08	0.78	2.6	0.22	2.3	0.018	2.54	0.004	0.04	3	450	63.1	147.1
	05/06/08	1.20	20.9	0.38	1.4	0.045	1.83	0.008	0.06	9	432	50.5	118.6
	08/04/08	0.87	26.1	0.80	0.97	0.047	1.82	0.004	<b>0.16</b>	27	313	40.0	91.5
	11/05/08		13.9	0.28	1.5	0.029	1.81	0.018	0.04	17	434	55.8	142.0
GB4 nr Laura Lane	02/12/08	1.66	1.5	0.22	2.0	0.009	2.23	0.050	<b>0.16</b>	< 3	472	82.9	179.4
	05/06/08	2.40	15.4	0.32	1.30	0.024	1.64	0.013	0.04	< 3	446	66.4	143.1
	08/04/08	2.08	21.8	0.33	0.87	0.011	1.21	0.024	<b>0.15</b>	3	382	53.2	115.1
	11/05/08	1.34	12.6	0.23	1.40	0.010	1.64	0.026	0.04	< 3	466	76.9	171.0
CMA Silver Brook nr Tiger Lily Lane	02/12/08	1.98	1.7	0.12	1.4	0.003	1.52	0.011	0.05	< 3	273	30.7	96.1
	05/06/08		14.0	0.38	0.93	0.006	1.32	0.029	0.07	6	285	28.3	74.5
	08/04/08		19.5	0.26	0.98	0.009	1.25	0.037	0.10	11	260	27.6	67.9
	11/05/08		11.8	0.25	0.77	0.005	1.03	0.034	0.07	18	259	26.2	79.3
HLT Bayne Brook at Wexford Ln	02/12/08	1.94	1.2	0.26	1.6	0.004	1.86	0.007	0.03	9	276	52.0	100
	05/06/08		16.0	0.32	0.59	0.019	0.93	0.021	0.07	11	221	37.3	66.7
	08/04/08		20.5	0.19	0.65	0.008	0.85	0.026	0.07	5	303	45.9	61.3
	11/05/08	0.70	12.0	0.25	0.73	0.006	0.99	0.015	0.03	3	241	38.7	59.8
GB3 nr Dickson's Mill Road	02/12/08	-----Not Measured----->											
	05/06/08	12.60	16.7	0.11	0.77	0.013	0.89	0.006	0.06	6	294	43.4	91.2
	08/04/08	5.94	25.3	0.19	0.20	0.010	0.40	0.030	0.07	< 3	253	34.8	69.8
	11/05/08	4.68	11.6	0.43	0.71	0.008	1.15	0.015	<b>0.11</b>	8	221	30.5	62.0
GB1 at Woodland Road	02/12/08		2.7	0.09	1.20	0.006	1.30	0.012	0.04	< 3	279	47.6	93.1
	05/06/08		10.6	0.35	0.72	0.014	1.08	0.014	0.05	< 3	274	40.2	88.2
	08/04/08	4.51	22.2	0.23	0.38	0.005	0.62	0.033	0.07	5	282	33.1	61.3
	11/05/08		11.3	0.20	0.70	0.005	0.91	0.033	0.06	3	228	28.4	52.2

1. Flow volume estimated using float travel time & stream X-section (Volunteer Stream Monitoring Partnership method)

2. Samples analysed by Environmental Compliance Monitoring, Inc., Hillsborough, NJ

**Red** entries indicate failure to meet the applicable NJ Surface Water Quality Standard



## A2. Lab Results: N- and P- Nutrients, TSS, TDS, Na & Cl, Great Brook, 2009

Sampling Site	Sampling Date	Flow Volume <sup>1</sup> cf/s	Water Temp. ° C	Results of Lab Analysis <sup>2</sup> , Concentrations in milligrams/liter									
				Total Kjeldahl Nitrogen			Total Nitrogen	Soluble Reactive Phosphate	Total Phosphorus	Total Suspended Solids	Total Dissolved Solids	Major TDS Components	
				"as N"	Nitrate "as N"	Nitrite "as N"	"as N"	"as P"	"as P"	Solids	Solids	Sodium	Chloride
GB5 below Foote's Pond (nr James St)	02/04/09	1.74	1.7	0.61	2.2	0.015	2.83	< 0.002	0.03	< 3	<b>1830</b>	570	<b>1015</b>
	05/13/09	0.62	18.8	0.57	1.6	0.041	2.21	0.005	0.06	7	454	58.4	144
	08/12/09	0.67	26.4	0.37	0.26	0.014	0.64	< 0.002	0.10	9	442	53.0	137
	11/04/09	0.85	10.0	0.33	0.97	0.020	1.32	0.014	0.07	11	397	51.4	113
GB4 nr Laura Lane	02/04/09	2.63	2.3	0.37	1.2	0.010	1.58	< .002	0.05	4	<b>1480</b>	419	<b>735</b>
	05/13/09	1.12	15.1	0.57	1.3	0.032	1.90	0.015	0.05	3	483	82.6	180
	08/12/09	1.60	22.5	0.20	0.64	0.011	0.85	0.019	0.05	< 3	431	55.4	132
	11/04/09	1.38	10.3	0.25	0.66	0.009	0.92	0.026	0.05	< 3	418	72.5	142
CMA Silver Brook nr Tiger Lily Lane	02/04/09		2.0	0.17	1.1	0.007	1.28	0.018	0.06	< 3	<b>1220</b>	392	<b>657</b>
	05/13/09		12.0	0.38	1.0	0.007	1.39	0.020	0.06	7	286	36.6	89.4
	08/12/09		20.6	0.27	0.67	0.007	0.95	0.040	0.07	3	314	33.1	91.0
	11/04/09		9.4	0.33	0.56	0.008	0.90	0.028	0.05	6	286	34.2	84.3
HLT Bayne Brook at Wexford Lane	02/04/09		0.9	0.33	1.0	0.005	1.34	0.002	0.07	22	<b>572</b>	133	<b>265</b>
	05/13/09	2.54	14.1	0.34	0.90	0.013	1.25	0.017	0.02	4	241	37.9	75.0
	08/12/09	1.69	23.2	0.18	0.52	0.011	0.71	0.043	0.08	3	270	36.4	59.0
	11/04/09		9.9	0.28	0.57	0.008	0.86	0.019	0.05	5	249	41.0	58.3
GB3 nr Dickson's Mill Road	02/04/09	19.88	2.3	0.61	0.98	0.010	1.60	0.005	0.06	6	<b>1050</b>	319	<b>564</b>
	05/13/09	9.25	16.4	0.62	0.91	0.016	1.55	0.026	0.06	4	278	41.0	83.6
	08/12/09	6.42	24.9	0.42	0.29	0.014	0.72	0.009	0.06	4	284	36.5	81.0
	11/04/09	10.7	11.5	0.43	0.61	0.014	1.05	0.042	0.09	7	247	37.0	65.7
GB1 at Woodland Road	02/04/09		1.2	0.61	0.89	0.007	1.51	0.006	0.05	6	<b>751</b>	221	<b>387</b>
	05/13/09		15.3	0.34	0.94	0.014	1.29	0.024	0.06	< 3	256	35.5	78.8
	08/12/09	9.22	23.3	0.30	0.35	0.009	0.66	0.023	0.06	< 3	281	33.2	76.0
	11/04/09	12.8	10.0	0.39	0.56	0.011	0.96	0.040	0.07	4	278	35.5	59.3

- Flow volume estimated using float travel time & stream X-section (Volunteer Stream Monitoring Partnership method)
  - Samples analysed by Environmental Compliance Monitoring, Inc., Hillsborough, NJ
- Red** entries indicate failure to meet the applicable NJ Surface Water Quality Standard

### A3. Lab Results: N- and P- Nutrients, TSS, TDS, Na & Cl, Great Brook, 2010

Sampling Site	Sampling Date	Flow Volume <sup>1</sup> cf/s	Water Temp. ° C	Results of Lab Analysis <sup>2</sup> , Concentrations in milligrams/liter										
				Total Kjeldahl Nitrogen			Total Nitrogen	Soluble Reactive Phosphate	Total Phosphorus	Total Suspended Solids	Total Dissolved Solids	Major TDS Components		
				"as N"	Nitrate "as N"	Nitrite "as N"	"as N"	"as P"	"as P"	Solids	Solids	Sodium	Chloride	
GB5 below Foote's Pond (nr James St)	02/17/10		2.3	0.52	2.0	0.017	2.54	< 0.002	0.04	3	<b>1851</b>	511	<b>1260</b>	
	05/13/10	1.1	16.7	0.49	1.3	0.021	1.81	0.009	0.04	< 2	363	41.9	112	
	08/12/10		25.8	1.20	0.09	0.025	1.32	0.003	<b>0.21</b>	<b>46</b>	<b>529</b>	62.2	158	
	11/04/10	27.0	8.9	0.36	0.65	0.011	1.02	0.15	<b>0.25</b>	28	206	23.5	55	
GB4 nr Laura Lane	02/17/10		2.4	0.61	1.1	0.008	1.72	< 0.002	0.02	< 3	<b>1419</b>	367	<b>630</b>	
	05/13/10	7.1	13.6	0.60	0.65	0.013	1.26	0.009	0.04	5	330	52.2	112	
	08/12/10	1.0	23.3	0.41	0.92	0.017	1.35	0.044	0.09	5	<b>598</b>	72.2	179	
	11/04/10	20.6	8.5	1.1	1.20	0.009	2.31	0.079	<b>0.16</b>	<b>53</b>	318	45.6	109	
CMA2 Silver Brook at footbridge	02/17/10		3.6	0.22	1.1	0.004	1.32	0.002	0.03	< 3	<b>896</b>	219	<b>398</b>	
	05/13/10	3.2	10.7	0.36	1.2	0.006	1.57	0.012	0.03	< 2	271	33.8	80.5	
	08/12/10	0.45	22.7	0.20	0.56	0.009	0.77	0.037	0.07	4	352	28.6	96.0	
	11/04/10		8.4	0.68	0.77	0.013	1.46	0.10	<b>0.14</b>	19	192	23.5	59.0	
GB3 nr Dickson's Mill Road	02/17/10		3.0	0.50	0.91	0.008	1.42	< 0.002	0.05	3	<b>813</b>	229	<b>343</b>	
	05/13/10	16.4	13.7	0.36	0.88	0.019	1.26	0.012	0.05	4	298	37.4	88.1	
	08/12/10	0.74	25.5	1.8	0.26	0.016	2.08	0.012	<b>0.28</b>	12	317	41.8	101	
	11/04/10	43.2	8.8	1.4	0.24	0.001	1.64	0.025	<b>0.18</b>	<b>46</b>	332	45.7	110	
GB1 at Woodland Road	02/17/10		2.5	0.46	1.0	0.007	1.47	< 0.002	0.04	< 3	<b>684</b>	142	<b>273</b>	
	05/13/10		12.2	0.60	0.87	0.015	1.49	0.014	0.08	< 2	286	40.6	84.7	
	08/12/10	3.0	24.1	0.20	0.34	0.005	0.55	0.035	0.08	19	297	36.2	81.0	
	11/04/10		8.0	0.36	0.17	0.002	0.53	0.020	0.06	7	290	38.3	83.0	
GBNWR at Pleasant Plains Road	02/17/10		1.0	0.80	0.97	0.008	1.78	0.004	0.10	20	490	113	190	
	05/13/10		12.0	0.23	0.60	0.014	0.84	0.018	0.04	< 2	244	40.2	74.6	
	08/12/10	2.4	24.5	0.71	0.20	0.004	0.91	0.025	<b>0.37</b>	16	493	82.2	163	
	11/04/10			SITE NOT ACCESSIBLE										

11/04/10 STORM FLOW CONDITIONS

1. Flow volume estimated using float travel time & stream X-section (Volunteer Stream Monitoring Partnership method). Flow was not measured on 02/17/10.

2. Samples analysed by Environmental Compliance Monitoring, Inc., Hillsborough, NJ

**Red** entries indicate failure to meet the applicable NJ Surface Water Quality Standard

## B1. On-site Measurements: Flow Volume and Meter Measurements, Great Brook, 2008

Sampling Site	Sampling Date	Flow Volume <sup>1</sup> cf/s	Water Temperature		pH	Dissolved Oxygen		Turbidity	Conductivity	Total Dissolved Solids	TDS	
			T. Gauge	Horiba <sup>2</sup>	Horiba <sup>2</sup>	Horiba <sup>2</sup>	Approx. % of Saturation	Horiba <sup>2</sup>	Horiba <sup>2</sup>	(from Conductivity) <sup>3</sup>	Lab results	
			°C	°C		mg/l		NTU	µS/cm	mg/l	mg/l	
GB5 below Foote's Pond (nr James St)	02/12/08	0.78	2.6	1.8	7.37	12.00	88.9%	2	698	420	450	
	05/06/08	1.20	20.9	20.7	7.63	8.76	99.5%		645	392	432	
	08/04/08	0.87	26.1	26.1	7.97	8.65	108.1%	22	570	353	313	
	11/05/08		13.9	13.7	7.14	6.55	64.2%	1	756	450	434	
GB4 nr Laura Lane	02/12/08	1.66	1.5	0.7	7.17	12.83	92.3%	1	760	452	472	
	05/06/08	2.40	15.4	15.5	7.53	10.92	110.3%		730	437	446	
	08/04/08	2.08	21.8	21.8	7.38	7.22	83.0%	5	705	424	382	
	11/05/08	1.34	12.6	12.5	6.78	5.45	51.9%		858	<b>503</b>	466	
CMA Silver Brook nr Tiger Lily Lane	02/12/08	1.98	1.7	1.0	<b>6.23</b>	13.50	97.8%	13	423	277	273	
	05/06/08		14.0	14.4	7.45	10.34	101.4%		461	297	285	
	08/04/08		19.5	19.3	<b>6.30</b>	7.60	83.5%	16	481	307	260	
	11/05/08		11.8	11.6	<b>6.30</b>	6.52	60.9%		464	298	259	
HLT Bayne Brook at Wexford Lane	02/12/08	1.94	1.2	0.4	6.58	12.55	89.6%	2	436	284	276	
	05/06/08		16.0	16.1	7.30	9.87	100.7%		391	260	221	
	08/04/08		20.5	20.1	6.63	7.45	83.7%	11	548	342	303	
	11/05/08	0.70	12.0	11.7	6.52	7.75	72.4%		447	289	241	
GB3 nr Dickson's Mill Road	02/12/08		<-----Not measured----->									
	05/06/08	12.60	16.7	16.4	7.54	10.51	109.5%		505	320	294	
	08/04/08	5.94	25.3	25.3	7.17	7.35	90.7%	4	494	314	253	
	11/05/08	4.68	11.6	11.1	<b>6.02</b>	5.30	49.1%	11	396	263	221	
GB1 at Woodland Road	02/12/08		2.7	1.9	7.73	14.58	108.8%	2	435	283	279	
	05/06/08		10.6	14.4	6.96	9.55	86.8%		484	309	274	
	08/04/08	4.51	22.2	22.3	7.41	6.62	77.0%	10	485	309	282	
	11/05/08		11.3	11.1	6.58	5.25	48.6%	8	386	258	228	

1. Flow volume estimated using float travel time & stream X-section (Volunteer Stream Monitoring Partnership method)

2. Horiba U-10 multiparameter meter

3. TDS derived from Conductivity using best linear fit to GSWA data collected from 2007 through 2010:  $TDS (mg/l) = 0.52 \times \text{Conductivity } (\mu S/cm) + 57$ .

**Red** entries indicate failure to meet the applicable NJ Surface Water Quality Standard

## B2. On-site Measurements: Flow Volume and Meter Measurements, Great Brook, 2009

Sampling Site	Sampling Date	Flow Volume <sup>1</sup> cf/s	Water Temperature		pH	Dissolved Oxygen		Turbidity	Conductivity	Total Dissolved Solids	TDS
			T. Gauge	Horiba <sup>2</sup>	Horiba <sup>2</sup>	Horiba <sup>2</sup>	Approx. %	Horiba <sup>2</sup>	Horiba <sup>2</sup>	(from Conductivity) <sup>3</sup>	Lab results
			<sup>o</sup> C	<sup>o</sup> C		mg/l	of Saturation	NTU	µS/cm	mg/l	mg/l
GB5 below Foote's Pond (nr James St)	02/04/09	1.74	1.7		8.3	12.4	89.9%		3500	<b>1877</b>	<b>1830</b>
	05/13/09	0.62		18.8	7.64	8.74	95.0%	8	681	411	454
	08/12/09	0.67	26.4	27.3	<b>8.82</b>	9.15	114.4%	19	527	331	442
	11/04/09	0.85	10.0	8.9	7.21	8.25	73.7%	8	654	397	397
GB4 nr Laura Lane	02/04/09	2.63	2.3		8.2	15.8	116.2%		2800	<b>1513</b>	<b>1480</b>
	05/13/09	1.12		15.1	7.42	8.65	86.5%	4	789	467	483
	08/12/09	1.60	22.5	23.8	7.92	6.73	78.3%	5	533	334	431
	11/04/09	1.38	10.3	9.3	6.98	7.25	65.3%	1	762	453	418
CMA Silver Brook nr Tiger Lily Lane	02/04/09		2.0		7.0	13.4	97.8%		1600	<b>889</b>	<b>1220</b>
	05/13/09			12.0	6.59	10.32	96.4%	10	440	286	286
	08/12/09		20.6	23.7	7.78	6.17	69.3%	30	352	240	314
	11/04/09		9.4	8.6	6.91	7.69	68.1%	6	491	312	286
HLT Bayne Brook at Wexford Lane	02/04/09		0.9		6.9	12.1	85.8%		1100	<b>629</b>	<b>572</b>
	05/13/09	2.54		14.1	6.71	10.67	104.6%	15	386	258	241
	08/12/09	1.69		23.7	7.57	6.20	73.8%	6	315	221	270
	11/04/09		9.9	8.9	6.90	9.37	83.7%	4	419	275	249
GB3 nr Dickson's Mill Road	02/04/09	19.88	2.3		7.6	14.2	104.4%		2100	<b>1149</b>	<b>1050</b>
	05/13/09	9.25		16.4	7.20	10.39	107.1%	12	417	274	278
	08/12/09	6.42	24.9	25.6	<b>8.52</b>	6.96	84.9%	5	373	251	284
	11/04/09	10.7	11.5	10.8	6.75	9.03	83.6%	7	427	279	247
GB1 at Woodland Road	02/04/09		1.2		7.5	16.0	114.3%		1600	<b>889</b>	<b>751</b>
	05/13/09			15.3	7.49	10.29	105.0%	7	399	264	256
	08/12/09	9.22	23.3	24.4	7.61	6.28	74.8%	5	360	244	281
	11/04/09	12.8	10.0	9.2	6.54	9.51	84.9%	9	409	270	278

1. Flow volume estimated using float travel time & stream X-section (Volunteer Stream Monitoring Partnership method)

2. Horiba U-10 multiparameter meter

3. TDS derived from Conductivity using best linear fit to GSWA data collected from 2007 through 2010:  $TDS (mg/l) = 0.52 \times Conductivity (\mu S/cm) + 57$ .

**Red** entries indicate failure to meet the applicable NJ Surface Water Quality Standard

### B3. On-site Measurements: Flow Volume and Meter Measurements, Great Brook, 2010

Sampling Site	Sampling Date	Flow Volume <sup>1</sup> cf/s	Water Temperature		pH	Dissolved Oxygen		Turbidity	Conductivity	Total Dissolved Solids	TDS
			T. Gauge	Horiba <sup>2</sup>	Horiba <sup>2</sup>	Horiba <sup>2</sup>	Approx. %	Horiba <sup>2</sup>	Horiba <sup>2</sup>	(from Conductivity) <sup>3</sup>	Lab results
			°C	°C		mg/l	of Saturation	NTU	µS/cm	mg/l	mg/l
GB5 below Foote's Pond (nr James St)	02/17/10		2.3	2.0	7.08	10.45	76.8%		3450	<b>1851</b>	<b>1851</b>
	05/13/10	1.1	16.7	16.4	7.00	8.40	85.7%	20	582	360	363
	08/12/10			25.8	8.49	7.50	92.6%	46	736	440	<b>529</b>
	11/04/10	27.0		8.9	7.33	9.92	86.3%	<b>52</b>	309	218	206
GB4 nr Laura Lane	02/17/10		2.9	2.6	6.97	11.18	82.8%		2350	<b>1279</b>	<b>1419</b>
	05/13/10	7.1	13.6	13.1	7.00	8.78	85.2%	15	551	344	330
	08/12/10	1.0		23.3	7.00	8.85	104.1%	6	855	<b>502</b>	<b>598</b>
	11/04/10	20.6		8.5	7.36	8.71	75.1%	<b>62</b>	475	304	318
CMA2 Silver Brook at footbridge	02/17/10		3.6	4.0	6.16	10.81	82.5%		1610	<b>894</b>	<b>896</b>
	05/13/10	3.2	10.7	10.3	6.35	9.49	97.8%	11	426	279	271
	08/12/10	0.45		22.7	6.98	5.93	69.0%	10	469	301	352
	11/04/10			8.4	6.69	8.60	74.1%	<b>243</b>	278	202	192
GB3 nr Dickson's Mill Road	02/17/10		3.0	2.7	7.17	10.18	76.5%		1530	<b>853</b>	<b>813</b>
	05/13/10	16.4	13.7	13.7	6.96	9.49	92.1%	27	479	306	298
	08/12/10	0.74		25.5	<b>8.51</b>	8.07	98.4%	18	528	332	317
	11/04/10	43.2		8.8	7.37	10.05	87.4%	47	537	336	332
GB1 at Woodland Road	02/17/10		2.5	2.1	7.40	15.13	112.1%		1280	<b>723</b>	<b>684</b>
	05/13/10		12.2	12.1	6.86	8.07	75.4%	48	466	299	286
	08/12/10	3.0		24.1	7.52	8.62	102.6%	4	481	307	297
	11/04/10			8.0	7.04	8.57	73.2%	13	468	300	290
GBNWR at Pleasant Plains Road	02/17/10		1.0	1.0	6.39	8.93	63.3%		926	539	490
	05/13/10		12.0	11.8	6.69	6.97	65.1%	11	427	279	244
	08/12/10	2.4		24.5	6.90	8.32	100.2%	14	802	474	493
	11/04/10		SITE NOT ACCESSIBLE								

11/04/10 STORM FLOW CONDITIONS

- Flow volume estimated using float travel time & stream X-section (Volunteer Stream Monitoring Partnership method). No flow meas. on 2/17/10
  - Horiba U-10 multiparameter meter
  - TDS derived from Conductivity using best linear fit to GSWA data collected from 2007 through 2010:  $TDS (mg/l) = 0.52 \times \text{Conductivity } (\mu S/cm) + 57$ .
- Red** entries indicate failure to meet the applicable NJ Surface Water Quality Standard