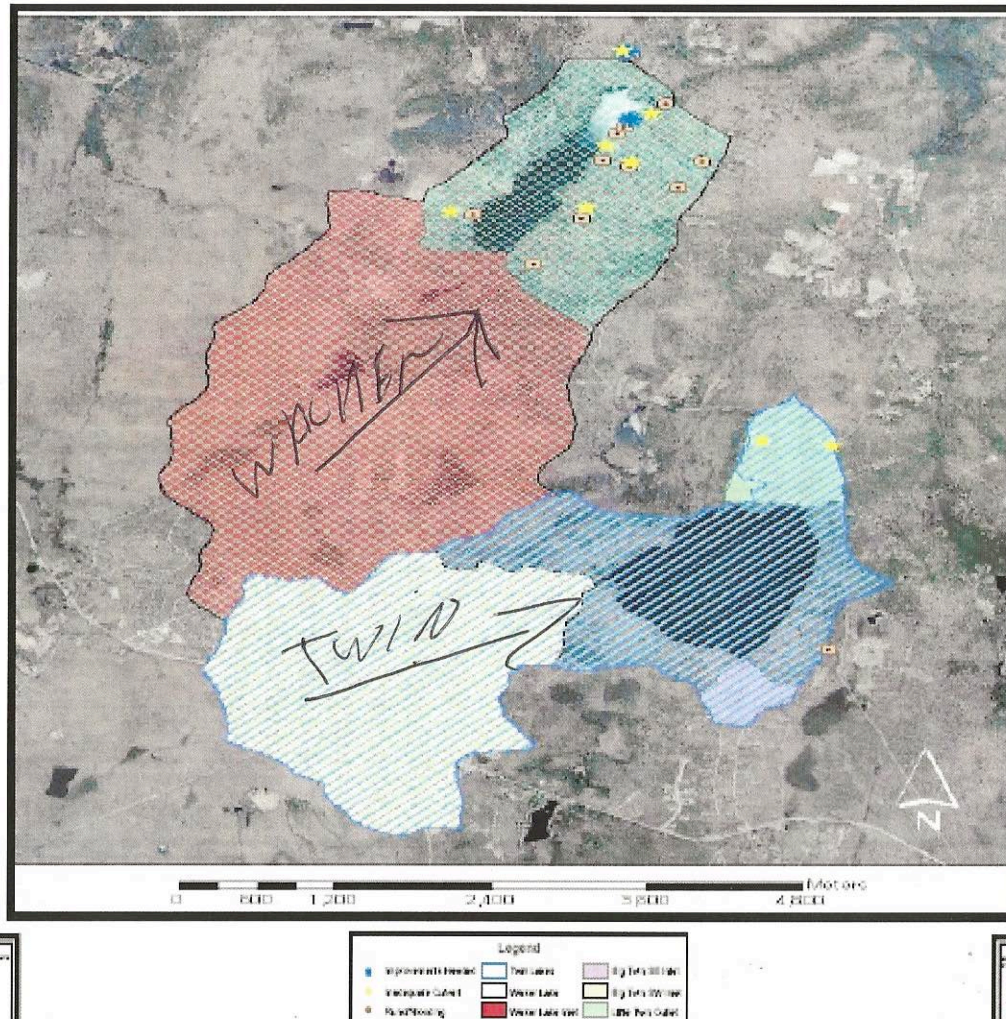
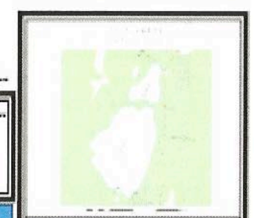
TWIN WALKER LAKE DRAINAGE ASSESSMENT





Source Stream Flow Statistics - Pennsylvania Stream Stats -http://water.usgs.gov/osw/streamstats/pennsylvania.html
Assuming Baseflow (0.74 of total flow) and Stormflow (0.26 of total flow)

Twin and Walker Creek Watershed
2008 Evaluation by Wilkes University
Through the Pocono Northeast RC&D Council and C-SAW Program

Review Report " 2008 Water Quality Monitoring – F. X. Browne, Inc."

1. The monitoring was limited to 3 or 4 sampling events on Big Twin, Little Twin, and Walker Lake samples that were collected by volunteers. During the field measurements, it appears the volunteers collected lake profile data. Field measurements were documented, including seechi depth, and the laboratory samples were tested for total phosphorous and chlorophyll a.

2. The F. X. Browne report indicates that the Big Twin and Little Twin Lake are classified as either mesotrophic and eutrophic, while Walker Lake is primarily classified as eutrophic. Because of the limited data, it is difficult to confirm a long-term trend, but it is likely that the Association has the data to conduct either a more detailed graphical analysis or statistical analysis of the data.

3. At a minimum, I would recommend that the Association consider plotting the following parameters by year – seechi, total phosphate, and chlorophyll a for each lake.

4. A base map for the project was generated and the GIS files are available at Wilkes University. The data was mapped using the ESRI ArcGIS programs and Trimble GPS units. The watershed boundaries and predicted pollutant loadings were calculated based on the available surface water quality data in the Twin – Walker Lake database, plus some grab samples collected by representatives of Wilkes University. The streamflow statistics presented in the attach base map were based on information download from the PA Stream Stats website – http://water.usgs.gov/osw/streamstats/pennsylvania.html.

5. The base map includes the data points that had been classified as critical areas.

6. During this analysis, it was not possible to calculate the watershed areas for many of the stormwater points of concern. Because of the road network and modified surface hydrology, this made this task very difficult within the time allocated for the project. With respect to the estimated watershed area for the stormwater critical areas and intermittent stream channels, it would be advisable to conduct a subsequent field assessment to evaluate the extent of the modified drainage area or watershed.

7. Preliminary annual pollutant loadings were calculated using the readily available data and assuming that baseflow accounted for 0.74 or 74 % of the total streamflow and stormflow accounted for 0.26 or 26 % of the total streamflow. This assumption was based on the information published for the Hydrogeology of Pike County, PA.

8. When evaluating the loading data, it is possible that the estimated storm runoff loading data is being underestimated. In general, there was a lack of stormwater event water quality data for the project and the default water quality parameter to calculate the stormwater loading would be the valuable used for baseflow conditions.

9. The mass loading data presented in this evaluation is not as detailed as the evaluation conducted by F. X. Browne, Inc. in 2003, but this data does provide some insights into the amount and flux of nutrients and sediment. From this preliminary analysis, it is clear that both Twin and Walker Lakes are discharging more total suspended solids then they receive. This reason is probably related to a change in the form of the solids. It is likely that the influent suspended solids is a relatively inert mixture of sand, silt, and clay with some organic material; while the discharge is mostly biosolids, i.e., algal material with some clay. Also, the phosphate loading data, strongly suggests that internal nutrient release or recycling plays a major role in the biological processed for the lake ecosystems, i.e., the estimated total phosphate discharge from the lake is greater than the estimated phosphate into the lake.

10. Again – the data analysis is limited to the readily available data and it is likely that the actual stormwater loads are higher than the levels suggested by this analysis.

Recommendations

a. It would be advisable for the organization to consider conducting the field measurements earlier in the season. If possible, the lake profile data collection should start in April or May and go to October and the Association should consider testing the inlet and outlet of the lake during baseflow conditions for total suspended solids and total phosphate.

b. From a review of the lake profile data, it appeared that some of the sampling occurred when the lake had a hypoliminion. During these periods, it would be advisable to collect a water sample from the photic zone and hypoliminion for total phosphate analysis.

c. The analysis prepared by F. X. Browne Inc. did not include a detailed analysis of the field data. This may not have been in the approved scope of work, but should be included in the scope of work for 2009.

d. With the exception of one detention limit of < 0.05 mg/L, it appears that the methods for total phosphate are suitable. The primary question is the form of the phosphate that is being reported. Is the phosphate result being reported as mg P/L or mg PO4/L ?

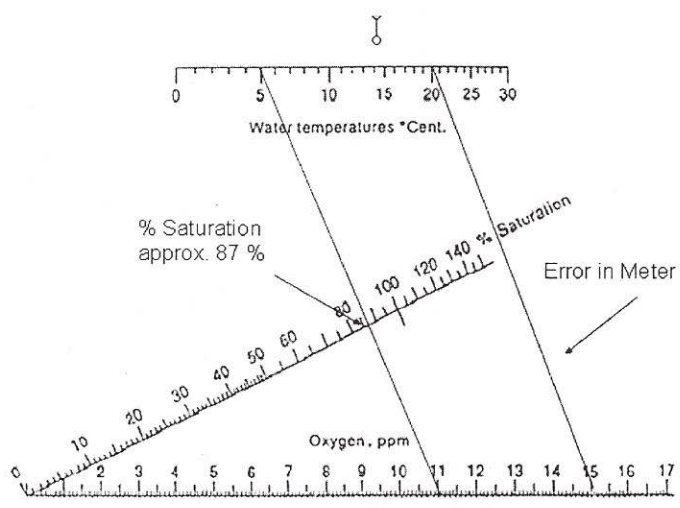
e. The seechi depth should be measured three times and all three readings recorded. The chlorophyll samples should be collected as an equal volume composite sample from the surface to 2x of the seechi depth or to a level where the dissolved oxygen concentration is < 2 mg/L.

f. If possible, the chlorophyll testing should include the testing for pheophytin.

g. The lake should consider conducting some phytoplankton and zooplankton analysis throughout the season. The sampling for phytoplankton is the same as chlorophyll, but the zooplankton analysis requires a Wisconsin Net. This type of information would be critical for the development of a long-term management plan for the lake and determine the relative amounts and percentage of blue-green algae.

h. The Association may want to consider updating the macrophyte inventory and a baseline evaluation for aquatic invasive species. This assessment was last conducted in 2001.

i. Regarding the field monitoring, it would be advisable to document the DO % saturation. Since the monitoring is being done with a YSI Meter, the meter will automatically calculated the percent saturation as a function of temperature or this field chart could be used. For example, temperature 5 C and 11 ppm O_2, - the percent saturation is about 87%. If the temperature was 20 C and the meter read 15 ppm O_2 – this would mean the saturation is over 140% (probably an error)



j. The available information did not clearly show the frequency that the YSI unit was calibrated. Wilkes University did calibrate the unit and clean the unit at the beginning of the 2008 season. In addition, Wilkes University did participate in training some of the volunteers.

k. Stormwater Sampling – At the stormwater points that have been ranged It would be advisable to conduct at least 3 stormwater samples throughout the year. At each stormwater monitoring site, the following field data should be recorded: pH, temperature, dissolved oxygen, DO % saturation, specific conductance, water appearance, and other observations. A water sample should be collected and tested for total suspended solids, volatile suspended solids, and total phosphate.

l. There appears to be overlap in the watershed areas for the various sub-basins. Based on the approved budget, it was not possible to visit and field verify the boundaries to make the necessary changes and updates to the watershed shapefiles available through the USGS.

Respectfully submitted,

Mr. Brian Oram, PG
Wilkes University

Memo

March 19, 2008

To: Mr. Peter Wulfhorst
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From: Mr. Brian Oram
Wilkes University
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RE: Twin & Walker Creek Watershed Conservancy – C-SAW Program Assistance

As per your request to the C-SAW Program, I have completed a review of the available water quality data for your projects. This evaluation was not a statistical analysis of the data, but a review of the findings, conclusions, and protocols being used to monitor/track lake quality. This report was prepared based on the understanding that the Conservancy collects one water sample from each lake during the period from June to September. The field evaluation appears to be limited to documenting the secchi depth and collection a surface water sample for total phosphorous and chlorophyll a analysis for the 4 month period.

During the review, it did not appear that the Conservancy was monitoring the general water quality of the lake or conducting a dissolved oxygen/temperature profile. In addition, the information suggested that the secchi depth was taken at one point on the lake and only one reading was recorded. Based on this field sampling protocol, the following are my general recommendations:

a. the frequency of field data collection should be increased to at least twice a month or weekly;

b. during the field evaluation the following data should be recorded, pH, dissolved oxygen/temperature profile, secchi depth (3 readings), and water appearance;

c. the Conservancy has other quality monitoring instruments that are not being used to monitoring lake and/stream quality; and

d. if the Conservancy had adequate funding, it may be advisable to expand the lake monitoring to include phytoplankton and zooplankton analysis.

To the best of my knowledge, your current lake consultant has the ability to conduct phytoplankton and zooplankton analysis.

Regarding watershed monitoring, the Conservancy may want to include conducting some stormwater monitoring and monitoring the surfacewater influents to the lake. If the Conservancy did not have the funding to pay for laboratory support, the Conservancy could use the available field equipment to track the general quality of the surfacewater. Based on my review of the equipment that is currently available, it may be advisable for the Conservancy to consider purchasing the following items:

a. Hach - Imhoff cone – to estimated the amount of settleable solids in a sample.
Product No. 206700 – approximately $ 27.00. *

b. Turbidity or Transparency Tube – Not 100 % sure of the part number for Hach– there was no photo on the companies website. |
Hach Product No. 6301000 – approximately $ 34.42. *
Forestry Supplies -77096 - 120cm Transparency/Turbidity Tube- $ 53.95 *.

c. Hach – Colorimeter II (nitrate+nitrite- detention limit – 0.40 mg/L)*
Product No. 587002 – $ 370.00

d. Hach – Colorimeter II (phosphate – detention limit – 0.02 mg/L)**
Product No. 587006 – $ 370.00

*Monitoring suitable for screening surfacewater samples – urban runoff.
** Monitoring generally suitable for surfacewater or groundwater monitoring of private wells.

If these items were purchased, Wilkes University would be happy to provide training in the use of this equipment.

Regarding the calibration and evaluation of the current equipment, Wilkes University has not completed that portion of the assistance. We would be happy to schedule a time to pick-up the equipment and evaluate the accuracy and calibrate the equipment. If necessary, we can provide basic maintenance and cleaning for the equipment and provide some supplementary reagent sets.

Walker Lake

The lake is associated with a watershed area of 2130 + acres. The lake has a surface area of 109.2 acres and average depth of 6.86 feet, but a maximum depth of 23 feet. The lake appears to have a baseflow that is equivalent to 0.00249 MG/d/acre or 76 % of the flow. based on a review of the available topographic and land-use data, it appears that most of the watershed is undeveloped woodland. The developed area is along the eastern boundary of the lake than the area appears to consist of rural residential housing that relies on land-based wastewater disposal and private wells. In general, the existing development and local road area lack the necessary stormwater control structures to manage stormwater volume. Based on the geological structure, the residential development is hydraulically upgradient of Walker Lake.

Because of the lower resident time in Walker Lake as compared to the other lakes, it is possible that Walker Lake would demonstrate a more rapid change in water quality in response to the implementation of appropriate best management practices within the watershed. Because the lake is strongly supported by baseflow, this means that the lake may show improvement when direct surfacewater inputs are reduced, such as during a "drought" year. The high baseflow for the lake means that the long-term management of the lake will need to include direct runoff into the lake, indirect recharge for the area around the lake, and proper nutrient management within the headwaters. In order for the watershed to maintain a high baseflow and assuming that a portion of the watershed is developed, the development of the watershed area will need to integrate low impact development and groundwater recharge.

From a review of the water quality data, Walker Lake would be classified as eutrophic. A trend analysis of the data was not completed. The trophic status based on chlorophyll and secchi depth suggests that the trophic status is unchanged, but the trend in the phosphate index suggests that trophic status is improving. Since this data may not help demonstrate the improvements and changes in the lake system, the primary recommendations were to conduct more frequent observations of the secchi depth and the population of the primary producers in the lake. As previous stated, it would be advisable for the Conservancy to conduct additional field monitoring assessments and consider monitoring the phytoplankton and zooplankton populations in the lake. At a minimum, the additional field monitoring should include more frequent measurements of secchi depth and pH and monitoring the dissolved oxygen/temperature profile of the lake.

Since most of the development is concentrated in the immediate vicinity of the lake, it is likely that decreasing the anthropogenic sources of pollutants via direct and indirect input would have a significant impact on water quality. During the on-site visit, it was clear that the primary problems are related to the lack of stormwater control measures and poorly designed culverts. The non-point source inventory indentified and prioritized the sources of non-point source pollution in a portion of the watershed for Walker Lake. From the available information, there appears to be over 20 sites in the vicinity of Walker Lake. During period from April to September 2008, we will be conducting an on-site survey of these areas. This survey will include photo documentation and if possible monitoring flow and background water quality.

Because of the number of sites that were identified and limited nature of funding, the Conservancy should select a variety of sites that could be used to demonstrate a range of stormwater management structures. With this approach, the Conservancy may be able to use this improvements as part of a "demonstration/implementation" project. From a review of the priorities, it may be advisable for the Conservancy to target BMP as clustered units. For example:

a. Site # 2, 3, 4, and 11 – Site # 4 has the highest priority and includes stabilizing the road, installing a retention basin near the culvert, and retention basin near the lake;

b. Site # 9, 17, 18, 19, 20 – improve culvert design or add culvert and add grass swales and consider wetland BMP;

c. Site #5, 6, and 7 – install rock channel, grass swales, infiltration trench, catchment basin, remove gravel bar and sediment, porous pavers for parking area, and consider some engineered sediment catchment or containment systems.

d. to promote some fire-flow protection, the Conservancy may want to consider the placement of wet detention basins or subsurface storage systems for stormwater control and fire protection; and

e. the Conservancy could consider purchasing lots or land to preserve the area as forest land or to permit the installation of bioretention areas or stormwater control features.

Walker Lake – Management Issues

The most appropriate management strategies that could be implemented or encouraged by the Conservancy for Walker Lake are listed.

1. Encourage, establish, and maintain shoreline set-backs or buffer zones and encourage the use of native vegetation or landscape features.

2. Install or maintain appropriate stormwater BMP's within the area controlled by the Conservancy and its partners and encourage the installation of stormwater BMP's for the direct runoff from roads maintained by the Township or other authorities.

3. Where possible encourage private landowners and homeowner to install stormwater management systems, such as water gardens and subsurface retention structures, maintain native vegetation, and limit the use of commercial fertilizers.

4. Encourage septic system owners to properly maintain system and potential encourage the use of alternative pretreatment systems or drip irrigation systems that would reduce the phosphate levels in the applied wastewater. In part, this could be accomplished by developing a local agency septic system operation, maintenance, and mandatory pumping program.

5. Because the lake has a high baseflow, the Conservancy could encourage testing of private wells for general water quality, including phosphates. This results of this testing could help to identify areas where the wells may be poorly constructed or areas where septic system may not be operating properly.

6. For lands not controlled or directly influenced by the Conservancy, the Conservancy should encourage maintaining forested and/or riparian zones, low impact and clustered developments, individual or decentralized land-based disposal, well construction standards, and development of on-site sewage management programs.

Walker Lake – Monitoring

Regarding the monitoring for Walker Lake, the primary recommendations are listed:

a. starting in April or ice off, the Conservancy on a monthly basis should monitor the lake using the available field equipment;

b. field monitoring should include secchi depth, lake depth, pH, dissolved oxygen, and temperature;

c. starting in June through September, the Conservancy should attempt to record the secchi depth and pH on a weekly basis;

d. the Conservancy may want to conduct some stormwater monitoring either visual and/or laboratory support to better identify and prioritize tributaries and non-point sources of population based on loadings; and

e. if adequate revenue is available, it would be advisable to collect a monthly phytoplankton and zooplankton sample for laboratory analysis.

Little Twin Lake

The lake is associated with a watershed area of only 124 acres. The lake has a surface area of 54.83 acres and the average depth of the lake is 20.7 feet, but the maximum depth is 49 feet. The lake appears to have a baseflow that is equivalent to 0.00213 MG/d/acre or 76 % of the annualized flow. From a review of the available data, the watershed area appears to consist of undeveloped woodland and rural residential housing. The flow within the lake ecosystem is supported by baseflow and then to a lesser extent by direct runoff from the watershed. There does not appear to be any first order stream entering Little Twin Lake, but there are likely gullies and seepages. Because of the lake size, depth, and flow regime, the lake has an estimated residence time of over 3.84 years. From a review of the water quality data, the lake would be classified as mesotrophic.

Little Twin Lake – Pollution Sources

Because of the lake location and position, the primary nutrient and sediment inputs would be associated with direct runoff/erosion, baseflow additions, and internal nutrient recycling. Because most of the development within the watershed is rural residential housing and local roads, the primary recommendations would be to stabilize roads and drainage structures using methods that would promote retention/recharge, decrease velocities, and limit nutrient/solid migration. Within this watershed, it is possible that anthropogenic sources of nutrients, such as: fertilizers and partially treated wastewater, are the primary sources of nitrogen and phosphate. For this area, it may be advisable to promote the use of on-lot disposal systems that maximize the retention of nutrients in the roots zone or pretreatment systems to reduce nutrient input.

For the watershed area upgradient of Little Twin Lake, the Conservancy has indentified three areas with non-point source pollution problems. During period from April to June 2008, we will be conducting an on-site survey of these areas. This survey will include photo documentation and if possible monitoring flow and background water quality.

Site # 24 and 25 – the primary problems appears to be hydraulic overload or flooding because of improper channel sizing and stability of the ditch.

Site # 31 – installation of rock-lined channel, infiltration swales, and possibly constructed wetland systems.

The Conservancy may want to consider conducting a survey of this area to determine if stormwater management features could be installed higher in the watershed profile. The Conservancy with local partners and homeowner support should attempt to install stormwater management systems upgradient of Site # 24 and 25.

Big Twin Lake

The lake has a surface or topographic watershed area of 1768+ acres. The lake has a surface area of 285.5 acres and average depth of 23.8 feet, but a maximum depth of 43.8 feet. The lake has a baseflow of 0.00152 MG/d/acre or 48% of the annualized flow. The lake is surrounded by rural residential and residential development using a combination of paved and dirt/gravel roads, on-lot septic systems, and private wells. The lake ecosystem is supported by a combination of direct runoff and groundwater discharge. Because of the configuration of the lake, the estimated hydraulic residence time is 2.26 years, but because of the configuration of the lake the nutrient residence time is likely significantly longer. The available water quality data indicates that the lake is classified as mesotrophic.

Big Twin Lake – Pollution Sources

Because of the location of Little Twin Lake, it is possible that Little Twin Lake is acting as a forebay for Big Twin Lake. For Big Twin Lake, the primary nutrient inputs would include direct runoff/erosion, dissolved nutrients in baseflow, and internal nutrient recycling. Because most of the development within the watershed is rural residential and secondary roads, the primary recommendations would be to stabilize roads, driveways, and drainageways using methods that would promote water retention/recharge, nutrient uptake, and minimizing erosive velocities.

For the watershed area upgradient of Big Twin Lake, the Conservancy has indentified four areas with non-point source pollution problems. At this time, I have not been able to visit these sites. During period from April to June 2008, we will be conducting an on-site survey of these areas. This survey will include photo documentation and if possible monitoring flow and background water quality.

Site # 21 – along Twin Lakes Road there area some drainage channels, but the channels are not adequate sized, lack stability, and have exposed soil surfaces. This condition causes the road to flood. Along this area there appears to be sufficient area to install a series of depression storage structures to decrease peak flows and control sediment movement. On the downgradient side of Twin Lake Road, there does appear to be undeveloped areas that would facilitate siting stormwater management structures.

Site # 22, 23, and 29- the primary issue is flooding because of the lack of stormwater features to decrease peak flows. In addition, the stormwater channels are not adequately sized. This condition could be improved by stabilizing the channels and installing stormwater management structures to control peak flows and grass lined swales and bioretention systems along the corridor or just upgradient of the lake.

Site # 30- for this area it appears that the area lacks drainage control structures and conveyance systems.

Big/ Little Twin Lake – Management Issues

The most appropriate management strategies that could be implemented or encouraged by the Conservancy for Big and Little Twin Lake are listed.

1. Encourage, establish, and maintain shoreline set-backs or buffer zones and encourage the use of native vegetation or landscape features.

2. Install or maintain appropriate stormwater BMP's within the area controlled by the Conservancy and its partners and encourage the installation of stormwater BMP's for the direct runoff from roads maintained by the Township or other authorities.

3. Where possible encourage private landowners and homeowner to install stormwater management systems, such as water gardens and subsurface retention structures, maintain native vegetation, and limit the use of commercial fertilizers.

4. Encourage septic system owners to properly maintain system and potential encourage the use of alternative pretreatment systems or drip irrigation systems that would reduce the phosphate levels in the applied wastewater. In part, this could be accomplished by developing a local agency septic system operation, maintenance, and mandatory pumping program.

5. For lands not controlled or directly influenced by the Conservancy, the Conservancy should encourage maintaining forested and/or riparian zones, low impact and clustered developments, individual or decentralized land-based disposal, well construction standards, and development of on-site sewage management programs.

6. The Conservancy or other Associations or Trusts should consider purchasing vacant lost and lands to provide areas for the installation of BMPs or maintaining forest habitat.

Big/ Little Twin Lake – Monitoring

Regarding the monitoring for Big/Little Twin Lake, the primary recommendations are listed:

a. starting in April or ice off, the Conservancy on a monthly basis should monitor the lake using the available field equipment;

b. field monitoring should include secchi depth, lake depth, pH, dissolved oxygen, and temperature;

c. starting in June through September, the Conservancy should attempt to record the secchi depth and pH on a weekly basis;

d. because of the lower base flow for Big Twin Lake, it is critical that the Conservancy conduct some stormwater monitoring either visual and/or laboratory support to better identify and prioritize tributaries and non-point sources of population based on loadings; and

e. because of the lower trophic status, it would be advisable to at least conduct phytoplankton analysis when the chlorophyll **a** in the lakes peak.