Buckeye Lake
Nutrient Reduction Plan

Prepared For:
Ohio Environmental Protection Agency

Prepared By:
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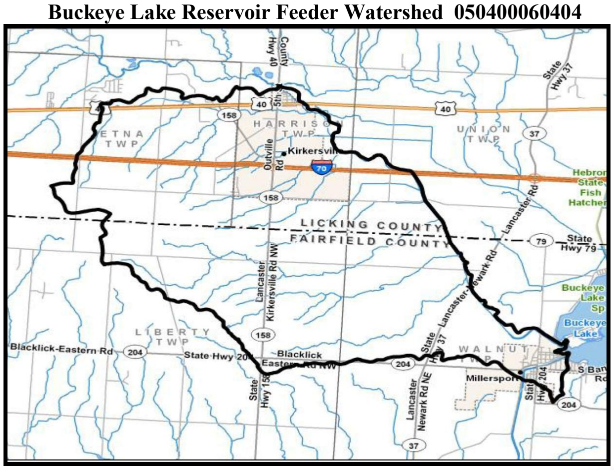
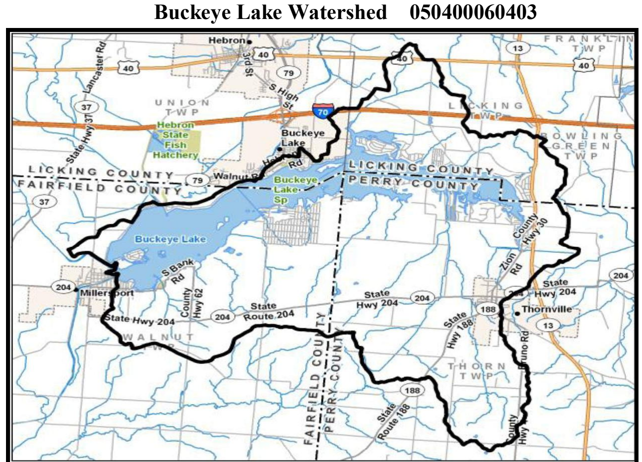
1.0 Background

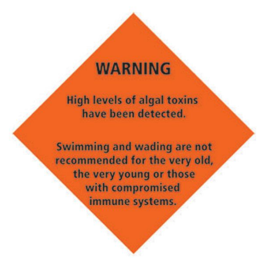
Buckeye Lake is located approximately 30 miles east of Columbus, Ohio. It has a surface area of approximately 3,200 acres and an average depth of approximately 5 ft. The lake provides aquatic habitat for a variety of freshwater species and recreational opportunities for a large number of people living throughout the State of Ohio.

Buckeye Lake Reservoir Feeder Watershed 050400060404



Buckeye Lake Watershed 050400060403





Buckeye Lake has reached hypereutrophic condition. Algal blooms and low dissolved oxygen levels caused by elevated nutrient concentrations [nitrogen and phosphorous] in the water column and sediment have become common and excessive. These water quality conditions have caused fish kills and may cause an unsafe setting for citizens who recreate on and in Buckeye Lake.

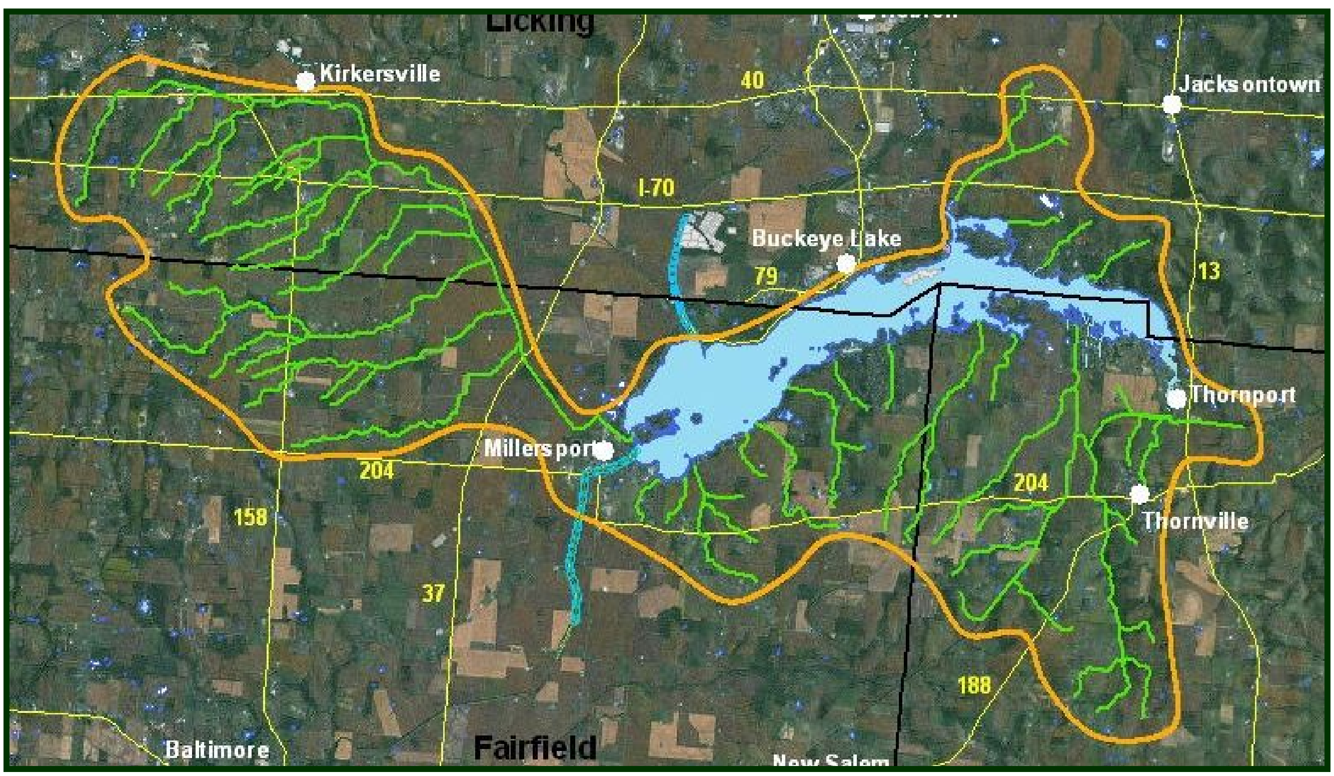
Eutrophication is the process by which impoundments age and become more productive – i.e. experience enhanced plant and algal growth. Excess plant and algae growth is primarily caused by the nutrients phosphorous and nitrogen added to a water body. Eutrophication accelerates the aging process via increased siltation and loss of dissolved oxygen. The U.S. Environmental Protection Agency reported in 2002 that an estimated 20% of the nation's rivers and 50% of the nation's lakes were impaired due to nutrient enrichment.

Cultural eutrophication is the process whereby human activity accelerates eutrophication by facilitating enrichment. Human activity exacerbates nutrient over-enrichment in two ways – 1) point sources, i.e. sewage treatment facilities; and 2) nonpoint sources, i.e. the nutrient-laden runoff from residential and agricultural land within the contributing watershed. Estimates indicate that the relative contribution of nutrient loading to streams and lakes from point sources can range from 5-30% annually, with nonpoint source sources responsible for the remainder. Nonpoint source loading is primarily dependent on rainfall amount and its intensity as well as the extent and effectiveness of agricultural and urban conservation practices.

Total phosphorous [TP] has been implicated as the limiting nutrient contributing to algal blooms in most lakes/reservoirs within the State, and is likewise the primary nutrient requiring control in Ohio. Increases in TP loading can cause the production of algae and/or plants which have the potential to adversely affect biological diversity, water quality, and drinking water quality. In particular, when phosphorus is available in excessive amounts, blue-green algae or cyanobacteria can dominate or overtake green algae and diatoms. Cyanobacteria cause taste and odor problems with drinking water and produce toxins that can affect the health of humans and animals.

In order to facilitate nutrient reduction and mitigate eutrophication with its attendant negative impacts, Buckeye Lake for Tomorrow has developed this Nutrient Reduction Plan. While the positive effects of nutrient reduction and control will probably not be noticed immediately, the Plan provides a framework for making meaningful long-term reductions in nutrients whereby sustained long term improvement in water quality within the watershed and in Buckeye Lake will be achieved.

Local citizen organizations, including Buckeye Lake for Tomorrow [BLT] and Buckeye Lake Area Civic Association [BLACA] have worked for several years in partnership with the State of Ohio Department of Natural Resources [ODNR] and Environmental Protection Agency [OEPA] to document and understand the concentration of Nitrogen and Phosphorous in Buckeye Lake. OEPA requires the development of a Nutrient Reduction Plan for Buckeye Lake so that efforts are strategically focused to effectively reduce tributary inputs to the lake and also to control the cyclical release of phosphorus from in-lake sediment.



Buckeye Lake Watershed

2.0 Goals and Outcomes

The primary goal of the Nutrient Reduction Plan is to achieve the level of water quality needed to support aquatic habitat and recreational activities. As a minimum, the goal includes:

- Prevention of excessive and potentially harmful algal blooms
- Minimization of periods where dissolved oxygen depletion leads to fish kills in the lake

This Plan documents the reduction strategy, and is intended to provide EPA and the public an understanding of the processes and methods we believe can be effectively used to reduce nutrients in Buckeye Lake and the tributaries located across the watershed. Through the Plan, a series of actions are outlined that would ultimately result in improved local water quality as well as meet the responsibility to protect downstream water quality.

It is expected that if the targets for improved water quality can be met, then the fish kills and other aesthetic impairments to recreational uses will be reduced, if not completely eliminated. It is also assumed that nutrient concentrations in the water column must be significantly reduced in order to achieve the desired outcome. Therefore, the OEPA has adopted numeric targets for certain chemical concentrations in Buckeye Lake. These chemical targets were intended to ensure water quality objectives that prohibit the discharge of substances that cause excessive algae growth or other undesirable conditions.

Water Chemistry Indicators and Load Allocations* for Buckeye Lake

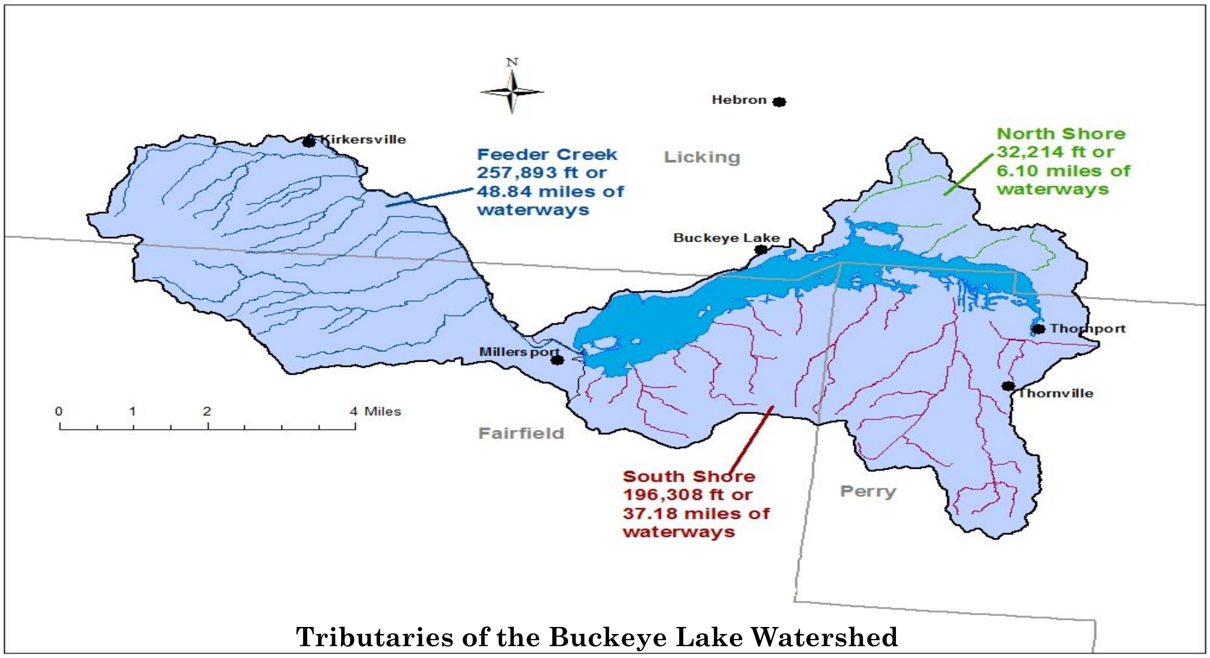
Indicator	**Final Target**
Total Phosphorous [TP]	Annual average no greater than 50 ug/L
Total Nitrogen [TKN]	Annual average no greater than 500 ug/L

Indicator	**Current Level ***	**Final Target**	**Required Reduction**
TP in Lake	204 ug/L	50 ug/L	154 ug/L
TP in Tributaries	172 ug/L	50 ug/L	122 ug/L
TKN in Lake	2500 ug/L	500 ug/L	2000 ug/L
TKN in Tributaries	1160 ug/L	500 ug/L	660 ug/L

* Current averages for all 17 sites taken on the following dates: 8/3/10 6/3/11 8/24/11

**Daily load targets and load allocations for Buckeye Lake and the tributaries that make up the Buckeye Lake Watershed are currently being redefined and calculated by the Ohio Environmental Protection Agency and will be included by addendum when available.*

3.0 Non-Point Source Nutrient Control Strategies



On June 28, 2013 the State of Ohio finalized Ohio's Nutrient Reduction Strategy. The action items contained in the Strategy have direct applicability to activity that would help reduce nutrient inputs from the landscape and watersheds draining into Buckeye Lake (as shown above). References to Ohio's Nutrient Reduction Strategy are provided in this section.

Agricultural Nutrient Reduction Strategies for Water Quality Protection

- Improve Upland Management Actions
- Improve Livestock Management Actions
- Improve Drainage Water Management Actions
- Practice Sound Riparian Area Management
- Improve In-Stream Management Actions

Recommended Management Practices to Prevent Agricultural Nutrient Losses to Surface Waters

Considerable improvements are needed for on-the-ground conservation practices that specifically focus on nutrient reduction and water quality protection and improvement. In addition to traditional goals of reducing erosion, it is becoming apparent that a concerted effort is needed to improve drainage water management. The increased percentage of cropland receiving systematic subsurface drainage is causing significant alterations to the physical integrity and hydrology of Ohio's streams. Management practices that improve a stream's capacity to assimilate existing pollutant loads also are needed to round out a comprehensive strategy for reducing the impact of nutrients running off the agricultural landscape and into Ohio's rivers and streams, and ultimately our lakes. The following practices are recommended as the most promising means of reducing the loss of nutrients from agricultural land use to surface waters. These recommendations are based in part on a ranking of the effectiveness of Ohio-USDA NRCS practices.

3.1 Upland Management Practices

3.1.1 Increase whole farm conservation planning so that water quality related resource concerns are prioritized for agricultural best management practices (BMP) selection and implementation.

Whole farm conservation planning and conformance with such plans has given way to more specialized plans such as nutrient management plans and/or grazing plans. This change occurred over a period of time and was the result of shifting priorities and changes in state and federal funding for agricultural cost-share practices and programs. Operations need to be evaluated holistically so all necessary BMPs are installed and working together to maximize nutrient reductions. Critical locations where nutrient losses occur must be identified so appropriate conservation measures can be implemented. It is also important for appropriate conservation practices to be designed and installed according to a whole farm conservation plan.

3.1.2 Erosion and sediment loss are significant contributors of nutrients to surface waters. Further reducing erosion is a critical goal in achieving measurable improvements in water quality.

A variety of best management practices have been designed and deployed for the control of erosion and to prevent the loss of soils from the agricultural landscape. Specific practices that are recommended for achieving measurable soil erosion reduction include the following practices.

3.2 Grassed Waterways:

Provided that they are strategically located in areas where ephemeral gully erosion is occurring, grassed waterways may be effective practices to reduce erosion and sediment loss, thereby reducing the input of nutrients into streams. It is imperative that design and installation of these practices be done to enable their full nutrient reduction capabilities to be achieved.

3.3 Treatment Filter Areas (Per Ohio-NRCS FOTG Standard):

For decades, the conservation practice of choice for many agricultural producers as well as conservation professionals has been the “grass filter strip.” However, the common “filter strip” practice of placing 30 to 100 foot wide bands of grass vegetation parallel to streams and water-ways has historically been installed under the Farm Service Agency Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP) per the NRCS Conservation Cover standard 327. As a result, these projects should not be equated with filter areas designed under NRCS 393 specifications. Conservation Cover installations plant grass only, and Treatment Filter Areas are designed and installed in areas where flow concentrates so that runoff can successfully be dispersed and passively treated as it flows into and passes through these filter areas.

3.4 Cover Crops:

Cover crops were first used in the Buckeye Lake Watershed, as a demonstration tool for managing excess nutrients, in the summer of 2011. The Buckeye Lake Nutrient Reduction Strategy encourages the planting of cover crops as a part of long term conservation crop rotations.

Cover crops provide multiple benefits including:

- Increasing soil organic matter to improve soil moisture holding capacity
- Maintaining a living root in the soil most of the year to uptake or scavenge excess nutrients
- Adding crop diversity to improve microbial communities
- More effective assimilation of applied nutrients in soils

3.5 Minimally Invasive Tillage Practices:

Minimally invasive tillage practices (also known as conservation tillage) such as no-till, strip till and/or mulch tillage are effective tools for reducing soil erosion and therefore retaining nutrients on harvested farm ground. Minimally invasive tillage such as strip till disturbs only 10-15% of the soil surface allowing for improved fertilizer efficiency and less soil erosion than traditional tillage practices.

USDA / NRCS practices that encourage minimally invasive tillage include:

- No Till/Strip Tillage
- Mulch Tillage

3.6 Install Retention Devices to Interrupt Surface Runoff and Drainage Tile Discharges:
Current agricultural drainage practices are designed to remove water quickly from fields through both surface and subsurface drains. Drainage has resulted in significant alterations to the hydrology and physical integrity of streams throughout the Buckeye Lake Watershed. Any effort to reduce erosion and improve water quality requires a commitment to better manage the flow of this nutrient rich drainage water. Retention structures such as passive treatment wetlands, storm water ponds and/or structures are encouraged. Several USDA / NRCS eligible best management practices that meet this need include:

- Structure for Water Control
- Sediment Basin
- Water and Sediment Control Basin
- Constructed Wetland
- Wetland Restoration
- Wetlands Creation
- Wetland Enhancement
- Drainage Water Management

3.7 Increase the retirement of marginal and highly vulnerable lands
Challenging economic conditions in recent years have contributed to continuing production on lands that are marginally productive and/or highly vulnerable riparian areas. With increased risk to flooding and high levels of nutrient loss the retirement of these vulnerable lands should become a priority. Land rental rates and cost-share amounts provided by USDA through programs such as the Conservation Reserve Program (CRP). The following table illustrates the current acreage enrolled in the Conservation Reserve Program across the Buckeye Lake Watershed.

HUC Code (12 digit)	CRP Practice	Clarification	# of Practices	Total Practice Acres
050400060403	CP1	Permanent Grasses and Legumes	1	18.51
[Buckeye Lake Watershed]	CP2	Permanent Native Grasses	1	17.59
	CP3A	Hardwood Tree Planting	6	3.83
	CP10	Vegetative Cover Grass	7	39.00
	CP21	Filter Strips	13	22.86
	CP25	Rare and Declining Habitat	2	11.50
	Total		**30**	**113.29**
050400060404	CP3A	Hardwood Tree Planting	2	4.44
[Buckeye Feeder Watershed]	CP4D	Permanent Wildlife Habitat	1	27.26
	CP8A	Grass Waterways	9	6.70
	CP10	Vegetative Cover Grass	1	8.59
	CP11	Vegetative Cover Trees	4	37.95
	CP21	Filter Strips	7	4.74
	CP29	Marginal Pastureland Wetland Buffer	5	8.96
	Total		**29**	**98.64**

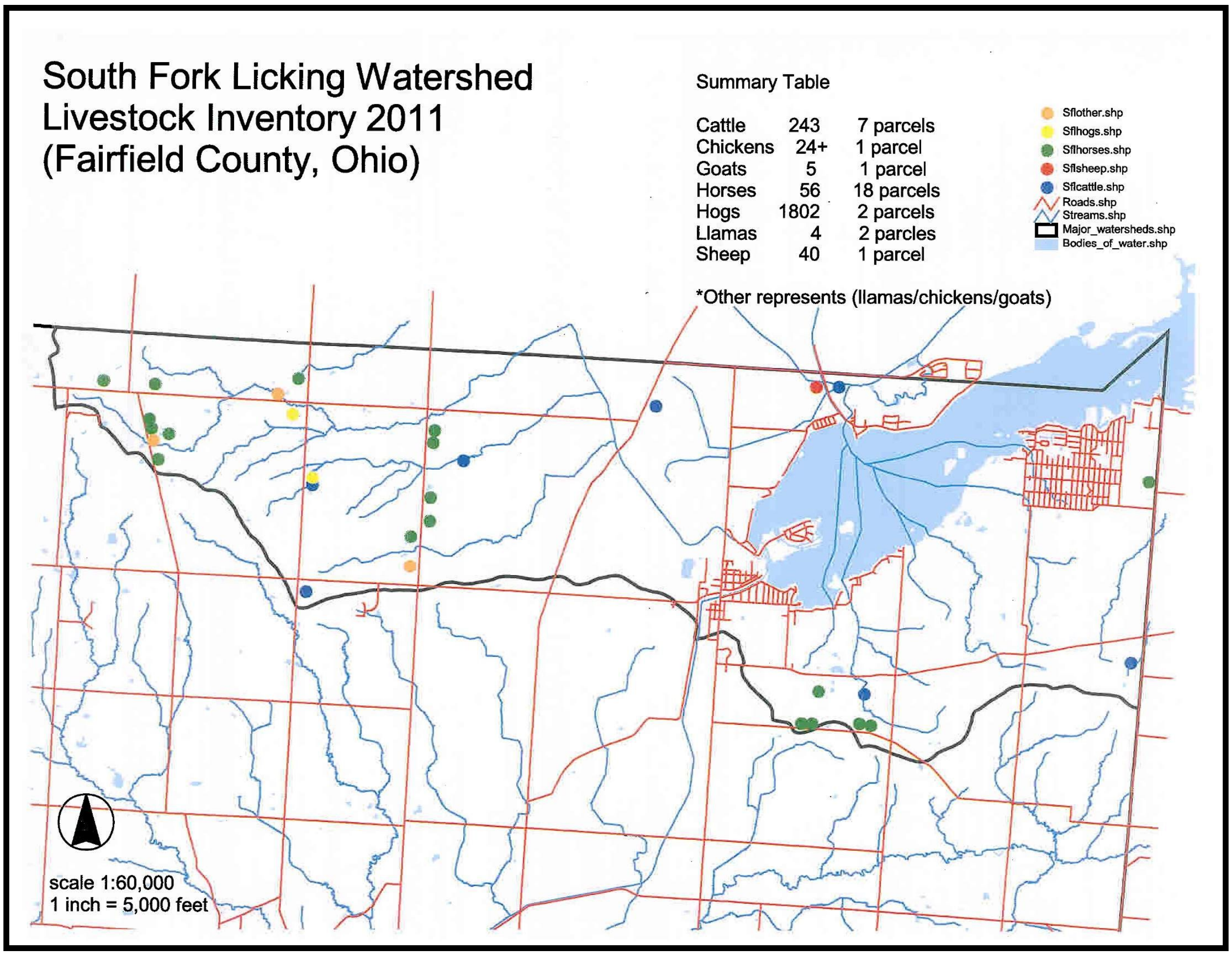
3.8 Manure, sludge and fertilizer application should be limited to only those levels that meet agronomic need of the crop(s) being grown.

The application of manure from livestock operations should be focused on utilizing the manure as a nutrient substitute to commercial fertilizer. Manure has high levels of phosphorus. If manure is applied in excess amounts, in vulnerable locations, or shortly before snowmelt or rainfall, the result may be very high levels of dissolved phosphorus moving from the field application site and into nearby waterways. This can result in fish kills and algae blooms.

The application of sludge from waste water treatment plants, like manure, should be focused on utilization as a substitute to commercial fertilizer. Like manure, some sludge has high levels of phosphorous and if applied in excess amounts may result in high levels of dissolved phosphorous moving from the field to nearby waterways.

Nutrient inputs, whether from manure, sludge or commercial fertilizer sources should be applied using the following guidelines:

- Develop and implement a nutrient management plan
- Manage fertilizer using the “4Rs” (Right source, Right time, Right place and Right rate)
- Use precision nutrient management practices and methods
- Only apply manure, sludge and fertilizer based on current soil sample tests
- Do not apply phosphorus if soil test levels are already greater than agronomic need
- Eliminate broadcast application of fertilizer unless readily incorporated or applied to a growing crop



Provided by Amy Boyer, Fairfield Soil and Water Conservation District

3.9 Reduce the rate and amount of runoff

Perhaps the single most important action that can be taken to reduce nutrient loadings and impacts on streams is to reduce the rate and amount of runoff from agricultural production areas. For decades, grass filter strips have been advocated as important tools to provide a buffering media for sheet flow runoff and cost share funding has resulted in the installation of many thousands of acres of these practices. Unfortunately, a significant percentage (estimated at between 25-75% in any given year) of the total drainage from farm fields in Ohio is flowing through sub-surface tiles and discharges directly into waterways without ever passing through a filter strip. There is a real need to design and install more effective buffers—filtering areas rather than strips specifically designed to capture, retain or disperse runoff. The challenge is convincing farmers and other landowners that these alternative drainage designs can be installed while still maintaining the overall functionality of the drainage systems. Reducing the rate and amount of runoff will require:

- ➢ Designing and installing more effective edge of field buffer areas to retain and/or disperse storm water runoff from fields
- ➢ Install water control devices that retain nutrient laden waters in subsurface drain tiles prior to release into streams
- ➢ Increase cover crop planting as part of a long-term conservation crop rotation designed to rebuild the soil's organic matter and increase the soil's water holding capacity
- ➢ Install drainage water devices on surface and subsurface tile drains

Drainage water management actions, also known as controlled drainage are an important emerging set of tools for dealing with field runoff and mitigating the impacts of tile drainage. Several NRCS approved practices that help with drainage water management include:

- ➢ Drainage Water Management
- ➢ Structure for Water Control
- ➢ Filter Strips/Areas
- ➢ Wetland Creation
- ➢ Discharge Ponds

3.10 Increase treatment of field runoff

It is neither practical nor likely that runoff from agricultural fields can be prevented or eliminated. What is encouraged is to install practices that increase assimilative treatment of runoff prior to its discharge into streams. For example, runoff from a livestock feeding area should be diverted through infiltration areas and/or wetlands so that nutrients can be assimilated via extended detention and/or vegetative uptake. Following are guidelines and recommendations for increasing the treatment of field runoff:

- ➢ Direct concentrated field runoff and drainage from livestock feeding areas through wetland and/or infiltration areas.
- ➢ Increase the use of fixed bed bioreactors containing coarse sand and organic carbon such as tree bark or wood chips.
- ➢ Increase the use of soil amendments such as iron, gypsum or water treatment residuals to increase the absorption of phosphorus and decrease the amount of phosphorus in runoff.
- ➢ USDA-NRCS eligible practices that will assist landowners with implementing this recommendation include the following:
    - ⇒ Wetlands Restoration
    - ⇒ Wetlands Creation
    - ⇒ Filter Strips/Areas
    - ⇒ Organic Bioreactors

3.11 Increase riparian wetland retention areas.

The buffering capacity of riparian areas has steadily declined as riparian forested and wetland areas have shrunk under increasing pressure to increase production acres. Combined with hydromodification, the alteration of riparian habitat are the two highest magnitude nonpoint causes of aquatic life use impairment in Ohio. Re-establishing, restoring and enhancing existing riparian wetlands to serve as detention areas for tile discharges and other drainage from agricultural fields is critical to reducing the impact of nutrient laden discharge water. Riparian wetland areas are highly effective at assimilating nutrients through infiltration and/or vegetative update. Numerous USDA programs offer generous cost-sharing incentives for increasing and/or restoring riparian wetland areas that meet the needs of an effective nutrient reduction strategy.

3.12 Increase riparian forested acres.

Like riparian wetland areas, Ohio's riparian forests have been in steady decline as agricultural equipment and production has expanded in size. The capacity for a riparian corridor of at least 120 feet wide (the equivalent of the canopy of two mature trees) to store water and assimilate nutrients is considerable. Riparian corridors provide important streamside habitat for wildlife, as well as important shading to the water, thereby reducing algae blooms and water temperatures. Numerous USDA-NRCS based programs such as Conservation Reserve Enhancement Program (CREP); the Conservation Reserve Program (CRP), EQIP and others provide cost-share incentives for the reestablishment and expansion of riparian forests. Program eligible best management practices include:

- Riparian Forest Buffer
- Tree/Shrub Establishment
- Upland Wildlife Habitat Improvement
- Windbreak/Shelterbelt Establishment ; and
- Renovation

3.13 Establish "no-tillage" zones in riparian areas.

This strategy needs careful consideration because while the approach of protecting stream banks and riparian areas has obvious water quality benefits the concept carries negative images of unwanted "land use control" There are currently many tracts of land where riparian areas are plowed or cultivated up to the stream's edge. The resulting bank slippage, sediment loss and potential nutrient loadings from such lack of conservation tillage, damages the soil and water resources of the State. Educational efforts targeting landowners and conservation incentive packages are needed to aggressively promote the benefits of "no-tillage zones"—those riparian areas where cultivating and plowing are carefully restricted along waterways. Farmers should consider voluntary installation of no-tillage zones, designed to an NRCS standard along with cost share options.

3.14 Soil and Water Conservation Districts

Local SWCDs will be a major part of any proposed process. These local offices, and their buy in, are an important key to successful implementation of the targeted strategies described above, or any future agreed upon modifications to the targeting strategy. Such demonstration areas would be funded using a combination of USDA Farm Bill programs, Conservation Innovation Grants and/or Ohio EPA section 319 and/or DEFA Linked Deposit funds. Comprehensive water quality monitoring would be conducted annually for the demonstration period to be able to document any water quality improvements that are resulting from these concentrated practices.

3.15 Urban and Suburban Nonpoint Nutrient Reduction Strategies

- Improve Storm Water Management Practices
- Enhance leadership role to address nonpoint source nutrient problem in the urban/suburban setting

3.15.1 Slow down, store and infiltrate runoff from impervious surfaces with municipality oriented BMPs.

Municipal BMPs include those that promote ground infiltration., filtration, and/or water storage of runoff from impervious surfaces, such as roofs, streets, parking lots and sidewalks. Many municipalities are starting to see the value of improved green infrastructure. Some traditional and emerging technologies are listed below.

3.16 Infiltration

3.16.1 Grassed Swales

In the context of BMPS to improve water quality, the term swale (a.k.a. grassed channel, dry swale, wet swale, biofilter, or bioswale) refers to a vegetated, open-channel management practices designed specifically to treat and attenuate storm water runoff for a specified water quality volume. As storm water runoff flows along these channels, it is treated through vegetation slowing the water to allow sedimentation, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Variations of the grassed swale include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs, but all are improvements on the traditional drainage ditch. These designs incorporate modified geometry and other features for use of the swale as a treatment and conveyance practice.

3.16.2 Infiltration Basin

An infiltration basin is a shallow impoundment which is designed to infiltrate storm water into the soil. This practice is believed to have high pollutant removal efficiency and can also help recharge the ground water, thus increasing base flow to stream systems. Infiltration basins can be challenging to apply on many sites.

3.16.3 Permeable pavers

Permeable interlocking concrete pavement (PICP) consists of manufactured concrete units that reduce storm water runoff volume, rate, and pollutants. The impervious units are designed with small openings between permeable joints. The openings typically comprise 5% to 15% of the paver surface area and are filled with highly permeable, small-sized aggregates. The joints allow storm water to enter a crushed stone aggregate bedding layer and base that supports the pavers while providing storage and runoff treatment. PICPs are highly attractive, durable, easily repaired, require low maintenance, and can withstand heavy vehicle loads.

3.16.4 Porous concrete and porous asphalt

Pervious concrete, also known as porous, gap-graded, or enhanced porosity concrete, is concrete with reduced sand or fines that allows water to drain through it. Pervious concrete over an aggregate storage bed will reduce storm water runoff volume, rate, and pollutants. The reduced fines leave stable air pockets in the concrete and a total void space of between 15 and 35 percent, with an average of 20 percent. The void space allows storm water to flow through the concrete and enter a crushed stone aggregate bedding layer and base that supports the concrete while providing storage and runoff treatment. When properly constructed, pervious concrete is durable, low maintenance, and has a low life cycle cost. Porous asphalt, also known as pervious, permeable, "popcorn," or open-graded asphalt, is standard hot-mix asphalt with reduced sand or fines that allows water to drain through it. Porous asphalt over an aggregate storage bed will reduce storm water runoff volume, rate, and pollutants. The reduced fines leave stable air pockets in the asphalt. The interconnected void space allows storm water to flow through the asphalt and enter a crushed stone aggregate bedding layer and base that supports the asphalt while providing storage and runoff treatment. When properly constructed, porous asphalt is a durable and cost competitive alternative to conventional asphalt.

3.17 Community and Institutional:

- Overcome and embrace paradigm shifts to leverage green infrastructure. Recognizing that highly visible green infrastructure can be dual purposed (I.e., providing recreational opportunities with flood protection).
- Highly visible green infrastructure creates opportunity for public conversation and education (e.g., value of water, infrastructure life cycle, detrimental effects of storm water, healthy watersheds).
- "Every city needs at least one demonstration project… These projects should be visible and attractive to a wide range of residents." Information should be visual, continual, and easy to access, as stated by the Ohio Environmental Protection Agency.

- Establish a sustainability coordinator or otherwise a leader at the local level to build relationships amongst city agencies, business community and residents. Create and advertise incentives with private-site developers.

Continue to work at state level with National Association of Counties and International City/County Management Association to inform these decision makers. Recognize the professional contributions of landscape architects. Seek development pioneers to educate and recruit early adopters.

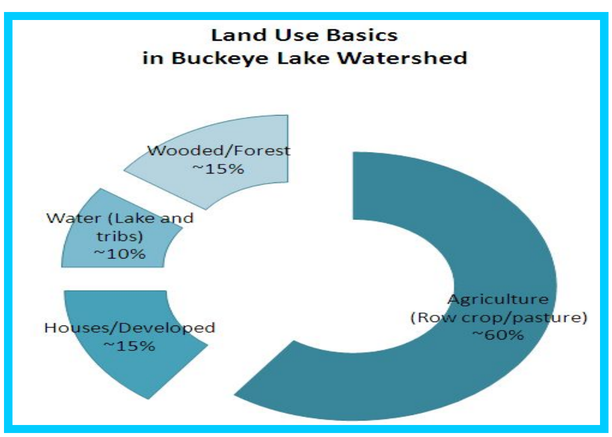
One example of leadership in this area is the Ohio Department of Transportation in the Ohio Local Technical Assistance Program (LTAP) which has sponsored the Low Impact Development (LID) Storm water Educational Workshop in 2011.

3.18 Financial

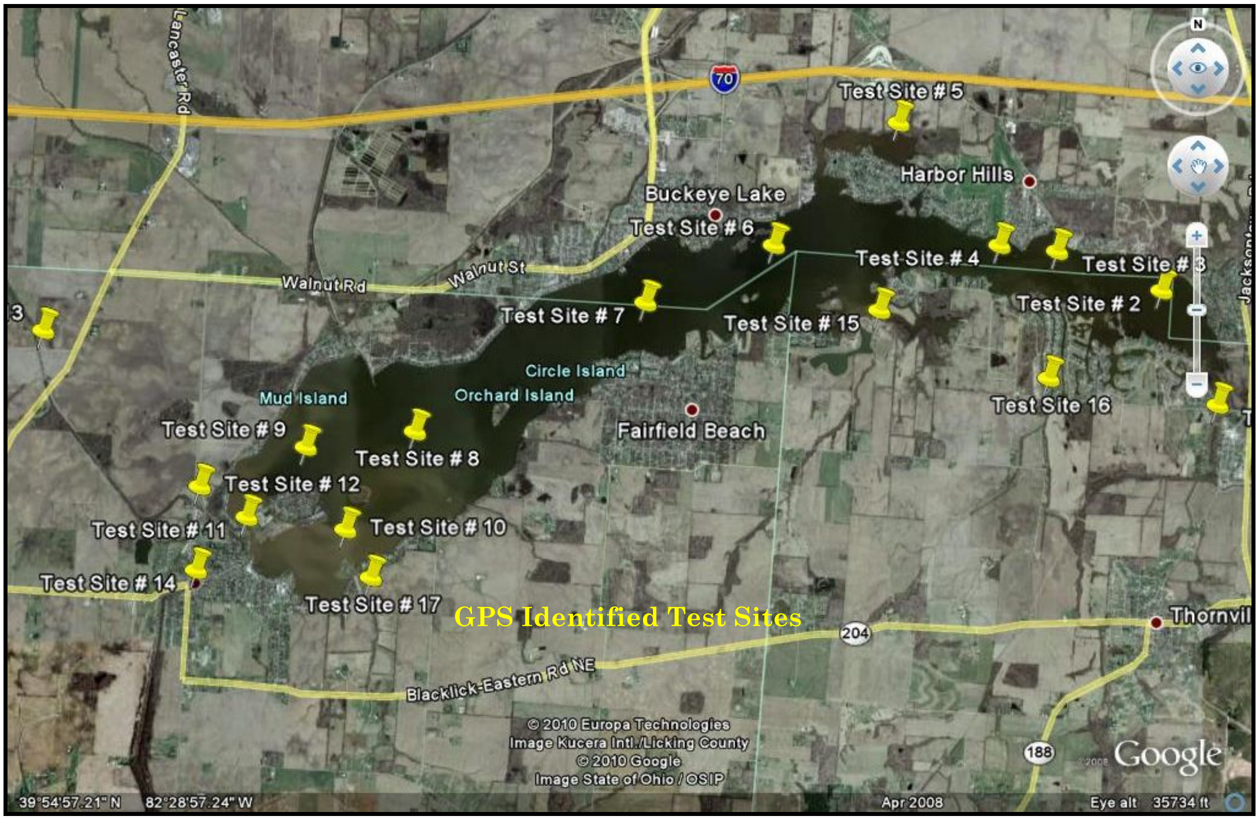
Continue to seek additional and more financing opportunities at federal and state level. (e.g., use transportation funding to install green infrastructure such as bioswales alongside new or existing roads

Land Use Categorized by HUC Code

Land Use Category	HUC Code 50400060403 Total Acres	HUC Code 50400060403 Percentage	HUC Code 50400060404 Total Acres	HUC Code 50400060404 Percentage
Open Water	2,868.00	16.6%	15.35	0.1%
Developed Open Space	1,787.61	10.3%	683.64	6.2%
Developed Low Intensity	959.41	5.5%	373.18	3.4%
Developed Medium Intensity	180.36	1.0%	91.40	0.8%
Developed High Intensity	26.35	0.1%	11.56	0.1%
Barren Land	3.11	0.0%	0.00	0.0%
Deciduous Forest	2,339.37	13.5%	1,621.93	14.7%
Evergreen Forest	39.59	0.2%	4.45	0.0%
Mixed Forest	0.00	0.0%	0.00	0.0%
Shrub/Scrub	100.52	0.6%	53.82	0.5%
Grassland/Herbaceous	43.59	0.3%	87.85	0.8%
Pasture/Hay	1,836.76	10.6%	1,293.00	11.7%
Cultivated Crops	7,033.68	40.6%	6,746.57	61.2%
Woody Wetlands	95.52	0.5%	41.59	0.4%
Emergent Herbaceous Wetland	11.79	0.1%	0.00	0.0%
Total Acreage	17,321.66	61.1%	11,024.34	38.9%



4.0 In-Lake Nutrient Control Strategies



Qualified Data Collector [QDC] volunteer test sites

Historical records and data from sediment core samples indicate that phosphorous levels in Buckeye Lake have been elevated for many decades. However, there is growing concern that agricultural activities and residential development may cause these natural water quality conditions to worsen. As a result, many studies have been performed to evaluate various nutrient reduction strategies for the lake.

4.1 Dredging

Removal of the phosphorus-enriched layer of sediment through suction dredging is probably the most permanent solution to reducing internal phosphorus loading. Dredging would involve removing the top half-meter of sediment over the whole lake, or in varying depths throughout the lake, depending on measured sediment profiles.

Dredging in Buckeye Lake is primarily focused to maintain navigable conditions throughout the lake. In an attempt to gain the most effective results, upland Dredge Material Relocation Areas [DMRA], are utilized whenever possible. Several sites have been developed in recent years and are currently available for increased dredging activity throughout the lake.

4.2 Drawdown

Drawdown is a management alternative that has limited long-term potential to improve water quality because of its effect on the long-term annual loading and retention of phosphorus in the lake. Drawdown in the winter results in the temporary loss of phosphorus through the lake outlet. However, when the lake refills in the late winter or early spring and external loading of phosphorus is high, the induced longer detention time results in longer phosphorus retention from the external loading of nutrient laden sediment and dissolved nutrients. That phosphorus is, in turn, available to be recycled from the sediments to the overlying water during the summer months. From an annual mass balance assessment of phosphorus loading, drawdown results in higher phosphorus availability. Unless a low-phosphorus water is used to refill the lake, the effect of drawdown in the system is a net gain in phosphorus. Such a method is not considered a viable alternative. A lake drawdown could be used to reduce the cost of site-specific dredging, but the water quality benefit would be derived from the dredging and not the drawdown itself. Additionally, some benefit might result from the consolidation of sediment that occurs after a drawdown. However, the consolidation would be temporary once the sediments are rehydrated and mixed with new sediment deposits.

4.3 Lake Alum Treatment

Phosphorus generally limits the growth of freshwater algae in most lakes. There is a direct relationship that exists between the phosphorus and algal growth in the lake; as phosphorus levels increase, the amount of algae increases as well. With very high phosphorus concentrations, other nutrients or light may limit the growth of algae. Long-term management of excessive algae requires the removal of phosphorus sources to the water body. Reducing phosphorus inputs removes the key algal nutrient.

External sources of phosphorus such as storm water runoff, septic system effluent, agriculture and lawn fertilizer, pet wastes, waterfowl, land applied organic nutrients (biosolids and manure), and even atmospheric deposition contribute phosphorus to a lake. Incremental reduction or eliminating external inputs is an important goal, but sometimes external source reduction is not enough. Phosphorus-enriched sediments will continue to release phosphorus to the water through a process known as internal loading.

When sediments are contributing phosphorus to the lake, lake managers can use nutrient inactivation techniques to remove phosphorus from the water column and to retard its release from the sediments. Lake managers use aluminum, iron, or calcium salts for phosphorus inactivation of lake sediments. Aluminum sulfate (alum) is the most commonly used nutrient inactivation chemical for lake projects. Managers may also apply alum in small doses to precipitate water column phosphorus. When applied to water, alum forms a fluffy aluminum hydroxide precipitate called a flocculent (or “floc”). As the floc settles, it removes phosphorus and particulates (including algae) from the water column (precipitation). The floc settles on the sediment where it forms a layer that acts as barrier to phosphorus. As sediments release phosphorus, it combines with the alum and is not released into the water to fuel algae blooms (inactivation). Algal levels decline after alum treatment because alum addition reduces phosphorus levels in the water, starving it from its food source.

Nutrient inactivation is only appropriate where internal loading is a significant phosphorus source. If most phosphorus comes through external sources, alum treatment will not have long-term effectiveness. For appropriate nutrient inactivation projects, the length of treatment effectiveness varies with the amount of alum applied and the depth of the lake. Alum treatment in shallow lakes for phosphorus inactivation may last for eight or more years. In deeper lakes, alum treatment may last longer. Buckeye Lake is a shallow lake.

4.4 Bio-Remediation

According to The American Academy of Microbiology, bioremediation is defined as the use of living organisms to reduce or eliminate environmental hazards resulting from accumulations of toxic chemicals and other hazardous waste.

Bioremediation uses indigenous microbes found in the environment creating an ecosystem that rapidly places hazardous sites back to their natural state. It is a single celled solution for mitigating environmental contamination by harnessing naturally occurring biogeochemical processes. Bioremediation destroys or immobilizes contaminants rather than transferring them from one environmental media to another.

An innovation and demonstration project was conducted the spring of 2012 to evaluate the efficacy of this technology in improving water quality issues in Buckeye Lake. Trial and control sites were established, followed by the introduction of specially prepared microbes into the sediment and water column. Samples were collected and analyzed by OEPA to determine the improvement caused by the introduction of the microbes to the environment. After evaluating the results over a 6 week period, it was determined that there was no improvement noted in the trial site in either the sediment or water column. It has been suggested that the introduction of oxygen to the trial site may have improved the results, however, there is no data to support this assumption.

4.5 Shoreline Maintenance

Reducing erosion of lakeshore areas will reduce phosphorus and sediment loading and improve temperature and dissolved oxygen conditions by allowing for re-established vegetation. Shorelines should be inspected for signs of erosion. Banks showing moderate to high erosion rates (indicated by poorly vegetated reaches, exposed tree roots, steep banks, and the like) can be stabilized by engineering controls, vegetative stabilization, and restoration of riparian areas. Peak flows and velocities from runoff areas can be mitigated by controlling drainage in the watershed and installing improved hydraulic buffers such as filter strips/areas, wetlands, forested riparian areas that are designed with consideration of contributing watershed.

4.6 Aeration/Circulation

The purpose of aeration in lake management is to increase the dissolved oxygen content of the water. Various systems are available to help do this—by either injecting air, mechanically mixing or agitating the water, or even injecting pure oxygen. Aeration can increase fish and other aquatic animal habitat, prevent fish kills, and improve the quality of domestic and industrial water supplies and decrease treatment costs. In some cases, nuisance algal blooms can be reduced or a shift to less objectionable algae species can occur. However, aeration can be misused. It is not a "cure-all" for a lake's ills.

Lakes get much of their oxygen from the atmosphere through a process called diffusion. Artificial circulation increases a lake's oxygen by forcefully circulating the water to expose more of it to the atmosphere. Proper choice and design of an artificial circulation system depends on lake management goals and the lake's physical characteristics.

Destratification is a type of artificial circulation that completely mixes a stratified lake's waters from top to bottom and thereby eliminates or prevents summer stratification (the division of a lake into water layers of different temperatures). Two techniques are most common: air injection and mechanical mixing.

- Air Injection (Diffuser) Systems are the most common destratification method. A compressor on shore delivers air through lines connected to a perforated pipe(s) or other simple diffuser(s) placed near the bottom, typically in the deep area of the lake.

- Mechanical Axial Flow Pumps use a "top-down" approach to set up a circulation pattern. Its rotation "pushes" water from the lake surface downward, setting up a circulation pattern that prevents thermal stratification.

4.7 In-Lake Plant Harvesting

Several studies indicate the uptake potential for cattails and other plant species normally found in wetland environments. Harvesting these plants removes total phosphorous from the area and provides a resource for making fuel pellets. Buckeye Lake has approximately 50 acres of water lilies and spatterdock plants. Although they do not possess the same uptake potential as cattails, they do hold significant amounts of phosphorous that could be removed from the lake. Harvesting these plants in late summer, prior to their normal die-off has the potential to remove significant nutrients from the lake and improving the water quality. Leaving them to nature, will return the nutrients contained in the leaves and stems to the sediment, increasing the nutrient load in the lake.

Spatterdock

Water Lily

4.8 Carp Removal

In an effort to increase awareness, promote community involvement and reduce the overall rough fish population, a Carp Fest has been developed and implemented for the spring of each year. The first three year's events have been responsible for removing over 10,000 pounds of carp from the lake and the awarding of over $ 9,000 in cash prizes for the largest catch in various categories.

In addition to the annual Carp Fest, we are working with ODNR to increase the sunfish population in the lake to consume the millions of carp eggs produced each spring.

2013 Youth Award Winner

5.0 Implementation Strategies

5.0 IMPLEMENTATION STRATEGY AND SCHEDULE

Improving the water quality in Buckeye Lake will need to be a multiyear effort and will require a continued commitment to reducing pollutant loading to the lake. Short-term improvements in water quality from implementing actions such as an alum treatment will not be enough to ensure the long-term sustainability of the lake. Buckeye Lake for Tomorrow [BLT] will continue to oversee the development and implementation of a comprehensive lake/watershed management plan. BLT can also evaluate whether alternative technologies not presented here make sense for the watershed. The actions presented below are suggested building blocks for the long-term comprehensive effort that is needed. Because of the extent of the watershed and the size of the lake, a strategic series of management actions has been proposed to most efficiently improve lake water quality on the basis of a combination of in-lake measures supported by sufficient and sustained levels of watershed management.

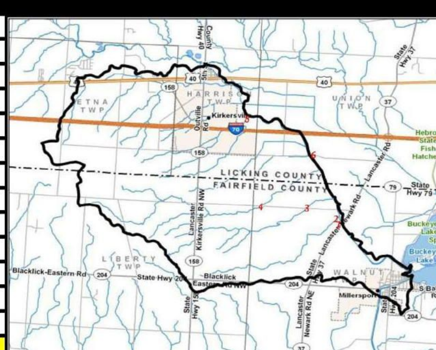
5.1 Determine Critical Areas

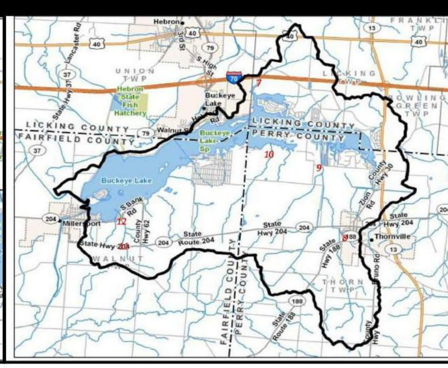
Critical areas of phosphorus loading in the watershed have been identified. Critical areas are those that contribute a disproportionate load to the lake based on a combination of their biophysical setting and human behavior. Such areas have been identified by taking the following steps:

1. Use biophysical measures (e.g., stream locations, topography, land use, soils) to identify vulnerable locations in the watershed
2. Assess the salient behaviors in these locations to determine where disproportionality might be occurring
3. Gain an understanding of why certain results are occurring in those locations.
4. Design an intervention effort based on this understanding

Test Site	Date	Rainfall	TP	TN	Date	Rainfall	TP	TN	Date	Rainfall	TP	TN
OFBF 1	4/12/2013	0.68"	808	9,540	6/3/2013	0.63"	181	22,400	10/7/2013	1.60"	301	8,400
OFBF 2	4/12/2013	0.68"	851	8,960	6/3/2013	0.63"	116	16,800	10/7/2013	1.60"	194	9,710
OFBF 3	4/12/2013	0.68"	934	8,340	6/3/2013	0.63"	171	25,900	10/7/2013	1.60"	287	11,060
OFBF 4	4/12/2013	0.68"	692	9,720	6/3/2013	0.63"	141	16,100	10/7/2013	1.60"	238	9,450
OFBF 5	4/12/2013	0.68"	221	2,940	6/3/2013	0.63"	143	6,160	10/7/2013	1.60"	194	5,750
OFBF 6	4/12/2013	0.68"	200	12,200	6/3/2013	0.63"	170	16,100	10/7/2013	1.60"	216	7,670
OFBF 7	4/12/2013	0.68"	370	13,100	6/3/2013	0.63"	980	24,000	10/7/2013	1.60"	< 100	13,140
OFBF 8	4/12/2013	0.68"	262	3,050	6/3/2013	0.63"	160	356	10/7/2013	1.60"	237	4,670
OFBF 9	4/12/2013	0.68"	138	3,570	6/3/2013	0.63"	167	5,520	10/7/2013	1.60"	159	5,300
OFBF 10	4/12/2013	0.68"	176	3,350	6/3/2013	0.63"	190	2,050	10/7/2013	1.60"	230	5,180
OFBF 11	4/12/2013	0.68"	278	3,950	6/3/2013	0.63"	165	3,170	10/7/2013	1.60"	308	4,260
OFBF 12	4/12/2013	0.68"	486	4,080	6/3/2013	0.63"	135	3,090	10/7/2013	1.60"	224	5,410

OFBF 1	Feeder Creek @ Rt 37
OFBF 2	Dix Creek @ Feeder
OFBF 3	Black Lick Road # 1
OFBF 4	Black Lick Road # 2
OFBF 5	Feeder @ Swamp Rd
OFBF 6	Feeder @ Palmer Rd
OFBF 7	Interstate 70 Rest Area
OFBF 8	Deep Cut @ Rt 204
OFBF 9	Honey Creek
OFBF 10	Buckeye Creek
OFBF 11	Murphy's Run @ 204
OFBF 12	Murphy's Run @ South Bank
TP = ug/L	Goal = 50 ug/L
TN = ug/L	Goal = 500 ug/L
High Readings	
Low Readings	





5.1.1 External Load Reduction - The primary source for external loading of excessive nutrients to Buckeye Lake is the Feeder. This man-made creek was originally constructed to supply water for the State of Ohio canal system. The Feeder is a relatively straight waterway that has been altered many times over the course of time to satisfy the needs of landowners whose property abutted the stream. There is no natural water source found in this stream making its primary purpose the removal of excess water from the adjoining crop land and the few natural tributaries that have been diverted to the Feeder for the purpose of flood control and water management. Most of the adjoining crop land has been drained with field tile, all of which have been located and identified using GPS coordinates. To address this nutrient loss and reduce the total phosphorus load, the following actions are planned.

5.1.1.1 The Feeder – The primary source of external nutrient loading to Buckeye Lake is originating from the streams found in the Buckeye Lake Reservoir Feeder Watershed HUC code 050400060404. To reduce the external load entering the lake from this primary tributary, it is recommended that primary streams that feed into the Feeder be addressed to reduce the level of nutrients coming from those areas providing the heaviest estimated annual nutrient load.

5.1.1.2 Cover Crops - The use of cover crops, including wheat, will be expanded with regular crop rotations to include fields adjacent to Black Lick Stream #1 [39.921864° -82.563652°] and #2 [39.922477° -82.579495°]. This change will result in improved retention of nutrients in the soil as well as a reduction of erosion, especially during early spring rainfalls.

5.1.1.3 4R – Further implementation of the 4R concept of the **R**ight fertilizer source, at the **R**ight rate, at the **R**ight time and in the **R**ight place will result in better nutrient management and increased productivity as well as decreased loss of excess nutrients into the streams. One area that greatly affects plant nutrient management and supports the 4R concept is variable rate technology (VRT). The capability to change the rate of fertilizer being applied has been available for a couple of decades, but there are some recent products or techniques that make better use of VRT.

5.1.1.4 Bank Stabilization – Introduce the use of bank stabilization techniques along the steep embankments of the Feeder to reduce the sediment entering the lake that is being eroded from the tributary itself. As part of this process, include the seeding of native grasses and plants in this area to aid in removing nutrients naturally, especially during normal flow periods.

5.1.1.5 Brooks Park [39.900105° -82.514097°] – Install a newly constructed wetland at this site to control the unexplained excess nutrients that are entering the lake from this tributary.

5.1.1.6 Interstate 70 Rest Area [39.945357° -82.460207°] – Install a newly constructed wetland to control nutrient loading coming into the lake and adjust water temperature in the run-off from the nearby interstate and rest area. It will also help mitigate stream flows carrying an elevated nitrate count.

5.1.2 Internal Load Reduction – Critical internal loading in Buckeye Lake is found in the accumulation of sediments the past 160 years and an increase in Canada Geese population the past 15 years. In conjunction with the non point source actions described above, the following activities are planned to reduce the internal loading of total phosphorus.

5.1.2.1 Canada Geese Removal – The population of Canada Geese has overwhelmed the capacity of Buckeye Lake to handle their fecal waste matter. It has been estimated that their annual contribution to the total phosphorus loading in the lake may be in excess of 4,000 pounds. Formal requests are being made by BLT to remove this population through a professionally managed, humane round-up and relocation of this huge flock that make their year-round home on the lake and surrounding communities.

5.1.2.2 Lake Dredging – The east end of the lake is targeted for the initial dredging operations to remove nutrient rich sediment from the lake. Upland Dredge Material Relocation Areas [DMRA] will be developed to accept the material for de-watering prior to transporting away from the lake.

5.1.2.3 Alum Application – The center of the lake No-Wake area is the deepest section and also contains the highest concentration of total phosphorus. This area has been identified to possibly accept alum treatments for the following reasons:

1. Due to the depth of the lake in this area, it is unlikely that it will be dredged anytime in the foreseeable future, therefore removing the risk that alum might pose to surrounding crop lands.

2. The depth of the lake as well as the No-Wake classification of this site assures that prop wake from the boats will not disturb the alum that has bound-up the phosphorus in the sediment.

5.2 Education and Communication – To preserve the improvements of the water quality in the lake and watershed, the "You Can Help" program will be continued and communicated to area residents at every opportunity.

5.2.1 Pick-Up after your Pet – The waste from our pets have the same effect on the lake as manure from area livestock. Residents can do their part by making certain that they are not adding nutrients to the lake.

5.2.2 No-Phosphorus Fertilizer – Insist that lawn-care services use no-phosphorus products on the lawns and in the landscaping.

5.2.3 Don't Feed the Geese – An adult Canada Goose deposits the equivalent of a 50 pound bag of fertilizer each year. Fewer geese equal a healthier lake.

5.2.4 No Leaves or Grass Clippings in the Lake – Find another location for lawn clippings and leaves. Composting is highly recommended, but in no instance should this yard waste be dumped in the lake.

5.2.5 Carp – Catch 'em & Keep 'em – They disturb the sediment, uproot the vegetation and crowd out the desirable fish in the lake. Catch all you can and keep them out of the lake.

Improving Buckeye Lake One Drop at a Time

Resolution of Support

Whereas, the objective of Buckeye Lake for Tomorrow, Inc. is the "Enhancement of Quality of Life through Improved Water Quality of the Buckeye Lake Watershed"; and

Whereas, the objective of the Buckeye Lake Nutrient Reduction Project is the "Implementation of Comprehensive In-Lake and Tributary Monitoring of the Buckeye Lake Watershed and Development of a Comprehensive Nutrient Reduction Implementation Plan completed by Local Partners in Collaboration with the State of Ohio.."; and

Whereas, the need for improved water quality of the Buckeye Lake Watershed is of extreme importance and of the highest concern for this region and the State of Ohio; and

Whereas, Buckeye Lake for Tomorrow, Inc. needs to collaborate with all local and regional organizations who share common views – both public and private – to coordinate efforts in identifying technologies and funding critically needed for water quality projects;

Therefore, by the resolution of the organizations and groups listed below;

Be it Resolved, that we support the need for enhanced water quality of the Buckeye Lake Watershed.

Be it Further Resolved, that the need for enhanced water quality is critical for the benefit of recreation, agriculture, wildlife, and other users of the Buckeye Lake Watershed aquatic resources.

Be it also Further Resolved, that we support the Buckeye Lake Nutrient Reduction Initiative to research and develop technologies and funding opportunities to improve the quality of water of the Buckeye Lake Watershed and agree to collaborate with all agencies listed here for the common good of the Buckeye Lake region.

Fairfield County Commissioner	Village of Buckeye Lake
Licking County Commissioner	Village of Millersport
Perry County Commissioner	Village of Thornville
Licking Township Trustee	Mallory Square Condominium Association
Thorn Township Trustee	West Bank Homeowners Association
Walnut Township Trustee	Harbor Hills Civic Association
Greater Buckeye Lake Historical Society	Cranberry Bay Homeowners Association
Buckeye Lake Region Chamber of Commerce	Heron Bay Homeowners Association
Buckeye Lake Area Civic Association	Honey Creek Homeowners Association