Virgin Run Lake TMDL:
For Nutrients

Prepared by Pennsylvania Department of Environmental Protection

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Introduction

This Total Maximum Daily Load (TMDL) report was completed to address impairments caused by excess nutrient loading to for Virgin Run Lake. The lake is listed as impaired on both Pennsylvania's 1996 and 1998 303(d) list of impaired waters, with agriculture indicated as the source of impairment. Nutrients from agricultural activities have stimulated excessive plant growth. Sedimentation from the same activities has made the lake shallower, intensifying the former problem. The lake was designed small and shallow, for the purpose of being a fishing lake, and the excessive plant growth may in fact be worsened by these design criteria (Table 1). During the development of this TMDL report, PADEP biologists determined that agricultural runoff was no longer the primary cause of impairment to Virgin Run Lake. Sources of agricultural runoff in the watershed have been largely reduced through best management practices. As the lake nears the end of its life expectancy, the major source of impairment to Virgin Run Lake is the internal regeneration of phosphorus from the bottom sediments into the water column.

This TMDL was developed to determine the phosphorus reductions needed in Virgin Run Lake to meet water quality standards and attain its protected uses as a High Quality – Trout Stocking Fishery (HQ-TSF). Since Pennsylvania does not currently have criteria for nutrients, the Carlson Trophic State Index (TSI) is used as an indicator of water quality to determine the necessary phosphorus reductions for this TMDL. Since Virgin Run Lake is phosphorus limited, we have used the established relationship between in-lake phosphorus concentration and TSI to estimate the load reductions. This TMDL determines that a 32% reduction in total phosphorus loading to the lake is needed to meet water quality standards and meet the protected use objectives.

Background

Virgin Run Lake is located in Franklin and Perry Townships, Fayette County. It was built in 1953 by the former Pennsylvania Fish Commission as a fishing lake. Virgin Run Lake is a unique and valuable asset to Fayette County. The use for recreational activities by local residents is significant. Anglers use the lake heavily during the spring trout-stocking season. There are no similar lakes in the area, and many streams nearby are affected by mine drainage. Originally, it was 15 ha. in size, had a capacity of 0.54 million cubic meters, and a maximum depth of 9.7 meters. Detention time was calculated as 42 days. The lake life expectancy was not specified in the design, however, a personal communication from the current Pennsylvania Fish and Boat Commission (Dick Mulsinger, 12/99), states that a 40-50 year life is not unreasonable.

By 1989, the maximum depth was 5.8 meters and most of the upper two arms of the lake are less than 1 meter deep. The lake is estimated to hold about one third of its design capacity or 0.18 million cubic meters. Additionally, the lake had become highly eutrophic. As part of the natural ageing process of a lake, eutrophication does not necessarily equate to poor water quality. Moderately high levels of algal and rooted aquatic plants (macrophyte) productivity can be desirable traits in a waterbody as a base for the food chain. Beds of aquatic macrophytes can provide optimal habitat for fish and their prey, the high plant productivity can ultimately yield high fish productivity. In Virgin Run Lake, this natural ageing process has been accelerated by the input of additional nutrients. The increase in plant productivity has created nuisance conditions, and become deleterious to fish production and overall water quality.

As the lake nears the end of its life expectancy, the major source of impairment to Virgin Run Lake is the internal regeneration of phosphorus from the bottom sediments into the water column. Phosphorus remains in the bottom sediments for decades, becoming available annually when the lake turns over. Phosphorus in bottom sediments is readily available to rooted aquatic plants contributing to the excessive plant growth. The over abundance of nutrient rich runoff depositing into the lake since its impoundment has stimulated plant growth creating an accelerated eutrophication process increasing biomass and creating water quality problems. Sedimentation from the same activities has made the lake shallower, intensifying the former problem by allowing light to penetrate through to the bottom sediments

The lake is drawn down 3 meters annually to help control rooted aquatic plants. Figure 1 shows how the lake looks in 1999 while drawn down.

Figure 1 Virgin Run Lake During Fall/Winter Drawdown 1999

Lake Alternatives Considered Prior to TMDL Development

There are three alternatives for this lake. The first is restoration, which may include sediment removal, maintenance of existing and implementation of new management practices or both. The second alternative is removal of the lake by breeching the dam and converting the land to other uses. The third alternative is no action.

When possible, restoration can more easily be accomplished by controlling external sediment and nutrient loads to a lake. However, because of the enormous amounts of phosphorus currently within the bottom sediments, reducing external phosphorus loads would not be adequate to improve overall water quality of Virgin Run Lake. To investigate this possibility of reducing further external loading to the lake, we examined area farms and noted land use and the management practices currently in place. It was a determined that further reductions in external loading to the lake, would not be effective without in-lake phosphorus controls. The in-lake restoration alternatives include the removal or treatment of sediments, and the control of rooted aquatic plants through such methods as harvesting and draw down. Through the treatment of bottom sediments the stored phosphorus is lessened, and proper management practices on the external agricultural sources can then maintain water quality.

The second alternative is removal of the dam and draining the lake. Two factors made this a reasonable alternative. First the lake is at the end of its designed life expectancy and it may be more cost effective to construct another lake in the area than to remove the sediments. This would also allow the land to revert to other uses. Second, breeching the dam is inexpensive. However, because the lake is designated as a high quality trout-stocking fishery, disturbances such as removal of the dam are not permitted. The loss of recreational activities by local residents is significant. There are no similar lakes in the area, and many streams nearby are affected by mine drainage. While no recreational use data are available, all parties agreed that the cost of sediment removal is much less than the value of lost recreational use over the life of the restored lake. This alternative was eliminated therefore, by lack of suitable replacement sites and the positive economic balance of sediment removal and the value of the recreation the lake provides.

The third alternative is not a viable option because it would allow the lake to continue to degrade and the lake would not meet water quality standards or support its use as a high quality trout-stocking fishery.

The discussion above notes the reasons for rejecting the external load reduction, dam breeching, and the no action alternatives. They were rejected because they would not allow the lake to meet water quality standards, to attain its designated uses, and in the end resulted in the loss of a significant recreational resource. The only activity that allows the lake to meet water quality standards and to support its protected use is in-lake management measures. Possible measures include harvesting of rooted aquatic plants, dredging and alum treatments. In-lake management measures to reduce phosphorus regeneration form sediments would be expected to result in the reduction of both aquatic plant growth and in-lake phosphorus concentration. Since this is a major undertaking, it is imperative that existing management practices are maintained, and any other necessary practices are implemented to insure nutrient problems do not arise again.

Data Compilation

The analysis contained in this TMDL document is based on lake eutrophication studies conducted in 1989 and reconnaissance and sampling conducted in 1999. We conducted the lake eutrophication study according to the guidance for Chapter 95.6 of the Department's Rules and Regulation in place in 1989. This document, "Discharges to Lakes, Reservoirs and Impoundments", called for seasonal chemical sampling of nutrients, chlorophyll *a*, and depth profiles of temperature, dissolved oxygen, pH, and conductivity. We used the Rechkow oxic equation to calculate phosphorus loads. For comparison purposes, we also derived loadings from various landuse, soils, geology, and animal concentration Geographical Information System (GIS) coverages. The Environmental Resources Research Institute (ERRI) of Pennsylvania State University developed these coverages under contract to the Department. Results from both approaches agreed very well.

In 1989, water chemistry, biological and physical measurements were collected in March, July and October, which accounts for seasonal variation. Chemical samples were collected 1 meter below the surface and 1 meter from the bottom. Given the shallow nature of this lake, these samples were spatially close. These measurements are shown in Table 1.

Table 1. Lake Information

Data	**Value**	**Source**
Lake Type	Oxic	1989 Study
Lake Status	High Quality	Special Protection
Phosphorus Conc. (surface)	0.054 mg/L	1989 Study
Phosphorus Conc. (Total)	0.063 mg/L	1989 Study
Calculated P. Conc. (Total)	0.057 mg/L	From Landuse Analysis
Current P Conc. (Surface)	0.054 mg/L	1999 Sample
Current P Conc. (Total)	0.060 mg/L	1999 Sample
Detention Time	41.5 days	1989 Avg. Calc. Value
Surface Area	40 Acres	Lake Design
Mean Depth	4 m	Lake Design
	2.1 m	Current Value
Maximum Depth	9.7 m	Lake Design
	5.8 m	Current Value

The phosphorus concentration measured in the lake was 0.060mg/L. In most fresh water bodies, phosphorus is the limiting nutrient for aquatic growth. In some cases, however, the determination of which nutrient is the most limiting is difficult. For this reason, the ratio of the amount of N to the amount of P is often used to make this determination (Thomann and Mueller, 1987). If the N/P ratio is less than 10, nitrogen is limiting; if the N/P ratio is greater than 10, phosphorus is the limiting nutrient as shown in Table 2. In the case of Virgin Run Lake, the N/P ratio is approximately 18, which points to phosphorus as the limiting nutrient.

Table 2. Nutrient Concentrations	
Total Nitrogen	1.08 mg/L
Total Phosphorus	0.060 mg/L
Ratio	18:1

The Pennsylvania lake eutrophication model uses average total phosphorus values, and this value was used for determining the limiting nutrient. Some analyses may use the total dissolved phosphorus or the ortho-phosphorus concentration. Data specifications are noted in the discussion.

TMDL Endpoints

PA does not currently have water quality criteria for nutrients or sediment. Therefore the water quality objectives for Phosphorus (the nutrient of concern) are set using PA Title 25 Chapter 93.5(c), which governs the use of ambient or natural conditions as a water quality criterion. For this reason to assess the nutrient problems in Virgin Run Lake we used the Carlson Trophic Status Index (TSI). TSI analysis is used to determine the necessary phosphorus reduction targets for this TMDL. The established relationship between in-lake phosphorus concentration and TSI was used to estimate the load reductions required to meet the water quality objectives. When these values are met, it is expected that Virgin Run Lake will support its protected use as a High Quality -Trout Stocking Fishery (HQ-TSF).

To determine where to target load reductions, the design criteria for the lake was examined to determine fill rate and life expectancy. We balanced the problems anticipated with small, shallow lakes at the end of their life expectancy with the reasonableness of requiring additional control of external nutrient and sediment loads. As discussed above, Virgin Run, like most Pennsylvania lakes, is phosphorus limited. An over abundance of nutrients to a lake stimulates plant growth creating an accelerated eutrophication process increasing biomass and creating water quality problems. Phosphorus, however, is a conservative substance and remains trapped in lake sediments for decades. This phosphorus becomes available annually when the lake turns over. Because Virgin Run Lake has filled in with sediment over the years, controlling external phosphorus loads without removing the in-system phosphorus will not result in any improvement in the short term. In-lake phosphorus from Phosphorus released from bottom sediments contributes significantly to water column phosphorus concentration. Phosphorus in the sediment is also readily available to rooted aquatic plants contributing to the excessive plant growth. The calculated landuses are shown in Table 3.

Table 3. Current Landuse

Landuse Type	% of Basin
Developed Residential	0.1
Disturbed	0.1
Forested	48.6
Agriculture	51.1
Row crops	12.6
Pasture	38.5

All phosphorus loads to Virgin Run Lake are from non-point sources. These contributions were calculated using standard landuse runoff coefficients as documented in Reckhow 1983. There is some residential development in the basin; however, the substantial relief of the basin severely limits the extent of development. Land use is summarized in Table 4. Agricultural activity is mostly confined to the southern portion of the basin.

We determined pollutant loadings for each type of landuse in the basin from the coverages developed by ERRI and phosphorus runoff coefficients documented in Reckhow 1983. Table 4 summarizes those values.

Table 4. Unit Area Loading for Virgin Run Lake				
Land Use	**Area (acres)**	**% of Total**	**Parameter**	**lb/yr**
Pasture	805	37.8	Total P	161
			TSS	179553
Forested	1018	47.8	Total P	122
			TSS	90817
Row Crops	264	12.4	Total P	66
			TSS	141276
Developed	2	0.1	Total P	1
			TSS	534
Disturbed	2	0.1	Total P	1
			TSS	712
Internal Loading	40	1.9	Total P	234
Total Area	**2131**	**100.0**	**Total P**	**585**
			TSS	**412891**

The best possible reduction in nutrient loads to the lake is obtained when the watershed is modeled for the all forested scenerio. If we allow a 20% increase for other man induced activities, such as development, and a 10% margin of safety (MOS), the resulting load is the best attainable. The results of these computations are shown in Table 5.

Consideration of Critical Conditions

It is not practical with existing data and resources to explicitly consider critical conditions in terms of both pollutant loading and in-lake conditions. Such an explicit approach would require continuous model simulation of the watershed and lake. Further, by expressing the TMDLs for sediment and nutrients as annual loads, both the storm loads and the dry weather loads have been implicitly included. Given that there is generally a significant lag time between the introduction of sediment and nutrients to a waterbody and the resulting impact on beneficial uses, establishing this TMDL using average annual conditions is protective.

Explanation of TMDL Computations for Phosphorus

The TMDL was computed by the following methods.

1. An existing TSI and Phosphorus loading were computed using the equations contained in the Lake for Windows program "TSI Only " option (see attachment D, excerpt from the Implementation Guidance for Section 95.6 Management of Point

Source Phosphorus Discharges to Lakes Ponds and Impoundments (Section shows the Reckhow Models and the TSI equation). Refer to page 10 to the TSI analysis titled, "Existing conditions".

Table 5. Summary of Restoration Needs			
Scenario	In- Lake P Conc.	**TSI**	Load (lb/yr.)
Existing	0.060 mg/L	63.2	585
All Forest	0.026 mg/L	51.1	251
Target TMDL	.031	53.7	301 *

* - The target TMDL represents the All Forest Load + 20 Percent
All Forest Load = 251 lb/yr
[All Forest Load + 20%] = 301 lb/yr
MOS = 10 % of the [All Forest Load + 20%] (301)*0.1 = 30 lb/yr.
Target TMDL = (251 * 1.2) – 30 = 271 lb/yr.

2. To establish the surface contributions of phosphorus to the lake, a TSI and loading were computed based on all of the land in the lake watershed being forested. The all forest scenario is an estimate of natural conditions, with no influence from man. This all forest scenario also represents the best possible condition for lake water quality.

3. To determine the target TMDL loading for the lake, the load from the all forest scenario was multiplied by a factor of 1.2. This allows for a 20 % increase in the in-lake phosphorus concentration. The MOS was then applied to this load to determine the TMDL target load.

The scientific justification for the 20% change in the allowable in-lake phosphorus concentration is based on relationships observed from Vollenweider-OECD eutrophication results by Lee and Jones (1982). These results indicated that a 20% change in the normalized phosphorus loading to a waterbody must occur before a change in the plankton algal chlorophyll concentrations due to a change in the phosphorus load would be discerned. These studies also indicated that the percent change that must occur in phosphorus load to produce a detectable change in water quality is independent of the trophic state of the waterbody. The 20% change in phosphorus concentration equates to an approximate 5% change in the lake Trophic Status Index (TSI).

The preceding paragraph states that a 20% change in phosphorus loading must occur before there is a discernable change in lake water quality. This is an aesthetic criteria defined by sight, using plankton algal chlorophyll as the indicator.

Pennsylvania is using the 20% change in load above the estimated natural condition, to allow for man induced activity. We feel this establishes a reasonable target for setting phosphorus controls. Our estimates show that it is much more difficult to reduce the phosphorus loading rate to the baseline, all forest condition.

Research to verify these relationships was conducted in September, 1998. Original documentation, and literature citations from the rationale documents were reviewed along with M.W. Marsden 1989.

4. The TMDL load for phosphorus is divided by the existing phosphorus load to determine the percent reduction.

%reduction = (1- (TMDL load/existing load)) * 100)

Table 6 shows individual land use phosphorus reductions, the cumulative phosphorus loading, and percent reduction.

.Table 6. Annual Unit Area Phosphorus Loading in the Virgin Run Waterhsed

	Current				TMDL		
Landuse	**Area (Ha.)**	**% Total**	**Loading Rate (Lb/acre/yr.)**	**Lb/yr.**	**Loading Rate (Lb/acre/yr.)**	**Lb/yr.**	**% Reduction**
Row Crops	264	13	0.25	66	0.13	34	48%
				0		0	
Pasture	805	38	0.2	161	0.125	101	38%
				0		0	
Developed	2	0	0.4	1	0.3	1	25%
				0		0	
Disturbed	2	0	0.4	1	0.3	1	25%
				0		0	
Forested	1018	49	0.12	122	0.12	122	0%
Total from Surface Runoff	2092	100		351		259	26%
Internal Loading	--	--	--	234	--	12	95%
Total				585		271	54%

Recommendations

The limnological survey of Virgin Run Lake identified the water quality problems in Virgin Run Lake. This TMDL was developed to determine the necessary reductions in phosphorus, the pollutant of concern, needed for the lake to meet water quality standards and attain its protected uses as a HQ-TSF. For most of the life of the lake, external loading from agricultural runoff was the major source of pollutants. However, these sources have been largely reduced through best management practices. As the lake nears the end of its life expectancy, the major source of impairment to Virgin Run Lake is the internal regeneration of phosphorus from the bottom sediments into the water column.

In addition to the lake draw down currently being practiced, several other alternatives are also available. A number of potential lake and watershed management measures are described below. The most suitable restoration measures for reducing internal loading in Virgin Run Lake will need to be determined as part of a restoration project that could be funded through several grants currently available including Federal Section 319 money, WRAP grants, Watershed Protection and Environmental Stewardship Grants or the state Growing Greener Program.

Control of Internal Sources:

Selective Dredging

Dredging projects have the immediate benefit of removing silt accumulations to restore portions of a lake to its original depth and in doing so can produce water quality benefits. Dredging is often relatively expensive when compared to other lake restoration methods. However these costs are often offset by the long-term benefits. Removing sediments removes sources of phosphorus to the lake and by dredging to depths below the photic zone, limiting the amount of light reaching the bottom sediments can reduce aquatic weed growth. This would yield immediate lake user benefits as well, by allowing for easier boat access.

Based on original design conditions it is estimated that to restore the entire lake to its original depth approximately 360,000 cubic meters of sediment would need to be removed form the lake. Dredging however often has a significant impact on lake ecosystems by destroying the benthic community, including fish food organisms, which could take several years to recover if the entire basin was dredged. A bathymetric survey of Virgin Lake should be conducted to determine the optimal locations and best dredging plan to benefit Virgin Run Lake.

Aquatic Plant Harvesting

The majority of nutrients for aquatic plant growth are obtained from phosphorus in the sediments. As they die off and decay, nutrients are re-released into the water column to be recycled again. Harvesting macrophytes removes the majority of the biomass from the lake, hence reducing the nutrient contributions released upon decay.

Nutrient Inactivation

Nutrient inactivation works by binding phosphorus and making it unavailable for algal growth. Although other salts, such as iron and calcium, can also inactivate phosphorus, aluminum is the most popular since it bids tightly to phosphorus over a wide range of ecological conditions, including low or zero dissolved oxygen (U.S. EPA 1988). When aluminum sulfate (alum) or sodium aluminate is added to the lake, a floc of aluminum hydroxide is formed. This floc binds with phosphorus in the water column and carries it to the bottom as the floc settles. The settled floc creates a layer of aluminum hydroxide on the lake bottom that is 1-2 inches thick. The settled floc significantly retards phosphorus release from the lake sediments (U.S. EPA 1988).

Alum use is highly effective in reducing phosphorus concentration and has long lasting influence on internal loading, particularly when combined with dredging. It can however have potential disadvantages associated with aluminum toxicity. Treatments are lake specific and the dosage rate must be carefully calculated.

Control of External Sources

The implementation of a Conservation Plan at the large farm has improved conditions slightly since the original survey was done in 1989. Samples collected in December 1999 show the total lake phosphorus level is less than during the 1989 survey (0.060 Vs 0.063 mg/L). As stated earlier, the agricultural sources of nutrient and sediment runoff in the past now have well-established management practices installed on the property. With these external sources under control, a restoration plan for the lake must concentrate on the internal source of phosphorus regeneration from bottom sediments.

There is some residential development in the basin; however, the basin has substantial relief that severely limits its extent. Land use is summarized in Table 4. Agricultural activity is mostly confined to the southern portion of the basin.

Figure 2 shows a farm in the basin in the background. The sheep pasture in the foreground is another small farm. Note the fence and riparian vegetation along the stream, near the middle of the picture. Generally farming in the Virgin Run Watershed is well managed, as an example the steep hill shown in figure 2 is in pasture and is rotated often. The row crops are on level ground and separated by buffer strips. Livestock densities are low. Manure is stored under eaves outside barns until spread in the fall.

Figure 2 Farmland in Virgin Run Watershed

Portions of streams could be fenced in the watershed, but generally, the pasturing of livestock and storage and useage of manure in this watershed are consistant with Department recommendations.

The tributary drainage characteristics of the Virgin Run Basin are shown in Table 7. Of the 2.4 km of agricultural drainage (22%), livestock has direct access to 0.15 km of the tributary drainage.

Table 7. Tributary Drainage Characteristics	
Tributary Drainage	10.97 km.
Agricultural Drainage	2.44 km.
Livestock Accessible	0.152 km.

Nutrient and sediment loading to the lake could be reduced by installing fencing along 152 m (2 banks X 76 m) of the stream.

Density of livestock on pasture could be reduced, and the use of springs can be developed properly for livestock watering. Manure management could be implimented to ensure a reduction of nutrients entering the lake.

Control of both internal and external sources of phosphorus and sediment is the most efficient means of meeting the TMDL target. As noted above control of the external load by implementation of BMPs will result in reduction of sediment and phosphorous loading to the lake. The result of this reduction is also reflected in a subsequent reduction in material available to internal loading. Removal of in-lake sediment and control of additional external sediment loading would provide substantial reduction of the in-lake phosphorous concentration.

Public Participation

A public meeting to discuss and accept comments on proposed TMDLs was held on January 24, 2001 beginning at 1 PM, at the Southwest Regional Office's Waterfront Conference Room, Building 500, Waterfront Drive, Pittsburgh, PA. Public notice of this draft TMDL and the public meeting was published in the *Pennsylvania Bulletin* and the *Connellsville Courier, Fayette and Westmoreland Counties, PA*. Notice of final plan approval will be published in the *Pennsylvania Bulletin*.

Existing Conditions

LAKE for Windows: Lake TSI Evaluation

Lake Name:	Virgin Run
Type:	Oxic
Status:	Regular
Existing Phosporous Concentration (mg/l):	0.06
Residence Time (days):	41.5
Surface Area (acres):	40
Mean Depth (meters):	2.1
Comment:	Lake is currently Eutrophic.
Expected TSI:	63.19
Expected Load:	14.64

The existing TSI was computed by using the measured in-lake Phosphorus concentration. The load predicted for the lake based on the model analysis is 585 lb/yr. The lake model shows the load as a yearly rate. Multiplying the rate (expected load) times the average yields a yearly loading rate. The total contribution from overland runoff, determined from multiplying the landuse acreage by a runoff coefficient is 436 lbs. The remaining 149 pounds was attributed to internal loading.

585 lbs./yr. / 40 ac = 14.64 lb/ac/yr

The Lake for Windows model uses the units of lb/ac/yr to describe the expected Phosphorus load. The acreage specified for this measurement is the lake surface area. The concentration associated with this load using the equation for an oxic lake is 0.06 mg/l. This concentration value falls within the range of measured in-lake P values of 0.54 to 0.63 mg/l.

All Forest Scenario

LAKE for Windows: Lake TSI Evaluation

Lake Name:	Virgin Run
Type:	Oxic
Status:	Regular
Existing Phosporous Concentration (mg/l):	0.026
Residence Time (days):	41.5
Surface Area (acres):	40
Mean Depth (meters):	2.1
Comment:	Lake is currently Eutrophic.
Expected TSI:	51.13
Expected Load:	6.34

The all forest Load is computed for use as a baseline condition. This is accomplished converting all land uses to a forested condition and determining the resulting load.

This represents the expected TSI and loading for the lake if it had no influence from man. Open water and developed and disturbed land is assumed to exist at their current state in the all forest scenario.

The All Forest TSI was computed by using the acreage for each land use and multiplying it times the run off coefficient for the forest land use. These loads were summed and divided by lake surface area to obtain the loading in lb/ac/yr (See table 4).

251 lbs./yr. / 40 ac = 6.34 lb/ac/yr

The program is used to derive the in-lake phosphorous concentration and the associated TSI value based on the load for this scenario.

TMDL Target

LAKE for Windows: Lake TSI Evaluation

Lake Name:	Virgin Run
Type:	Oxic
Status:	Regular
Existing Phosporous Concentration (mg/l):	0.031
Residence Time (days):	41.5
Surface Area (acres):	40
Mean Depth (meters):	2.1
Comment:	Lake is currently Eutrophic.
Expected TSI:	53.67
Expected Load:	7.56

The TMDL Target was computed using 1.2 times the all forest in-lake Phosphorus concentration. The scientific justification for using the multiplier of 1.2 is explained on page 6 of the written documentation.

The expected load for the existing condition will be divided into the expected load of the TMDL target scenario to determine the percent reduction of Phosphorus needed to attain the TMDL target TSI.

The allowable load for Phosphorus to meet the TMDL TSI for Phosphorus is as follows:

301 lbs./yr. / 40 ac = 7.53 lb/ac/yr

The body of this paper explains how the margin of safety is factored into the evaluation.

References

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Thomann, R.V. and J.A. Mueller, 1987. Principles of Surface Water Quality Modeling and Control. Harper & Row, New York.

Attachment D

Comment and Response

Comment and Response Document for the Virgin Run Lake TMDL.
Comments from USEPA Region III
Comment: EPA believes the runoff coefficients for the watershed may need to be adjusted to more accurately reflect the characteristics of the watershed.

The TMDL states that phosphorus loads from non-point source contributions were calculated using standard land-use runoff coefficients as documented in Reckow, 1983. EPA recognizes this as a valid source and methodology. However, due to the site specific characteristics of the Virgin Run Lake watershed, EPA believes the standard runoff coefficients may not accurately reflect the current conditions in the watershed.

The TMDL discusses that conservation management practices on the majority of agricultural lands in the watershed are well established. It states that the live stock density in the watershed is low, and the pasturing of livestock, and storage and use of manure in the watershed is consistent with Department recommendations. The TMDL also explains that there is substantial relief in the basin, which limits development, this would also effect the rate of watershed runoff in non-agricultural areas.

Response: The department agrees and the TMDL was recalculated using more realistic runoff coefficients. All tables have been adjusted to reflect the recalculations.

Comment: Please separate the 'internal' loading from the baseline load of the 'all-forested' scenario

The 'all-forested' scenario serves as a baseline loading value. By representing the surrounding watershed as a completely forested scenario, absent anthropogenic impacts, the natural condition for phosphorus loading, and the trophic status of Virgin Run Lake is estimated. The internal loading, which is assigned a reduction, is considered separate of this baseline load, and should not be included in as part of the value.

Response: The department agrees and the TMDL was recalculated separating the internal loading from surface loading. All tables have been adjusted to reflect the recalculations.

Comment: Please include a discussion further supporting the reasonable assurance that the TMDL can be implemented. Specifically, that the technologies described in the recommendations section are capable of reducing the internal loading to the level required to meet the TMDL.

Response: As noted in the TMDL control of the external load by implementation of BMPs will result in reduction of sediment and phosphorous loading to the lake. The result of this reduction is also reflected in a subsequent reduction in material available to internal loading. Removal of in-lake sediment and control of additional external sediment loading would provide substantial reduction of the in-lake phosphorous concentration.

Attachment A

Carlsons Trophic Status Index paper

Attachment B

Excerpt from PADEP Guidance -- "Implementation Guidance for Section 95.6 Management of Point Source Phosphorus Discharges to Lakes, Ponds, and Impoundments”

Attachment C

PADEP Methodology for Lake TMDLs