Final

TMDLs for Castleman Run Lake, West Virginia

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EXECUTIVE SUMMARY

The objective of this study was to summarize the background information, analyze load reductions, and document Total Maximum Daily Loads (TMDLs) for nutrients and siltation. The West Virginia Division of Environmental Protection (WVDEP) has identified Castleman Run Lake (designated code WV_O(L)-92-L-1for aquatic life) as being impacted by these pollutants, as reported in the 1998 303(d) list of water-quality-limited waters (WVDEP 1998). WVDEP has determined that the aquatic life use designation (Class B1 for warm water fishery) has been impaired by nutrients and siltation.

- West Virginia uses a trophic state index when considering lakes for listing due to nutrient impairment. Lakes with a total phosphorus or chlorophyll *a* trophic state index (TSI) greater than or equal to 65 were considered to be impacted by nutrients. For Castleman Run Lake, the nutrient loading was calculated to maintain a total phosphorus and chlorophyll *a* TSI below 65.

- Siltation has no specific water quality criteria; however, elevated inputs of sediment has been demonstrated to cause impairment of the support of aquatic life and recreational uses of the lake. The endpoint for the development of a TMDL for siltation of Castleman Run Lake is based on the evaluation of the total sediment load delivered to the lake, as indicated by the average accumulation rate of sediment in selected lake locations allowing for a life span of 40 years for the reservoir.

To evaluate the relationship between the sources, their loading characteristics, and the resulting conditions in the lake, a combination of analytical tools were used. Assessments of the nonpoint source loading into the lake were developed for Castleman Run Lake watershed using the Generalized Watershed Loading Function (GWLF) computer program. GWLF provided estimates of nutrients and sediments transported to the lake for individual land use categories. The lake was evaluated using the BATHTUB water quality simulation computer model to estimate the concentrations of nutrients and chlorophyll *a*. The lake was segmented into two cells to better represent the system. The results of the watershed and reservoir models were compared with observed water quality data, literature values, previous studies, and reservoir conditions to evaluate the models' performance.

TMDLs are composed of the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and natural background levels. A representative hydrologic simulation year was used for testing and development of the TMDL by averaging the hydrologic conditions for the period from 1978 to 1997. The resulting allocation for the two listed pollutants includes a 30 percent reduction of nutrients (expressed as total phosphorus) and a 40 percent reduction of sediment load.

The TMDLs are described as average annual loads, which is typically appropriate for reservoirs and impoundments. The margin of safety has been addressed through an explicit load in the development of the TMDL analysis. The load reductions can be achieved through a combination of land use and restoration practices such as erosion and sediment control practices, forest management, and stream restoration.

1 INTRODUCTION

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions. By following the TMDL process, states can establish water quality-based controls to reduce pollution from both point and nonpoint sources and to restore and maintain the quality of their water resources (USEPA, 1991).

The West Virginia Division of Environmental Protection (WVDEP) has determined that the use designation of Castleman Run Lake for aquatic life has been impaired by nutrients and siltation. The United States Environmental Protection Agency (USEPA) conducted this study to analyze the loadings to the lake and to establish TMDLs that will restore and maintain the quality of Castleman Run Lake for the uses designated by West Virginia.

This report presents the background information, analyses, and TMDLs that address the designated use impairments of Castleman Run Lake. The report is organized as follows:

- Section 2 - A description of the waterbody and the impairments listed by West Virginia as required under Section 303(d) of the Clean Water Act
- Section 3 - A presentation of the essential information that characterizes the impaired waterbody and watershed
- Section 4 - A description of the applicable water quality standards and the selection of TMDL endpoints to achieve the standards and to meet the designated uses
- Section 5 - An assessment of the water quality data and information pertinent to developing TMDLs
- Section 6 - An assessment of the sources of pollutants pertinent TMDL allocation
- Section 7 - A description of the modeling process used to develop TMDLs
- Section 8 - Allocation of the load reductions to sources
- Section 9 - A description of the process used to monitor the effectiveness of the proposed TMDLs and compliance

This report also provides a description of the waterbody and associated pollution sources, provides a summary of water quality monitoring data, and describes the analytical approach used to develop the TMDL. The report specifically addresses each of the elements of a TMDL, including the following:

1. Describe waterbody, pollutant of concern, pollutant sources, and priority ranking	(Section 2)
2. Describe applicable water quality standards and numeric water quality targets	(Section 4)
3. Loading capacity- linking water quality	(Section 8)

and pollutant sources
4. Load allocations (LAs) (Section 8)
5. Wasteload allocations (WLAs) (Section 8)
6. Margin of safety (MOS) (Section 8)
7. Seasonal variation (Section 8)
8. Reasonable assurances for implementation (Section 9)

2 PROBLEM STATEMENT

A general description of the impaired waterbody, Castleman Run Lake, and the causes for its listing on the 303(d) list are presented in this section.

The Castleman Run Lake watershed is located within the Upper Ohio River 2 hydrologic cataloging unit (05030106), as shown in Figure 2.1. The land area of the watershed is approximately 2,128 hectares (5,256 acres) located in Brooke County, WV and Ohio County, WV, and Washington County, PA. Runoff from the watershed flows into Castleman Run Lake from Castleman Run. Castleman Run receives flow from Crupe Run, Rices Run, Murray Run, Blayney Run, Curtis Run, Garrison Run, and unnamed creeks. Water discharged from the lake in Castleman Run and then to the Buffalo Creek. The lake is used for recreational activities such as fishing and picnicking. Private boats with electric motors are permitted on the lake. The lake's watershed is primarily rural, and the main land uses are forest and hay/pasture. Castleman Run Lake is a 8.9-hectare impoundment located 5 miles east of West Liberty, WV.

WVDEP listed Castleman Run Lake on the 1998 303(d) list for not meeting its designated uses. The waterbody is given a high priority for TMDL development. The lake (designated code WV_O(L)-92-L-1) was listed for nutrients and siltation (WVDEP, 1998). The impairments, from the West Virginia Primary Waterbody List, are presented in Table 2.1.

The water quality uses that are impaired are aquatic life (impaired by nutrients and siltation). The primary source column provides the "general source descriptions, if confirmed" (WVDEP, 1998). WVDEP assumed that the lake impairments are primarily due to agricultural sources.

West Virginia classifies a waterbody as impaired for the listed pollutants based on the following considerations:

- Nutrients: Impairment due to nutrients "means enrichment from phosphorus and nitrogen compounds, both of which lead to eutrophic conditions. Eutrophic conditions can occur without a numeric water quality standard violation. In fact, West Virginia has no phosphorus standard, and the nitrate standard is centered around public health concerns" (WVDEP, 1998).

- Siltation: West Virginia considers lakes to be impaired by siltation if sediments are visually observed to accumulate to a depth approaching the lake normal pool elevation.

The development of TMDLs for Castleman Run Lake includes a review of the potential causes of impairment and the establishment of the TMDL loading capacity, load allocation, wasteload allocation, and margin of safety.

Table 2.1. Water quality impairments of Castleman Run pursuant to section 303(d) of the Clean Water Act

Stream Name	Stream Code	Use Affected	Pollutant	Primary Source	Size Affected (acres)
Castleman Run Lake	O(L)-92-L-1	Aquatic Life	Nutrients and siltation	Agriculture	22

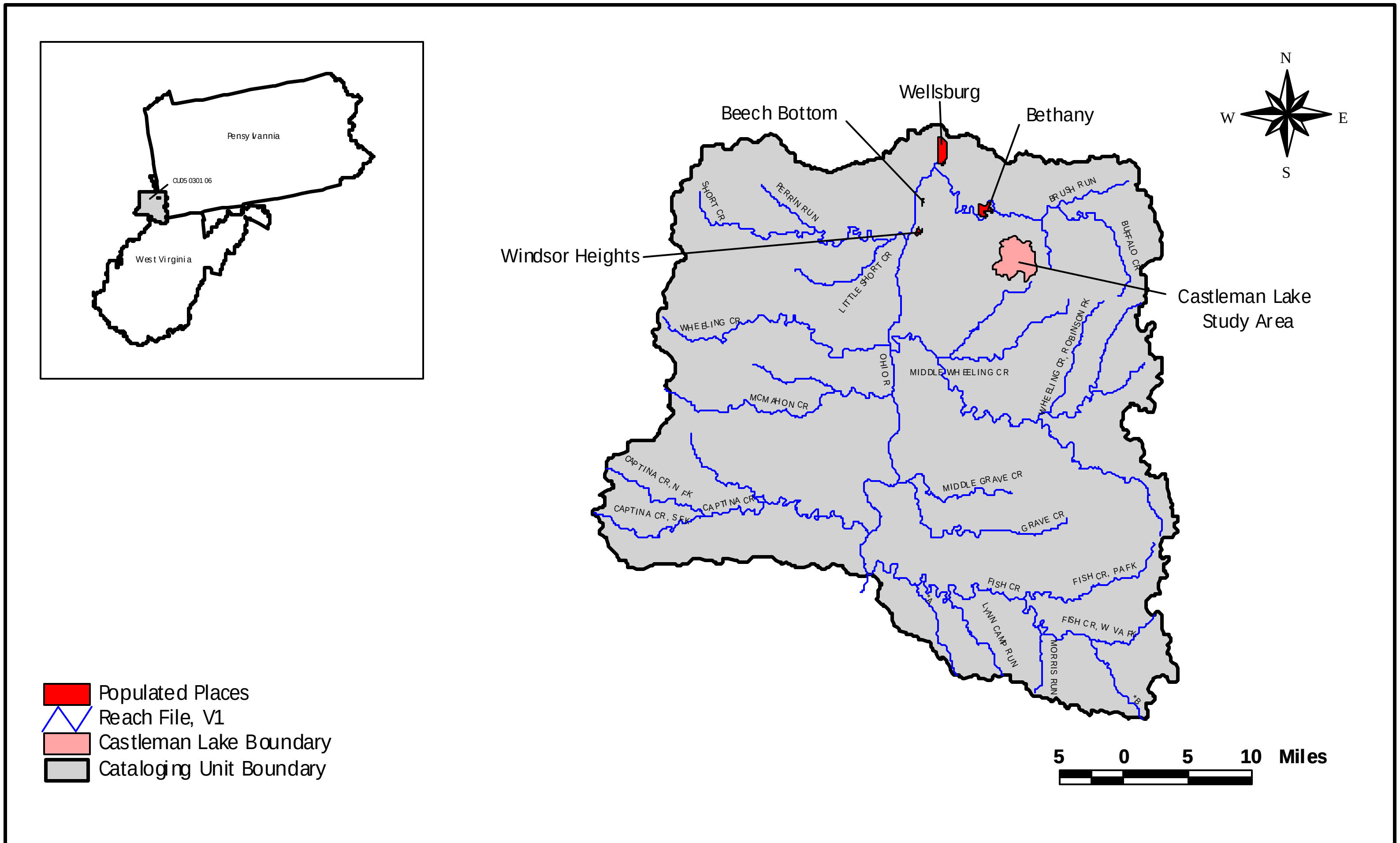


Figure 2.1. Site and Location Map
Castleman Lake Watershed, Brooke and Ohio, Counties, West Virginia

Map Projection: Albers Equal Area, GRS 80

Data Sources: USGS (RF1), ESRI 1995

3 ENVIRONMENTAL SETTINGS

The environmental settings that contribute to the impairment of Castleman Run Lake include those of the lake itself, the watershed, and the atmosphere. This section presents the environmental information that will be used in subsequent sections.

3.1 Lake Characteristics

3.1.1 Physical Characteristics

Based on discussion with WVDEP personnel, historical information regarding the Castleman Run Lake was collected. The lake was formed by an earth dam in 1962 (WVDNR, 1983). The impoundment was excavated and the underlying clay was used to construct the dam. The excavated topsoil was used to help landscape the shores of the lake with two constrictions created in the middle of the lake. These constrictions effectively cause the shallow upstream portion of the lake to act as a forebay (Stutler, personal communication, May 1999).

The lake consists of the flooded Castleman Run stream valley. The oldest records available are the West Virginia Department of Natural Resources (WVDNR) description and bathymetric survey (WVDNR, 1983), which show a shallow lake bed extending from the Castleman Run outfall (at a depth of 0 meters) to the constriction (at a depth of less than 3 meters) at a grade of 0.9 percent. This shallow bed accounts for approximately half of the total lake surface area and is expected to have collected the majority of the sediment load delivered by Castleman Run. The grade steepens to approximately 6 percent in the deep pool as the lake bed drops to a depth of approximately 5.9 meters.

There have been no known construction or dredging activities in the lake since its construction.

A bathymetric survey of Castleman Run Lake was conducted in 1999 which shows that since 1980, erosion and subsequent sedimentation processes have developed a small delta at the tributary inflow to the lake that limits the storage capacity of the lake thus affecting the lake limnologic characteristics.. The 1999 bathymetry provided better definition of the lake side slopes. As both surveys are reported to have occurred at lake normal pool elevation, a comparison of the bathymetric depths between the two surveys indicate the thickness of sediment accumulation at various regions within the lake. For example, the shallow upstream segment of the lake appears to have accumulated from 0 to 1 or more meters of sediment. The deeper pool shows no accumulation at the end adjacent to the dam and up to 1.3 meters (4 feet) near the inflow location at the shallow end.

Based on the available bathymetric and physical characteristics data obtained from the 1980 survey (WVDNR, 1983), several physical characteristics of Castleman Run Lake have been derived and are presented in Table 3.1a and b. The lake surface area extends over approximately 8.9 hectares (22 acres). The lake is shallow with a maximum depth of 5.8 meters (19 feet) and a mean depth of 1.5 meters (4.9 feet). The overall storage volume of the lake at normal pool is about 135,000 cubic meters (130 acre-feet) and drains a watershed area totaling 2,128 hectares (5,256 acres).

Table 3.1a. Description of the physical characteristic of Castleman Run Lake

Characteristics	Original (1962)	1980[a]	Present (1999)[b]
Lake volume (cubic meters)	NA	135,000	NA
Surface Area (hectares)	NA	9	8.3
Drainage Area (hectares)	2,227	2,128	2,128
Mean Depth (meters)	NA	1.5	NA
Maximum Depth (meters)	NA	5.8	5.8
Length (meters)	NA	655	655
Mean Width (meters)	NA	204	NA

[a]WVDNR, 1983.
[b]WVDEP 1999 bathymetric survey

Table 3.1b. Description of the physical characteristic of Castleman Run Lake

	Shallow Forebay		Deep Pool	
Characteristics	1980[a]	Present (1999)[b]	1980[a]	Present (1999)[b]
Lake volume (cubic meters)	39,600	35,200	95,400	90,800
Surface Area (hectares)	4.4	4.4	4.6	4.6
Drainage Area (hectares)	2,227	2,227	2,227	2,227
Mean Depth (meters)	0.9	0.8	2.1	2.0
Maximum Depth (meters)	3.4	1.4	5.8	5.8
Length (meters)	350	350	305	305

[a]WVDNR, 1983
[b]WVDEP 1999 bathymetric survey

3.1.2 Morphometric Characteristics

The 1980 bathymetric analysis (summarized in Table 3.2) showed that the ratio of mean to maximum depth is close to 0.26, indicating steep side slopes. As the lake continues to lose capacity to siltation, sediment deposits around the inflow points reduce the slopes at lake entrance areas. The bathymetric data collected in 1980 indicate that the south and west shores of the deep pool have side slopes with up to a 30 percent grade.

The ratio of the drainage area to lake surface area is about 250, which indicates that the watershed loading, including both sediment and nutrient, could have a significant impact on the lake water quality. The drainage watershed is very large in comparison to the impoundment area, making the lake sensitive to increased loading, especially in the areas surrounding the lake.

The ratio of the length of Castleman Run Lake to its mean width (5) indicates that the length of the lake is the slightly more dominant process. Because of the size of the impounded area, the lake appears to act as a wide river rather than a lake, especially during high flow and storm events.

The lake began in 1962 as an excavated streambed and floodplain. As is typical of reservoirs, its deepest point is at the downstream (northern) shore adjacent to the dam. The shallowest area is located at the upstream (northern) edge of the lake at the inflow from Castleman Run. The siltation has resulted in significant accumulation in the upper shallow segment, and moderate accumulation in the upper half of the deeper pool. Overall about 75% of the lake shows significant sediment accumulation.

Table 3.2. Morphometric parameters of Castleman Run Lake

Characteristics	Original (1962)	1980[a]	Present[b]
Mean to max depth ratio	NA	0.26	NA
Drainage area to surface area ratio	NA	250	NA
Length to mean width ratio	NA	5	NA

[a]WVDNR, 1983.
[b]1999 Screening bathymetry.

3.1.3 Hydrologic Characteristics of the Lake

Two key hydrologic parameters of Castleman Run Lake were determined based on estimates of streamflow rates and volumetric characteristics of the impoundment. The lake residence time, calculated as lake volume over the annual flow rate, is estimated to range between 1.3 and 7.6 days, as shown in Table 3.3. This short residence time is typical for lakes with a large drainage area-to-lake surface area ratio. In lakes with short residence times, a significant portion of the sediment and nutrient loads is transported farther into the impoundment into the deeper portion of the lake.

Table 3.3. Hydraulic residence time estimates for Castleman Run Lake

Annual Precipitation (cm)	Date of Occurrence	Magnitude	Annual Discharge (m^3/yr)	Residence Times		
				Shallow Forebay	Deep Pool	Total Lake
110	1978 to 1996	Average	$1.0X10^7$	1.3	7.6	4.8
126	1978	Maximum	$1.2X10^7$	1.1	6.6	4.2
79	1987	Minimum	$0.7X10^7$	1.8	10.6	6.7

Rainfall data source: Morgantown, West Virginia.

3.2 Watershed Characteristics

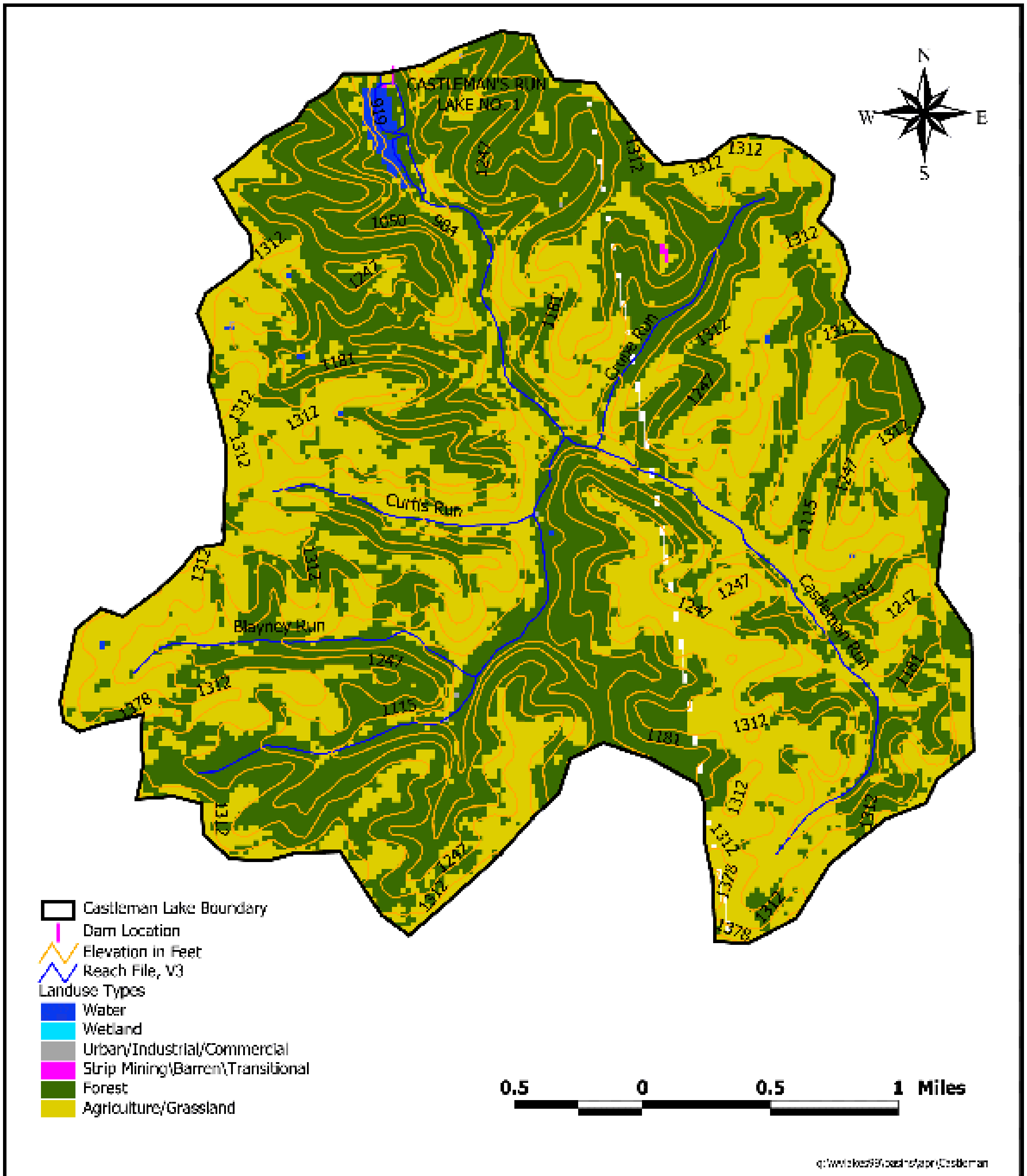
The Castleman Run Lake watershed is a moderately sized drainage basin of 2,128 hectares (5,256 acres). All of the watershed consists of hydrologic soil group C (STASTGO, 1997). The major soil series include Dormont, Culleoka, and Westmoreland. The watershed size yields an estimated sediment delivery rate of 0.19, that is 19 percent of the eroded soil reaches the lake based on long-term average annual loading analysis (Vanoni, 1975).

Multi-Resolution Land Classification (MRLC) coverage was used to develop the land use distributions within the Castleman Run Lake watershed (USEPA, 1998), which are presented in Table 3.4.

Table 3.4. Watershed land use distributions

TMDL Land Use Classes	Pervious/Impervious (Percent)	MRLC Land Use Class (Class No.)	Land Use Distribution in Watershed (hectares)
Residential	Pervious (50%) Impervious (50%)	Low-Intensity Developed (21)	0.5
Forest	Pervious (100%)	Deciduous Forest (41) Evergreen Forest (42) Mixed Forest (43)	1158.1
Cropland	Pervious (100%)	Row Crop (82)	8.5
Pasture/Hay	Pervious (100%)	Hay and Pasture (81)	950.7
Barren (includes grading or construction)	Pervious (100%)	Quarries/Strip Mines/Gravel Pits (32)	0.5
Water	Impervious (100%)	Lakes and Streams	9.6
Total			**2127.9**

The spatial distribution of different land uses is shown in Figure 3.1.



Castleman Lake Watershed Brooke, Ohio, West Virginia and Washington County, Pensylvannia

Data Sources: West Virginia State

Map Projection: Albert Equal Area

4 WATER QUALITY STANDARDS AND TMDL ENDPOINT

4.1 Water Quality Standards

The state water quality standards include water use categories, antidegradation criteria, numeric criteria, and narrative descriptions of conditions in waters of the state.

The relevant water use categories for Castleman Run Lake include the following:

- Propagation and Maintenance of Fish and Other Aquatic Life (Category B-1)
- Water Contact Recreation (Category C)

No special exceptions or use designations are identified for Castleman Run Lake.

4.2 Nutrients

No numeric criteria are available in the West Virginia water quality standards relevant to the 303(d) listing. The relevant narrative description of condition includes the following:

> §46-1.3 Conditions Not Allowable in State Waters.
> 3.2 No sewage, industrial wastes or other wastes present in any of the water of the State shall cause therein or materially contribute to any of the following conditions thereof:
> a. Distinctly visible floating or settleable solids, suspended solids, scum, foam or oily slicks;
> b. Deposits or sludge banks on the bottom;
> ...
> i. Any other condition ... which adversely alters the integrity of the waters of the State including wetlands; no significant adverse impact to the chemical, physical, hydrologic, or biological components of aquatic ecosystems shall be allowed. (Title 46, Series 1, Requirements Governing Water Quality Standards, 1999)

WVDEP identifies lakes as impaired due to nutrients on the state's 303(d) list

> "...if summer total phosphorus or chlorophyll *a* levels in surface waters resulted in a trophic state index value of $ 65 (highly eutrophic) or summer algal blooms or excessive aquatic vegetation were noted." (WVDEP, 1998).

The concept of trophic states was developed by Einar Naumann to characterize the condition of lakes (Naumann 1919). The principle behind trophic states is that physical and chemical factors control the production of algae which in turn affects the biological structure of the lake. The amount of algal production plays an important role in lake conditions such as color, visible light penetration, dissolved oxygen concentrations, and odor. Common trophic state classifications include oligotrophic (low production, low nitrogen and phosphorus, oxygenated hypolimnion), mesotrophic (moderate production, moderate nitrogen and phosphorus), and eutrophic (high production, high nitrogen and phosphorus, anoxic hypolimnion).

The Carlson Trophic State Index (TSI) (Carlson 1977) was developed to estimate the algal production and determine trophic state based upon chlorophyll pigments, secchi depth, and total phosphorus. The TSI is a logarithmic scale that ranges from approximately 0 to 100. The three index variables chlorophyll pigments (CHL), Secchi depth (SD), and total phosphorus (TP) use regression equations to estimate the index value and algal production. These three index variables are interrelated and should produce the same index value for a given combination of variables values. The regression equations used to calculate the TSI are shown in equations 4.1 to 4.3.

$$TSI(SD) = 60 - 14.41 \ln (SD) \quad (4.1)$$
$$TSI(CHL) = 9.81 \ln (CHL) + 30.6 \quad (4.2)$$
$$TSI\ (TP) = 14.42 \ln (TP) + 4.15 \quad (4.3)$$

The trophic state can be related to the trophic state index and lakes conditions as shown in Table 4.1.

Table 4.1. Trophic state, trophic state index and lakes conditions

TSI	Trophic State	Attributes	Aquatic Life
< 30	Oligotrophic	Clear water, low production, oxygenated hypolimnion.	Trout possible in deep lakes.
30-50	Mesotrophic	Moderately clear water, possible anoxia in summer.	Warm Water Fishery
50-70	Eutrophic	Low transparency, anoxic hypolimnion in summer.	Warm Water Fishery
>70	Hypereutrophic	Dense algae and macrophytes, noticeable odor, fish kills possible.	

Review of the available water quality monitoring information from 1993 to 1996 and 1998 indicates the likely source of impairment is periodic nuisance algal blooms. Based on monitoring (15 samples), observed chlorophyll *a*, an indicator of algae, is periodically elevated during the growing season, ranging from 6 to 130 ug/l with a mean of 59.5 ug/l (see section 5.2). For Castleman Run Lake, the total phosphorus and chlorophyll *a* TSI were calculated from the available sampling information. Insufficient monitoring data was available to calculate the secchi depth TSI. The phosphorus TSI is 70.7 and the chlorophyll TSI is 63.2. The phosphorus TSI clearly exceeds the West Virginia listing guideline of 65.

This lake is characterized by a shallow depth, a high watershed to surface area ratio, and a short residence time. These characteristics make the lake highly sensitive to nutrient loading even under managed conditions. On the basis of the site specific characteristics of the lake, a target is selected which is consistent with the best water quality that this lake can be expected to achieve. The identified target is less than the state listing guidelines of a TSI of 65. The values used to designate the acceptable limit in Castleman Run Lake are a total phosphorus TSI of 63.2 and a chlorophyll *a* TSI of 62.5.

4.3 Sediment

Castleman Run Lake is listed as impaired due to siltation on the 303(d) list. Siltation is the excessive accumulation of sediment in the reservoir. The accumulation of sediment can impair the water uses of Fish and Other Aquatic Life and Recreation. The excessive accumulation of sediment can adversely affect aquatic life by creating thick mud deposits, filling habitat, and increasing turbidity. The excessive accumulation of sediment impairs recreational use by reducing access and degrading the aesthetic character of the lake.

The state has no numeric criteria related to the impairment of siltation in lakes. The relevant narrative conditions specify the following:

> §46-1-3.3.2 No sewage, industrial wastes or other wastes present in any of the water of the State shall cause therein or materially contribute to any of the following conditions thereof:
> ...
> c. Deposits or sludge banks on the bottom.
> ...
> i. Any other condition ... which adversely alters the integrity of the waters of the State including wetlands; no significant adverse impact to the chemical, physical, hydrologic, or biological components of aquatic ecosystems shall be allowed. (Title 46, Series 1, Requirements Governing Water Quality Standards)

In the absence of numeric criteria for lake siltation in West Virginia, a numeric limit is selected for the development of the Castleman Run Lake siltation TMDL. This numeric limit is selected to be protective of the lake uses and serves as a target for identifying achievement of water quality standards associated with the lake listing. The selection of this numeric limit was based on several considerations:

- The selected endpoint, expressed as a long-term sedimentation rate for Castleman Run Lake, is consistent with the causes of the Castleman Run Lake listing. Excessive siltation is reported by the state as the main cause of the lake impairment.

- The long-term annual siltation rate should not be excessive and should allow for a reasonable life span of the lake before deposits become evident at normal pool elevations or create barrier to recreational uses. For small impoundments such as Castleman Run Lake with large drainage areas, and in the absence of the design specifications of the lake, a minimum 40-year life span is selected as a target and is used in derivation of siltation rate limit for this TMDL.

- Siltation does not occur uniformly over the entire lake bottom. Selected locations within the lake experience high siltation rates compared to other locations within the lake. The selected locations are the areas most likely to create barrier for recreational uses. Specifically for Castleman Run Lake, characterized by a small area (9 hectares) and a shallow depth (1.5 meters mean depth), the high siltation locations are assumed to correspond to 55,970 cubic meters.

Based on the above considerations regarding the life span of the impoundment and the siltation volume (or critical volume), a long-term average annual siltation rate limit of 0.63 cm was calculated and established as the numeric criteria for this siltation TMDL.

5 WATER QUALITY ASSESSMENT

This section provides an inventory and analysis of the available water quality data for Castleman Run Lake, its tributary (Castleman Run), and the watershed.

5.1 Inventory of Available Water Quality Monitoring Data

Limited water quality monitoring activities have been conducted for Castleman Run Lake and its inflows. Water quality data reviewed as part of this report were collected as follows: WVDEP seasonal sampling of Castleman Run Lake and its inflow (Castleman Run) from spring to fall during 1993, 1994, 1995, and 1996 (a total of 10 sampling events) and from spring to fall 1998 (a total of 3 sampling events). Data include the monitoring of nutrients, metals, temperature, suspended solids, and other water quality parameters.

5.2 Analysis of Water Quality Monitoring Data for Castleman Run Lake

Summaries of the minimum, maximum, and average values for the monitored water quality parameters are presented on Tables 5.1, 5.2, and 5.3 for the tributary, lake, and lake sediments, respectively. The summaries were derived using the following practices:

- Analytical results of less than the detection limit were assigned a value of one-half the detection limit when calculating the average value.
- Numerous samples collected on a single date were averaged and treated as one sample when calculating an overall average value.

The conclusions from the review of the data are as follows:

- Although a few parameters showed a range of nearly two orders of magnitude (for example, dissolved oxygen, total suspended solids, and ammonia), the wide range was generally due to an extreme value from a single sampling date.
- Nutrient and suspended sediment concentrations are generally higher in the lake than in the tributary.
- The long-term average chlorophyll *a* concentration (59.5 ug/l) is higher than the TMDL endpoint of 25.8 ug/l, with a maximum value of 310 ug/l.

Table 5.1. Summary of WVDEP tributary sampling observations of selected pollutants: Castleman Run Lake, 1993-96, 1998

Pollutant Type	Pollutant	Units	Criteria	Total Obs.	Minimum	Maximum	Total Average
Nutrient	TKN	mg/l		16	0.04	0.97	0.40
	NO2-NO3-N	mg/l	10 [a]	16	0.05	1.14	0.28
	TN	mg/l					
	TP	mg/l		11	0.01	0.04	0.02
	Ammonia	mg/l		12	0.05	0.50	0.32
	Chlorophyll a	mg/l					
Siltation	Suspended Solids	mg/l		16	1	10	5.44

[a] Nitrate as nitrogen is not to exceed the 10 mg/l acute human health use designation.

Table 5.2. Summary of WVDEP lake sampling observations for selected pollutants: Castleman Run Lake, 1993-96, 1998

Pollutant Type	Pollutant	Units	Total Obs.	Min	Max	Total Average	Lake Bottom Average
Nutrient	TKN	mg/l	26	0.32	1.40	0.80	0.84
	NO2-NO3-N	mg/l	28	0.01	0.83	0.21	0.26
	TN	mg/l	28	0.39	1.65	0.96	1.02
	TP	mg/l	28	0.02	0.12	0.06	0.06
	Ammonia	mg/l	28	0.01	0.50	0.25	0.22
	Chlorophyll *a*	ug/l	14	6	310	59.5[a]	
Siltation	Suspended Solids	mg/l	28	2	41	12.71	12.18
	Turbidity	NTU	11	49.10	149	75.77	

[a]Based on one sample per day

Table 5.3. Summary of WVDEP lake sediment sampling observations of selected pollutants: Castleman Run Lake, 1993-96, 1998

Pollutant Type	Pollutant	Units	Total Obs	Minimum	Maximum	Mean
Nutrient	TP	mg/kg	3	83.00	890.00	389.00

Nitrogen : Phosphorus Ratio

The levels of nitrogen and phosphorus in the water column control the growth of aquatic plants. It is important to determine which nutrient is limiting in order to accurately model the system. A general guide used to determine the limiting nutrient is the Nitrogen : Phosphorus (N:P) ratio. Aquatic systems where the N:P ratio is greater than 7.2 are considered to be phosphorus limited (Chapra, 1997). Castleman Run

Lake has a N:P ratio of 16, indicating phosphorus concentrations drive the aquatic plant growth in the lake.

Trophic State

Trophic state indices have been developed to help define the usability of a lake for fishing and recreational uses. These indices are frequently based upon factors such as nutrient levels, temperature, light, and lake geometry (Carlson and Simpson, 1996). A common classification based on these factors includes the trophic states; oligotrophic (low production), mesotrophic (medium production), eutrophic (high production), and hypereutrophic (very high production). Castleman Run Lake has an observed total phosphorus TSI of 63.2 and a chlorophyll *a* TSI of 70.7. TSI values above 70 indicate a hypereutrophic condition (Carson and Simpson, 1996). The TSI also exceeds West Virginia listing guideline of 65 (WVDEP, 1998).

Table 5.4. Common trophic state characteristics [a]

Trophic State	Characteristics	Attributes
Oligotrophic	Low phosphorus (3.0 - 17.7 ug/L) Low nitrogen (307 - 1630 ug/L) Low Chl a (0.3 - 4.5 ug/L) High secchi depth (5.4 - 28.3 m)	Oxygenated hypolimnion, clear water, suitable for cold water aquatic life in deeper lakes.
Mesotrophic	Moderate phosphorus (10.9 - 95.6 ug/L) Moderate nitrogen (361 - 1387 ug/L) Moderate Chl a (3 - 11 ug/L) Moderate secchi depth (1.5 - 8.1 m)	Hypolimnetic anoxia possible, moderately clear water, suitable for warm water aquatic life.
Eutrophic	Moderate phosphorus (16 - 386 ug/L) Moderate nitrogen (393 - 6100 ug/L) Moderate Chl a (3 - 78 ug/L) Moderate secchi depth (0.8 - 7.0 m)	Decreased transparency, noticeable odor and color, possible macrophyte problems, suitable for warm water aquatic life.
Hypereutrophic	High phosphorus (750 -1200 ug/L) High nitrogen (Not available) High Chl a (1 - 150 ug/L) Low secchi depth (0.4 - 0.5 m)	Dense algae growth, nuisance weeds present, noticeable odor and color, low transparency, winter fish kills possible.

[a] Vollenweider and Kerekes, 1980.

6 SOURCE ASSESSMENT

6.1 Assessment of Point Sources

Several databases were reviewed to determine if permitted or regulated point source discharges were present within the watershed. The databases reviewed were obtained primarily from the USEPA mainframe computer system. In addition to the review of available databases, local agencies, including WVDEP and USEPA Region 3 were contacted by telephone. The following database systems were searched:

- Permit Compliance System for permitted industrial or municipal facilities
- Hazardous and solid waste facilities
- Abandoned mines
- Oil and gas wells
- Toxic release inventory

No point sources were identified within the drainage area of the listed water (Donaghy, personal communication, June 1999).

6.2 Assessment of Nonpoint Sources

Nonpoint sources of pollutants within the watershed can generally be associated with the different types of land uses and land activities within the watershed. For example, sediment loadings can originate from silvicultural activities and road construction. Expansion of residential and commercial/industrial areas can also cause an increase in storm water flows and sediment loads through soil erosion and sediment transport. In addition, the erosion rate can potentially increase phosphorus loads since phosphorus is readily adsorbed onto soil particles. For nutrient enrichment, animal waste handling, manure and fertilizer application, and septic systems are the key potential sources.

The primary land uses within the Castleman Run Lake watershed are agriculture and forest with minor components of residential uses. The land uses within the watershed are presented on Table 6.1.

The broad categories of land uses have been separated into more detailed classes based on information obtained from the West Virginia Forestry Service (Warren, personal communication, May 1999). The information indicated that, as a long term average, 2.4 percent of the forest land is selectively logged every year. In addition, under existing conditions, 75 percent of the forest harvesting activities comply with erosion/sediment control practices (Warren, personal communication, May 1999).

The potential contribution of nutrients from failing septic systems was also assessed. No sanitary sewer exists within the watershed. Data associated with the number of reported septic systems present in Brooke and Ohio County, WV, and Washington County, PA were obtained from 1990 U.S. Census data and the analysis of existing maps.

Urban development and associated construction activities were assumed not to exist. An analysis, indicated a roughly zero population growth in Brooke, Ohio, and Washington Counties. Therefore, construction activities are taken to be negligible.

Cattle have been observed roaming in at least two of the tributaries that drain to Castleman Run. Cattle can contribute nutrient loadings and degrade vegetative buffers to streams. Wildlife, especially waterfowl, can contribute significant nutrient loadings directly to the lake. While waterfowl are expected to be present during the warmer months, no specific wildlife counts are available at this time.

Table 6.2 presents a summary of additional potential sources considered in this analysis.

Table 6.1. Land use categories

Land Use Classes	Area (hectares)	Percentages
Residential	0.5	<1
Barn Yard	0.3	<1
Forest	1158.1	54
Cropland	8.5	<1
Pasture/Hay	950.4	45
Barren (includes grading or construction)	0.5	<1
Water	9.6	<1
Total	**2127.9**	**100**

Table 6.2. Additional potential nonpoint sources in the watershed

Potential Nonpoint Sources	Magnitude	Data Sources	Comments
Silvicultural activities (hectares/year)	27.8	WV Forestry Service	Selective tree logging methods assumed - considered as part of forest loadings
Septic Releases (population)	189	USGS quads; US Census data	Assumes zero population growth per year
Wildlife and waterfowl (counts)	NA[a]	–	Incorporated into forest loadings
Barn Yards, or animal holding area (hectares)	0.3	Census of Agriculture, 1992	Converts number of animals to minimum barnyard area

[a] Not available.

6.3. Representation of Potential Sources in the Development of Loading Estimation

The representation of the nonpoint sources in the loading model was determined based on the available data and considering the differences among the various categories of sources.

Nutrients

The sources simulated in the model include four land use categories representing surface loading, the septic system as an independent source, and the contribution of nutrient from ground water. Table 6.3 presents the nutrient sources simulated.

Table 6.3. The nutrient sources simulated in the loading model.

Sources Simulated	**Characteristics**
Forest	All the forest land, including forest harvesting and wildlife and waterfowl.
Agriculture	Cropland, pasture / hayland, and barnyards.
Urban	Residential areas.
Construction	Barren and construction areas
Groundwater	Nutrients from groundwater
Septic System	Septic release from human population

Sediment

The sediment sources represented in the model are shown in Table 6.4.

Table 6.4. The sediment sources simulated in the loading model.

Sources Simulated	**Characteristics**
Forest	All the forested land, including forest harvesting
Agriculture	Cropland and pasture/hay land
Urban	Residential areas
Construction	Barren and construction areas.

7 MODELING AND ANALYSIS SUMMARY

Based on a review of the available data, listed pollutants, and lake characteristics the following approach was identified. The analysis is presented and described by pollutant—nutrients and sediment. In-lake modeling is compared with trophic state indices (for nutrients) and available depth (for sediment).

7.1 Nutrient Model

7.1.1 Nutrient Loading Model

The loading assessment requires the evaluation of seasonal and annual loadings of nitrogen and phosphorus to the reservoir. The GWLF model was selected as consistent with the land use type, available information, and loading time scale. The GWLF model provides predictions of monthly total and dissolved nitrogen and phosphorus (Haith and Shoemaker, 1987; Haith, Mandel, and Wu, 1992). The model requires standard inputs of soil and land cover information. Daily precipitation and temperature are used for the selected simulation period. The GWLF model was applied as follows:

- Land use classification: MRLC (USEPA, 1998)
- Hydrologic soil group: C soils
- Simulation time period: 1978-97
- Meteorologic station: Morgantown, West Virginia

The flow to Castleman Run Lake was estimated using the GWLF model. The flow consists of surface water runoff and groundwater contributions. The surface water runoff was simulated in GWLF using curve number information from Natural Resources Conservation Service (NRCS) Technical Release 55 (TR-55) (SCS, 1986). For comparative purposes, the average streamflow obtained from the model was estimated to be approximately 45 percent of the total precipitation. This value is within the range of estimates from five USGS gaging stations for small watersheds (less than 5 square miles) in West Virginia that have characteristics similar to those of the Castleman Run Lake watershed (see Table 7.1). The precipitation records were obtained from Morgantown, West Virginia, for the period of 1978 to 1997.

Table 7.1. Long-term average discharges reported by USGS gaging stations for small watersheds

USGS Station ID	Watershed Area (mi^2)	USGS Gaging Station Average Discharge (cfs)	Estimated Watershed Precipitation Rate (cfs)	Streamflow As A Percentage Of Precipitation
03193776	0.91	1.20	2.95	40.6%
03193778	1.44	1.96	4.66	42.0%
03198020	2.73	2.72	8.84	30.8%
03181200	3.06	5.20	9.91	52.5%
03114650	4.19	5.61	13.57	41.3%
03113700	4.95	6.48	16.03	40.4%
Average	2.88	3.86	9.33	41.3%
Minimum	0.91	1.20	2.95	30.8%
Maximum	4.95	6.48	16.03	52.5%

The GWLF model was used to estimate nutrient loading for the identified sources as described in Table 7.2.

Table 7.2. Information used to quantify source loadings [a]

Land Use	Existing Area (hectares)	Percent of Watershed	Consideration
Forest	1158.1	54.7%	Forest harvesting, wildlife, background erosion losses
Agriculture	959.2	45.3%	Includes crops, pasture and hay
Urban (Residential)	0.5		Includes residential, commercial and industrial
Construction	0.5		Includes estimated mean annual construction area
Ground water			Assume background concentrations of 0.34 mg/l total nitrogen and 0.015 mg/l total phosphorous
Septic System	From 189 People		Conventional septic systems with 32% nitrogen removal efficiency; 2.5% septic failure rate
Total	2119[b]	100%	

[a] Based on MRLC land use coverage representative of 1986-94 conditions (USEPA, 1998).

[b] Excludes the lake area but includes 0.64 ha of the other water area..

A summary of phosphorus loading obtained from the GWLF application is presented in Table 7.3.

Table 7.3. Nonpoint source loadings

Source	Phosphorus Loading (kg)
Forest	116.9
Agriculture	653.5
Urban (Residential)	0.1
Construction	2.2
Groundwater	113.6
Septic Systems	3.7
Total	890

The phosphorus loads were converted to concentrations (mg/l) and then compared to observed lake concentrations. Comparisons between predicted and observed nutrient concentrations are presented in Table 7.4.

Table 7.4. Annual mean simulated and observed nutrients concentrations

Constituent	Simulation Results	Observed Lake Concentration*
Total Nitrogen (mg/L)	1.14	0.96
Total Phosphorus (mg/L)	0.085	0.06

[a]Based on 51 samples collected during the period from 1993-1998.

7.1.2 Lake Nutrient Analysis

For in-lake assessment, the BATHTUB model (USACE, 1996) was selected to evaluate the chlorophyll *a* concentration resulting from nutrient inputs under existing and TMDL conditions. The BATHTUB model uses empirical relationships to evaluate lake conditions based on the physical characteristics of the lake, the nutrient inputs, and the meteorologic conditions. The BATHTUB model was set up as follows:

- Time period: Average annual loading
- Bathymetry: Existing conditions derived from 1980 bathymetry data and 1999 observations
- Configuration: Lake segmentation represented in the BATHTUB model (Table 7.5)

Table 7.5. Castleman Run Lake morphology as represented in the BATHTUB model

Segment	1980 Lake Volume	1999 Lake Volume
Segment 1	36,400	32,000
Segment 2	99,000	90,000

Results of the BATHTUB analysis, under existing conditions, were compared with the observed lake data for the 1993-98 sampling seasons. The observed chlorophyll *a* concentrations were used to calibrate the model. The calibration results are shown in Table 7.6.

Table 7.6. In-lake chlorophyll *a* concentrations

Constituent	In-lake Simulation Results	In-lake Observed Concentration*
chlorophyll *a* (ug/L)	53 (32 deep portion only)	59.5

[a] based on 13 samples collected during the period from 1993-1998.

The lake model results were used to calculate the total phosphorus and chlorophyll *a* TSI under various loading conditions. The model could not be used to calculate secchi depth, so the secchi depth TSI was not predicted.

7.2 Sediment Model

7.2.1 Sediment Loading Model

The loading evaluation requires the simulation of annual loading of sediment to the reservoir. The GWLF model was used to estimate sediment loading. The model provides monthly and annual estimates of sediment yield to the reservoir, taking into consideration soil characteristics and land use information. Setup, analysis, and model testing were based on the same configuration as the nutrient loading model. Insufficient monitoring information is available to compare predictions to the observed tributary loadings. Table 7.7 presents the sediment loading estimates for Castleman Run Lake.

Table 7.7. Sediment loading estimates by source

Source	Existing Sediment Loading (metric tons)
Forest	320.2
Agriculture	826.9
Soil Disturbance due to Construction	5.1
Urban	negligible
Total	1152.2

7.2.2 Sediment Lake Analysis

The sediment accumulation in Castleman Run Lake is assessed using trap efficiency calculations. Trap efficiency refers to the ability of lakes and reservoirs to retain a portion of the sediment loading. This efficiency is expressed as the percent of sediment retained compared to total incoming sediment. The key factors that affect the efficiency of lakes/reservoirs to trap sediment include sediment particle size distribution, the lake hydraulic residence time, and the design and operation of the reservoir outlets. Brune's method for estimating lakes and reservoirs trap efficiency was developed based on analysis of numerous reservoir siltation studies (Chow, 1953). The method establishes a graphical relationship between the sediment trap efficiency and the ratio of the reservoir available storage capacity to the total annual inflow. This relationship has been extensively used to estimate siltation rates, reservoir life span, and other engineering parameters used in economic feasibility studies of reservoirs.

Using a volume of 135,687 cubic meters and estimated annual inflows from the GWLF model, the trap efficiency of Castleman Run Lake is estimated to vary between 53 percent to 75 percent (65 percent median value). Using a median value of 65 percent as the lake trap efficiency, the siltation rate was estimated at 1.05 cm/year (Table7.8).

Table 7.8. Estimated sediment loadings to Castleman Run Lake

Mean Sediment Loading (metric tons/yr)	Siltation (metric tons/yr)	Accumulation (cm/yr)
1152	748.8	1.05

8 TMDL

The load estimation model and the lake model were used to derive the TMDLs for Castleman Run Lake. Presented in this section are the results of the TMDL analysis for each of the listed pollutants.

8.1 Nutrients

Nutrient loading capacity was evaluated based on simulated phosphorus and chlorophyll *a* concentrations and resulting estimates of the Trophic State Index (TSI) for phosphorus and chlorophyll *a*. Several loading reduction scenarios were simulated and summarized in Table 8.1. Table 8.1 describes the derivation of the required load reduction for nutrients and presents the selected level of control that meets at the minimum TMDL endpoint of a TSI below 65.

Table 8.1 Analysis of Loading Reduction Scenarios for Castleman Run Lake

Scenario	TP	TSI(TP)	Chlorophyll a	TSI(CHL)
Observed Value	60	63.2	59.5	70.7
Allocation Value				
Dredged	88	68.7	28.3[a]	63.4
10%	77	66.8	27.7[a]	63.2
20%	68	65.0	26.8[a]	62.8
30%	60	63.2	25.8[a]	62.5
40%	52.8	60.6	24.6[a]	62.0
A 30% reduction in nutrient loading meets the targeted endpoint of 65 TSI for both TSI (TP) and TSI (CHL)				

[a] Allocation values are for deep pool section of Castleman Run Lake

The 1999 bathymetry data was used to set up the lake model under existing conditions. The designated use of the lake was specified using the as-built volumetric conditions. The original bathymetric data was not available to determine the as-built condition. The allocation scenarios were simulated using the 1980 bathymetry data to approximate the as-built conditions.

Based on the evaluation of the lake monitoring and modeling analysis and evaluation of the nitrogen-phosphorus ratio (see section 5.2), phosphorus was determined to be the limiting nutrient for the reservoir. It is assumed that the forebay is used to provide the control of the recreational portion of the lake. The endpoint is evaluated as the TSI calculated from predicted phosphorus and chlorophyll *a* in the deep pool. Table 8.2 summarizes the existing loading, the loading capacity, the projected load reductions, and the load allocation for the nutrient TMDL.

Table 8.2. Castleman Run Lake nutrient TMDL

Source	Existing Loading Total Phosphorus (kg)	Estimated Percent Reduction	Load Allocation (kg)	Comments
Forest	116.9	20	93.5	
Agriculture	653.5	40	392.1	
Urban	0.1	0	0.1	
Transitional Barren	2.2	50	1.1	
Septic Systems	3.7	100	3.7	
Groundwater	113.6	0	113.6	
Total Load	**890.0**	**3 Load Allocation**	**600.4**	
Load Reduction	**267 (30%)**	**Waste Load Allocation**	**0**	**No point sources**
		Margin of Safety	**22.6**	**3.5 % of the loading capacity**
TMDL = Loading Capacity =			**623.0**	

[a]**Margin of Safety**. An explicit margin of safety was calculated as a percentage of the loading capacity (3.5%). The selected margin of safety is consistent with level of uncertainty identified in performance of the TMDL analysis.

Seasonality. The analysis considered seasonality in the loading through the simulation of monthly loadings. The evaluation of nutrient impacts in the reservoir was considered for the average annual conditions and the growing season. The allocation is presented as an annual average loading consistent with the impairment of the reservoir and the expression of the load reduction required to achieve water quality standards.
Critical Condition. The critical conditions for the nutrient TMDL are selected to evaluate the impairments observed in the lake. The lake condition is evaluated based on TSI in response to long-term annual loading of nutrients (phosphorus).

Margin of Safety

The MOS one of the required elements of a TMDL. There are two basic methods for incorporating the MOS (USEPA 1991):

C Implicitly incorporate the MOS using conservative model assumptions to develop allocations.
C Explicitly specify a portion of the total TMDL as the MOS; use the remainder for allocations.

The margin of safety for this TMDL was expressed as an explicit number, calculated as a percentage of the total loading capacity. A 3.5 percent margin of safety was selected to reflect the uncertainty in the modeling analysis and the selection of the TMDL endpoint. Other implicit conservative assumptions provide an additional margin of safety. Specific assumptions which are conservative include:

C The endpoint for the reservoir is defined as a TSI less than 65. The selected load reduction is below 65 providing an additional margin of safety.

- The loadings calculated by the nonpoint source model (GWLF) were derived using conservative assumptions in the selection of nutrient potency factors. The use of conservative assumptions in developing the loading model results in relatively highly loads and slightly larger required load reductions.

Seasonality

The nutrient analysis considered seasonality in the loading through the simulation of monthly watershed loadings based on historic precipitation records. The evaluation of nutrient impacts in the reservoir was considered for the average annual conditions representing the response to long term, cumulative nutrient loading. The TMDL and load allocation are presented as annual average loading consistent with the type of impairment (eutrophication) and waterbody type (reservoir). Reduction of the average annual load is expected to result in achievement of water quality standards.

Critical Condition.

The critical conditions for the nutrient TMDL are selected to evaluate the type of impairment (eutrophication) and the type of waterbody (reservoir). Protection of the lake condition requires the control of long term loadings and accumulation of phosphorus. The lake condition is evaluated based on trophic state indices in response to long-term annual loading of nutrients (phosphorus).

Background Conditions

The TMDL load allocation should include, when possible as a separate allocation, the natural background loading of the pollutant. In this analysis natural background is included as an allocation to groundwater or baseflow loadings, and the forest loadings. Note that the forest category also includes some additional loads due to forestry activities, which are in addition to the naturally occurring runoff and erosion from forested areas. The monitoring data were insufficient to separate natural forest loadings from other forest sources.

8.2 Sediment

The sediment allocation was based on the long-term average siltation rate as an endpoint and a numeric limit of 0.63 cm per year. Table 8.3 provides the computed mean siltation rate of the lake for three different conditions: (1) existing condition; (2) predevelopment condition (assuming the watershed is totally forested); and (3) a loading scenario that meet the numeric limit of 0.63 cm per year as the long-term average siltation rate. The table also compares the life span of the lake under these 3 conditions.

Table 8.4 summarizes the sediment load allocation scheme corresponding to an overall reduction of 40% and extending the useful life of the lake from 24 to 40 years.

Table 8.3. Siltation Analysis for Castleman Run Lake

	Existing Conditions	Predevelopment Conditions	Loading Scenario
Mean annual load (kg)	1,152,211	444,632	691,327
Siltation rate (cm)	1.05	0.41	0.63
Fill time (years)[a]	24	62	40
Loading scenario for 40 year time span corresponds to a 40% load reduction			

[a]Based on a siltation volume of 55,9700 m^3

Table 8.4. Castleman Run Lake sediment TMDL

Source	Existing Loading Sediment (metric tons)	Percent Reduction	Load Allocation (metric tons)	Comment
Forest	320.2	25%	240.2	
Agriculture	826.9	50%	413.4	
Urban	0			
Transitional Barren	5.1	50%	2.55	
Septic Systems	0			
Groundwater	0			
Total Load	**1152.2**	**3 Load Allocation**	**656.2**	
Load Reduction	**460 (40%)**	**Waste Load Allocation**	**0**	**No point sources**
		Margin of Safety	**36**	**5.2% of Load Capacity**
TMDL = Loading Capacity =			**692.2**	

Margin of Safety. An explicit margin of safety was calculated as a percentage of the loading capacity (5.2%). The selected margin of safety is consistent with level of uncertainty identified in performance of the TMDL analysis.
Seasonality. The analysis considered seasonality in the loading through the simulation of monthly loadings. The evaluation of sediment impacts in the reservoir was considered for the long-term average annual conditions. The allocation is expressed as a load reduction required to achieve water quality standards.
Critical Condition. The critical conditions for the sediment TMDL are selected to evaluate the long-term siltation impairments observed in the lake.

Margin of Safety

The margin of safety for this TMDL was expressed as an explicit number, calculated as a percentage of the total loading capacity. A 5.2 percent margin of safety was selected to reflect the uncertainty in the modeling analysis and the selection of the TMDL endpoint. Other implicit conservative assumptions provide an additional margin of safety. Specific assumptions which are conservative include:

- The endpoint for the reservoir is defined based on a 40 year lifespan for a selected volume of the lake.
- The loadings calculated by the nonpoint source model (GWLF) were derived using conservative assumptions in the selection of soil erosion factors. The use of conservative assumptions in developing the loading model results in relatively high loads and slightly larger required load reductions.

Seasonality

The sediment analysis considered seasonality in the loading through the simulation of monthly watershed loadings based on historic precipitation records. The evaluation of sediment impacts in the reservoir was considered for the average annual conditions representing the response to long term, cumulative siltation. The TMDL and load allocation are presented as annual average loading consistent with the type of impairment (siltation) and waterbody type (reservoir). Reduction of the average annual load is expected to result in achievement of water quality standards.

Critical Condition.

The critical conditions for the sediment TMDL are selected to evaluate the type of impairment (siltation) and the type of waterbody (reservoir). Protection of the lake condition requires the control of long term loadings and accumulation of sediment. The lake condition is evaluated based on mean siltation rates, in selected locations, in response to long-term annual loading and trapping of sediments in the reservoir.

Background Conditions

The TMDL load allocation should include, when possible as a separate allocation, the natural background loading of the pollutant. For sediment natural background is included as an allocation to the forest loadings. Note that the forest category also includes some loads due to forestry activities, which are in addition to the naturally occurring runoff and erosion from forested areas. The monitoring data were insufficient to separate natural forest loadings from other forest sources.

9 REASONABLE ASSURANCES FOR IMPLEMENTATION

9.1 Management Practices

There are number of best management practices that can be adopted to minimize the nutrient, sediment and metals loadings in accordance with the identified TMDLs and load reduction targets.

Nutrient

The nutrient TMDL identifies load allocations and reductions from forested land, agricultural operations, urban, transition/ barren areas, construction areas, and septic systems. Some of the management practices that can be used to achieve the identified load reductions include:

Forestry management: forestry practices including preharvest planning, streamside area management and buffers, road construction/reconstruction/management, timber harvest management, site preparation, erosion and sediment control, and forest regeneration. Wildlife and water fowl control can also be used to manage nutrient loads.

Agricultural management: Agricultural management practices can reduce sediment and associated nutrient loads. Typical practices include conservation tillage, terraces, crop rotations, and stream buffers. A nutrient management plan can be adopted for individual farms. The plan addresses the methods to utilize manure nutrient and to apply manure and fertilizers at agronomic rates. Fencing or alternative water supplies can assist in reducing the time where livestock are in or near streams.

Urban areas: Sediment and associated nutrient loads can be reduced through management of new developments, site planning, pollution prevention, and stormwater management.

Maintenance and inspection of septic systems: By properly maintaining septic systems, the failure rate and associated nutrients loadings could be greatly reduced.

Sediment

The sediment TMDL identifies load allocations and reductions from forest land, agricultural operations, and construction areas. Some of the management practices that can be used to achieve the identified load reductions include:

Forestry management: forestry practices including preharvest planning, streamside area management and buffers, road construction/reconstruction/management, timber harvest management, site preparation, erosion and sediment control, and forest regeneration.

Agricultural management: Agricultural management practices can reduce erosion and sediment delivery. Typical practices include conservation tillage, terraces, crop rotations, and stream buffers. Fencing or alternative water supplies can assist in reducing the time when livestock are in or near streams. Trampling of stream corridors can increase erosion and turbidity.

Construction: Sediment loads can be reduced through management of new developments, erosion and sediment control practices, site planning, and stormwater management.

9.2 West Virginia Nonpoint Source Programs

The West Virginia Division of Environmental Protection-Office of Water Resources, as the lead agency for West Virginia's nonpoint source program, coordinates with other cooperating state agencies to address nonpoint source impacts, develop and implement best management practices reducing pollutant loads for agricultural, silvicultural, oil and gas, abandoned mines and construction activities. Activities in the various categories include education, technical assistance, financial assistance, research, regulatory and enforcement.

Silvicultural

The Division of Forestry administers several state and federally funded programs that relate to water quality protection and improvement. These include programs that provide technical and financial assistance, education and enforcement of state regulations. In coordination between the Office of Water Resources and the Division of Forestry, the Logging Sediment Control Act is enforced. Under the West Virginia Logging Sediment Control Act, all logging operations are required to be registered with the Division of Forestry and are to be in compliance with all regulations and laws of the state. Timber harvesting operators are required to protect the environment through the judicious use of silviculture best management practices adopted by the Division of Forestry to minimize soil erosion and sedimentation.

The West Virginia Division of Forestry may be reached at (304) 558-2788.

Agriculture

In cooperation with the West Virginia Soil Conservation Agency, agricultural nonpoint source problems are addressed through state and federal assistance programs to develop and apply best management practices. When water quality problems emanate from agricultural activity, the Division of Environmental Protection relies on the Soil Conservation Agency to contact and work with the landowner to correct problems. The two prominent areas of direct assistance provided to the agricultural community are technical and financial assistance that involves the following:

a. Nutrient Management/Pesticide Management planning with land users,
b. Agriculture erosion control conservation planning and BMP implementation with land users,
c. Manage NPS demonstration projects and coordinate with assisting agencies to carry out this management program.

For additional information on agricultural best management practices, you may contact the West Virginia Soil Conservation Agency at (304) 558-2204.

Oil and Gas Exploration

In West Virginia a well work permit from the Office of Oil and Gas of the West Virginia Division of Environmental Protection is required before any well work, including site preparation, can be performed. An erosion and sediment control plan must accompany each application for a well work permit, with the exception of permits to plug or replug a well. Each plan must contain methods of stabilization and drainage control that must meet the minimum requirements established in the Division of Environmental Protections "Erosion and Sediment Control Technical Manual," adopted by the Office of Oil and Gas. The erosion and sediment control plan becomes part of the terms and conditions of the well work permit which is issued. The erosion and sediment control plan also establishes the method of reclamation that will comply with the Oil and Gas regulations.

For additional information on oil and gas, you may contact the WVDEP - Office of Oil and Gas, (304) 759-0514

Construction

The West Virginia Nonpoint Source Program for construction activity involves coordination with the State Soil Conservation Agency and Office of Environmental Enforcement to provide education, technical assistance, compliance assistance and regulatory enforcement to minimize sediment and other pollutants impacts on surface and ground water resources.

For construction sites of less than 3 acres, voluntary Sediment Control Plans are prepared and submitted by the developer to one of the 14 Soil Conservation Districts in the State. They are reviewed by a Nonpoint Source Technician for adequacy to protect sediment runoff during the period of construction is ongoing. Construction sites of less than 3 acres are not subject to the Stormwater NPDES permitting process in West Virginia. Therefore, it is the responsibility of the developer to work with the local SCD to submit sediment and erosion control plans. Approved erosion and sediment control plans are forwarded to the Nonpoint Source Program at the Office of Water Resources, where upon agency approval, provides protection in the event a violation of the turbidity water standard should occur while the plan is being properly implemented.

For additional information on construction sites which are less than three acres contact the WVDEP - Office of Water Resources, at (304) 558-2108.

Construction activities involving greater than 3 acres require a Stormwater NPDES Permit from the Office of Water Resources. The Permit Section may be contacted for additional information at (304) 558-4086.

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