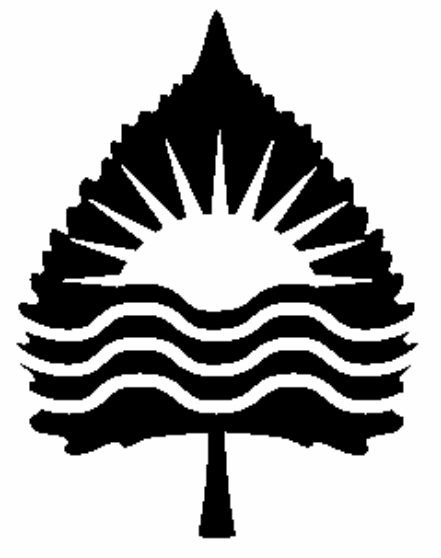

Total Maximum Daily Loads
for
Yankee Hill Lake – Lancaster County, Nebraska

**Parameters of Concern: Siltation/Sedimentation,
And Nutrients**

Pollutants Addressed: Sediment and Phosphorus

**Nebraska Department of Environmental Quality
Planning Unit, Water Quality Division**

August 2002

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Executive Summary

Yankee Hill Lake was included on the 1998 Nebraska Section 303(d) List of Impaired Waters (NDEQ 1998) due to impairment by siltation/sedimentation, nutrients, pesticides (atrazine) and arsenic. As such, a total maximum daily load must be developed in accordance with the Clean Water Act. This document presents 2 TMDLs, one each for sediment and phosphorus to address the siltation/sedimentation and nutrient impairments, respectively. In the future these goal may be revised based upon the completion of a community based water quality management plan.

Revisions to Title 117 – Nebraska Surface Water Quality Standards criteria will allow the de-listing of Yankee Hill Lake for impairment caused by pesticides and arsenic and therefore it is not necessary to address these pollutants. The de-listing has been included on the proposed 2002 Nebraska Section 303(d) list.

These TMDLs have been prepared to comply with the current (1992) regulations found at 40 CFR Part 130.7.

1. **Name and geographic location of the impaired waterbody for which the TMDL is being developed.**
   Yankee Hill Lake, Section 19, T 9 North, R 6 East, Lancaster County, Nebraska. Lat. 40 43' 50", Long. 96 46' 59.16"

2. **Identification of the pollutant and applicable water quality standard**
   The pollutants causing the impairment(s) of the water quality standard and designated beneficial uses are sediment and nutrients (phosphorus). Designated uses assigned to Yankee Hill Lake include: primary contact recreation, aquatic life Warmwater class A, agriculture water supply class A and aesthetics (NDEQ 2000). Excessive sediment and nutrient inputs have been determined to be impairing the aesthetic and aquatic life beneficial uses.

3. **Quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of the water quality standards.**
   Bathymetric survey data and the EUTROMOD water quality model which utilizes the *Universal Soil Loss Equation* were employed to determine the current and maximum sediment and nutrient loads that if achieved should result in beneficial use attainment. These values are 13,350 tons/year and 997.2 lbs/year for sediment and phosphorus, respectively.

4. **Quantification of the amount or degree by which the current pollutant load in the waterbody, including upstream sources that is being accounted for as background loading deviates from the pollutant load needed to attain and maintain water quality standards.**
   The average annual sediment load and identified land use patterns are exceeding the water quality target by 650 tons/year. Empirical data indicates approximately 14,000 tons/year of sediment is delivered to Yankee Hill Lake.

   The total phosphorus load delivered to Yankee Hill Lake is estimated to be 9,972 lbs/year. To meet the water quality goals, the average annual loading capacity is 997.2 lbs/year. To achieve the loading capacity a 90% reduction is needed.

5. **Identification of the pollution source categories.**
   Nonpoint source of sediment and nutrients have been identified as the cause of impairment to Yankee Hill Lake.

6. **Wasteload allocations for pollutants from point sources.**
   No point sources discharge in the watershed and therefore the wasteload allocation will be set at zero (0).

7. Load allocations for pollutants from nonpoint sources.

For this TMDL the sediment and phosphorus load allocation were set at 13,350 tons/year and 997.2 lbs/year, respectively. These allocations were developed using models and empirical data. No specific load allocations were made of natural sources as allowed by 40 CFR Part 130.7.

8 A margin of safety.

These two TMDLs contain an implicit margin of safety. Pollutants are discharged from the system via the reservoir's outlet. These TMDLs will assume all pollutants delivered to the waterbody remain, again reflecting a worst-case condition.

9. Consideration for seasonal variation.

The pollutants of concern are delivered on a year round basis and the assessment of the data considers annual average conditions. However, in-lake and watershed model inputs require that seasonal changes (e.g. vegetative cover, precipitation) be accounted for. Because nonpoint sources have been identified as the sole contributor, management practices and implementation will be targeted at those times when the nonpoint source influence is the greatest. This usually revolves around the precipitation events of mid to late spring when there is a high potential for run-off of sediment, phosphorus (attached to sediment), and nitrogen. The effects of the excess pollutant loadings are: large quantities of algae growth occurring during the growing season, potential for future dissolved oxygen impairments and sediment reducing the volume of the lake.

10. Allowances for reasonably foreseeable increases in pollutant loads.

There was no allowance for future growth included in these TMDLs.

11. Implementation Plan

Although not required an implementation plan has been included with these TMDLs. Also, the Lower Platte South Natural Resource District and the NDEQ will be initiating the development of a community based watershed management plan in the near future. Components of these plans include strategies necessary to implement best management practices.

The TMDLs included in the following text can be considered "phased TMDLs" and as such are an iterative approach to managing water quality based on the feedback mechanism of implementing a required monitoring plan that will determine the adequacy of load reductions to meet water quality standards and revision of the TMDL in the future if necessary. A description of the future monitoring (Section 5.0) that is planned has been included. .

Monitoring is essential to all TMDLs in order to:

- Assess the future beneficial use status;
- Determine if the water quality is improving, degrading or remaining status quo;
- Evaluate the effectiveness of implemented best management practices.

The additional data collected should be used to determine if the implemented TMDL and watershed management plan have been or are effective in addressing the identified water quality impairments. As well the data and information can be used to determine if the TMDLs have accurately identified the required components (i.e. loading/assimilative capacity, load allocations, in lake response to pollutant loads, etc.) and if revisions are appropriate.

1.0 Introduction

Yankee Hill Lake was listed on the 1998 Section 303(d) list of impaired waters (NDEQ 1998) as not supporting beneficial uses with the pollutants of concern being atrazine, arsenic, nutrients and siltation/sedimentation.

For the 1998 atrazine listing, the applicable water quality criteria used in the assessment was 1 μg/l, which was intended to protect aquatic life from chronic exposures. In 1999, the Nebraska Department of Environmental Quality (NDEQ) proposed and received approval to change the chronic water quality standard from 1 μg/l to 12 μg/l. Using this modified standard, the NDEQ's assessment procedures and existing data, Yankee Hill Lake was re-assessed and determined not to be impaired due to atrazine. Therefore, for the 2002 Section 303(d) listing, the parameter will be removed and no TMDL will be developed for atrazine.

Similarly, in 1999 the chronic water quality standard for arsenic was changed from 1.4 μg/l to 16.7 μg/l. Using the modified arsenic standard, assessment procedures and existing data, the waterbody was re-assessed and determined not to be impaired due to arsenic. This parameter too will be delisted in 2002 and no TMDL will be developed for arsenic.

Based on the above, and as required by Section 303(d) of the Clean Water Act and 40 CFR Part 130, total maximum daily loads (TMDLs) for sediment and phosphorus have been developed and contained herein to address sedimentation/siltation and nutrient impairments, respectively.

1.1 Background Information

Yankee Hill Lake is located in Lancaster County, Nebraska (Figure 1.1) and was constructed by the United States Army Corps of Engineers (USACE) primarily as a flood control structure with completion occurring in 1965. The lake also supports recreation as a secondary use. Physical description information is provided in Table 1.1. The Nebraska Game and Parks Commission (NGPC) manage the fishery and immediate surrounding area (728 acres). According to Resource Census data provided by the Nebraska Natural Resource Commission (NRCS) no towns exist in the watershed but the lake is with 30 minutes of 215,000 people.

1.1.1 Waterbody Description

1.1.1.1 Waterbody Name: Yankee Hill Lake

Lake Identification Number: LP2-L0090 (Title 117 – Nebraska Surface Water Quality Standards)

1.1.1.2 Major River Basin: Missouri River

1.1.1.3 Minor River Basin: Lower Platte

1.1.1.4 Hydrologic Unit Code: 10200203

1.1.1.5 Assigned Beneficial Uses: Primary Contact Recreation, Aquatic Life Warmwater Class A, Agricultural Water Supply Class A and Aesthetics. (Title 117 – Nebraska Surface Water Quality Standards)

1.1.1.6 Major Tributary: Cardwell Branch

Figure 1.1 Location of Yankee Hill Lake and Watershed in Lancaster County, Nebraska.

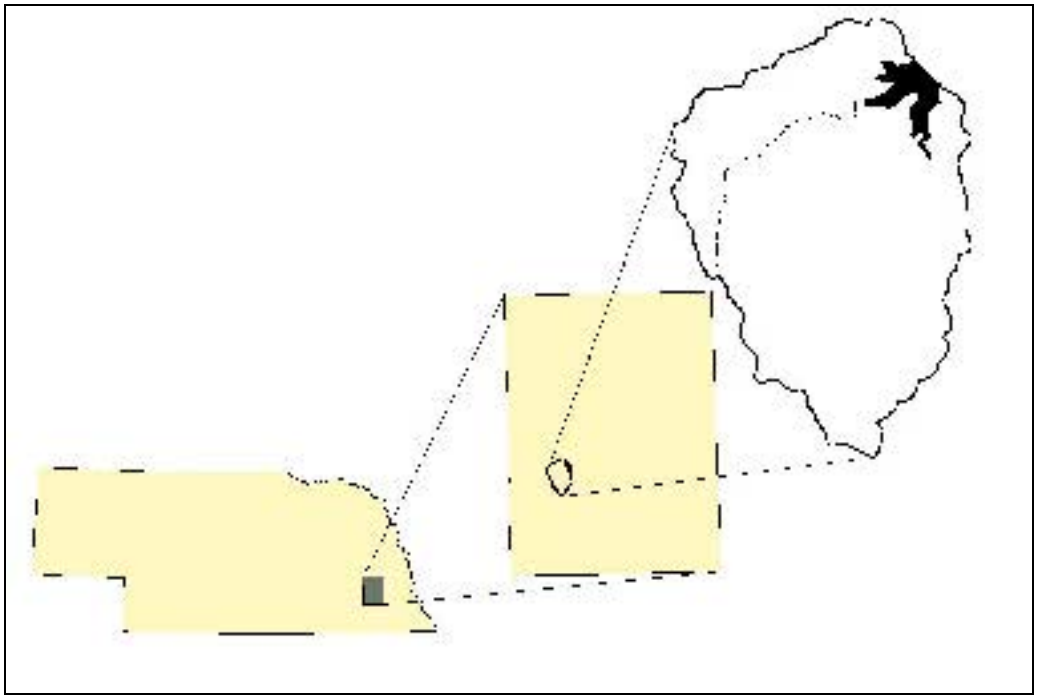


Table 1.1 Physical Description of Yankee Hill Lake

Parameter	Yankee Hill Lake
State	Nebraska
County	Lancaster
Latitude (center of dam)	40 43' 50"
Longitude (center of dam)	96 46' 59.16"
Section, Township, Range (dam)	Section 19, T 9 North, R 6 East
Surface Area – original (1966)	216 acres
Surface Area - current	208 acres
Shoreline length (approximate)	4.0 miles
Mean Depth – original (1966)	8.83 feet (2.69 meters)
Mean Depth – current	7.8 feet (2.38 meters)
Conservation Pool Volume - original (1966)	1,907 acre-feet
Conservation Pool Volume – current	1,627 acre-feet
Number of Major Inlets	2
Watershed Area	5,373 acres
Lake to Watershed Area Ratio	1:25.8

1.1.2 Watershed Characterization

1.1.2.1 Physical Features: The Yankee Hill Lake watershed consists of approximately 5,400 acres, is located near the eastern edge of the Great Plains areas and is in the Western Corn Belt Plains ecoregion as defined by Omernik and Gallant (1987). The reservoir was completed in 1965 by the USACE who maintains ownership. General agriculture (i.e. row crops, pasture, etc.) is the dominant land use within the watershed. Due to the lake's close proximity to the City of Lincoln, portions of the watershed have been and continue to be converted from the traditional agriculture use to residential acreages.

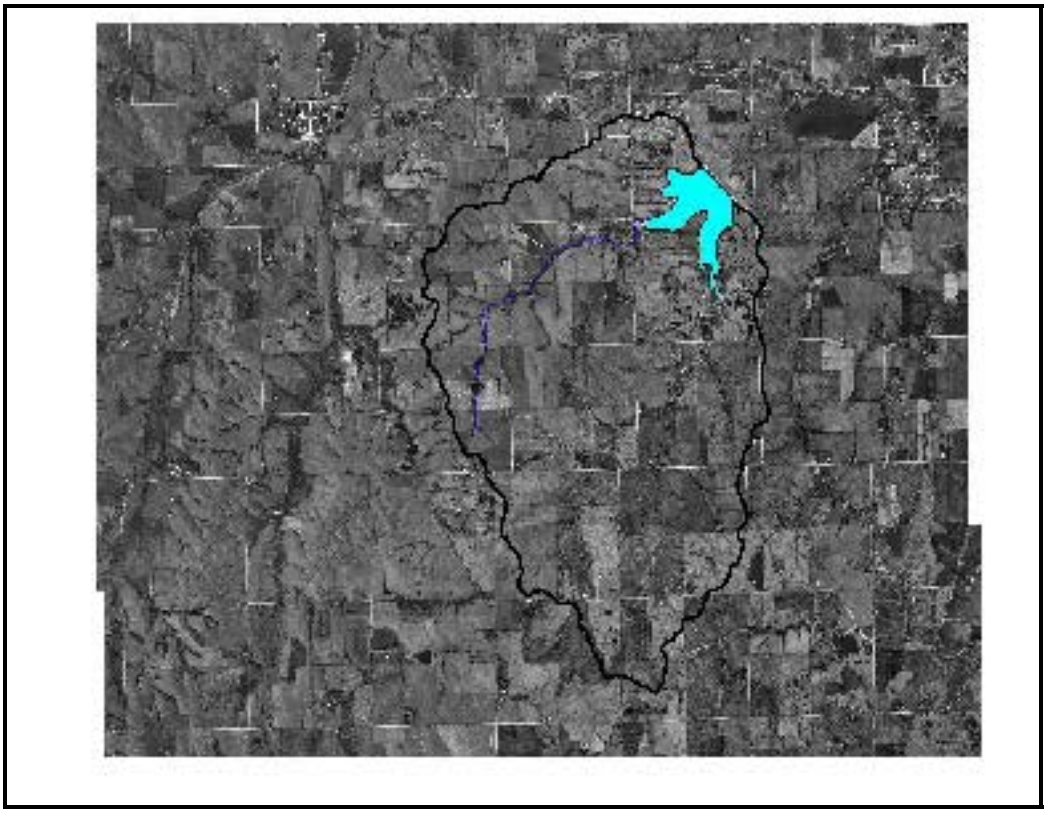
Yankee Hill Lake is fed by two tributaries Cardwell Branch (LP2-30100) from the northwest and an intermittent tributary from the southwest. The aspect is mostly northward and eastward through Salt Creek to the Platte River (NDEQ 1996). Relief throughout the watershed is gently to strongly sloping. Two major soil associations are present in the watershed, the Pawnee-Burchard association and to a lesser extent the Wymore-Pawnee association (Brown *et al*. 1980). Soils of the Pawnee-Burchard Association are deep, gently sloping to steep, moderately well drained and well-drained, loamy clayey soils that formed in glacial till. The Wymore-Pawnee Association is also deep, nearly level to strongly sloping, moderately well drained, silty soils formed in loess and loamy soils formed in glacial till. Both of these soils associations are considered to be upland soils. Nearly all of the soils in the Yankee Hill Lake watershed are considered erosive (NRCS 1993).

1.1.2.2 Climate: Winters in the watershed are cold and summers are hot but are marked with occasional interruptions of cooler air. Snowfall is fairly frequent in the winter but the snow cover is not continuous. Annual precipitation is about 28 inches with rainfall being the heaviest in late spring and early summer.

1.1.2.3 Demographics: While no city or village lie in the Yankee Hill watershed boundary, Denton (population 205) lies just to the west and Lincoln (population 215,928) lies to the east. Both municipalities reside in Lancaster County, which has shown an approximate 12% growth in the last 10 years.

1.1.2.4 Land Uses: General agriculture dominates the land use in the watershed with cropland and pasture accounting for 95% of the land use (NRCS 1993). Dryland crop rotation consisting of row crops (corn or sorghum), wheat and soybeans are the primary crops. Residential acreages are increasing in the watershed due to the close proximity to Lincoln. An aerial photograph of the watershed is provided in Figure 1.1.2.4.

Figure 1.1.2.4 Aerial Photograph of Yankee Hill Lake and Watershed.



2. Sediment TMDL

2.1 Problem Identification

This section details the extent and nature of the water quality impairments caused by excessive sedimentation in Yankee Hill Lake.

2.1.1 Water Quality Criteria Violated and/or Beneficial Uses Impaired: The *Aquatic Life* – Warmwater Class A and *Aesthetics* beneficial uses assigned to Yankee Hill Lake are not being met (impaired) due to excessive sedimentation.

2.1.2 Data Sources: Original reservoir storage capacity was derived from USACE "as-built" construction plans. Current storage capacity was developed based upon the USACE periodic sedimentation survey (USACE 1995).

2.1.3 Water Quality Data Assessment: Nebraska does not have numeric water quality criteria for sediment or total suspended solids but the NDEQ has adopted methods, to evaluate the severity of sedimentation in reservoirs. One consideration is the overall loss of the reservoir multi-purpose pool (e.g. conservation and sediment pool combined). Generally, the NDEQ considers a lake to be "impaired" when a 25% volume loss has been reached. For Yankee Hill, the 1994 volume loss was estimated to be approximately 15%. While the total volume loss criterion has not been exceeded, the calculated sedimentation rate of 0.52%/year does fall into the "moderate" category, which will be described in section 2.1.3.2.

The NGPC is responsible for the management of the state's fisheries and will expend resources to rehabilitate waterbodies when interested parties or the general public express concerns over degrading recreational opportunities and when the aquatic communities exhibit a shift from the original management scheme (i.e. bass/bluegill to carp/catfish). Therefore, the public ultimately decides if a waterbody is aesthetically acceptable or un-acceptable. In regards to Yankee Hill, the NGPC has deemed Yankee Hill a high priority for renovation and did so following public meetings and the receipt of public comments. The main focus of the renovation will be to address sediment deposition problems including the addition of sediment retention structures, increasing the water depth and improving the water clarity (NGPC 2002). Although originally not a high priority for TMDL development, the NDEQ has opted to complete the sediment and nutrient TMDL as an accompaniment to the renovation project. Both the NGPC action and the NDEQ action should result in an enhanced fishery and increase public acceptance and use. As well, the NDEQ has identified the waterbody as a high priority for the development and implementation of nonpoint source pollution management actions.

2.1.3.1 Water Quality Conditions: Based on USACE "as-built" plans Yankee Hill Lake's multi-purpose pool (elevation 1,244.9 feet) was reported to be ≅1,907 acre-feet at the time of construction. The 1994 sedimentation study completed by the USACE determined the multi-purpose pool volume to be ≅1,627 acre-feet for a realized volume loss of 280 acre-feet or 14.7 % loss for the entire lake. This equates to a long term, average annual volume loss of 0.52%. (USACE 1995)

2.1.3.2 Severity and Extent of Water Quality Problems: As stated, Nebraska does not have numeric water quality criteria for sediment or total suspended solids in Title 117. To evaluate the severity of sedimentation problems, for categories of annual volume loss/sedimentation rate have been adopted:

Substantial/Severe = >0.75%
Moderate = >0.5 to <0.75%
Slight = >0.25 to 0.50%
Minimal = <0.25%

Based on the 1994 USACE sedimentation survey, Yankee Hill Lake falls within the "moderate" category (>0.5 to <0.75%).

2.1.4 Potential Pollutant Sources

2.1.4.1 Point Sources: No point sources of sediment exist in the Yankee Hill watershed.

2.1.4.2 Nonpoint Sources: Multiple nonpoint sources of sediment have been identified in the Yankee Hill Lake watershed. Sources include: sheet and rill erosion from agricultural lands, gully and streambank erosion.

2.1.4.3 Natural Background Conditions: Although natural sources of sedimentation exist, background conditions were not separated from the total nonpoint source load.

2.2 TMDL Endpoint

The endpoint for this sedimentation TMDL is based on narrative criteria translated to a numeric water quality target. As described below, annual volume loss targets in comparison with current sediment load estimates allowed for the determination of the allowable load (desired endpoint) and the associated degree of sediment load reduction needed to attain assigned beneficial uses.

2.2.1 Criteria for Assessing Water Quality Attainment

2.2.1.1 Numeric Water Quality Standards Criteria: As previously stated, Nebraska does not have numeric water quality standard for sediment.

2.2.1.2 Quantification of Narrative Water Quality Standards Criteria: The Warmwater Class A Aquatic Life use is protected through the annual reservoir sedimentation rate utilized by NDEQ. For this TMDL the NDEQ has chosen to target an average annual multi-purpose pool volume loss not to exceed 0.5%. In support of this criteria, Nebraska water quality standards for Aesthetics states in part " To be aesthetically acceptable, waters shall be free from human induced pollution which causes floating, suspended, colloidal or settleable materials that produce objectionable films, colors, turbidity of deposits (NDEQ 2000).

2.2.1.3 Local Stakeholder defined Criteria: Along with the NDEQ defined endpoint, in the near future a community-based watershed/waterbody planning process will be initiated whereby stakeholders will be responsible for establishing goals and endpoints. Past experience with the community-based process has resulted in more stringent water quality goals being selected in comparison to those chosen by the NDEQ. Once established, these goals will be incorporated into the implementation planning process and if more stringent, will replace the below defined goals.

2.2.2 Selection of Environmental Conditions

There are no "specific environmental or critical conditions" associated with this sediment TMDL because once this pollutant settles in a reservoir, it is assumed to have an infinite residence time and is present on a year round basis.

2.2.3 Waterbody Loading Capacity

The loading capacity for this TMDL is defined as the amount of sediment Yankee Hill Lake can receive on an annual basis and still meet its assigned beneficial use criteria and in-lake water quality targets. To achieve an average annual multi-purpose pool volume loading rate of <0.5% the sediment loading capacity for Yankee Hill Lake will be set at 13,350 tons/year (a sediment density value of 1,400 was used in the conversion of acre-feet to tons).

2.3 Pollution Source Assessment

For this TMDL, a combination of methods was used: 1) the Agriculture Nonpoint Source (AGNPS) model (Young, et. al. 1987) was used to identify critical erosion areas within the Yankee Hill watershed (the main focus of AGNPS was for implementation planning purposes), 2) the EUTROMOD model (Reckhow 1992) – *Universal Soil Loss Equation* component was employed to estimate annual sediment loads from the watershed and 3) existing information (storage capacity changes) and monitoring data was used as a verification for the modeled sediment load predictions.

2.3.1 Existing Pollutant Load

In 1995, the pollutant load being delivered to Yankee Hill Lake was estimated to be 14,000 tons/year. This load was based on the calculated volume loss using bathymetric and empirical data collected and provided by the United States Army Corps of Engineers (USACE 1995).

2.3.2 Deviance From Loading Capacity

The sediment loading capacity for Yankee Hill Lake is currently being exceeded by approximately 650 tons per year. To achieve an average annual volume loss of <0.5% the sediment load being delivered to the lake must be ≤13,350 tons/year. (The reduction specified should be considered the minimum reduction necessary to meet the sedimentation goal established by the NDEQ. In the near future, the NDEQ and the Lower Platte South Resource District (LPSNRD) will undertake a local watershed planning process at which time locally derived stakeholder sedimentation goals will be established. Local watershed planning goals often are set beyond those of the TMDL.)

2.3.3 Identification of Pollutant Sources

As stated no point sources of sediment have been identified in the watershed therefore the necessary nonpoint sediment source identification and quantification was completed through the application of the EUTROMOD model and field surveys. For the purposes of modeling the Yankee Hill Lake watershed was delineated into 11 sub-watersheds. Utilizing resource census data the watersheds were classified into 10 different land use categories with 5 of these being considered directly related to production agriculture.

2.3.3.1 Nonpoint Sources of Sediment

Sediment loads by land use estimated by the EUTROMOD model are presented in Table 2.3.3.1. Ten land uses were recognized as occurring in the watershed. The intent of the modeling exercise was to identify the sediment contributors by land type and watershed. For the TMDL the actual pollutant load will be based on the empirical data. Of these, row crops (milo and soybeans) were identified as the largest contributor, accounting for approximately 83% of the load. The model estimated sub-watershed #3 and #5 contribute 90% of the sediment load. It should be noted that the area (acres) of these two sub-watersheds account for 80% of the total Yankee Hill Lake watershed.

Table 2.3.3.1 EUTROMOD Modeled Sediment Contributions by Land Use

Land Use	Total Acres Modeled	Net Sediment Load (tons/year)
Pasture	329.4	200.14
Residential	88.5	50.61
Grass	566.1	164.18
Roads	124.4	65.871
Milo	1769.9	6313.76
Wheat	475.8	642.5
Wooded	735.6	585.19
Soybeans	672.6	2461.18
Cover Crop	85.7	97.84
Feed Lot	1.3	3.09
Totals	**4849.3**	**10584.36**

One sediment source that cannot be predicted by the EUTROMOD model is gully and stream bank erosion. However, NRCS estimated the sediment load from stream bank and gully erosion to be 20% of the modeled sheet and rill erosion. This amounts to an additional 2,116 tons per year being delivered. The total predicted/estimated (EUTROMOD and NRCS estimated) load being delivered to Yankee Hill Lake is approximately 12,700 tons/year. This estimate roughly agrees with the 14,000 tons/year loading value that was determined using empirical data and information.

Based on the information collected from other reservoirs, it is estimated that 4% of the sediment delivered will be discharged via the reservoir's outlet structure. As well, approximately 16% of the sediment load will be deposited in the flood storage zone. The result is a multi-purpose pool zone (conservation + sediment pool) deposition estimate of approximately 10,157 tons/year. In the TMDL a margin of safety (MOS) must be incorporated. For this TMDL, the MOS will not considered losses of sediment though the outlet or from deposition in the flood storage zone. This will be further explained in the allocation process.

2.3.4 Linkage of Sources to Endpoint

The average annual sediment load of 14,000 tons delivered to Yankee Hill Lake has been determined to originate entirely from nonpoint sources. To meet this TMDL's desired endpoint, the annual nonpoint source sediment contribution of 14,000 tons needs to be reduced by 650 tons/year.

2.4 Pollutant Allocation

A TMDL is defined as:

$$\text{TMDL} = \text{Loading Capacity} = \text{WLA} + \text{LA} + \text{Background} + \text{MOS}$$

As stated above, the loading capacity for Yankee Hill Lake is 13,350 tons/year and to achieve the defined sediment loading capacity the required allocations are as follows:

2.4.1 Wasteload Allocation

No point sources of sediment exist in the watershed therefore the wasteload allocations (WLA) will be "zero" (0 tons/year).

2.4.2 Load Allocation

The load allocation distributed among the nonpoint sources will be 13,350 tons/year. Base flows carry indiscernible amounts of sediment and thus natural background will not be separated from the load allocation.

2.4.3 Margin of Safety

The MOS associated with this sediment TMDL will be:

1) The Universal Soil Loss Equation (USLE) applied average "spring season" (worst case) values for soil and climatic conditions for the particular area being evaluated. The resulting soil loss/load estimate predicted by the model is expressed as a long-term average. Sediment loads are then considered to be conservative and an implicit margin of safety has been factored into the load estimate.
2) The effects of sedimentation are most greatly realized when deposition occurs in the multi-purpose pool. Losses through the outlet and deposition in the flood storage zone will not be separated out. This assumes then that all the sediment delivered is deposited in the multi-purpose pool.

2.4.4 Sediment TMDL Summary

TMDL/Waterbody Loading Capacity = 0 tons/year (WLA) + 13,350 tons/year (LA & Natural Background) + Implicit Margin of Safety

3. Nutrient TMDL

3.1 Problem Identification

Yankee Hill Lake was included on the 1998 Section 303(d) list as being impaired by excessive nutrients. In-lake conditions indicate accelerated eutrophication caused by excessive nutrient loading. The linkage between accelerated eutrophication and water quality impairments has been repeatedly documented (USEPA 1999). Eastern Nebraska reservoirs classified as being eutrophic or hypereutrophic are generally high in phosphorus, particularly in agricultural watersheds that produce high sediment yields. Yankee Hill watershed modeling and in-lake conditions have resulted in phosphorus being the targeted parameter of concern. The following sections detail the extent and nature of the water quality impairments related to accelerated eutrophication in Yankee Hill Lake.

3.1.1 Water Quality Impairments

Yankee Hill was included on the 1998 Section 303(d) list as being impaired by excessive nutrients. Excessive nutrients can lead to accelerated algae growth (algal blooms) that degrade a waterbodies aesthetic quality and may cause dissolved oxygen problems. Phosphorus was selected as the nutrient/parameter of concern because past monitoring has indicated eastern Nebraska lakes to be phosphorus limited.

3.1.2 Data Sources

The NDEQ and USACE have collected various water quality data and information on a semi-regular basis from 1974 through 1994. NDEQ has continued to collect such information in accordance with basin rotation and other priorities. The existing data includes, water transparency, dissolved oxygen, temperature, conductivity, pH, pesticides, chlorophyll *a*, nitrogen series, dissolved and total phosphorus and total suspended solids.

3.1.3 Water Quality Data Assessments

Nebraska currently does not have numeric water quality criteria for nutrients however; a biomass trophic state index (TSI) (Carlson 1977; Carlson and Simpson 1996) is used as the metric for evaluating this sources/stressor. TSI's calculated from transparency (secchi depth), chlorophyll *a*, and total phosphorus concentration data, were utilized to infer whether algal growth was nutrient or light limited (if the three indices are approximately equal, it can be inferred that algal growth is phosphorus limited (USEPA 1999)). Also, the average of the three TSI scores is used as a single measure of lake conditions (e.g., oligotrophic, mesotrpophic, eutrophic or hypereutrophic) as described in Carlson and Simpson (1996). The following classification is used to interpret the TSI:

Trophic State Index Score	Trophic Status	Assessment Criteria	NDEQ Beneficial Use Attainment Status
<40	Oligotrophic	2 of 3 parameters	Full Support
>35 but <45	Mesotrophic	2 of 3 parameters	Full Support
>45	Eutrophic	2 of 3 parameters	Full Support
>60	Hypereutrophic	2 of 3 parameters	Partial Support

3.1.3.1 Water Quality Conditions

Trophic State Indices scores for Yankee Hill Lake using average growing season in-lake data collected from 1997-2001 include:

Parameter	TSI Score
Secchi depth (meters)	67.9
Chlorophyll *a* (mg/m^3)	63.2
Total Phosphorus (μg/l)	69.3
Mean TSI	**66.83**

With a mean TSI score of 66.83, the waterbody is considered hypereutrophic and because at least 2 of the 3 parameters are greater than the hypereutrophic threshold, the waterbody is considered partially supporting the aesthetic and aquatic life beneficial uses. As well, the TSI scores for each of the parameters are similar which is a demonstration that the waterbody system is phosphorus limited and thus the parameter targeted for reduction. It should be noted that although phosphorus is the targeted parameter of concern, implementation of controls should also result in a reduction of the nitrogen (and other nutrient) contributions.

3.1.4 Potential Pollutant Sources

3.1.4.1 Point Sources: No point sources have been identified in the Yankee Hill Lake watershed.

3.1.4.2 Nonpoint Sources: Multiple nonpoint phosphorus sources have been identified in the Yankee Hill Lake watershed. They include stream bank and gully erosion, agricultural, and numerous other land uses (i.e., urban, grasslands, wooded, etc.).

3.1.4.3 Natural Background Sources: Base flow or natural sources were not separated from the total nonpoint source load.

3.2 TMDL Endpoint

The endpoint for the nutrient TMDL is based on the assessment criteria associated with beneficial use attainment. As described below, the targeted in-lake water quality conditions will result in the lake being deemed fully supporting the aesthetic beneficial use.

3.2.1 Criteria for Assessing Water Quality Standards Attainment

3.2.1.1 Numeric Water Quality Standards: No numeric water quality standard exists for phosphorus or nitrogen. Although not identified as an impairment, excessive nutrients can lead to dissolved oxygen problems and the TMDL endpoint will be a preventative measure for the protection of the applicable dissolved oxygen criteria.

3.2.1.2 Quantification of Narrative Water Quality Criteria: As previously outlined in Section 3.1.3, Nebraska does not have numeric water quality standards for nutrients. However, Nebraska's water quality standards for "Aesthetics" states in part, "To be aesthetically acceptable, waters shall be free from human-induced pollution which causes floating, suspended, colloidal, or settleable materials that produce objectionable films, colors, turbidity, or deposits (NDEQ 2000).

The application of the "Aesthetics" beneficial use is through the assessment of a lake's trophic status using Carlson's trophic state index (TSI) as described in Section 3.1.3. In order for a water body to achieve a "full support status", 2 of 3 TSI parameters must be less than 60. Table 3.2.1.1 presents the conditions necessary and the associated TSI score for the waterbody fully support the beneficial use.

Table 3.2.1.2 Yankee Hill Lake Growing Season Water Quality Goals

TSI Parameter	Desired In-Lake Condition (growing season)	TSI Score	Mean TSI Value
Transparency (Secchi depth)	1.0 m	60	****
Chlorophyll *a*	20 mg/m^3	60	****
Total phosphorus	48 µg/l	60	****
			60

3.2.1.3 Local Stakeholder Defined Criteria

Along with the NDEQ defined endpoint, in the near future a community-based watershed/waterbody planning process will be initiated whereby stakeholders will be responsible for establishing goals and endpoints. Past experience with the community-based process has resulted in more stringent water quality goals being selected in comparison to those chosen by the NDEQ. Once established, these goals will be incorporated into the implementation planning process and if more stringent, will replace the below defined goals.

3.2.2 Selection of Critical Environmental Conditions

The "critical condition" for which this nutrient TMDL applies is the entire year. An annual loading period was utilized in modeling Yankee Hill Lake's assimilative capacity and for estimating loading reductions necessary to meet in-lake water quality targets. This approach also takes into consideration that nutrients being lost from the water column and trapped in the bottom sediments have the potential to re-enter the water column at a later time. However, implementation of non-point source controls will target those times when a large percent of the loading is occurring.

3.2.3 Waterbody Pollutant Loading Capacity

The loading capacity for this nutrient TMDL is defined as the amount of phosphorus Yankee Hill Lake can receive on an annual basis and still meet its assigned beneficial use criteria and established in-lake water quality targets. In comparison to empirical data, the EUTROMOD model tends to underestimate water transparency (secchi depth). Because of this, the EUTROMOD model (EPA Region 7 draft spreadsheet version) was used to determine the reduction necessary to meet an in-lake phosphorus concentration of 47 μg/l necessary to achieve a TSI of 60. Based upon this the phosphorus loading capacity for Yankee Hill Lake is 997.2 lbs/year.

3.3 Pollutant Source Assessment

For this TMDL, a combination of methods was used: 1) the Agriculture Nonpoint Source (AGNPS) model was used to identify critical erosion areas within the Yankee Hill watershed (the main focus of AGNPS was for implementation planning purposes), 2) the EUTROMOD model (Reckhow 1992) was employed to estimate annual phosphorus load from the watershed and 3) in-lake monitoring data was used as a to calibrate the EUTROMOD model, and define the loading capacity, current load and the in-lake response predictions.

3.3.1 Existing Pollutant Load

The annual average phosphorus load is estimated to be 9,972 lbs/year. This value was estimated using the EUTROMOD model calibrated to in-lake data and response and based on 1992-3 land use conditions.

3.3.2 Deviance from Loading Capacity

The targeted waterbody loading capacity for phosphorus, to meet the in-lake goals is 997.2 lbs/year and the modeled average annual load is 9,972 lbs/year. The loading capacity is being exceeded by 8,974.8 lbs/year and to achieve the loading capacity, a 90% reduction from the current phosphorus load is needed.

3.3.3 Identification of Pollutant Sources

No point sources of phosphorus have been identified in the watershed. Therefore, the necessary nonpoint sediment source identification and quantification was completed through the application of the EUTROMOD model and field surveys. For the purposes of modeling, the Yankee Hill Lake watershed was delineated into 11 sub-watersheds. Utilizing resource census data the watersheds were classified into 10 different land use categories with 5 being considered directly related to production agriculture.

3.3.3.1 Nonpoint Sources of Phosphorus

Phosphorus loads by land use estimated by the EUTROMOD model are presented in Table 3.3.3.1. Ten land uses were recognized as occurring the watershed. Of these, row crops (milo and soybeans) were identified as the largest contributor, accounting for approximately 81% of the modeled load. In terms of subwatersheds contributions, subwatershed #3 and #5 were modeled to contribute 91% of the annual phosphorus load. It should be noted that acreages of these two subwatersheds account for 80% of the total Yankee Hill Lake watershed.

The purpose of the EUTROMOD exercise was to identify the significant land use contributions of the net phosphorus loads with the associated sub-watersheds. The total annual net phosphorus load value identified in Table 3.3.3.1 differs from the in-lake response phosphorus value of 997.2 lbs/yr identified in section 3.2.3 above because the latter value was calibrated to in-lake conditions. It should be noted although not equal, the two net phosphorus load values are 93% similar.

Table 3.3.3.1 EUTROMOD Modeled Phosphorus Contributions by Land Use

Land Use	Total Acres Modeled	Net Phosphorus Load (lbs/year)
Pasture	329.4	346.08
Residential	88.5	58.06
Grass	566.1	412.6
Roads	124.4	140.72
Milo	1769.9	6299.38
Wheat	475.8	578.24
Wooded	735.6	291.66
Soybeans	672.6	2450.15
Cover Crop	85.7	149.64
Feed Lot	1.3	9.39
Totals	**4849.3**	**10735.92**

3.3.4 Linkage of Sources to Endpoint

The average annual phosphorus load of 9,972 lbs/year to Yankee Hill reservoir has been determined to originate entirely from nonpoint sources. To meet the desired endpoint for the TMDL, the annual nonpoint source phosphorus contributions must be reduced 90% (8,974.8 lbs) down to 997.2 lbs/year.

3.4 Pollutant Allocation

A TMDL is defined as:

TMDL = Loading Capacity = WLA + LA + Background + MOS

As stated above, the phosphorus loading capacity for Yankee Hill Lake is 997.2 lbs/year. To achieve the defined phosphorus loading capacity the required allocations are contained in the following sections.

3.4.1 Wasteload Allocation

No point sources of phosphorus discharge in the Yankee Hill Lake watershed therefore the wasteload allocation (WLA) will be “zero” (0).

3.4.2 Load Allocation

The load allocation distributed among the nonpoint sources will be 997.2 lbs/year. Information on base flow contributions is unknown and thus natural background will not be separated from the load allocation.

3.4.3 Margin of Safety

The margin of safety for the nutrient TMDL includes:

- Phosphorus can be discharged from the Yankee Hill reservoir outlet without being utilized. While this reduction is realized in the system, the TMDL will not account for this and assume the phosphorus load delivered to the lake remains available for algae production.

3.4.4 Nutrient (Phosphorus) TMDL Summary

TMDL/Waterbody Loading Capacity = 0 lbs/year (WLA) + 997.2 lbs/year (LA & Natural Background) + Implicit Margin of Safety

4.0 Implementation Plan

The implementation plan for this TMDL will be fairly simple and straightforward. Several layers of control are necessary to achieve the sediment and nutrient reduction goals. Because phosphorus readily attaches to sediment particles, nonpoint source reduction activities that target sediment will be pursued. These include:

Overland and Gully Erosion: Desired implementation activities will be targeted at the areas identified as being the largest contributors of sediment to the lake. These areas typically correspond to crop areas on steeper slopes that do not have best management practices in place.

- Implement management practices that will increase crop residue such as no-till farming,
- Construct terraces and grassed waterways.
- Install buffer strips along stream corridors.
- Construct grade stabilization structures to reduce head cutting and gully expansion.

Stream bank Erosion: Desired implementation activities will be targeted at the areas identified as being that largest contributor of sediment from eroding stream banks.

- Install check dams on smaller tributaries to reduce peak flows during runoff events.
- Install stream bank protection using vegetation and graded rock.

As stated previously, the NGPC has targeted Yankee Hill Lake for renovation. Also, the LPSNRD has expressed interest in developing a water quality/watershed management plan for Yankee Hill Lake. In developing watershed management plans the sponsor (LPSNRD) brings stakeholders to develop a community based plan that includes goals and management strategies. Once complete, the plan will be made an addendum to this TMDL for pollutant management purposes.

4.1 Interim Reduction Goal

The reductions identified in section 3.3.4 are based upon meeting the phosphorus TSI score of 60 and in doing this, 2 of 3 TSI parameters (total P and chlorophyll *a*) will be ≤60 resulting in a waterbody assessment of full support. The driving factor in determining the reduction necessary is the assumption that the TSI score of 60 defines hypereutrophic conditions. In order to effectively manage the lake resources, differences in water quality due to hydrology, geographic location and physical morphology must be evaluated.

Rather than rely upon Carlson's definition of hypereutrophic (Carlson 1996), the NDEQ, using Section 319 funds, has contracted with the University of Nebraska to develop a State of Nebraska lake classification system. The intent of project is to develop a statewide lake classification system and methodologies to evaluate water quality that are specific to a group of lakes or (eco)region. The classification system will be based on physical, chemical and biological information.

The result of this classification system may differ from Carlson's and a modification of the nutrient TMDL may be necessary. However, it is unclear when the classification system will be final and the NDEQ does not want to hinder the watershed management planning process with this uncertainty. Rather than delay the TMDL or community based planning process, implementation will initially strive to meet interim water quality and pollutant load reduction goals. Once these goals are met, the data collected (See Section 5.0) will be assessed to determine Yankee Lake's beneficial use status. For this TMDL the interim goals will be to meet a phosphorus trophic state index score of 65. Meeting this goal will require a 70% reduction in the estimated load of 9,972 lbs/year (annual load = 2991.6 lbs).

It should noted, this goal is only an interim (implementation) goal with the final goal being the load allocation of 997.2 stated in Section 3.4.2. In the future, should this load allocation be deemed inappropriate, a modification will be made to the TMDL and submitted to EPA for approval/disapproval.

4.2 Reasonable Assurances

Effective management of nonpoint source pollution in Nebraska necessarily requires a cooperative and coordinated effort by many agencies and organizations, both public and private. Each organization is uniquely equipped to deliver specific services and assistance to the citizens of Nebraska to help reduce the effects of nonpoint source pollution on the State's water resources. Appendix A lists those entities that may be included in the implementation process. These agencies have been identified as being responsible for program oversight or fund allocation that may be useful in addressing and reducing sedimentation and nutrient delivery to Yankee Hill Lake. Participation will depend on the agency/organization's program capabilities.

5.0 Future Monitoring

Monitoring of Yankee Lake will be conducted in the future to determine if the water quality is improving, degrading or remaining status quo. As well, monitoring will be conducted to evaluate the effectiveness of implemented best management practices (BMPs). The NDEQ has entered into an agreement with the USACE whereby the USACE will conduct monthly monitoring throughout the growing season and forward the results to NDEQ for assessment. Also, the USACE will periodically evaluate the impacts of sedimentation (bathymetry). Monitoring by the USACE will begin following the lake rehabilitation activities that are projected to be completed in Fall 2003. As well, NDEQ may periodically conduct monitoring to evaluate the effectiveness of BMPs (i.e. in-lake basins).

6.0 Public Participation

The public was invited to review and comment on the draft TMDLs with an announcement being published in the Lincoln Journal Star. The review and comment period ran from June 28,2002 to August 1, 2002. These TMDLs were also made available to the public on the NDEQ's Internet site and announcement letters were mailed to identified stakeholders. One comment letter was received however; modification to the TMDL was not necessary as a result of the submitted comments.

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Appendix A – Federal, State Agency and Private Organizations Included in TMDL Implementation.

FEDERAL

- Bureau of Reclamation
- Environmental Protection Agency
- Fish and Wildlife Service
- Geological Survey
- Department of Agriculture - Farm Services Agency
- Department of Agriculture - Natural Resources Conservation Service

STATE

- Association of Resources Districts
- Department of Agriculture
- Department of Environmental Quality
- Department of Roads
- Department of Water Resources
- Department of Health and Human Services
- Environmental Trust
- Game and Parks Commission
- Natural Resources Commission
- University of Nebraska Institute of Agriculture and Natural Resources (IANR)
- UN-IANR: Agricultural Research Division
- UN-IANR: Cooperative Extension Division
- UN-IANR: Conservation and Survey Division
- UN-IANR: Nebraska Forest Service
- UN-IANR: Water Center and Environmental Programs

LOCAL

- Natural Resources Districts
- County Governments (Zoning Board)
- City/Village Governments

NON-GOVERNMENTAL ORGANIZATIONS

- Nebraska Wildlife Federation
- Pheasants Forever
- Nebraska Water Environment Association
- Nebraska Corn Growers Association, Wheat Growers, etc.
- Nebraska Cattlemen's Association, Pork Producers, etc
- Other specialty interest groups
- Local Associations (i.e. homeowners associations)

Appendix B – Nebraska Game and Parks Commission News Release (Source: NGPC web page).

04/04/02

YANKEE HILL RESERVOIR AQUATIC HABITAT PROJECT UNDERWAY

Keywords: General (1418)

LINCOLN, Neb. – The Nebraska Game and Parks Commission has begun an Aquatic Habitat Project on Yankee Hill Reservoir southeast of Denton.

The emphasis of the project will be to construct sediment retention structures, repair shoreline erosion, increase water depth in the upper arms, improve water clarity and increase the amount of aquatic vegetation in the reservoir. Also scheduled will be improvements to the outlet structure, boat ramp facilities and fish community.

Water is being released from the lake and water levels are expected to decline nearly eight feet, which will expose shorelines and shallow bays. This is an important component of the project, because the areas where construction activities will occur must dry out before heavy equipment can begin work. It will also allow weeds, cottonwoods and willows to grow in exposed areas which will provide excellent habitat and food resources for young largemouth bass, bluegill, catfish and walleye that will be stocked as part of the project.

Yankee Hill Reservoir was placed on the list of waters needing rehabilitation following the establishment of the $5 Aquatic Habitat Stamp required by licensed anglers over 18 years of age.

Appendix C – Summary of EUTROMOD Model Inputs

The EUTROMOD model was utilized to estimate average annual sediment (sheet and rill) erosion and nutrient loading by sub-watersheds (Figure C.1) and land use to Yankee Hill Lake. Due to the variation in land uses, land use acreages and existing treatments (i.e. terraces, retention ponds), each watershed was modeled separately and the results summed. The final products of the modeling can be found in Tables 2.3.3.1 and 3.3.3.1 for sediment and phosphorus, respectively. Table C.1 presents the various land uses and the total acreages within the watershed. For modeling purposes the agriculture category was further segregated into crops grown. Tables CA.2-C.4 contain the EUTROMOD model inputs.

Table C.1 Land Use (1992-3) within the Yankee Hill Lake Watershed

Land Use Category	Total Acres Modeled
Pasture	329.4
Residential	88.5
Grass/CRP	566.1
Roads	124.4
Milo	1769.9
Wheat	475.8
Wooded	735.6
Soybeans	672.6
Cover Crop	85.7
Feed Lot	1.3
Totals	**4849.3**

Table C.2 EUTROMOD/USLE Model Inputs for Yankee Hill Lake

Land Use	Runoff Coefficient (RC)	Rainfall Erosivity (RE)	Land Slope Factor (LS)	Soil Erodibility (K)	Cropping Factor (C)	Practice Factor (P)
Pasture	0.15-0.27	277	0.4-1.2	0.37-0.38	0.03-0.06	0.8-1.0
Residential	0.2-0.3	277	0.4-1.2	0.37-0.38	0.03-0.05	1.0
Grass/CRP	0.15	277	0.4-0.75	0.37-0.38	0.03	0.9-1.0
Roads	0.5-0.6	277	0.4-1.2	0.37-0.38	0.03-0.1	1.0
Milo	0.35	277	0.4-1.2	0.37-0.38	0.29-0.32	0.75-1.0
Wheat	0.24	277	0.4-1.2	0.37-0.38	0.05-0.15	0.75-1.0
Wooded	0.15	277	0.4-1.2	0.37-0.38	0.02-0.03	1.0
Soybeans	0.3	277	0.4-1.2	0.37-0.38	0.36	0.75-1.0
Cover Crop	0.18	277	0.4-0.55	0.37-0.38	0.05-0.06	0.75-1.0
Feedlot	0.6	277	0.4	0.37	0.9	1.0

Table C.3 EUTROMOD Model Inputs for Yankee Hill Lake Subwatersheds

Land Use	Dissolved Phosphorus	Sediment Attached Phosphorus	Total Phosphorus	Dissolved Nitrogen	Sediment Attached Nitrogen	Total Nitrogen
Pasture	0.25	211		3	625	
Residential		211	0.1		625	1.75
Grass/CRP	0.25	211		3	625	
Roads	0.1	200		0.5	200	
Milo	0.26	211		2.9	625	
Wheat	0.3	211		1.8	500	
Wooded	0.008	211		0.07	625	
Soybeans	0.26	211		2.9	625	
Cover Crop	0.15	211		2.8	625	
Feedlot			0			0
Precipitation			0.05			0.1

Table C.4 EUTROMOD Model Inputs for Yankee Hill Lake Subwatersheds

Miscellaneous Inputs	Value
Precipitation Mean	73 cm
Precipitation C_v	0.25
P Enrichment	2
N Enrichment	2
Trapping Efficiency Range	0.1 – 1.0

Land use information and conservation practices was initially obtained from digital ortho-photo quadrangles (aerial photos) and verified/updated using information provided by the Natural Resource Conservation Service.

Figure C.1 Yankee Hill Lake Subwatersheds