Total Maximum Daily Load (TMDL)

Oil Creek Watershed
York County

Pennsylvania Department of Environmental Protection
Central Office
Office of Water Management

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Table of Contents

List of Tables

List of Figures

List of Appendices

Summary of the Oil Creek TMDL

1. The impaired segment of Oil Creek addressed by this TMDL is located in York County, just east of Hanover. The watershed area covers approximately 4 square miles. Traveling East from Hanover, Pennsylvania, state route 116 bisects the TMDL segment.

2. The TMDL for the Oil Creek segment was developed to address use impairments caused by siltation. Oil Creek first appeared on Pennsylvania's 303(d) list in 1996, when 1.2 miles of the tributary were listed as impaired by an unknown cause emanating from urban runoff. The study noted stream bank erosion to be a significant problem. Assessments conducted by the Pennsylvania Department of Environmental Protection (Pa. DEP) in 2001 documented designated use impairments for segments downstream of this TMDL. Agricultural land use activities were also identified as a source of impairment, with siltation and nutrients causing the impairments. These additional segments are expected to be included on Pennsylvania's 2002 303(d) list. However, the sediment TMDL was developed to address impairments identified in the Department's current 305(b) database. In order to ensure attainment and maintenance of water quality standards in Oil Creek for the 1996 listed segment, mean annual loading of sediment will need to be limited to 1,039,943.14 lbs/yr.

   The major components of the Oil Creek TMDL are summarized below:

Component	Sediment (lbs/yr)
TMDL (Total Maximum Daily Load)	1,039,943.14
WLA (Wasteload Allocation)	0.00
MOS (Margin of Safety)	103,994.31
LA (Load Allocation)	935,948.83

3. Mean annual total sediment loading is estimated to be 1,549,618.60 lbs/yr. To meet the TMDL, the sediment loading will require a 33% reduction.

4. There are no point sources to address in this TMDL. Load Allocations (LA) for sediment were made to the following nonpoint sources: hay and pasture lands; croplands; coniferous forest; mixed forest; deciduous forest; developed areas; and stream banks.

5. The sediment TMDL includes a nonpoint source LA of 935,948.83 lbs/yr. Allocations to sources receiving reductions (hay/pasture, cropland, developed, and stream banks) add up to 935,548.83 lbs/yr. Sediment loadings from all other sources were maintained at 400.00 lbs/yr. Allocations of sediment to all nonpoint sources in the TMDL segment are summarized below:

Load Allocations for Sources of Sediment			
Source	**Current Loading (lbs/yr)**	**Load Allocation (lbs/yr)**	**% Reduction**
Hay and Pasture	235,800.00	157,802.26	33%
Cropland	1,086,800.00	626,088.70	42%
Developed	30,000.00	20,076.62	33%
Stream banks	196,618.60	131,581.25	33%
Loads Not Reduced	400.00	400.00	0%
Total	1,549,618.60	935,948.83	39%

6. Ten percent of the Oil Creek sediment TMDL was set-aside as a margin of safety (MOS). The MOS is that portion of the pollutant loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis. The MOS for the sediment TMDL was set at 103,994.31 lbs/yr.

7. The continuous simulation model used for developing the Oil Creek TMDL considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model requires specification of the growing season and hours of daylight for each month. The model also considers the months of the year when manure is applied to the land. The combination of these actions accounts for seasonal variability.

I. Introduction

A. Watershed Description

The impaired segment of Oil Creek is located in York County, just east of Hanover (Figure 1). The Oil Creek subwatershed addressed in this TMDL drains an area of approximately 4 square miles. Traveling East from Hanover, Pennsylvania, state route 116 bisects the TMDL segment.

The subwatershed addressed by this TMDL drains the area of Penn Township that borders the Hanover municipal boundary. The segment flows north, and then changes direction to the northeast before leaving the township. The segment ends shortly before crossing into Heidelberg Township.

Protected uses of include aquatic life and recreation. The entire basin is currently designated as warm water fishes (WWF) under §93.9f in Title 25 of the Pa. Code (Commonwealth of Pennsylvania, 2001).

B. Topography & Geology

The Oil Creek subwatershed is located in both the Upland and Lowland Sections of the Piedmont Province in south-central Pennsylvania. The watershed area is typical of watersheds in the Piedmont Province. The elevations range from 520 to 780 feet. In general, the elevation decreases from the south to the northeast, and the drainage follows this pattern. This area receives approximately 38.5 inches of precipitation per year.

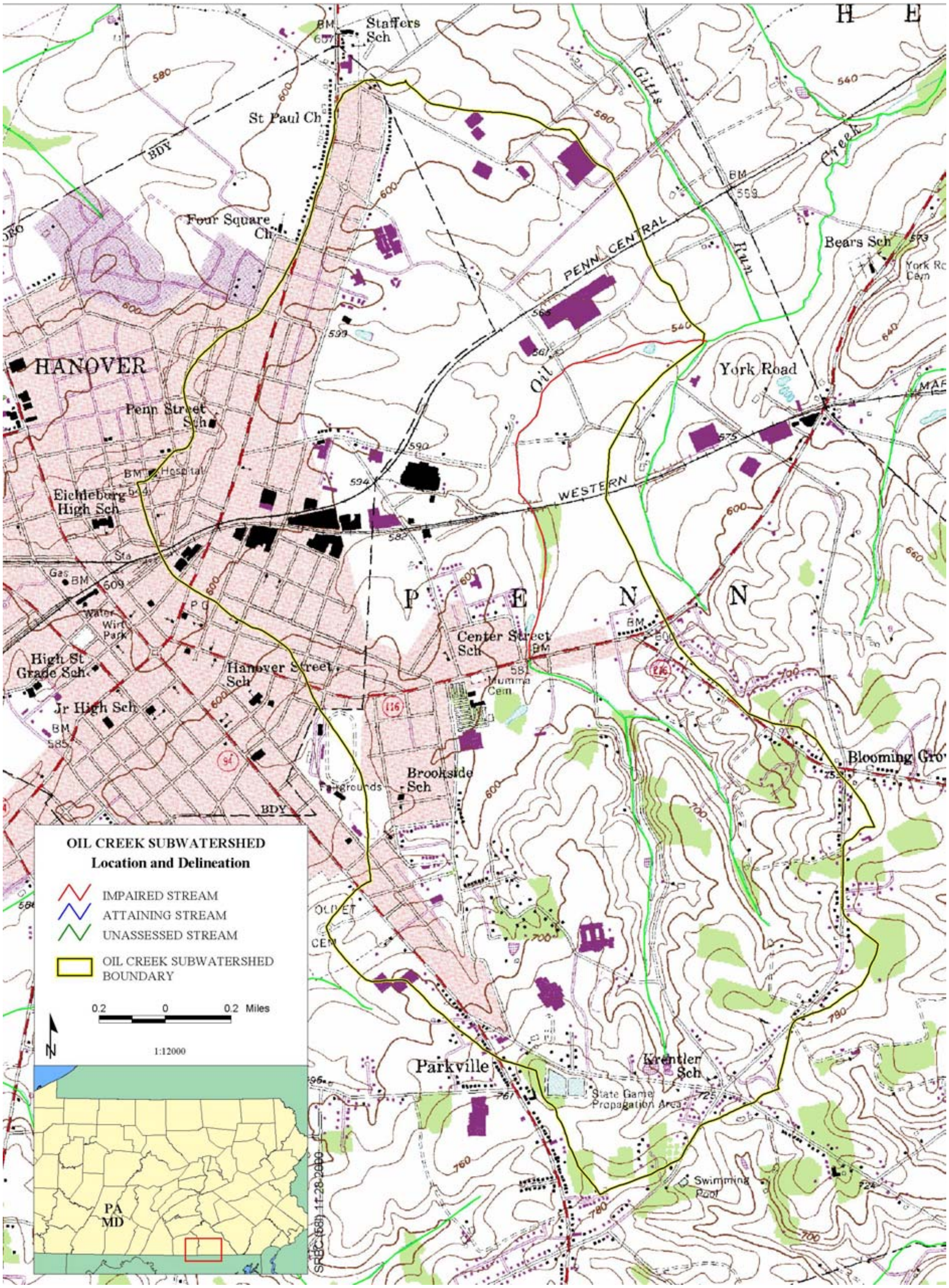
The surficial geology of the Oil Creek subwatershed is 60% carbonate, 37% igneous/metamorphic, and 3% sedimentary. The strata include the Conestoga Formation that is carbonate limestone, the Antietam and Harpers Formations that are the igneous/metamorphic units in the upland areas, and the Kinzer Formation that is a shale unit found close to the boundary of the carbonate and igneous/metamorphic units.

The soils found in the subwatershed are comprised of the Chester-Glenelg-Manor and Hagerstown-Duffield-Clarksburg series. The Chester series are moderately deep and well drained with moderate to rapid permeability. The soils tend to highly fertile with a high available moisture capacity. The extent of the Chester series in the watershed is predominantly in the uplands area, characterized by the more resistant igneous/metamorphic ridges. The Hagerstown soils are typically deep and well-drained soils. The parent material is predominantly limestone, hence the soils are found predominantly in the carbonate areas in the immediate vicinity of the municipality. To a large extent, the soil is used for pasture and cropland throughout the Oil Creek subwatershed; the remaining areas are typically forested. The erodibility (k) factor is a measure of inherent soil erosion potential based on the soils texture and composition. The k factor for both soils is approximately 0.32, so soil erosion is a significant concern for the subwatershed.

C. Land Use

Based on GIS datasets, land use values were calculated for the Oil Creek subwatershed. Agriculture was the dominant land use at 59%. Forested areas account for 6% of the watershed. Developed areas are 35% of the watershed. Riparian buffer zones are nearly nonexistent in the agricultural and developed areas. Livestock have unlimited access to streambanks throughout most of the watershed, resulting in streambank trampling and severe erosion. Impervious surface is greatly increased in developed areas, contributing to an increase in stream velocities and decrease in infiltration and recharge. This increase in flow can cause stream bank erosion problems, as is documented on Pennsylvania's 303(d) list.

Figure 1. Oil Creek Subwatershed, York County



D. Surface Water Quality

Pennsylvania's 1996 303(d) list identified 1.2 miles of a segment of Oil Creek as impaired by an unknown cause emanating from urban activities in the basin (Table 1). The miles impaired were then increased on Pennsylvania's 1998 303(d) list. Figure 1 shows the segment addressed by this TMDL. The comment field in the 2000 305(b) database indicates that stream bank erosion is a problem for the listed segment of stream. Upon visiting the stream segment, stream bank erosion was easily apparent and the substrate showed evidence of heavy siltation. Although the original listing made no mention of agricultural sources, there is a significant portion of the watershed area upstream of the listed segment dedicated to agricultural activities.

As part of the Pa. DEP's ongoing Unassessed Waters (UW) program, assessments were conducted on selected segments of Oil Creek in 2001. Information collected during these assessments identified designated use impairments for segments of Oil Creek downstream of the 1996 and 1998 listed segment. The cause is considered to be related to siltation and nutrients emanating from agricultural activities.

<table>
<tr><th colspan="6">Table 1. 1996 & 1998 303(d) Listings for the Oil Creek Watershed</th></tr>
<tr><th colspan="6">1996 303(d) LIST</th></tr>
<tr><td colspan="2">STREAM NAME</td><td>STREAM CODE</td><td>SOURCE</td><td>CAUSE</td><td>MILES</td></tr>
<tr><td colspan="2">Oil Creek</td><td>8213</td><td>Urban Runoff / Storm Sewers</td><td>Other</td><td>1.2</td></tr>
<tr><th colspan="6">1998 303(d) LIST</th></tr>
<tr><td>SEGMENT ID</td><td>WATERSHED</td><td>STREAM CODE</td><td>SOURCE</td><td>CAUSE</td><td>MILES</td></tr>
<tr><td>6428</td><td>Oil Creek</td><td>8213</td><td>Urban Runoff / Storm Sewers</td><td>Cause Unknown</td><td>1.41</td></tr>
</table>

II. Approach to TMDL Development

A. Pollutants & Sources

Based on field observations, siltation from both urban and agricultural runoff was identified as the pollutant causing designated use impairments in the Oil Creek subwatershed. Parking lots and other impervious surfaces lie adjacent to the stream, with no riparian buffers present. The presence of these impervious surfaces decreases infiltration and contributes to an increase in stream velocities during storm events. The effects on peak flow cause an increase in stream bank erosion. In addition, pastures and croplands upstream of the impaired segment extend right up to the edge of the stream with little to no riparian buffer zone. In many places, cropland channels drains directly into the stream. Livestock also have unlimited access to streambanks throughout most of the watershed, resulting in accelerated stream bank erosion. Best Management Practices (BMPs) are very limited in the watershed.

B. TMDL Endpoints

The TMDL developed for the Oil Creek subwatershed addresses sediment loads. Limiting the sediment from urban runoff and agriculture will reduce siltation in the stream. The surface water monitoring data collected made note of severe stream bank erosion. The TMDL method used in this report will outline reductions needed to be made to restore the applicable designated uses.

C. Reference Watershed Approach

The TMDL developed for Oil Creek watershed addresses sediment. Because neither Pennsylvania nor the U.S. Environmental Protection Agency (USEPA) has in-stream numerical water quality criteria for sediment, a method was developed to implement the applicable narrative criteria for this pollutant. The method for these types of TMDLs is termed the “Reference Watershed Approach”. Meeting the water quality objectives specified for this TMDL will result in the impaired stream segment attaining its designated uses.

The Reference Watershed Approach compares two watersheds, one attaining its uses and one that is impaired based on biological assessments. Both watersheds ideally have similar land use/cover distributions. Other features such as base geologic formation should be matched to the extent possible; however, most variations can be adjusted for in the model. The objective of the process is to reduce the loading rate of pollutants in the impaired stream segment to a level equivalent to the loading rate in the nonimpaired, reference stream segment. This load reduction will result in conditions favorable to the return of a healthy biological community to the impaired stream segments.

D. Selection of the Reference Watershed

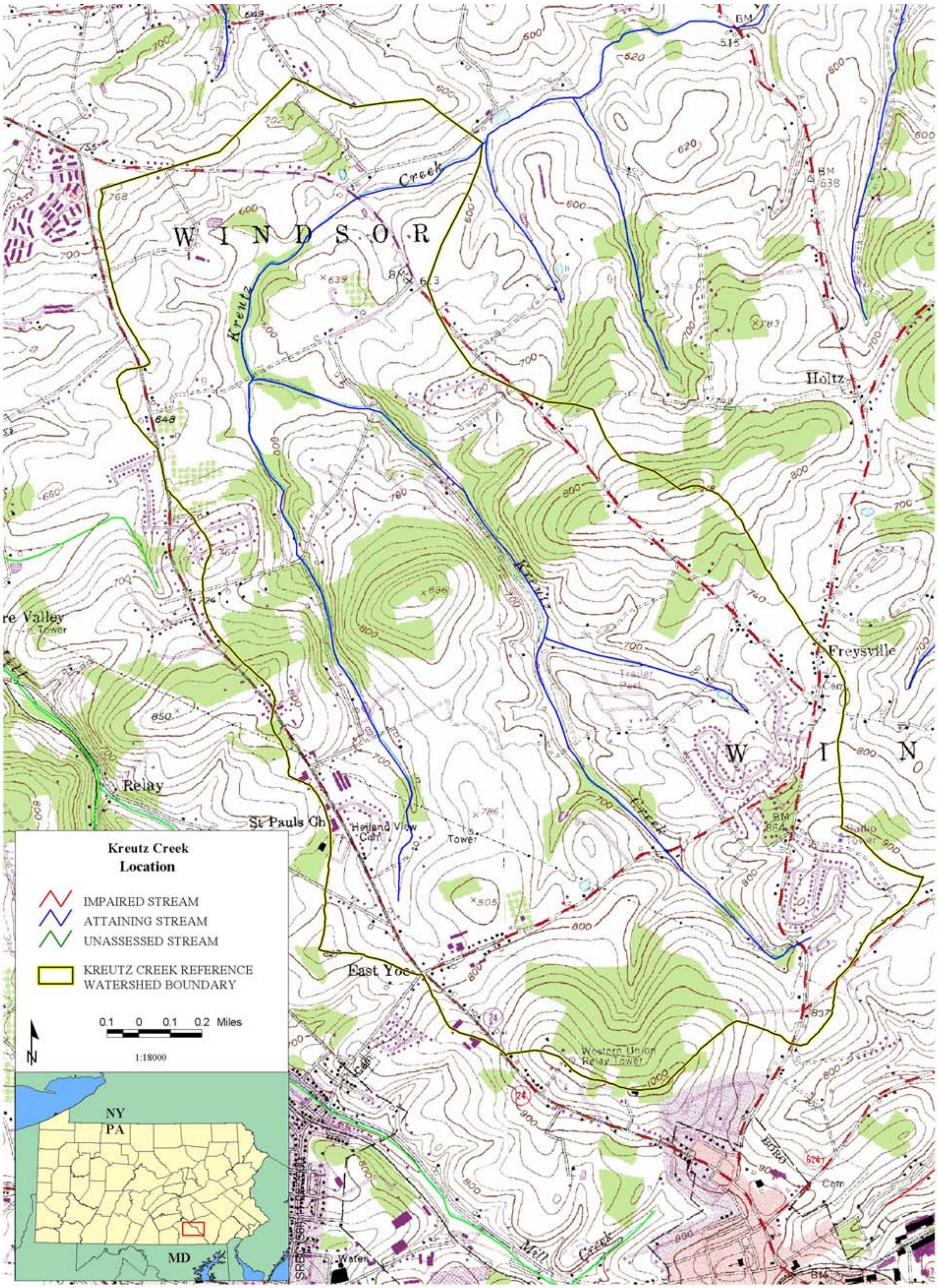
In general, three factors are considered when selecting a suitable reference watershed. The first factor is to use a watershed that the Pa. DEP has assessed and determined to be attaining water quality standards. The second factor is to find a watershed that closely resembles the impaired watershed in physical properties such as land cover/land use, physiographic province, and geology/soils. Finally, the size of the reference watershed should be within 20-30% of the impaired watershed area. The search for a reference watershed for the Oil Creek subwatershed, that would satisfy the above characteristics, was done by means of a desktop screening using several GIS coverages, including the Multi-Resolution Land Characteristics (MRLC), Landsat-derived land cover/use grid, the Pennsylvania's 305(b) assessed streams database, and geologic rock types.

A headwater tributary of Kreutz Creek, stream code 7881, was selected as the reference watershed for developing the Oil Creek subwatershed TMDL. Kreutz Creek is located northwest of Red Lion in Windsor Township, York County, Pennsylvania (Figure 2). The watershed is located in State Water Plan subbasin 7I, and protected uses include aquatic life and recreation. The entire basin is currently designated as WWF under §93.9z in Title 25 of the Pa. Code (Commonwealth of Pennsylvania, 2001). Based on the Department's 305(b) report database, Kreutz Creek is currently attaining its designated uses. The attainment of designated uses is based on sampling done by the Department in 1999, as part of its Unassessed Waters Protocol.

Drainage area, location, and other physical characteristics of the Oil Creek subwatershed were compared to the reference portion of the Kreutz Creek watershed (Table 2). Land cover/use distributions in both watersheds are somewhat similar. Agriculture is the dominant land use category in both the Kreutz subwatershed (71%) and the Oil Creek subwatershed (59%). Surficial geology in the Kreutz Creek subwatershed and the Oil Creek subwatershed also were compared. The geology between the two watersheds differs, however, the method used to determine sediment loading does not use geologic material in its calculations. Geology in the model primarily affects background nutrient loads. Although the predominant geologic materials for Oil and Kreutz Creek are carbonate and igneous/metamorphic respectively, both have similar characteristics with respect to being fracture-dominated rocks. The primary factor driving sediment loading is the K factor, or soil erodibility. This K factor is very similar when comparing the two watersheds. The Oil Creek and Kreutz Creek watersheds are very similar in terms of precipitation and soil K factor (Table 2). The soil K factor is very important with relation to sediment loads.

Table 2. Comparison Between Oil and Kreutz Watersheds		
Attribute	**Watershed**	
	Oil	**Kreutz**
Physiographic Province	Piedmont (100%)	Piedmont (100%)
Area (mi^2)	4.5	5.0
Land Use	Agriculture (59%) Forested (6%) Development (35%)	Agriculture (71%) Forested (24%) Development (5%)
Geology	Igneous/Metamorphic (40%) Sedimentary (6%) Carbonate (54%)	Igneous/Metamorphic (81%) Sedimentary (14%) Carbonate (5%)
Soils	Hagerstown-Duffield-Clarksburg Chester-Glenelg-Manor	Chester-Glenelg-Manor Mt. Airy-Glenelg-Linganore
Dominant HSG	Dominantly B/C	Dominantly B
K Factor	0.32	0.30-0.32
20-Yr. Ave. Rainfall (in)	38.5	41.2
20-Yr. Ave. Runoff (in)	4.3	1.8

Figure 2. Kreutz Creek Subwatershed, York County



III. Watershed Assessment and Modeling

The TMDL for the Oil Creek subwatershed was developed using the Arcview Generalized Watershed Loading Function model (AVGWLF) as described in Appendix B. The AVGWLF model was used to establish existing loading conditions for the Oil Creek subwatershed and the reference portion of the Kreutz Creek watershed. All modeling inputs have been attached to this TMDL as Appendices C and D. Susquehanna River Basin Commission staff visited the Oil Creek and Kreutz subwatersheds in the fall and winter of 2001. The field visits were conducted to get a better understanding of existing conditions that might influence the AVGWLF model. General observations of the individual watershed characteristics include:

Oil Creek Subwatershed

- Local geology dominated by carbonate rocks.
- Heavily grazed pastures with no stream bank fencing (Figure 3).
- Severely limited riparian buffer zones, with pastures, cropland, and developed areas extending right up to stream banks (Figures 3, 4, and 5).
- Significant presence of developed areas.
- General lack of strip cropping and contour plowing.

Kreutz Creek Subwatershed

- Local geology dominated by igneous/metamorphic rocks.
- Newly developed areas with best management practices in place for stormwater.
- Forest buffers along streams in many areas (Figure 6).
- Presence of cover crops and contour planting (Figure 7).
- Abundant silt-free gravel substrate throughout the entire subwatershed.

Minor adjustments were made to specific parameters used in the AVGWLF model based on observations made while touring the watersheds. These adjustments are summarized at the end of Appendix B.

Figure 3. Typical Riparian Zone in Oil Creek

Figure 4. Cropland Draining Directly into Oil Creek

Figure 5. Typical Riparian Zone in Developed Areas of Oil Creek

Figure 6. Typical Riparian Zone in the Kreutz Creek Watershed
(Riparian Zone consists of the tree line in the background)

Figure 7. Example of Contour Planting in Kreutz Creek Watershed

The AVGWLF model produced information on watershed size, land use, and sediment loading (Appendices C and D). The sediment loads represent an annual average over a 20-year period (1978 to 1998). The existing loads for each of the subwatersheds in shown in Table 3. This information was then used to calculate existing unit area loading rates for the Oil Creek and Kreutz Creek subwatersheds.

Unit area loading rates were estimated by dividing the mean annual loading (lbs/yr) of each pollutant by the total area (acres) of the watershed. Unit area loading rates for sediment in the Oil Creek subwatershed was estimated to be 624.26 lbs/acre/yr (Table 4). Estimated unit area loading rate for sediment in the Kreutz Creek watershed was 418.94 lbs/acre/yr.

Table 3. Existing Sediment Loads for the Oil Creek and Kreutz Creek Subwatersheds

			Oil Creek		Kreutz Creek	
Pollutant Source	**Oil Creek Acreage**	**Kreutz Creek Acreage**	**Mean Annual Loading (lbs/yr)**	**Unit Area Loading (lbs/ac/yr)**	**Mean Annual Loading (lbs/yr)**	**Unit Area Loading (lbs/ac/yr)**
HAY/PAST	501.6	721.50	235800.00	470.10	52800.00	73.18
CROPLAND	963.7	1238.00	1086800.00	1127.74	1039000.00	839.26
CONIF_FOR	34.6	46.90	0.00	0.00	200.00	4.26
MIXED_FOR	17.3	44.50	0.00	0.00	200.00	4.49
DECID_FOR	96.4	560.90	400.00	4.15	9800.00	17.47
UNPAVED_RD	0.0	2.50	--	--	0.00	0.00
LO_INT_DEV	583.2	133.40	21400.00	36.69	12800.00	95.95
HI_INT_DEV	269.3	9.90	8600.00	31.93	200.00	20.20
Stream Bank	--	--	196618.60	--	40270.40	--
Groundwater	--	--	--	--	--	--
Point Source	--	--	--	--	--	--
Septic Systems	--	--	--	--	--	--
Total	2466.10	2757.60	1549618.60	628.37	1155270.40	418.94

Table 4. Existing Unit Area Loading Rates for Sediment for the Oil Creek and Kreutz Creek Subwatersheds

		Mean Annual Loading (lbs/yr)	Unit Area Loading Rate (lbs/ac/yr)
Watershed	**Area (ac)**	**Sediment**	**Sediment**
Oil Creek	2,482.32	1,549,618.60	624.26
Kreutz Creek	2,757.60	1,155,270.40	418.94

IV. TMDLs

Targeted TMDL values for the Oil Creek subwatershed were established based on current loading rates for sediment in the Kreutz Creek reference subwatershed. Biological assessments have determined that the Kreutz Creek subwatershed is currently attaining its designated uses. Reducing the loading rate of sediment in the Oil Creek subwatershed to levels equivalent to those in the reference portion of the Kreutz Creek subwatershed will provide conditions favorable for the reversal of current use impairments.

A. Background Pollutant Conditions

There are two separate considerations of background pollutants within the context of this TMDL. First, there is the inherent assumption of the reference watershed approach that because of the similarities between the reference and impaired watershed, the background pollutant contributions will be similar. Therefore, the background pollutant contributions will be considered when determining the loads for the impaired watershed that are consistent with the loads from the reference watershed. Second, the AVGWLF model implicitly considers background pollutant contributions through the soil and the groundwater component of the model process.

B. Targeted TMDLs

The targeted TMDL value for sediment was determined by multiplying the total area of the Oil Creek subwatershed (2,482.32 acres) by the appropriate unit area loading rate for the Kreutz Creek subwatershed (Table 5). The existing mean annual loading of sediment to the Oil Creek subwatershed (1,549,618.60 lbs/yr) will need to be reduced by 33% to meet the targeted TMDL of 1,039,943.14 lbs/yr.

Table 5. Targeted TMDL for the Oil Creek Subwatershed

Pollutant	Area (ac)	Unit Area Loading Rate Kreutz Creek Subwatershed (lbs/ac/yr)	Targeted TMDL (lbs/yr)
Sediment	2,482.32	418.94	1,039,943.14

Targeted TMDL values were than used as the basis for load allocations and reductions in the Oil Creek subwatershed, using the following two equations:

1. TMDL = WLA + LA + MOS
2. LA = ALA + LNR

where:

TMDL = Total Maximum Daily Load
WLA = Waste Load Allocation (point sources)
LA = Load Allocation (nonpoint sources)
ALA = Adjusted Load Allocation
LNR = Loads not Reduced

C. Wasteload Allocation

There are no known wasteload allocations for sediment in the Oil Creek subwatershed.

D. Margin of Safety

The MOS is that portion of the pollutant loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis. For this analysis, the MOS is explicit. Ten percent of the targeted TMDL for sediment was reserved as the MOS. Using 10% of the TMDL load is based on professional judgment and will provide an additional level of protection to the designated uses of the Oil Creek subwatershed. The MOS used for the sediment TMDL was 103,994.31 lbs/yr.

MOS = 1,039,943.14 lbs/yr (TMDL) x 0.1 = 103,994.31 lbs/yr

E. Load Allocation

The LA is that portion of the TMDL that is assigned to nonpoint sources. The LA was computed by subtracting the WLA and MOS values from the targeted TMDL value. LA for the Oil Creek subwatershed is 935,948.83 lbs/yr.

LA = 1,039,943.14 lbs/yr (TMDL) – 0.0 lbs/yr (WLA) – 103,994.31 lbs/yr (MOS) = 935,948.83 lbs/yr

F. Adjusted Load Allocation

The adjusted load allocation (ALA) is the actual portion of the LA distributed among those nonpoint sources receiving reductions. It is computed by subtracting those nonpoint source loads that are not being considered for reductions (loads not reduced or LNR) from the LA. Sediment reductions were made to the hay/pasture, cropland, developed areas, and streambanks. Those land uses/sources for which existing loads were not reduced (CONIF_FOR, MIXED_FOR, DECID_FOR) were carried through at their existing loading values (Table 6). The ALA for the Oil Creek subwatershed was 935,548.83 lbs/yr.

Table 6. Load Allocations, Loads Not Reduced, and Adjusted Load Allocations for the Oil Creek Subwatershed Sediment TMDL	
	Sediment (lbs/yr)
Load Allocation	935,948.83
Loads Not Reduced	400.00
CONIF_FOR	0.00
MIXED_FOR	0.00
DECID_FOR	400.00
Adjusted Load Allocation	935,548.83

G. TMDLs

The sediment TMDL established for the Oil Creek subwatershed consists of a LA and a MOS. The individual components of the TMDL are summarized in Table 7.

Table 7. TMDL, WLA, MOS, LA, LNR, and ALA for the Oil Creek Subwatershed	
Component	**Sediment (lbs/yr)**
TMDL (Total Maximum Daily Load)	1,039,943.14
WLA (Wasteload Allocation)	0.00
MOS (Margin of Safety)	103,994.31
LA (Load Allocation)	935,948.83
LNR (Loads Not Reduced)	400.00
ALA (Adjusted Load Allocation)	935,548.83

V. Calculation of Sediment Load Reductions

The ALA is established in the previous section represent the annual sediment load that is available for allocation between contributing sources in the Oil Creek subwatershed. The ALA for sediment was allocated between agricultural and developed land uses. LA and reduction procedures were applied to the entire Oil Creek subwatershed using the Equal Marginal Percent Reduction (EMPR) allocation method (Appendix E). The LA and EMPR procedures were performed using MS Excel and results are presented in Appendix F.

In order to meet the sediment TMDL for the Oil Creek subwatershed (1,039,943.14 lbs/yr), the load currently emanating from agricultural sources (1,322,600 lbs/yr) must be reduced to 783,890.96 lbs/yr (Table 8). This can be achieved through a 33% and 42% reduction in current sediment loading from hay/pasture and cropland respectively. The load currently emanating from developed sources (30,000 lbs/yr) must be reduced by 33% to reach 20,076.62 lbs/yr (Table 8). The load currently emanating from stream banks (196,618.60 lbs/yr) must be reduced by 33% to reach 131,581.25 lbs/yr (Table 8).

Table 8. Sediment Load Allocations & Reductions for the Oil Creek Subwatershed

Pollutant Source	Acres	Unit Area Loading Rate (lbs/ac/yr)		Pollutant Loading (lbs/yr)		% Reduction
		Current	Allowable	Current	Allowable (LA)	
HAY/PASTURE	492.59	478.69	320.35	235,800.00	157,802.26	33%
CROPLAND	989.42	1,098.42	632.78	1,086,800.00	626,088.70	42%
Developed	855.09	35.08	23.48	30,000.00	20,076.62	33%
Stream banks				196,618.60	131,581.25	33%
Total				**1,549,218.60**	**935,548.83**	**39%**

VI. Consideration of Critical Conditions

The AVGWLF model is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for nutrient loads, based on the daily water balance accumulated to monthly values. Therefore, all flow conditions are taken into account for loading calculations. Because there is generally a significant lag time between the introduction of nutrients to a waterbody and the resulting impact on beneficial uses, establishing these TMDLs using average annual conditions is protective of the waterbody.

VII. Consideration of Seasonal Variations

The continuous simulation model used for this analysis considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model requires specification of the growing season and hours of daylight for each month. The model also considers the months of the year when manure is applied to the land. The combination of these actions by the model accounts for seasonal variability.

VIII. Recommendations for Implementation

TMDLs represent an attempt to quantify the pollutant load that may be present in a waterbody and still ensure attainment and maintenance of water quality standards. The Oil Creek TMDL identifies the necessary overall load reduction for the pollutant currently causing use impairments and distributes the reduction goals to the appropriate nonpoint sources. Reaching the reduction goals established by this TMDL will only occur through stream restoration efforts and the use of BMPs. BMPs that would be helpful in lowering the amount of sediment reaching the Oil Creek segment include stream bank fencing, riparian buffer strips, strip cropping, contour plowing, conservation crop rotation, stormwater management controls, and heavy use area protection, among many others.

Numerous restoration initiatives are currently underway in the Upper Codorus Creek Watershed. The York County Conservation District has been assisting with the coordination of many of these initiatives. The projects completed to date have been funded both through both the Pennsylvania Growing Greener Grant Program and the USEPA Clean Water Act Section 319 Grant Program. Several reaches of stream bank have been restored since 2000. In addition, the Codorus Trout Unlimited Chapter recently received a Pa. Department of Conservation and Natural Resources Rivers Conservation Grant. The conservation plan is near completion, and covers the area of the watershed from the headwaters to Spring Grove. The project area includes Oil Creek Watershed.

In addition, continuing studies are underway to assess future restoration priorities. The Codorus Creek Watershed Association and U.S. Army Corps of Engineers (USACE) are developing plans to further protect and restore the watershed through a Rivers Conservation Plan and a USACE 206 Study respectively.

All of the above mentioned efforts have been supported by numerous government, industry, and citizen partnerships. The umbrella organization for many of the efforts in York County is the Watershed Alliance of York (WAY).

For more information on the utility of BMPs, the Natural Resources Conservation Service maintains a National Handbook of Conservation Practices (NHCP). The NHCP is available online at http://www.ncg.nrcs.usda.gov/nhcp_2.html. Many of the practices described in the handbook could be used on agricultural lands and urban areas in the Oil Creek Watershed to help limit sediment impairments. Determining the most appropriate BMPs, where they should be installed, and actually putting them into practice, requires the development and implementation of a comprehensive watershed restoration plan. Development of any restoration plan involves the gathering of site-specific information regarding current land uses and existing conservation practices. For the Oil Creek Watershed, some aspects of a comprehensive plan are close to completion.

By developing TMDLs for the Oil Creek Watershed, the Pa. DEP has set the stage for the design and implementation of restoration plans to correct current use impairments. The Pa. DEP welcomes local efforts to support these watershed restoration plans. For more information about this TMDL, interested parties should contact the appropriate Watershed Manager in the Pa. DEP's Southcentral Regional Office (717-705-4700).

IX. Public Participation

A notice of availability for comments on the draft Oil Creek watershed TMDL was published in the PA Bulletin on December 14, 2002. The document is on the Pa. DEP's web page, at http://www.dep.state.pa.us/watermanagement_apps/tmdl. In addition, a public meeting was held on January 8th, 2003, at 7 p.m. in the Penn Township Municipal Building, 20 Wayne Avenue, Hanover, to address any outstanding concerns regarding the draft TMDL. A 60-day period (ended on February 14, 2003) was provided for the submittal of comments. Comments and responses are summarized in Appendix G.

Notice of final TMDL approvals will be posted on the Pa. DEP's website.

Literature Cited

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

Appendix A. Information Sheet for the Oil Creek Subwatershed TMDL

What is being proposed?

Total Maximum Daily Load (TMDL) plans have been developed to improve water quality in a segment of Oil Creek.

Who is proposing the plans? Why?

The Pennsylvania Department of Environmental Protection (Pa. DEP) is proposing to submit the plans to the U.S. Environmental Protection Agency (USEPA) for review and approval as required by federal regulation. In 1995, USEPA was sued for not developing TMDLs when Pennsylvania failed to do so. Pa. DEP has entered into an agreement with USEPA to develop TMDLs for certain specified waters over the next several years. This TMDL has been developed in compliance with the state/USEPA agreement.

What is a TMDL?

A TMDL sets a ceiling on the pollutant loads that can enter a waterbody so that it will meet water quality standards. The Clean Water Act requires states to list all waters that do not meet their water quality standards even after pollution controls required by law are in place. For these waters, the state must calculate how much of a substance can be put in the water without violating the standard, and then distribute that quantity to all the sources of the pollutant on that water body. A TMDL plan includes waste load allocations for point sources, load allocations for nonpoint sources, and a margin of safety. The Clean Water Act requires states to submit their TMDLs to USEPA for approval. Also, if a state does not develop the TMDL, the Clean Water Act states that USEPA must do so.

What is a water quality standard?

The Clean Water Act sets a national minimum goal that all waters be "fishable" and "swimmable." To support this goal, states must adopt water quality standards. Water quality standards are state regulations that have two components. The first component is a designated use, such as "warm water fishes" or "recreation." States must assign a use, or several uses to each of their waters. The second component relates to the instream conditions necessary to protect the designated use(s). These conditions or "criteria" are physical, chemical, or biological characteristics such as temperature and minimum levels of dissolved oxygen, and maximum concentrations of toxic pollutants. It is the combination of the "designated use" and the "criteria" to support that use that make up a water quality standard. If any criteria are being exceeded, then the use is not being met and the water is said to be in violation of water quality standards.

What is the purpose of the plans?

The Oil Creek subwatershed is impaired due to sediment emanating from urban and agricultural runoff. The plans include a calculation of the loading for sediment that will correct the problem and meet water quality objectives.

Why was the Oil Creek sub watershed selected for TMDL development?

In 1996, Pa. DEP listed a portion of the Oil Creek under Section 303(d) of the federal Clean Water Act as impaired due to causes linked to sediment loads.

What pollutants do these TMDLs address?

The proposed plans provide calculations of the stream's total capacity to accept sediment.

Where do the pollutants come from?

The sediment related impairment in the Oil Creek subwatershed comes from nonpoint sources of pollution, primarily overland runoff from agricultural and developed areas, as well as from stream bank erosion.

How was the TMDL developed?

Pa. DEP used a reference watershed approach to estimate the necessary loading reduction of sediment that would be needed to restore a healthy aquatic community. The reference watershed approach is based on selecting a nonimpaired watershed that has similar land use characteristics and determining the current loading rates for the pollutants of interest. This is done by modeling the loads that enter the stream, using precipitation and land use characteristic data. For this analysis, Pa. DEP used the AVGWLF model (the Environmental Resources Research Institute of the Pennsylvania State University's Arcview based version of the Generalized Watershed Loading Function model developed by Cornell University). This modeling process uses loading rates in the nonimpaired watershed as a target for load reductions in the impaired watershed. The impaired watershed is modeled to determine the current loading rates and determine what reductions are necessary to meet the loading rates of the nonimpaired watershed. The reference stream approach was used to set allowable loading rates in the affected watershed because neither Pennsylvanian nor USEPA has water quality criteria for sediment.

How much pollution is too much?

The allowable amount of pollution in a water body varies depending on several conditions. TMDLs are set to meet water quality standards at the critical flow condition. For a free flowing stream impacted by nonpoint source pollution loading of sediments, the TMDL is expressed as an annual loading. This accounts for pollution contributions over all stream flow conditions. Pa. DEP established the water quality objectives for sediment by using the reference watershed approach. This approach assumes that the impairment is eliminated when the impaired watershed achieves loadings similar to the reference watershed. Reducing the current loading rates for sediment in the impaired watershed to the current loading rates in the reference watershed will result in meeting the water quality objectives.

How will the loading limits be met?

Best Management Practices (BMPs) will be encouraged throughout the watershed to achieve the necessary load reductions.

How can I get more information on the TMDL?

To request a copy of the full report, contact Bill Brown at (717) 783-2951 between 8:00 a.m. and 3:00 p.m., Monday through Friday. Mr. Brown also can be reached by mail at the Office of Water Management, PADEP, Rachel Carson State Office Building, 400 Market Street, Harrisburg, PA 17105 or by e-mail at willbrown@state.pa.us.

How can I comment on the proposal?

You may provide e-mail or written comments postmarked no later than February 14th, 2003, to the above address.

Appendix B. AVGWLF Model Overview & GIS-Based Derivation of Input Data

The TMDL for the Oil Creek subwatershed was developed using the Generalized Watershed Loading Function or GWLF model. The GWLF model provides the ability to simulate runoff, sediment, and nutrient (nitrogen and phosphorus) loadings from watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. It is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values.

GWLF is a combined distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios. Each area is assumed to be homogenous in regard to various attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but aggregates the loads from each area into a watershed total. In other words, there is no spatial routing. For subsurface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for subsurface flow contributions. Daily water balances are computed for an unsaturated zone as well as a saturated subsurface zone, where infiltration is computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

GWLF models surface runoff using the Soil Conservation Service Curve Number (SCS-CN) approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation (USLE) algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (e.g., land cover/soil type combination). The KLSCP factors are variables used in the calculations to depict changes in soil loss erosion (K), the length slope factor (LS) the vegetation cover factor (C) and conservation practices factor (P). A sediment delivery ratio based on watershed size and transport capacities based on average daily runoff are applied to the calculated erosion to determine sediment yield for each source area. Surface nutrient losses are determined by applying dissolved nitrogen and phosphorus coefficients to surface runoff and a sediment coefficient to the yield portion for each agricultural source area. Point source discharges also can contribute to dissolved losses to the stream and are specified in terms of kilograms per month. Manured areas, as well as septic systems, can also be considered. Urban nutrient inputs are all assumed to be solid-phase, and the model uses an exponential accumulation and washoff function for these loadings. Subsurface losses are calculated using dissolved nitrogen and phosphorus coefficients for shallow ground-water contributions to stream nutrient loads, and the subsurface sub-model only considers a single, lumped-parameter contributing area. Evapotranspiration is determined using daily weather data and a cover factor dependent upon land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values. All of the equations used by the model can be viewed in GWLF Users Manuel.

For execution, the model requires three separate input files containing transport-, nutrient-, and weather-related data. The transport (TRANSPRT.DAT) file defines the necessary parameters for each source area to be considered (e.g., area size, curve number, etc.) as well as global parameters (e.g., initial storage, sediment delivery ratio, etc.) that apply to all source areas. The nutrient (NUTRIENT.DAT) file specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations, etc.). The weather

(WEATHER.DAT) file contains daily average temperature and total precipitation values for each year simulated.

The primary sources of data for this analysis were geographic information system (GIS) formatted databases. A specially designed interface was prepared by the Environmental Resources Research Institute of the Pennsylvania State University in ArcView (GIS software) to generate the data needed to run the GWLF model, which was developed by Cornell University. The new version of this model has been named AVGWLF (ArcView Version of the Generalized Watershed Loading Function).

In using this interface, the user is prompted to identify required GIS files and to provide other information related to "non-spatial" model parameters (e.g., beginning and end of the growing season, the months during which manure is spread on agricultural land, and the names of nearby weather stations). This information is subsequently used to automatically derive values for required model input parameters, which are then written to the TRANSPRT.DAT, NUTRIENT.DAT and WEATHER.DAT input files needed to execute the GWLF model. For use in Pennsylvania, AVGWLF has been linked with statewide GIS data layers such as land use/cover, soils, topography, and physiography; and includes location-specific default information such as background nitrogen and phosphorus concentrations and cropping practices. Complete GWLF-formatted weather files also are included for 80 weather stations around the state.

Adjustments made to specific AVGWLF model parameters, based on existing land use practices in each of the watersheds, included:

Oil Creek Subwatershed

- Reset default C factor for cropland (0.21) to 0.40 to reflect the presence of large continuous cornfields and a general lack of strip cropping, contour plowing, and cover crops. Hay/pasture (0.03) was reset to 0.20 as well to reflect the effects of heavily grazed pastureland.
- Reset default P factors for cropland and hay/pasture land uses (0.52) to 0.60 to account for:
    - Pastures and cropland generally extending right up to streambanks with unrestricted livestock access to the streams.
    - Poor quality riparian vegetation resulting in many exposed banks.

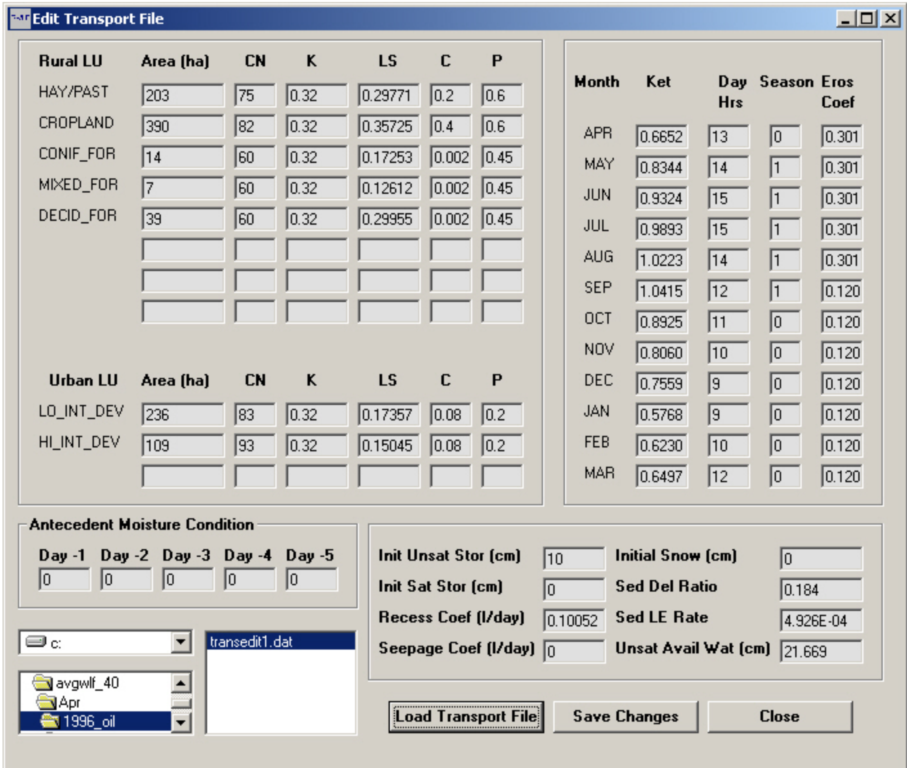
Kreutz Creek Subwatershed

- Reset C factor for cropland (0.21) and hay/pasture (0.03) to 0.18 and 0.02 respectively, to account for prevalent use of strip cropping, contour plowing, and cover crops.
- Reset P factor for cropland (0.45) and hay/pasture (0.45) land uses to 0.30 respectively, to account for the pervasiveness of riparian buffer zones, stream bank fencing, and stable stream banks.

The following table lists the statewide GIS data sets and provides an explanation of how they were used for development of the input files for the GWLF model.

GIS Data Sets	
DATASET	**DESCRIPTION**
Censustr	Coverage of Census data including information on individual homes septic systems. The attribute *usew_sept* includes data on conventional systems, and *sew_other* provides data on short-circuiting and other systems.
County	The County boundaries coverage lists data on conservation practices, which provides C and P values in the Universal Soil Loss Equation (USLE).
Gwnback	A grid of background concentrations of N in groundwater derived from water well sampling.
Landuse5	Grid of the MRLC that has been reclassified into five categories. This is used primarily as a background.
Majored	Coverage of major roads. Used for reconnaissance of a watershed.
MCD	Minor civil divisions (boroughs, townships and cities).
Npdespts	A coverage of permitted point discharges. Provides background information and cross check for the point source coverage.
Padem	100-meter digital elevation model. Used to calculate landslope and slope length.
Palumrlc	A satellite image derived land cover grid that is classified into 15 different landcover categories. This dataset provides land cover loading rate for the different categories in the model.
Pasingle	The 1:24,000 scale single line stream coverage of Pennsylvania. Provides a complete network of streams with coded stream segments.
Physprov	A shapefile of physiographic provinces. Attributes *rain_cool* and *rain_warm* are used to set recession coefficient
Pointsrc	Major point source discharges with permitted nitrogen and phosphorus loads.
Refwater	Shapefile of reference watersheds for which nutrient and sediment loads have been calculated.
Soilphos	A grid of soil phosphorous loads, which has been generated from soil sample data. Used to help set phosphorus and sediment values.
Smallsheds	A coverage of watersheds derived at 1:24,000 scale. This coverage is used with the stream network to delineate the desired level watershed.
Statsgo	A shapefile of generalized soil boundaries. The attribute *mu_k* sets the k factor in the USLE. The attribute *mu_awc* is the unsaturated available capacity, and the *muhsg_dom* is used with landuse cover to derive curve numbers.
Strm305	A coverage of stream water quality as reported in the Pennsylvania's 305(b) report. Current status of assessed streams.
Surfgeol	A shapefile of the surface geology used to compare watersheds of similar qualities.
T9sheds	Data derived from a Pa. DEP study conducted at PSU with N and P loads.
Zipcode	A coverage of animal densities. Attribute *aeu_acre* helps estimate N & P concentrations in runoff in agricultural lands and over manured areas.
Weather Files	Historical weather files for stations around Pennsylvania to simulate flow.

Appendix C. AVGWLF Model Outputs for the Oil Creek Subwatershed



Edit Transport File

Rural LU	Area (ha)	CN	K	LS	C	P
HAY/PAST	203	75	0.32	0.29771	0.2	0.6
CROPLAND	390	82	0.32	0.35725	0.4	0.6
CONIF_FOR	14	60	0.32	0.17253	0.002	0.45
MIXED_FOR	7	60	0.32	0.12612	0.002	0.45
DECID_FOR	39	60	0.32	0.29955	0.002	0.45

Urban LU	Area (ha)	CN	K	LS	C	P
LO_INT_DEV	236	83	0.32	0.17357	0.08	0.2
HI_INT_DEV	109	93	0.32	0.15045	0.08	0.2

Month	Ket	Day Hrs	Season	Eros Coef
APR	0.6652	13	0	0.301
MAY	0.8344	14	1	0.301
JUN	0.9324	15	1	0.301
JUL	0.9893	15	1	0.301
AUG	1.0223	14	1	0.301
SEP	1.0415	12	1	0.120
OCT	0.8925	11	0	0.120
NOV	0.8060	10	0	0.120
DEC	0.7559	9	0	0.120
JAN	0.5768	9	0	0.120
FEB	0.6230	10	0	0.120
MAR	0.6497	12	0	0.120

Antecedent Moisture Condition

Day -1	Day -2	Day -3	Day -4	Day -5
0	0	0	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0
Init Sat Stor (cm)	0	Sed Del Ratio	0.184
Recess Coef (l/day)	0.10052	Sed LE Rate	4.926E-04
Seepage Coef (l/day)	0	Unsat Avail Wat (cm)	21.669

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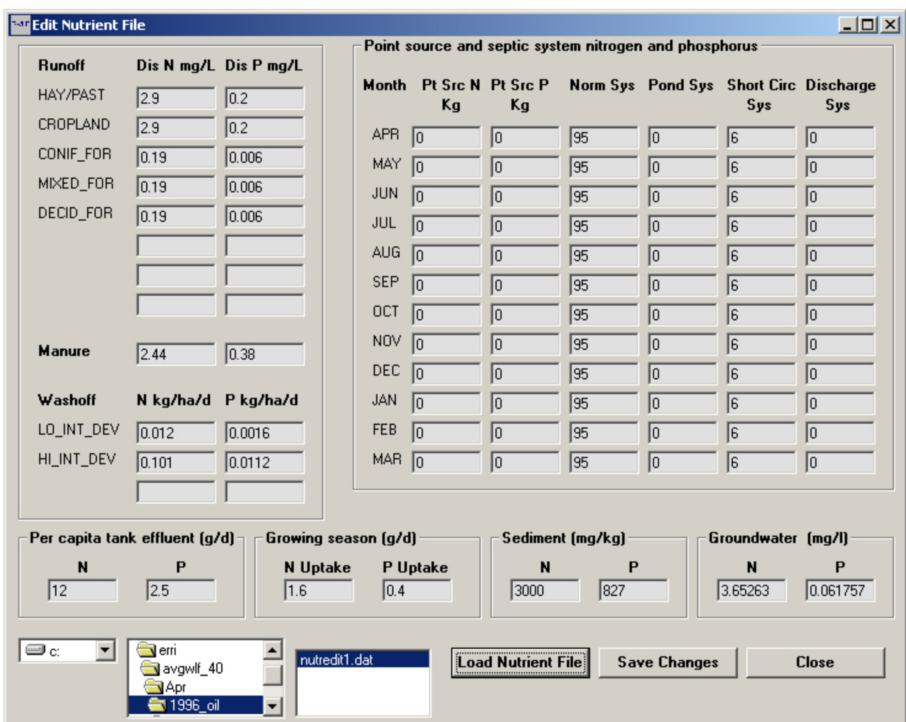
Load Transport File | Save Changes | Close



Edit Nutrient File

Runoff	Dis N mg/L	Dis P mg/L
HAY/PAST	2.9	0.2
CROPLAND	2.9	0.2
CONIF_FOR	0.19	0.006
MIXED_FOR	0.19	0.006
DECID_FOR	0.19	0.006
Manure	2.44	0.38

Washoff	N kg/ha/d	P kg/ha/d
LO_INT_DEV	0.012	0.0016
HI_INT_DEV	0.101	0.0112

Point source and septic system nitrogen and phosphorus

Month	Pt Src N Kg	Pt Src P Kg	Norm Sys	Pond Sys	Short Circ Sys	Discharge Sys
APR	0	0	95	0	6	0
MAY	0	0	95	0	6	0
JUN	0	0	95	0	6	0
JUL	0	0	95	0	6	0
AUG	0	0	95	0	6	0
SEP	0	0	95	0	6	0
OCT	0	0	95	0	6	0
NOV	0	0	95	0	6	0
DEC	0	0	95	0	6	0
JAN	0	0	95	0	6	0
FEB	0	0	95	0	6	0
MAR	0	0	95	0	6	0

Per capita tank effluent (g/d) N	P	Growing season (g/d) N Uptake	P Uptake	Sediment (mg/kg) N	P	Groundwater (mg/l) N	P
12	2.5	1.6	0.4	3000	827	3.65263	0.061757

c: erri avgwlf_40 Apr 1996_oil nutredit1.dat

Load Nutrient File | Save Changes | Close

Average Loads by Month

GWLF Nutrient Summary for oil_1996

Period of analysis: 20 years, from Apr 1978 to Mar 1998

	MG (1000 Kg)		Nutrient Loads (Kg)			
Month	**Erosion**	**Sediment**	**Dis. Nitr.**	**Tot. Nitr.**	**Dis. Phos.**	**Tot. Phos**
APR	402.0	10.8	2000.2	2057.3	39.2	54.1
MAY	609.2	35.5	1596.4	1727.5	30.8	65.8
JUN	435.7	13.5	740.2	796.1	20.8	35.5
JUL	514.1	35.8	307.2	427.5	14.7	46.9
AUG	403.8	6.2	49.6	74.8	2.5	8.9
SEP	236.3	46.6	210.6	358.6	8.0	48.3
OCT	177.6	46.7	428.3	577.1	12.1	52.7
NOV	221.3	76.9	412.6	653.5	15.6	81.5
DEC	122.8	73.8	1012.8	1248.2	24.5	89.1
JAN	53.7	92.3	947.8	1237.6	41.9	121.7
FEB	55.5	92.6	1409.9	1702.6	51.0	131.6
MAR	102.9	82.8	2075.1	2343.2	43.5	117.2
Total	3335.0	613.6	11190.7	13204.1	304.5	853.4

Go Back | Loads by Source | Print

Export to Jpeg | Close

Average Hydrology by Month

GWLF Transport Summary for oil_1996

Period of analysis: 20 years, from Apr 1978 to Mar 1998

	Units in Centemeters				
Month	**Precip**	**Evapotrans**	**Gr. Wat. Flow**	**Runoff**	**Streamflow**
APR	7.9	3.2	4.9	0.9	5.8
MAY	10.4	6.7	3.9	0.8	4.7
JUN	8.1	11.1	1.8	0.6	2.4
JUL	9.1	13.7	0.6	0.6	1.3
AUG	8.0	10.3	0.1	0.3	0.3
SEP	8.2	6.1	0.3	0.6	1.0
OCT	7.2	3.2	0.9	0.7	1.6
NOV	9.2	1.6	0.7	1.2	1.9
DEC	7.1	0.7	2.3	1.0	3.3
JAN	7.6	0.3	2.0	1.5	3.5
FEB	6.6	0.5	3.2	1.6	4.8
MAR	8.3	1.6	5.0	1.3	6.2
Total	97.9	58.9	25.7	11.1	36.8

Go Back | Loads by Month | Print

Export to Jpeg | Close

Average Loads by Source

GWLF Total Loads for oil_1996

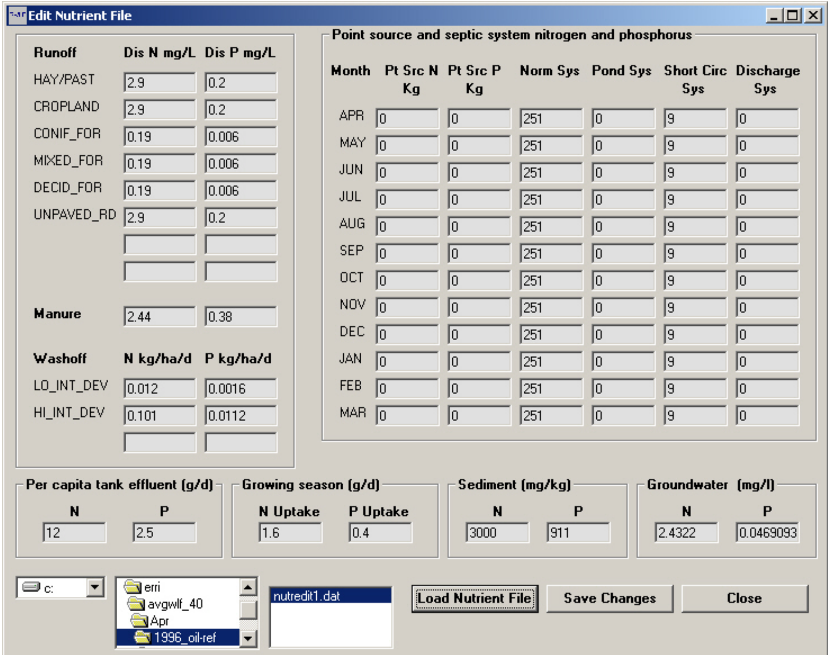
Period of analysis: 20 years, from Apr 1978 to Mar 1998

Source	(Ha) Area	(cm) Runoff	Mg (1000 Kg) Erosion	Mg (1000 Kg) Sediment	Total Loads (Kg) Dis. Nitr.	Total Loads (Kg) Tot. Nitr.	Total Loads (Kg) Dis. Phos.	Total Loads (Kg) Tot. Phos.
HAY/PAST	203	5.59	581.08	106.92	307.0	627.76	31.46	119.89
CROPLAND	390	10.29	2679.28	492.99	1088.93	2567.89	109.36	517.06
CONIF_FOR	14	1.35	0.17	0.03	0.36	0.46	0.01	0.04
MIXED_FOR	7	1.35	0.06	0.01	0.18	0.22	0.01	0.02
DECID_FOR	39	1.35	0.84	0.16	1.0	1.47	0.03	0.16
LO_INT_DEV	236	11.23	52.52	9.66	0.0	10.59	0.0	1.41
HI_INT_DEV	109	29.63	21.02	3.87	0.0	28.11	0.0	3.12
Stream Bank				89.2		133.8		36.9
Groundwater					9375.28	9375.28	158.51	158.51
Point Sources					0	0	0	0
Septic Syst.					417.96	417.96	5.11	5.11
Totals	998	11.1	3335.0	702.8	11190.71	13163.51	304.49	842.19

Go Back | Print | Export to Jpeg | Close

Source	Area (acres)	Runoff (in/yr)	Erosion (tons/yr)	Sediment (tons/yr)	Dis. Nitr (lbs/yr)	Tot. Nitr (lbs/yr)	Dis. Phos (lbs/yr)	Tot. Phos (lbs/yr)
HAY/PAST	501.6	2.2	640.53	117.9	676.8	1384	69.4	264.3
CROPLANE	963.7	4.05	2953.4	543.4	2400.7	5661.2	241.1	1139.9
CONIF_FOI	34.6	0.53	0.19	0	0.8	1	0	0.1
MIXED_FO	17.3	0.53	0.07	0	0.4	0.5	0	0
DECID_FOI	96.4	0.53	0.93	0.2	2.2	3.2	0.1	0.4
LO_INT_DE	583.2	4.42	57.89	10.7	0	23.3	0	3.1
HI_INT_DE'	269.3	11.67	23.17	4.3	0	62	0	6.9
Stream Banl				98.3093		294.928		81.3018
Groundwatc					20668.9	20668.9	349.5	349.5
Point Sourc					0	0	0	0
Septic Syst					921.4	921.4	11.3	11.3

Appendix D. AVGWLF Model Outputs for the Kreutz Creek Reference Subwatershed



Edit Nutrient File

Runoff	Dis N mg/L	Dis P mg/L
HAY/PAST	2.9	0.2
CROPLAND	2.9	0.2
CONIF_FOR	0.19	0.006
MIXED_FOR	0.19	0.006
DECID_FOR	0.19	0.006
UNPAVED_RD	2.9	0.2
Manure	2.44	0.38

Washoff	N kg/ha/d	P kg/ha/d
LO_INT_DEV	0.012	0.0016
HI_INT_DEV	0.101	0.0112

Point source and septic system nitrogen and phosphorus

Month	Pt Src N Kg	Pt Src P Kg	Norm Sys	Pond Sys	Short Circ Sys	Discharge Sys
APR	0	0	251	0	9	0
MAY	0	0	251	0	9	0
JUN	0	0	251	0	9	0
JUL	0	0	251	0	9	0
AUG	0	0	251	0	9	0
SEP	0	0	251	0	9	0
OCT	0	0	251	0	9	0
NOV	0	0	251	0	9	0
DEC	0	0	251	0	9	0
JAN	0	0	251	0	9	0
FEB	0	0	251	0	9	0
MAR	0	0	251	0	9	0

Per capita tank effluent (g/d) N	P	Growing season (g/d) N Uptake	P Uptake	Sediment (mg/kg) N	P	Groundwater (mg/l) N	P
12	2.5	1.6	0.4	3000	911	2.4322	0.0469093

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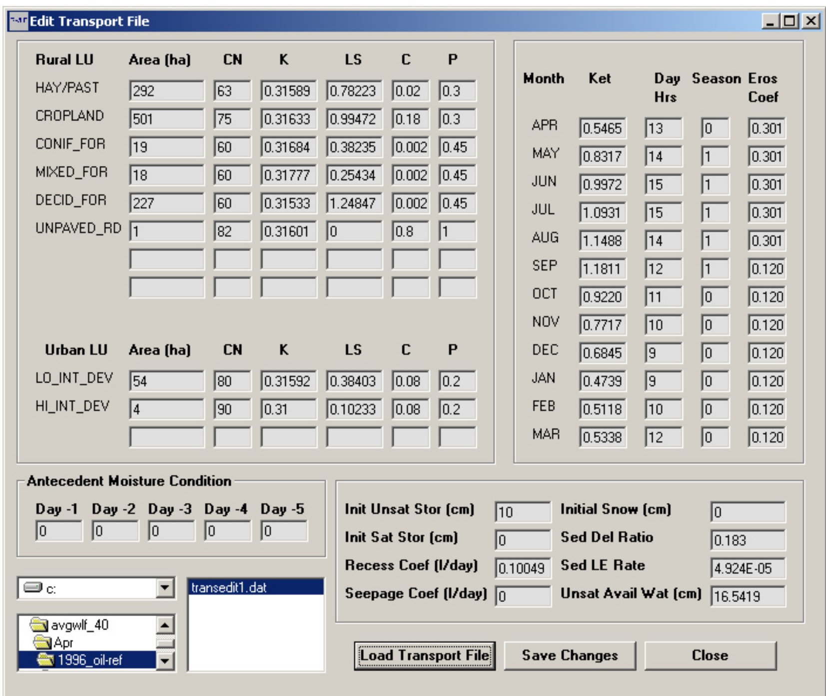

Edit Transport File

Rural LU	Area (ha)	CN	K	LS	C	P
HAY/PAST	292	63	0.31589	0.78223	0.02	0.3
CROPLAND	501	75	0.31633	0.99472	0.18	0.3
CONIF_FOR	19	60	0.31684	0.38235	0.002	0.45
MIXED_FOR	18	60	0.31777	0.25434	0.002	0.45
DECID_FOR	227	60	0.31533	1.24847	0.002	0.45
UNPAVED_RD	1	82	0.31601	0	0.8	1

Urban LU	Area (ha)	CN	K	LS	C	P
LO_INT_DEV	54	80	0.31592	0.38403	0.08	0.2
HI_INT_DEV	4	90	0.31	0.10233	0.08	0.2

Month	Ket	Day Hrs	Season	Eros Coef
APR	0.5465	13	0	0.301
MAY	0.8317	14	1	0.301
JUN	0.9972	15	1	0.301
JUL	1.0931	15	1	0.301
AUG	1.1488	14	1	0.301
SEP	1.1811	12	1	0.120
OCT	0.9220	11	0	0.120
NOV	0.7717	10	0	0.120
DEC	0.6845	9	0	0.120
JAN	0.4739	9	0	0.120
FEB	0.5118	10	0	0.120
MAR	0.5338	12	0	0.120

Antecedent Moisture Condition

Day -1	Day -2	Day -3	Day -4	Day -5
0	0	0	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0
Init Sat Stor (cm)	0	Sed Del Ratio	0.183
Recess Coef (l/day)	0.10049	Sed LE Rate	4.924E-05
Seepage Coef (l/day)	0	Unsat Avail Wat (cm)	16.5419

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Average Loads by Month

GWLF Nutrient Summary for oil-ref_1996

Period of analysis: 20 years, from Apr 1978 to Mar 1998

Month	MG (1000 Kg) Erosion	MG (1000 Kg) Sediment	Nutrient Loads (Kg) Dis. Nitr.	Nutrient Loads (Kg) Tot. Nitr.	Nutrient Loads (Kg) Dis. Phos.	Nutrient Loads (Kg) Tot. Phos
APR	301.6	7.4	1934.9	1961.2	39.0	47.0
MAY	440.6	13.5	1490.1	1534.3	29.0	42.4
JUN	365.4	11.3	634.4	670.6	16.0	27.0
JUL	525.6	25.9	309.8	389.1	15.7	39.8
AUG	307.8	7.3	46.5	68.8	2.5	9.3
SEP	169.6	17.1	39.0	90.7	2.9	18.6
OCT	160.9	53.0	356.4	516.2	10.7	59.2
NOV	188.6	56.3	510.3	680.6	15.9	67.5
DEC	88.2	51.8	1277.3	1435.4	28.7	76.7
JAN	60.8	97.2	1523.4	1818.1	53.8	143.3
FEB	51.7	84.6	1783.5	2040.9	52.5	130.6
MAR	103.3	80.4	2263.3	2509.1	46.7	121.3
Total	2764.1	505.8	12168.8	13715.0	313.2	782.5

Go Back | Loads by Source | Print

Export to Jpeg | Close

Average Hydrology by Month

GWLF Transport Summary for oil-ref_1996

Period of analysis: 20 years, from Apr 1978 to Mar 1998

Units in Centemeters

Month	Precip	Evapotrans	Gr. Wat. Flow	Runoff	Streamflow
APR	8.1	2.8	6.1	0.3	6.5
MAY	11.1	7.1	4.7	0.2	5.0
JUN	9.1	12.4	2.0	0.2	2.1
JUL	11.6	14.7	0.8	0.3	1.1
AUG	8.5	11.3	0.1	0.1	0.2
SEP	8.4	6.5	0.0	0.1	0.1
OCT	8.0	3.7	1.0	0.3	1.2
NOV	9.8	1.7	1.3	0.5	1.8
DEC	7.3	0.7	4.0	0.4	4.4
JAN	7.7	0.3	4.4	0.9	5.3
FEB	6.7	0.5	5.4	0.7	6.1
MAR	8.8	1.5	7.1	0.5	7.6
Total	105.1	63.2	36.9	4.5	41.5

Go Back | Loads by Month | Print

Export to Jpeg | Close

Average Loads by Source

GWLF Total Loads for oil-ref_1996

Period of analysis: 20 years, from Apr 1978 to Mar 1998

Source	(Ha) Area	(cm) Runoff	Mg (1000 Kg) Erosion	Mg (1000 Kg) Sediment	Total Loads (Kg) Dis. Nitr.	Total Loads (Kg) Tot. Nitr.	Total Loads (Kg) Dis. Phos.	Total Loads (Kg) Tot. Phos.
HAY/PAST	292	2.43	130.97	23.97	189.33	261.24	20.65	42.48
CROPLAND	501	6.47	2575.41	471.3	871.92	2285.82	91.17	520.52
CONIF_FOR	19	1.88	0.63	0.11	0.68	1.02	0.02	0.13
MIXED_FOR	18	1.88	0.4	0.07	0.64	0.86	0.02	0.09
DECID_FOR	227	1.88	24.33	4.45	8.09	21.45	0.26	4.31
UNPAVED_RD	1	11.45	0.0	0.0	3.32	3.32	0.23	0.23
LO_INT_DEV	54	9.7	31.71	5.8	0.0	1.26	0.0	0.17
HI_INT_DEV	4	23.49	0.61	0.11	0.0	0.03	0.0	0.0
Stream Bank				18.3		27.4		8.3
Groundwater					10018.93	10018.93	193.23	193.23
Point Sources					0	0	0	0
Septic Syst.					1075.93	1075.93	7.67	7.67
Totals	1116	4.5	2764.1	524.1	12168.84	13697.25	313.24	777.15

Go Back | Print | Export to Jpeg | Close

Source	Area (acres)	Runoff (in/yr)	Erosion (tons/yr)	Sediment (tons/yr)	Dis. Nitr (lbs/yr)	Tot. Nitr (lbs/yr)	Dis. Phos (lbs/yr)	Tot. Phos (lbs/yr)
HAY/PAST	721.5	0.96	144.37	26.4	417.4	575.9	45.5	93.7
CROPLAND	1238	2.55	2838.9	519.5	1922.3	5039.4	201	1147.5
CONIF_FOI	46.9	0.74	0.69	0.1	1.5	2.3	0	0.3
MIXED_FO	44.5	0.74	0.44	0.1	1.4	1.9	0	0.2
DECID_FOI	560.9	0.74	26.82	4.9	17.8	47.3	0.6	9.5
UNPAVED_	2.5	4.51	0	0	7.3	7.3	0.5	0.5
LO_INT_DE	133.4	3.82	34.96	6.4	0	2.8	0	0.4
HI_INT_DE	9.9	9.25	0.68	0.1	0	0.1	0	0
Stream Banl				20.1352		60.4057		18.3431
Groundwate					22087.9	22087.9	426	426
Point Sourc					0	0	0	0
Septic Syst					2372	2372	16.9	16.9

Appendix E. Equal Marginal Percent Reduction Method

The Equal Marginal Percent Reduction (EMPR) allocation method was used to distribute Adjusted Load Allocations (ALAs) between the appropriate contributing nonpoint sources. The load allocation and EMPR procedures were performed using the MS Excel and results are presented in Appendix F. The 5 major steps identified in the spreadsheet are summarized below:

1. Calculation of the TMDL based on impaired watershed size and unit area loading rate of the reference watershed.

2. Calculation of Adjusted Load Allocation based on TMDL, Margin of Safety, and existing loads not reduced.

3. Actual EMPR Process.

    a. Each land use/source load is compared with the total ALA to determine if any contributor would exceed the ALA by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load of the receiving waterbody. If the contributor exceeds the ALA, that contributor would be reduced to the ALA. If a contributor is less than the ALA, it is set at the existing load. This is the baseline portion of the EMPR.
    b. After any necessary reductions have been made in the baseline, the multiple analyses are run. The multiple analyses will sum all of the baseline loads and compare them to the ALA. If the ALA is exceeded, an equal percent reduction will be made to all contributors' baseline values. After any necessary reductions in the multiple analyses, the final reduction percentage for each contributor can be computed.

4. Calculation of total loading rate of all sources receiving reductions.

5. Summary of existing loads, final load allocations, and % reduction for each pollutant source.

Appendix F. Equal Marginal Percent Reduction Calculations for the Oil Creek Subwatershed

Step 1:	TMDL Total Load Load = TP loading rate in ref. * Acres in Impaired 1039943	Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable 935548.83 935549

Step 3:		Annual Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reduction	Initial LA	Acres	Allowable Loading Rate	% Reduction
	Hay/Past.	235800.00	1549218.6	good	235800	ADJUST	0.17	77998	157802.26	493	320.35	33.1%
	Cropland	1086800.00		bad	935549	462419	0.67	309460	626088.70	989	632.78	42.4%
	Developed	30000.00		good	30000		0.02	9923	20076.62	855	23.48	33.1%
	Stream bank	196618.60		good	196619		0.14	65037	131581.25	0		33.1%
	Total	1549218.60			1397967.42		1		935548.83			

Step 4:	All Ag. Loading Rate	528.94

Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.
	Final Hay/Past. LA	492.59	320.35	157802.26	478.69	235800	33%
	Final Cropland LA	989.42	632.78	626088.70	1098.42	1086800	42%
	Developed	855.09	23.48	20076.62	35.08	30000	33%
	Stream bank	0.00		131581.25		196619	33%

Oil Creek

Appendix G. Comment & Response Document
Oil Creek Subwatershed TMDL

Comment

Reference Condition Approach - It is not correct to say that neither EPA or PADEP have WQ criteria for sediment. This should be corrected to say that while EPA and PADEP have no numeric in-stream criteria for sediment, there is narrative criteria for these pollutants. This is important because the Regs require the TMDLs be written to implement applicable standards

Response

The language in the document was corrected to clarify the point expressed in the comment.

Comment

Some of the tables indicate coniferous and mixed forest types contributed 0 sediment load. Please include a Table indicating the landuse size and actual loading from the non-agricultural landuse types. If the loading is negligible then this should be indicated. Previous TMDLs included Tables that outlined existing loading rates for the impaired and the reference watersheds. This information must be provided. I suggest that it continue to be included in the mainbody of the TMDL to give the reader a broader understanding of the watersheds. It also serves to help put the watershed information into context by indicating the size of the landuse areas that the loads are coming from.

Response

A table of existing loads for both the impaired and reference watersheds was added to the document.

Comment

EPA recommends including a "Background Conditions" discussion in this section with the other Regulatory Conditions. You could insert the language used in our Approval Rationales which says: "There are two separate considerations of background pollutants within the context of these TMDLs. First, there is the inherent assumption of the Reference Watershed Approach that because of the similarities between the reference and impaired watershed, the background pollutant contributions will be similar. Therefore, the background pollutant contributions will be considered when determining the loads for the impaired watershed which are consistent with the loads from the reference watershed. Secondly, the AVGWLF model implicitly considers background pollutant contributions through the soil and the groundwater component of the model process".

Response

The recommended section and language were included in the document.

Comment

Please include GWLF model output frames indicating values for total loads, transport summary. The appendices should clearly include information on the current loads of the land uses not allocated to, as well as those for which reductions are expected. The GWLF model output frames for sediment loads from streambank erosion also need to be included.

Response

The requested information has been included in the appendices.

Comment
What "Best Management Practices" (BMPs) are to be used to reduce urban erosion runoff by thirty-three (33%) percent?

Response
Please refer to the *Pennsylvania Handbook of Best Management Practices in Developing Areas*. A copy can be obtained from the Pa. DEP, Natural Resources Conservation Service, or the Pennsylvania Association of Conservation Districts.

Comment
How are BMPs to be regulated? Will a periodic re-evaluation of Oil Creek be made?

Response
BMP implementation is voluntary within the context of the Pennsylvania's TMDL Program, since there is no regulatory requirement for implementation. And yes, Pa. DEP will continue to re-evaluate streams throughout the state on a periodic basis. Information about the state's assessment schedule can be obtained from the Southcentral Region DEP office.

Comment
Will DEP provide technical assistance to the non-point sources and property owners where erosion occurs to assist in affecting improvements?

Response
Yes, Pa. DEP, as well as the York County Conservation District, have several programs available to assist with funding and technical needs in addressing nonpoint source pollution.

Comment
What grant programs – funding sources are available to affect BMPs?

Response
Pa. DEP has several programs to address nonpoint source pollution concerns through BMP implementation. Two such grant programs are Growing Greener and the 319 Nonpoint Source Program. Please contact the watershed manager at the Southcentral Region DEP office for more information.

Comment
The information obtained from the Internet states "Oil Creek first appeared on Pennsylvania's 303(d) list in 1996 when one point two (1.2) meters [miles] of the tributary were listed as impaired by an unknown cause emanating from the urban runoff." Then the description goes on to note: "The study noted stream bank erosion to be a significant problem." "Agricultural land use activities were identified as the source of the impairment, with siltation and nutrients causing the impairments." Is this an apparent contradiction? What does the 1996 unknown impairment have to do with erosion of stream banks? How will best management practice affect an "unknown impairment"? The recent upper Codorus Watershed Study lists the urban storm system discharge to Oil Creek as "good", "without apparent problem." Are the plans for Oil Creek aimed at a single 1996 incident?

Response
The Oil Creek Subwatershed TMDL was developed to address sediment problems noted in the assessment leading to the 1996 303(d) listing. The TMDL must address all sources of the specified

pollutant, regardless whether or not the source was specifically noted on the 303(d) list. Based on this premise, all land uses upstream of the 1996 listed impairment must have an allocation. Recent assessment surveys conducted by Pa. DEP have supported that sediment is responsible for designated use impairments within the Oil Creek watershed.

Comment

I read a recent story in the Hanover Evening Sun Paper about sediment in Oil Creek. I have lived along Oil Creek in Heidelberg Township for 71 years. Whenever a rain of 3 inches or more, or snow melt and warm rain, or ice form and warm rain, we have a flood because the creek isn't deep enough to handle all the water and the creek overflows on to the land. When it recedes it brings sediment into Oil Creek. The solution to the sediment problem is to dredge or dig out the creek beds and put the ground along each side of the creek making it deeper to hold more water when Mother Nature acts up. The farmers and land owners along Oil Creek haven't the money to pay for it and Heidelberg Township hasn't the money. Does DEP or SRBC have the money? If you let the trees and bushes grow along the creek, how can a fisherman get to the bank to fish? If you put up a fence when Mother Nature acts up and we have a flood, it would destroy the fence and pile them up against the first bridge they came to and damage the bridge or destroy it. I am sending this letter because I can't attend the meeting January 29.

Response

Pa. DEP has several grant programs that provide financial and technical assistance to address nonpoint source problems with sediment. Proper BMP implementation can safely reduce sediment loads, as well reduce the effects of increased storm flows from impervious areas. Please refer to the *Pennsylvania Handbook of Best Management Practices in Developing Areas*. A copy can be obtained from the Pa. DEP, Natural Resources Conservation Service, or the Pennsylvania Association of Conservation Districts. Please contact the watershed manager at the Southcentral Region DEP office for more information.