Total Maximum Daily Loads (TMDLs)

Quittapahilla Creek Watershed, Lebanon County

Pennsylvania Department of Environmental Protection
Southcentral Regional Office, Water Management Program

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TABLE OF CONTENTS

TABLE OF CONTENTS i

LIST OF TABLES ii

LIST OF FIGURES iii

EXECUTIVE SUMMARY iv

I. INTRODUCTION 1

II. TMDL ENDPOINTS 11

III. SELECTION OF THE REFERENCE WATERSHED 12

IV. HYDROLOGIC/WATER QUALITY MODELING 14
  4.1 DATA COMPILATION AND MODEL OVERVIEW 14
  4.2 GIS BASED DERIVATION OF INPUT DATA 15
  4.3 WATERSHED ASSESSMENT AND MODELING 16

V. CALCULATION OF SEDIMENT LOADING AND UNIT AREA LOADING RATES 20

VI. DEVELOPMENT OF SEDIMENT TMDL 20
  6.1 WASTELOAD ALLOCATION 21
  6.2 MARGIN OF SAFETY 21
  6.3 LOAD ALLOCATION 21
  6.4 ADJUSTED LOAD ALLOCATION 21
  6.5 SEDIMENT TMDL 22

VII. CALCULATION OF SEDIMENT LOAD REDUCTIONS 22

VIII. CALCULATION OF TOTAL PHOSPHORUS LOADING AND UNIT AREA LOADING RATES 26

IX. DEVELOPMENT OF PHOSPHORUS TMDLS 28
  9.1 WASTELOAD ALLOCATION 28
  9.2 MARGIN OF SAFETY 29
  9.3 LOAD ALLOCATION 29
  9.4 ADJUSTED LOAD ALLOCATION 30
  9.5 TOTAL PHOSPHORUS TMDLs 30

X. CALCULATION OF PHOSPHORUS LOAD REDUCTIONS 31

XI. CONSIDERATION OF CRITICAL CONDITIONS 33

XII. CONSIDERATION OF SEASONAL VARIATIONS 33

XIII. REASONABLE ASSURANCE OF IMPLEMENTATION 33

XIV. PUBLIC PARTICIPATION 35
  LITERATURE CITED 36

APPENDICES

APPENDIX A - INFORMATION SHEET FOR QUITTAPAHILLA CREEK WATERSHED TMDLS

APPENDIX B - MAPS DEPICTING IMPAIRED STREAM SEGMENTS IN THE QUITTAPAHILLA CREEK WATERSHED BASED ON 2000 305(B) REPORT

APPENDIX C - AVGWLF MODEL OUTPUTS FOR QUITTAPAHILLA CREEK WATERSHED

APPENDIX D - AVGWLF MODEL OUTPUTS FOR CONOCOCHEAGUE CREEK WATERSHED

APPENDIX E - AVGWLF MODEL OUTPUTS FOR BACHMAN RUN, BECK CREEK, KILLINGER CREEK, AND SNITZ CREEK WATERSHEDS

APPENDIX F - AVGWLF MODEL OUTPUTS FOR FALLING BRANCH WATERSHED

APPENDIX G - EMPR WORKBOOKS FOR SEDIMENT LOAD ALLOCATIONS

APPENDIX H - EMPR WORKBOOKS FOR TOTAL PHOSPHORUS LOAD ALLOCATIONS

LIST OF TABLES

TABLE 1 - 1996 303(d) LISTINGS IN THE QUITTAPAHILLA CREEK WATERSHED 1

TABLE 2 - 1998 303(D) LISTINGS IN THE QUITTAPAHILLA CREEK WATERSHED 2

TABLE 3 - IMPAIRED STREAM SEGMENTS IN THE QUITTAPAHILLA CREEK WATERSHED BASED ON 2000 305(b) REPORT 4

TABLE 4 - SOURCES AND CAUSES OF IMPAIRMENTS IN THE QUITTAPAHILLA CREEK BASIN BASED ON THE 2000 305(b) REPORT 7

TABLE 5 - COMPARISON BETWEEN QUITTAPAHILLA & CONOCOCHEAGUE CREEK WATERSHEDS 13

TABLE 6 - COMPARISON OF BACHMAN RUN, BECK CREEK, KILLINGER CREEK AND SNITZ CREEK WATERSHEDS TO FALLING BRANCH WATERSHED 14

TABLE 7 - GIS DATA SETS 16

TABLE 8 - EXISTING SEDIMENT LOADS AND LOADING RATES FOR QUITTAPAHILLA CREEK AND CONOCOCHEAUGE CREEK (REFERENCE) 20

TABLE 9 - SEDIMENT LOAD ALLOCATION, LOADS NOT REDUCED, AND ADJUSTED LOAD ALLOCATION 22

TABLE 10 - COMPONENTS OF THE QUITTAPAHILLA CREEK WATERSHED SEDIMENT TMDL 22

TABLE 11 - AGRICULTURAL LAND USE LOAD ALLOCATIONS & SEDIMENT REDUCTIONS IN THE QUITTAPAHILLA CREEK WATERSHED 24

TABLE 12 - EXISTING PHOSPHORUS LOADS FOR BACHMAN RUN, BECK CREEK, KILLINGER CREEK, AND SNITZ CREEK WATERSHEDS AND FALLING BRANCH (REFERENCE) WATERSHED 27

TABLE 13 - UNIT AREA LOADING RATES[1] FOR PHOSPHORUS IN BACHMAN RUN, BECK CREEK, KILLINGER CREEK, AND SNITZ CREEK WATERSHEDS AND FALLING BRANCH (REFERENCE) WATERSHED 27

TABLE 14 - TARGETED TMDL VALUES FOR TOTAL PHOSPHORUS IN THE BACHMAN RUN, BECK CREEK, KILLINGER CREEK, AND SNITZ CREEK WATERSHEDS 28

TABLE 15 - NPDES POINT SOURCES OF TOTAL PHOSPHORUS IN THE KILLINGER CREEK WATERSHED 29

TABLE 16 - MOS FOR TOTAL PHOSPHORUS TMDLS 29

TABLE 17 - LOAD ALLOCATIONS FOR TOTAL PHOSPHORUS TMDLS 30

TABLE 18 - TOTAL PHOSPHORUS LOAD ALLOCATIONS, LOADS NOT REDUCED, AND ADJUSTED LOAD ALLOCATIONS 30

TABLE 19 - COMPONENTS OF THE BACHMAN RUN, BECK CREEK, KILLINGER CREEK, AND SNITZ CREEK TOTAL PHOSPHORUS TMDLS 31

TABLE 20 - AGRICULTURAL LAND USE LOAD ALLOCATIONS & REDUCTIONS FOR TOTAL PHOSPHORUS 32

LIST OF FIGURES

FIGURE 1 - QUITTAPAHILLA CREEK WATERSHED 8

FIGURE 2 - NAMED TRIBUTARIES IN THE QUITTAPAHILLA CREEK WATERSHED 9

FIGURE 3 - ALGAE GROWTH CAUSED BY EXCESS NUTRIENTS FROM UPSTREAM AGRICULTURAL ACTIVITIES (BACHMAN RUN) 10

FIGURE 4 - SEDIMENT DEPOSISTION FROM UPSTREAM AGRICULTURAL ACTIVITIES IN THE QUITTAPAHILLA CREEK WATERSHED 10

FIGURE 5 - TYPICAL CROPLAND IN THE QUITTAPAHILLA CREEK WATERSHED 18

FIGURE 6 - EXAMPLE OF STREAMBANK EROSION IN THE QUITTAPAHILLA CREEK WATERSHED 19

FIGURE 7 - EXAMPLE OF PASTURES EXTENDING TO STREAMBANKS IN THE QUITTAPAHILLA CREEK WATERSHED 19

FIGURE 8 - LOAD ALLOCATION UNITS (LAUS) FOR THE QUITTAPAHILLA CREEK WATERSHED SEDIMENT TMDL 25

FIGURE 9 - LOAD ALLOCATION UNITS (LAUS) FOR THE KILLINGER CREEK WATERSHED TOTAL PHOSPHORUS TMDL 32

FIGURE 10 - STREAMBANK FENCING IN THE QUITTAPAHILLA CREEK WATERSHED 34

FIGURE 11 - STABLE LIVESTOCK CROSSING IN THE QUITTAPAHILLA CREEK WATERSHED 34

FIGURE 12 - RIPARIAN ZONE PLANTINGS IN THE QUITTAPAHILLA CREEK WATERSHED 35

EXECUTIVE SUMMARY

Quittapahilla Creek is a tributary to Swatara Creek located in Lebanon County, Pennsylvania. The stream travels 16.8 miles from its source in South Lebanon Township to its mouth near Valley Glen. Land use in the 77 square mile watershed is predominately agricultural, with increasing levels of residential development. The entire Quittapahilla Creek basin, including its named tributaries (Killinger Creek, Gingrich Run, Buckholder Run, Bachman Run, Beck Creek, Snitz Creek, and Brandywine Creek) is currently designated as Trout Stocking.

Total Maximum Daily Loads (TMDLs) were developed to address impairments noted in Pennsylvania's 1996 and 1998 303(d) lists and the 2000 305(b) report. The impairments were documented during chemical sampling and biological surveys of the aquatic life present in the watershed. Excessive sediment and nutrient loads resulting from agricultural activities have been identified as one of the primary causes of impairments in the basin. The TMDL developed for sediment applies to the entire Quittapahilla Creek basin. Individual total phosphorus TMDLs were developed for the Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek basins. The TMDLs developed for nutrient impairments focus on the control of total phosphorus, since it is the limiting nutrient. Impairments in the Gingrich Run basin due to suspended solids were addressed through a combination of the sediment TMDL developed for the Quittapahilla Creek watershed and the total phosphorus TMDL developed for the Killinger Creek basin.

Pennsylvania does not currently have water quality criteria for sediment and nutrients. TMDL endpoints for sediment and nutrients were identified using a reference watershed approach. Existing sediment loading in the Quittapahilla Creek basin is 36,740,900 pounds per year (lbs./yr.). Based on a comparison to a similar, unimpaired watershed, the maximum sediment loading that would still allow water quality objectives to be met in the Quittapahilla Creek watershed is 9,833,734 lbs./yr. Existing total phosphorus loadings in the Bachman Run, Beck Creek, Killinger Creek, and Snitz Run basins range from 7,302 lbs./yr. to 15,028 lbs./yr for the Beck Creek and Killinger Creek basins, respectively. Based on a comparison to a similar, unimpaired watershed, the maximum total phosphorus loadings that would still allow water quality objectives to be met in the four basins range from 2,912 lbs./yr. to 5,055 lbs./yr. for the Bachman Run and Killinger Creek basins, respectively.

Reducing sediment and phosphorus loads to the TMDLs identified should allow the entire Quittapahilla Creek watershed to support its designated aquatic life uses. Allocations of the TMDLs developed for the Quittapahilla Creek watershed and the four tributary basins are summarized below:

Summary of TMDLs for the Quittapahilla Creek Watershed (lbs./yr.)

WATERSHED	POLLUTANT	TMDL	WLA	MOS	LA	LNR	ALA
Quittapahilla Creek	Sediment	9,833,734	-	983,373	8,850,361	3,602,453	5,247,908
Bachman Run	Phosphorus	2,912	-	291	2,621	917	1,704
Beck Creek	Phosphorus	3,067	-	307	2,761	801	1,960
Killinger Creek	Phosphorus	5,055	1,128.5	506	3,421	1,566	1,855
Snitz Creek	Phosphorus	4,608	-	461	4,147	2,402	1,745

The TMDLs developed for the Quittapahilla Creek watershed and its four tributary basins are allocated to point sources (Killinger Creek basin, only) and nonpoint sources, with 10% of the TMDL reserved as a margin of safety (MOS). The wasteload allocation (WLA) is that portion of the total load assigned to point sources. The load allocation (LA) is that portion of the total load assigned to nonpoint sources. Loads not reduced (LNR) are the portion of the LA associated with nonpoint sources other than agricultural and is equal to the sum of existing loadings. The adjusted load allocation (ALA) represents the remaining portion of the LA to be distributed among agricultural land uses receiving load reductions. The sediment TMDL developed for the Quittapahilla Creek watershed establishes a 73% reduction in the current loading of 36,740,900 pounds per year. Total phosphorus TMDLs developed for the four tributary basins establish reductions of 42% (Snitz Creek), 58% (Beck Creek), 62% (Bachman Run), and 66% (Killinger Creek).

A more complete discussion of the sediment and total phosphorus TMDLs developed for the Quittapahilla Creek watershed and TMDLs in general are contained in the attached Information Sheet (Appendix A).

I. INTRODUCTION

Quittapahilla Creek is located in Lebanon County, Pennsylvania (Figure 1). U.S. Route 422 parallels most of the Quittapahilla Creek mainstem. The watershed can be accessed by traveling east on Rte. 422 from Hershey, PA or west on Rte. 422 from Reading, PA. The stream originates in South Lebanon Township and flows for 16.8 miles to its confluence with Swatara Creek near Valley Glenn. There are 7 named tributaries in the watershed, including Killinger Creek, Gingrich Run, Buckholder Run, Bachman Run, Beck Creek, Snitz Creek, and Brandywine Creek (Figure 2). Quittapahilla Creek drains 77 square miles of the Ridge and Valley and the Piedmont physiographic provinces. Protected uses of the Quittapahilla Creek watershed include aquatic life, water supply, and recreation. The entire basin is currently designated as Trout Stocking in Title 25 Pa. Code Department of Environmental Protection Chapter 93, Section 93.9o (Commonwealth of Pennsylvania, 1999).

Land use in the basin is dominated by agriculture (67%). Development covers nearly 13% of the basin with the city of Lebanon and Palmyra Borough being the largest urban areas. Slightly more than 18% of the Quittapahilla Creek basin can be described as “open space” (i.e., forest, wetlands, and/or waterbodies).

Surveys conducted in the Quittapahilla Creek watershed by the Department in 1989, 1996, and 1999 clearly identified aquatic life use impairments due to extensive agricultural activities. Lack of riparian vegetation, pastures and croplands that extended right up to streambanks, and unrestricted livestock access to streams have allowed excessive levels of sediment and nutrients to reach surface waters. These same conditions were noted in the watershed during a site visit conducted in August 2000 as part of the TMDL development. Excess nutrients were causing increased algae growths (Figure 4) and sediment deposited in large quantities on the streambed was degrading the habitat of benthic macroinvertebrates (Figure 4).

Total Maximum Daily Loads (TMDLs) were developed for the Quittapahilla Creek watershed to address siltation, suspended solids, and nutrient impairments identified in Pennsylvania’s 1996 and 1998 303(d) lists and 2000 305(b) report. The 1996 303(d) list included 23.7 miles of impaired streams in the Quittapahilla Creek basin (Table 1). Designated use impairments attributed to nutrient enrichment from agricultural activities were identified in the Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek basins. These listings were the result of chemical and biological sampling conducted by the Department’s Central Office in 1989. The sampling was done as part of a special nonpoint source survey. Chemical sampling consisted of one-time grab samples. Biological sampling included kick screen sampling of benthic macroinvertebrates. Benthic macroinvertebrates were identified to family in the field. Water samples contained elevated levels of nitrogen and phosphorus. Benthic macroinvertebrate communities consisted of 5 or fewer families.

TABLE 1 - 1996 303(d) LISTINGS IN THE QUITTAPAHILLA CREEK WATERSHED

STREAM	MILES	SOURCE	CAUSE
Bachman Run	4.7	Agriculture	Nutrients
Beck Creek	7.5	Agriculture	Nutrients
Killinger Creek	5.5	Agriculture	Nutrients
Snitz Creek	6	Agriculture	Nutrients

The 1998 303(d) list included one additional listing in the Quittapahilla Creek watershed, along with GIS based revisions to the miles of impairment listed in 1996 (Table 2). Nearly 4.1 miles of streams in the Gingrich Run basin (a tributary to Killinger Creek) were identified as being impaired by suspended solids from agriculture and organic enrichment/low dissolved oxygen from urban runoff/storm sewers. This listing resulted, in part, from an October 1996 investigation by the Department's Southcentral Regional Office regarding impacts from a lumber mill located in the headwaters of the basin. The survey documented that Gingrich Run was severely impacted by stormwater runoff from the site, which carried wood fibers, sawdust, mulch, and leachate from wood by-products. Approximately one mile of Gingrich Run was degraded by the presence of solids and bacterial and/or fungal growths. When the individual who conducted the investigation looked at the list of sources and causes available at the time, there was no better option for the impairments being caused by the lumber mill available than the selected urban runoff/storm sewer and organic enrichment/low D.O. In retrospect, the identified source and cause were probably inappropriate. This impairment caused by the lumber mill, should not have been included in the 1998 303(d) list, since it was the result of a compliance/enforcement issue and not addressable by the TMDL process. Under a Consent Order issued in 1997, corrective actions have been taken at the site to eliminate the impacts, including placing all wood products under cover and on an impervious surface. The organic enrichment/low D.O. impairments included in the 1998 303(d) list no longer exist in the Gingrich Run

TABLE 2 - 1998 303(D) LISTINGS IN THE QUITTAPAHILLA CREEK WATERSHED

STREAM	GIS KEY	MILES	SOURCE	CAUSE
Bachman Run	1401	4.7	Agriculture	Nutrients
Beck Creek	1404	7.5	Agriculture	Nutrients
Gingrich Run	7037	4.09	Agriculture	Suspended Solids
			Urban Runoff/Storm Sewers	Organic Enrichment/Low D.O.
Killinger Creek	1399	5.5	Agriculture	Nutrients
Snitz Creek	1405	6	Agriculture	Nutrients

The 2000 305(b) report indicates that there are 88.91 miles of streams in the Quittapahilla Creek watershed. Ninety five percent of these stream miles (84.78 miles) are identified as impaired (Table 3). GIS based depictions of these impaired segments can be found in Appendix B. The Quittapahilla Creek watershed was surveyed in 1999 as part of the Department's ongoing unassessed waters program. Only 1.82 miles of stream (2%) were found to be supporting designated aquatic life uses. There are 2.31 stream miles (3%) in the basin that have not yet been assessed. The identified sources of impairment included agriculture, crop related agriculture, urban runoff/storm sewers, and bank modification. Causes of impairment include nutrients, siltation, suspended solids, organic enrichment/low D.O., flow alteration, and other habitat alterations. Agriculture was identified as the sole source for 40.19 (47%) of the impaired miles (Table 4). Agriculture and urban runoff/storm sewers were listed as the sources of impairment for 27.13 miles (32%). Only 17.46 miles (21%) of impaired stream segments in the Quittapahilla Creek watershed do not have agriculture listed as a source.

Table 3 identifies those impaired segments that are addressed by the TMDLs developed for the Quittapahilla Creek watershed. The TMDLs address agriculture related impairments caused by siltation, nutrients, and suspended solids. A sediment TMDL was developed for the entire Quittapahilla Creek watershed to address siltation listings. Phosphorus TMDLs were developed for the Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek basins to address nutrient impairments. Phosphorus was chosen due to its being the limiting nutrient in these basins. The Gingrich Run segment listed for impairment due to suspended solids was addressed through a combination of load reductions under the Quittapahilla Creek sediment TMDL and the Killinger Creek phosphorus TMDL. Total suspended solids (TSS) include both an inorganic and an organic component. The sediment TMDL will reduce the inorganic portion of the suspended solids, while the organic fraction of TSS is addressed through the prescribed phosphorus reduction. This TMDL does not address any 303(d) listings for the category of flow alterations. TMDLs are not the appropriate mechanism to address this type of stream impairment. TMDLs are designed to address pollutant loadings that cause exceedances of water quality standards. There is no pollutant loading to address for this type of impairment.

TABLE 3 - IMPAIRED STREAM SEGMENTS IN THE QUITTAPAHILLA CREEK WATERSHED BASED ON 2000 305(b) REPORT

STREAM NAME (STREAM CODE)	GIS KEY	MILES	SOURCE	CAUSE	YEAR LISTED*	ADDRESSED BY TMDL
Bachman Run (09724)	1401	4.87	Agriculture	Nutrients	1996	Yes
Bachman Run, Unt (09725)	990318-1000-MSE	1.15	Crop Related Agric	Siltation	2000	Yes
Bachman Run, Unt (09726)	990318-1000-MSE	0.79	Crop Related Agric	Siltation	2000	Yes
Beck Creek (09728)	1404	7.14	Agriculture	Nutrients	1996	Yes
Brandywine Creek (09734)	990329-1147-MSE	2.12	Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Brandywine Creek, Unt (09735)	990329-1147-MSE	0.92	Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Brandywine Creek, Unt (09736)	990329-1147-MSE	1.44	Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Brandywine Creek, Unt (09737)	990329-1147-MSE	0.79	Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Buckholder Run (09711)	990311-0928-MSE	1.69	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
Gingrich Run (09710)	7037	4.09	Agriculture	Suspended Solids	1998	Yes
			Urban Runoff/Storm Sewers	Organic Enrichment/Low D.O.	1998	No
Gingrich Run, Unt (09712)	990311-0928-MSE	1.45	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
Gingrich Run, Unt (09713)	990311-0928-MSE	0.33	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
Killinger Creek (09705)	1399	5.27	Agriculture	Nutrients	1996	Yes
	990311-0928-MSE	1.26	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
Killinger Creek, Unt (09706)	990311-0928-MSE	0.7	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
Killinger Creek, Unt (09707)	990311-0928-MSE	0.91	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
Killinger Creek, Unt (09708)	990311-0928-MSE	0.8	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
Killinger Creek, Unt (09709)	990311-0928-MSE	0.98	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
Killinger Creek, Unt (09714)	990311-0928-MSE	0.37	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
Killinger Creek, Unt (09715)	990311-0928-MSE	0.09	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
Killinger Creek, Unt (09716)	990311-0928-MSE	0.09	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
Killinger Creek, Unt (09717)	990311-0928-MSE	0.73	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes

TABLE 3 - continued

STREAM NAME (STREAM CODE)	GIS KEY	MILES	SOURCE	CAUSE	YEAR LISTED*	ADDRESSED BY TMDL
Quittapahilla Creek (09691)	990311-1213-MSE	12.11	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
	990329-1336-MSE	4.66	Bank Modifications	Other Habitat Alterations	2000	No
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (064063)	990311-1213-MSE	1.15	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09692)	990311-1213-MSE	0.6	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09693)	990311-1213-MSE	0.43	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09694)	990311-1213-MSE	0.16	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09696)	990311-1213-MSE	0.48	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09697)	990311-1213-MSE	2.12	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09698)	990311-1213-MSE	0.05	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09699)	990311-1213-MSE	0.26	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09701)	990311-1213-MSE	0.58	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09702)	990311-1213-MSE	0.51	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No

TABLE 3 - continued

STREAM NAME (STREAM CODE)	GIS KEY	MILES	SOURCE	CAUSE	YEAR LISTED[*]	ADDRESSED BY TMDL
Quittapahilla Creek, Unt (09704)	990311-1213-MSE	0.49	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09718)	990311-1213-MSE	1.36	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09719)	990311-1213-MSE	0.18	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09720)	990311-1213-MSE	0.5	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09721)	990311-1213-MSE	0.7	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09722)	990311-1213-MSE	0.54	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09723)	990311-1213-MSE	0.06	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09727)	990311-1213-MSE	0.76	Agriculture	Flow Alterations	2000	No
				Siltation	2000	Yes
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Quittapahilla Creek, Unt (09744)	990329-1336-MSE	6.36	Bank Modifications	Other Habitat Alterations	2000	No
			Urban Runoff/Storm Sewers	Flow Alterations	2000	No
Snitz Creek (09729)	1405	6.59	Agriculture	Nutrients	1996	Yes
Snitz Creek, Unt (09730)	990318-1110-MSE	1.79	Crop Related Agric	Siltation	2000	Yes
Snitz Creek, Unt (09731)	990318-1110-MSE	0.64	Crop Related Agric	Siltation	2000	Yes
Snitz Creek, Unt (09732)	990318-1110-MSE	1.44	Crop Related Agric	Siltation	2000	Yes
Snitz Creek, Unt (09733)	990318-1110-MSE	1.11	Crop Related Agric	Siltation	2000	Yes

[*] YEAR LISTED – When these TMDLs were written (Sept. 2000), the 2000 303(d) list had not been submitted to EPA. Segments identified as listed in 2000 are in the 305(b) report database and will appear on any 2000 303(d) list submitted to EPA.

TABLE 4 - SOURCES AND CAUSES OF IMPAIRMENTS IN THE QUITTAPAHILLA CREEK BASIN BASED ON THE 2000 305(b) REPORT

SOURCE(S)	CAUSE(S)	MILES IMPAIRED
Agriculture	Nutrients	23.87
Crop Related Agriculture	Siltation	6.92
Agriculture	Flow Alterations & Siltation	9.40
Agriculture Urban Runoff/Storm Sewers	Flow Alterations & Siltation Flow Alterations	23.04
Agriculture Urban Runoff/Storm Sewers	Suspended Solids Organic Enrichment/Low D.O.	4.09
Urban Runoff/Storm Sewers	Flow Alterations	6.44
Bank Modifications Urban Runoff/Storm Sewers	Other Habitat Alterations Flow Alterations	11.02

FIGURE 1 - QUITTAPAHILLA CREEK WATERSHED

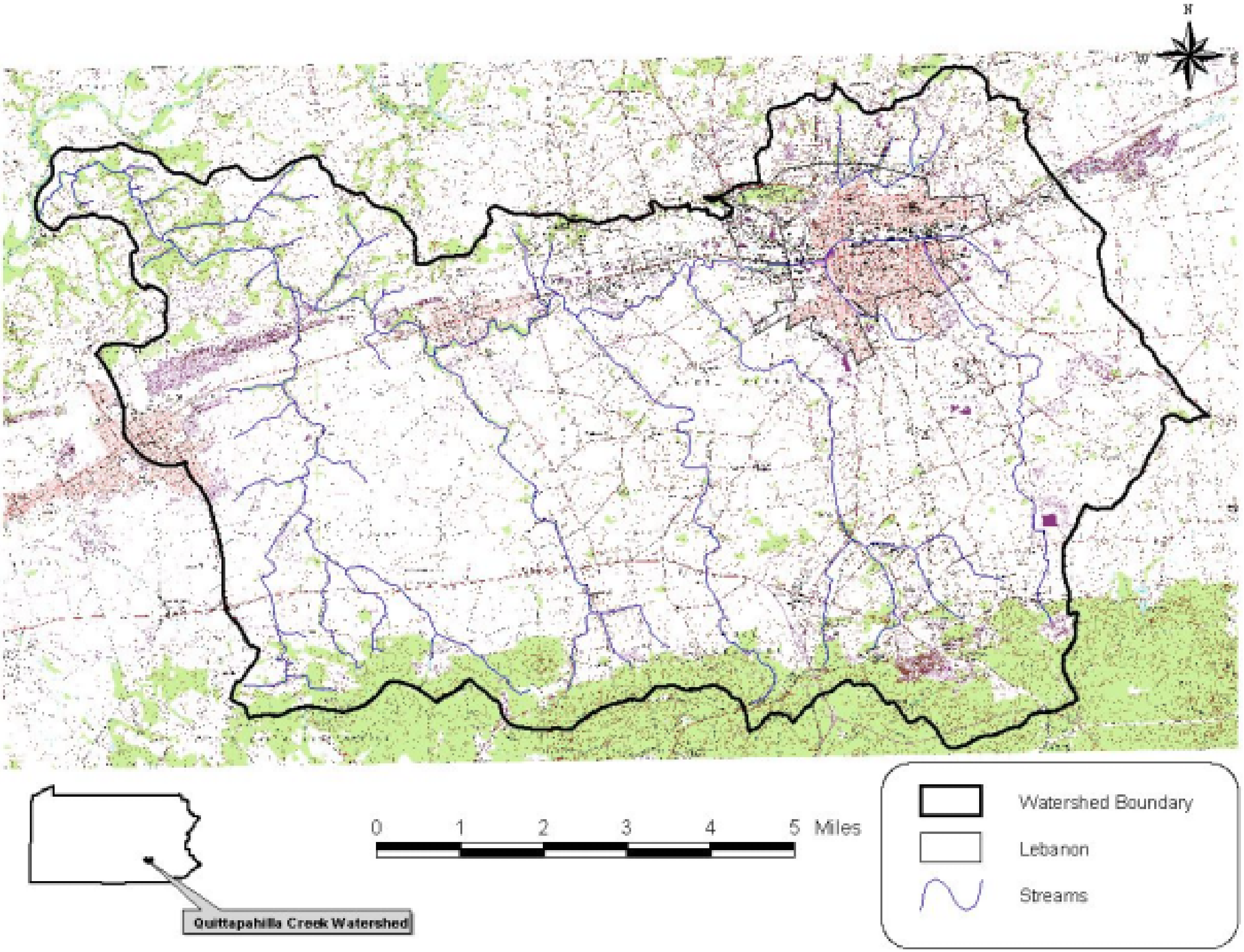


FIGURE 2 - NAMED TRIBUTARIES IN THE QUITTAPAHILLA CREEK WATERSHED

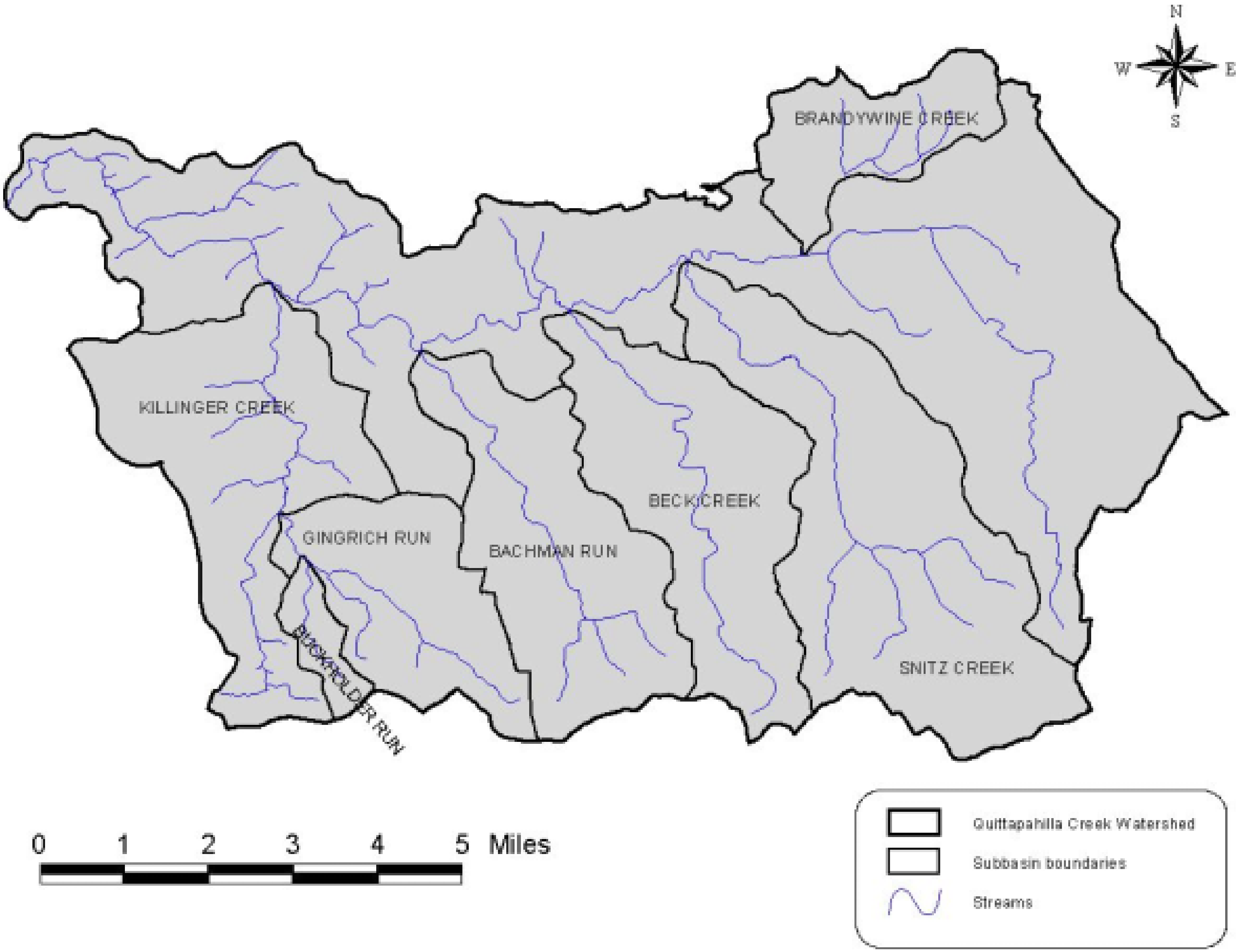


FIGURE 3 - ALGAE GROWTH CAUSED BY EXCESS NUTRIENTS FROM UPSTREAM AGRICULTURAL ACTIVITIES (BACHMAN RUN)

FIGURE 4 - SEDIMENT DEPOSISTION FROM UPSTREAM AGRICULTURAL ACTIVITIES IN THE QUITTAPAHILLA CREEK WATERSHED

II. TMDL ENDPOINTS

The TMDLs developed for the Quittapahilla Creek watershed involve loading reductions for sediment and phosphorus. The sediment TMDL covers the entire Quittapahilla Creek watershed and addresses impairments caused by siltation. Phosphorus TMDLs address nutrient impairments in the Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek basins. Phosphorus was used as the nutrient TMDL endpoint since it was determined to be the nutrient limiting plant growth in these basins. Because neither Pennsylvania nor EPA has water quality criteria for sediments or phosphorus, a method was developed to determine water quality objectives for these parameters that would result in the impaired stream segments attaining their designated uses. The method employed for these TMDLs is termed the "Reference Watershed Approach."

The Reference Watershed Approach compares two watersheds, one attaining its uses and one that is impaired based on biological assessment. Both watersheds must 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 in the model. The objective of the process is to reduce the loading rate of sediments and nutrients in the impaired stream segment to a level equivalent to or slightly lower than the loading rate in the non-impaired, reference stream segment. This load reduction will allow the biological community to return to the impaired stream segments. The TMDL endpoints established for this analysis were determined using the Conococheague Creek basin and one of its tributaries (Falling Branch) as reference watersheds.

Impairments in the Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek basins resulting from agricultural activities and caused by nutrients will be addressed by reducing phosphorus loading. The use of phosphorus load reductions to address nutrient impairments in these watersheds is based on an understanding of the relationship between nitrogen, phosphorus, and organic enrichment in stream systems. In stream systems, elevated nutrient loads (nitrogen and phosphorus in particular) can lead to increased productivity of plants and other organisms (Novotny and Olem, 1994). Typically in aquatic ecosystems the quantities of trace elements are plentiful; however, nitrogen and phosphorus may be in short supply. The nutrient that is in the shortest supply is called the limiting nutrient because its relative quantity affects the rate of production (growth) of aquatic biomass. If the nutrient load to a water body can be reduced, the available pool of nutrients that can be utilized by plants and other organisms will be reduced and, in general, the total biomass can subsequently be decreased as well (Novotny and Olem, 1994). In most efforts to control eutrophication processes in water bodies, emphasis is placed on the limiting nutrient. This is not always the case, however. For example, if nitrogen is the limiting nutrient, it still may be more efficient to control phosphorus loads if the nitrogen originates from difficult to control sources such as nitrates in ground water.

In most freshwater systems, phosphorus is the limiting nutrient for aquatic growth. In some cases, however, the determination of which nutrient is the most limiting is difficult. For this reason, the ratio of the amount of N to the amount of P is often used to make this determination (Thomann and Mueller, 1987). If the N/P ratio is less than 10, nitrogen is limiting. If the N/P ratio is greater than 10, phosphorus is the limiting nutrient. N/P ratios in Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek range 16 to 20 which points to phosphorus as the limiting nutrient. Controlling the phosphorus loading to surface waters in these basins will limit plant growth, thereby helping to eliminate use impairments currently caused by excess nutrients.

Impairments throughout the Quittapahilla Creek basin resulting from agricultural activities and caused by siltation will be addressed by reducing the sediment loading. The impairment to Gingrich Run due to agricultural activities and suspended solids was addressed by load reductions resulting from the Quittapahilla Creek sediment TMDL and the Killinger Creek phosphorus TMDL. Gingrich Run is a tributary of Killinger Creek. Total suspended solids (TSS) include both an inorganic and an organic component. The sediment TMDL will reduce the inorganic portion of the suspended solids, while the organic fraction of TSS is addressed through the prescribed phosphorus reductions.

III. SELECTION OF THE REFERENCE WATERSHED

The reference watershed approach was used to estimate the appropriate reduction of sediment and phosphorus loading necessary to restore healthy aquatic communities to the Quittapahilla Creek watershed. This approach is based on selecting a non-impaired watershed ("reference") and determining its current loading rates for the pollutants of interest. The objective of the process is to reduce loading rates of those pollutants identified as causing impairment to a level equivalent to the loading rates in the reference watershed. Achieving the appropriate load reductions should allow the return of a healthy biological community to affected stream segments.

In general, three factors should be considered when selecting a suitable reference watershed. The first factor is to use a watershed that has been assessed by the Department using the Unassessed Waters Protocol and has been determined to attain 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. Finally, the size of the reference watershed should be within 20-35% of the impaired watershed area. The search for a reference watershed 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.

The watersheds used as references for the Quittapahilla Creek sediment TMDL were obtained by screen-digitizing a subbasin of the Conococheague Creek watershed. This portion of the Conococheague Creek watershed is located near Chambersburg in Franklin County. The watershed is located in the Ridge and Valley Province in State Water Plan (SWP) Basin 13C. Table 5 compares the Quittapahilla Creek and Conococheague Creek watersheds in terms of their size, location, and other physical characteristics. Most of Conococheague stream segments have been assessed and were found to be unimpaired. This watershed is also within the size range for reference watersheds. It has an area of 62.6 square miles, or 81% of the Quittapahilla Creek watershed area. The analysis of value counts for each pixel of the MRLC grid revealed that land cover/use distributions in both watersheds are similar. The agricultural land use, which is one of the primary sources of impairment in the Quittapahilla Creek watershed, accounts for 67% of the total land area as compared to 84% in Conococheague watershed. Surficial geology in the Quittapahilla Creek and Conococheague Creek watersheds were also compared. The geology of Quittapahilla Creek watershed consists primarily of carbonate (72%) and interbedded sedimentary rocks (17%) with lesser amounts of metamorphic/igneous (4%), shale (4%), and conglomerate (3%). The Conococheague watershed is made of carbonate (63%) and shale (37%). Bedrock geology primarily affects surface runoff and background nutrient loads through its influences on soils, landscape, fracture density, and directional permeability. A look at these attributes in Table 5 indicates that these watersheds are very similar in terms of average runoff, precipitation, and soil K factor.

TABLE 5 - COMPARISON BETWEEN QUITTAPAHILLA & CONOCOCHEAGUE CREEK WATERSHEDS

ATTRIBUTE	QUITTAPAHILLA CREEK	CONOCOCHEAUGE CREEK
Physiographic Province	Ridge and Valley Piedmont	Ridge and Valley
Area (square miles)	77.0	62.6
Predominant Land Use	Agriculture (67%)	Agriculture (84%)
Predominant Geology	Carbonate (72%)	Carbonate (63%)
Soils		
Dominant HSG	B(34%), C(57%), D(10%)	B(13%), C (87%)
K Factor	0.30	0.28
20-Year Average Rainfall (in)	40.5	39.3
20-Year Average Runoff (in)	4.3	4.3

The Falling Branch watershed was used as a reference for the Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek phosphorus TMDLs. Falling Branch is a tributary to Conococheague Creek, located in the portion of the basin used as a reference for the Quittapahilla Creek sediment TMDL. The watershed is located in the Ridge and Valley Province in State Water Plan (SWP) Basin 13C. Table 6 compares the 5 watersheds in terms of their size, location, and other physical characteristics. Falling Branch has been assessed and was found to be unimpaired. This watershed is also within the size range for reference watersheds. It has an area of 9.7 square miles. Analyses of value counts for each pixel of the MRLC grid in the 5 watersheds revealed that land cover/use distributions were similar. Agricultural land uses account for 83% of the Falling Branch basin and ranges 57% in the Snitz Creek basin to 82% in the Beck Creek basin. Surficial geology in the watersheds was also compared. Carbonate rocks make up the predominate geology in all the basins, ranging from 66% in the Snitz Creek basin to 83% in the Beck Creek basin. Carbonate rocks accounts for 100% of the Falling Branch basin. Bedrock geology primarily affects surface runoff and background nutrient loads through its influences on soils, landscape, fracture density, and directional permeability. A look at these attributes in Table 6 indicates that these watersheds are very similar in terms of average runoff, precipitation, and soil K factor.

TABLE 6 - COMPARISON OF BACHMAN RUN, BECK CREEK, KILLINGER CREEK AND SNITZ CREEK WATERSHEDS TO FALLING BRANCH WATERSHED

ATTRIBUTE	BACHMAN RUN	BECK CREEK	KILLINGER CREEK	SNITZ CREEK	FALLING BRANCH
Physiographic Province	Ridge&Valley (82%) Piedmont (18%)	Ridge&Valley (83%) Piedmont (17%)	Ridge&Valley (77%) Piedmont (23%)	Ridge&Valley (67%) Piedmont (33%)	Ridge&Valley (100%)
Area (mi^2)	7.72	8.12	13.38	12.36	9.66
Predominant Land Use	Agriculture (80%)	Agriculture (82%)	Agriculture (75%)	Agriculture (57%)	Agriculture (83%)
Predominant Geology	Carbonate (79%)	Carbonate (83%)	Carbonate (73%)	Carbonate (66%)	Carbonate (100%)
Soils					
Dominant HSG	B(38%) C(57%) D(5%)	B(37%) C(59%) D(4%)	B(38%) C(56%) D(6%)	B(38%), C(53%) D(9%)	B(37%) C(61%) D(2%)
K Factor	0.32	0.32	0.32	0.31	0.32
20-Year Ave. Rainfall (in)	40.4	40.4	40.4	40.4	39.3
20-Year Ave. Runoff (in)	3.6	3.7	3.9	3.4	4.4

IV. HYDROLOGIC/WATER QUALITY MODELING

4.1 DATA COMPILATION AND MODEL OVERVIEW

The TMDLs were developed using the Generalized Watershed Loading Function or GWLF model. The GWLF model provides the ability to simulate runoff, sediment, and nutrient (N and P) 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 sub-surface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for sub-surface flow contributions. Daily water balances are computed for an unsaturated zone as well as a saturated sub-surface 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 N and P coefficients to surface runoff and a sediment coefficient to the yield portion for each agricultural source area. Point source discharges can also 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. Sub-surface losses are calculated using dissolved N and P coefficients for shallow groundwater contributions to stream nutrient loads, and the sub-surface sub-model only consider 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, available from the Department's Bureau of Watershed Conservation, Division of Assessment and Standards.

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.

4.2 GIS BASED DERIVATION OF INPUT DATA

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 N and P concentrations and cropping practices. Complete GWLF-formatted weather files are also included for eighty weather stations around the state. Table 6 lists the statewide GIS data sets and provides explanation of how they were used for development of the input files for the GWLF model.

TABLE 7 - 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. This used to calculate landslope and slope length.
Palumrlc	A satellite image derived land cover grid which is classified into 15 different landcover categories. This dataset provides landcover 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 N and P 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 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.

4.3 WATERSHED ASSESSMENT AND MODELING

The AVGWLF model was used to establish existing sediment loading conditions for the Quittapahilla Creek watershed and the Conococheague Creek reference watershed. The AVGWLF model was also used to establish existing nutrient loading conditions in the Bachman Run, Beck Creek, Killinger Creek and Snitz Creek basins and the Falling Branch reference watershed. All modeling outputs have been attached to this TMDL as Appendices C, D, E, and F.

Personnel from the Department, the Susquehanna River Basin Commission, and the Pennsylvania State University toured the Conococheague Creek watershed on July 28, 2000. DEP staff visited the Quittapahilla Creek watershed on August 3, 2000. These 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:

<u>Quittapahilla Creek Watershed (including Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek):</u>

-Less topographic relief.
-Dominated by carbonate rocks.
-Cropland primarily continuous corn (no rotation) or only a corn-soybean rotation (Figure 5).
-Lack of strip cropping.
-Severely limited riparian buffers, with many exposed and eroding banks (Figures 6).
-Pastures and cropland extending right up to streams (Figures 7) and roads.

<u>Conococheague Creek Watershed (including Falling Branch)</u>

-More topographic relief.
-Dominated by carbonate rocks.
-More hay/pasture and cover crops.
-More crop residue left.
-More use of strip cropping and forest buffers along streams.
-More evidence of conservation practices and lower animal densities.

Adjustments were made to specific parameters used in the AVGWLF model based on observations made while touring the watersheds. These adjustments included:

<u>Quittapahilla Creek Watershed (including Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek):</u>

-Reset C factor to 0.3 for Cropland land use to reflect the presence of large farms with continuous corn (no rotation) or only a corn-soybean rotation.

-Reset P factor to 0.56 to account for:

- The lack of strip cropping in the watershed.
- Poor quality riparian vegetation resulting in many exposed banks.
- Pastures and cropland generally extending right up to streambanks with unrestricted livestock access to the streams.

-Reset point source total P loading in the Killinger Creek basin to 1.3949 kg/month in order to more accurately represent existing conditions. The South Londonderry Township Municipal Authority discharges approximately 39.3 lbs. of total phosphorus per year to Killinger Creek. An estimated 36.9 lbs./year (94%) reaches the downstream loading point used in the AVGWLF model.

<u>Conococheague Creek Watershed (including Falling Branch)</u>

-Reset “C” factor to 0.16 for Hay/Pasture and Cropland land uses to account for use of continuous cover crop.

-Reset “P” factor to 0.30 for Cropland land use to account for use of riparian forest and grasses along streams, strip cropping, and buffer strips.

-Since there are no point source discharges of phosphorus located in the Falling Branch watershed, the total P loading from point sources was set to zero in the AVGWLF model.

FIGURE 5 - TYPICAL CROPLAND IN THE QUITTAPAHILLA CREEK WATERSHED

FIGURE 6 - EXAMPLE OF STREAMBANK EROSION IN THE QUITTAPAHILLA CREEK WATERSHED

FIGURE 7 - EXAMPLE OF PASTURES EXTENDING TO STREAMBANKS IN THE QUITTAPAHILLA CREEK WATERSHED

V. CALCULATION OF SEDIMENT LOADING AND UNIT AREA LOADING RATES

The AVGWLF model produced information on watershed size, land use, and existing sediment loading in the Quittapahilla Creek and Conococheague Creek watersheds (Table 8). The sediment loads represent an annual average over the 20 years simulated by the model (1978 to 1998). Unit area loading rates were calculated by dividing the mean annual sediment load (lbs./yr.) by total area (acres). Unit area loading rates for sediment in the Quittapahilla Creek and Conococheague Creek watersheds were estimated to be 750.91 lbs./acre/yr. and 200.98 lbs./acre/yr., respectively.

TABLE 8 - EXISTING SEDIMENT LOADS AND LOADING RATES FOR QUITTAPAHILLA CREEK AND CONOCOCHEAUGE CREEK (REFERENCE)

LAND USE CATEGORY[1]	QUITTAPAHILLA CREEK WATERSHED			CONOCOCHEAGUE CREEK WATERSHED		
	Area[2] (acres)	**Sediment Load[3] (lbs./yr.)**	**Unit Area Loading Rate[4] (lbs./acre/yr.)**	**Area[2] (acres)**	**Sediment Load[3] (lbs./yr.)**	**Unit Area Loading Rate[4] (lbs./acre/yr.)**
HAY/PAST	11,460.88	1,688,356.39	147.31	12,404	731,691	58.99
CROPLAND	21,536.91	31,450,090.31	1,460.29	19,511	7,070,707	362.40
CONIF_FOR	565.32	3,157.49	5.59	324	924	2.86
MIXED_FOR	693.63	3,969.82	5.72	823	3,157	3.84
DECID_FOR	7,488.32	224,464.76	29.98	2,711	15,965	5.89
QUARRY	501.93	2,254,748.90	4,492.16	-	-	-
COAL_MINES	155.67	1,089,103.96	6,996.24	-	-	-
TRANSITION	8.00	4,096.04	512.00	49	57,782	1,169.21
LO_INT_DEV	3,614.52	13,203.08	3.65	2,024	12,461	6.16
HI_INT_DEV	2,903.74	9,709.25	3.34	1,470	8,791	5.98
TOTAL	**48,928.92**	**36,740,900.00**	**750.90**	**39,316**	**7,901,478**	**200.98**

[1] Land cover classification obtained from the MRLC database.

[2] Area of the specific land cover/land use category found in the watershed, produced by ArcView GIS analysis and rounded to the nearest hundredth.

[3] Estimated total sediment loading resulting from the identified land use, produced by AVGWLF model and rounded to the nearest hundredth.

[4] Estimated sediment loading rate for the identified land use, calculated as sediment load divided by area and rounded to the nearest hundredth.

VI. DEVELOPMENT OF SEDIMENT TMDL

A targeted TMDL value for sediment in the Quittapahilla Creek basin was determined by multiplying the unit area loading rate of the reference watershed (Conococheague Creek) by the total area of the Quittapahilla Creek watershed. Conococheague Creek is currently designated as a Cold Water Fishery (CWF), with many of its tributaries classified as High Quality Cold Water Fishery (HQ-CWF). Recent biological assessments have determined that the portion of the basin used as a reference is attaining its designated uses. Reducing the loading rates of sediment in the Quittapahilla Creek basin to a level equal to, or less than, the reference watershed will allow for the reversal of current use impairments.

The targeted sediment TMDL for the entire Quittapahilla Creek watershed is 9,833,734 lbs./yr.

Targeted TMDL = 200.98 lbs./acre/yr. (unit area loading rate of reference watershed) x 48,928.92 acres (total area of the Quittapahilla Creek watershed) = 9,833,734.34 lbs./yr.

The targeted sediment TMDL value was then used as the basis for load allocations and reductions in the Quittapahilla Creek watershed, 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

6.1 WASTELOAD ALLOCATION

The waste load allocation (WLA) portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. Although there are NPDES permitted discharges present in the Quittapahilla Creek basin, they are not considered to be a source of sediment. There is no WLA in the sediment TMDL established for the Quittapahilla Creek watershed.

6.2 MARGIN OF SAFETY

The margin of safety (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 sediment TMDL 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 Quittapahilla Creek. The MOS used for the sediment TMDL is 983,373 lbs./yr.

MOS = 9,833,734 lbs./yr. (TMDL) x 0.1 = 983,373 lbs./yr.

6.3 LOAD ALLOCATION

The load allocation (LA) is that portion of the TMDL that is assigned to nonpoint sources. Since there is no WLA for sediment, the load allocation was computed by subtracting the MOS value from the TMDL value. The sediment load allocation is 8,850,361 lbs./yr.

LA = 9,833,734 lbs./yr. (TMDL) - 983,373 lbs./yr. (MOS) = 8,850,361 lbs./yr.

6.4 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 non-point source loads that are not being considered for reductions (loads not reduced or LNR) from the LA. Since the Quittapahilla Creek watershed sediment TMDL was developed to address impairments primarily caused by agricultural activities, only these land uses (HAY/PASTURE and CROPLAND) were considered for reductions. Those land uses/sources loads not reduced (LNR) were carried through at their existing loading value (Table 9). The ALA for the sediment TMDL is 5,247,908 lbs./yr.

TABLE 9 - SEDIMENT LOAD ALLOCATION, LOADS NOT REDUCED, AND ADJUSTED LOAD ALLOCATION	
LOAD ALLOCATION	8,850,361
LOADS NOT REDUCED	3,602,453
CONIF_FOR	3,157
MIXED_FOR	3,970
DECID_FOR	224,465
QUARRY	2,254,749
COAL_MINES	1,089,104
TRANSITION	4,096
LO_INT_DEV	13,203
HI_INT_DEV	9,709
Groundwater	-
Septic Systems	-
ADJUSTED LOAD ALLOCATION	**5,247,908**

6.5 SEDIMENT TMDL

The final sediment TMDL established for the Quittapahilla Creek watershed consists of a Load Allocation (LA) and a Margin of Safety (MOS). The individual components of the sediment TMDL are summarized in Table 10.

TABLE 10 - COMPONENTS OF THE QUITTAPAHILLA CREEK WATERSHED SEDIMENT TMDL

COMPONENT	SEDIMENT (lbs./yr.)
TMDL (Total Maximum Daily Load)	9,833,734
WLA (Wasteload Allocation)	0
MOS (Margin of Safety)	983,373
LA (Load Allocation)	8,850,361
LNR (Loads Not Reduced)	3,602,453
ALA (Adjusted Load Allocation)	5,247,908

VII. CALCULATION OF SEDIMENT LOAD REDUCTIONS

The adjusted load allocation established in the previous section represents the sediment load that is available for allocation between Hay/Pasture and Cropland land uses in the Quittapahilla Creek watershed. For purposes of sediment reductions, the Quittapahilla Creek watershed was subdivided into 8 smaller load allocation units (LAUs)(Figure 8). Load allocation and reduction procedures were applied to the entire Quittapahilla Creek watershed and each of the LAUs. The LAUs were obtained by delineating contributing areas to each of the impacted segments listed in the 1996 and 1998 303(d) lists and contained in the 2000 305(b) report (Tables 1, 2, and 3). Data needed for load reduction analyses, including land use distribution in each LAU, were obtained by a GIS analysis.

The Equal Marginal Percent Reduction (EMPR) allocation method was used to distribute the ALA between Hay/Pasture and Cropland. The process is summarized below:

1. Each land use/source load is compared with the total allocable load to determine if any contributor would exceed the allocable load by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load to the receiving waterbody. If the contributor exceeds the allocable load, that contributor would be reduced to the allocable load. This is the baseline portion of EMPR.

2. After any necessary reductions have been made in the baseline, the multiple analysis is run. The multiple analysis will sum all of the baseline loads and compare them to the total allocable load. If the allocable load is exceeded, an equal percent reduction will be made to all contributors' baseline values. After any necessary reductions in the multiple analysis, the final reduction percentage for each contributor can be computed.

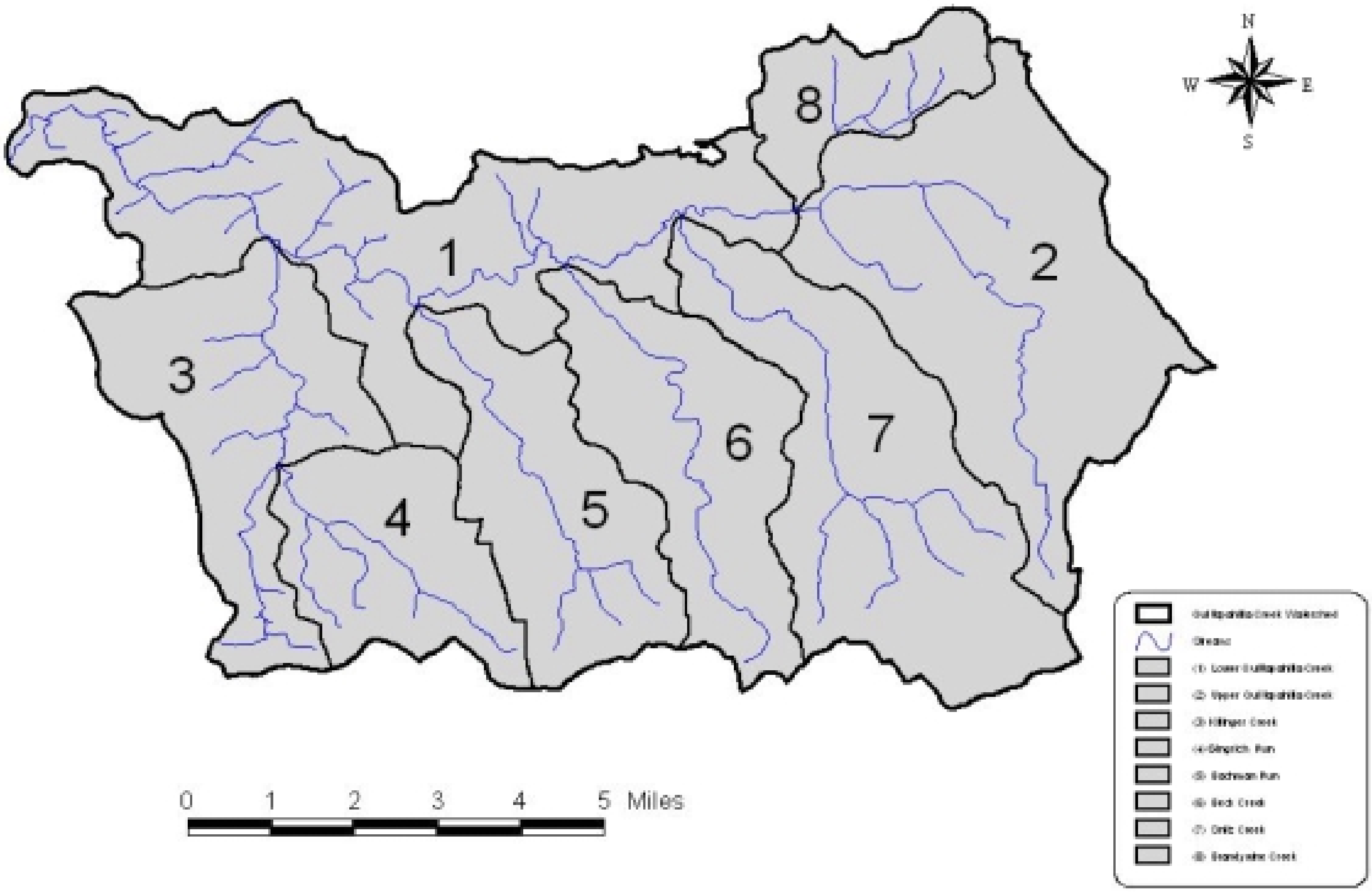
3. Now that the load allocation for Hay/Pasture and Cropland in the Quittapahilla Creek watershed has been calculated, portions of the whole watershed load can be allocated to each LAU. The TMDL total load for each LAU was computed as the product of the unit area load for that land use determined in the watershed analysis and the area covered by the land use/source in the LAU. The load allocation for each land use was determined by multiplying the allowable unit area loading rate for that land use (after EMPR) and the area of the land use in the impaired LAU. Results of the load reduction procedure are load allocations to agricultural activities and associated percent reductions needed to reach water quality standards in the entire Quittapahilla Creek watershed and each of the LAUs.

The load allocation and EMPR procedures were performed using MS Excel and results are presented in Appendix G. Table 11 contains the results of the sediment EMPR for HAY/PASTURE and CROPLAND in the Quittapahilla Creek watershed and each of the LAUs. The load allocation for each land use is shown along with the percent reduction of current loads necessary to reach the targeted LA. Sediment reductions were estimated for each of the 8 load allocation units, based on the identification of this pollutant as a cause of use impairment throughout the Quittapahilla Creek basin.

TABLE 11 - AGRICULTURAL LAND USE LOAD ALLOCATIONS & SEDIMENT REDUCTIONS IN THE QUITTAPAHILLA CREEK WATERSHED

LAND USE	ACRES	CURRENT LOADING RATE (lbs./acre/yr.)	ALLOWABLE LOADING RATE (lbs./acre/yr.)	CURRENT LOAD (lbs./yr.)	LOAD ALLOCATION (lbs./yr.)	PERCENT REDUCTION
Quittapahilla Creek Watershed						
HAY/PASTURE	11,460.9	147.31	111.46	1,688,356.39	1,277,393.47	24%
CROPLAND	21,536.9	1,460.29	184.36	31,450,090.31	3,970,514.13	87%
Load Allocation Unit 1 - Lower Quittapahilla Creek						
HAY/PASTURE	2,455.19	147.31	111.46	361,685.64	273,647.72	24%
CROPLAND	4,046.61	1,460.29	184.36	5,909,215.85	746,027.27	87%
Load Allocation Unit 2 – Upper Quittapahilla Creek						
HAY/PASTURE	2,081.13	147.31	111.46	306,581.09	231,956.17	24%
CROPLAND	3,924.30	1,460.29	184.36	5,730,608.03	723,478.37	87%
Load Allocation Unit 3 – Killinger Creek						
HAY/PASTURE	1,262.06	147.31	111.46	185,920.02	140,665.22	24%
CROPLAND	2,862.38	1,460.29	184.36	4,179,899.04	527,704.31	87%
Load Allocation Unit 4 – Gingrich Run						
HAY/PASTURE	823.73	147.31	111.46	121,347.56	91,810.34	24%
CROPLAND	1,917.00	1,460.29	184.36	2,799,372.01	353,415.40	87%
Load Allocation Unit 5 – Bachman Run						
HAY/PASTURE	1,434.42	147.31	111.46	211,311.19	159,875.92	24%
CROPLAND	2,532.13	1,460.29	184.36	3,697,638.95	466,819.89	87%
Load Allocation Unit 6– Beck Creek						
HAY/PASTURE	1,461.32	147.31	111.46	215,273.95	162,874.11	24%
CROPLAND	2,805.67	1,460.29	184.36	4,097,086.11	517,249.34	87%
Load Allocation Unit 7 – Snitz Creek						
HAY/PASTURE	1,475.34	147.31	111.46	217,339.31	164,436.73	24%
CROPLAND	3,035.84	1,460.29	184.36	4,433,200.59	559,683.15	87%
Load Allocation Unit 8 – Brandywine Creek						
HAY/PASTURE	467.69	147.31	111.46	68,897.62	52,127.25	24%
CROPLAND	412.98	1,460.29	184.36	603,069.72	76,136.41	87%

FIGURE 8 - LOAD ALLOCATION UNITS (LAUS) FOR THE QUITTAPAHILLA CREEK WATERSHED SEDIMENT TMDL



VIII. CALCULATION OF TOTAL PHOSPHORUS LOADING AND UNIT AREA LOADING RATES

Multiple runs of the AVGWLF model produced information on watershed size, land use, and existing total phosphorus loading in the Bachman Run, Beck Creek, Killinger Creek, Snitz Creek, and Falling Branch watersheds (Table 12). Total phosphorus loads represent an annual average for each basin over the 20 years simulated by the model (1978 to 1998). Unit area loading rates were calculated by dividing the mean annual total phosphorus load (lbs./yr.) by total area (acres)(Table 13). Unit area loading rates for total phosphorus in the four basins ranged from 1.01 lbs./acre/yr. in the Snitz Creek basin to 1.76 lbs./acre/yr. in the Killinger Run basin. The unit area loading rate for total phosphorus in the Falling Branch reference watershed was estimated to be 0.59 lbs./acre/yr.

TABLE 12 - EXISTING PHOSPHORUS LOADS FOR BACHMAN RUN, BECK CREEK, KILLINGER CREEK, AND SNITZ CREEK WATERSHEDS AND FALLING BRANCH (REFERENCE) WATERSHED

LAND USE CATEGORY[1]	BACHMAN RUN		BECK CREEK		KILLINGER CREEK		SNITZ CREEK		FALLING BRANCH	
	Area[2] (acres)	Total P[3] (lbs./yr.)	Area[2] (acres)	Total P[3] (lbs./yr.)	Area[2] (acres)	Total P[3] (lbs./yr.)	Area[2] (acres)	Total P[3] (lbs./yr.)	Area[2] (acres)	Total P[3] (lbs./yr.)
HAY/PAST	1,434.42	495.15	1,461.32	467.84	1,974.60	509.03	1,475.34	300.00	1,832.49	336.56
CROPLAND	2,532.13	6,312.56	2,805.67	6,033.48	4,434.90	12,916.52	3,035.84	5,200.66	3,321.17	2,595.81
CONIF_FOR	38.70	0.44	37.36	0.44	65.60	1.10	151.67	1.98	44.26	0.44
MIXED_FOR	45.81	0.66	44.92	0.44	79.61	0.88	177.24	1.76	86.95	0.88
DECID_FOR	828.40	132.60	751.46	35.02	1,322.33	62.56	2,227.90	110.13	286.88	3.74
QUARRY	-	-	-	-	0.00	-	121.20	644.27	-	-
COAL_MINES	-	-	-	-	0.00	-	72.94	617.40	-	-
TRANSITION	6.89	48.90	0.89	-	0.00	-	0.22	0.00	-	-
LO_INT_DEV	19.79	1.98	63.83	5.51	411.87	36.56	389.63	36.12	392.96	34.58
HI_INT_DEV	18.90	31.72	21.79	25.99	259.97	291.19	140.33	149.78	180.36	225.99
Groundwater	-	674.23	-	716.52	-	1,143.83	-	790.31	-	431.94
Point Source	-	0.00	-	0.00	-	36.78	-	0.00	-	0.00
Septic Systems	-	26.21	-	16.96	-	29.96	-	50.66	-	3.74
TOTAL	**4,925.04**	**7,724.45**	**5,187.24**	**7,302.20**	**8,548.88**	**15,028.41**	**7,792.31**	**7,903.08**	**6,145.07**	**3,633.70**

[1] Land cover classification obtained from the MRLC database.

[2] Area of the specific land cover/land use category found in the watershed, produced by ArcView GIS analysis and rounded to the nearest hundredth.

[3] Estimated total phosphorus loading resulting from the identified land use, produced by AVGWLF model and rounded to the nearest hundredth.

TABLE 13 - UNIT AREA LOADING RATES[1] FOR PHOSPHORUS IN BACHMAN RUN, BECK CREEK, KILLINGER CREEK, AND SNITZ CREEK WATERSHEDS AND FALLING BRANCH (REFERENCE) WATERSHED

LAND USE CATEGORY[2]	BACHMAN RUN	BECK CREEK	KILLINGER CREEK	SNITZ CREEK	FALLING BRANCH
HAY/PAST	0.35	0.32	0.26	0.20	0.18
CROPLAND	2.49	2.15	2.91	1.71	0.78
CONIF_FOR	0.01	0.01	0.02	0.01	0.01
MIXED_FOR	0.01	0.01	0.01	0.01	0.01
DECID_FOR	0.16	0.05	0.05	0.05	0.01
QUARRY	-	-	-	5.32	-
COAL_MINES	-	-	-	8.46	-
TRANSITION	7.10	-	-	0.00	-
LO_INT_DEV	0.10	0.09	0.09	0.09	0.09
HI_INT_DEV	1.68	1.19	1.12	1.07	1.25
TOTAL	1.57	1.41	1.76	1.01	0.59

[1] Estimated total phosphorus loading rate for the identified land use, calculated as sediment load divided by area and rounded to the nearest hundredth.

[2] Land cover classification obtained from the MRLC database.

IX. DEVELOPMENT OF PHOSPHORUS TMDLS

Targeted TMDL values for total phosphorus in the Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek basins were determined by multiplying the unit area loading rate of the reference watershed (Falling Branch) by the total area in each of the 4 basins (Table 14). Falling Branch is currently designated as a High Quality Cold Water Fishery (HQ-CWF) and recent biological assessments have determined that the portion of the basin used as a reference is attaining its designated uses. Reducing the loading rates of total phosphorus in the Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek basins to levels equal to, or less than, the reference watershed will allow for the reversal of current use impairments. Targeted total phosphorus TMDLs ranged from 2,912 lbs./yr. in the Bachman Run basin to 5,055 lbs./yr. in the Killinger Run basin.

TABLE 14 - TARGETED TMDL VALUES FOR TOTAL PHOSPHORUS IN THE BACHMAN RUN, BECK CREEK, KILLINGER CREEK, AND SNITZ CREEK WATERSHEDS

WATERSHED	WATERSHED AREA (acres)	UNIT AREA LOADING RATE IN REF. WATERSHED (lbs./acre/yr.)	TARGET TMDL VALUE (lbs./yr.)
Bachman Run	4,925.04	0.5913	2,912
Beck Creek	5,187.24	0.5913	3,067
Killinger Creek	8,548.88	0.5913	5,055
Snitz Creek	7,792.31	0.5913	4,608

Targeted TMDL values were then used as the basis for load allocations and reductions in the Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek watersheds, 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

9.1 WASTELOAD ALLOCATION

The waste load allocation (WLA) portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. Reviewing the Department’s permitting files identified 2 significant point sources discharging phosphorus in the Killinger Run basin (Table 15). South Londonderry’s discharge is located in the upper reaches of the Killinger Creek basin, south of U.S. Route 322. The Palmyra Boro outfall is located in the lower end of the basin at river mile index 0.7. The discharge flows into a segment of Killinger Creek that flows through a poured concrete channel. Land use immediately upstream of the discharge includes row crops and fallow fields. Land use downstream of the Palmyra

Boro discharge is 100% quarry all the way to it confluence with Quittapahilla Creek. The phosphorus TMDL developed for the Killinger Creek basin was intended to address impacts resulting from agricultural activities. There are no agricultural activities located in the Killinger Creek basin downstream of the Palmyra Boro discharge and there are no nutrient impairments in Quittapahilla Creek. Therefore, the phosphorus TMDL for the Killinger Creek basin is based on existing loadings upstream of RMI 0.7.

A review of 1999 discharge monitoring reports (DMRs) for South Londonderry Township indicates that the plant is capable of discharging well within permit limits. This point source currently accounts for less than 1% of the total phosphorus loading to the Killinger Creek basin and will not be included in the recommended reductions. The WLA for phosphorus in the Killinger Creek watershed was set at 1,128.5 lbs./yr. based on South Londonderry's current NPDES permit limits.

TABLE 15 - NPDES POINT SOURCES OF TOTAL PHOSPHORUS IN THE KILLINGER CREEK WATERSHED

FACILITY	NPDES PERMIT #	FLOW (mgd) PERMIT LIMIT	FLOW (mgd) AVE. FROM 1999 DMR	TOTAL P (mg/l) PERMIT LIMIT	TOTAL P (mg/l) AVE. FROM 1999 DMR
South Londonderry Twp. MA	PA0080551	0.21	0.032	2.0	0.403
Palmyra Boro STP	PA0024287	1.42	0.770	2.0	1.367

9.2 MARGIN OF SAFETY

The margin of safety (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 TMDLs for each basin were reserved as the MOS (Table 16). 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 basins. MOSs ranged from 291 lbs./yr for Bachman Run to 506 lbs./yr. for Killinger Creek.

TABLE 16 - MOS FOR TOTAL PHOSPHORUS TMDLS

WATERSHED	TARGETED TMDL (lbs./yr.)	MOS (lbs./yr.)
Bachman Run	2,912	291
Beck Creek	3,067	307
Killinger Creek	5,055	506
Snitz Creek	4,608	461

9.3 LOAD ALLOCATION

The load allocation (LA) is that portion of the TMDL that is assigned to nonpoint sources. Load allocations were computed by subtracting the WLA (where applicable) and the MOS from the targeted TMDL value (Table 17). Load allocations ranged from 2,621 lbs./yr. for Bachman Run to 4,147 lbs./yr. for Snitz Creek.

TABLE 17 - LOAD ALLOCATIONS FOR TOTAL PHOSPHORUS TMDLS

WATERSHED	TARGETED TMDL (lbs./yr.)	WLA (lbs./yr.)	MOS (lbs./yr.)	LOAD ALLOCTION (lbs./yr.)
Bachman Run	2,912	NA	291	2,621
Beck Creek	3,067	NA	307	2,761
Killinger Creek	5,055	1,128.50	506	3,421
Snitz Creek	4,608	NA	461	4,147

9.4 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 non-point source loads that are not being considered for reductions (loads not reduced or LNR) from the LA. Since the Quittapahilla Creek watershed TMDLs were developed to address impairments primarily caused by agricultural activities, only these land uses (HAY/PASTURE and CROPLAND) were considered for reductions. Those land uses/sources loads not reduced (LNR) were carried through at their existing loading value (Table 18). ALAs ranged from 1,704-lbs./yr. for Bachman Run to 1,960 lbs./yr. for Beck Creek.

TABLE 18 - TOTAL PHOSPHORUS LOAD ALLOCATIONS, LOADS NOT REDUCED, AND ADJUSTED LOAD ALLOCATIONS

	TOTAL PHOSPHORUS (lbs./yr.)			
	Bachman Run	**Beck Creek**	**Killinger Creek**	**Snitz Creek**
LOAD ALLOCATION	2,621	2,761	3,421	4,147
LOADS NOT REDUCED	917	801	1,566	2,402
CONIF_FOR	0.44	0.44	1.10	1.98
MIXED_FOR	0.66	0.44	0.88	1.76
DECID_FOR	132.60	35.02	62.56	110.13
QUARRY	-	-	-	644.27
COAL_MINES	-	-	-	617.40
TRANSITION	48.90	-	-	-
LO_INT_DEV	1.98	5.51	36.56	36.12
HI_INT_DEV	31.72	25.99	291.19	149.78
Groundwater	674.23	716.52	1,143.83	790.31
Septic Systems	26.21	16.96	29.96	50.66
ADJUSTED LOAD ALLOCATION	**1,704**	**1,960**	**1,855**	**1,745**

9.5 TOTAL PHOSPHORUS TMDLs

The total phosphorus TMDL established for the Killinger Creek basin consists of a Waste Load Allocation (WLA), Margin of Safety (MOS), and Load Allocation (LA). The total phosphorus TMDLs established for the Bachman Run, Beck Creek, and Snitz Creek basins consist of a Margin of Safety (MOS) and a Load Allocation (LA). No TMDLs were established for nitrogen because these basins are phosphorus limited. The individual components of the total phosphorus TMDLs are summarized in Table 19.

TABLE 19 - COMPONENTS OF THE BACHMAN RUN, BECK CREEK, KILLINGER CREEK, AND SNITZ CREEK TOTAL PHOSPHORUS TMDLS

COMPONENT	TOTAL PHOSPHORUS (lbs./yr.)			
	Bachman Run	**Beck Creek**	**Killinger Creek**	**Snitz Creek**
TMDL **(Total Maximum Daily Load)**	2,912	3,067	5,055	4,608
WLA **(Wasteload Allocation)**	NA	NA	1,128.50	NA
MOS **(Margin of Safety)**	291	307	506	461
LA **(Load Allocation)**	2,621	2,761	3,421	4,147
LNR **(Loads Not Reduced)**	917	801	1,566	2,402
ALA **(Adjusted Load Allocation)**	1,704	1,960	1,855	1,745

X. CALCULATION OF PHOSPHORUS LOAD REDUCTIONS

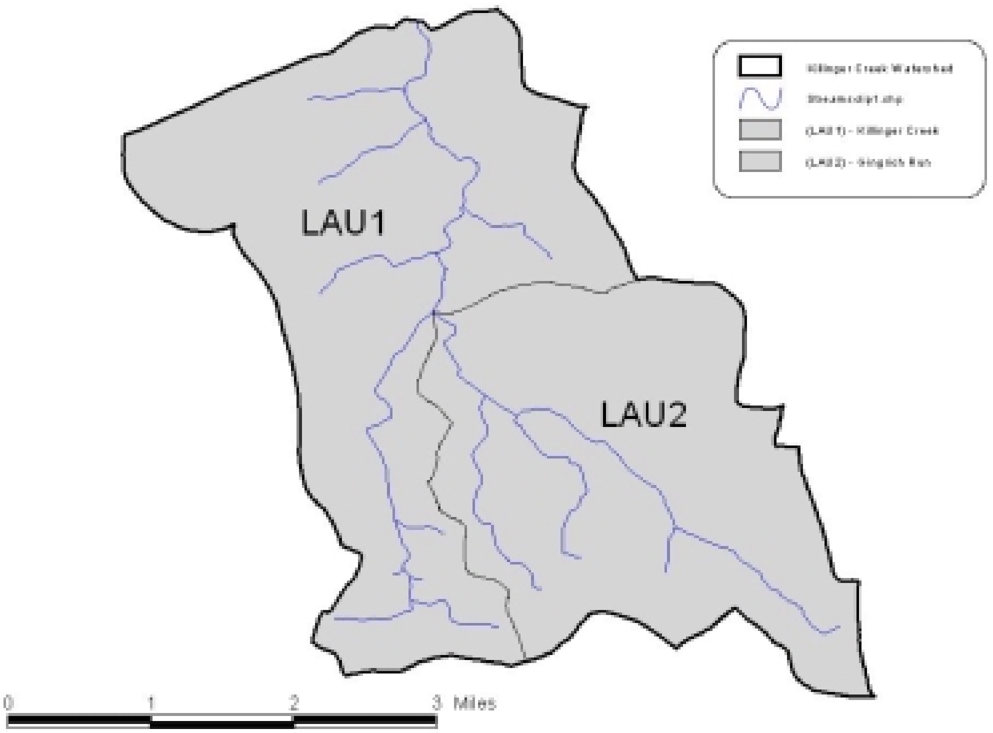
The adjusted load allocations established in the previous section represent the total phosphorous loads that are available for allocation between Hay/Pasture and Cropland land uses in the Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek basins. Load allocation and reduction procedures were applied individually to all four basins. In addition, the Killinger Creek basin was subdivided into two smaller allocation units (LAU)(Figure 9), based on the need for specific phosphorus reductions in the Gingrich Run basin. Impairments in the Gingrich Run basin caused by suspended solids were addressed by a combination of phosphorus and sediment load reductions. Data needed for load reduction analyses, including land use distribution, were obtained by a GIS analysis. The Equal Marginal Percent Reduction (EMPR) allocation method (as described in section VII - Calculation of Sediment Load Reductions) was used to distribute the ALA between Hay/Pasture and Cropland land uses.

The load allocation and EMPR procedures were performed using MS Excel and results are presented in Appendix H. Table 20 contains the results of the total phosphorus EMPRs for HAY/PASTURE and CROPLAND in the Bachman Run, Beck Creek, Killinger Creek, and Snitz Creek and the two LAUs in the Killinger Creek basin. The load allocation for each land use is shown along with the percent reduction of current loads necessary to reach the targeted LAs.

TABLE 20 - AGRICULTURAL LAND USE LOAD ALLOCATIONS & REDUCTIONS FOR TOTAL PHOSPHORUS

LAND USE	ACRES	CURRENT LOADING RATE (lbs./acre/yr.)	ALLOWABLE LOADING RATE (lbs./acre/yr.)	CURRENT LOAD (lbs./yr.)	LOAD ALLOCATION (lbs./yr.)	PERCENT REDUCTION
Bachman Run Basin						
HAY/PASTURE	1,434.42	0.35	0.27	495.15	383.68	23%
CROPLAND	2,532.13	2.49	0.52	6,312.56	1,320.63	79%
Beck Creek Basin						
HAY/PASTURE	1,461.32	0.32	0.26	467.84	377.68	19%
CROPLAND	2,805.67	2.15	0.56	6,033.48	1,582.02	74%
Killinger Creek Basin						
HAY/PASTURE	1,974.60	0.26	0.20	509.03	399.43	22%
CROPLAND	4,434.90	2.91	0.33	12,916.52	1,455.60	89%
Killinger Creek – LAU1						
HAY/PASTURE	1,150.87	0.26	0.20	296.68	232.80	22%
CROPLAND	2,517.90	2.91	0.33	7,333.31	826.41	89%
Killinger Creek – LAU2 (Gingrich Run)						
HAY/PASTURE	823.73	0.26	0.20	212.35	166.63	22%
CROPLAND	1,917.00	2.91	0.33	5,583.21	629.19	89%
Snitz Creek Basin						
HAY/PASTURE	1,475.34	0.20	0.17	300.00	255.98	15%
CROPLAND	3,035.84	1.71	0.49	5,200.66	1,488.57	71%

FIGURE 9 - LOAD ALLOCATION UNITS (LAUS) FOR THE KILLINGER CREEK WATERSHED TOTAL PHOSPHORUS TMDL



XI. 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 sediment and 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 sediment and nutrients to a waterbody and the resulting impact on beneficial uses, establishing these TMDLs using average annual conditions is protective of the waterbody.

XII. 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.

XIII. REASONABLE ASSURANCE OF IMPLEMENTATION

Sediment and phosphorus reductions in the TMDLs are allocated entirely to agricultural activities in the watershed. Implementation of best management practices (BMPs) in the affected areas should achieve the loading reduction goals established in the TMDLs. Substantial reductions in the amount of sediment reaching the streams can be made through the planting of riparian buffer zones, contour strips, and cover crops. These BMPs range in efficiency from 20% to 70% for sediment reduction. Implementation of BMPs aimed at sediment reduction will also assist in the reduction of phosphorus. Additional phosphorus reductions can be achieved through the installation of more effective animal waste management systems and stone ford cattle crossings. Other possibilities for attaining the desired reductions in phosphorus and sediment include stabilization of streambanks and streambank fencing. An excellent start has already been made in the implementation of these types of BMPs in the Quittapahilla Creek basin. The local watershed association began installing streambank fencing (Figure 10), stable livestock crossings (Figure 11), and planting of riparian vegetation (Figure 12) during 1999 and have continued to do so in 2000. A number of these sites were visited on August 4, 2000 and noticeable reductions in the severity of streambank erosion and sediment deposition have already occurred. Further “ground truthing” will be performed in order to assess both the extent of existing BMPs, and to determine the most cost-effective and environmentally protective combination of BMPs required for meeting the sediment and nutrient reductions outlined in this report.

FIGURE 10 - STREAMBANK FENCING IN THE QUITTAPAHILLA CREEK WATERSHED

FIGURE 11 - STABLE LIVESTOCK CROSSING IN THE QUITTAPAHILLA CREEK WATERSHED

FIGURE 12 - RIPARIAN ZONE PLANTINGS IN THE QUITTAPAHILLA CREEK WATERSHED

XIV. PUBLIC PARTICIPATION

A notice of availability for comments on the draft Quittapahilla Creek watershed TMDLs was published in the *PA Bulletin* on December 2, 2000 and in local newspapers shortly thereafter. A 60-day period (ending on January 31, 2002) was provided for submittal of comments. In addition, a public meeting was scheduled for December 21, 2000 at the Lebanon County Court House to address any outstanding concerns regarding the draft TMDLs. Notice of final TMDL approvals will be posted on the Department's website.

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APPENDIX A - INFORMATION SHEET FOR QUITTAPAHILLA CREEK WATERSHED TMDLS

What is being proposed?
Total Maximum Daily Load (TMDL) plans have been developed to improve water quality in the Quittapahilla Creek watershed.

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

What is a TMDL?
A TMDL sets a ceiling on the pollutant loads that can enter a water body so that the water body 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 U.S. EPA for approval. Also, if a state does not develop the TMDL, the Clean Water Act states that U.S. EPA 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 meet and the water is said to be in violation of water quality standards.

What is the purpose of the plans?
The Quittapahilla Creek watershed is impaired due to excess sediment and nutrient contributions to the water body. The plans include a calculation of loadings for sediment and nutrients that will meet water quality objectives.

Why was the Quittapahilla Creek watershed selected for TMDL development?
In 1996, Pa. DEP listed stream segments in the Quittapahilla Creek watershed under Section 303(d) of the federal Clean Water Act as impaired due to excess sediment and nutrient loading from agricultural activities. Portions of the watershed were assessed in 1997 and 1999. The 1998 303(d) list and the 2000 305(b) report reflect the results of those reassessments. A total of 67 stream miles in the Quittapahilla Creek watershed are listed as impaired due siltation, suspended solids, nutrients, and flow alterations caused by agricultural activities.

What pollutants do these TMDLs address?
The proposed plans provide calculations of the stream’s total capacity to accept sediments and phosphorus. Based on evaluation of the concentrations of nutrients in the impaired stream segments, phosphorus is the cause of nutrient impairment in four tributary basins. Sediment loading is being used to address siltation and phosphorus loading is being used to address nutrients. A combination of sediment and phosphorus loadings are being used to address impairments due to suspended solids.

Where do the pollutants come from?

All of the sediment related impairments in the Quittapahilla Creek watershed come from nonpoint sources (NPS) of pollution, primarily from overland runoff. Phosphorus in the basin comes from both point and nonpoint sources, with nonpoint sources responsible for more than 75%.

How was the TMDL developed?

PADEP used a reference watershed approach to estimate the necessary loading reduction of sediment and phosphorus that would be needed to restore a healthy aquatic community. The reference watershed approach is based on selecting a non-impaired 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, PADEP 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 non-impaired watershed as a target for loading 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 non-impaired watershed.

The reference stream approach was used to set allowable loading rates in the affected watersheds because neither Pennsylvanian nor U.S. EPA has water quality criteria for sediment or phosphorus.

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 from sediment and nutrients, the TMDL is expressed as an annual loading. This accounts for pollution contributions over all stream flow conditions.

PADEP established the water quality objectives for sediment and phosphorus 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 and phosphorus 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 installed throughout the watershed to achieve the necessary loading reductions.

How can I get more information on the TMDL?

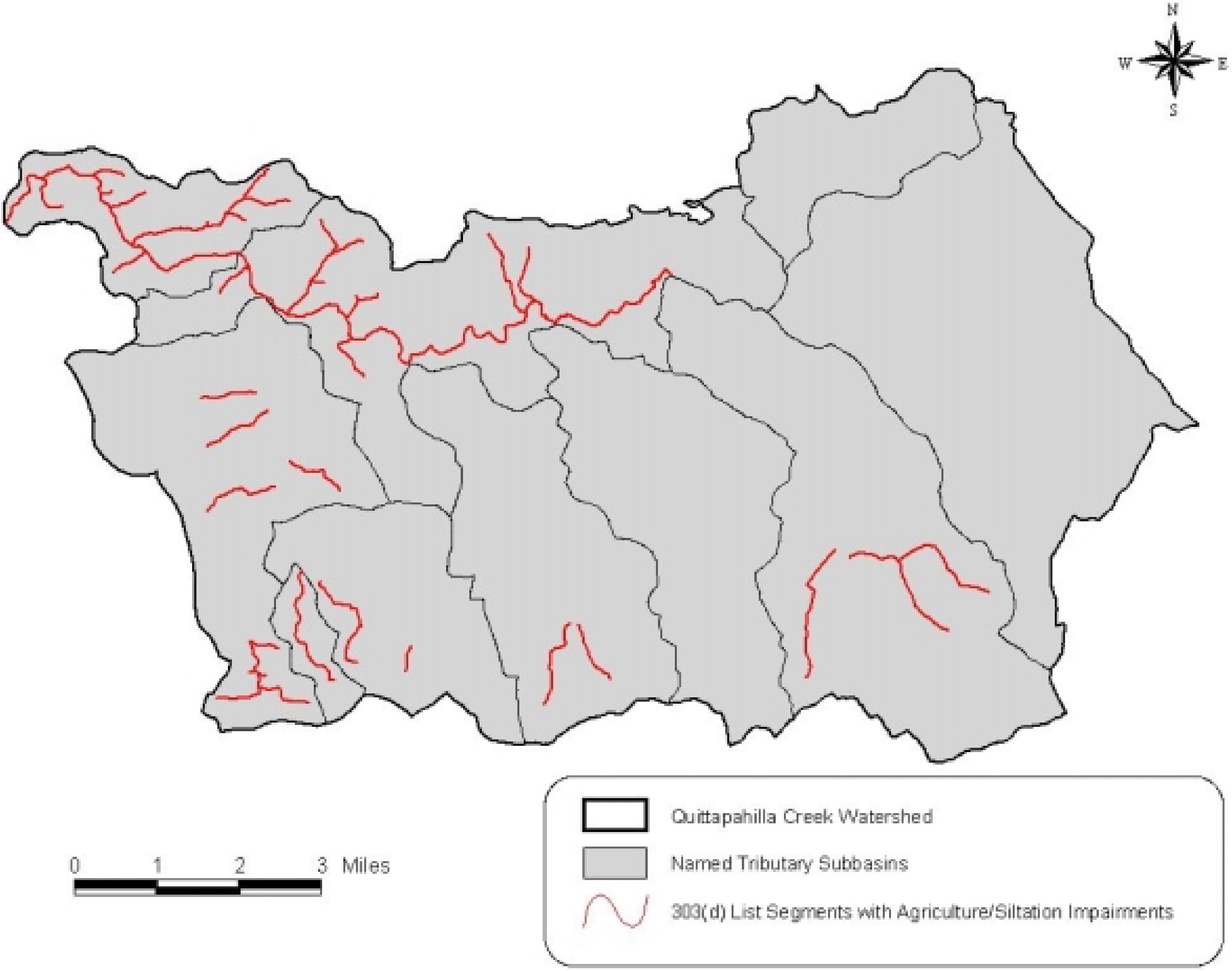
To request a copy of the full report, contact Joseph P. Hepp at 717-705-4788 during the business hours of 8:00 a.m. to 3:00 p.m., Monday through Friday. One may also contact Mr. Hepp by mail at the Water Management Program, SCRO PADEP, 909 Elmerton Avenue Harrisburg, PA 17110 or by email at hepp.joseph@dep.state.pa.us.

How can I comment on the proposal?

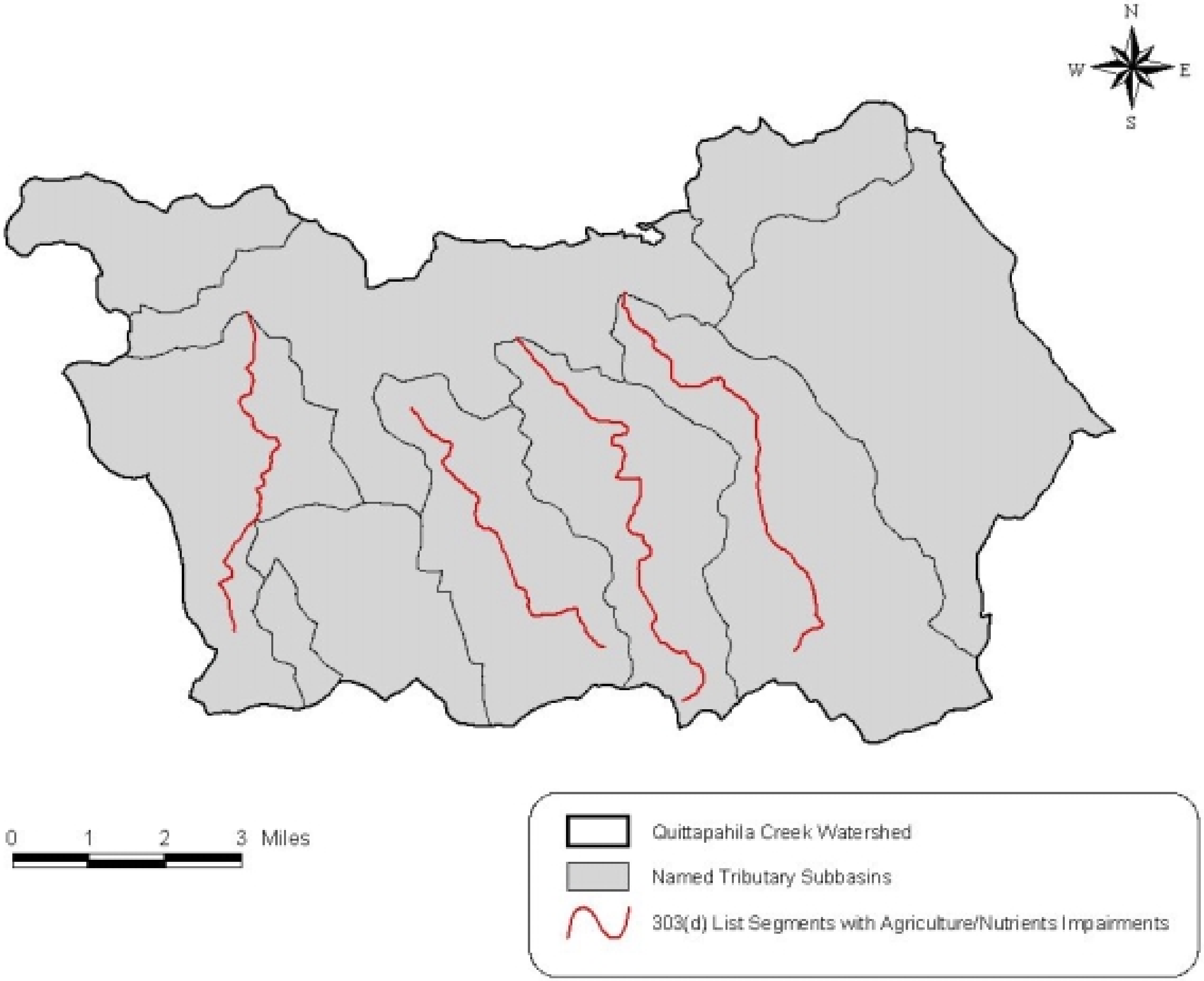
You may provide e-mail or written comments postmarked no later than January 31, 2001, 2000 to the above addresses.

APPENDIX B - MAPS DEPICTING IMPAIRED STREAM SEGMENTS IN THE QUITTAPAHILLA CREEK WATERSHED BASED ON 2000 305(B) REPORT

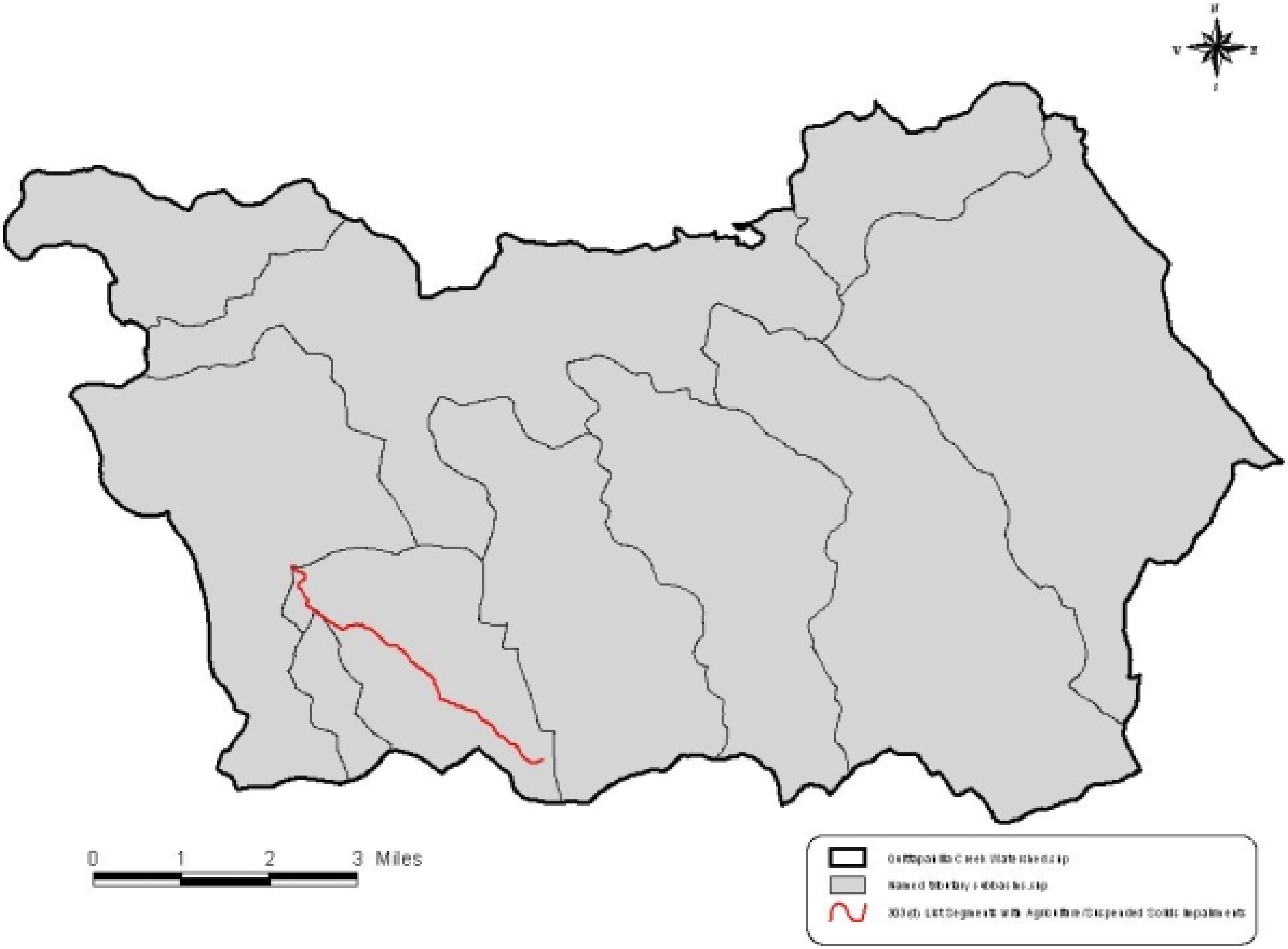
AGRICULTURE/CROP RELATED AGRICULTURE & SILTATION IMPAIRMENTS
QUITTAPAHILLA CREEK WATERSHED



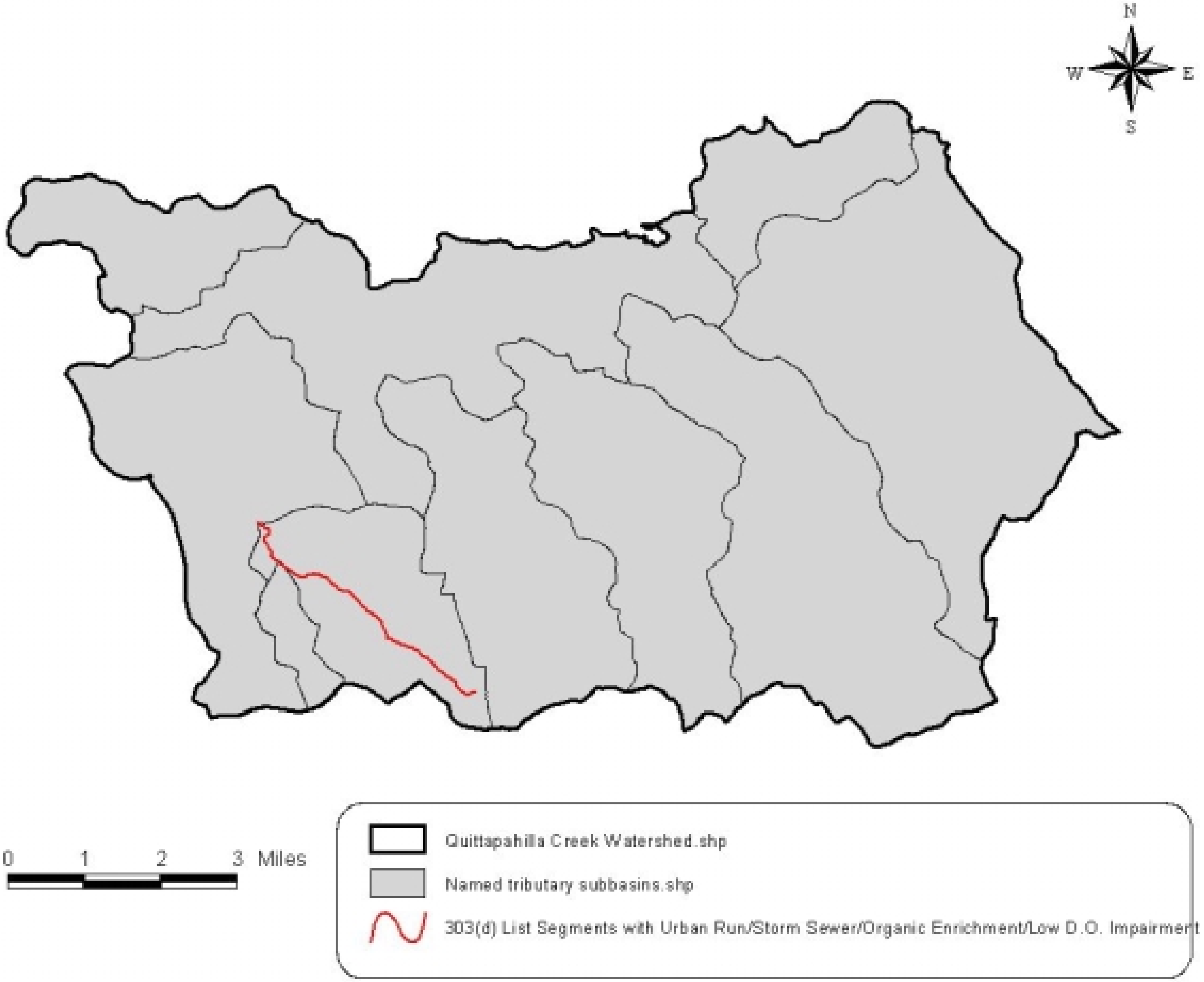
AGRICULTURE & NUTRIENTS IMPAIRMENTS
QUITTACAPAHILLA CREEK WATERSHED



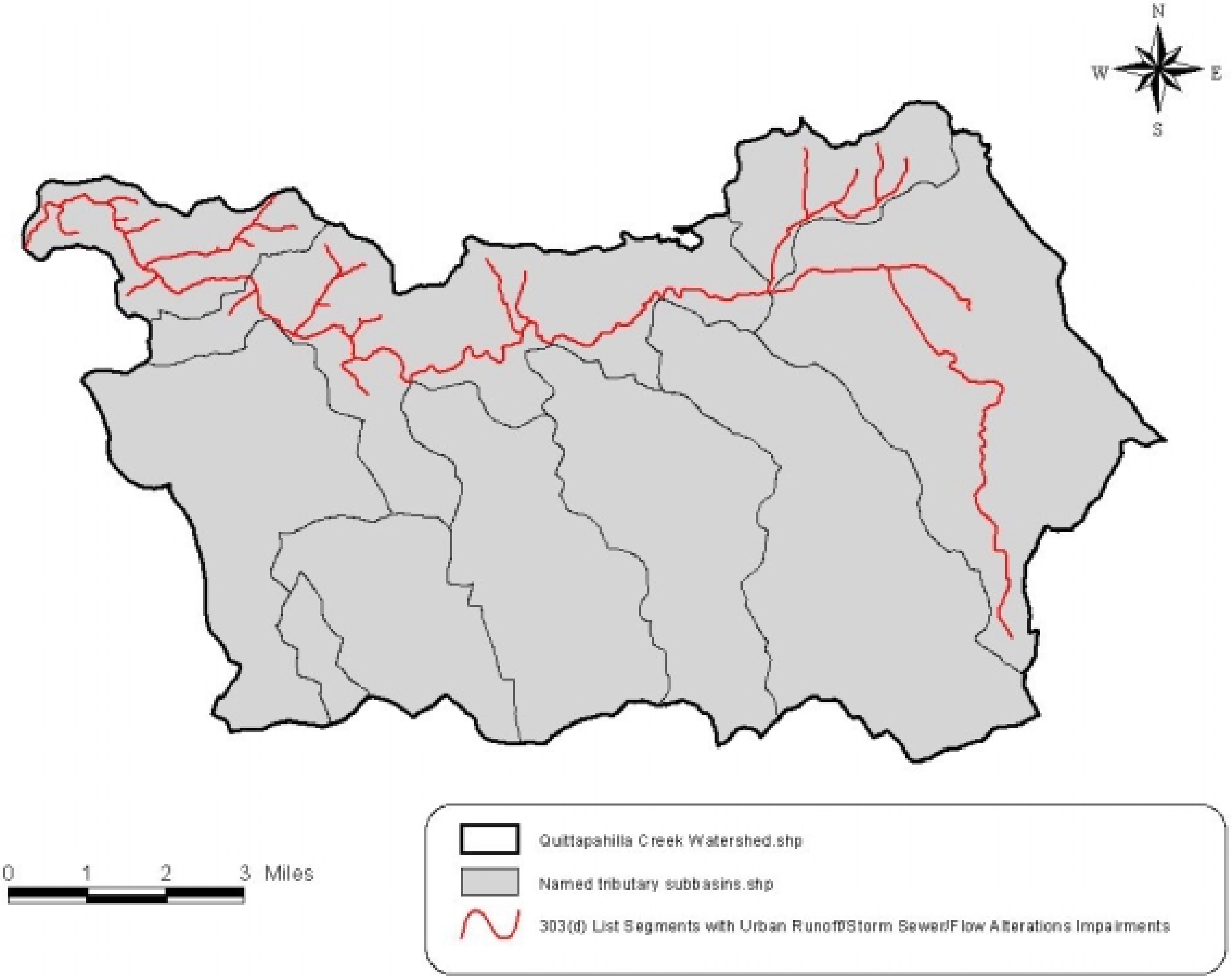
AGRICULTURE & SUSPENDED SOLIDS IMPAIRMENTS
QUITTAPAHILLA CREEK WATERSHED



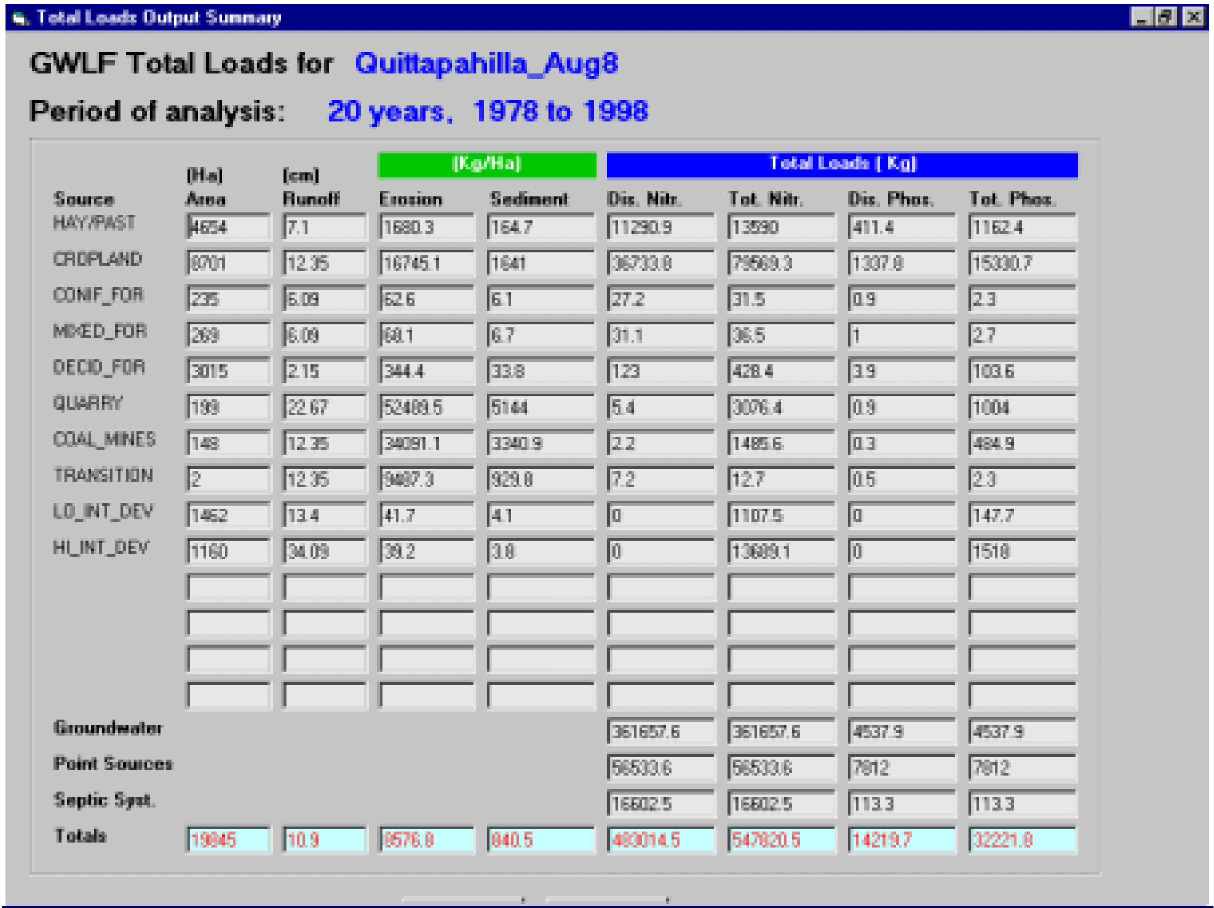
URBAN RUNOFF/STORM SEWERS & ORGANIC ENRICHMENT/LOW D.O. IMPAIRMENTS
QUITTAPAHILLA CREEK WATERSHED



URBAN RUNOFF/STORM SEWERS & FLOW ALTERATION IMPAIRMENTS
QUITTAPAHILLA CREEK WATERSHED



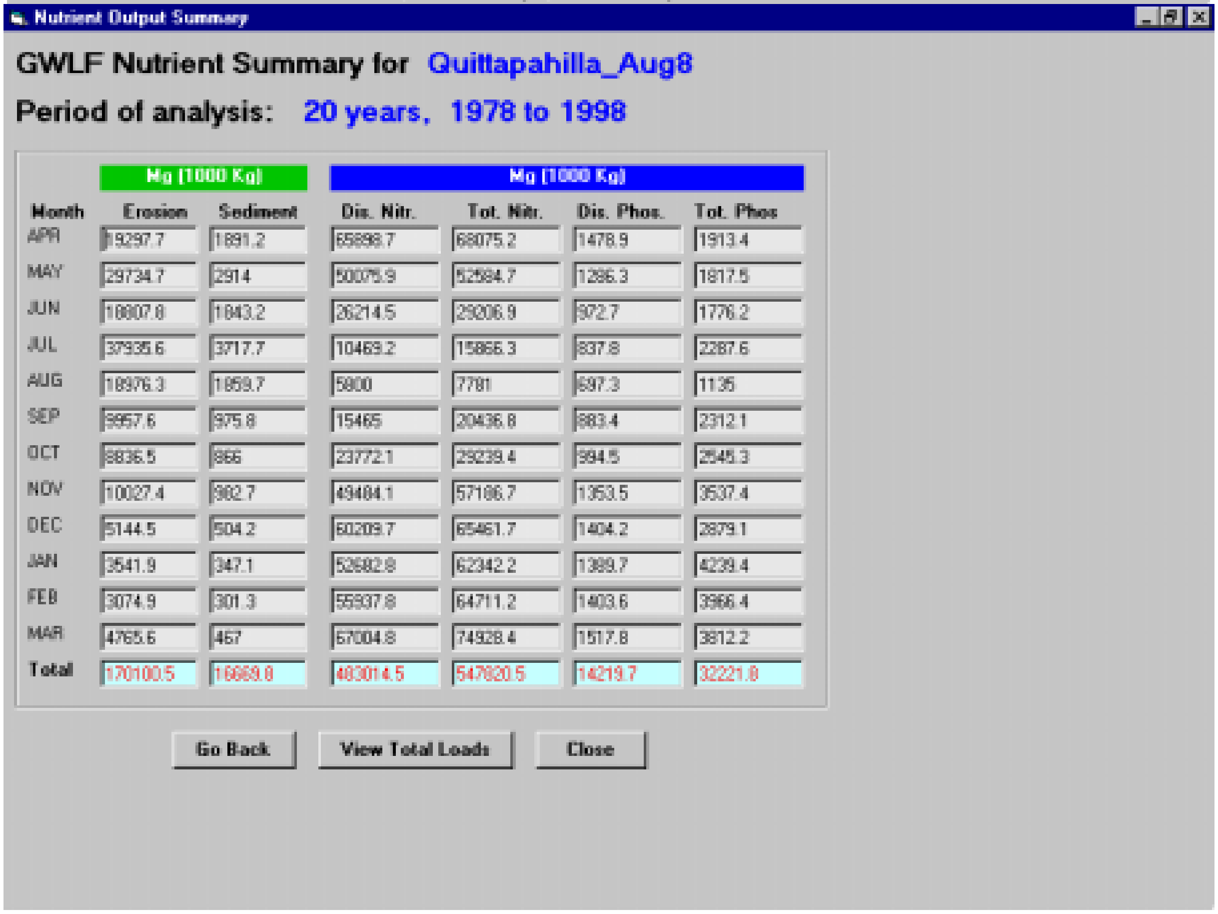
APPENDIX C - AVGWLF MODEL OUTPUTS FOR QUITTAPAHILLA CREEK WATERSHED



GWLF Total Loads for Quittapahilla_Aug8

Period of analysis: 20 years, 1978 to 1998

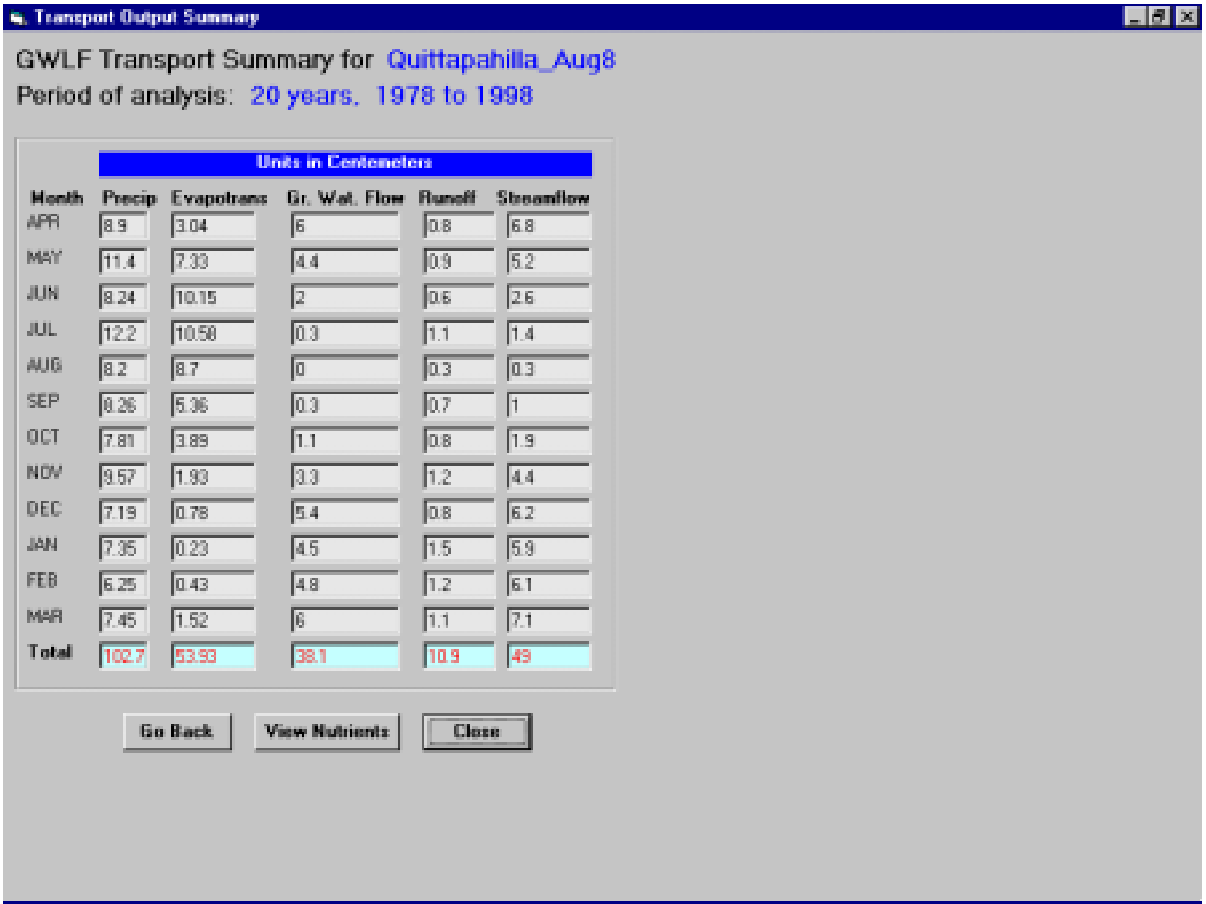
	(Ha)	(cm)	(Kg/Ha)		Total Loads (Kg)			
Source	Area	Runoff	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
HAY/PAST	4654	7.1	1680.3	164.7	11290.9	13590	411.4	1162.4
CROPLAND	8701	12.35	16745.1	1641	36733.8	79569.3	1307.8	15300.7
CONIF_FOR	235	6.09	62.6	6.1	27.2	31.5	0.9	2.3
MIXED_FOR	269	6.09	68.1	6.7	31.1	36.5	1	2.7
DECID_FOR	3015	2.15	344.4	33.8	123	428.4	3.9	103.6
QUARRY	199	22.67	52489.5	5144	5.4	3076.4	0.9	1004
COAL_MINES	148	12.35	34091.1	3340.9	2.2	1485.6	0.3	484.9
TRANSITION	2	12.35	9487.3	929.8	7.2	12.7	0.5	2.3
LO_INT_DEV	1462	13.4	41.7	4.1	0	1107.5	0	147.7
HI_INT_DEV	1160	34.09	39.2	3.8	0	13689.1	0	1518
Groundwater					361657.6	361657.6	4537.9	4537.9
Point Sources					56533.6	56533.6	7812	7812
Septic Syst.					16602.5	16602.5	113.3	113.3
Totals	19845	10.9	8576.8	840.5	480014.5	547820.5	14219.7	32221.8



GWLF Nutrient Summary for Quittapahilla_Aug8

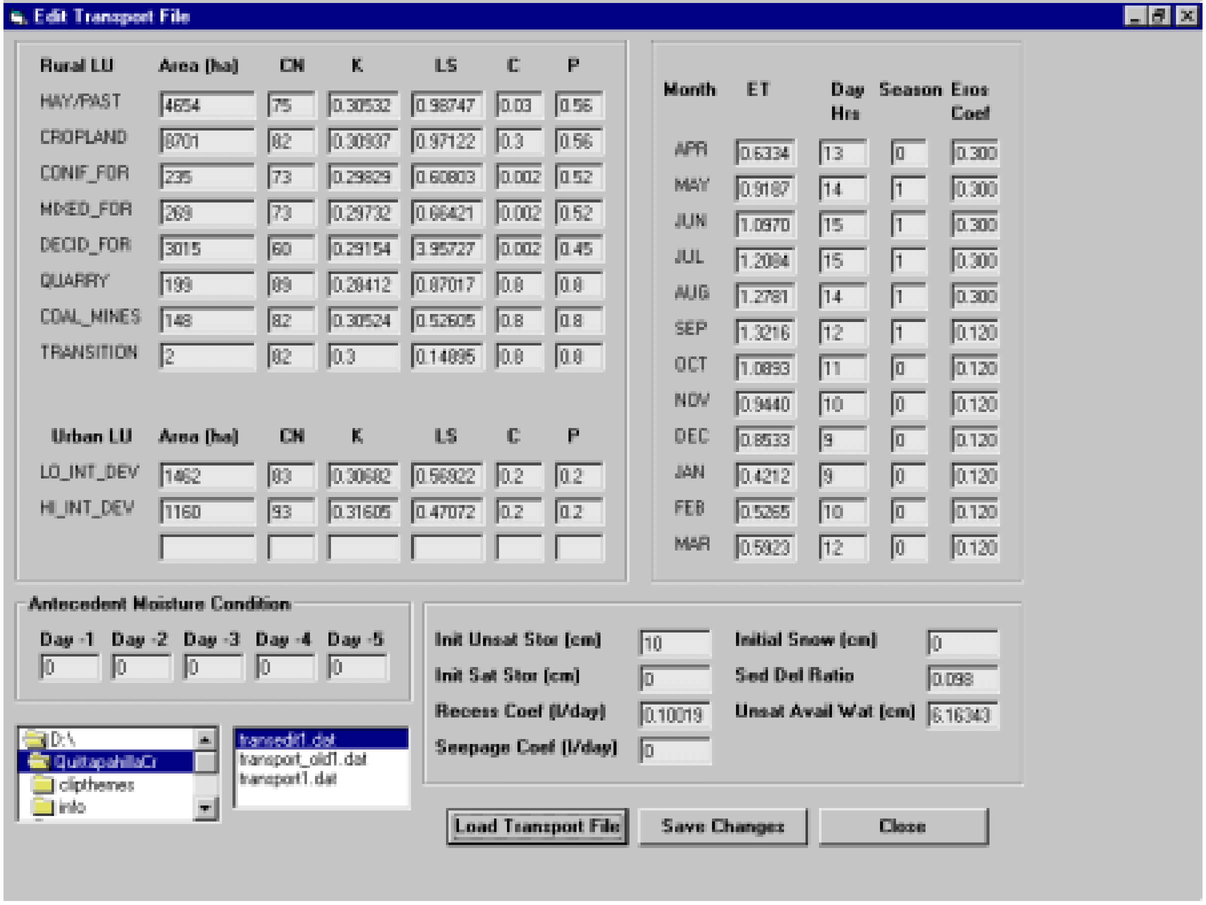
Period of analysis: 20 years, 1978 to 1998

	Mg (1000 Kg)		Mg (1000 Kg)			
Month	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos
APR	19297.7	1891.2	65898.7	68075.2	1478.9	1913.4
MAY	29734.7	2914	50075.9	52584.7	1286.3	1817.5
JUN	18807.8	1843.2	26214.5	29206.9	972.7	1776.2
JUL	37935.6	3717.7	10469.2	15866.3	837.8	2287.6
AUG	18976.3	1859.7	5800	7781	697.3	1135
SEP	9957.6	975.8	15465	20436.8	883.4	2312.1
OCT	8836.5	866	23772.1	29239.4	994.5	2545.3
NOV	10027.4	982.7	49484.1	57186.7	1353.5	3537.4
DEC	5144.5	504.2	60209.7	65461.7	1404.2	2879.1
JAN	3541.9	347.1	52682.8	62342.2	1389.7	4239.4
FEB	3074.9	301.3	55937.8	64711.2	1403.6	3966.4
MAR	4765.6	467	67004.8	74928.4	1517.8	3812.2
Total	170100.5	16669.8	483014.5	547820.5	14219.7	32221.8



GWLF Transport Summary for Quittapahilla_Aug8
Period of analysis: 20 years, 1978 to 1998

	Units in Centemeters				
Month	**Precip**	**Evapotrans**	**Gr. Wat. Flow**	**Runoff**	**Streamflow**
APR	8.9	3.04	6	0.8	6.8
MAY	11.4	7.33	4.4	0.9	5.2
JUN	8.24	10.15	2	0.6	2.6
JUL	12.2	10.58	0.3	1.1	1.4
AUG	8.2	8.7	0	0.3	0.3
SEP	8.26	5.36	0.3	0.7	1
OCT	7.81	3.89	1.1	0.8	1.9
NOV	9.57	1.93	3.3	1.2	4.4
DEC	7.19	0.78	5.4	0.8	6.2
JAN	7.35	0.23	4.5	1.5	5.9
FEB	6.25	0.43	4.8	1.2	6.1
MAR	7.45	1.52	6	1.1	7.1
Total	102.7	53.93	38.1	10.9	49



Rural LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
HAY/PAST	4654	75	0.30532	0.98747	0.03	0.56
CROPLAND	8701	82	0.30937	0.97122	0.3	0.56
CONIF_FOR	235	73	0.29829	0.60803	0.002	0.52
MIXED_FOR	269	73	0.29732	0.66421	0.002	0.52
DECID_FOR	3015	60	0.29154	3.95727	0.002	0.45
QUARRY	199	89	0.28412	0.87017	0.8	0.8
COAL_MINES	148	82	0.30524	0.52605	0.8	0.8
TRANSITION	2	82	0.3	0.14895	0.8	0.8

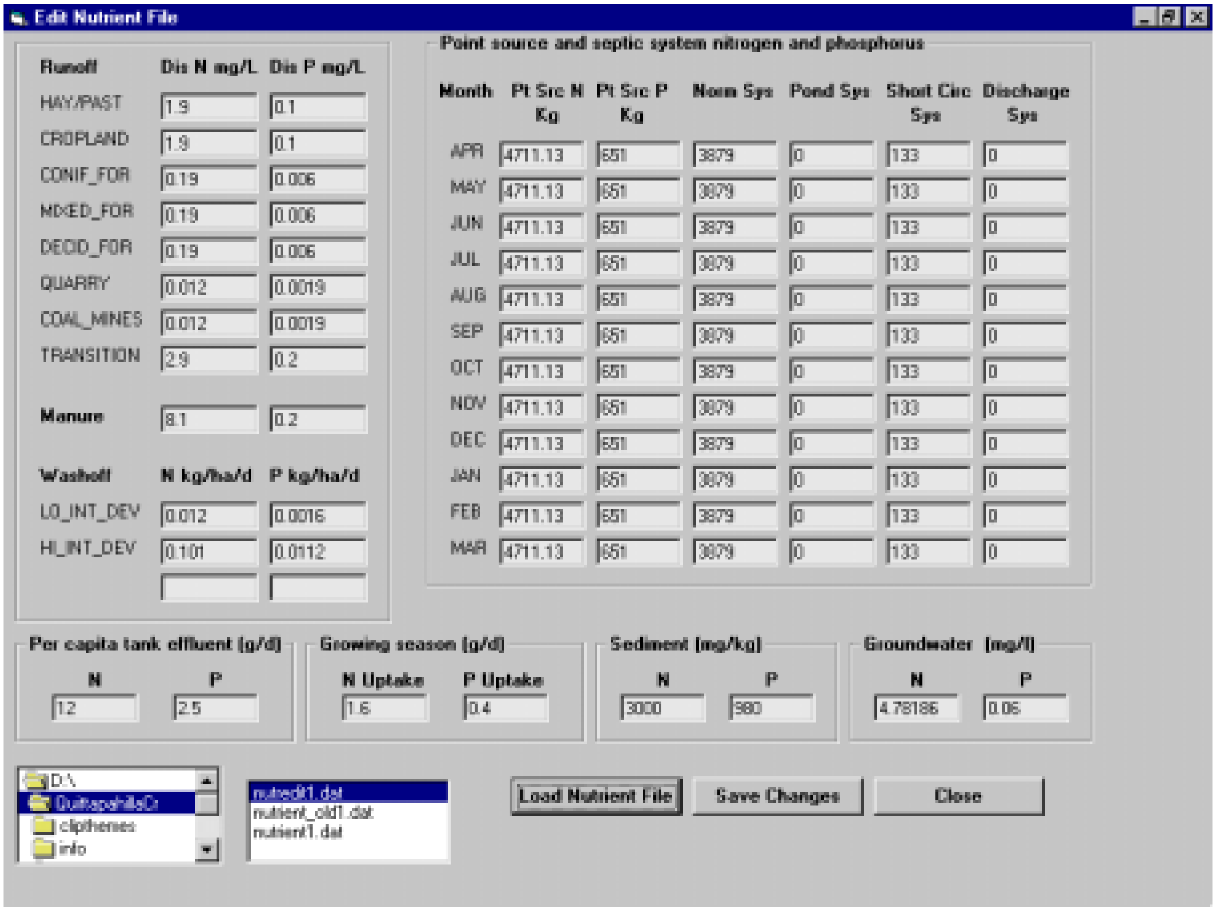
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
LO_INT_DEV	1462	83	0.30682	0.56922	0.2	0.2
HI_INT_DEV	1160	93	0.31605	0.47072	0.2	0.2

Month	**ET**	**Day Hrs**	**Season**	**Eros Coef**
APR	0.6334	13	0	0.300
MAY	0.9187	14	1	0.300
JUN	1.0970	15	1	0.300
JUL	1.2084	15	1	0.300
AUG	1.2781	14	1	0.300
SEP	1.3216	12	1	0.120
OCT	1.0893	11	0	0.120
NOV	0.9440	10	0	0.120
DEC	0.8533	9	0	0.120
JAN	0.4212	9	0	0.120
FEB	0.5265	10	0	0.120
MAR	0.5923	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**	0.098
Recess Coef (l/day)	0.10019	**Unsat Avail Wat (cm)**	6.16343
Seepage Coef (l/day)	0		



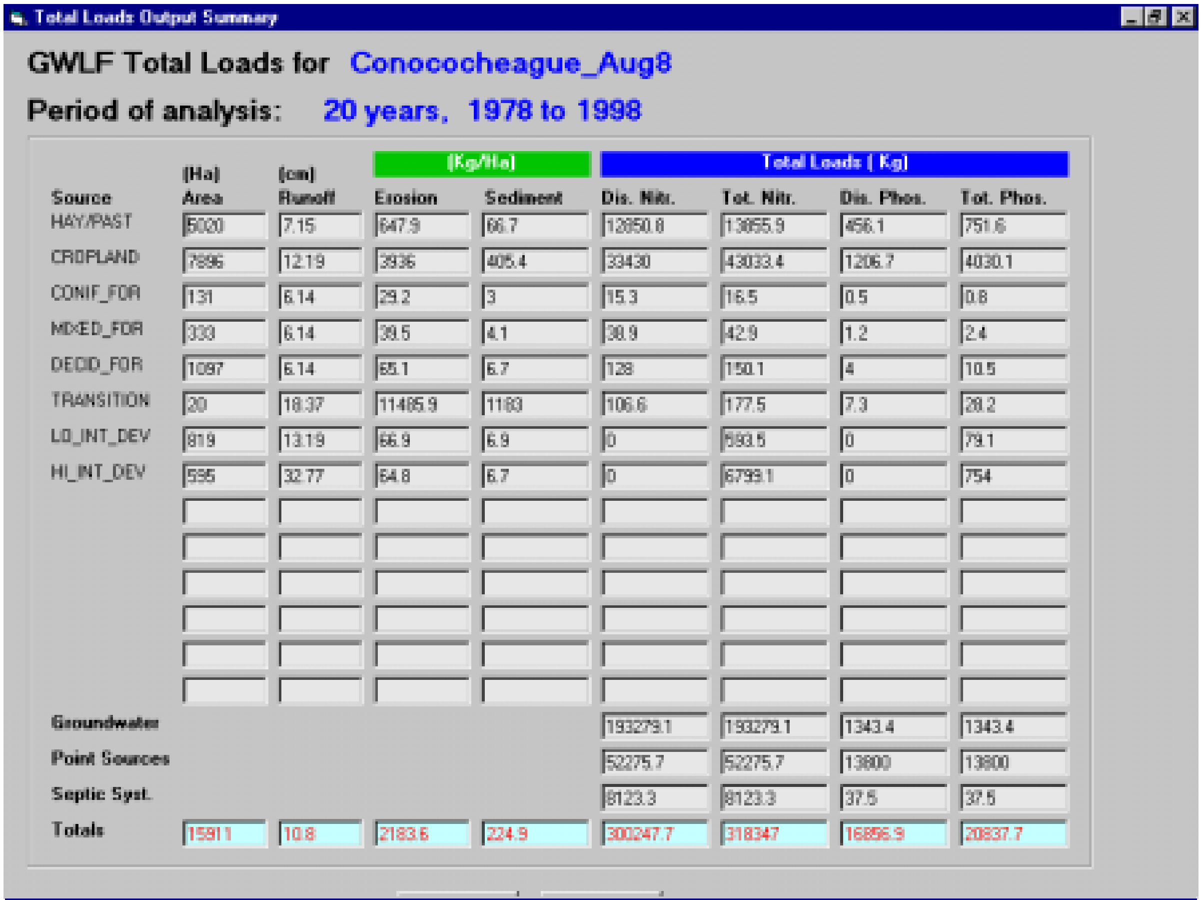
Runoff	Dis N mg/L	Dis P mg/L
HAY/PAST	1.9	0.1
CROPLAND	1.9	0.1
CONIF_FOR	0.19	0.006
MIXED_FOR	0.19	0.006
DECID_FOR	0.19	0.006
QUARRY	0.012	0.0019
COAL_MINES	0.012	0.0019
TRANSITION	2.9	0.2
Manure	8.1	0.2
Washoff	**N kg/ha/d**	**P kg/ha/d**
LO_INT_DEV	0.012	0.0016
HI_INT_DEV	0.101	0.0112

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	4711.13	651	3879	0	133	0
MAY	4711.13	651	3879	0	133	0
JUN	4711.13	651	3879	0	133	0
JUL	4711.13	651	3879	0	133	0
AUG	4711.13	651	3879	0	133	0
SEP	4711.13	651	3879	0	133	0
OCT	4711.13	651	3879	0	133	0
NOV	4711.13	651	3879	0	133	0
DEC	4711.13	651	3879	0	133	0
JAN	4711.13	651	3879	0	133	0
FEB	4711.13	651	3879	0	133	0
MAR	4711.13	651	3879	0	133	0

Per capita tank effluent (g/d)		Growing season (g/d)		Sediment (mg/kg)		Groundwater (mg/l)	
N	P	N Uptake	P Uptake	N	P	N	P
12	2.5	1.6	0.4	3000	980	4.78186	0.06

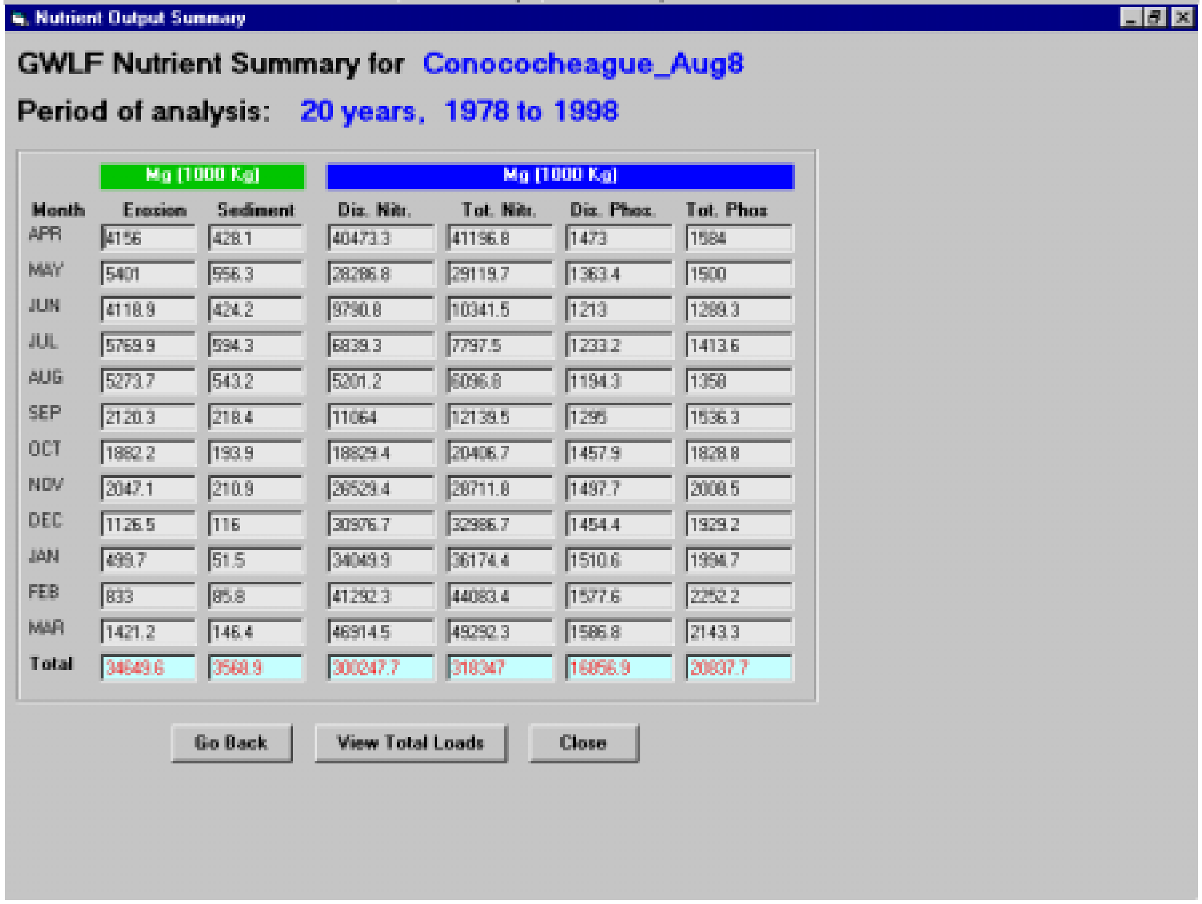
APPENDIX D - AVGWLF MODEL OUTPUTS FOR CONOCOCHEAGUE CREEK WATERSHED



GWLF Total Loads for Conococheague_Aug8

Period of analysis: 20 years, 1978 to 1998

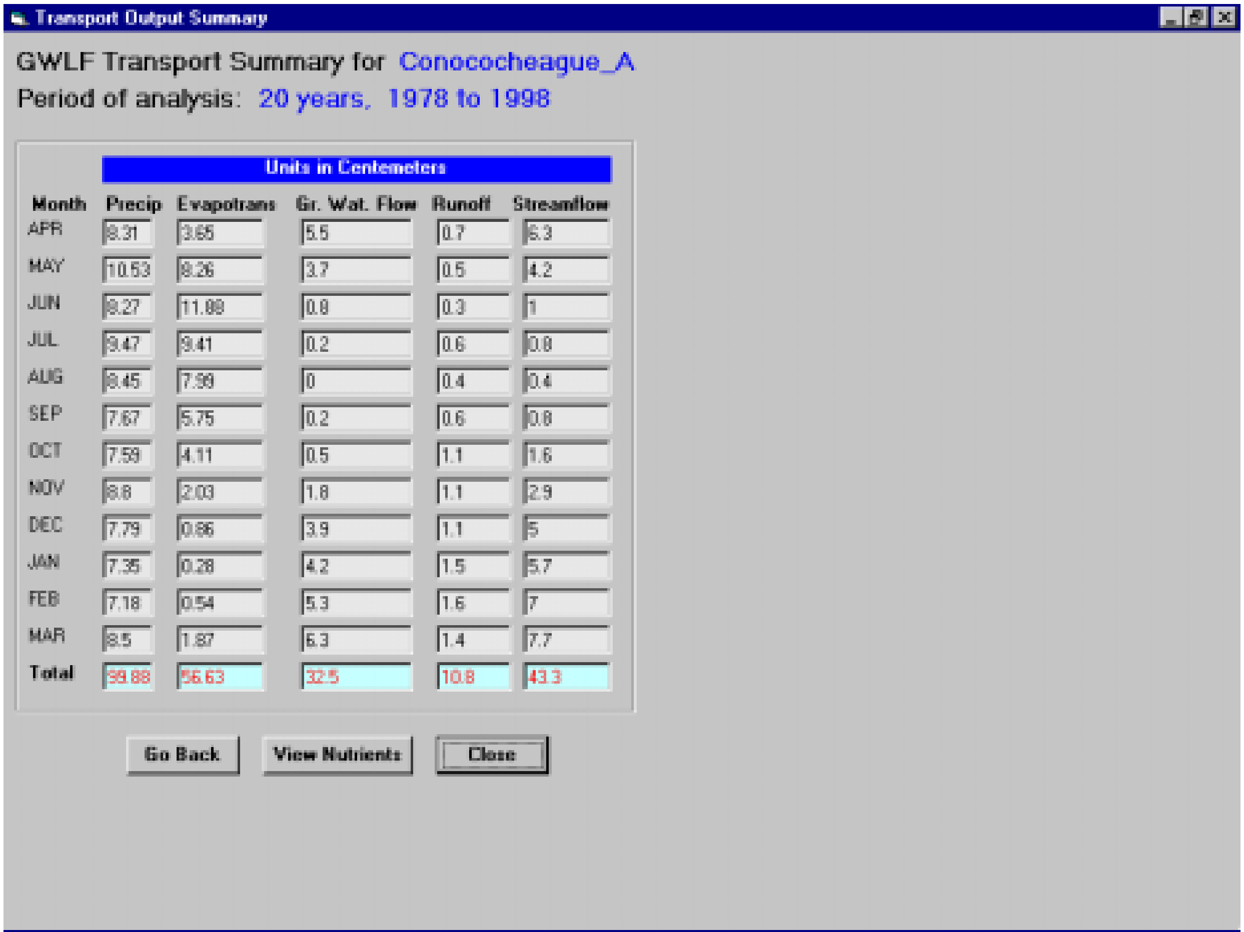
	(Ha)	(cm)	(Kg/Ha)		Total Loads (Kg)			
Source	Area	Runoff	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
HAY/PAST	5020	7.15	647.9	66.7	12850.8	13855.9	456.1	751.6
CROPLAND	7896	12.19	3936	405.4	33430	43033.4	1206.7	4030.1
CONIF_FOR	131	6.14	29.2	3	15.3	16.5	0.5	0.8
MIXED_FOR	333	6.14	39.5	4.1	38.9	42.9	1.2	2.4
DECID_FOR	1097	6.14	65.1	6.7	128	150.1	4	10.5
TRANSITION	20	18.37	11485.9	1183	106.6	177.5	7.3	28.2
LO_INT_DEV	819	13.19	66.9	6.9	0	593.5	0	79.1
HI_INT_DEV	595	32.77	64.8	6.7	0	6799.1	0	754
Groundwater					193279.1	193279.1	1343.4	1343.4
Point Sources					52275.7	52275.7	13800	13800
Septic Syst.					8123.3	8123.3	37.5	37.5
Totals	15911	10.8	2183.6	224.9	300247.7	318347	16856.9	20837.7



GWLF Nutrient Summary for Conococheague_Aug8

Period of analysis: 20 years, 1978 to 1998

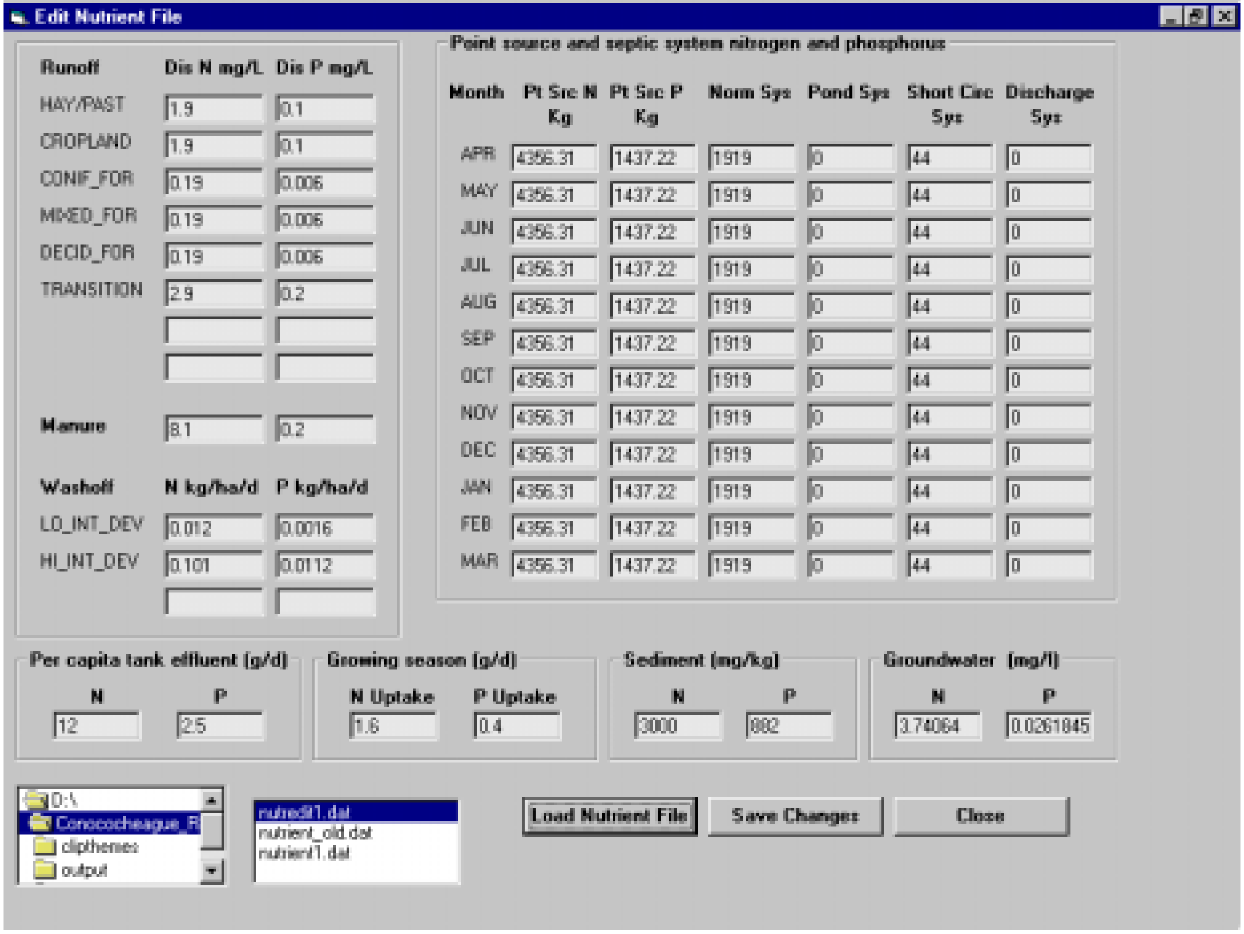
	Mg (1000 Kg)		Mg (1000 Kg)			
Month	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos
APR	4156	428.1	40473.3	41196.8	1473	1584
MAY	5401	556.3	28286.8	29119.7	1363.4	1500
JUN	4118.9	424.2	9790.8	10341.5	1213	1289.3
JUL	5769.9	594.3	6839.3	7797.5	1233.2	1413.6
AUG	5273.7	543.2	5201.2	6096.8	1194.3	1358
SEP	2120.3	218.4	11064	12139.5	1295	1536.3
OCT	1882.2	193.9	18829.4	20406.7	1457.9	1828.8
NOV	2047.1	210.9	26529.4	28711.8	1497.7	2008.5
DEC	1126.5	116	30976.7	32986.7	1454.4	1929.2
JAN	499.7	51.5	34049.9	36174.4	1510.6	1994.7
FEB	833	85.8	41292.3	44083.4	1577.6	2252.2
MAR	1421.2	146.4	46914.5	49292.3	1586.8	2143.3
Total	34649.6	3568.9	300247.7	318347	16856.9	20837.7



GWLF Transport Summary for Conococheague_A
Period of analysis: 20 years, 1978 to 1998

Units in Centemeters

Month	Precip	Evapotrans	Gr. Wat. Flow	Runoff	Streamflow
APR	8.31	3.65	5.5	0.7	6.3
MAY	10.53	8.26	3.7	0.5	4.2
JUN	8.27	11.88	0.8	0.3	1
JUL	9.47	9.41	0.2	0.6	0.8
AUG	8.45	7.99	0	0.4	0.4
SEP	7.67	5.75	0.2	0.6	0.8
OCT	7.59	4.11	0.5	1.1	1.6
NOV	8.8	2.03	1.8	1.1	2.9
DEC	7.79	0.86	3.9	1.1	5
JAN	7.35	0.28	4.2	1.5	5.7
FEB	7.18	0.54	5.3	1.6	7
MAR	8.5	1.87	6.3	1.4	7.7
Total	99.88	56.63	32.5	10.8	43.3



Runoff	Dis N mg/L	Dis P mg/L
HAY/PAST	1.9	0.1
CROPLAND	1.9	0.1
CONIF_FOR	0.19	0.006
MIXED_FOR	0.19	0.006
DECID_FOR	0.19	0.006
TRANSITION	2.9	0.2
Manure	8.1	0.2

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

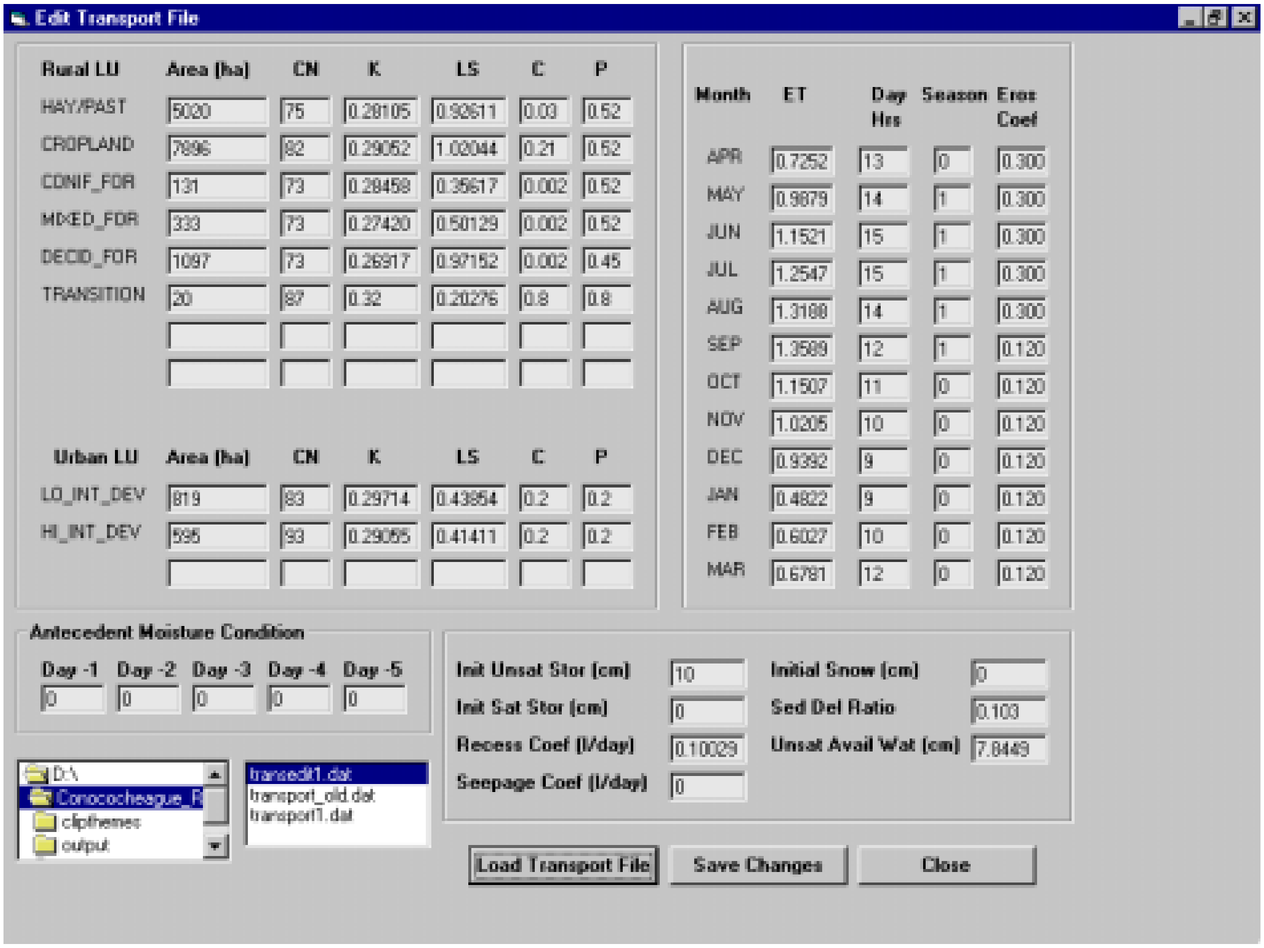
Month	Pt Src N Kg	Pt Src P Kg	Norm Sys	Pond Sys	Short Circ Sys	Discharge Sys
APR	4356.31	1437.22	1919	0	44	0
MAY	4356.31	1437.22	1919	0	44	0
JUN	4356.31	1437.22	1919	0	44	0
JUL	4356.31	1437.22	1919	0	44	0
AUG	4356.31	1437.22	1919	0	44	0
SEP	4356.31	1437.22	1919	0	44	0
OCT	4356.31	1437.22	1919	0	44	0
NOV	4356.31	1437.22	1919	0	44	0
DEC	4356.31	1437.22	1919	0	44	0
JAN	4356.31	1437.22	1919	0	44	0
FEB	4356.31	1437.22	1919	0	44	0
MAR	4356.31	1437.22	1919	0	44	0

Per capita tank effluent (g/d): N 12, P 2.5

Growing season (g/d): N Uptake 1.6, P Uptake 0.4

Sediment (mg/kg): N 3000, P 882

Groundwater (mg/l): N 3.74064, P 0.0261845



Rural LU	Area (ha)	CN	K	LS	C	P
HAY/PAST	5020	75	0.28105	0.92611	0.03	0.52
CROPLAND	7896	82	0.29052	1.02044	0.21	0.52
CONIF_FOR	131	73	0.28458	0.35617	0.002	0.52
MIXED_FOR	333	73	0.27420	0.50129	0.002	0.52
DECID_FOR	1097	73	0.26917	0.97152	0.002	0.45
TRANSITION	20	87	0.32	0.20276	0.8	0.8

Urban LU	Area (ha)	CN	K	LS	C	P
LO_INT_DEV	819	83	0.29714	0.43854	0.2	0.2
HI_INT_DEV	595	93	0.29055	0.41411	0.2	0.2

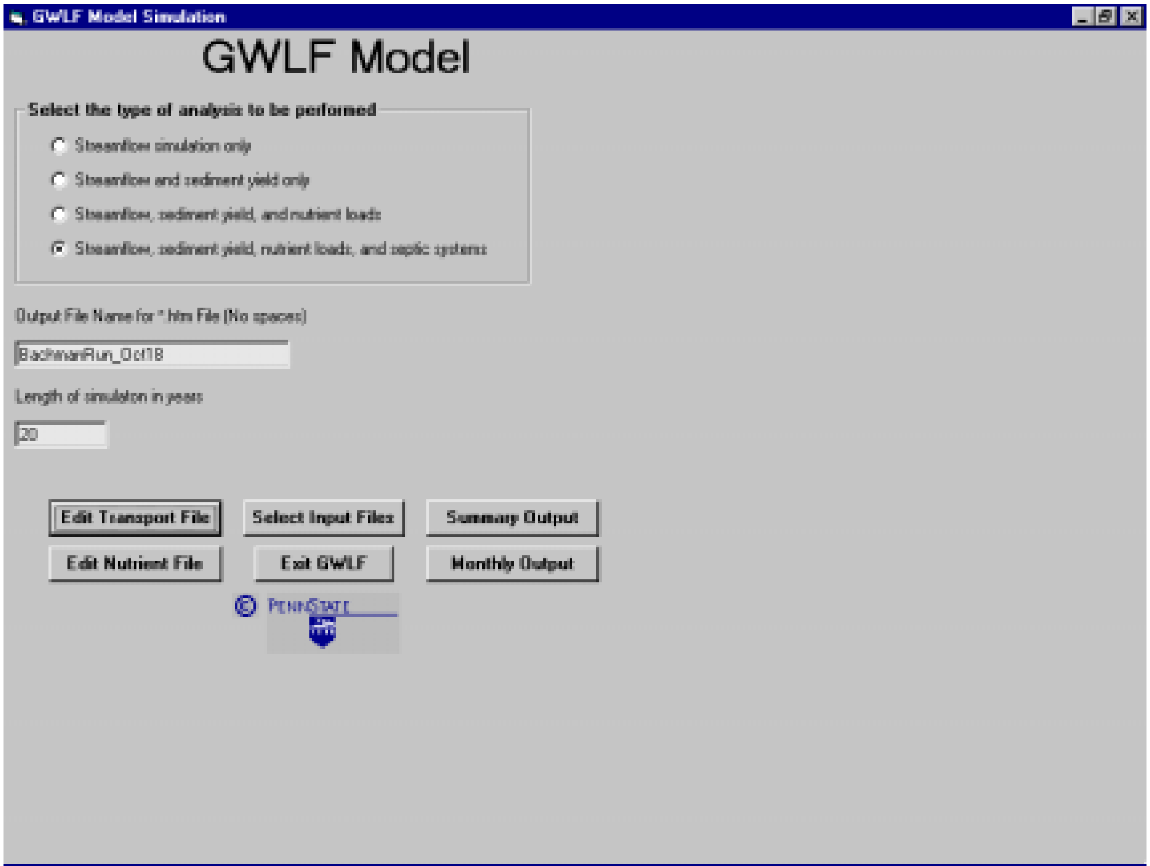
Month	ET	Day Hrs	Season	Eros Coef
APR	0.7252	13	0	0.300
MAY	0.9879	14	1	0.300
JUN	1.1521	15	1	0.300
JUL	1.2547	15	1	0.300
AUG	1.3188	14	1	0.300
SEP	1.3589	12	1	0.120
OCT	1.1507	11	0	0.120
NOV	1.0205	10	0	0.120
DEC	0.9392	9	0	0.120
JAN	0.4822	9	0	0.120
FEB	0.6027	10	0	0.120
MAR	0.6781	12	0	0.120

Antecedent Moisture Condition

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

Init Unsat Stor (cm) 10
Init Sat Stor (cm) 0
Recess Coef (l/day) 0.10029
Seepage Coef (l/day) 0
Initial Snow (cm) 0
Sed Del Ratio 0.103
Unsat Avail Wat (cm) 7.8449

APPENDIX E - AVGWLF MODEL OUTPUTS FOR BACHMAN RUN, BECK CREEK, KILLINGER CREEK, AND SNITZ CREEK WATERSHEDS

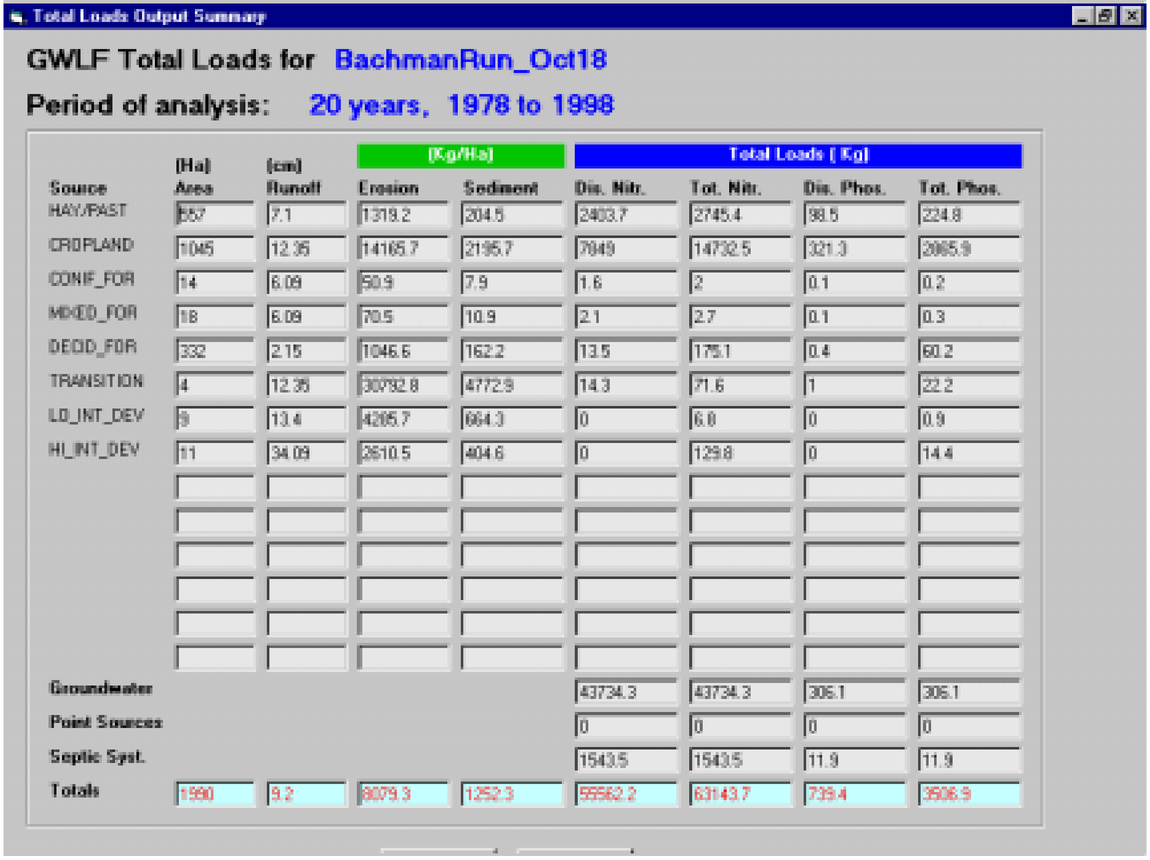


Select the type of analysis to be performed

- ○ Streamflow simulation only
- ○ Streamflow and sediment yield only
- ○ Streamflow, sediment yield, and nutrient loads
- ● Streamflow, sediment yield, nutrient loads, and septic systems

Output File Name for *.htm File (No spaces): BachmanRun_Oct18

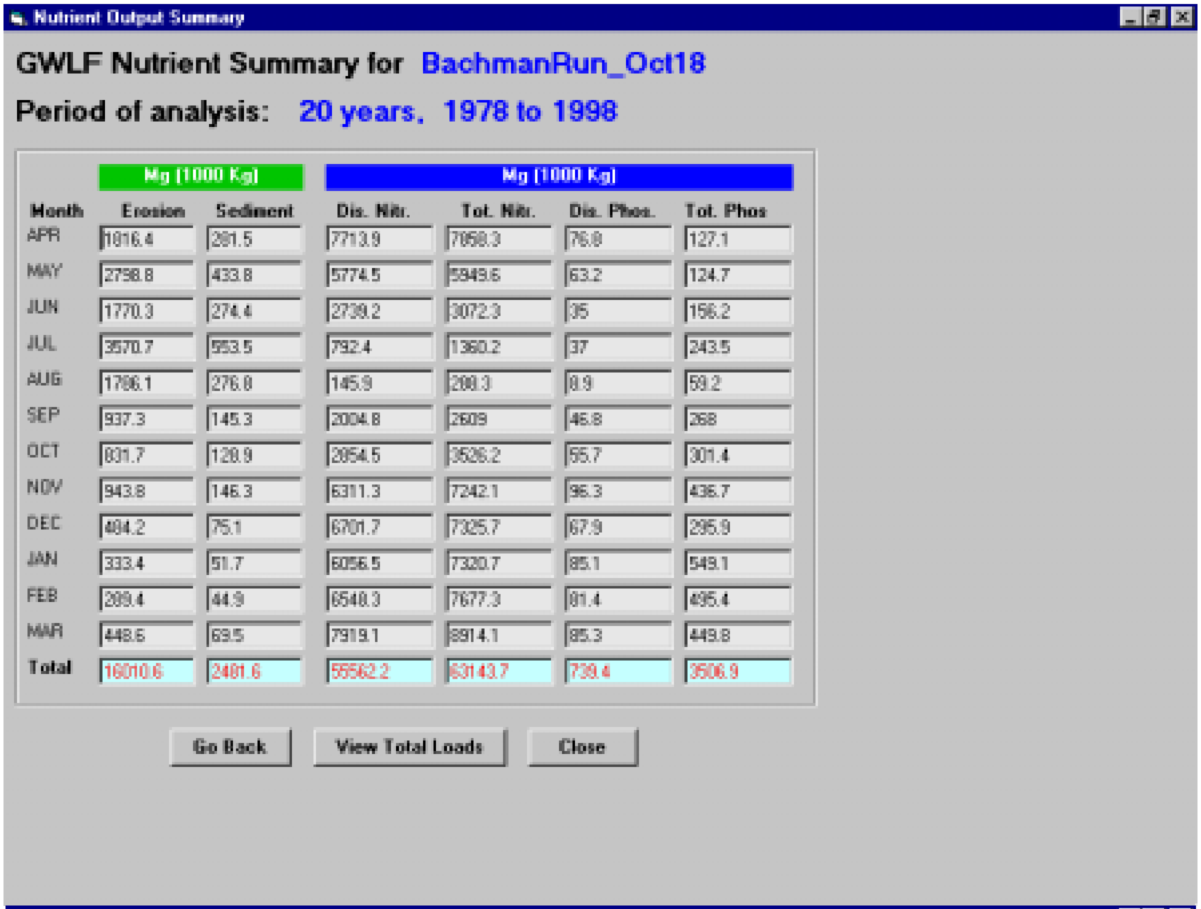
Length of simulaton in years: 20



GWLF Total Loads for BachmanRun_Oct18

Period of analysis: 20 years, 1978 to 1998

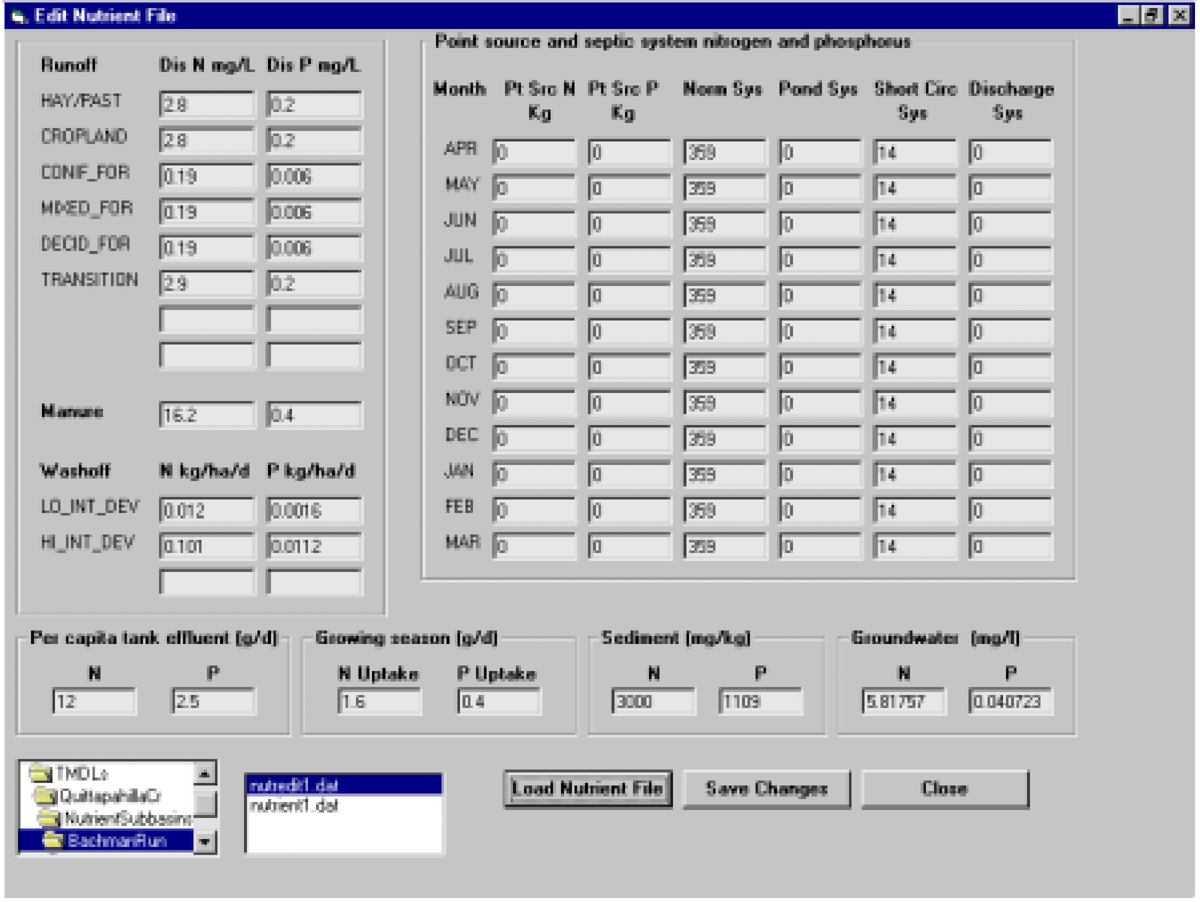
	(Ha)	(cm)	(Kg/Ha)		Total Loads (Kg)			
Source	Area	Runoff	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
HAY/PAST	557	7.1	1319.2	204.5	2403.7	2745.4	98.5	224.8
CROPLAND	1045	12.35	14165.7	2195.7	7049	14732.5	321.3	2065.9
CONIF_FOR	14	6.09	50.9	7.9	1.6	2	0.1	0.2
MIXED_FOR	18	6.09	70.5	10.9	2.1	2.7	0.1	0.3
DECID_FOR	332	2.15	1046.6	162.2	13.5	175.1	0.4	60.2
TRANSITION	4	12.35	30792.8	4772.9	14.3	71.6	1	22.2
LO_INT_DEV	9	13.4	4285.7	664.3	0	6.8	0	0.9
HI_INT_DEV	11	34.09	2610.5	404.6	0	129.8	0	14.4
Groundwater					43734.3	43734.3	306.1	306.1
Point Sources					0	0	0	0
Septic Syst.					1543.5	1543.5	11.9	11.9
Totals	1990	9.2	8079.3	1252.3	55562.2	63143.7	739.4	3506.9



GWLF Nutrient Summary for BachmanRun_Oct18

Period of analysis: 20 years, 1978 to 1998

	Mg (1000 Kg)		Mg (1000 Kg)			
Month	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos
APR	1816.4	281.5	7713.9	7858.3	76.8	127.1
MAY	2798.8	433.8	5774.5	5949.6	63.2	124.7
JUN	1770.3	274.4	2739.2	3072.3	35	156.2
JUL	3570.7	553.5	792.4	1360.2	37	243.5
AUG	1786.1	276.8	145.9	288.3	8.9	59.2
SEP	937.3	145.3	2004.8	2609	46.8	268
OCT	831.7	128.9	2854.5	3526.2	55.7	301.4
NOV	943.8	146.3	6311.3	7242.1	96.3	436.7
DEC	484.2	75.1	6701.7	7325.7	67.9	295.9
JAN	333.4	51.7	6056.5	7320.7	85.1	549.1
FEB	289.4	44.9	6548.3	7677.3	81.4	495.4
MAR	448.6	69.5	7919.1	8914.1	85.3	449.8
Total	16010.6	2481.6	55562.2	63143.7	739.4	3506.9



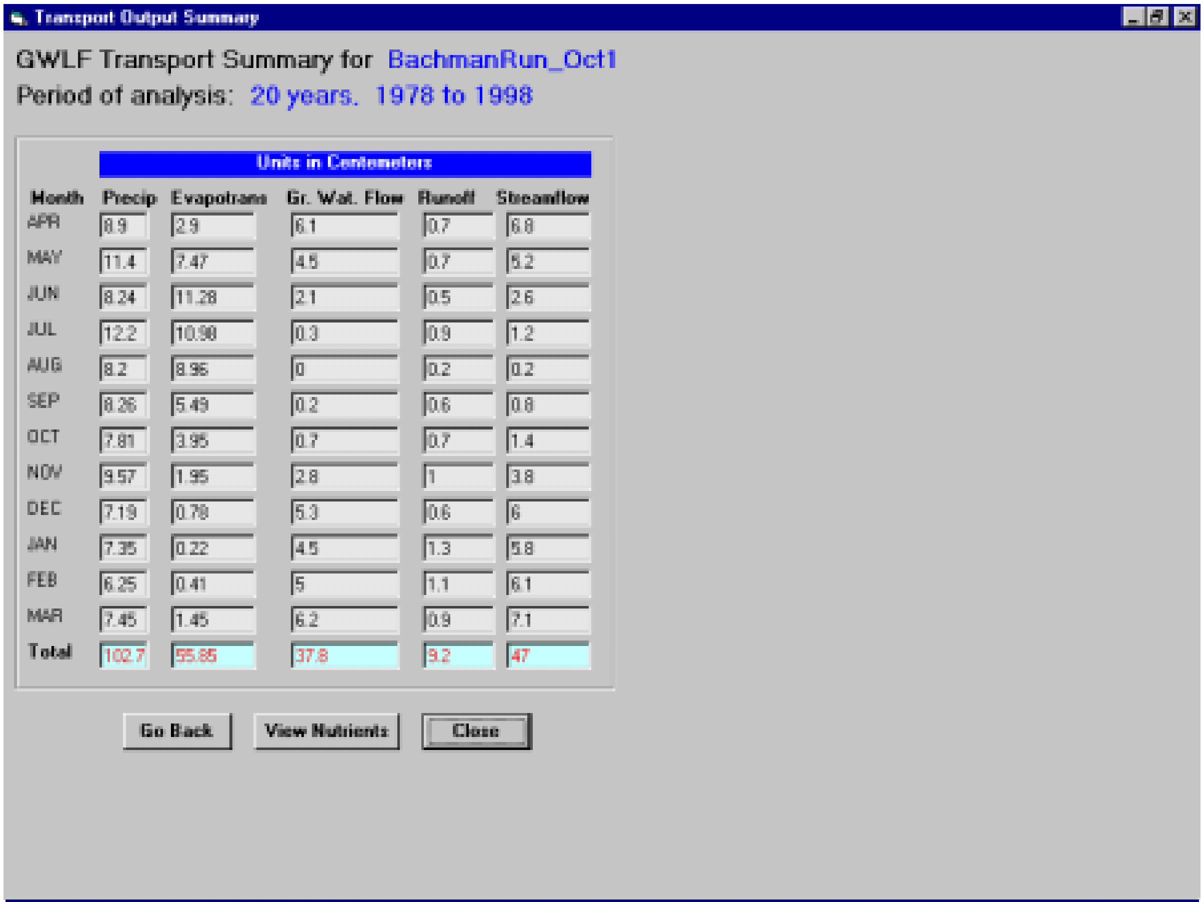
Runoff	Dis N mg/L	Dis P mg/L
HAY/PAST	2.8	0.2
CROPLAND	2.8	0.2
CONIF_FOR	0.19	0.006
MIXED_FOR	0.19	0.006
DECID_FOR	0.19	0.006
TRANSITION	2.9	0.2
Manure	16.2	0.4

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	359	0	14	0
MAY	0	0	359	0	14	0
JUN	0	0	359	0	14	0
JUL	0	0	359	0	14	0
AUG	0	0	359	0	14	0
SEP	0	0	359	0	14	0
OCT	0	0	359	0	14	0
NOV	0	0	359	0	14	0
DEC	0	0	359	0	14	0
JAN	0	0	359	0	14	0
FEB	0	0	359	0	14	0
MAR	0	0	359	0	14	0

Per capita tank effluent (g/d)		Growing season (g/d)		Sediment (mg/kg)		Groundwater (mg/l)	
N	P	N Uptake	P Uptake	N	P	N	P
12	2.5	1.6	0.4	3000	1109	5.81757	0.040723

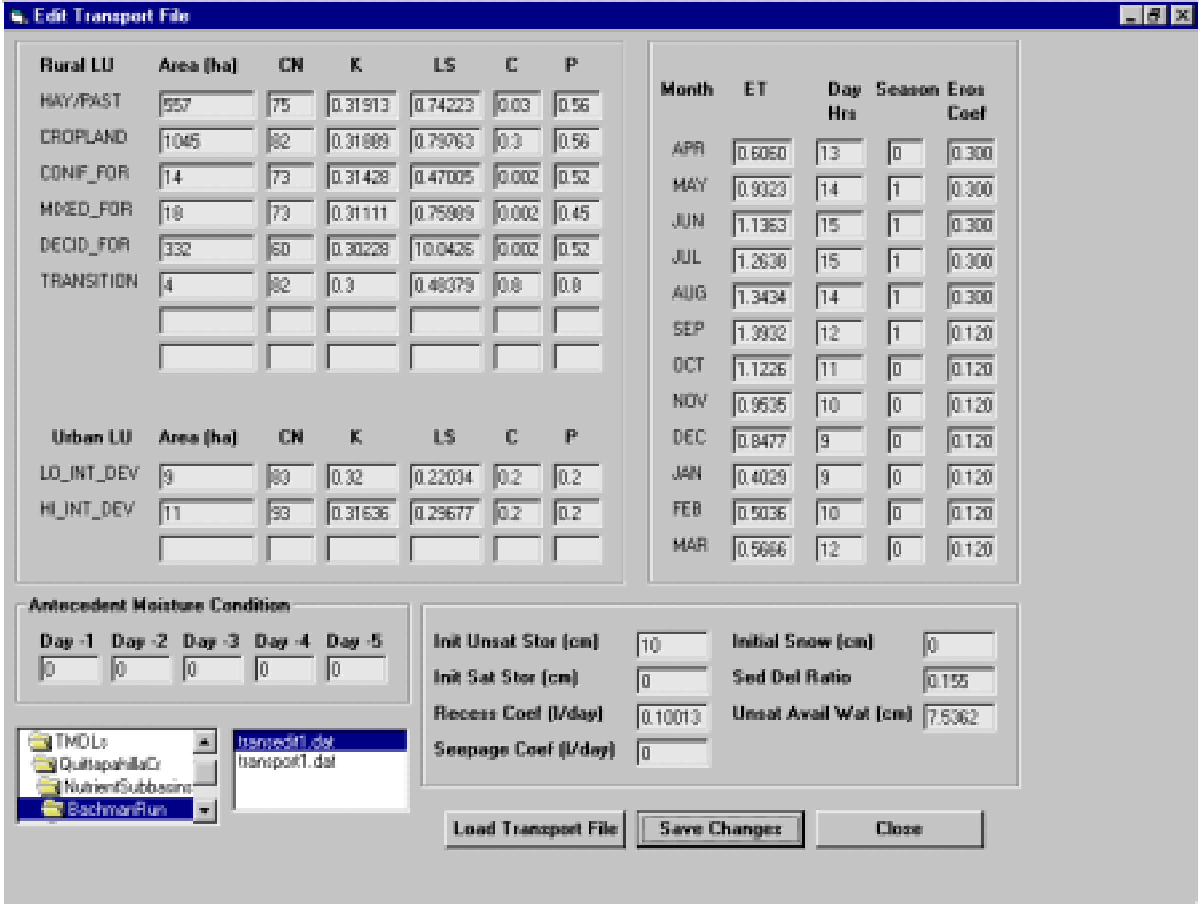


GWLF Transport Summary for BachmanRun_Oct1

Period of analysis: 20 years. 1978 to 1998

Units in Centemeters

Month	Precip	Evapotrans	Gr. Wat. Flow	Runoff	Streamflow
APR	8.9	2.9	6.1	0.7	6.8
MAY	11.4	7.47	4.5	0.7	5.2
JUN	8.24	11.28	2.1	0.5	2.6
JUL	12.2	10.98	0.3	0.9	1.2
AUG	8.2	8.96	0	0.2	0.2
SEP	8.26	5.49	0.2	0.6	0.8
OCT	7.81	3.95	0.7	0.7	1.4
NOV	9.57	1.95	2.8	1	3.8
DEC	7.19	0.78	5.3	0.6	6
JAN	7.35	0.22	4.5	1.3	5.8
FEB	6.25	0.41	5	1.1	6.1
MAR	7.45	1.45	6.2	0.9	7.1
Total	102.7	55.85	37.8	9.2	47



Rural LU	Area (ha)	CN	K	LS	C	P
HAY/PAST	557	75	0.31913	0.74223	0.03	0.56
CROPLAND	1045	82	0.31889	0.79763	0.3	0.56
CONIF_FOR	14	73	0.31428	0.47005	0.002	0.52
MIXED_FOR	18	73	0.31111	0.75989	0.002	0.45
DECID_FOR	332	60	0.30228	10.0426	0.002	0.52
TRANSITION	4	82	0.3	0.48079	0.8	0.8

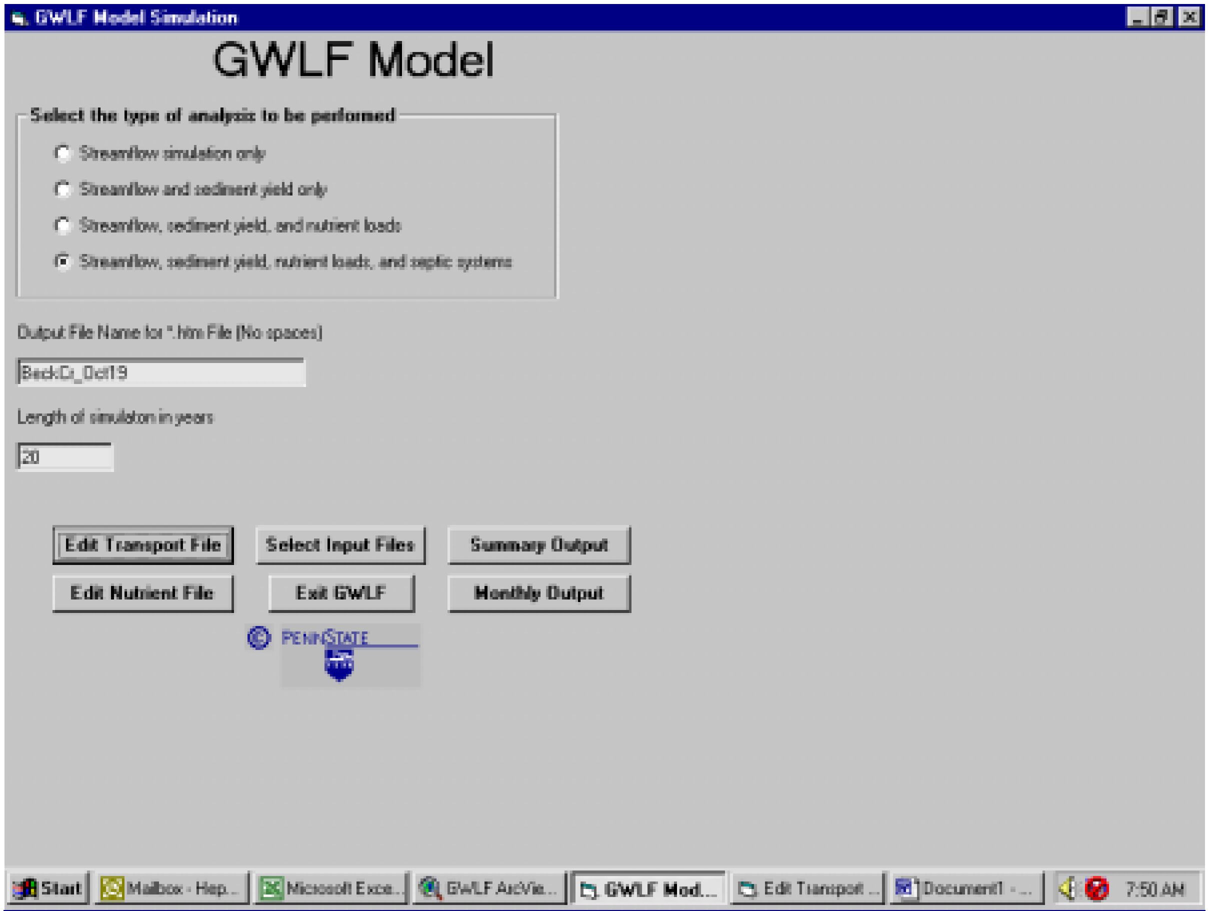
Urban LU	Area (ha)	CN	K	LS	C	P
LO_INT_DEV	9	83	0.32	0.22034	0.2	0.2
HI_INT_DEV	11	93	0.31636	0.29677	0.2	0.2

Month	ET	Day Hrs	Season	Eros Coef
APR	0.6060	13	0	0.300
MAY	0.9323	14	1	0.300
JUN	1.1363	15	1	0.300
JUL	1.2638	15	1	0.300
AUG	1.3434	14	1	0.300
SEP	1.3932	12	1	0.120
OCT	1.1226	11	0	0.120
NOV	0.9535	10	0	0.120
DEC	0.8477	9	0	0.120
JAN	0.4029	9	0	0.120
FEB	0.5036	10	0	0.120
MAR	0.5866	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	0.155
Recess Coef (l/day)	0.10013	Unsat Avail Wat (cm)	7.5362
Seepage Coef (l/day)	0		



GWLF Model

Select the type of analysis to be performed

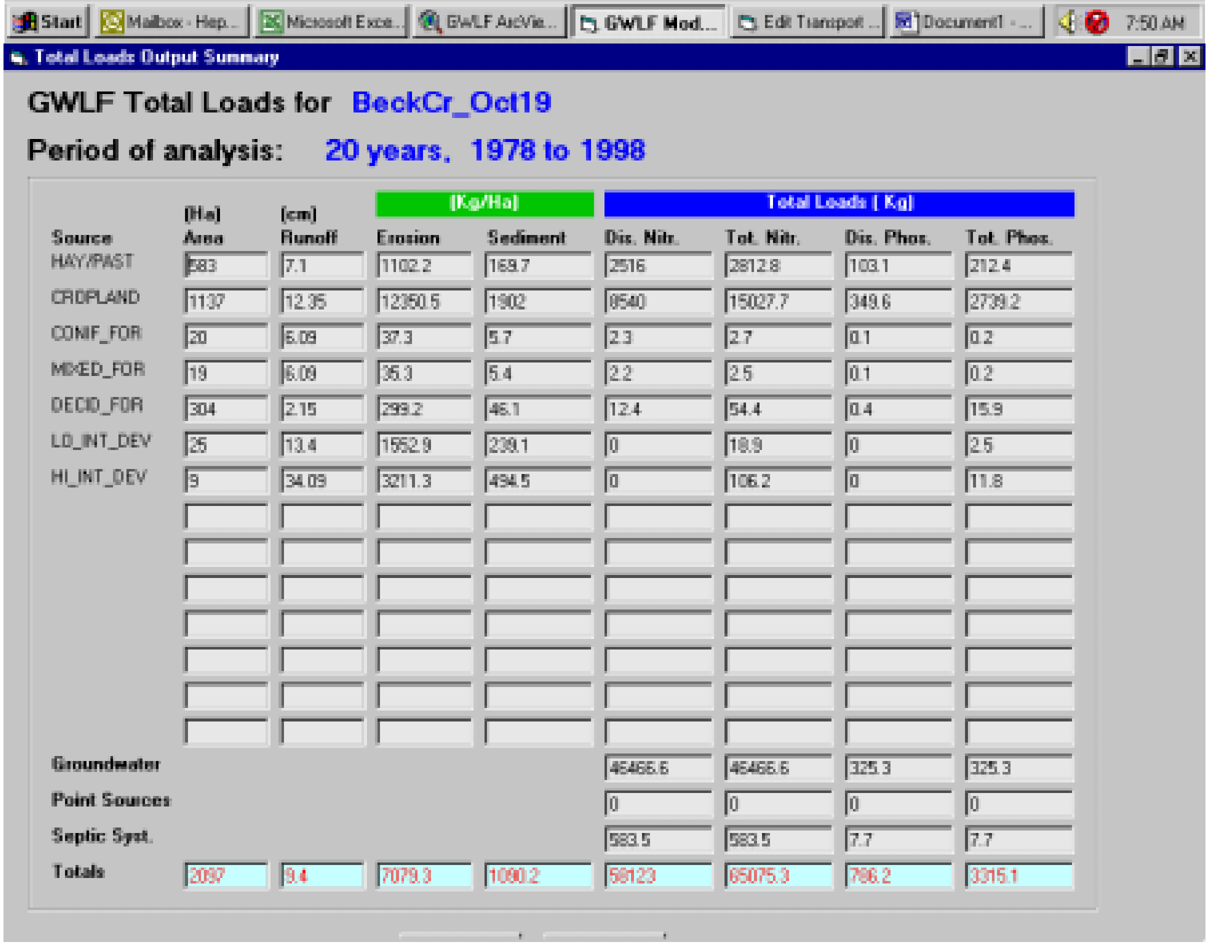
○ Streamflow simulation only
○ Streamflow and sediment yield only
○ Streamflow, sediment yield, and nutrient loads
● Streamflow, sediment yield, nutrient loads, and septic systems

Output File Name for *.htm File (No spaces)

BeckCr_Oct19

Length of simulation in years

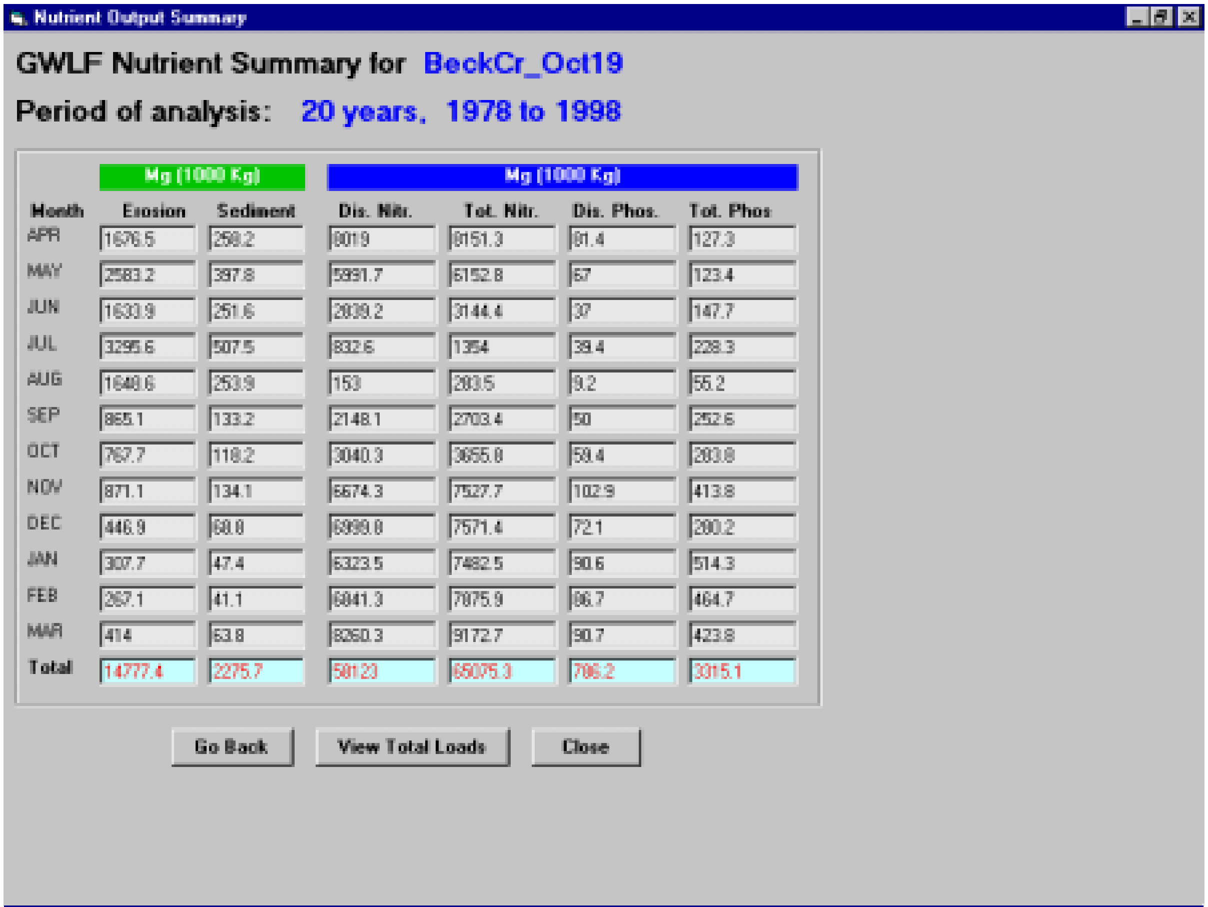
20



GWLF Total Loads for BeckCr_Oct19

Period of analysis: 20 years, 1978 to 1998

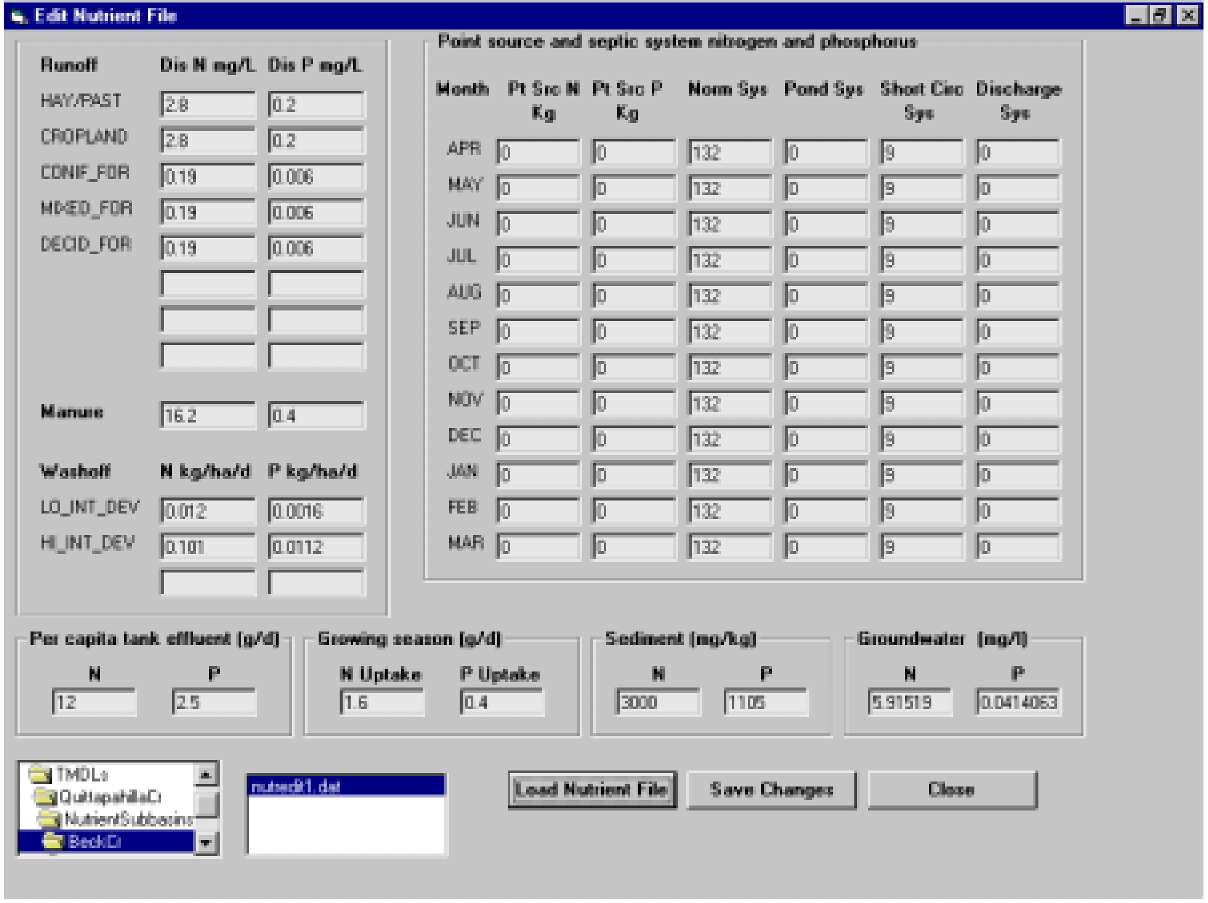
	(Ha)	(cm)	(Kg/Ha)		Total Loads (Kg)			
Source	**Area**	**Runoff**	**Erosion**	**Sediment**	**Dis. Nitr.**	**Tot. Nitr.**	**Dis. Phos.**	**Tot. Phos.**
HAY/PAST	583	7.1	1102.2	169.7	2516	2812.8	103.1	212.4
CROPLAND	1137	12.35	12350.5	1902	8540	15027.7	349.6	2739.2
CONIF_FOR	20	6.09	37.3	5.7	2.3	2.7	0.1	0.2
MIXED_FOR	19	6.09	35.3	5.4	2.2	2.5	0.1	0.2
DECID_FOR	304	2.15	299.2	46.1	12.4	54.4	0.4	15.9
LO_INT_DEV	25	13.4	1552.9	239.1	0	18.9	0	2.5
HI_INT_DEV	9	34.09	3211.3	494.5	0	106.2	0	11.8
Groundwater					46466.6	46466.6	325.3	325.3
Point Sources					0	0	0	0
Septic Syst.					583.5	583.5	7.7	7.7
Totals	2097	9.4	7079.3	1090.2	58123	65075.3	786.2	3315.1



GWLF Nutrient Summary for BeckCr_Oct19

Period of analysis: 20 years, 1978 to 1998

	Mg (1000 Kg)		Mg (1000 Kg)			
Month	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos
APR	1676.5	258.2	8019	8151.3	81.4	127.3
MAY	2583.2	397.8	5991.7	6152.8	67	123.4
JUN	1633.9	251.6	2839.2	3144.4	37	147.7
JUL	3295.6	507.5	832.6	1354	39.4	228.3
AUG	1648.6	253.9	153	283.5	9.2	55.2
SEP	865.1	133.2	2148.1	2703.4	50	252.6
OCT	767.7	118.2	3040.3	3655.8	59.4	283.8
NOV	871.1	134.1	6674.3	7527.7	102.9	413.8
DEC	446.9	68.8	6999.8	7571.4	72.1	280.2
JAN	307.7	47.4	6323.5	7482.5	90.6	514.3
FEB	267.1	41.1	6841.3	7875.9	86.7	464.7
MAR	414	63.8	8260.3	9172.7	90.7	423.8
Total	14777.4	2275.7	58123	65075.3	786.2	3015.1

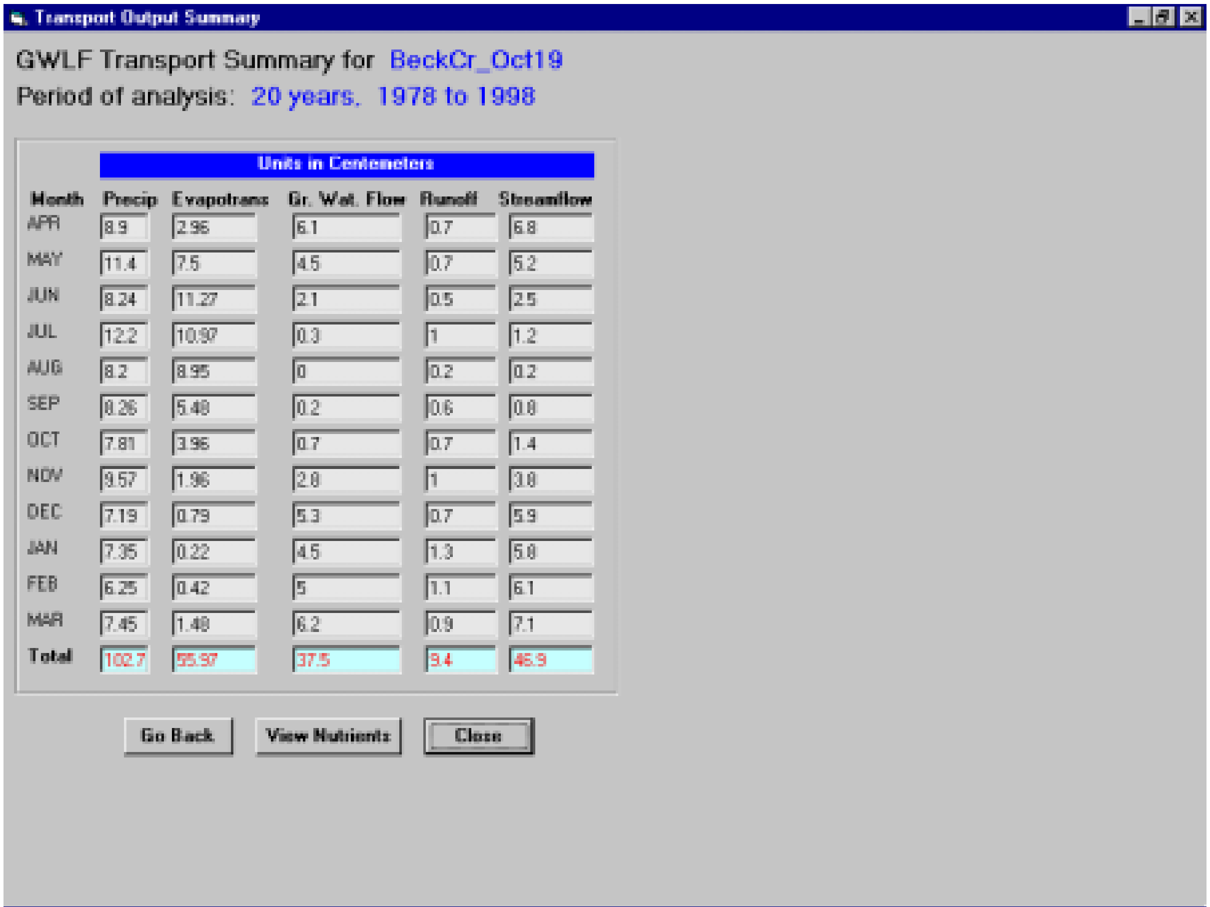


Runoff	Dis N mg/L	Dis P mg/L
HAY/PAST	2.8	0.2
CROPLAND	2.8	0.2
CONIF_FOR	0.19	0.006
MIXED_FOR	0.19	0.006
DECID_FOR	0.19	0.006
Manure	16.2	0.4
Washoff	N kg/ha/d	P kg/ha/d
LO_INT_DEV	0.012	0.0016
HI_INT_DEV	0.101	0.0112

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	132	0	9	0
MAY	0	0	132	0	9	0
JUN	0	0	132	0	9	0
JUL	0	0	132	0	9	0
AUG	0	0	132	0	9	0
SEP	0	0	132	0	9	0
OCT	0	0	132	0	9	0
NOV	0	0	132	0	9	0
DEC	0	0	132	0	9	0
JAN	0	0	132	0	9	0
FEB	0	0	132	0	9	0
MAR	0	0	132	0	9	0

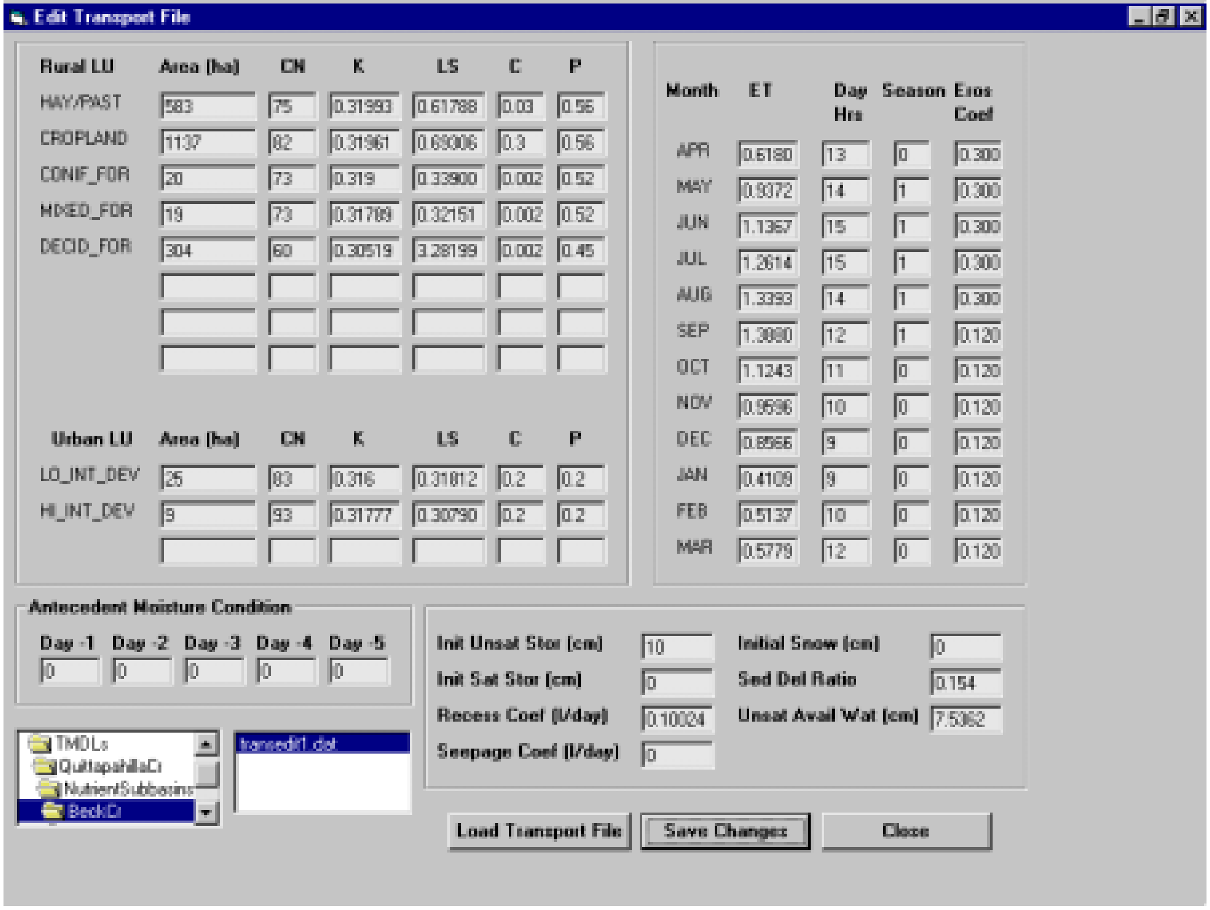
Per capita tank effluent (g/d)		Growing season (g/d)		Sediment (mg/kg)		Groundwater (mg/l)	
N	P	N Uptake	P Uptake	N	P	N	P
12	2.5	1.6	0.4	3000	1105	5.91519	0.0414063



GWLF Transport Summary for BeckCr_Oct19
Period of analysis: 20 years, 1978 to 1998

Units in Centemeters

Month	Precip	Evapotrans	Gr. Wat. Flow	Runoff	Streamflow
APR	8.9	2.96	6.1	0.7	6.8
MAY	11.4	7.5	4.5	0.7	5.2
JUN	8.24	11.27	2.1	0.5	2.5
JUL	12.2	10.97	0.3	1	1.2
AUG	8.2	8.95	0	0.2	0.2
SEP	8.26	5.48	0.2	0.6	0.8
OCT	7.81	3.96	0.7	0.7	1.4
NOV	9.57	1.96	2.8	1	3.8
DEC	7.19	0.79	5.3	0.7	5.9
JAN	7.35	0.22	4.5	1.3	5.8
FEB	6.25	0.42	5	1.1	6.1
MAR	7.45	1.48	6.2	0.9	7.1
Total	102.7	55.97	37.5	9.4	46.9



Rural LU	Area (ha)	CN	K	LS	C	P
HAY/PAST	583	75	0.31993	0.61788	0.03	0.56
CROPLAND	1137	82	0.31961	0.69006	0.3	0.56
CONIF_FOR	20	73	0.319	0.33900	0.002	0.52
MIXED_FOR	19	73	0.31789	0.32151	0.002	0.52
DECID_FOR	304	60	0.30519	3.28199	0.002	0.45

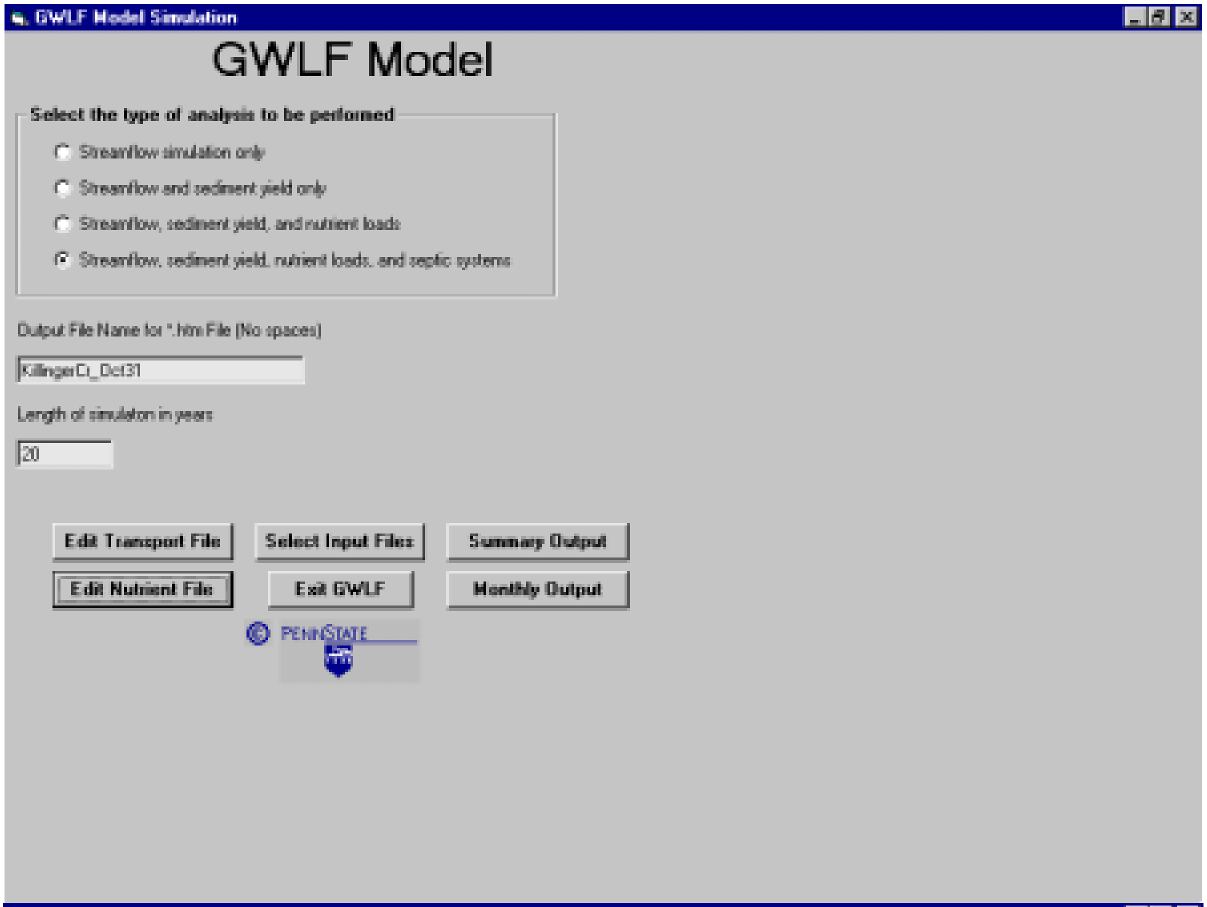
Urban LU	Area (ha)	CN	K	LS	C	P
LO_INT_DEV	25	83	0.316	0.31812	0.2	0.2
HI_INT_DEV	9	93	0.31777	0.30790	0.2	0.2

Month	ET	Day Hrs	Season	Eros Coef
APR	0.6180	13	0	0.300
MAY	0.9072	14	1	0.300
JUN	1.1367	15	1	0.300
JUL	1.2614	15	1	0.300
AUG	1.3393	14	1	0.300
SEP	1.3080	12	1	0.120
OCT	1.1243	11	0	0.120
NOV	0.9696	10	0	0.120
DEC	0.8566	9	0	0.120
JAN	0.4109	9	0	0.120
FEB	0.5137	10	0	0.120
MAR	0.5779	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
Init Sat Stor (cm) 0
Recess Coef (l/day) 0.10024
Seepage Coef (l/day) 0
Initial Snow (cm) 0
Sed Del Ratio 0.154
Unsat Avail Wat (cm) 7.5362



Select the type of analysis to be performed

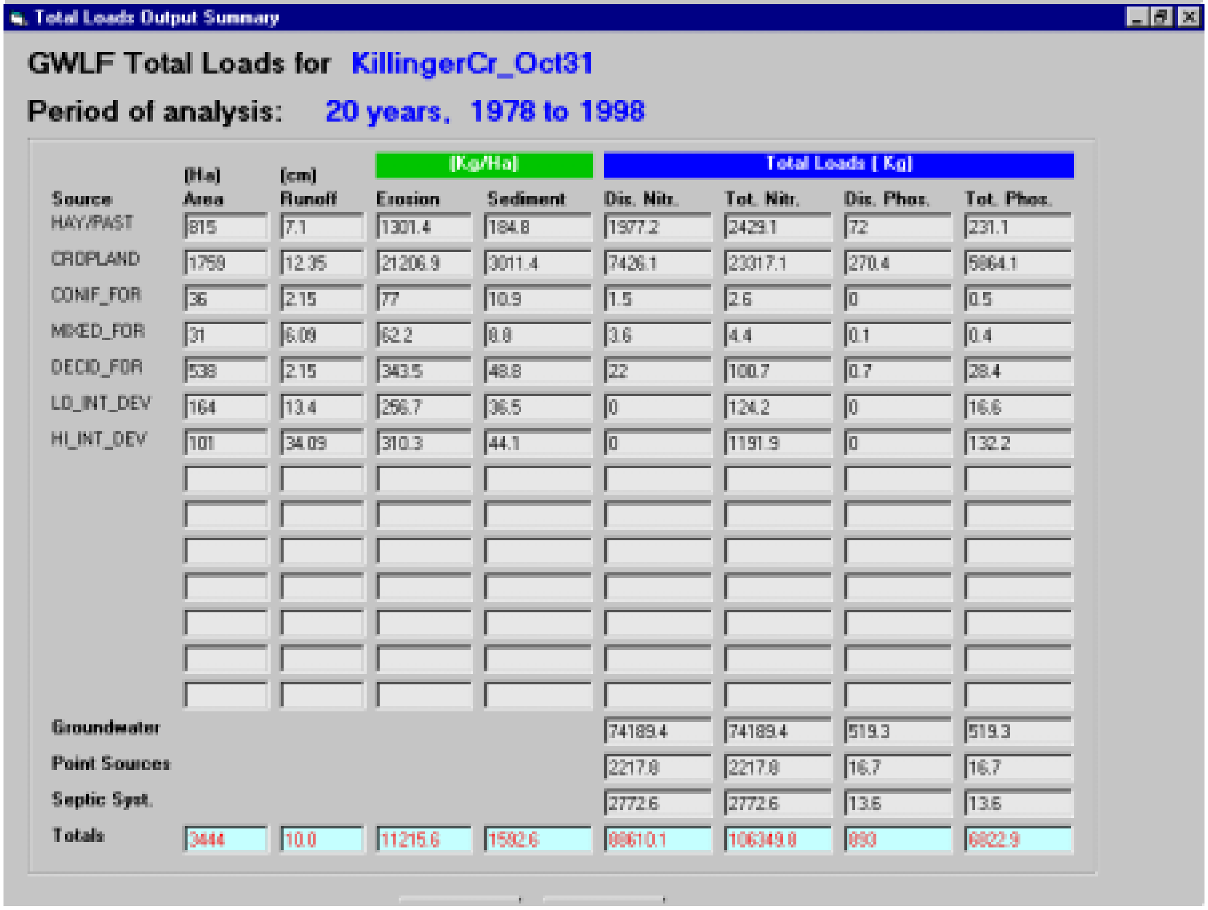
○ Streamflow simulation only
○ Streamflow and sediment yield only
○ Streamflow, sediment yield, and nutrient loads
● Streamflow, sediment yield, nutrient loads, and septic systems

Output File Name for *.htm File (No spaces)

KillingerCr_Oct31

Length of simulation in years

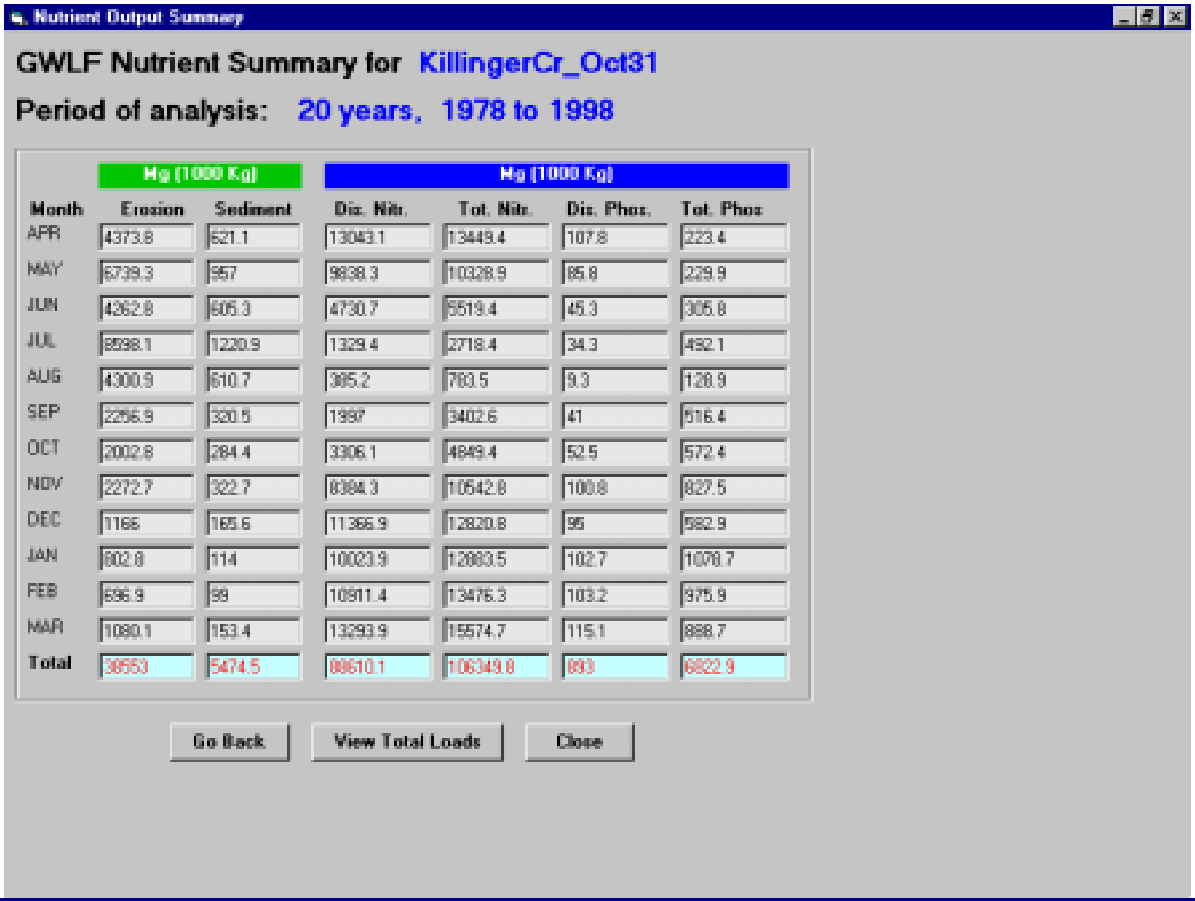
20



GWLF Total Loads for KillingerCr_Oct31

Period of analysis: 20 years, 1978 to 1998

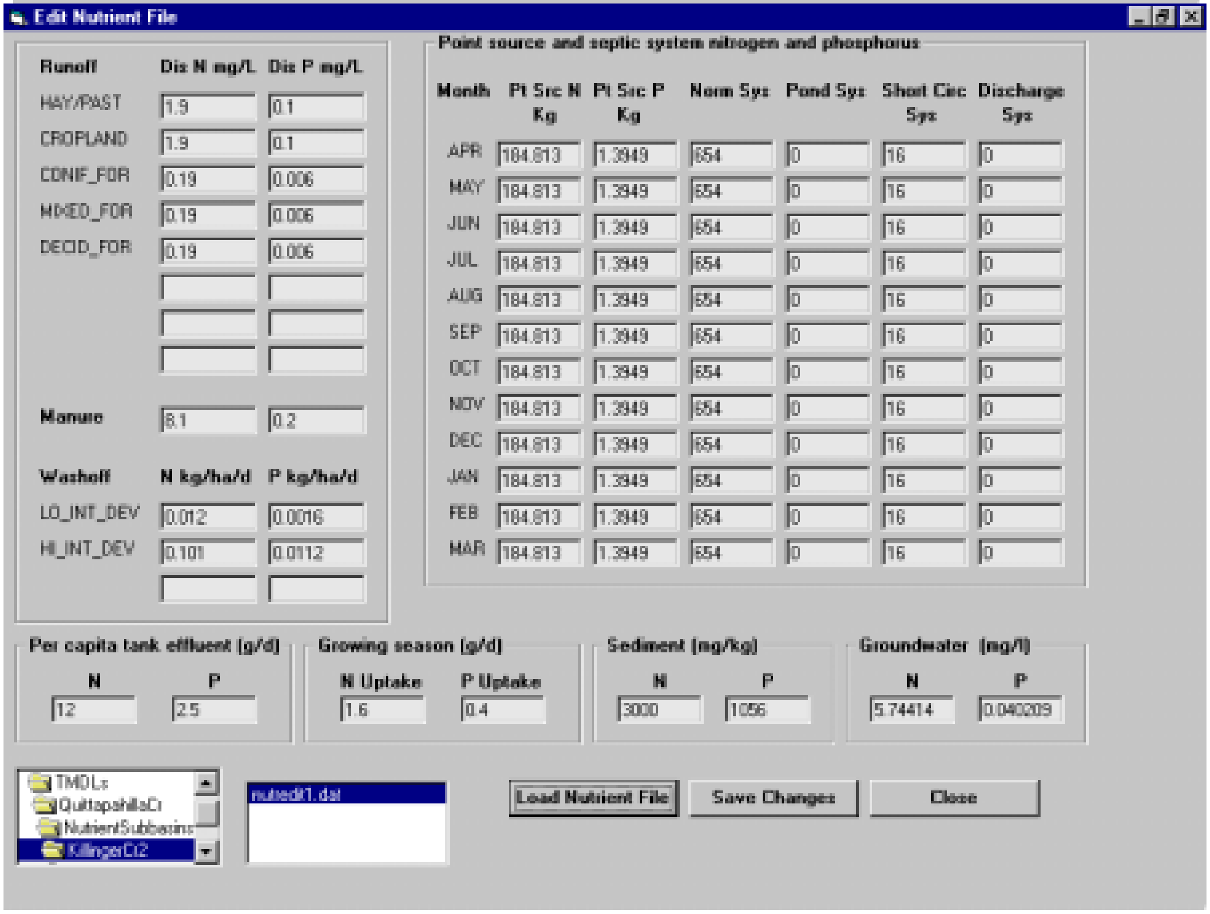
	(Ha)	(cm)	(Kg/Ha)		Total Loads (Kg)			
Source	Area	Runoff	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
HAY/PAST	815	7.1	1301.4	184.8	1977.2	2429.1	72	231.1
CROPLAND	1759	12.35	21206.9	3011.4	7426.1	23317.1	270.4	5864.1
CONIF_FOR	36	2.15	77	10.9	1.5	2.6	0	0.5
MIXED_FOR	31	6.09	62.2	8.8	3.6	4.4	0.1	0.4
DECID_FOR	538	2.15	343.5	48.8	22	100.7	0.7	28.4
LO_INT_DEV	164	13.4	256.7	36.5	0	124.2	0	16.6
HI_INT_DEV	101	34.09	310.3	44.1	0	1191.9	0	132.2
Groundwater					74189.4	74189.4	519.3	519.3
Point Sources					2217.8	2217.8	16.7	16.7
Septic Syst.					2772.6	2772.6	13.6	13.6
Totals	3444	10.0	11215.6	1592.6	88610.1	106349.8	893	6822.9



GWLF Nutrient Summary for KillingerCr_Oct31

Period of analysis: 20 years, 1978 to 1998

	Mg (1000 Kg)		Mg (1000 Kg)			
Month	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos
APR	4373.8	621.1	13043.1	13449.4	107.8	223.4
MAY	6739.3	957	9838.3	10328.9	85.8	229.9
JUN	4262.8	605.3	4730.7	5519.4	45.3	305.8
JUL	8598.1	1220.9	1329.4	2718.4	34.3	492.1
AUG	4300.9	610.7	385.2	783.5	9.3	128.9
SEP	2256.9	320.5	1997	3402.6	41	516.4
OCT	2002.8	284.4	3306.1	4849.4	52.5	572.4
NOV	2272.7	322.7	8384.3	10542.8	100.8	827.5
DEC	1166	165.6	11366.9	12820.8	95	582.9
JAN	802.8	114	10023.9	12883.5	102.7	1078.7
FEB	696.9	99	10911.4	13476.3	103.2	975.9
MAR	1080.1	153.4	13293.9	15574.7	115.1	888.7
Total	38553	5474.5	88610.1	106349.8	893	6822.9

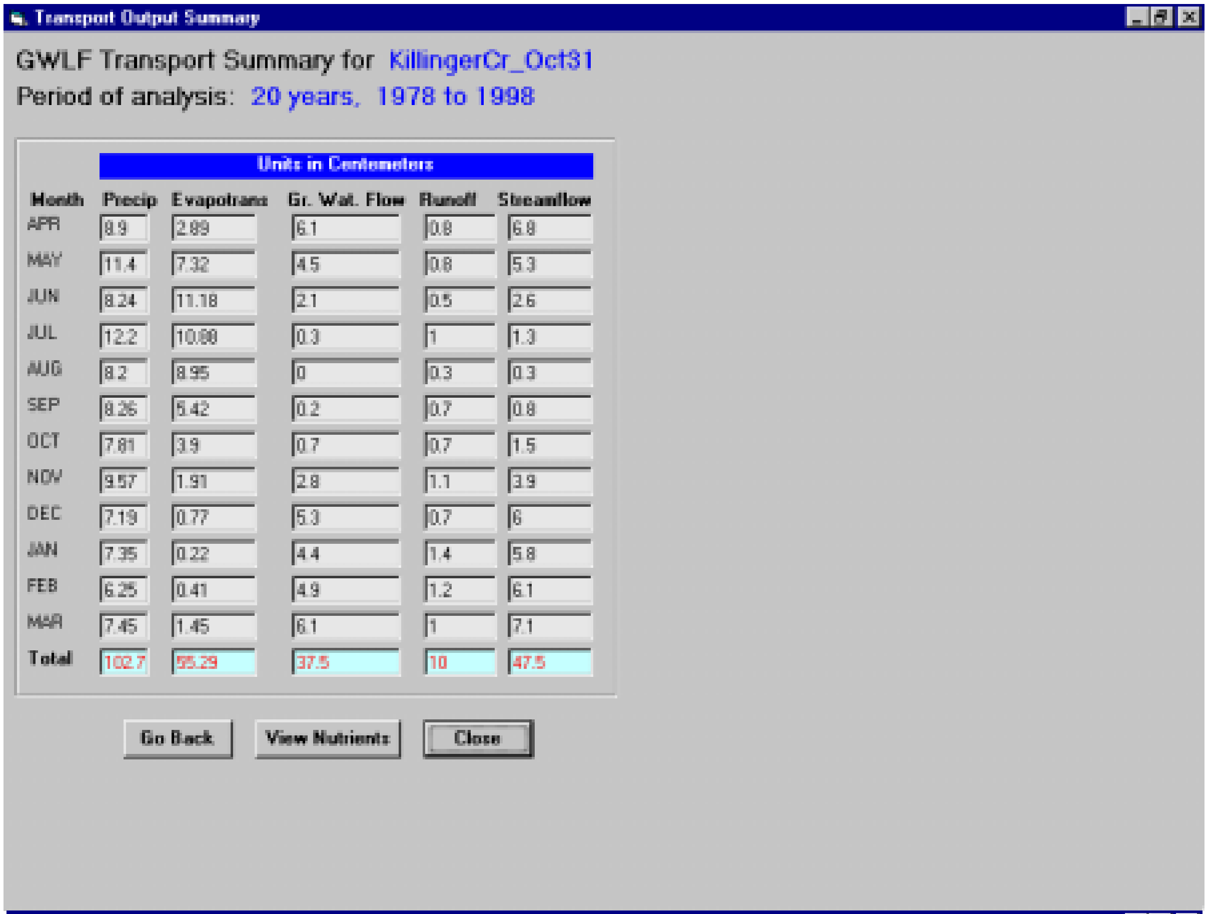


Runoff	Dis N mg/L	Dis P mg/L
HAY/PAST	1.9	0.1
CROPLAND	1.9	0.1
CONIF_FOR	0.19	0.006
MIXED_FOR	0.19	0.006
DECID_FOR	0.19	0.006
Manure	8.1	0.2
Washoff	**N kg/ha/d**	**P kg/ha/d**
LO_INT_DEV	0.012	0.0016
HI_INT_DEV	0.101	0.0112

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	184.813	1.3949	654	0	16	0
MAY	184.813	1.3949	654	0	16	0
JUN	184.813	1.3949	654	0	16	0
JUL	184.813	1.3949	654	0	16	0
AUG	184.813	1.3949	654	0	16	0
SEP	184.813	1.3949	654	0	16	0
OCT	184.813	1.3949	654	0	16	0
NOV	184.813	1.3949	654	0	16	0
DEC	184.813	1.3949	654	0	16	0
JAN	184.813	1.3949	654	0	16	0
FEB	184.813	1.3949	654	0	16	0
MAR	184.813	1.3949	654	0	16	0

Per capita tank effluent (g/d)		Growing season (g/d)		Sediment (mg/kg)		Groundwater (mg/l)	
N	P	N Uptake	P Uptake	N	P	N	P
12	2.5	1.6	0.4	3000	1056	5.74414	0.040209

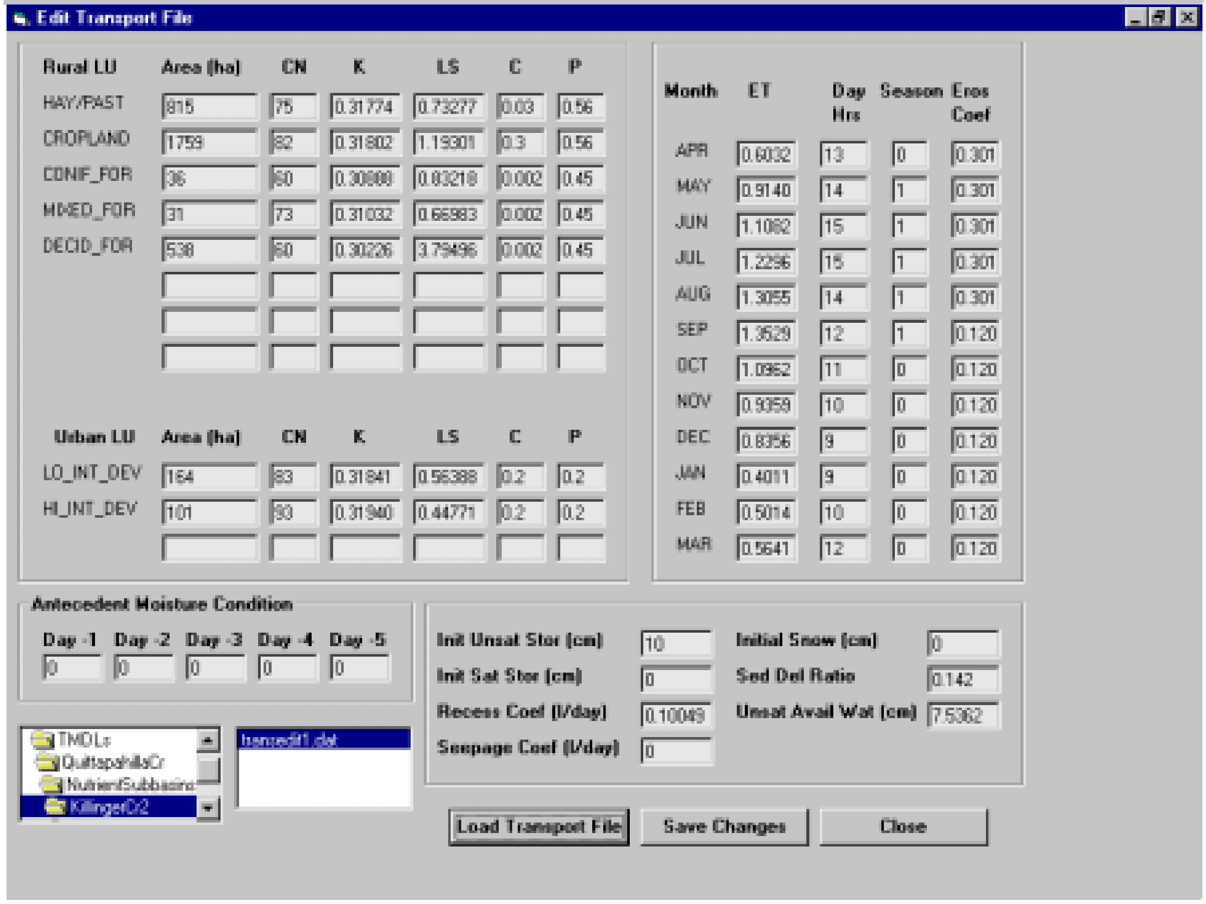


GWLF Transport Summary for KillingerCr_Oct31

Period of analysis: 20 years, 1978 to 1998

Units in Centemeters

Month	Precip	Evapotrans	Gr. Wat. Flow	Runoff	Streamflow
APR	8.9	2.89	6.1	0.8	6.8
MAY	11.4	7.32	4.5	0.8	5.3
JUN	8.24	11.18	2.1	0.5	2.6
JUL	12.2	10.88	0.3	1	1.3
AUG	8.2	8.95	0	0.3	0.3
SEP	8.26	5.42	0.2	0.7	0.8
OCT	7.81	3.9	0.7	0.7	1.5
NOV	9.57	1.91	2.8	1.1	3.9
DEC	7.19	0.77	5.3	0.7	6
JAN	7.35	0.22	4.4	1.4	5.8
FEB	6.25	0.41	4.9	1.2	6.1
MAR	7.45	1.45	6.1	1	7.1
Total	102.7	55.29	37.5	10	47.5



Rural LU	Area (ha)	CN	K	LS	C	P
HAY/PAST	815	75	0.31774	0.73277	0.03	0.56
CROPLAND	1759	82	0.31802	1.19301	0.3	0.56
CONIF_FOR	36	60	0.30888	0.83218	0.002	0.45
MIXED_FOR	31	73	0.31032	0.66983	0.002	0.45
DECID_FOR	538	60	0.30226	3.79496	0.002	0.45

Urban LU	Area (ha)	CN	K	LS	C	P
LO_INT_DEV	164	83	0.31841	0.56388	0.2	0.2
HI_INT_DEV	101	93	0.31940	0.44771	0.2	0.2

Month	ET	Day Hrs	Season	Eros Coef
APR	0.6032	13	0	0.301
MAY	0.9140	14	1	0.301
JUN	1.1082	15	1	0.301
JUL	1.2296	15	1	0.301
AUG	1.3055	14	1	0.301
SEP	1.3529	12	1	0.120
OCT	1.0962	11	0	0.120
NOV	0.9359	10	0	0.120
DEC	0.8356	9	0	0.120
JAN	0.4011	9	0	0.120
FEB	0.5014	10	0	0.120
MAR	0.5641	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

Init Sat Stor (cm) 0

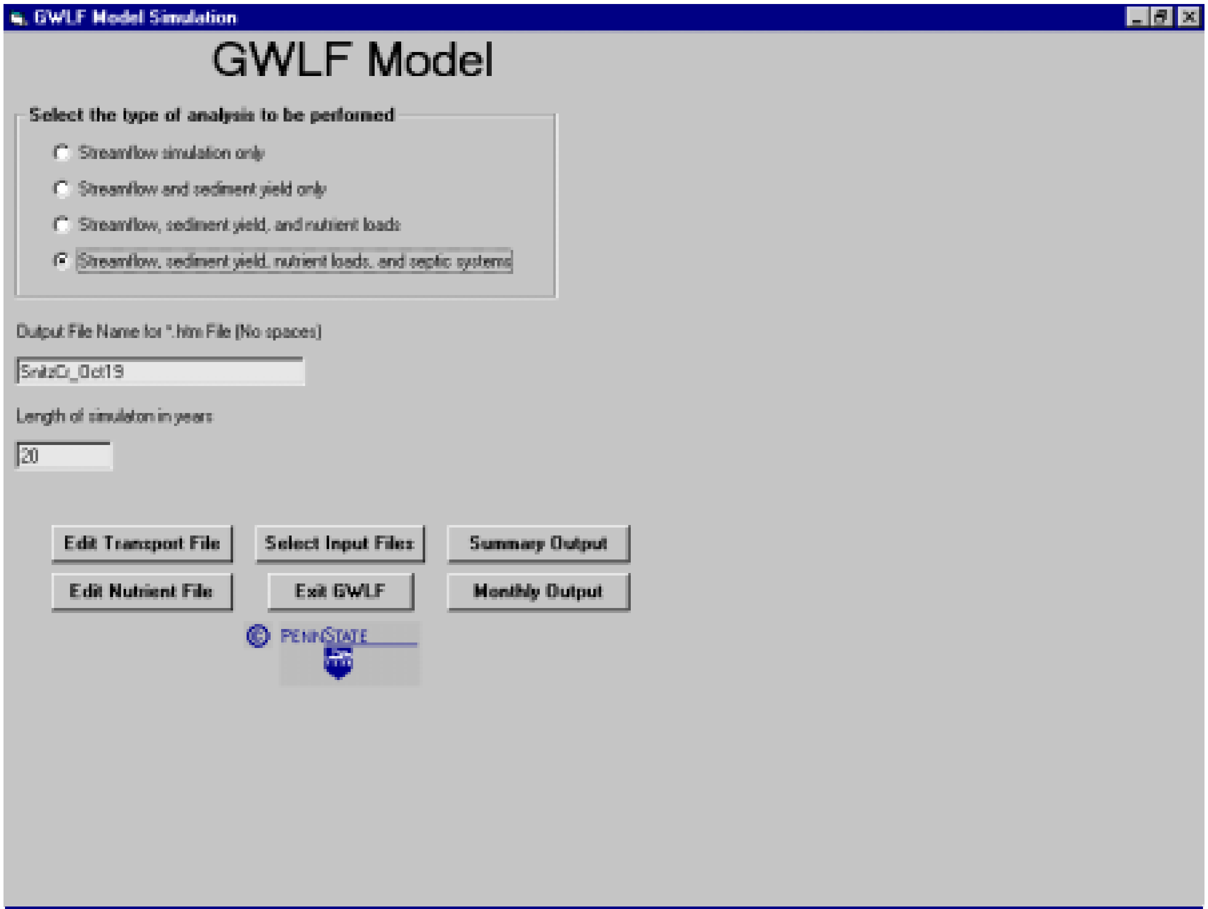
Recess Coef (l/day) 0.10049

Seepage Coef (l/day) 0

Initial Snow (cm) 0

Sed Del Ratio 0.142

Unsat Avail Wat (cm) 7.5362



GWLF Model

Select the type of analysis to be performed

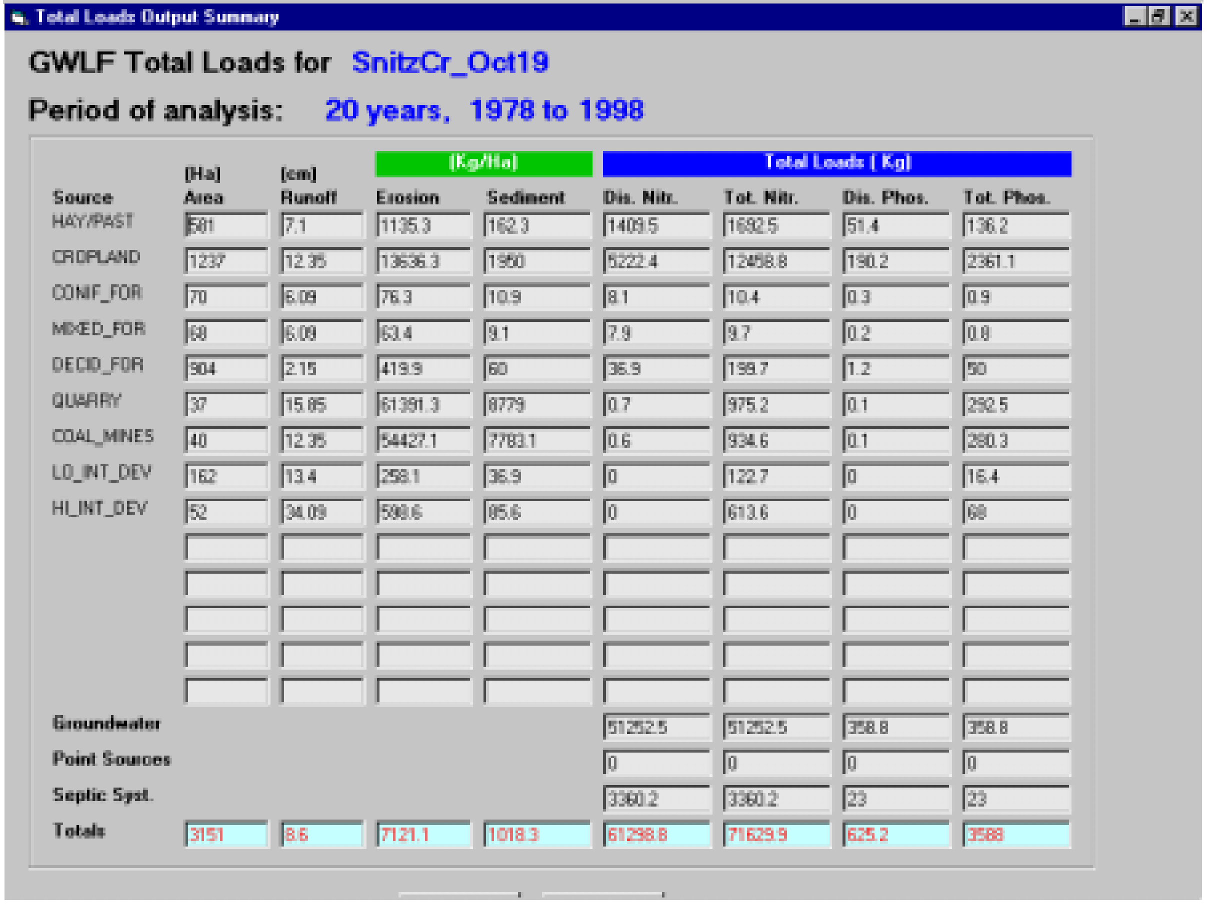
○ Streamflow simulation only
○ Streamflow and sediment yield only
○ Streamflow, sediment yield, and nutrient loads
● Streamflow, sediment yield, nutrient loads, and septic systems

Output File Name for *.htm File (No spaces)

SnitzCr_Oct19

Length of simulation in years

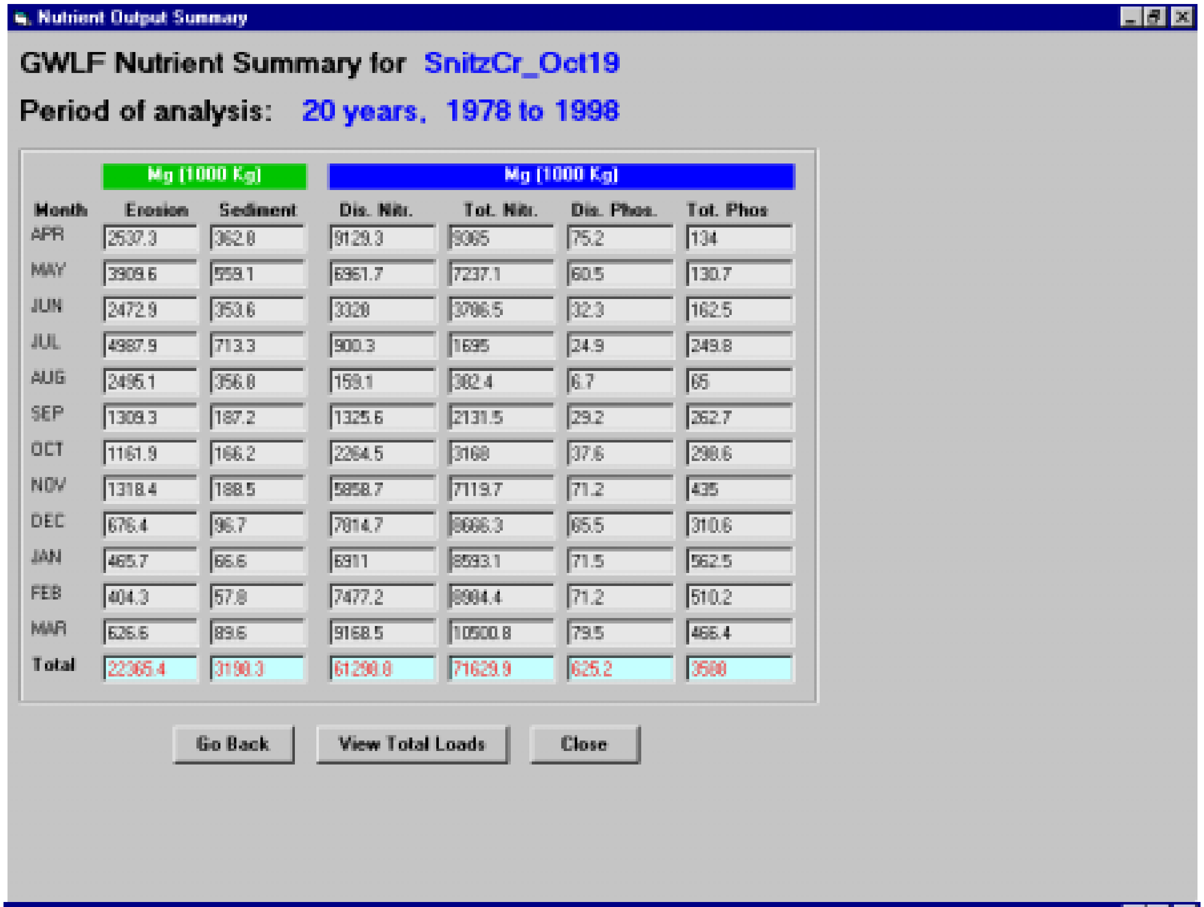
20



GWLF Total Loads for SnitzCr_Oct19

Period of analysis: 20 years, 1978 to 1998

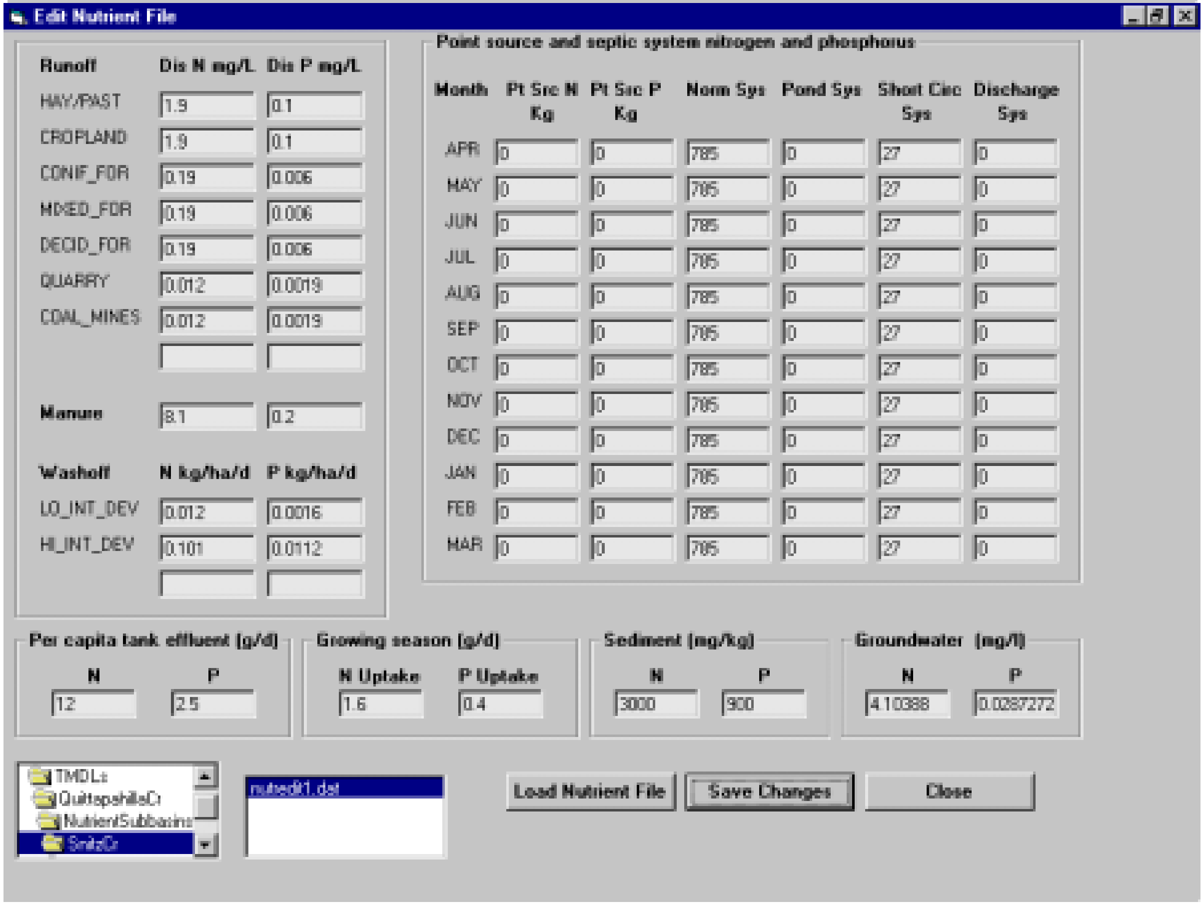
	(Ha)	(cm)	(Kg/Ha)		Total Loads (Kg)			
Source	Area	Runoff	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
HAY/PAST	581	7.1	1135.3	162.3	1409.5	1692.5	51.4	136.2
CROPLAND	1237	12.35	13636.3	1950	5222.4	12458.8	190.2	2361.1
CONIF_FOR	70	6.09	76.3	10.9	8.1	10.4	0.3	0.9
MIXED_FOR	68	6.09	63.4	9.1	7.9	9.7	0.2	0.8
DECID_FOR	904	2.15	419.9	60	36.9	199.7	1.2	50
QUARRY	37	15.85	61391.3	8779	0.7	975.2	0.1	292.5
COAL_MINES	40	12.35	54427.1	7783.1	0.6	934.6	0.1	280.3
LO_INT_DEV	162	13.4	258.1	36.9	0	122.7	0	16.4
HI_INT_DEV	52	34.09	598.6	85.6	0	613.6	0	68
Groundwater					51252.5	51252.5	358.8	358.8
Point Sources					0	0	0	0
Septic Syst.					3360.2	3360.2	23	23
Totals	3151	8.6	7121.1	1018.3	61298.8	71629.9	625.2	3588



GWLF Nutrient Summary for SnitzCr_Oct19

Period of analysis: 20 years, 1978 to 1998

	Mg (1000 Kg)		Mg (1000 Kg)			
Month	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos
APR	2537.3	362.8	9129.3	9385	75.2	134
MAY	3909.6	559.1	6961.7	7237.1	60.5	130.7
JUN	2472.9	353.6	3328	3706.5	32.3	162.5
JUL	4987.9	713.3	900.3	1695	24.9	249.8
AUG	2495.1	356.8	159.1	382.4	6.7	65
SEP	1309.3	187.2	1325.6	2131.5	29.2	262.7
OCT	1161.9	166.2	2264.5	3168	37.6	298.6
NOV	1318.4	188.5	5858.7	7119.7	71.2	435
DEC	676.4	96.7	7814.7	8686.3	85.5	310.6
JAN	465.7	66.6	6911	8593.1	71.5	562.5
FEB	404.3	57.8	7477.2	8984.4	71.2	510.2
MAR	626.6	89.6	9168.5	10500.8	79.5	466.4
Total	22365.4	3198.3	61298.8	71629.9	625.2	3588



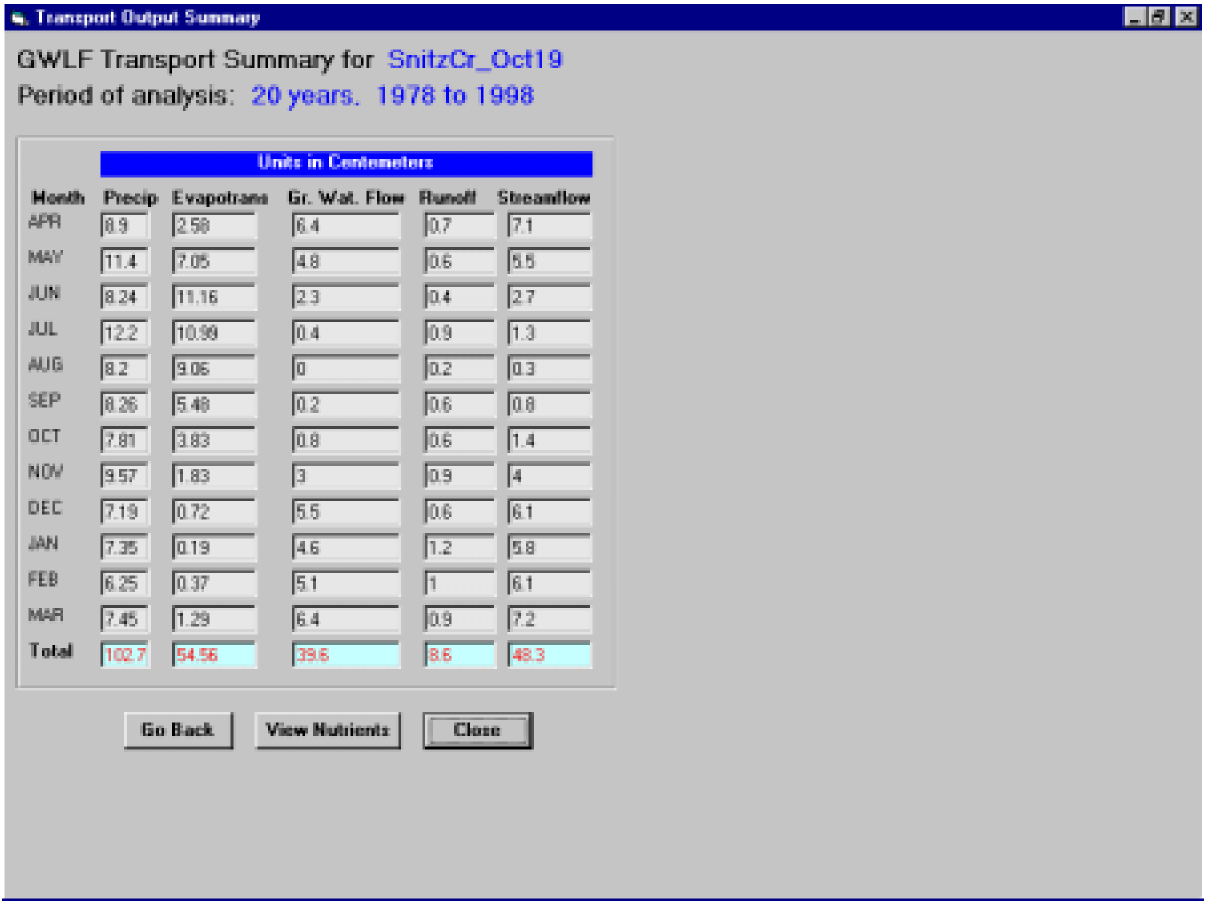
Runoff	Dis N mg/L	Dis P mg/L
HAY/PAST	1.9	0.1
CROPLAND	1.9	0.1
CONIF_FOR	0.19	0.006
MIXED_FOR	0.19	0.006
DECID_FOR	0.19	0.006
QUARRY	0.012	0.0019
COAL_MINES	0.012	0.0019
Manure	8.1	0.2

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	785	0	27	0
MAY	0	0	785	0	27	0
JUN	0	0	785	0	27	0
JUL	0	0	785	0	27	0
AUG	0	0	785	0	27	0
SEP	0	0	785	0	27	0
OCT	0	0	785	0	27	0
NOV	0	0	785	0	27	0
DEC	0	0	785	0	27	0
JAN	0	0	785	0	27	0
FEB	0	0	785	0	27	0
MAR	0	0	785	0	27	0

Per capita tank effluent (g/d)		Growing season (g/d)		Sediment (mg/kg)		Groundwater (mg/l)	
N	P	N Uptake	P Uptake	N	P	N	P
12	2.5	1.6	0.4	3000	900	4.10388	0.0287272

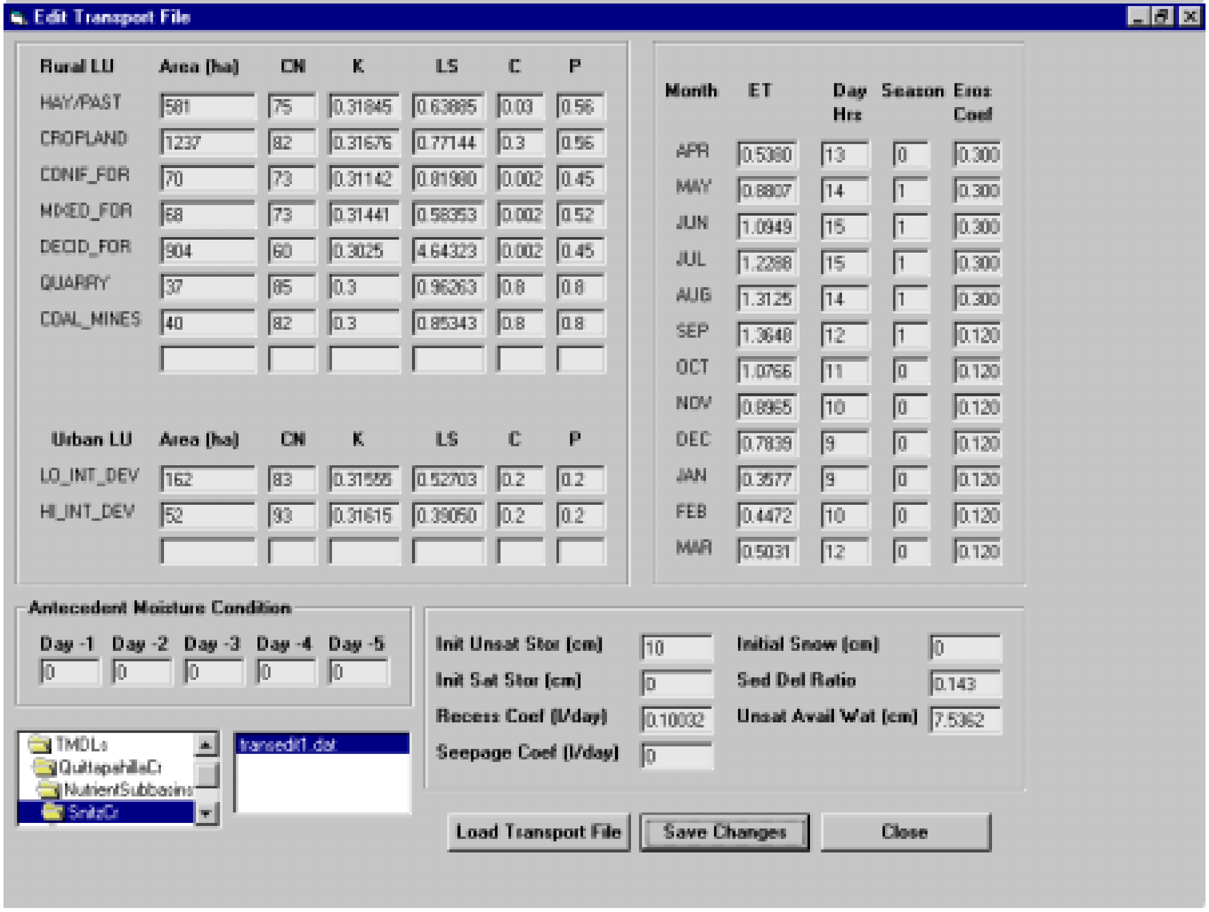


GWLF Transport Summary for SnitzCr_Oct19

Period of analysis: 20 years. 1978 to 1998

Units in Centemeters

Month	Precip	Evapotrans	Gr. Wat. Flow	Runoff	Streamflow
APR	8.9	2.58	6.4	0.7	7.1
MAY	11.4	7.05	4.8	0.6	5.5
JUN	8.24	11.16	2.3	0.4	2.7
JUL	12.2	10.98	0.4	0.9	1.3
AUG	8.2	9.06	0	0.2	0.3
SEP	8.26	5.48	0.2	0.6	0.8
OCT	7.81	3.83	0.8	0.6	1.4
NOV	9.57	1.83	3	0.9	4
DEC	7.19	0.72	5.5	0.6	6.1
JAN	7.35	0.19	4.6	1.2	5.8
FEB	6.25	0.37	5.1	1	6.1
MAR	7.45	1.29	6.4	0.9	7.2
Total	102.7	54.56	39.6	8.6	48.3



Rural LU	Area (ha)	CN	K	LS	C	P
HAY/PAST	581	75	0.31845	0.63885	0.03	0.56
CROPLAND	1237	82	0.31676	0.77144	0.3	0.56
CONIF_FOR	70	73	0.31142	0.81980	0.002	0.45
MIXED_FOR	68	73	0.31441	0.58353	0.002	0.52
DECID_FOR	904	60	0.3025	4.64323	0.002	0.45
QUARRY	37	85	0.3	0.96263	0.8	0.8
COAL_MINES	40	82	0.3	0.85343	0.8	0.8

Urban LU	Area (ha)	CN	K	LS	C	P
LO_INT_DEV	162	83	0.31555	0.52703	0.2	0.2
HI_INT_DEV	52	93	0.31615	0.39050	0.2	0.2

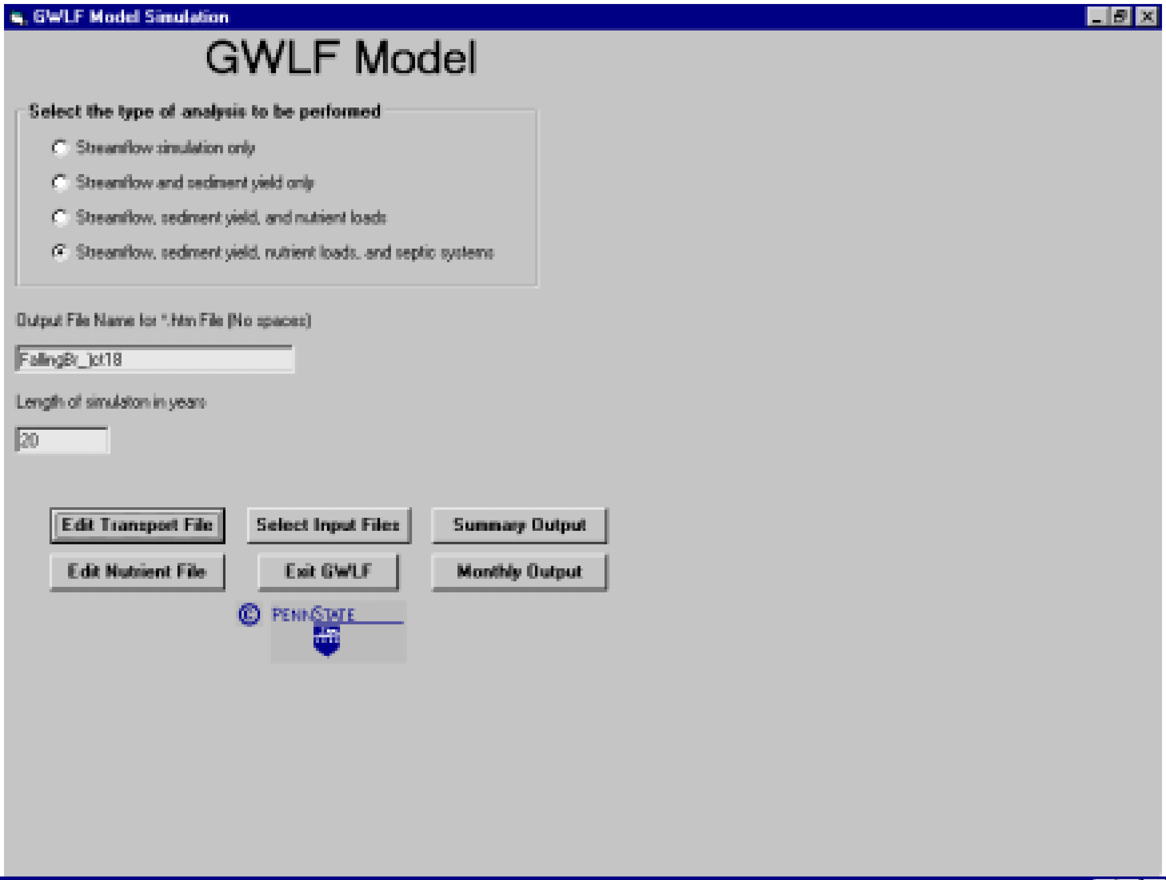
Month	ET	Day Hrs	Season	Eros Coef
APR	0.5380	13	0	0.300
MAY	0.8807	14	1	0.300
JUN	1.0949	15	1	0.300
JUL	1.2288	15	1	0.300
AUG	1.3125	14	1	0.300
SEP	1.3648	12	1	0.120
OCT	1.0766	11	0	0.120
NOV	0.8965	10	0	0.120
DEC	0.7839	9	0	0.120
JAN	0.3577	9	0	0.120
FEB	0.4472	10	0	0.120
MAR	0.5031	12	0	0.120

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	0.143
Recess Coef (l/day)	0.10032	Unsat Avail Wat (cm)	7.5362
Seepage Coef (l/day)	0		

APPENDIX F - AVGWLF MODEL OUTPUTS FOR FALLING BRANCH WATERSHED



Select the type of analysis to be performed

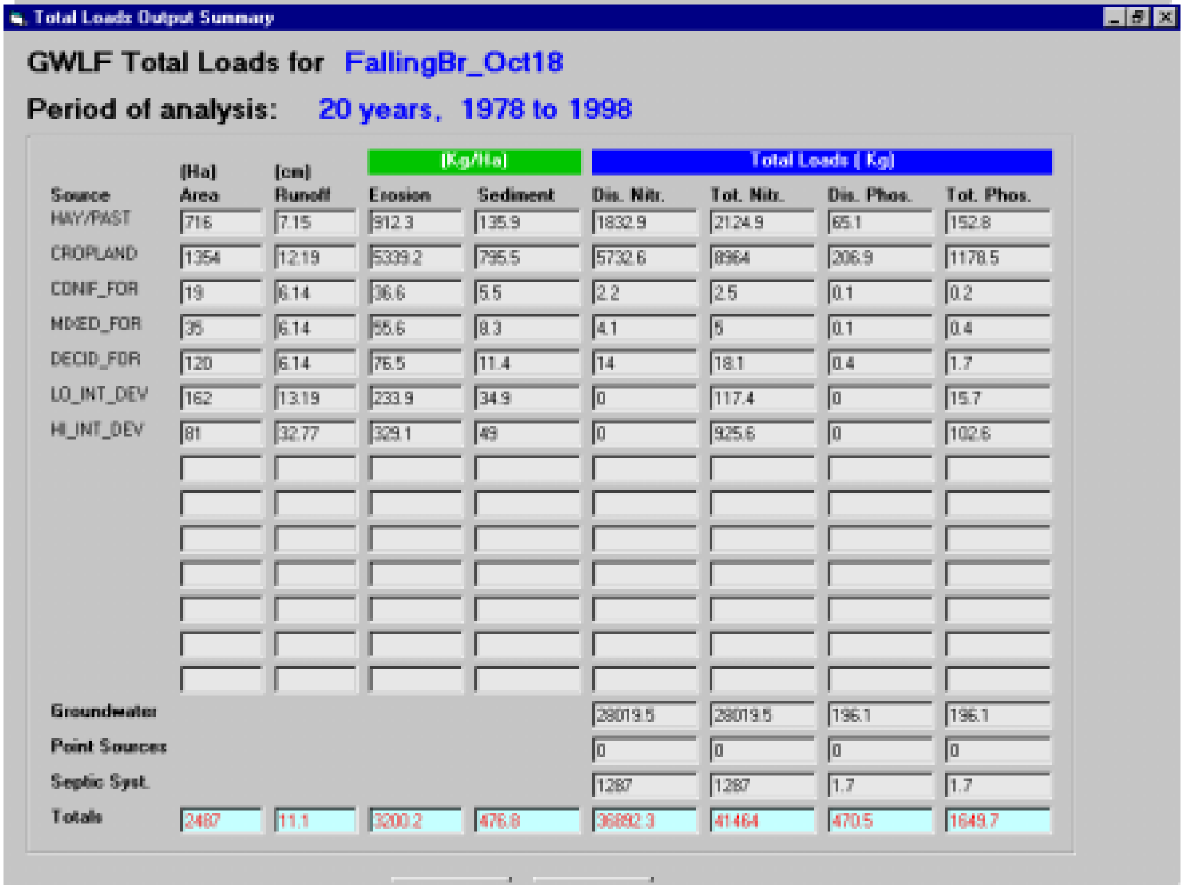
○ Streamflow simulation only
○ Streamflow and sediment yield only
○ Streamflow, sediment yield, and nutrient loads
● Streamflow, sediment yield, nutrient loads, and septic systems

Output File Name for *.htm File (No spaces)

FallingBr_Oct18

Length of simulation in years

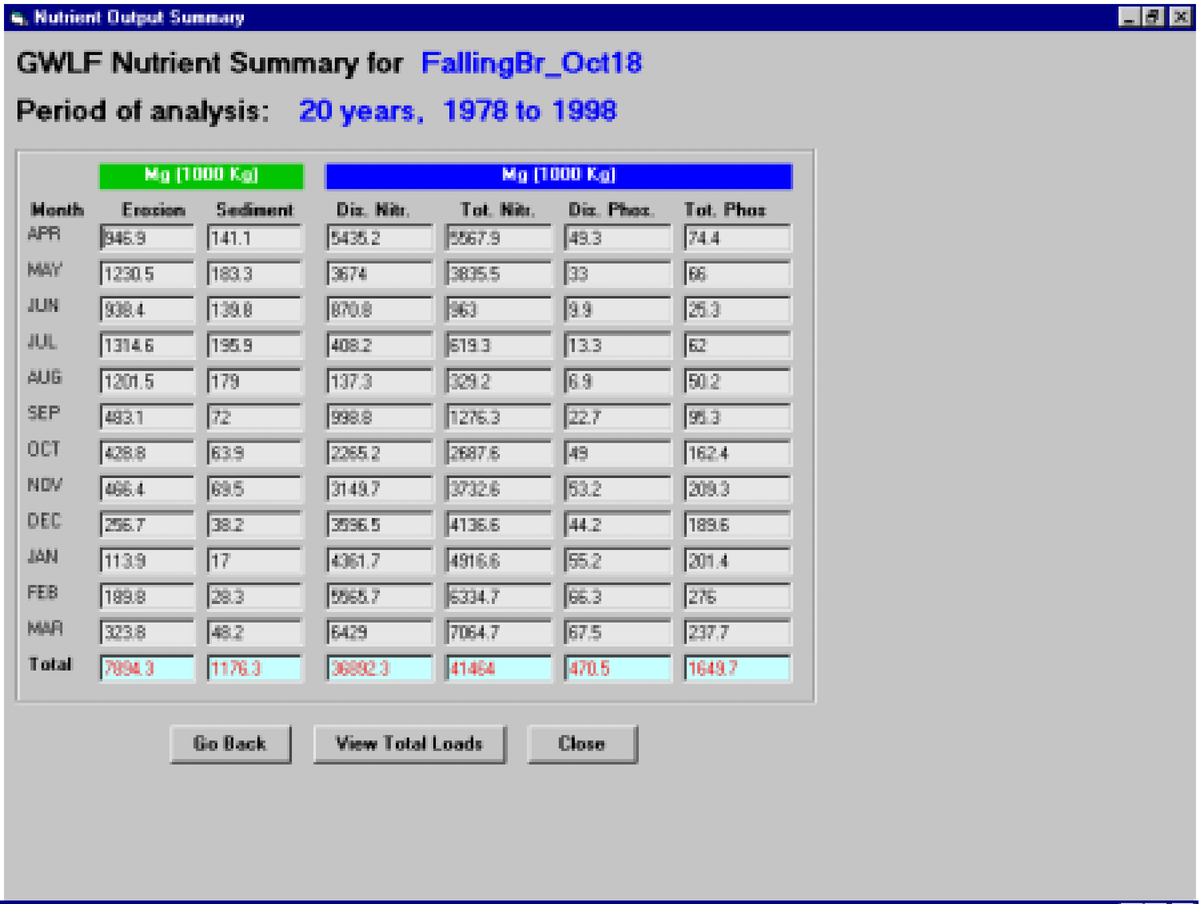
20



GWLF Total Loads for FallingBr_Oct18

Period of analysis: 20 years, 1978 to 1998

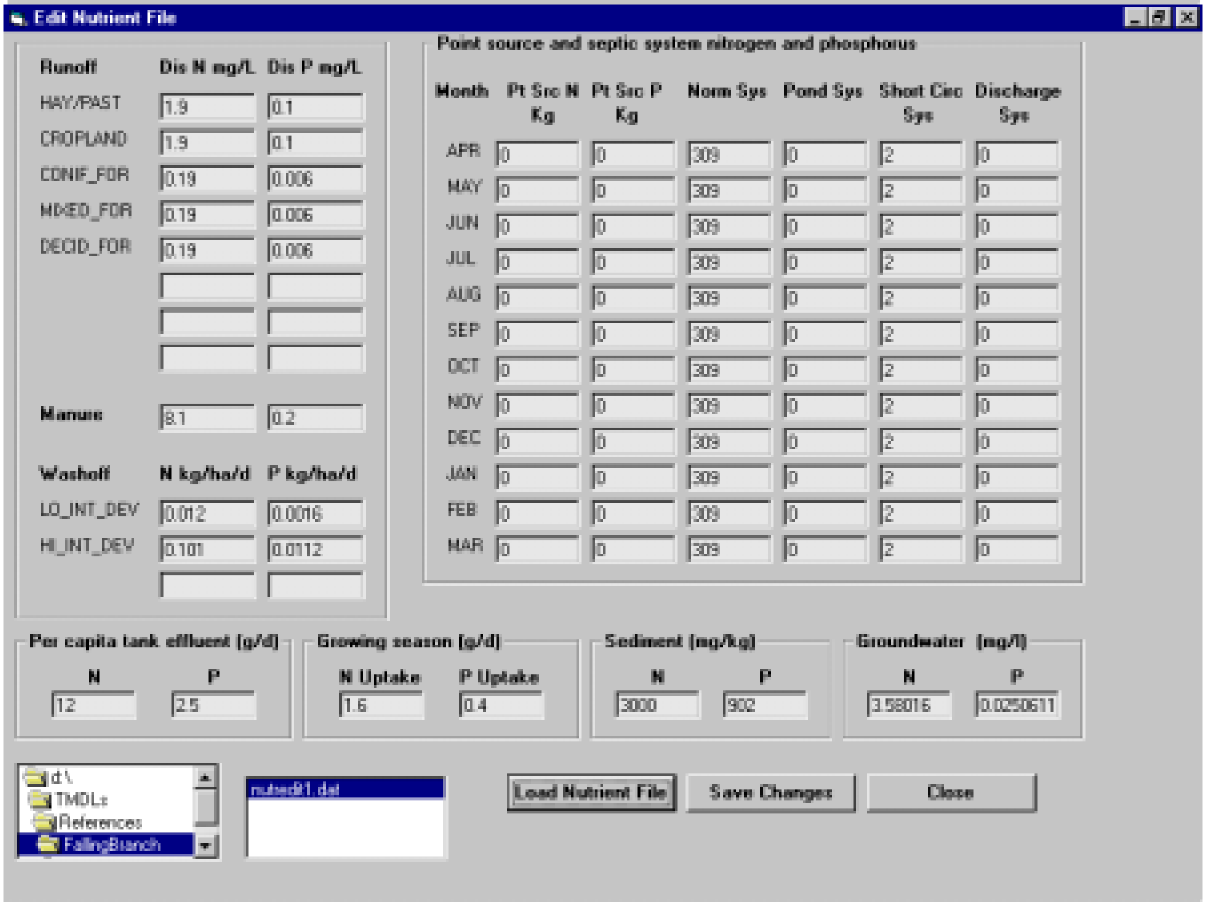
	(Ha)	(cm)	(Kg/Ha)		Total Loads (Kg)			
Source	Area	Runoff	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
HAY/PAST	716	7.15	912.3	135.9	1832.9	2124.9	65.1	152.8
CROPLAND	1354	12.19	5339.2	795.5	5732.6	8964	206.9	1178.5
CONIF_FOR	19	6.14	36.6	5.5	2.2	2.5	0.1	0.2
MIXED_FOR	35	6.14	55.6	8.3	4.1	5	0.1	0.4
DECID_FOR	120	6.14	76.5	11.4	14	18.1	0.4	1.7
LO_INT_DEV	162	13.19	233.9	34.9	0	117.4	0	15.7
HI_INT_DEV	81	32.77	329.1	49	0	925.6	0	102.6
Groundwater					28019.5	28019.5	196.1	196.1
Point Sources					0	0	0	0
Septic Syst.					1287	1287	1.7	1.7
Totals	2487	11.1	3200.2	476.8	36892.3	41464	470.5	1649.7



GWLF Nutrient Summary for FallingBr_Oct18

Period of analysis: 20 years, 1978 to 1998

	Mg (1000 Kg)		Mg (1000 Kg)			
Month	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos
APR	846.9	141.1	5435.2	5567.9	49.3	74.4
MAY	1230.5	183.3	3674	3835.5	33	66
JUN	938.4	139.8	870.8	963	9.9	25.3
JUL	1314.6	195.9	408.2	619.3	13.3	62
AUG	1201.5	179	137.3	329.2	6.9	50.2
SEP	483.1	72	998.8	1276.3	22.7	95.3
OCT	428.8	63.9	2265.2	2687.6	49	162.4
NOV	466.4	69.5	3149.7	3732.6	53.2	209.3
DEC	256.7	38.2	3596.5	4136.6	44.2	189.6
JAN	113.9	17	4361.7	4916.6	55.2	201.4
FEB	189.8	28.3	5565.7	6334.7	66.3	276
MAR	323.8	48.2	6429	7064.7	67.5	237.7
Total	7894.3	1176.3	36892.3	41464	470.5	1649.7



Runoff	Dis N mg/L	Dis P mg/L
HAY/PAST	1.9	0.1
CROPLAND	1.9	0.1
CONIF_FOR	0.19	0.006
MIXED_FOR	0.19	0.006
DECID_FOR	0.19	0.006
Manure	8.1	0.2
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

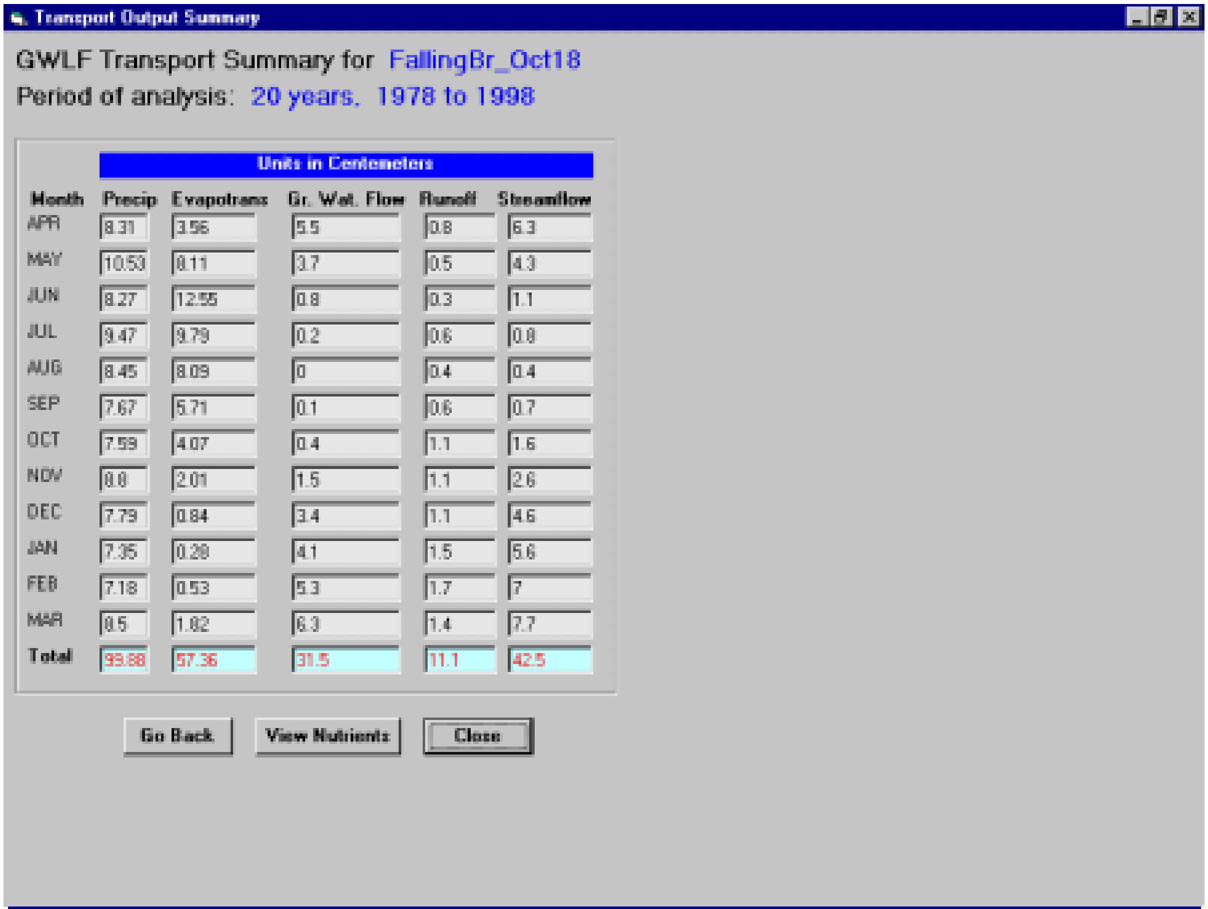
Month	Pt Src N Kg	Pt Src P Kg	Norm Sys	Pond Sys	Short Circ Sys	Discharge Sys
APR	0	0	309	0	2	0
MAY	0	0	309	0	2	0
JUN	0	0	309	0	2	0
JUL	0	0	309	0	2	0
AUG	0	0	309	0	2	0
SEP	0	0	309	0	2	0
OCT	0	0	309	0	2	0
NOV	0	0	309	0	2	0
DEC	0	0	309	0	2	0
JAN	0	0	309	0	2	0
FEB	0	0	309	0	2	0
MAR	0	0	309	0	2	0

Per capita tank effluent (g/d): N 12, P 2.5

Growing season (g/d): N Uptake 1.6, P Uptake 0.4

Sediment (mg/kg): N 3000, P 902

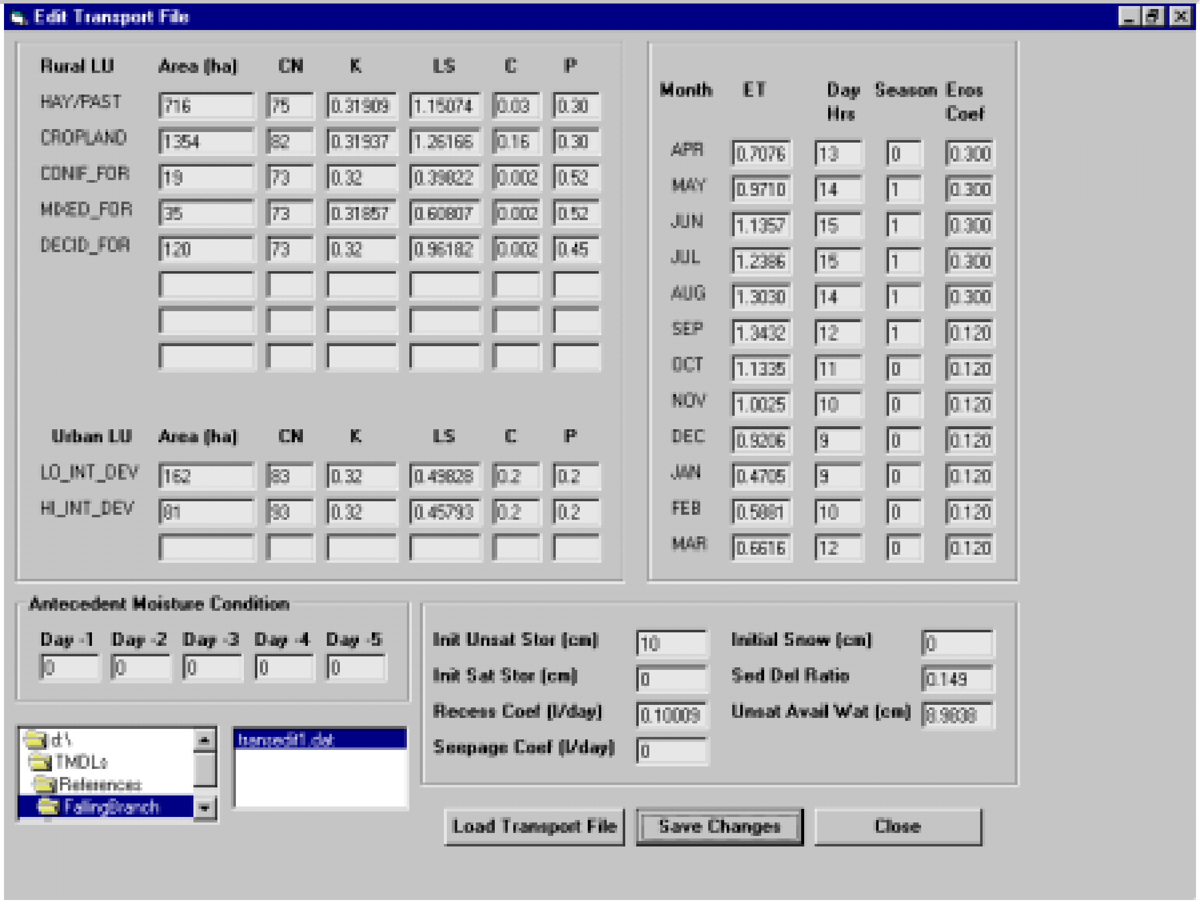
Groundwater (mg/l): N 3.58016, P 0.0250611



GWLF Transport Summary for FallingBr_Oct18

Period of analysis: 20 years, 1978 to 1998

	Units in Centemeters				
Month	Precip	Evapotrans	Gr. Wat. Flow	Runoff	Streamflow
APR	8.31	3.56	5.5	0.8	6.3
MAY	10.53	8.11	3.7	0.5	4.3
JUN	8.27	12.55	0.8	0.3	1.1
JUL	9.47	9.79	0.2	0.6	0.8
AUG	8.45	8.09	0	0.4	0.4
SEP	7.67	5.71	0.1	0.6	0.7
OCT	7.59	4.07	0.4	1.1	1.6
NOV	8.8	2.01	1.5	1.1	2.6
DEC	7.79	0.84	3.4	1.1	4.6
JAN	7.35	0.28	4.1	1.5	5.6
FEB	7.18	0.53	5.3	1.7	7
MAR	8.5	1.82	6.3	1.4	7.7
Total	99.88	57.36	31.5	11.1	42.5



Rural LU	Area (ha)	CN	K	LS	C	P
HAY/PAST	716	75	0.31909	1.15074	0.03	0.30
CROPLAND	1354	82	0.31937	1.26166	0.16	0.30
CONIF_FOR	19	73	0.32	0.39822	0.002	0.52
MIXED_FOR	35	73	0.31857	0.60807	0.002	0.52
DECID_FOR	120	73	0.32	0.96182	0.002	0.45

Urban LU	Area (ha)	CN	K	LS	C	P
LO_INT_DEV	162	83	0.32	0.49828	0.2	0.2
HI_INT_DEV	81	93	0.32	0.45793	0.2	0.2

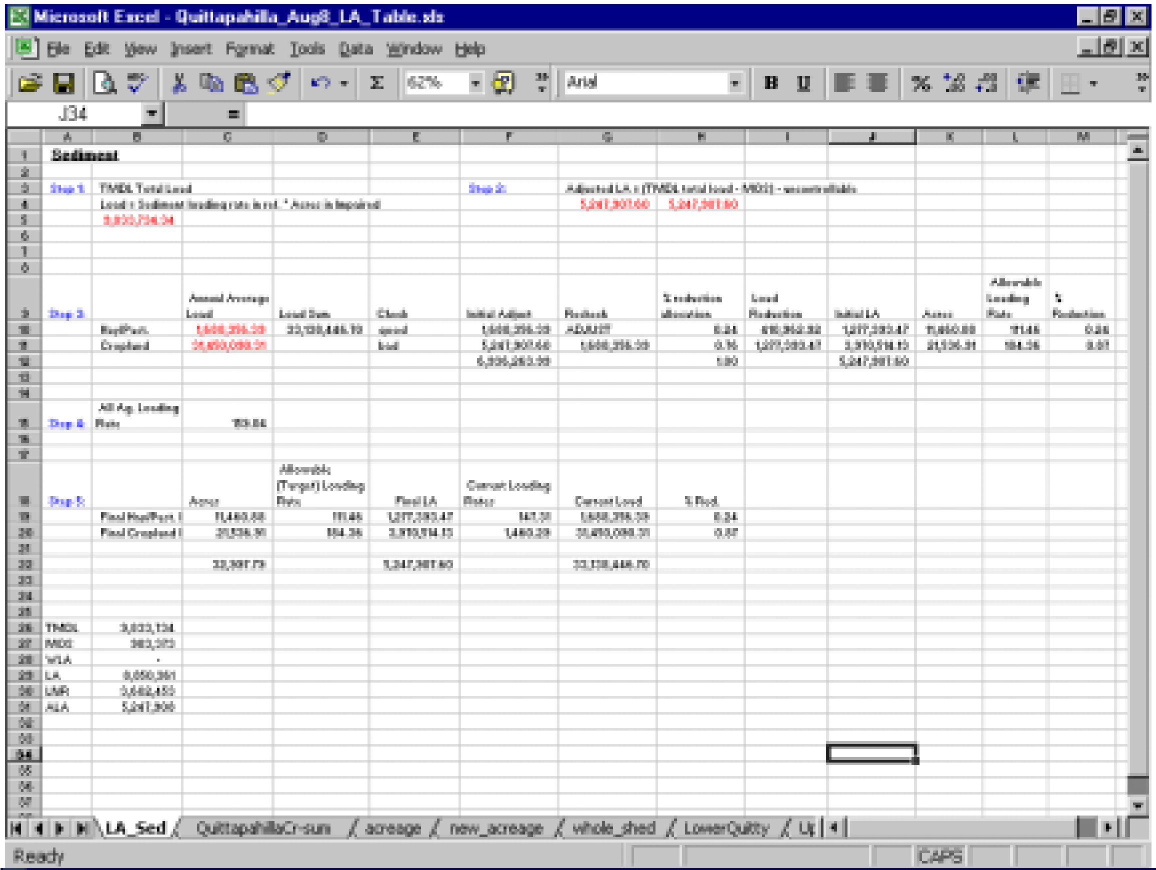
Month	ET	Day Hrs	Season	Eros Coef
APR	0.7076	13	0	0.300
MAY	0.9710	14	1	0.300
JUN	1.1357	15	1	0.300
JUL	1.2386	15	1	0.300
AUG	1.3030	14	1	0.300
SEP	1.3432	12	1	0.120
OCT	1.1335	11	0	0.120
NOV	1.0025	10	0	0.120
DEC	0.9206	9	0	0.120
JAN	0.4705	9	0	0.120
FEB	0.5081	10	0	0.120
MAR	0.6616	12	0	0.120

Antecedent Moisture Condition

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

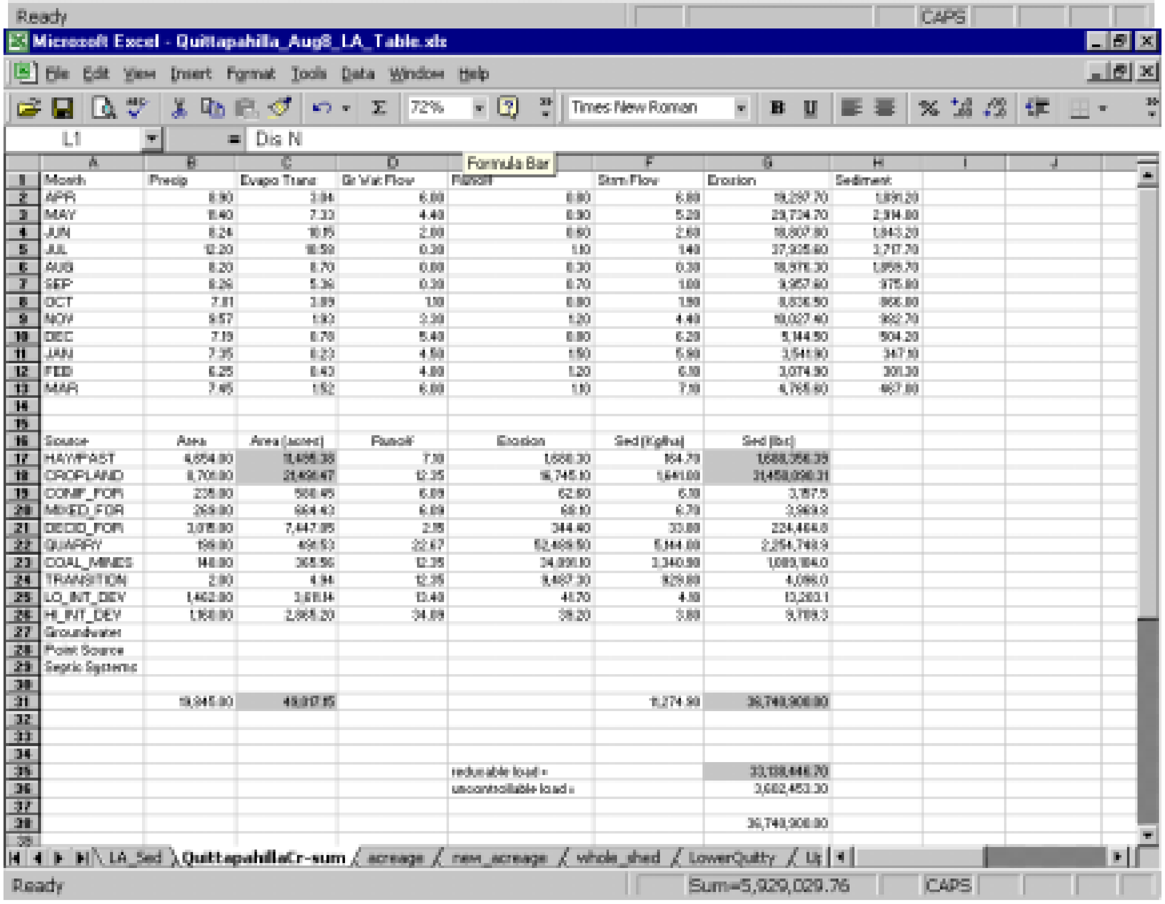
Init Unsat Stor (cm)	10	Initial Snow (cm)	0
Init Sat Stor (cm)	0	Sed Del Ratio	0.149
Recess Coef (l/day)	0.10009	Unsat Avail Wat (cm)	8.9808
Seepage Coef (l/day)	0		

APPENDIX G - EMPR WORKBOOKS FOR SEDIMENT LOAD ALLOCATIONS



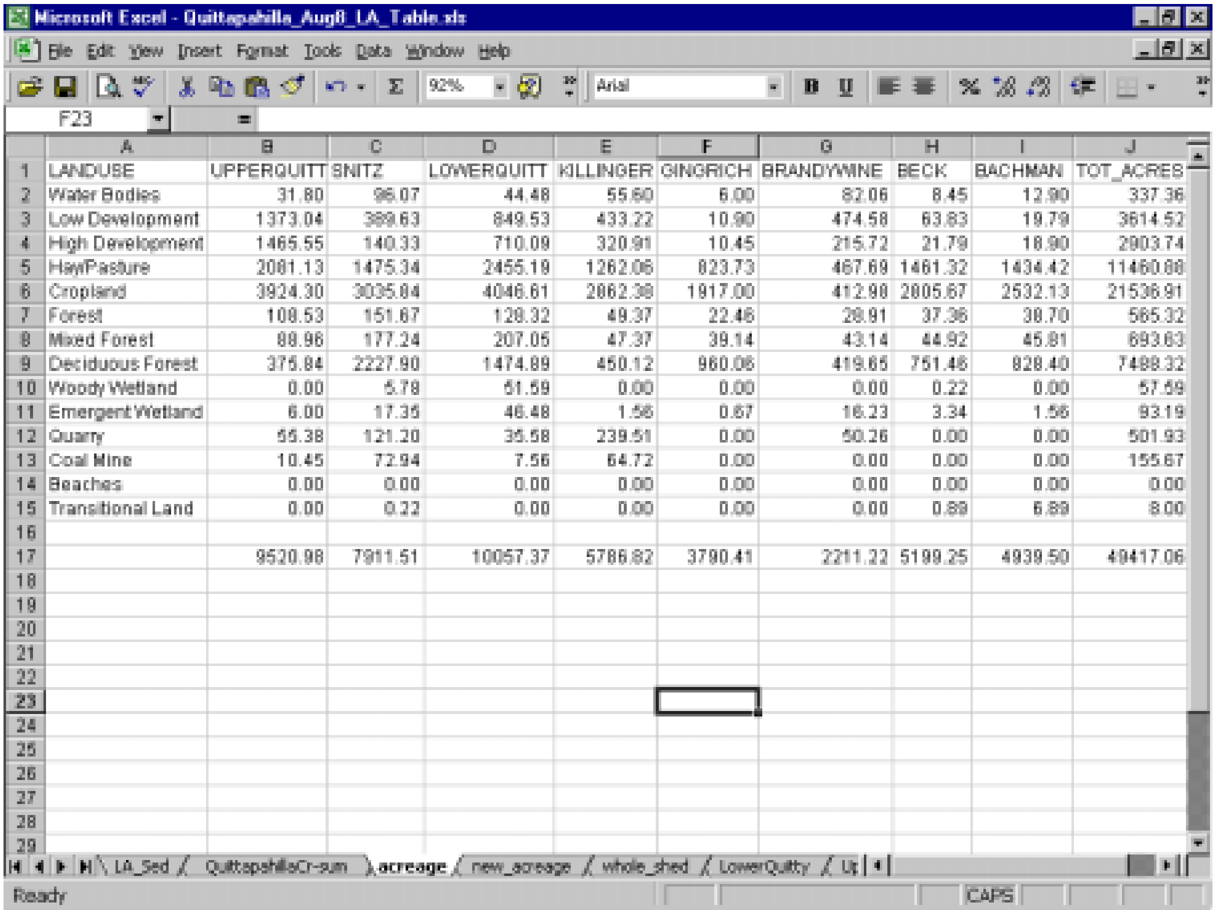
Sediment

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Sediment**												
3	Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable						
4		Load = Sediment loading rate in ref. * Acres in impaired					5,247,907.60	5,247,907.60					
5		9,833,734.34											
9	Step 3:		Annual Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reduction	Initial LA	Acres	Allowable Loading Rate	% Reduction
10		Hay/Past.	1,688,356.39	33,138,446.70	good	1,688,356.39	ADJUST	0.24	410,962.92	1,277,393.47	11,460.88	111.46	0.24
11		Cropland	31,450,090.31		bad	5,247,907.60	1,688,356.39	0.76	1,277,393.47	3,970,514.13	21,536.91	184.36	0.87
12						6,936,263.99		1.00		5,247,907.60			
15	Step 4:	All Ag. Loading Rate	159.04										
18	Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.					
19		Final Hay/Past. l	11,460.88	111.46	1,277,393.47	147.31	1,688,356.39	0.24					
20		Final Cropland l	21,536.91	184.36	3,970,514.13	1,460.29	31,450,090.31	0.87					
22			32,997.79		5,247,907.60		33,138,446.70						
26	TMDL	9,833,734											
27	MOS	983,373											
28	WLA	-											
29	LA	8,850,361											
30	UNR	3,602,453											
31	ALA	5,247,908											

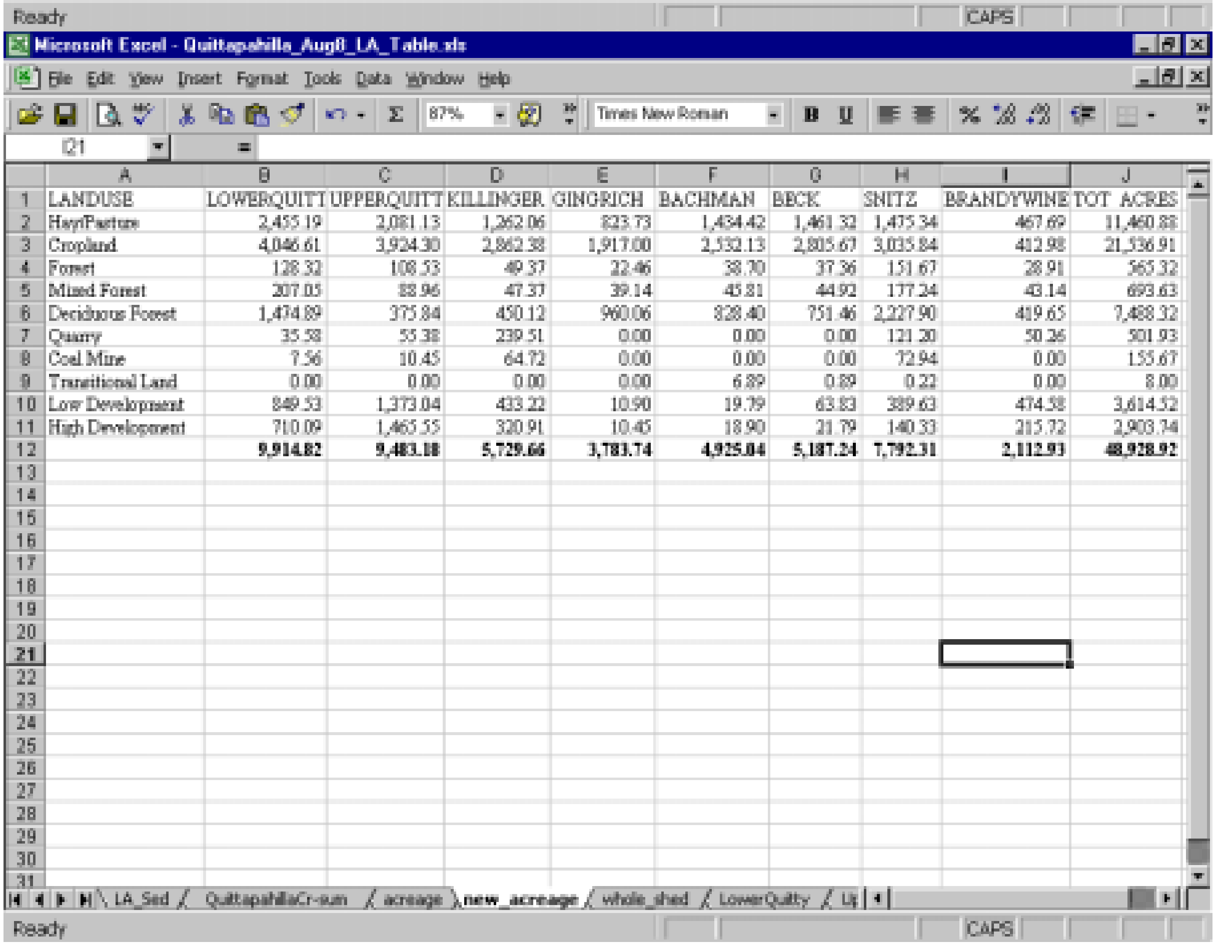


Month	Precip	Evapo Trans	Gr Wat Flow	Runoff	Strm Flow	Erosion	Sediment
APR	8.90	3.84	6.00	0.80	6.80	19,297.70	1,891.20
MAY	8.40	7.33	4.40	0.90	5.20	23,724.70	2,314.00
JUN	8.24	10.15	2.00	0.60	2.60	18,807.80	1,843.20
JUL	12.20	16.59	0.30	1.10	1.40	37,925.60	3,717.70
AUG	8.20	8.70	0.00	0.30	0.30	18,976.30	1,859.70
SEP	8.26	5.36	0.30	0.70	1.00	9,957.60	975.80
OCT	7.81	3.89	1.00	0.80	1.90	8,836.50	866.00
NOV	9.57	1.93	3.30	1.20	4.40	10,027.40	982.70
DEC	7.19	0.78	5.40	0.80	6.20	5,144.50	504.20
JAN	7.35	0.23	4.50	1.50	5.90	3,541.90	347.10
FEB	6.25	0.43	4.00	1.20	6.10	3,074.90	301.30
MAR	7.45	1.52	6.00	1.10	7.10	4,765.60	467.00

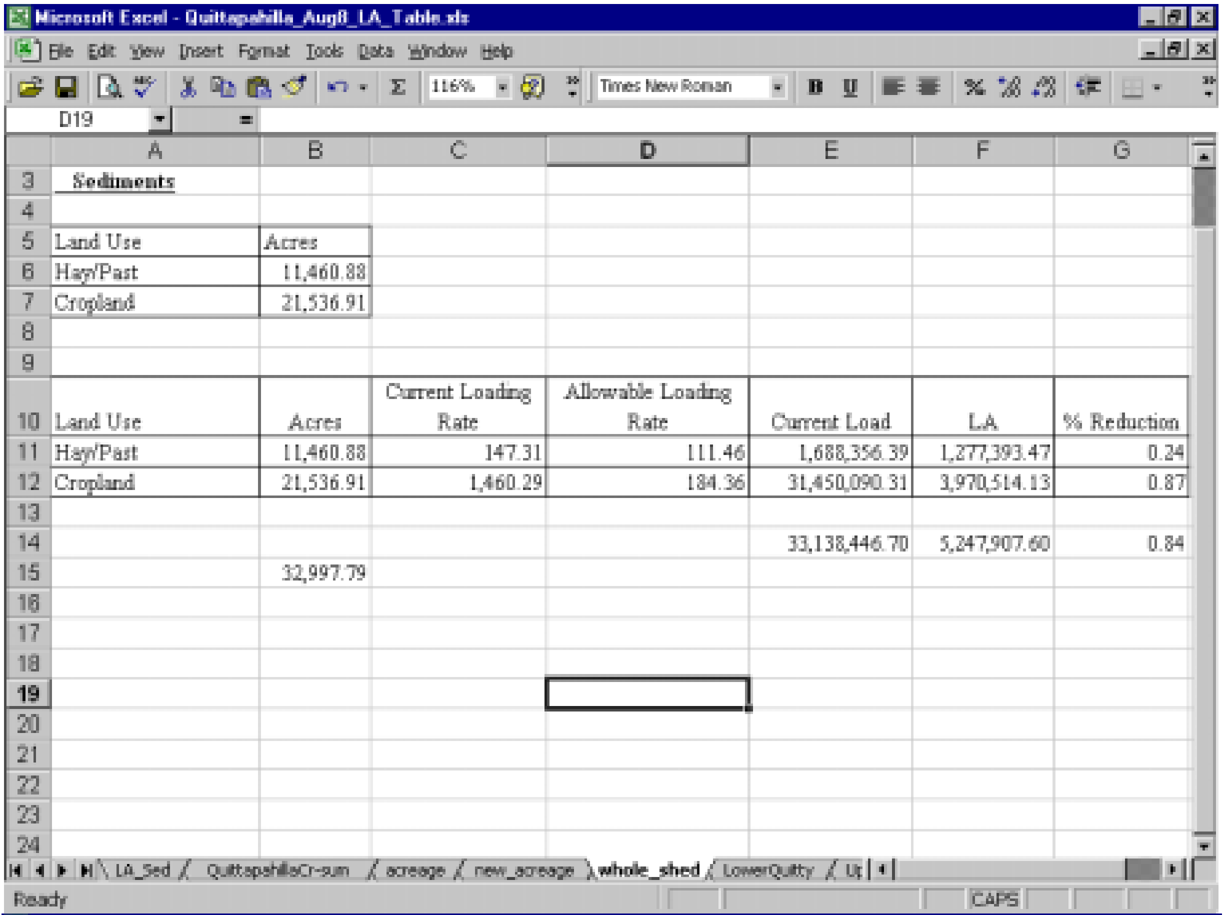
Source	Area	Area (acres)	Runoff	Erosion	Sed (Kg/ha)	Sed (lbs)
HAY/PAST	4,654.00	11,495.38	7.10	1,688.30	164.70	1,688,356.39
CROPLAND	8,706.00	21,496.47	12.35	16,745.10	1,641.00	31,450,090.31
CONIF_FOR	235.00	580.45	6.09	62.90	6.10	3,157.5
MIXED_FOR	269.00	664.43	6.09	68.10	6.70	3,969.9
DECID_FOR	3,015.00	7,447.05	2.35	344.40	33.80	224,464.8
QUARRY	199.00	491.53	22.67	52,469.50	5,144.00	2,254,749.9
COAL_MINES	148.00	365.56	12.35	34,099.10	3,340.90	1,089,184.0
TRANSITION	2.00	4.94	12.35	9,487.30	929.80	4,098.0
LO_INT_DEV	1,462.00	3,611.14	13.40	41.70	4.10	13,203.1
HI_INT_DEV	1,160.00	2,865.20	34.09	39.20	3.80	9,789.3
Groundwater						
Point Source						
Septic Systems						
	19,945.00	49,317.85			11,274.90	36,740,900.00
				reducable load =		33,138,446.70
				uncontrollable load =		3,602,453.30
						36,740,900.00



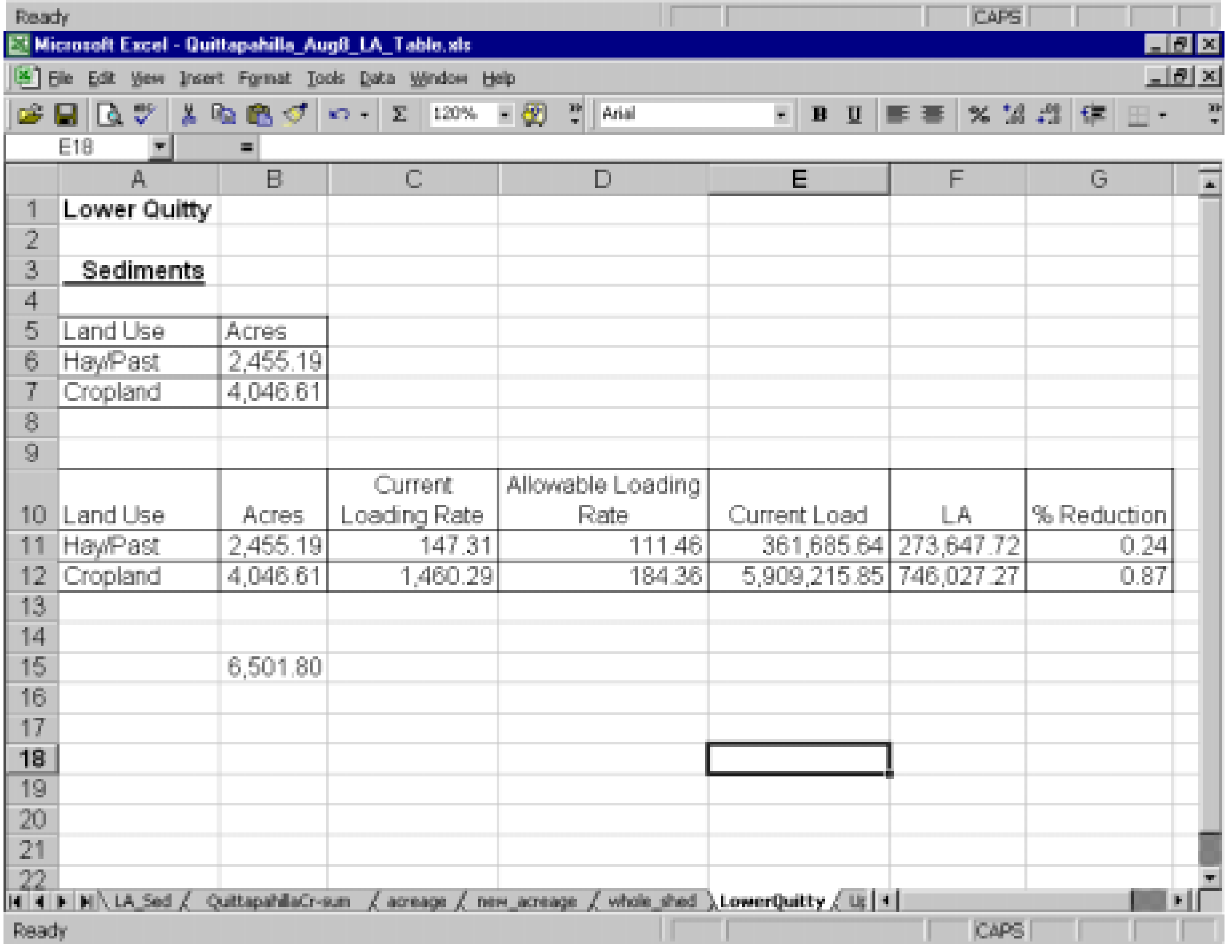
	A	B	C	D	E	F	G	H	I	J
1	LANDUSE	UPPERQUITT	SNITZ	LOWERQUITT	KILLINGER	GINGRICH	BRANDYWINE	BECK	BACHMAN	TOT_ACRES
2	Water Bodies	31.80	96.07	44.48	55.60	6.00	82.06	8.45	12.90	337.36
3	Low Development	1373.04	389.63	849.53	433.22	10.90	474.58	63.83	19.79	3614.52
4	High Development	1465.55	140.33	710.09	320.91	10.45	215.72	21.79	18.90	2903.74
5	Hay/Pasture	2081.13	1475.34	2455.19	1262.06	823.73	467.69	1461.32	1434.42	11460.88
6	Cropland	3924.30	3035.84	4046.61	2862.38	1917.00	412.98	2805.67	2532.13	21536.91
7	Forest	108.53	151.67	128.32	49.37	22.46	28.91	37.36	38.70	565.32
8	Mixed Forest	88.96	177.24	207.05	47.37	39.14	43.14	44.92	45.81	693.63
9	Deciduous Forest	375.84	2227.90	1474.89	450.12	960.06	419.65	751.46	828.40	7488.32
10	Woody Wetland	0.00	5.78	51.59	0.00	0.00	0.00	0.22	0.00	57.59
11	Emergent Wetland	6.00	17.35	46.48	1.56	0.67	16.23	3.34	1.56	93.19
12	Quarry	55.38	121.20	35.58	239.51	0.00	50.26	0.00	0.00	501.93
13	Coal Mine	10.45	72.94	7.56	64.72	0.00	0.00	0.00	0.00	155.67
14	Beaches	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	Transitional Land	0.00	0.22	0.00	0.00	0.00	0.00	0.89	6.89	8.00
16										
17		9520.98	7911.51	10057.37	5786.82	3790.41	2211.22	5199.25	4939.50	49417.06



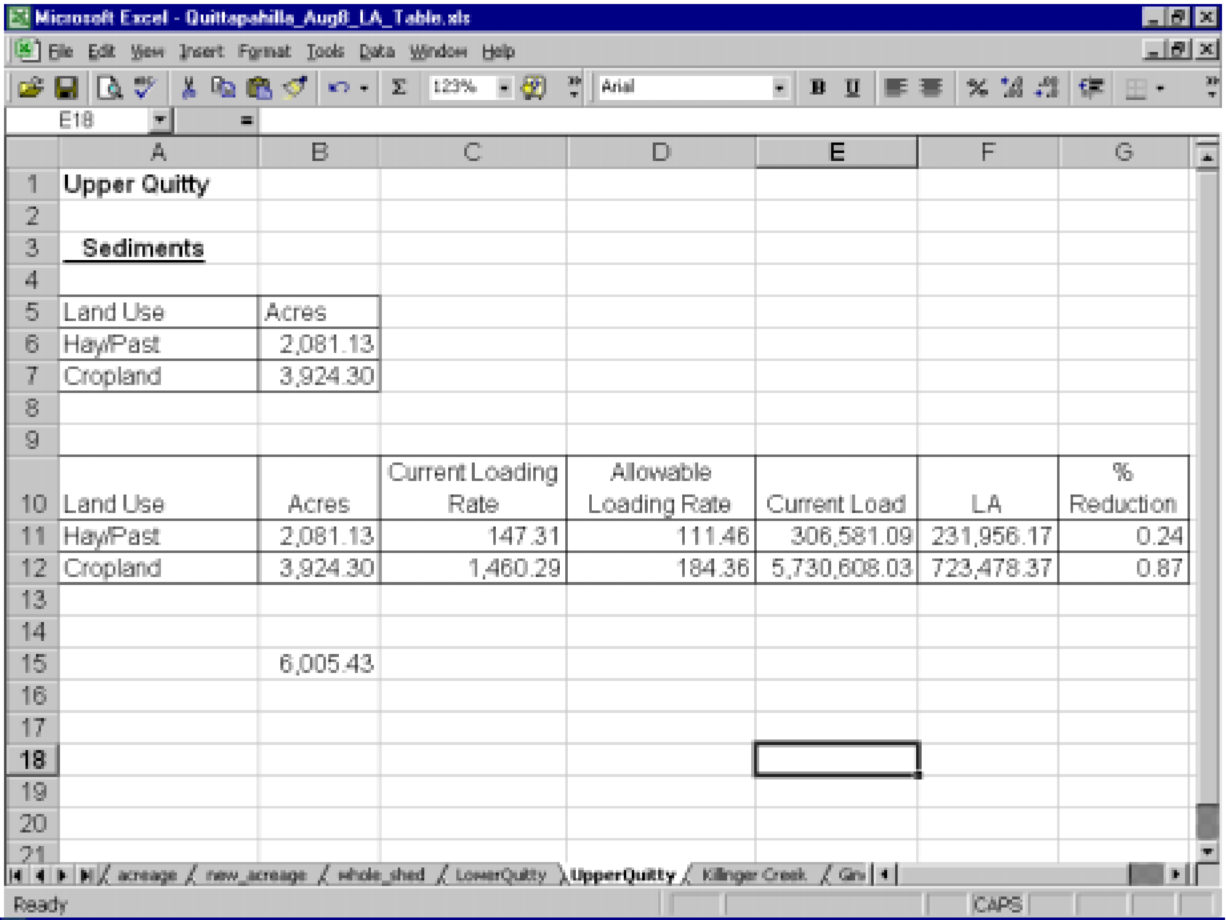
	A	B	C	D	E	F	G	H	I	J
1	LANDUSE	LOWERQUITT	UPPERQUITT	KILLINGER	GINGRICH	BACHMAN	BECK	SNITZ	BRANDYWINE	TOT_ACRES
2	Hay/Pasture	2,455.19	2,081.13	1,262.06	823.73	1,434.42	1,461.32	1,475.34	467.69	11,460.88
3	Cropland	4,046.61	3,924.30	2,862.38	1,917.00	2,532.13	2,805.67	3,035.84	412.98	21,536.91
4	Forest	128.32	108.53	49.37	22.46	38.70	37.36	151.67	28.91	565.32
5	Mixed Forest	207.05	88.96	47.37	39.14	45.81	44.92	177.24	43.14	693.63
6	Deciduous Forest	1,474.89	375.84	450.12	960.06	828.40	751.46	2,227.90	419.65	7,488.32
7	Quarry	35.58	55.38	239.51	0.00	0.00	0.00	121.20	50.26	501.93
8	Coal Mine	7.56	10.45	64.72	0.00	0.00	0.00	72.94	0.00	155.67
9	Transitional Land	0.00	0.00	0.00	0.00	6.89	0.89	0.22	0.00	8.00
10	Low Development	849.53	1,373.04	433.22	10.90	19.79	63.83	389.63	474.58	3,614.52
11	High Development	710.09	1,465.55	320.91	10.45	18.90	21.79	140.33	215.72	2,903.74
12		**9,914.82**	**9,483.18**	**5,729.66**	**3,783.74**	**4,925.04**	**5,187.24**	**7,792.31**	**2,112.93**	**48,928.92**



	A	B	C	D	E	F	G
3	**Sediments**						
4							
5	Land Use	Acres					
6	Hay/Past	11,460.88					
7	Cropland	21,536.91					
8							
9							
10	Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
11	Hay/Past	11,460.88	147.31	111.46	1,688,356.39	1,277,393.47	0.24
12	Cropland	21,536.91	1,460.29	184.36	31,450,090.31	3,970,514.13	0.87
13							
14					33,138,446.70	5,247,907.60	0.84
15		32,997.79					



	A	B	C	D	E	F	G
1	**Lower Quitty**						
2							
3	**Sediments**						
4							
5	Land Use	Acres					
6	Hay/Past	2,455.19					
7	Cropland	4,046.61					
8							
9							
10	Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
11	Hay/Past	2,455.19	147.31	111.46	361,685.64	273,647.72	0.24
12	Cropland	4,046.61	1,460.29	184.36	5,909,215.85	746,027.27	0.87
13							
14							
15		6,501.80					



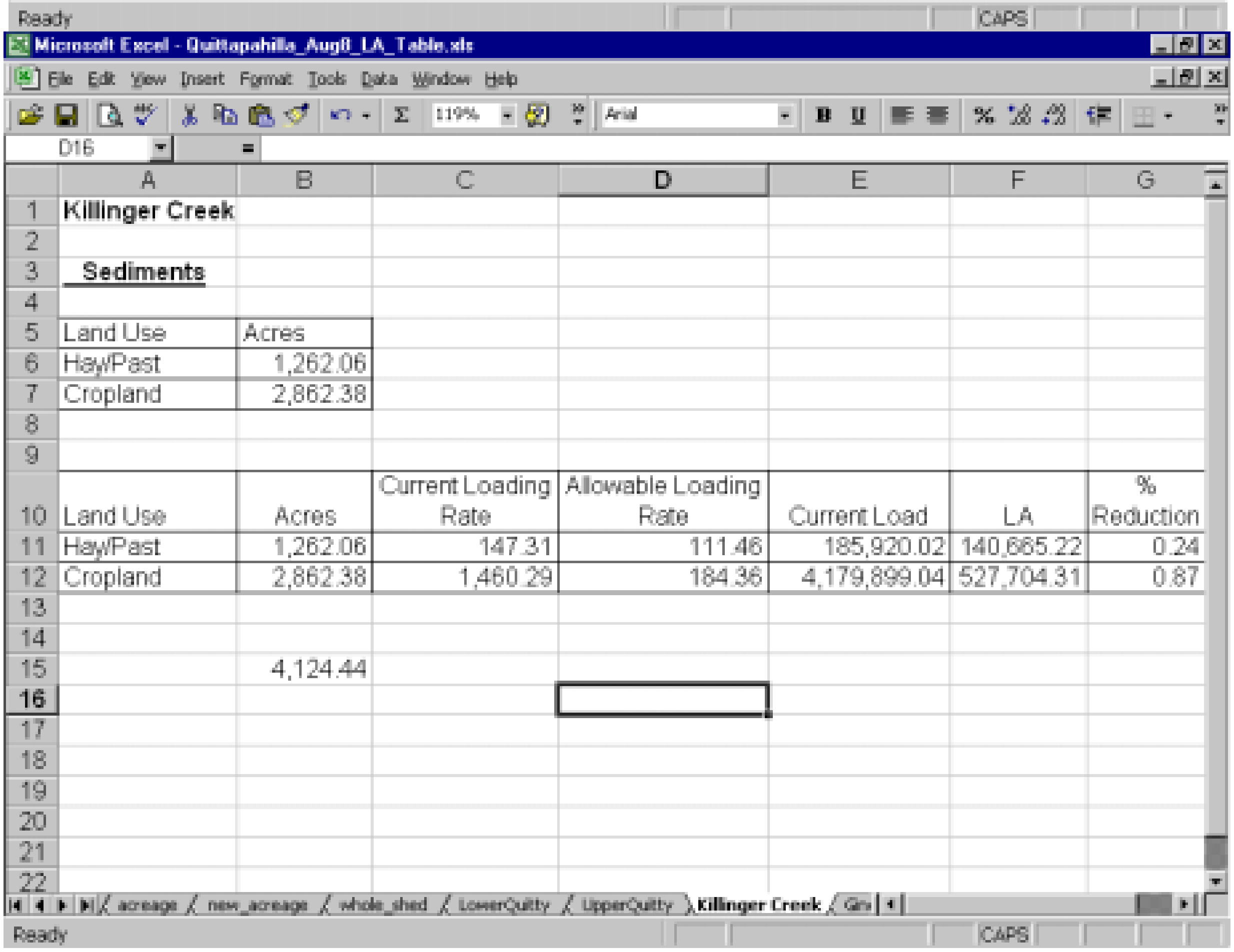
Upper Quitty

Sediments

Land Use	Acres
Hay/Past	2,081.13
Cropland	3,924.30

Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
Hay/Past	2,081.13	147.31	111.46	306,581.09	231,956.17	0.24
Cropland	3,924.30	1,460.29	184.36	5,730,608.03	723,478.37	0.87

6,005.43



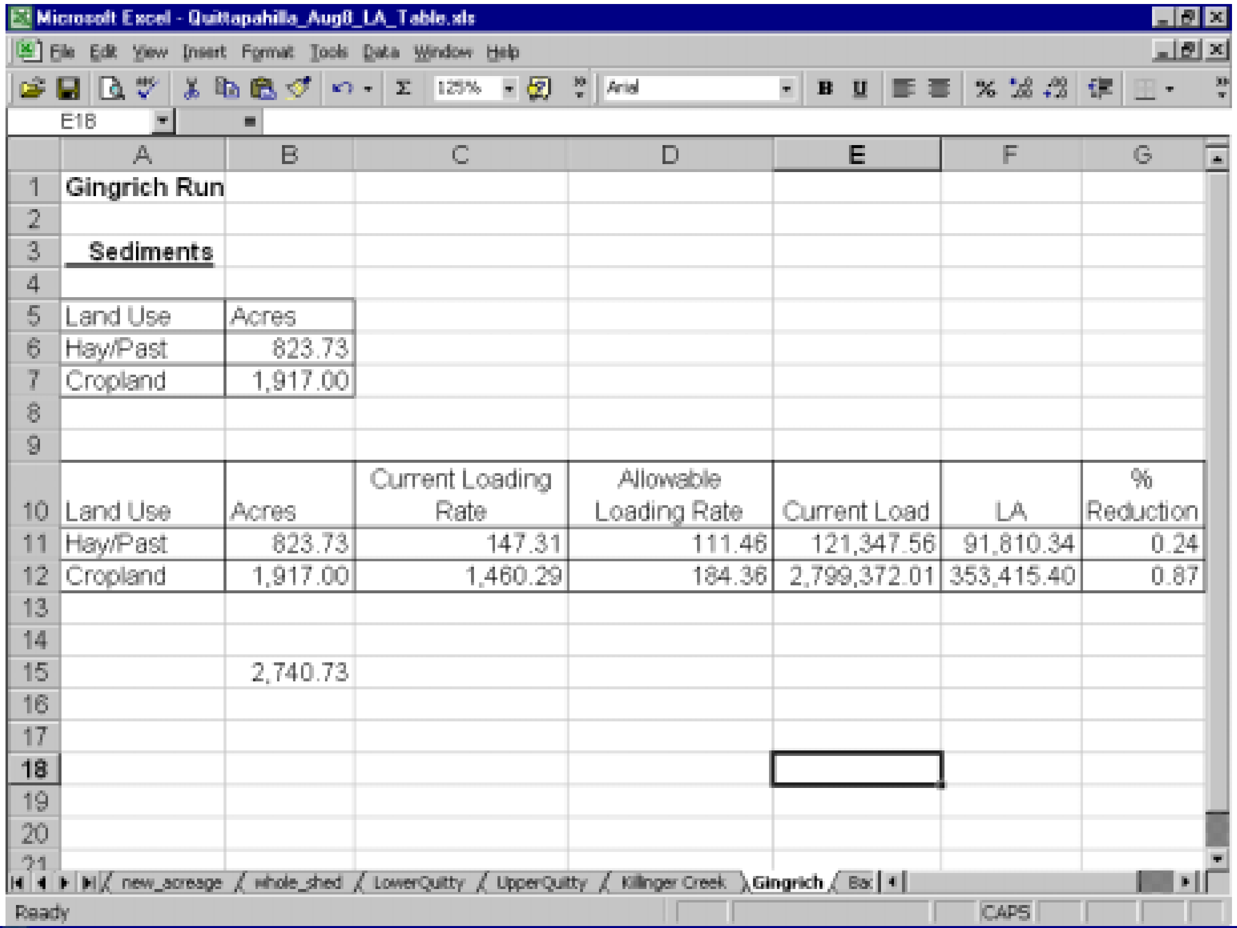
Killinger Creek

Sediments

Land Use	Acres
Hay/Past	1,262.06
Cropland	2,862.38

Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
Hay/Past	1,262.06	147.31	111.46	185,920.02	140,665.22	0.24
Cropland	2,862.38	1,460.29	184.36	4,179,899.04	527,704.31	0.87

4,124.44

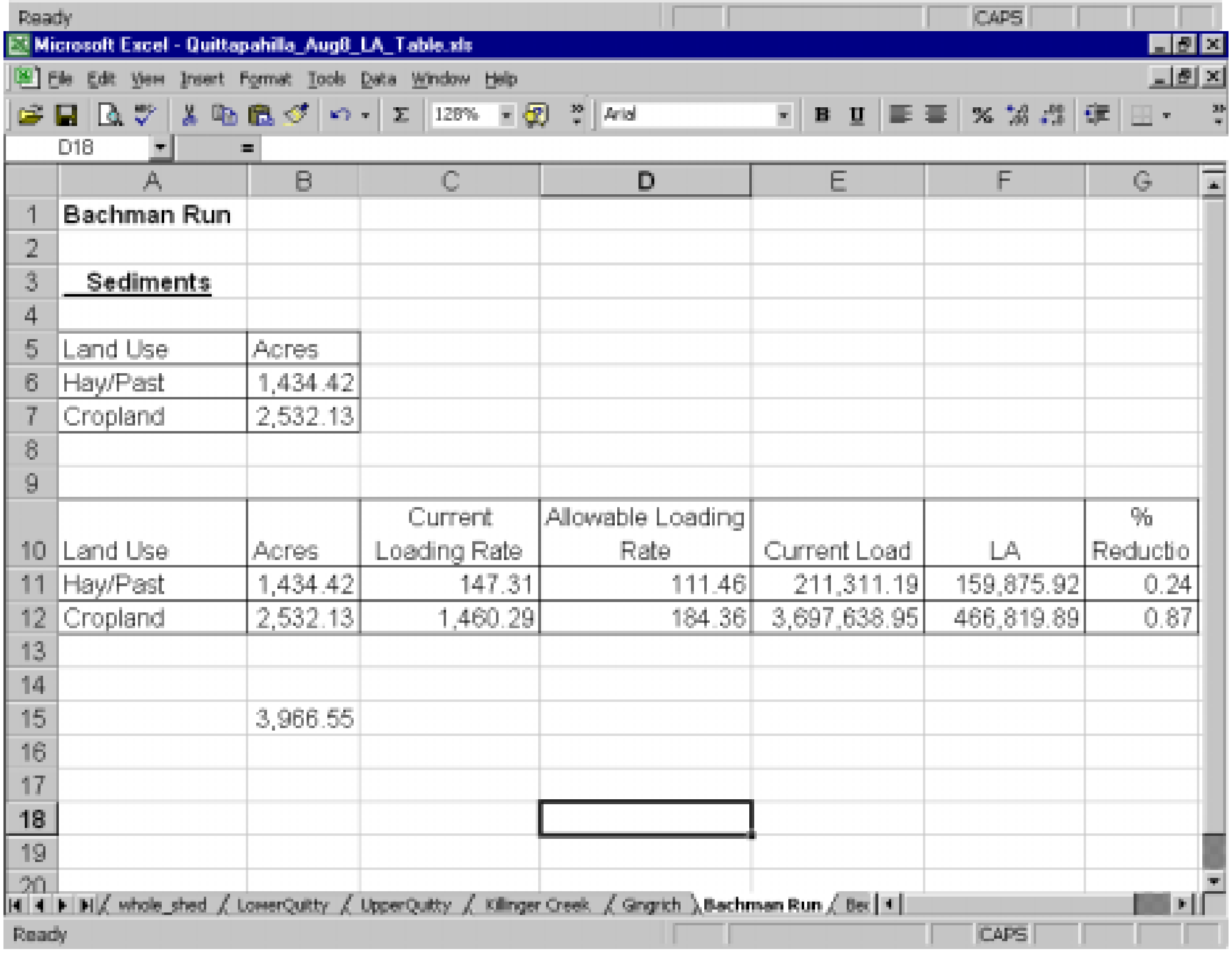


Gingrich Run

Sediments

Land Use	Acres
Hay/Past	823.73
Cropland	1,917.00

Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
Hay/Past	823.73	147.31	111.46	121,347.56	91,810.34	0.24
Cropland	1,917.00	1,460.29	184.36	2,799,372.01	353,415.40	0.87
	2,740.73					

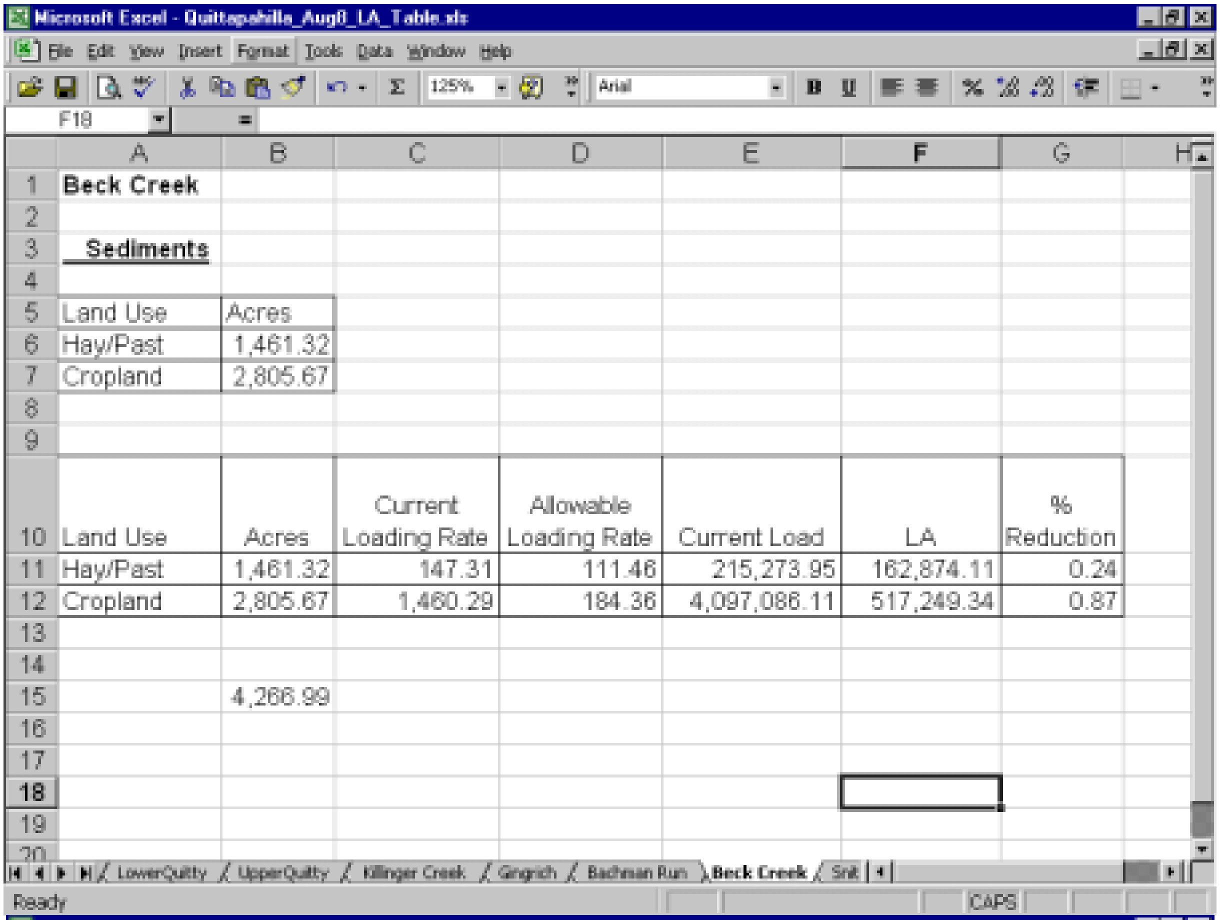


Bachman Run

Sediments

Land Use	Acres
Hay/Past	1,434.42
Cropland	2,532.13

Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reductio
Hay/Past	1,434.42	147.31	111.46	211,311.19	159,875.92	0.24
Cropland	2,532.13	1,460.29	184.36	3,697,638.95	466,819.89	0.87
	3,966.55					



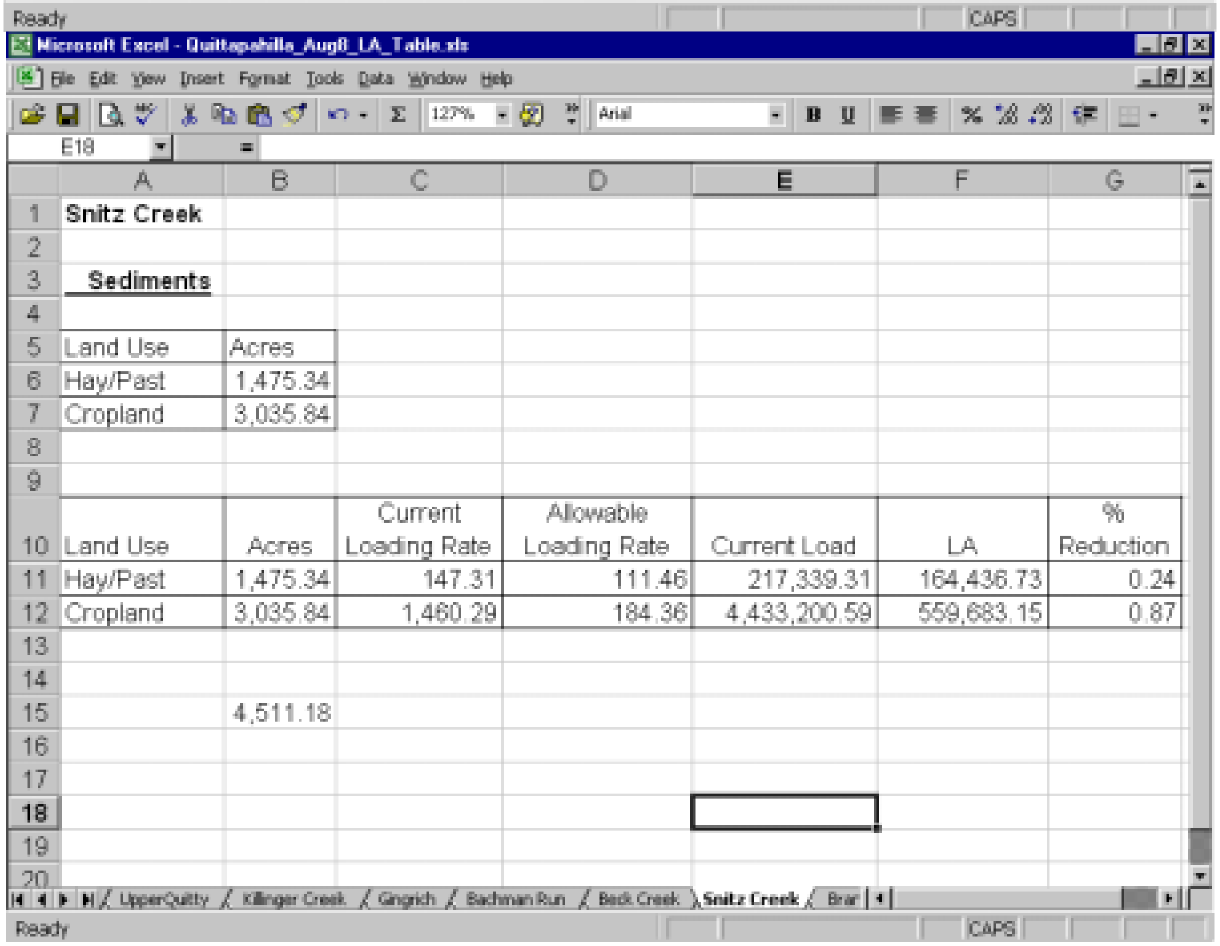
Beck Creek

Sediments

Land Use	Acres
Hay/Past	1,461.32
Cropland	2,805.67

Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
Hay/Past	1,461.32	147.31	111.46	215,273.95	162,874.11	0.24
Cropland	2,805.67	1,460.29	184.36	4,097,086.11	517,249.34	0.87

4,266.99



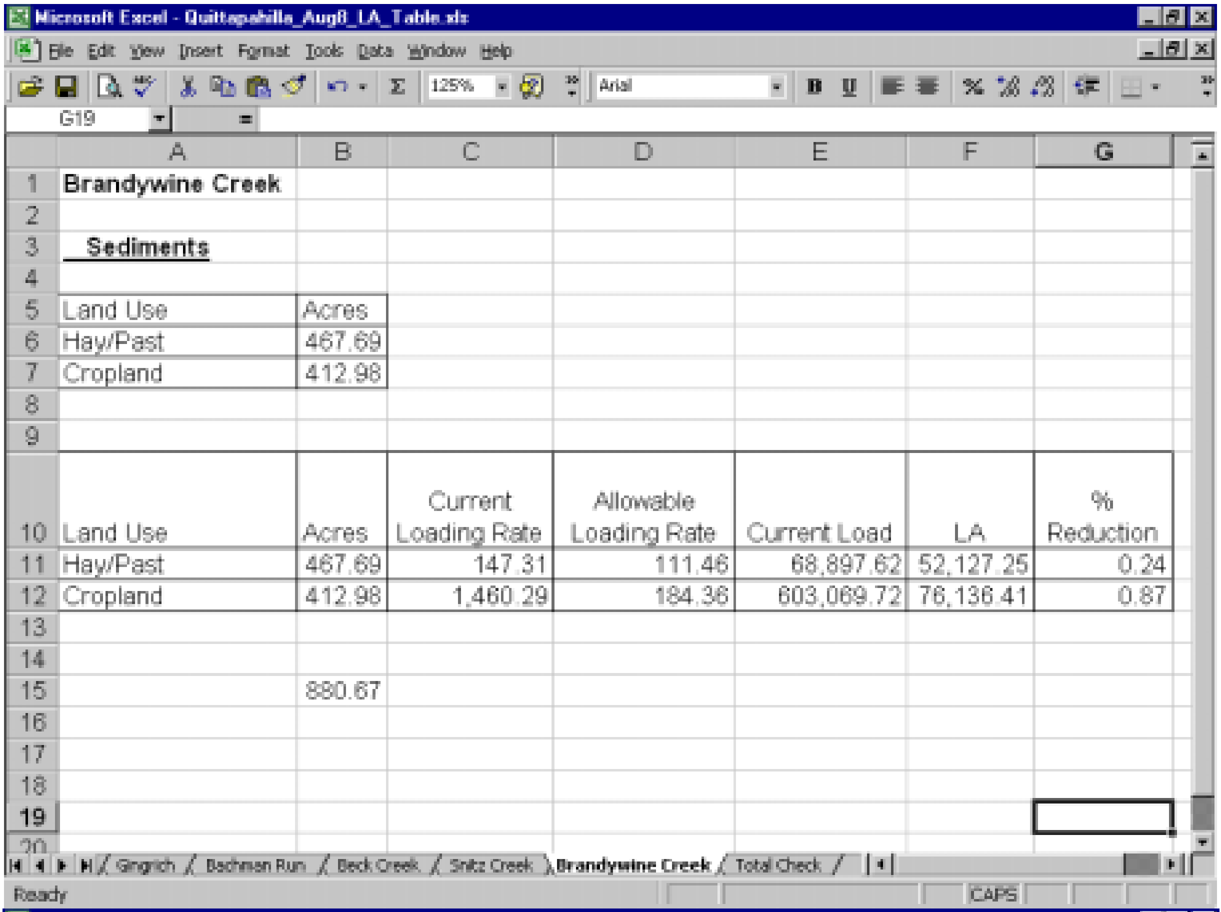
Snitz Creek

Sediments

Land Use	Acres
Hay/Past	1,475.34
Cropland	3,035.84

Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
Hay/Past	1,475.34	147.31	111.46	217,339.31	164,436.73	0.24
Cropland	3,035.84	1,460.29	184.36	4,433,200.59	559,683.15	0.87

4,511.18



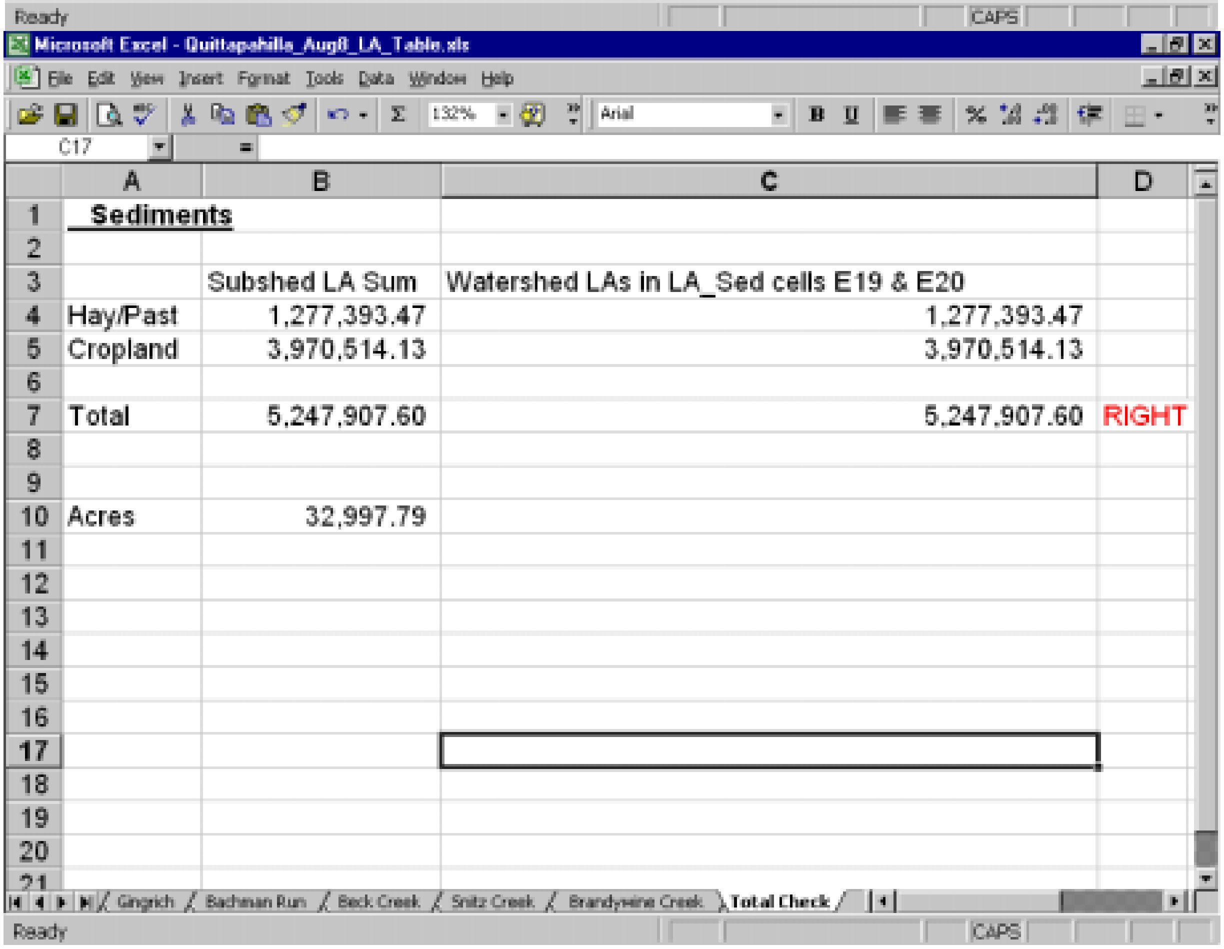
Brandywine Creek

Sediments

Land Use	Acres
Hay/Past	467.69
Cropland	412.98

Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
Hay/Past	467.69	147.31	111.46	68,897.62	52,127.25	0.24
Cropland	412.98	1,460.29	184.36	603,069.72	76,136.41	0.87

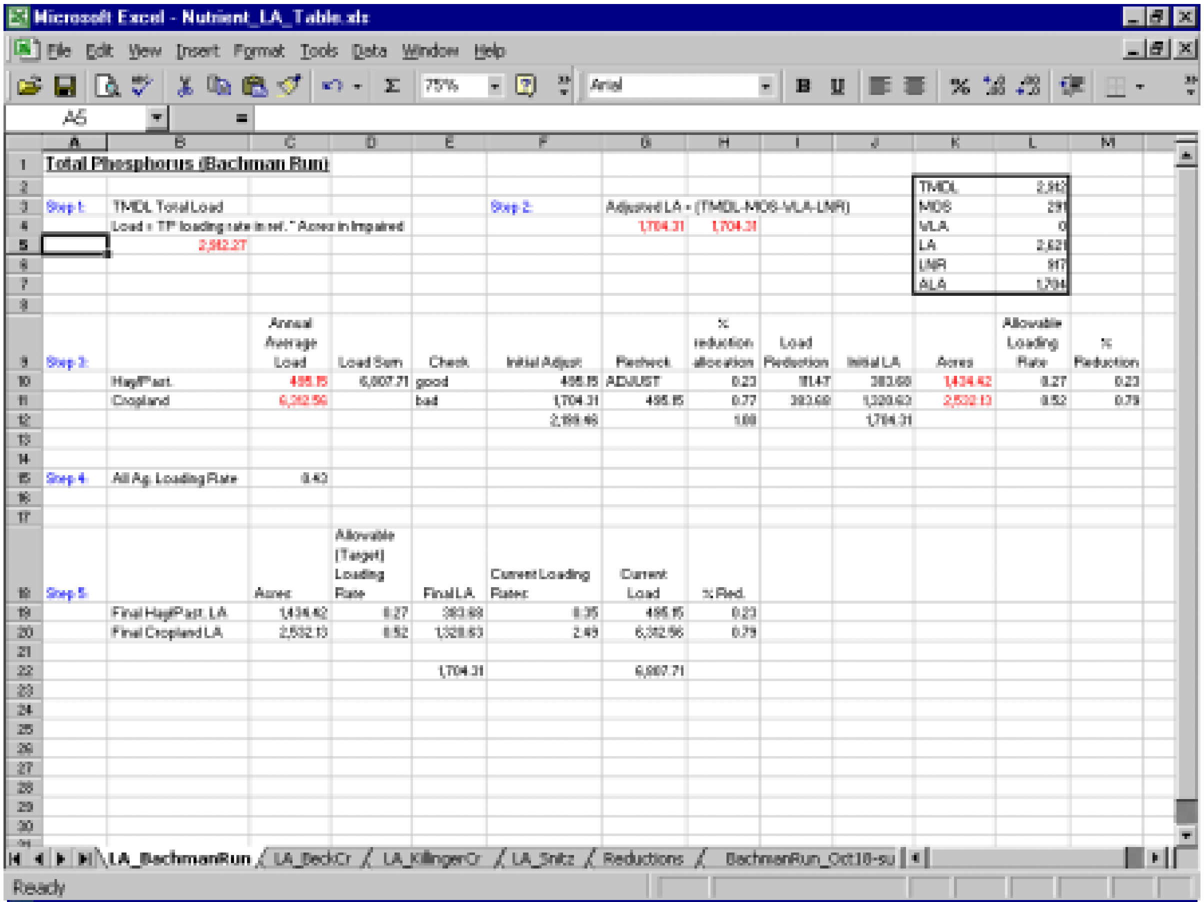
880.67



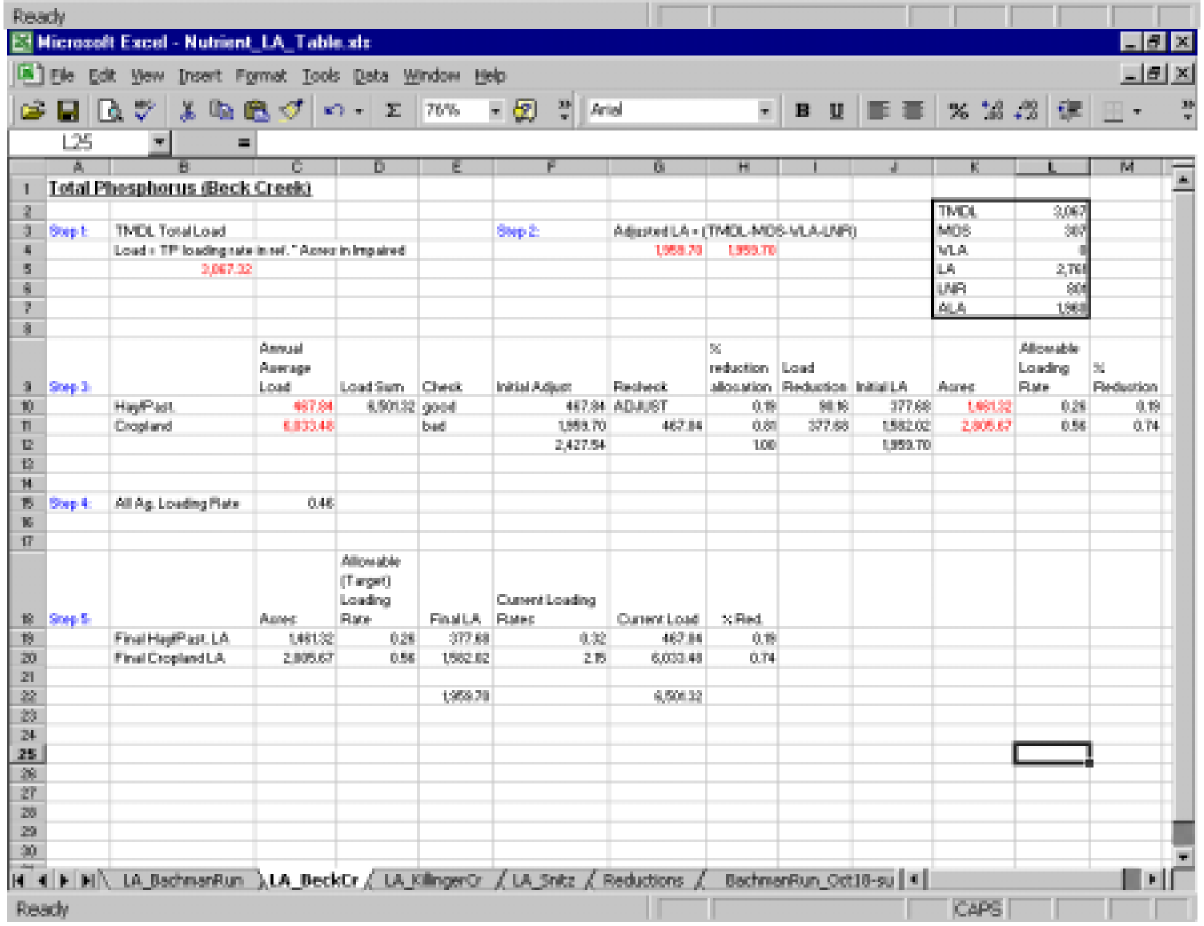
Sediments

	Subshed LA Sum	Watershed LAs in LA_Sed cells E19 & E20	
Hay/Past	1,277,393.47	1,277,393.47	
Cropland	3,970,514.13	3,970,514.13	
Total	5,247,907.60	5,247,907.60	RIGHT
Acres	32,997.79		

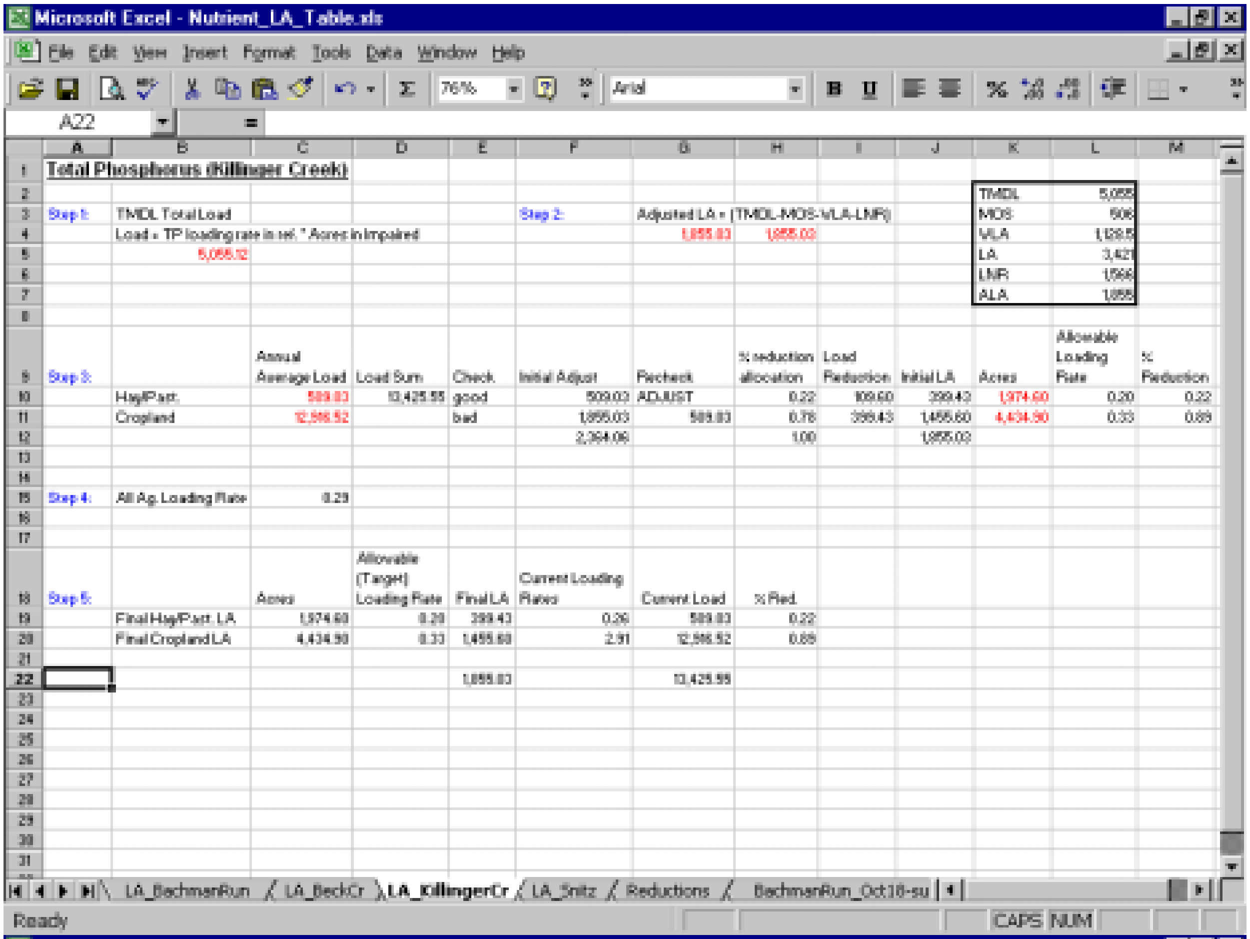
APPENDIX H - EMPR WORKBOOKS FOR TOTAL PHOSPHORUS LOAD ALLOCATIONS



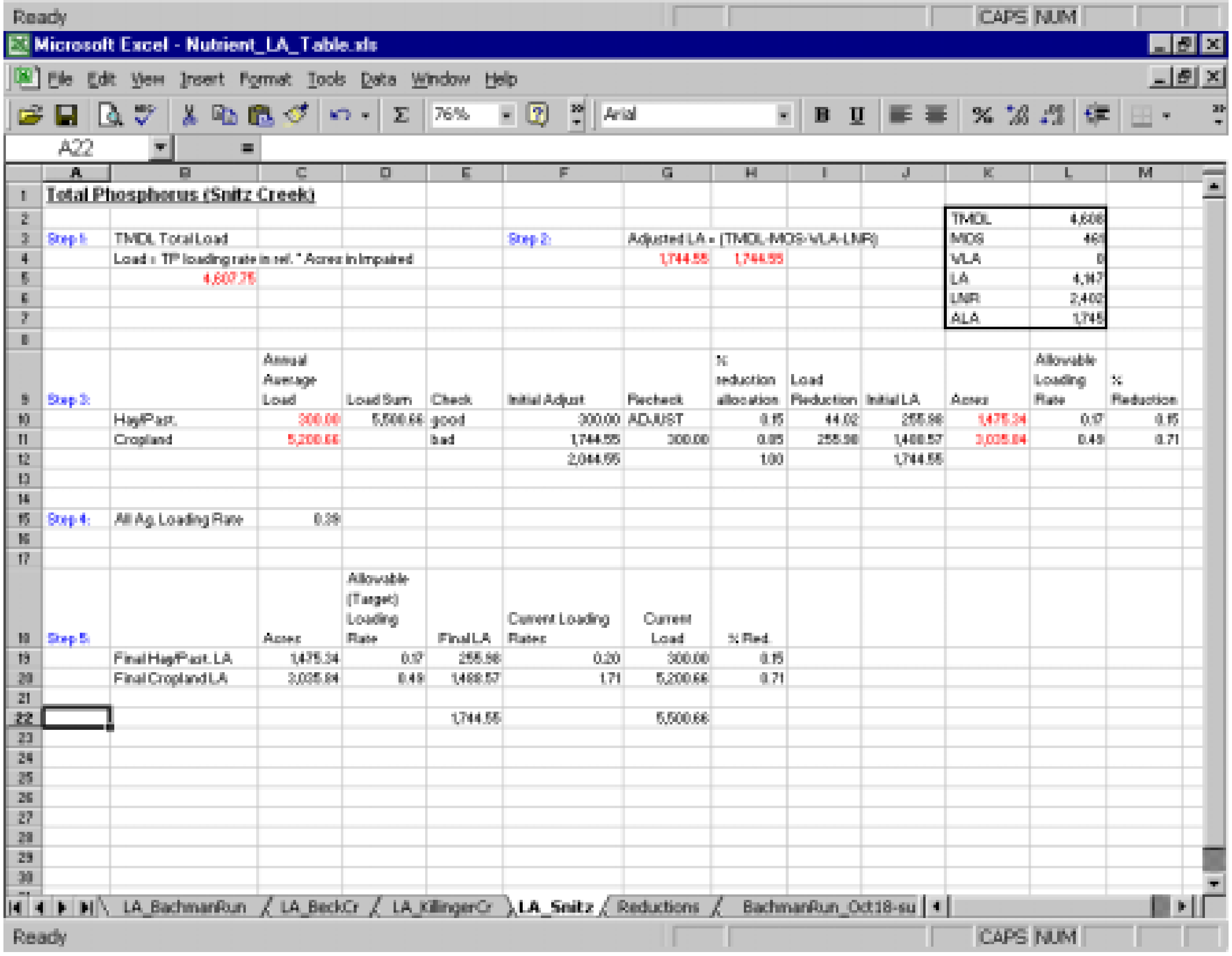
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Total Phosphorus (Bachman Run)												
2											TMDL	2,912	
3	Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL-MOS-VLA-LNR)				MOS	291	
4		Load = TP loading rate in ref. * Acres in Impaired					1,704.31	1,704.31			VLA	0	
5		2,912.27									LA	2,621	
6											LNR	917	
7											ALA	1,704	
8													
9	Step 3:		Annual Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reduction	Initial LA	Acres	Allowable Loading Rate	% Reduction
10		Hay/Past.	495.15	6,807.71	good	495.15	ADJUST	0.23	111.47	383.68	1,434.42	0.27	0.23
11		Cropland	6,312.56		bad	1,704.31	495.15	0.77	383.68	1,320.63	2,532.13	0.52	0.79
12						2,199.46		1.00		1,704.31			
13													
14													
15	Step 4:	All Ag. Loading Rate	0.43										
16													
17													
18	Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.					
19		Final Hay/Past. LA	1,434.42	0.27	383.68	0.35	495.15	0.23					
20		Final Cropland LA	2,532.13	0.52	1,320.63	2.49	6,312.56	0.79					
21													
22					1,704.31		6,807.71						
23													
24													
25													
26													
27													
28													
29													
30													



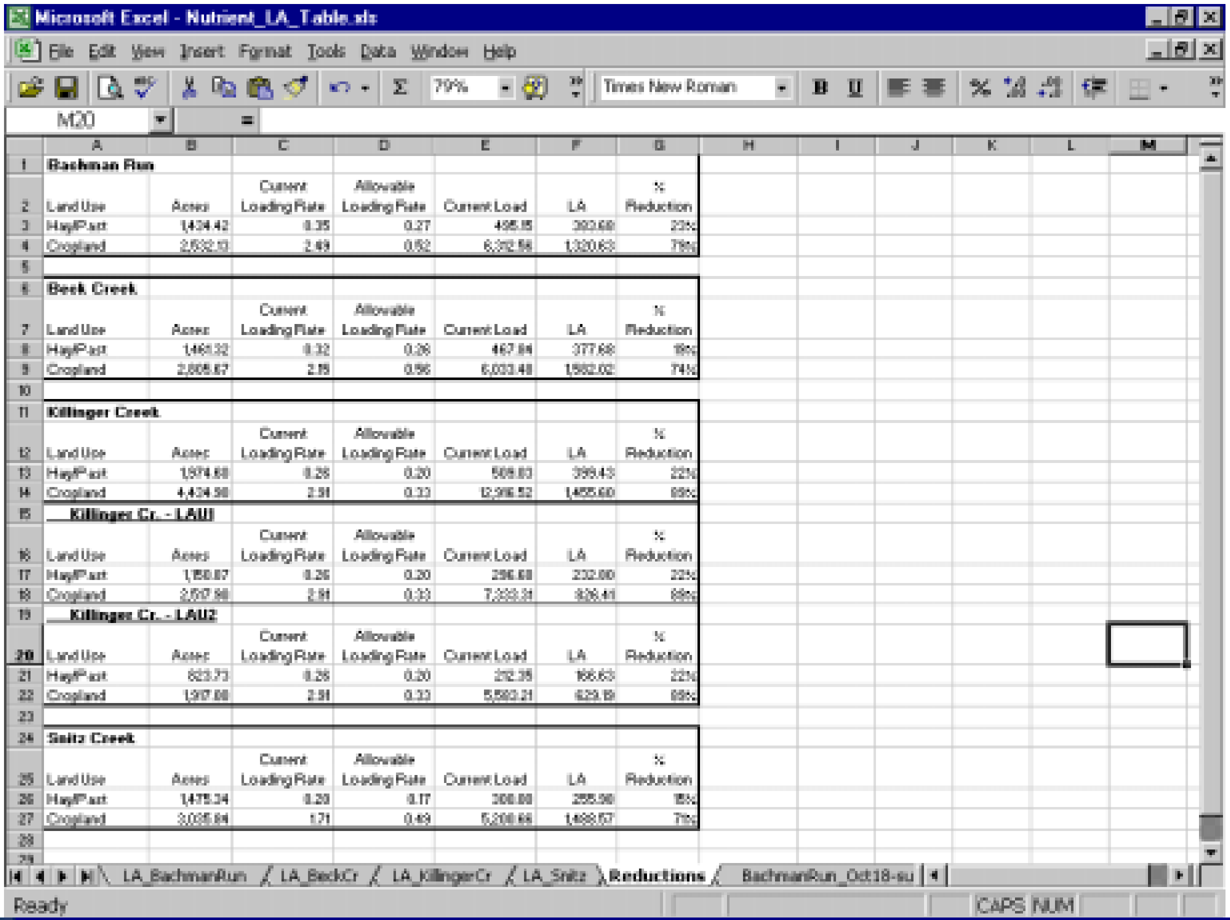
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Total Phosphorus (Beck Creek)												
2											TMDL	3,067	
3	Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL-MOS-VLA-LNR)				MOS	307	
4		Load = TP loading rate in ref. * Acres in Impaired					1,959.70	1,959.70			VLA	0	
5		3,067.32									LA	2,761	
6											LNR	801	
7											ALA	1,960	
8													
9	Step 3:		Annual Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reduction	Initial LA	Acres	Allowable Loading Rate	% Reduction
10		Hay/Past.	467.84	6,501.32	good	467.84	ADJUST	0.19	90.16	377.68	1,481.32	0.26	0.19
11		Cropland	6,033.48		bad	1,959.70	467.84	0.81	377.68	1,582.02	2,805.67	0.56	0.74
12						2,427.54		1.00		1,959.70			
13													
14													
15	Step 4:	All Ag. Loading Rate	0.46										
16													
17													
18	Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.					
19		Final Hay/Past. LA	1,481.32	0.26	377.68	0.32	467.84	0.19					
20		Final Cropland LA	2,805.67	0.56	1,582.02	2.15	6,033.48	0.74					
21													
22					1,959.70		6,501.32						
23													
24													
25													
26													
27													
28													
29													
30													



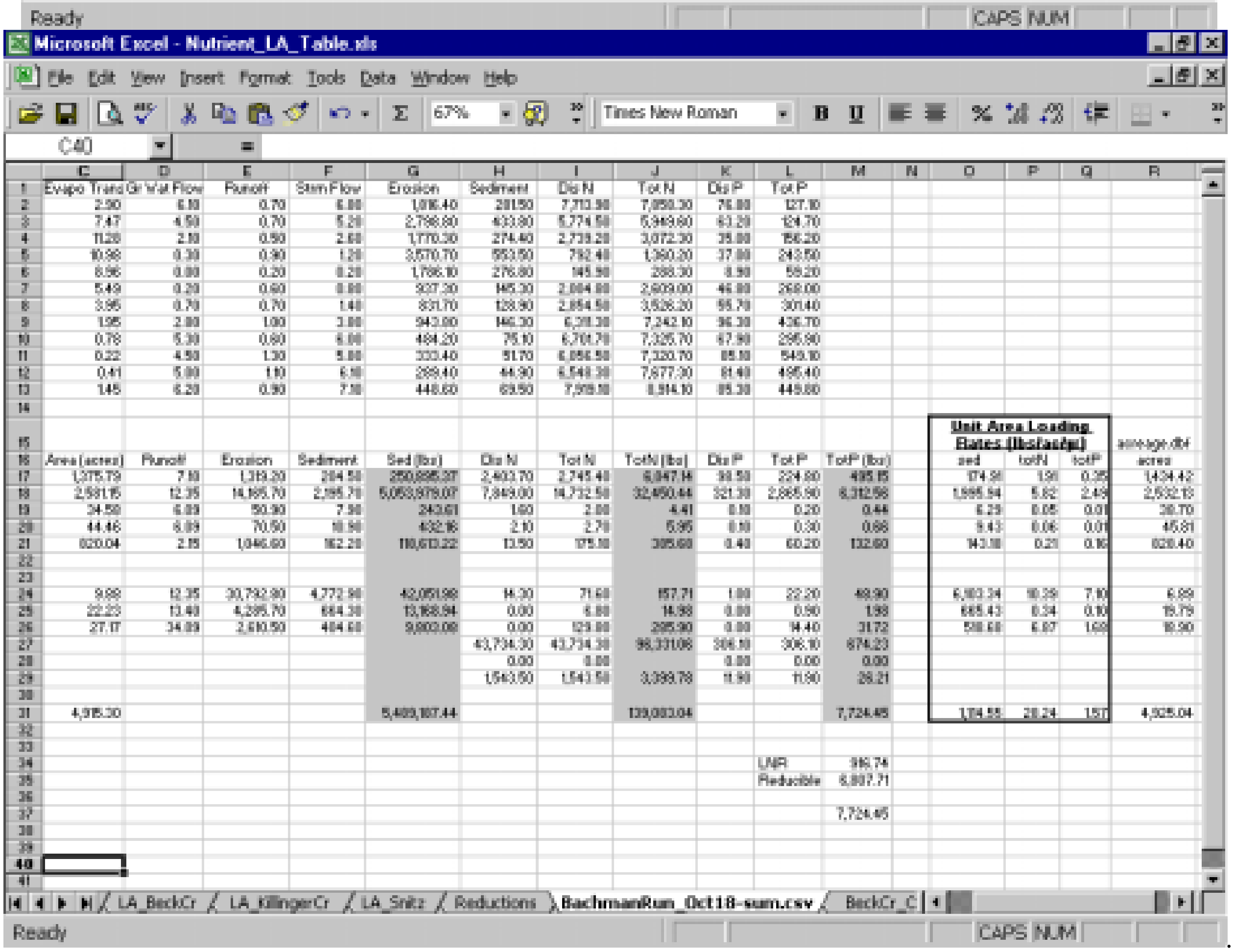
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Total Phosphorus (Killinger Creek)**												
2											TMDL	5,058	
3	Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL-MOS-VLA-LNR)				MOS	506	
4		Load = TP loading rate in ref. * Acres in Impaired					1,855.03	1,855.03			VLA	1,128.5	
5		5,058.12									LA	3,421	
6											LNR	1,566	
7											ALA	1,855	
8													
9	Step 3:		Annual Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reduction	Initial LA	Acres	Allowable Loading Rate	% Reduction
10		Hay/Past.	509.03	13,425.55	good	509.03	ADJUST	0.22	109.60	399.43	1,974.60	0.20	0.22
11		Cropland	12,916.52		bad	1,855.03	509.03	0.78	399.43	1,455.60	4,434.90	0.33	0.89
12						2,364.06		1.00		1,855.03			
13													
14													
15	Step 4:	All Ag. Loading Rate	0.29										
16													
17													
18	Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.					
19		Final Hay/Past. LA	1,974.60	0.20	399.43	0.26	509.03	0.22					
20		Final Cropland LA	4,434.90	0.33	1,455.60	2.91	12,916.52	0.89					
21													
22					1,855.03		13,425.55						
23													
24													
25													
26													
27													
28													
29													
30													
31													



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Total Phosphorus (Snitz Creek)**												
2											TMDL	4,608	
3	Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL-MOS-VLA-LNR)				MOS	461	
4		Load = TP loading rate in ref. * Acres in Impaired					1,744.55	1,744.55			VLA	0	
5		4,607.75									LA	4,147	
6											LNR	2,402	
7											ALA	1,745	
8													
9	Step 3:		Annual Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Reduction	Initial LA	Acres	Allowable Loading Rate	% Reduction
10		Hay/Past.	300.00	5,500.66	good	300.00	ADJUST	0.15	44.02	255.98	1,475.34	0.17	0.15
11		Cropland	5,200.66		bad	1,744.55	300.00	0.85	255.98	1,488.57	3,035.84	0.49	0.71
12						2,044.55		1.00		1,744.55			
13													
14													
15	Step 4:	All Ag. Loading Rate	0.39										
16													
17													
18	Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.					
19		Final Hay/Past. LA	1,475.34	0.17	255.98	0.20	300.00	0.15					
20		Final Cropland LA	3,035.84	0.49	1,488.57	1.71	5,200.66	0.71					
21													
22					1,744.55		5,500.66						
23													
24													
25													
26													
27													
28													
29													
30													

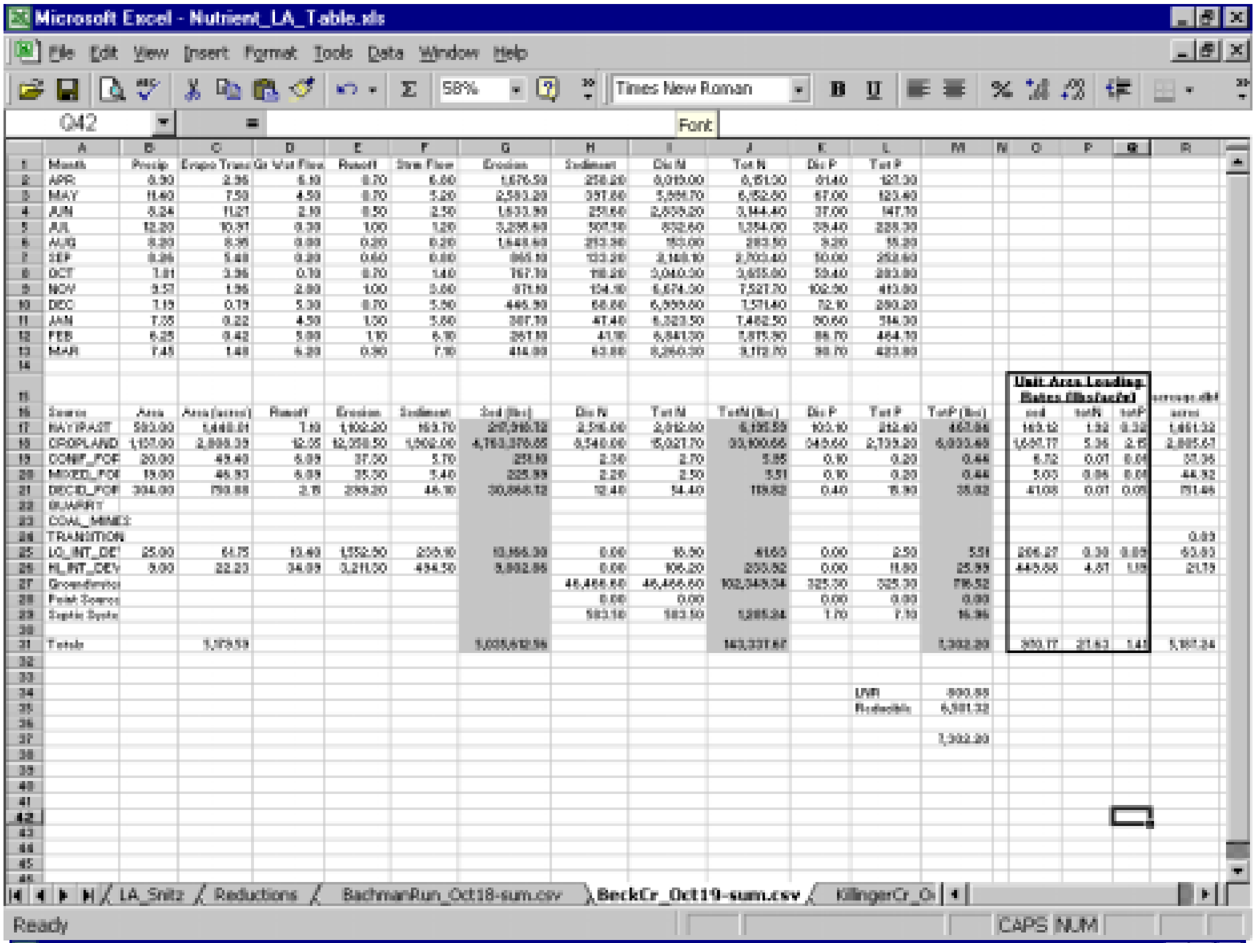


	A	B	C	D	E	F	G
1	**Bachman Run**						
2	Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
3	Hay/Past	1,434.42	0.35	0.27	495.15	383.68	23%
4	Cropland	2,532.13	2.49	0.52	6,312.58	1,320.63	79%
5							
6	**Beck Creek**						
7	Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
8	Hay/Past	1,461.32	0.32	0.26	467.84	377.68	19%
9	Cropland	2,805.67	2.15	0.56	6,033.48	1,582.02	74%
10							
11	**Killinger Creek**						
12	Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
13	Hay/Past	1,974.60	0.26	0.20	509.83	399.43	22%
14	Cropland	4,424.90	2.91	0.33	12,916.52	1,455.60	89%
15	**Killinger Cr. - LAU1**						
16	Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
17	Hay/Past	1,150.87	0.26	0.20	296.68	232.80	22%
18	Cropland	2,507.90	2.91	0.33	7,333.31	826.41	89%
19	**Killinger Cr. - LAU2**						
20	Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
21	Hay/Past	823.73	0.26	0.20	212.35	166.63	22%
22	Cropland	1,917.00	2.91	0.33	5,583.21	629.19	89%
23							
24	**Snitz Creek**						
25	Land Use	Acres	Current Loading Rate	Allowable Loading Rate	Current Load	LA	% Reduction
26	Hay/Past	1,475.34	0.20	0.17	300.80	255.90	15%
27	Cropland	3,035.84	1.71	0.49	5,200.66	1,488.57	71%



	C	D	E	F	G	H	I	J	K	L
1	Evapo Trans	Gr Wat Flow	Runoff	Strm Flow	Erosion	Sediment	Dis N	Tot N	Dis P	Tot P
2	2.90	6.10	0.70	6.80	1,016.40	201.50	7,713.90	7,050.30	76.80	127.10
3	7.47	4.50	0.70	5.20	2,798.80	433.80	5,774.50	5,949.60	63.20	124.70
4	11.28	2.10	0.50	2.60	1,770.30	274.40	2,739.20	3,072.30	35.80	156.20
5	10.98	0.30	0.90	1.20	3,570.70	553.50	792.40	1,360.20	37.00	243.50
6	8.96	0.00	0.20	0.20	1,706.10	276.80	145.90	288.30	8.90	59.20
7	5.49	0.20	0.60	0.80	937.30	145.30	2,004.80	2,609.00	46.80	268.00
8	3.95	0.70	0.70	1.40	831.70	128.90	2,854.50	3,526.20	55.70	301.40
9	1.95	2.80	1.00	3.80	943.00	146.30	6,318.30	7,242.10	96.30	436.70
10	0.78	5.30	0.80	6.00	484.20	75.10	6,701.70	7,325.70	67.90	295.90
11	0.22	4.50	1.30	5.80	333.40	51.70	6,056.50	7,320.70	85.10	549.10
12	0.41	5.00	1.10	6.10	289.40	44.90	6,548.30	7,877.30	81.40	495.40
13	1.45	6.20	0.90	7.10	448.60	69.50	7,919.50	8,914.10	85.30	449.80
14										

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
15													**Unit Area Loading Rates (lbs/ac/yr)**			acreage dbf
16	Area (acres)	Runoff	Erosion	Sediment	Sed (lbs)	Dis N	Tot N	TotN (lbs)	Dis P	Tot P	TotP (lbs)		sed	totN	totP	acres
17	1,375.79	7.10	1,319.20	204.50	250,895.37	2,403.70	2,745.40	6,047.14	30.50	224.80	495.15		174.91	1.91	0.35	1434.42
18	2,591.15	12.35	14,185.70	2,195.70	5,053,979.07	7,849.00	14,732.50	32,450.44	321.30	2,865.90	6,312.58		1,995.54	5.62	2.49	2,532.13
19	34.50	6.09	50.30	7.90	243.61	1.60	2.00	4.41	0.10	0.20	0.44		6.29	0.05	0.01	38.70
20	44.46	6.09	70.50	10.90	432.16	2.10	2.70	5.95	0.10	0.30	0.66		9.43	0.06	0.01	45.81
21	820.04	2.15	1,046.60	162.20	110,613.22	13.50	175.10	385.60	0.40	60.20	132.60		143.18	0.21	0.16	820.40
22																
23																
24	9.88	12.35	30,792.90	4,772.90	42,051.98	14.30	71.60	157.71	1.00	22.20	48.90		6,103.24	10.29	7.10	6.89
25	22.23	13.40	4,295.70	664.30	13,168.94	0.00	6.80	14.98	0.00	0.90	1.98		665.43	0.34	0.10	19.79
26	27.17	34.09	2,610.50	404.60	9,803.08	0.00	129.80	285.90	0.00	14.40	31.72		518.68	6.07	1.68	18.90
27						43,734.30	43,734.30	98,331.08	306.10	306.10	674.23					
28						0.00	0.00		0.00	0.00	0.00					
29						1,543.50	1,543.50	3,399.78	11.90	11.90	26.21					
30																
31	4,915.30				5,409,107.44			139,003.04			7,724.45		1,104.55	28.24	1.57	4,525.04
32																
33																
34										UNR	916.74					
35										Reducible	6,807.71					
36																
37											7,724.45					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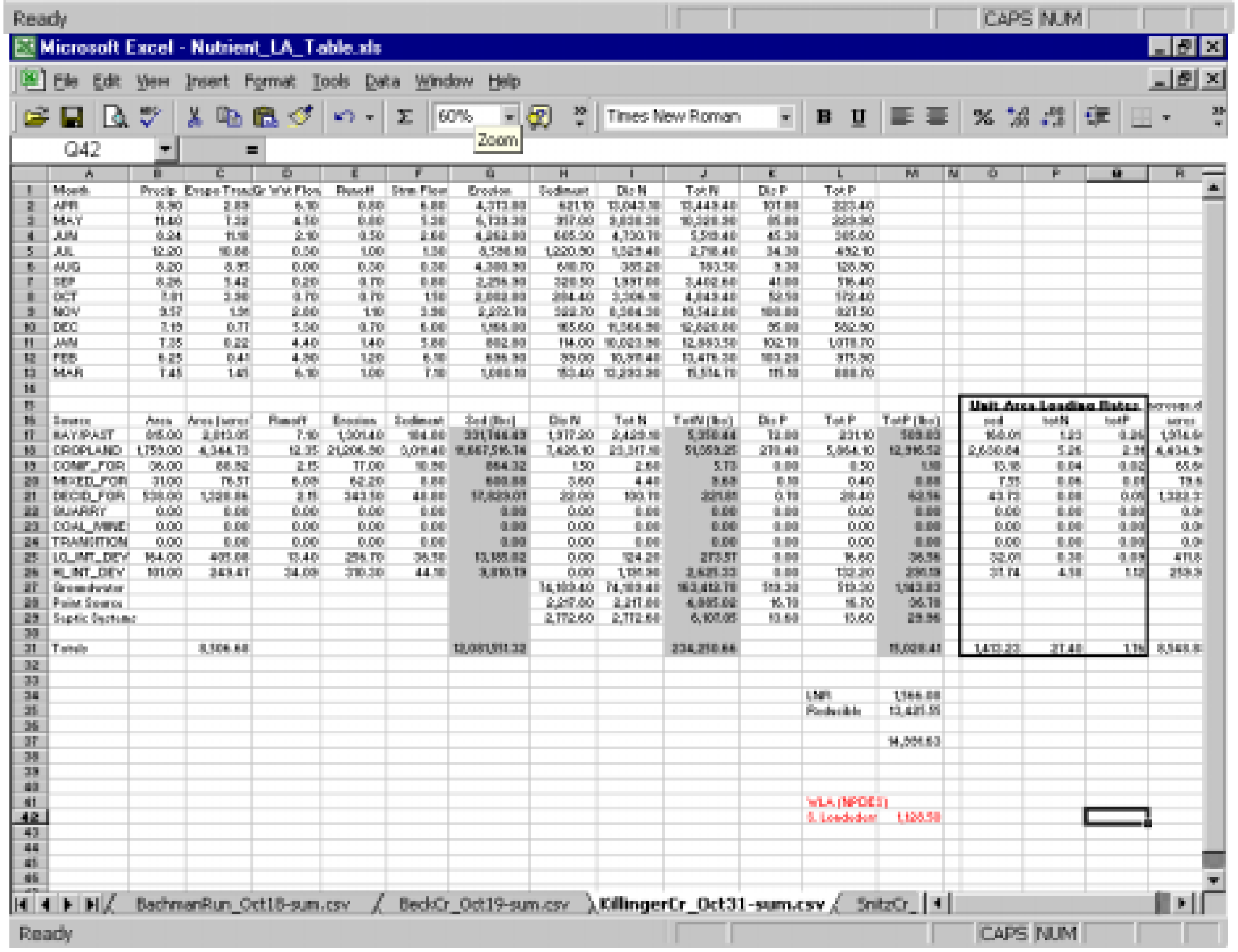
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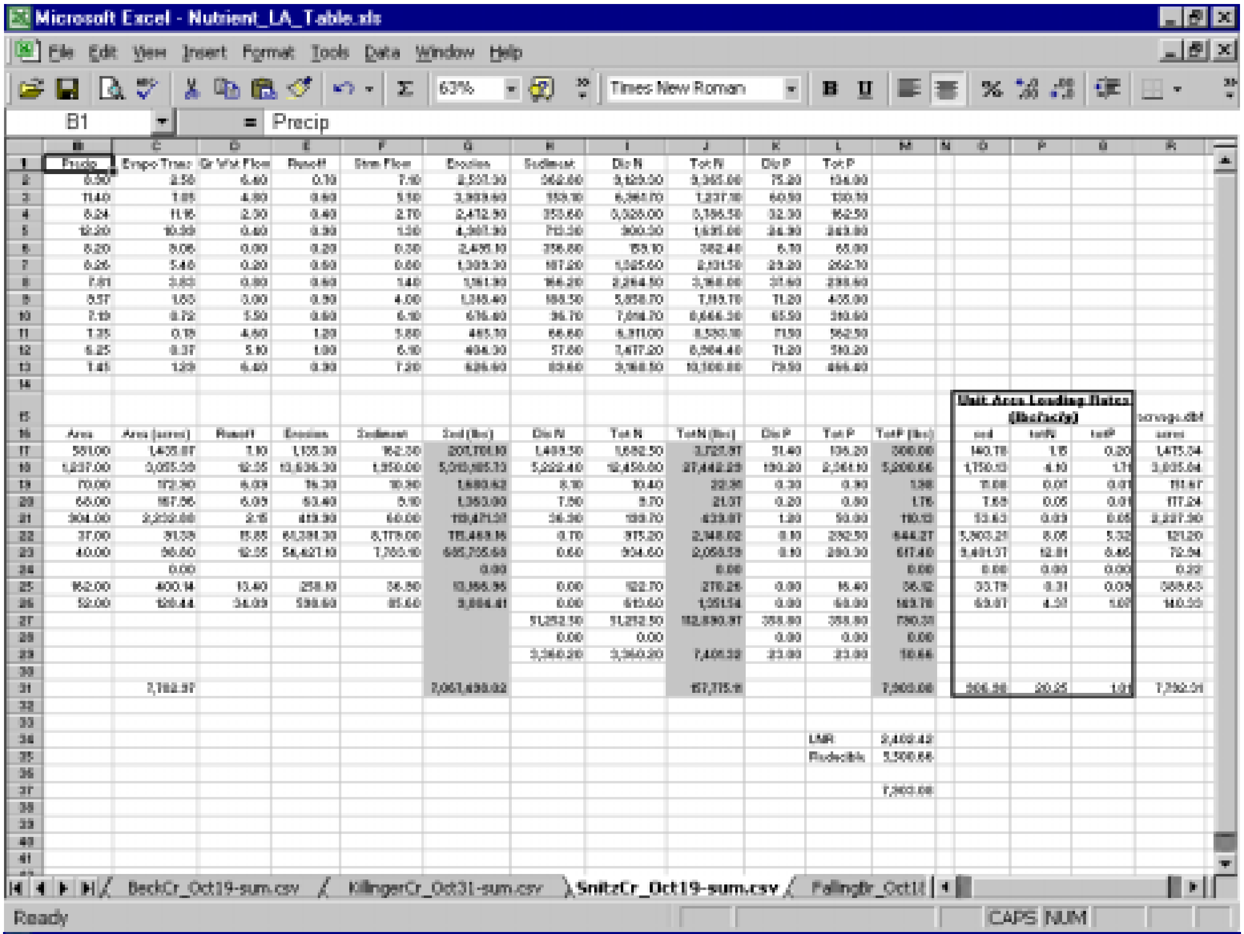
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Unit Area Loading Rates (lbs/ac/yr)
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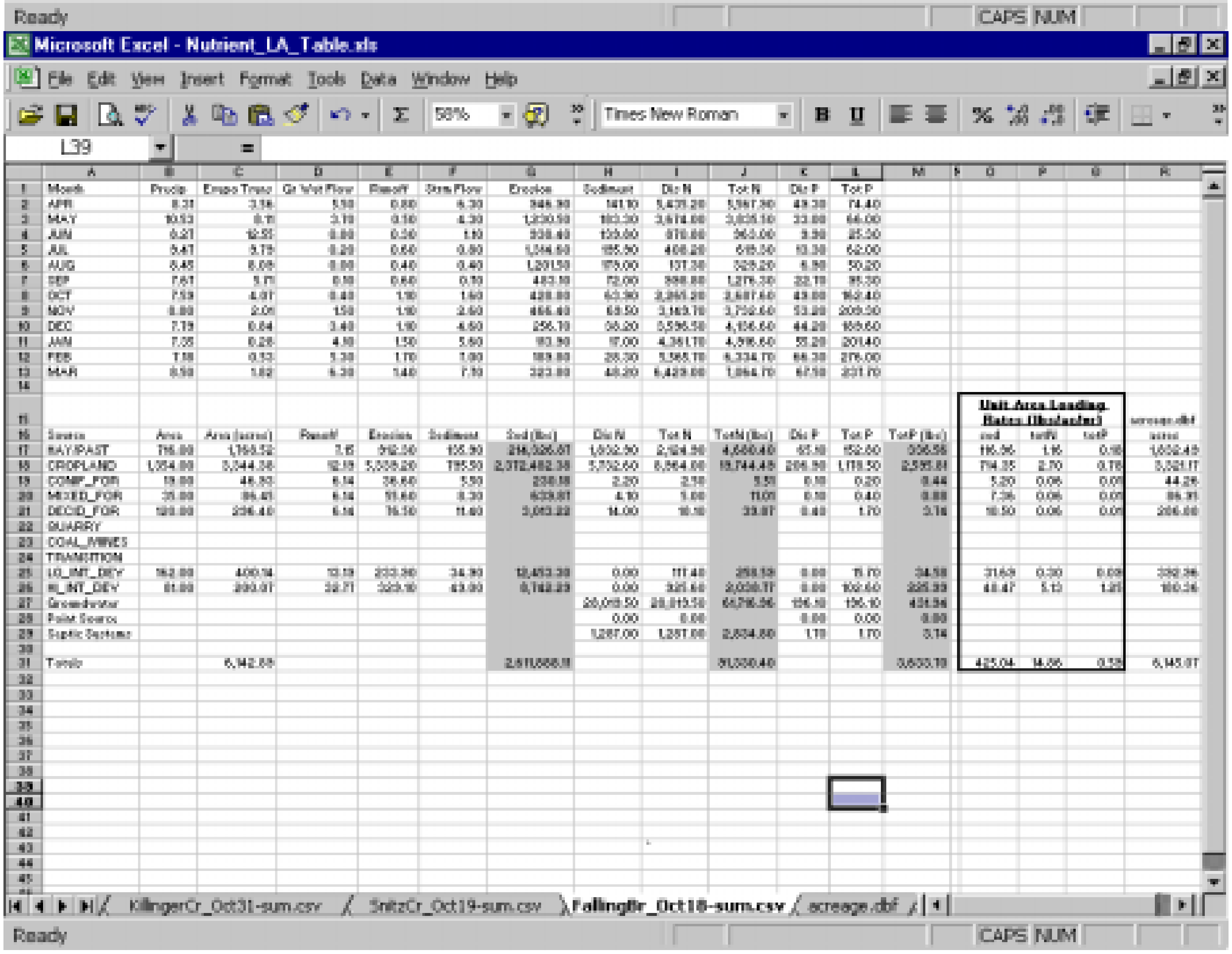
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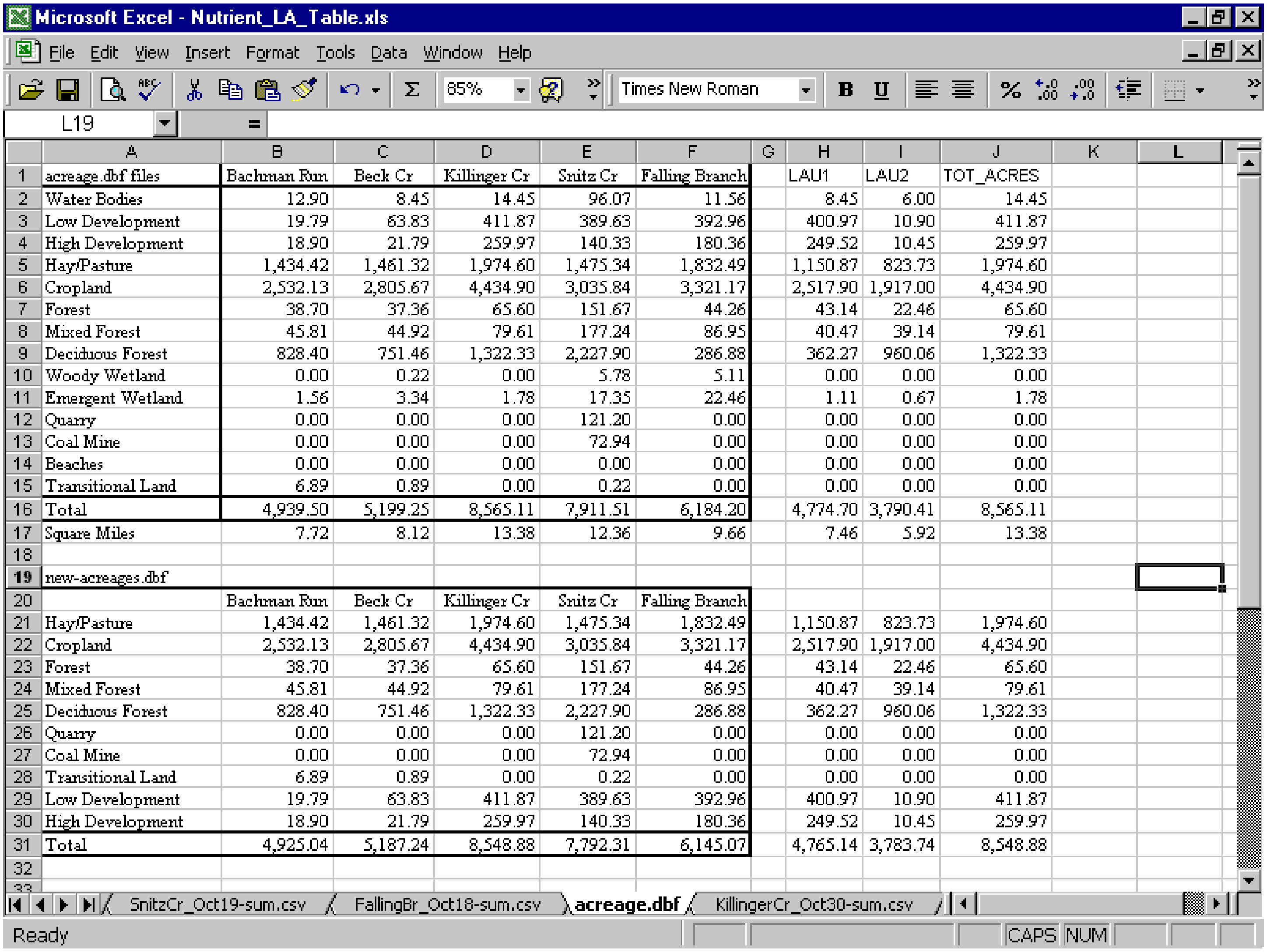

	A	B	C	D	E	F	G	H	I	J	K	L
1	acreage.dbf files	Bachman Run	Beck Cr	Killinger Cr	Snitz Cr	Falling Branch		LAU1	LAU2	TOT_ACRES		
2	Water Bodies	12.90	8.45	14.45	96.07	11.56		8.45	6.00	14.45		
3	Low Development	19.79	63.83	411.87	389.63	392.96		400.97	10.90	411.87		
4	High Development	18.90	21.79	259.97	140.33	180.36		249.52	10.45	259.97		
5	Hay/Pasture	1,434.42	1,461.32	1,974.60	1,475.34	1,832.49		1,150.87	823.73	1,974.60		
6	Cropland	2,532.13	2,805.67	4,434.90	3,035.84	3,321.17		2,517.90	1,917.00	4,434.90		
7	Forest	38.70	37.36	65.60	151.67	44.26		43.14	22.46	65.60		
8	Mixed Forest	45.81	44.92	79.61	177.24	86.95		40.47	39.14	79.61		
9	Deciduous Forest	828.40	751.46	1,322.33	2,227.90	286.88		362.27	960.06	1,322.33		
10	Woody Wetland	0.00	0.22	0.00	5.78	5.11		0.00	0.00	0.00		
11	Emergent Wetland	1.56	3.34	1.78	17.35	22.46		1.11	0.67	1.78		
12	Quarry	0.00	0.00	0.00	121.20	0.00		0.00	0.00	0.00		
13	Coal Mine	0.00	0.00	0.00	72.94	0.00		0.00	0.00	0.00		
14	Beaches	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00		
15	Transitional Land	6.89	0.89	0.00	0.22	0.00		0.00	0.00	0.00		
16	Total	4,939.50	5,199.25	8,565.11	7,911.51	6,184.20		4,774.70	3,790.41	8,565.11		
17	Square Miles	7.72	8.12	13.38	12.36	9.66		7.46	5.92	13.38		
18												
19	new-acreages.dbf											
20		Bachman Run	Beck Cr	Killinger Cr	Snitz Cr	Falling Branch						
21	Hay/Pasture	1,434.42	1,461.32	1,974.60	1,475.34	1,832.49		1,150.87	823.73	1,974.60		
22	Cropland	2,532.13	2,805.67	4,434.90	3,035.84	3,321.17		2,517.90	1,917.00	4,434.90		
23	Forest	38.70	37.36	65.60	151.67	44.26		43.14	22.46	65.60		
24	Mixed Forest	45.81	44.92	79.61	177.24	86.95		40.47	39.14	79.61		
25	Deciduous Forest	828.40	751.46	1,322.33	2,227.90	286.88		362.27	960.06	1,322.33		
26	Quarry	0.00	0.00	0.00	121.20	0.00		0.00	0.00	0.00		
27	Coal Mine	0.00	0.00	0.00	72.94	0.00		0.00	0.00	0.00		
28	Transitional Land	6.89	0.89	0.00	0.22	0.00		0.00	0.00	0.00		
29	Low Development	19.79	63.83	411.87	389.63	392.96		400.97	10.90	411.87		
30	High Development	18.90	21.79	259.97	140.33	180.36		249.52	10.45	259.97		
31	Total	4,925.04	5,187.24	8,548.88	7,792.31	6,145.07		4,765.14	3,783.74	8,548.88		
32												

Comment and Response Document

General:

Comment: How was the sediment load calculated for the Quittapahilla Creek? (1)
Response: Average annual sediment loads were estimated using the AVGWLF model. Please refer to Attachment E – GWLF User Manual for a complete review of algorithms used in these computations.

Comment: What source or sources have been identified as contributing to the sediment problem? Is there a list of contributing point sources of sediment currently available? (1,2)
Response: The Department's 305(b) database identifies agriculture, including crop related agriculture, as the source of siltation and suspended solids currently causing impairments in the Quittapahilla Creek watershed. The Department does not have data on any point sources of sediment that are contributing to impairments in the watershed.

Comment: Does the sediment criteria extend to the entire watershed, i.e. tributaries? (1)
Response: As depicted in Appendix C, siltation impairments are primarily restricted to the mainstem of Quittapahilla Creek, and the Killinger Creek, Bachman Run, and Snitz Creek sub-basins. Since siltation impairments extend to the mouth of the Quittapahilla Creek watershed, sediment loading from the entire watershed, including all tributaries, is addressed under the TMDL

Comment: What TMDL can be applied to protect the thermal level of the stream to protect the TSF or raise it to cold water fishery? Does the TMDL have to monitor sediment only, or can temperature and water additions be monitored too? (1,2)
Response: Under current regulations, TMDLs are only developed for those sources and causes of impairment found on the 303(d) list. The 1996 and 1998 303(d) list did not identify any temperature related impairments in the Quittapahilla Creek watershed. The Department will review any submitted information regarding thermal impacts to the stream. If appropriate, the information would be used in developing future 303(d) lists. If the commentor has data to indicate that the watershed's current Trout Stocking designation is incorrect, the Environmental Quality Board may be petitioned for a stream redesignation.

Comment: Has any thought been given to setting a TMDL for the withdrawal and or the addition of water to the Quittapahilla Creek beyond the normal flows or runoff patterns? Proposed changes in the Quittapahilla headwater area will further the channelization of the stream and further threaten downstream property owners. Does anybody monitor the water from storm sewers directly adding water from manmade impervious surfaces like parking lots that may result in additional oil and road salts to our streams, raised temperatures from the hot macadam, and more frequent and intense flooding? (1,2)
Response: As mentioned in the above response, the Department develops TMDLs for those sources and causes of impairment found on the 303(d) list. No portion of the Quittapahilla Creek watershed is currently on the 303(d) list for water quantity related impairments. Flow alteration or other impairments would be addressed in the future if they are later listed under section 303(d).

Comment: Many of the charts in appendix H are unreadable, both online and printed out on paper. (3)

Response: Changes have been made to the final TMDL report in an effort to make all the tables readable.

Listing Issues:

Comment: The draft TMDLs fail to specify whether water quality is impaired all year, or whether water quality is only impaired during particular time periods. Aquatic biological surveys were conducted to determine whether Quittapahilla Creek watershed is impaired, they do not indicate whether this assessment method accounts for seasonal variations in water quality. (3)

Response: Portions of the Quittapahilla Creek watershed were placed on the 1996 and 1998 303(d) lists based on survey work which included both chemical sampling of instream water quality and biological assessments of the benthic macroinvertebrate community. The entire basin was surveyed during 1999 using the Unassessed Waters Program protocol. Information collected during 1999 confirmed the impairments included on the 303(d) list. The 1999 survey work utilized the benthic macroinvertebrate community as a long-term indicator of water quality and use attainment. Those portions of the Quittapahilla Creek watershed covered by this report are considered to be impaired throughout the year.

Reference Watersheds:

Comment: The TMDLs need to more fully discuss whether the differences that exist (such as the differences in topographic relief, geology, and 20-year average runoff) are compensated for in the model used by the TMDLs that result from the watershed comparisons. (3)

Response: The AVGWLF model does take into account differences in topographic relief, geology, and 20-year average runoff. Topography and stream density are used in derivation of Universal Soil Loss Equation (USLE) parameters assigned to model soil erosion. Geologic similarity is used as one of the criteria for choosing a reference watershed and model parameters such as the groundwater recession coefficient are adjusted based on the underlying geology in each watershed. Loading rates discussed in the TMDL are delivered loading rates, not edge-of-stream loading rates. AVGWLF models surface runoff using the SCS-CN approach with daily weather (temperature and precipitation) inputs.

Comment: The draft document fails to discuss whether the differences in agricultural practices and condition of riparian buffers and streambanks reasonably account for Conococheague Creek (and its Falling Branch tributary) meeting water quality standards while Quittapahilla Creek watershed (and the four sub-watersheds) do not. (3)

Response: The 1996 and 1998 303(d) lists specifically identify agriculture as the source of use impairment in the Quittapahilla Creek watershed. Nutrients and siltation are identified as the causes of impairments. The portion of the Conococheague Creek watershed used in this report has been assessed using the Department’s Unassessed Waters Program protocol and was determined to be supporting its designated uses. These two watersheds are a fairly close match in terms of land cover/land use, physiographic province, geology, and size. The extent of agricultural land uses in each watershed is similar. The primary difference between the two watersheds at the time of the section 303(d) listing of Quittapahilla Creek was the presence of agricultural Best Management Practices (BMPs) in the Conococheague Creek watershed. The differences in BMP implementation identified by the commentor appear to be the reason for nonsupport of designated uses in the Quittapahilla Creek watershed at the time of the original listing survey. Since that time, extensive work has been done in the Quittapahilla Creek watershed particularly with respect to restoration of the riparian zone and the fencing of streams. This work was not represented in the modeling of initial conditions presented in the TMDL, rather, it represents progress toward the nutrient and sediment reductions required by the TMDL.

Comment: The TMDLs fail to discuss whether the water quality standards, and the biological assessments made to determine compliance with those standards, differ between the target and reference watersheds. (3)

Response: The water quality standard for both watersheds is the combination of designated uses and the criteria developed to protect those uses. Portions of the Quittapahilla Creek watershed were placed on the 1996 303(d) list due to documented water quality criteria violations from instream water samplings and non-support of designated uses based on qualitative sampling of the benthic macroinvertebrate community. The 1998 303(d) list includes additional impairments that were documented with qualitative sampling of the benthic macroinvertebrate community. These use impairments were affirmed in 1999 by surveys using the Department's Unassessed Waters (UW) protocol. Documented use impairments from this survey work are summarized in the report. As mentioned in the report, the Conococheague Creek watershed has been assessed under the UW protocol and was determined to be supporting all its designated uses.

Comment: The draft TMDLs indicate that the reference watershed is not impaired for nutrients or sediment, but does not specify what testing was done to reach this conclusion and whether this testing accounted for seasonal variations. To be an appropriate reference watershed, Conococheague Creek must meet water quality standards throughout the year. (3)

Response: The reference watersheds were assessed using the Department's Unassessed Waters protocol and were documented to be meeting water quality standards. The UW protocol includes an evaluation of the benthic macroinvertebrate community, which is a long-term indicator of water quality that accounts for seasonal variation.

Comment: The TMDLs need to discuss the differences in aquatic life use designations and why they do or do not affect the appropriateness of choosing Conococheague Creek/Falling Branch as the reference watershed. If Conococheague Creek is a significantly lower temperature than Quittapahilla Creek watershed, the nutrient loads in Conococheague Creek may not produce as many negative effects, such as algae blooms, as the same nutrient loads would in the warmer waters of Quittapahilla Creek watershed. (3)

Response: The reference watersheds used for developing these TMDLs include waters with designated aquatic life uses that include Cold Water Fishes (CWF), Trout Stocking (TSF), and Warm Water Fishes (WWF). The most downstream portion of both the Conococheague Creek and Falling Branch reference watersheds (i.e., the point at which annual loadings were calculated) are designated as WWF and TSF, respectively. The entire Quittapahilla Creek watershed is currently designated as TSF. The reference watershed used in the development of these nutrient TMDLs had the exact same aquatic life use designation (i.e., TSF) as the impaired subbasins in the Quittapahilla Creek watershed. No nutrient TMDL was developed for the mainstem of Quittapahilla Creek, because the 303(d) list does not include that impairment. During any time of the year, instream temperature at the mouth of Quittapahilla Creek (TSF) are protected at the same or lower levels compared to the downstream portion of the Conococheague Creek (WWF).

Comment: Falling Branch is not an appropriate reference watershed for Killinger Creek, because the two watersheds are not well matched in the type of pollution sources. Pollution loads in a watershed with point sources (such as Killinger Creek) would be distributed much more evenly through the year than the pollution loads in a watershed with only non-point sources (such as Falling Branch). Differences in pollution sources could be expected to result in differences in water quality impacts. The commentor suggests that a watershed with similar point source contribution would be a more appropriate reference. (3)

Response: The relative loading of total phosphorus from the one point source included in the Killinger Run TMDL is minor compared to all other sources. The amount of total phosphorus coming from the South Londonderry Township STP accounts for less than 1% of the existing load used in the development of the Killinger Creek TMDL. The lack of such a minor point source contribution in the Falling Branch watershed is not significant enough to eliminate its use as a reference watershed.

Modeling Issues:

Comment: Is it possible to break out the actual data used verses the model projections? (2)

Response: Developing these TMDLs did not involve additional data collection from the Quittapahilla Creek watershed. Transport, nutrient, and weather related data used in the AVGWLF simulations were derived from statewide GIS layers. These GIS layers include actual data for land use, land cover, elevation, physiographic provinces, generalized soil boundaries, surficial geology, animal densities, sewage disposal methods, conservation practice, N concentrations in ground water, NPDES discharges, point source nitrogen and phosphorus loads, soil phosphorus loads, and weather.

Comment: The proposed TMDLs fail to establish total maximum daily loads. DEP has not explained why setting a yearly limit, which presumably allows for daily, weekly, or monthly fluctuations in loads as long as the yearly totals are not exceeded, adequately protect water quality on a daily basis. (3)

Response: The Clean Water Act requirement for total maximum daily loads allows for the expression of a TMDL in units of mass per time, toxicity, or other appropriate measures. DEP in consultation with EPA has determined that annual loadings are more appropriate for expression of nonpoint source TMDLs for nutrients and sediment.

Comment: Setting only an annual load is inadequate for performance monitoring and regulatory enforcement. Daily loadings and stream flows should be calculated for one or several critical or frequently encountered seasonal weather conditions. They would be more readily useful measures for monitoring of loads and enforcement of the TMDLs. (3)

Response: See previous response.

Comment: The TMDLs fail to meet the Clean Water Act requirement for establishing a maximum daily load for impaired waters that reflect seasonal variations.

Response: The continuous simulation model used for this analysis considers seasonal variations 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.

Comment: The TMDLs fail to establish nitrogen limits without sufficient justification for not doing so. If the N:P ratio is calculated from total yearly loads including groundwater as a source, the ratios are above the 10:1 threshold on which DEP bases its limiting nutrient determination. If the N:P ratio is calculated from nutrient loads from surface sources alone, the ratios become significantly lower. Nitrogen may be the rate-limiting nutrient rather than phosphorus when surface runoff becomes the major source of stream flow and nutrient loadings. Because of the uncertainty over which nutrient is limiting at any given time during the year, the commentor strongly urges DEP to establish nitrogen TMDLs in addition to the phosphorus TMDLs. (3)

Response: Although ground water contributions of N will be highest relative to overland runoff contributions during the summer months (May through September), total nitrogen loads will normally be lowest in these months due to low flows and increased plant uptake. Phosphorus does enter the stream through overland flow (runoff); however, periods of high P exports correspond to periods of high soil loss. During the wet winter months, there is normally enough ground cover to dissipate the erosive energy of precipitation. Total P loads, on a unit area basis, are typically highest in the fall (after harvest when more bare soil is exposed) and in the spring (more intense rainfall events on fields being prepared for planting). However, TN loads are also higher in the fall and spring such that the N:P ratio remains greater than 10.

Comment: The largest point source in the Killinger Creek watershed, the Palmyra Boro STP, should have been included in the Killinger Creek TMDL. (1,3)

Response: As described in the report, the phosphorus TMDL developed for the Killinger Creek basin was intended to address impacts resulting from agricultural activities. Pollutants emanating from agricultural sources are not the cause of use impairments to Killinger Creek downstream of the Palmyra Boro STP. The Palmyra Boro STP is not a source of use impairment to Killinger Creek or Quittapahilla Creek. Although use impairments exist downstream of the STP, they are the result of the stream being placed into a poured concrete channel and subterranean flow. There is no level of nutrient load reductions from agricultural or point sources that will allow the lower 0.7 miles of Killinger Creek to support its designated uses. Including Palmyra Boro STP in the WLA, as suggested, would not result in any advancement toward the objective of designated use attainment in Killinger Creek.

Comment: In calculating the TMDLs, DEP is inadequately accounting for the differences between the reference watershed and Quittapahilla Creek watershed. There may be differences besides watershed size, e.g., topographic relief, stream density (stream miles/mi^2), geology, annual water yield, animal densities, crops, and cropping practices, that influence the pollutant loads that can be accommodated by the streams. (3)

Response: The TMDLs developed for the Quittapahilla Creek watershed did account for differences in many of the factors listed. Topography and stream density are used in the derivation of the Universal Soil Loss Equation (USLE) parameters used to model soil erosion. Differences in these factors are reflected in the LS factor in the USLE for each watershed. Differences in animal density are accounted for in the model using a GIS coverage of animal populations by zip code as obtained from the U.S. Census of Agriculture. This data layer is used in determining the amount, and nutrient content, of manure applied to cropland in each watershed. Differences in crops and cropping practices are also accounted for both through GIS generation and manual manipulation of the C and P factors in the USLE. Using GIS coverages with typical county-based cropping and BMP implementation practices, C and P factors are generated for each watershed. These factors were further adjusted for Quittapahilla Creek and reference watersheds based on specific information obtained during site visits and discussions with district conservationists working in these watersheds. The adjustments made to the GIS generated C and P values are documented in the Watershed Assessment and Modeling section of this report. Geologic similarity is used as one of the criteria for choosing a reference watershed. Model parameters such as the groundwater recession coefficient are adjusted based on the underlying geology in the watershed. Therefore, differences in groundwater contributions due to dissimilar geology are accounted for in the analysis.

Comment: The calculation of point source loads for the maximum daily WLAs need to be done from the maximum permit limits, not average permit limits.
Response: The WLA for Killinger Creek, although expressed as an annual load, was calculated from maximum permit limits.

Comment: DEP has made a reasonable allocation of the loads among non-point sources in the watershed. The commentor commends DEP for making this allocation in the TMDLs, as the TMDLs established by other states often fail to do so.
Response: Thank you.

Comment: DEP fails to provide a rationale for selecting 10% as the margin of safety. The margin of safety should be based on the inherent uncertainty of the models used rather than the undefined "best professional judgment." (3)
Response: The margin of safety used in these TMDLs does take into consideration the inherent uncertainty of the AVGWLF model. The "best professional judgment" referred to in the report includes information from those individuals who developed, calibrated, and currently maintain the AVGWLF model. Inclusion of the 10% margin of safety provides an additional level of protection to designated uses.

Recommendations, BMPs:

Comment: The TMDLs do not provide reasonable assurance that the required reductions in phosphorus and sediment loadings will be met. The document does not specify if BMP implementation is planned for the whole watershed or just for impaired areas and the document fails to consider the expected BMP compliance rate of landowners. (3)
Response: TMDLs developed under section 303(d) of the CWA are not intended to be a step-by-step description of how to restore an impaired watershed. Federal law requires establishment of a pollutant load that will ensure attainment of water quality standards and an allocation of that load among point and nonpoint sources. These TMDLs have established pollutant loads, along with allocations of those loads, which will ensure attainment of water quality standards. Implementation plans, including assurances of specified load reductions, are not currently required as part of the TMDL under section 303(d). Information on potential remediation activities, including BMPs, was provided as an indication that the identified load reductions were achievable. The information should prove helpful to those developing plans to meet the specified reductions. While the Department insures compliance with all

applicable laws and regulations, the most effective and achievable means of meeting the goals set forth in these TMDLs will come from the local level. The Department will also provide organizational, technical and financial assistance to watershed groups who undertake implementation. Please contact the Department if you want further information.

Comment: The commentor urges DEP to make appropriate use of the AVGWLF model in developing site-specific implementation plans. (3)
Response: The Department will provide information and documentation on the AVGWLF model upon request.

Comment: A significant problem with the Killinger Creek watershed implementation plan is the failure to require any reductions in loadings from the South Londonderry Township point source. The commentor is not convinced that the BMPs discussed in the implementation plans can achieve a 90% reduction from cropland. (3)
Response: The South Londonderry Township STP is not identified as a source of impairment on the 303(d) list and is currently contributing less than 1% of the total phosphorus loading to Killinger Creek. The WLA for the TMDL is based on the maximum flow (0.21 mgd) and phosphorus concentrations (2.0 mg/l) allowable under its NPDES permit. Average flows and phosphorus concentrations at the STP (based on 1999 DMR data) are 0.032 mgd and 0.403 mg/l respectively. The 89% reduction in phosphorus loading from cropland in the Killinger Creek basin is only slightly higher than those recommended for the other subbasins (71% to 79%). If the reductions called for under the Killinger Creek TMDL cannot be met, additional considerations will be used to update the TMDL.

Follow-up Monitoring:

Comment: What physical measurements will be used to identify whether the sediment problem has been resolved? How will we know if or when the sediment problem is solved? (1,2)
Response: Sediment impairments in the Quittapahilla Creek watershed were documented using the Department's Unassessed Waters Program protocol, including evaluations of the benthic macroinvertebrate community and physical habitat. Rather than attempt to measure/monitor sediment loads in the basin, a determination on the elimination of siltation impairments will be based on future assessments conducted under the UW protocols. The siltation problems in the Quittapahilla Creek watershed will be "resolved", when the benthic macroinvertebrate community and physical habitat no longer indicate use impairment.

Comment: Will State monitoring gauge the impact of local stream bank fencing and riparian buffer projects? (2)
Response: Yes. As the Quittapahilla Creek watershed continues to be assessed using the Unassessed Waters Program protocol, changes in the benthic macroinvertebrate community and physical habitat resulting from local stream bank fencing and riparian buffer projects will be documented.

Comment: What type of controls and monitoring are anticipated for the reduction of phosphorus in the four creeks? What type of monitoring projects will track phosphorus? Is phosphorus the only nutrient that will be tracked? Will other nutrients be monitored? (1,2)
Response: The Department is not proposing any additional regulatory controls to obtain load reductions specified in the TMDLs. BMPs such as streambank fencing, restoration of

riparian vegetation and planting of cover crops will reduce both phosphorus and sediment loading to the water bodies. Follow-up monitoring will be addressed through the Department's current assessment and regulatory activities.

Comment: The commentor recommends that a monitoring program be part of any implementation plans to determine if the BMPs are having their intended effect on water quality or if other remedial measures are required. (3)

Response: The Department agrees with this comment. The Department will continue to assess water quality and designated use attainment in the Quittapahilla Creek watershed through its ongoing assessment and regulatory activities.

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