BEST MANAGEMENT PRACTICE SCENARIOS

INTRODUCTION

The SWAT modeling results for Cedar Creek watershed showed that the annual sediment yield to the lake was about 467,730 metric tons, the annual Total Nitrogen (TN) yield was 1,666,005 kg, and the annual Total Phosphorous (TP) yield was 218,202 kg. To reduce the impacts on water quality at the lake, best management practices (BMPs) scenario need to be adopted. Based on the statistical analyses and consent from local stakeholders, the target of TP reduction has been set at 35%. A 35% reduction in TP results in a statistically significant reduction in Cedar Creek Reservoirs Chlorophyll-a level, a measure of eutrophication.

Twenty-one BMPs were simulated at the maximum practical rate or at a100% adoption rate in SWAT model, assuming those BMPs were implemented on all suitable land. The 100% adoption rate was also used for sensitivity analyses of each BMP and it provided useful information on the effectiveness of each BMP.

To assess the 35% TP reduction goal, each BMP was implemented in the model one at a time until the total TP reduction at the lake reached 35%. Of the twenty-one BMPs simulated the top eight BMPs are addressed ion this report which reached the reduction goals.

CROPLAND BMPs

Despite making up only 6.17% of the land use in the Cedar Creek Watershed, croplands due to current and historical use account for a large portion of the nutrient loadings. In total, 40.78% of sediment, 23.44% of Total Nitrogen, and 42% of Total Phosphorus originate from cropland areas.

1. Filter Strips (USDA-NRCS Practice # 393)

Filter strips are vegetated areas that are situated between surface water bodies (i.e., streams and lakes) and cropland, grazing land, forestland, or disturbed land (Figure 1). They are generally located where runoff water leaves a field with the intention that sediment, organic material, nutrients, and chemicals can be trapped or filtered from the runoff water. Specifically-designed vegetative strips slow runoff water leaving a field so that larger particles, including soil and organic material can settle out. Due to entrapment of sediment and the establishment of vegetation, nutrients can be absorbed into the sediment that is deposited and remain on the field landscape, enabling plant uptake (USDA-NRCS Conservation Practice Guide 2003).

Figure.1 Filter Strip (NRCS Online Photo Gallery).

SWAT specifications for the Cedar Creek model indicated that the filter strips are constructed to be 15 meters wide. SWAT models filter strips as simple edge-of-field vegetation with a trapping efficiency.

Table 1. Eligible areas and SWAT modeled impact of filter strip implementation.

Hectares Eligible for Practice	Acres Eligible for Practice	Percent of Watershed Eligible	Proposed Adoption Rate	Sediment Reduction	Total Nitrogen Reduction	Total Phosphorus Reduction
16104.80	39796	6.17%	50%	8.3%	9.8%	14.2%

2. Grassed Waterways (USDA-NRCS Practice # 412)

Grassed waterways are natural or constructed channels established for the transport of concentrated flow at safe velocities using adequate vegetation. The vegetative cover slows the water flow, minimizing channel surface erosion and preventing the formation of gullies and subsequent channel erosion. When properly constructed, grassed waterways can safely transport large flows of runoff down slopes (Figure 3). The vegetation improves the soil aeration and water quality due to its nutrient removal through plant uptake and sorption by the soil (USDA-NRCS Conservation Practice Guide 2003).

Figure 2. Grassed waterway (NRCS Online Photo Gallery).

In the SWAT model analysis for the Cedar Creek Watershed, grassed waterways were implemented only in subbasins that have at least 10% of croplands in the subbasin. It was simulated in the model by increasing Manning's n roughness coefficient in each subbasin from 0.014 to 0.15 to reflect a good channel cover in the tributary.

Table 2. Eligible area and SWAT modeled impact of grassed waterway implementation.

Hectares Eligible for Practice	Acres Eligible for Practice	Percent of Watershed Eligible	Proposed Adoption Rate	Sediment Reduction	Total Nitrogen Reduction	Total Phosphorus Reduction
35112	86763	13.46	20%	1.1%	1.9%	1%

3. Terracing (USDA-NRCS Practice # 600)

Terraces are series of earthen embankments constructed across fields at designed vertical and horizontal intervals based on land slope, crop rotation, and soil conditions (Figure 3). Construction of terraces involves a heavy capital investment to move large quantity of earth for forming earthen embankments. Hence terracing should be considered only if other low-cost alternates are determined to be ineffective.

Figure 3. Terracing. (NRCS Online Photo Gallery)

In the SWAT model, terraces were assumed to be constructed only on croplands with slopes with a grade of at least 2%. For eligible areas, Universal Soil Loss Equation (USLE) support practice factor (USLE_P) was reduced to 0.5 and curve number (CN2) was reduced by 6 from the calibrated value. These values were selected based on the suggested values from the NRCS National Engineering Handbook and SWAT user manual. (USDA-NRCS Conservation Practice Guide 2003)

Table 3. Eligible area and SWAT modeled impact of terracing implementation.

Hectares Eligible for Practice	Acres Eligible for Practice	Percent of Watershed Eligible	Proposed Adoption Rate	Sediment Reduction	Total Nitrogen Reduction	Total Phosphorus Reduction
4386.34	10839	1.68%	15%	4.4%	.6%	4.3%

PASTURE AND RANGELAND BMPs

Rangelands and pasturelands account for 64.59% of the landuse within the Cedar Creek watershed. The abundance of pastureland and rangeland and the associated nutrient-based fertilizer use mandate serious consideration of practices to mitigate water quality concerns. Additionally, overgrazing of pasture and rangeland reduces the vegetative cover needed to filter nutrients and trap sediment during a rain event. As a result, pasture and rangeland account for 15.78% of the sediment, 44.08% of the Total Nitrogen, and 22.59% of the Total Phosphorus flowing to Cedar Creek Reservoir.

4. Pasture and Range Planting (Conversion of Cropland to Pasture)

The planting of pastures and crop lands with native or introduced vegetation allows for reduction and absorption of nutrients (Figure 4). Grass, forbs, legumes, shrubs and trees work to restore a plant community similar to historically natural conditions yet sensitive to the nutritional needs of livestock and native species. Further, native or introduced forage species that are well adapted to North Central Texas could be planted periodically to maintain a dense vegetative cover and improve the hydrologic condition of the farmlands (USDA-NRCS Conservation Practice Guide 2003).

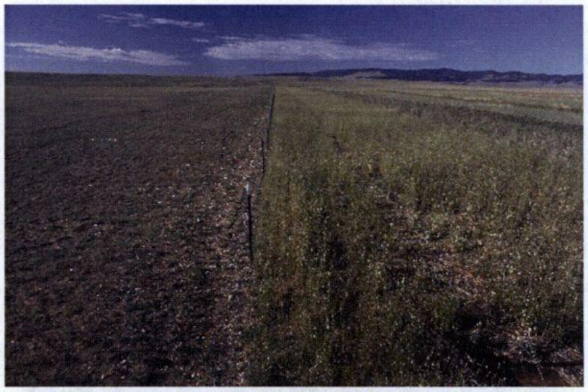


Figure 4. Pasture Planting. (NRCS Online Photo Gallery)

Implementation of this BMP was modeled as replacing all cropland into pastureland in the model. The pastureland in the Cedar Creek watershed was assumed to be fertilized (67 kg N per hectare) every year with two hay cuttings per year on fertilized pasture. The curve numbers were also changed from cropland to pastureland conditions based on National Engineering Hand Book and SWAT user manual.

Table 4. Eligible area and SWAT modeled impact of cropland conversion to pasture.

Hectares Eligible for Practice	Acres Eligible for Practice	Percent of Watershed Eligible	Proposed Adoption Rate	Sediment Reduction	Total Nitrogen Reduction	Total Phosphorus Reduction
16,104.80	39796	6.17%	20%	3.7%	2%	5.8%

5. **Prescribed Grazing**

Prescribed, or rotational, grazing manages the controlled harvest of vegetation with livestock to improve or maintain the desired species composition and vigor of plant communities, which improves surface and subsurface water quality and quantity. Prescribed grazing also includes the combined use of fencing and stock watering facilities. (Figure 5) (USDA-NRCS Conservation Practice Guide 2003).

Figure 5. Prescribed Grazing (NRCS Online Photo Gallery).

For simulation in the model, pastureland was assumed to be in fair hydrologic condition (USLE_C,cover factor: 0.007). These two BMPs would improve the groundcover of the pasture across the watershed. Implementation of these BMPs was done by reducing the USLE_C factor for pasture across the watershed, which was SWAT's default value for good ground cover of vegetation.

Table 5. Eligible area and SWAT modeled impact of prescribed grazing.

Hectares Eligible for Practice	Acres Eligible for Practice	Percent of Watershed Eligible	Proposed Adoption Rate	Sediment Reduction	Total Nitrogen Reduction	Total Phosphorus Reduction
165989.70	410169	64%	25%	1.8%	4.1%	1.4%

WATERSHED BMPs

6. **Grade Stabilization (USDA-NRCS Practice # 410)**

Grade stabilization structures are constructed lakeside and streambank reinforcements placed to reduce erosion and sedimentation from steep embankments that are prone to soil loss during storm events (Figure 6). Structures must be logistically situated for maximum effectiveness. This practice must be strategically engineered from concrete, steel, or other fabricated material.

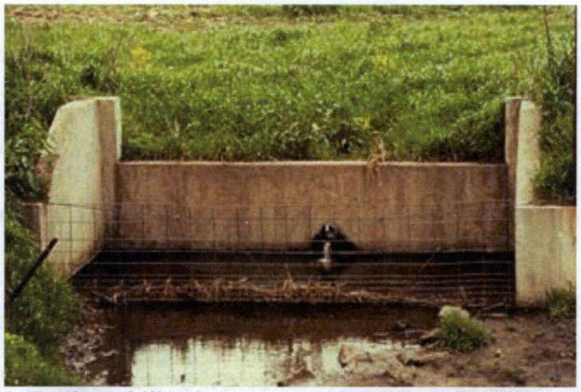


Figure 6. Grade stabilization structure (NRCS Online Photo Gallery)

SWAT modeling for Cedar Creek Watershed projected 10 structures per every 1000 hectares (2471 acres). The effect of grade stabilization structures is to reduce the energy of flowing water due to slope. Therefore, grade stabilization structures are simulated in SWAT by reducing the slope of the subbasins. The overland slope that was greater than 3% was reduced to 3%.

Table 6. Eligible area and SWAT modeled impact of grade stabilization structure implementation.

Hectares Eligible for Practice	Acres Eligible for Practice	Percent of Watershed Eligible	Proposed Adoption Rate	Sediment Reduction	Total Nitrogen Reduction	Total Phosphorus Reduction
33,052	81673	12.67%	100%	2.5%	1.7%	1.9%

7. Upgrade of WWTP

Nutrients originating from direct permitted discharges into Cedar Creek Reservoir and its tributaries are limited to the nine wastewater treatment plants operating within the watershed. These facilities account for .03% of the sediment, 7.21% of the Total Nitrogen, and 13.3% of the Total Phosphorus flowing to Cedar Creek Reservoir. Modeling of wastewater treatment plant discharges and recommended upgrades for the watershed plan are based on the nine plants in operation (figure 7) and evaluated in a 2007 Alan Plummer Associates, Inc. report.

Figure 7. Wastewater treatment plant (Alan Plummer 2007)

Point source discharges from wastewater treatment plants are regulated by the Texas Commission on Environmental Quality as part of a regulation and permitting process. A proposed series of graduated improvements to each operating plant has been outlined by the environmental engineering firm of Alan Plummer Associates, Inc. following extensive surveys of the outflows and infrastructure of each plant. The proposed structural improvements will allow each plant to reduce pollutant discharges beyond current permit requirements to 1.0/mg/L of Phosphorus.

Table 7. Upgrade of WWTP Facilities from Level I to Level II.

Number of WWTP Plants Included	Proposed Adoption Rate	Sediment Reduction	Total Nitrogen Reduction	Total Phosphorus Reduction
9	100%	0	1.6%	4.5%

8. 2000 Foot Nutrient Buffer Strip Surrounding Lake

Impervious surfaces, residential landscape fertilizing, and construction activities in city areas present challenges to watershed improvement through the transport of pollutants to receiving water bodies. Although urbanized areas only account for 6.39 percent of total watershed land use, contributions to the sediment and nutrient flows to Cedar Creek Reservoir are noteworthy. 7.4% of sediment, 14.4% of Total Nitrogen, and 13.3% of Total Phosphorus originates in urban areas.

This proposed practice seeks to reduce the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments to minimize urban nonpoint source pollution of surface and groundwater resources. The practice encourages the limited use of phosphorus-based fertilizers, proper blends of fertilizers to be available to watershed consumers, and the encouragement of landscaping techniques that require limited fertilizer and irrigation (Figure 8) (USDA-NRCS Conservation Practice Guide 2003).

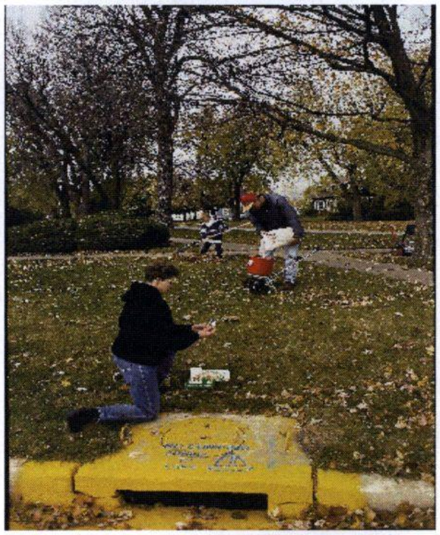


Figure 8. Urban Nutrient Management (NRCS Online Photo Gallery)

Although this practice is considered voluntary, the 2000 foot threshold represents the extent of jurisdictional power granted to lake management authorities to regulate waterside activities. SWAT model sequences performed for the Cedar Creek Watershed estimated a 140kg per hectare reduction in Nitrogen usage (73.7 percent) and a 27.5kg per hectare reduction of Phosphorus (91.7 percent) for implementation of a 2,000 foot nutrient buffer zone.

Table 8. Eligible area and SWAT modeled impact of 2000 foot nutrient buffer.

Hectares Eligible for Practice	Acres Eligible for Practice	Percent of Watershed Eligible	Proposed Adoption Rate	Sediment Reduction	Total Nitrogen Reduction	Total Phosphorus Reduction
16,636.62	41109	6.3%	70%	0%	2.8%	1.5%

BEST AMNAGEMENT PRACTICE ADOPTION

The effectiveness of each BMP was simulated not only to reach the TP reduction goal (35%) but also analyzed for spatially distributed impacts. Every time a BMP was simulated/ implemented as shown in Table 9, TP loading maps were re-drawn for subbasin level assessment. Figure 9 shows the sequential, spatially distributed effectiveness of each BMP. The series of maps shows TP reduction in each subbasin compared to the baseline simulation for TP reduction in each subbasin. TP reductions in each subbasin were accumulated reduction as each BMP was added one at a time.

Table 9. BMPs and adoption rates and reduction percentages.

		Reduction %		
BMP	**Adoption**	**Sediment**	**Total N**	**Total P**
Filter Strips	50%	8.3%	9.8%	14.2%
Grade Stabilization Structures	100%	2.5%	1.7%	1.9%
Critical Pasture Planting	20%	1.1%	1.9%	1%
Terracing	15%	4.4%	.6%	4.3%
WWTP Upgrades	100%	0%	1.6%	4.5%
Conversion of Cropland to Grass	20%	3.7%	3%	5.8%
Prescribed Grazing	25%	1.8%	4.1%	1.4%
2,000 Ft Buffer around Lake	70%	0%	2.8%	1.5%
TOTAL		**21.8%**	**25.5%**	**34.6%**

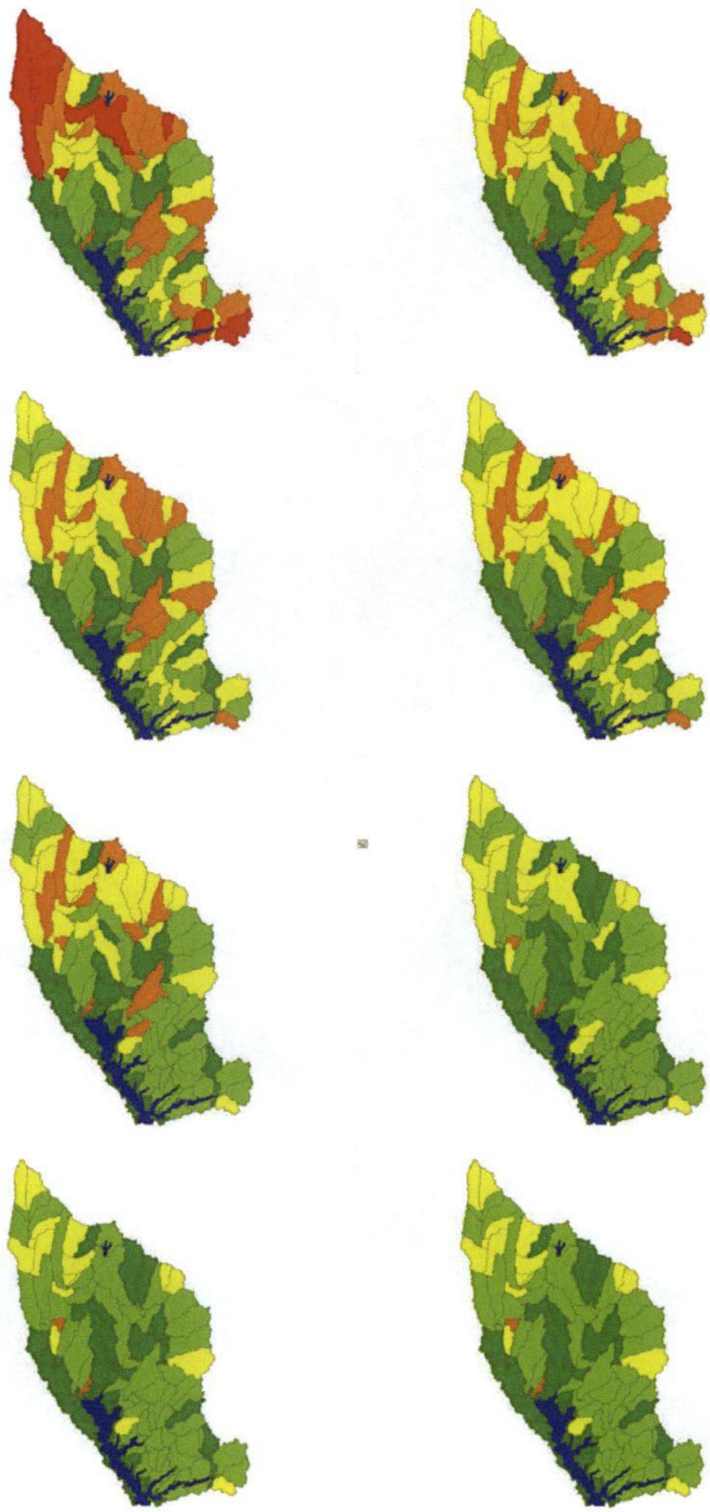
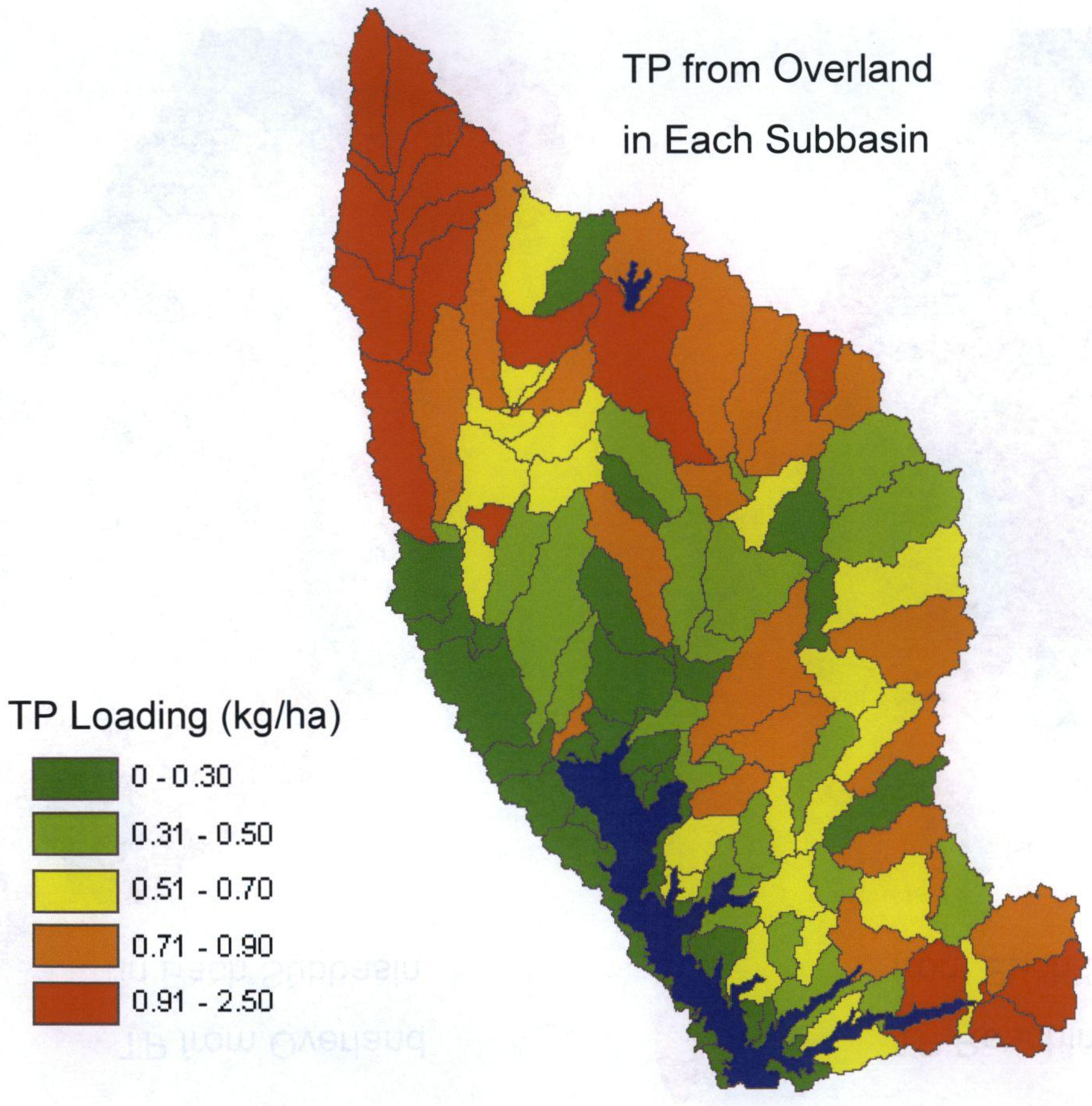
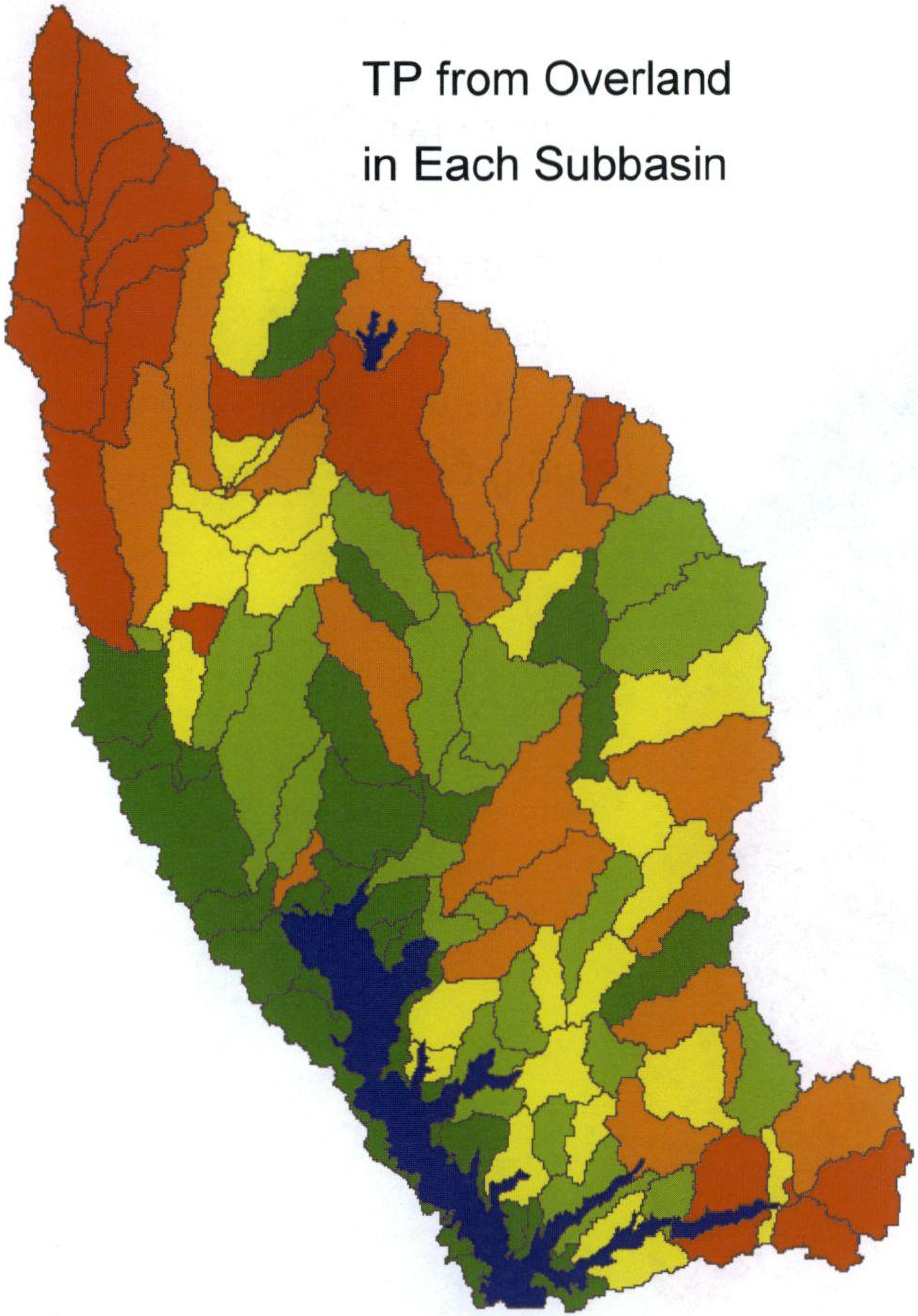
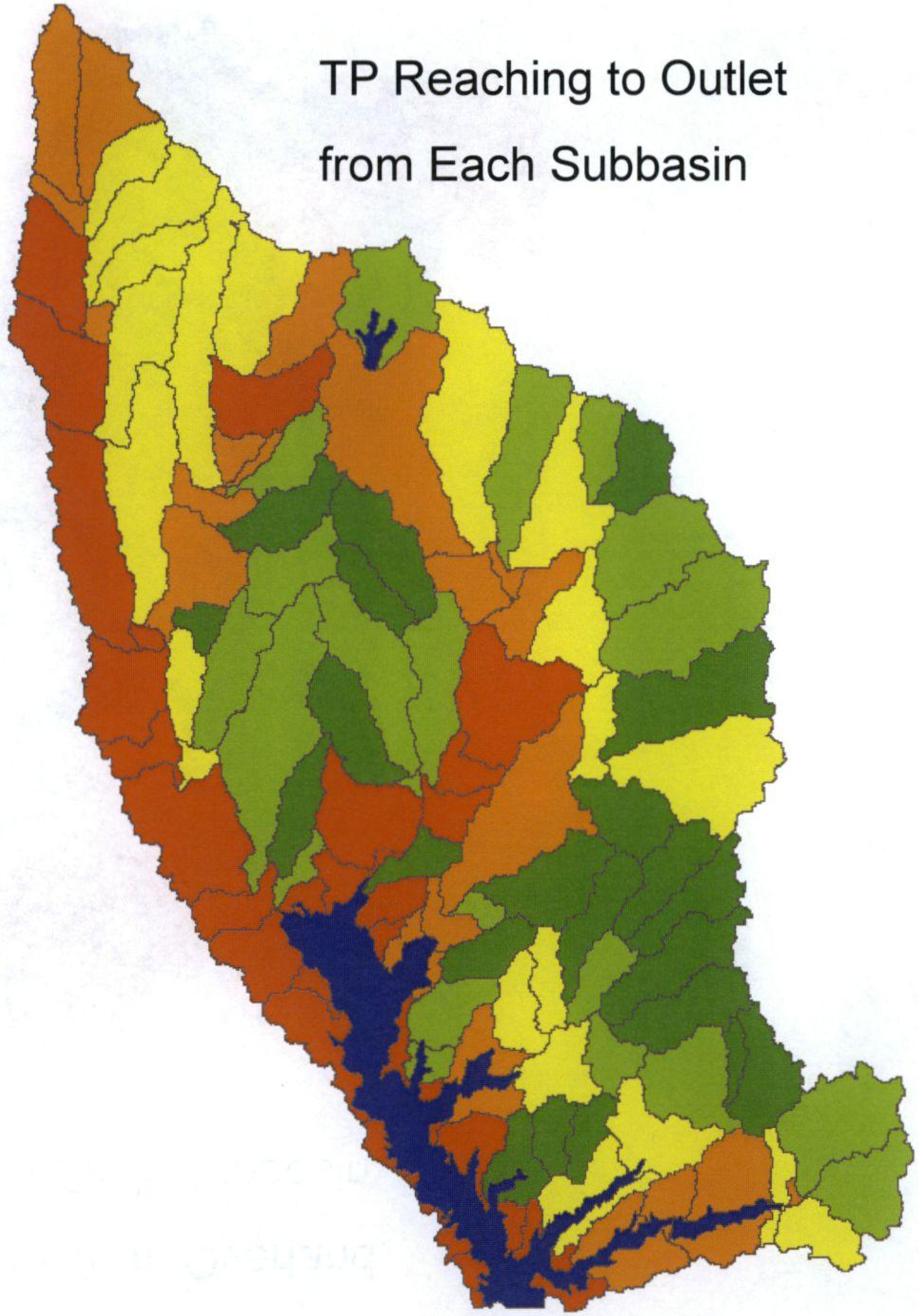
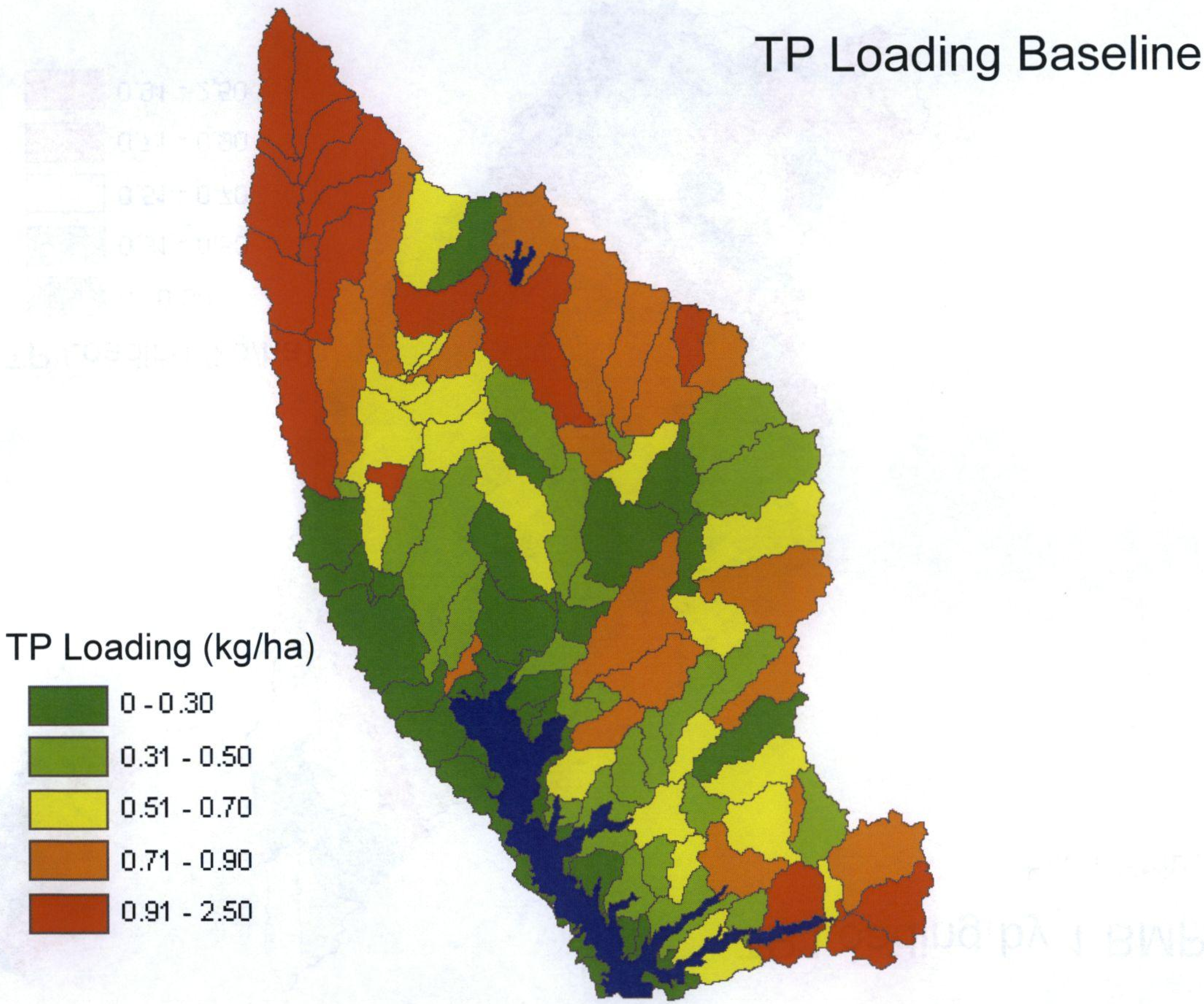


Figure 9. Spatial Distributed Effectiveness of BMPs


TP from Overland
in Each Subbasin
TP Loading (kg/ha)
0 - 0.30
0.31 - 0.50
0.51 - 0.70
0.71 - 0.90
0.91 - 2.50

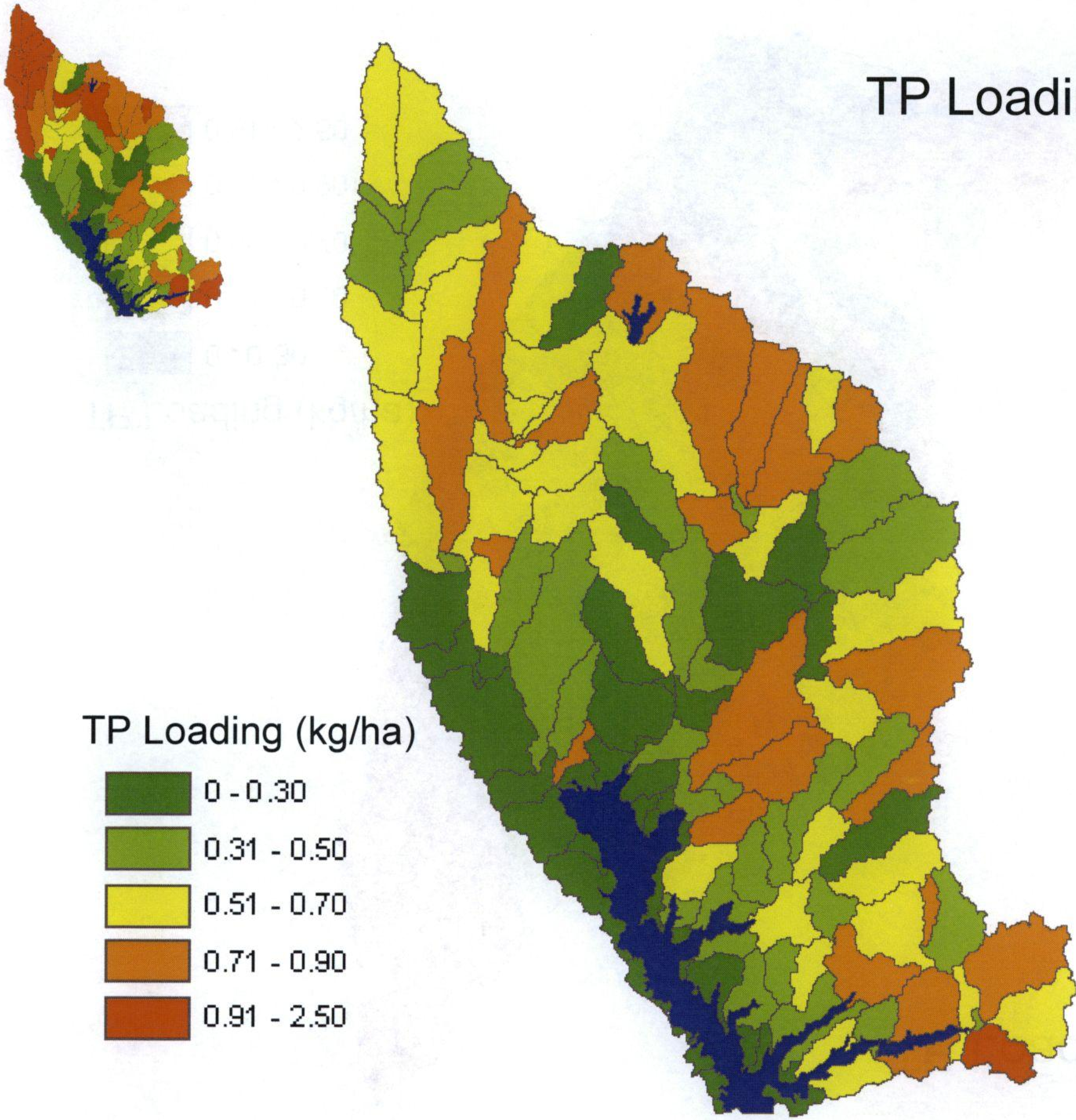

TP from Overland
in Each Subbasin


TP Reaching to Outlet
from Each Subbasin


TP Loading Baseline
TP Loading (kg/ha)
0 - 0.30
0.31 - 0.50
0.51 - 0.70
0.71 - 0.90
0.91 - 2.50

TP Loading by 1 BMP

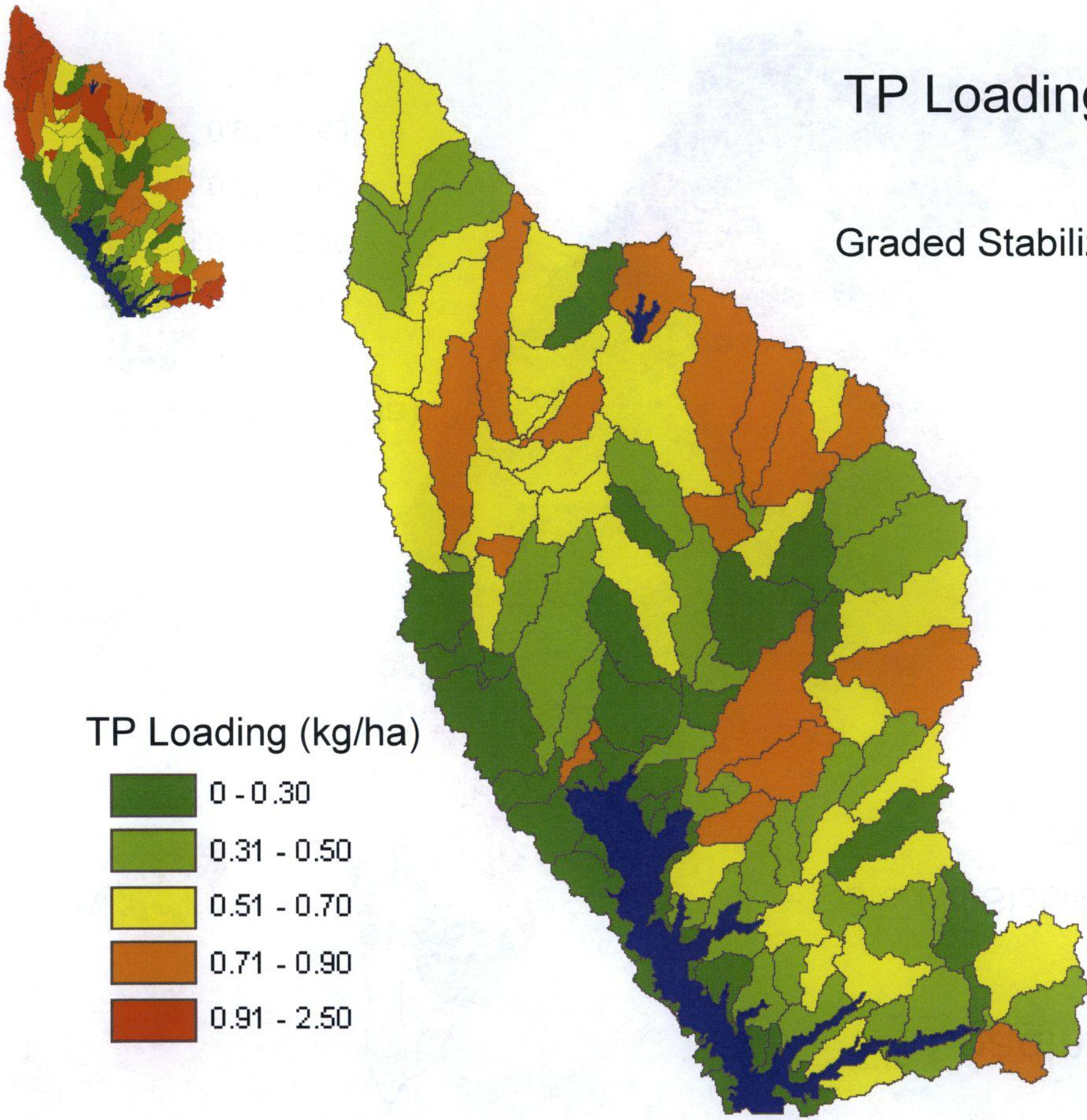
Filter Strips

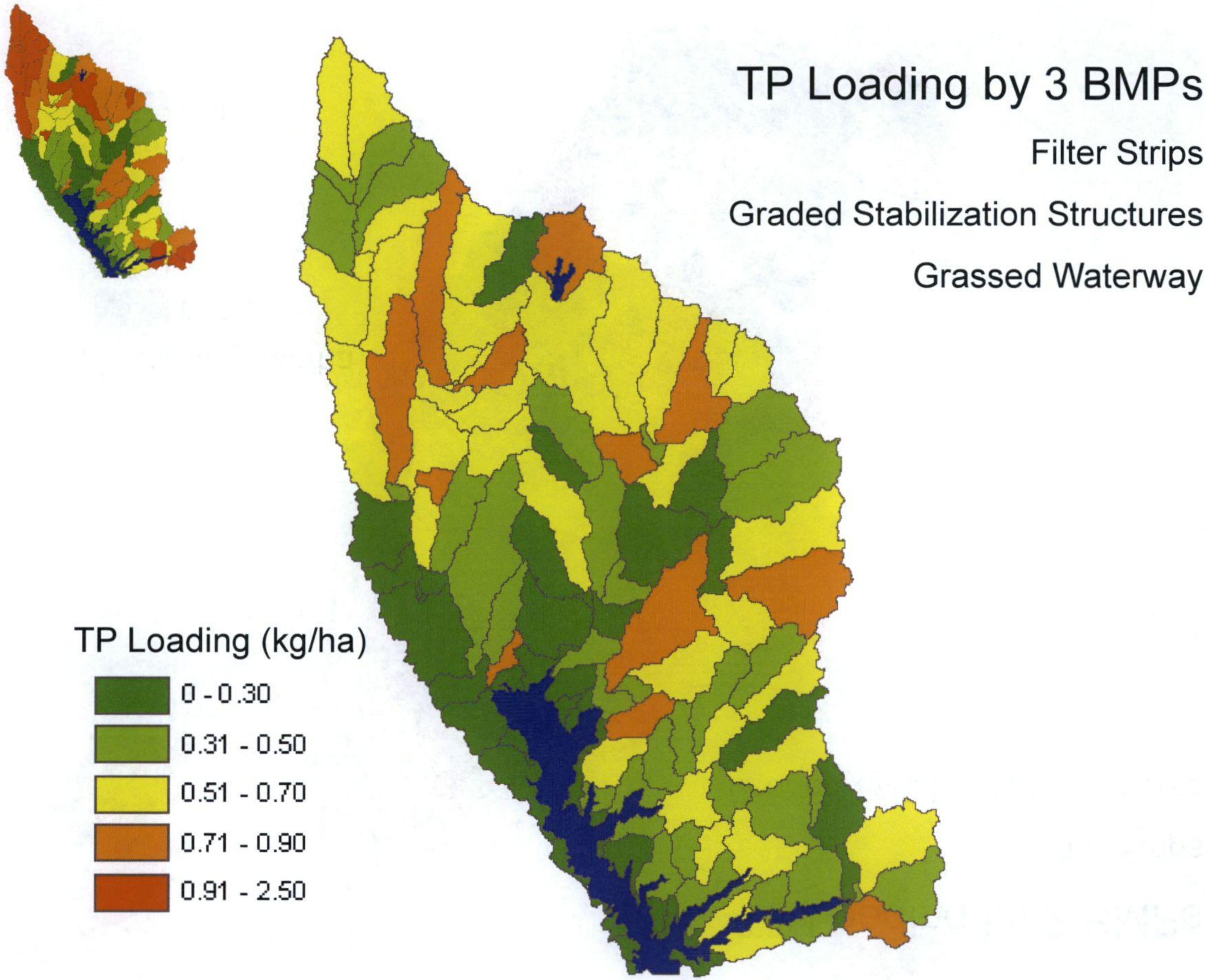


TP Loading by 2 BMPs

Filter Strips

Graded Stabilization Structures





TP Loading by 3 BMPs
Filter Strips
Graded Stabilization Structures
Grassed Waterway
TP Loading (kg/ha)
0 - 0.30
0.31 - 0.50
0.51 - 0.70
0.71 - 0.90
0.91 - 2.50

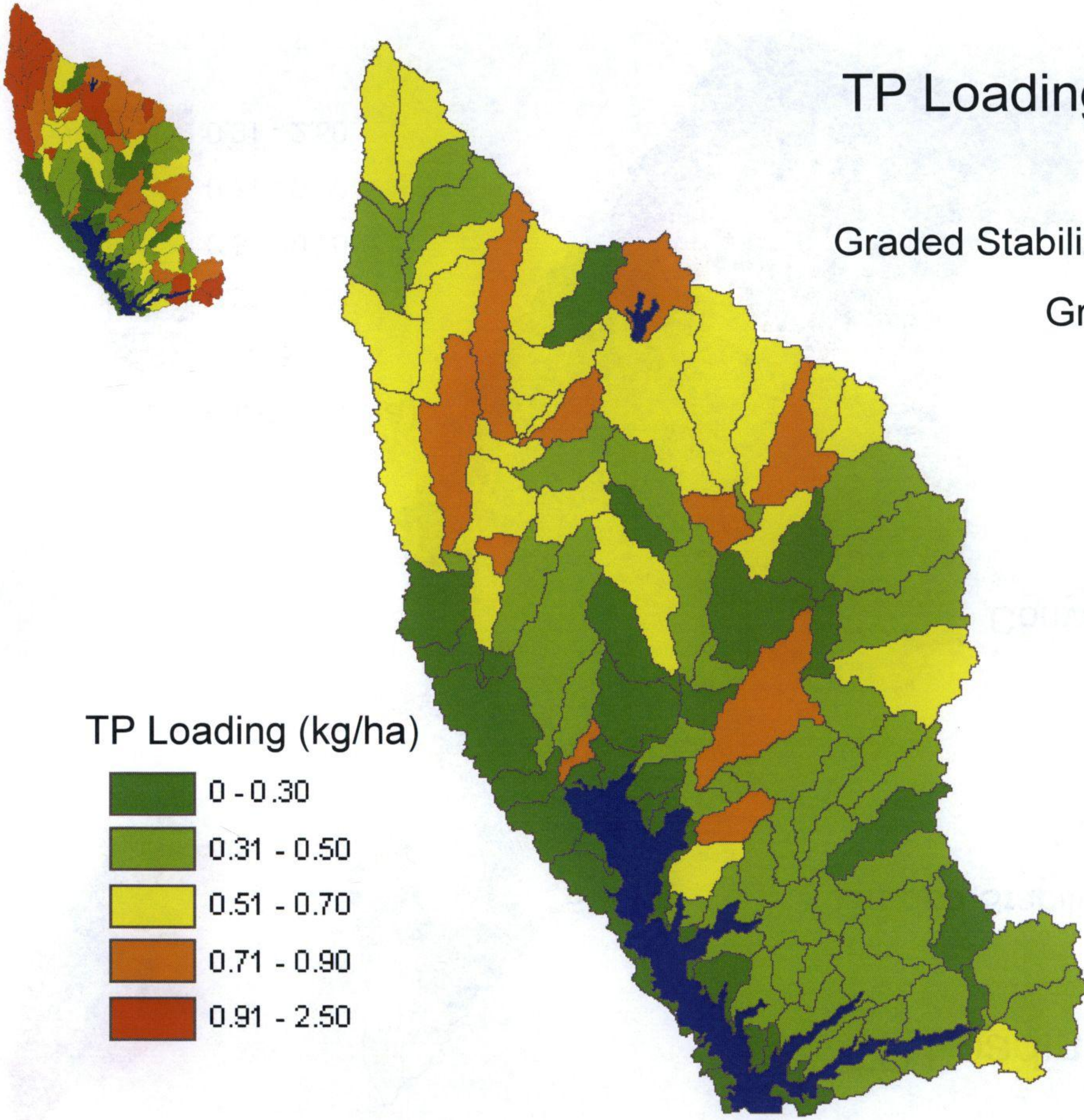
TP Loading by 4 BMPs

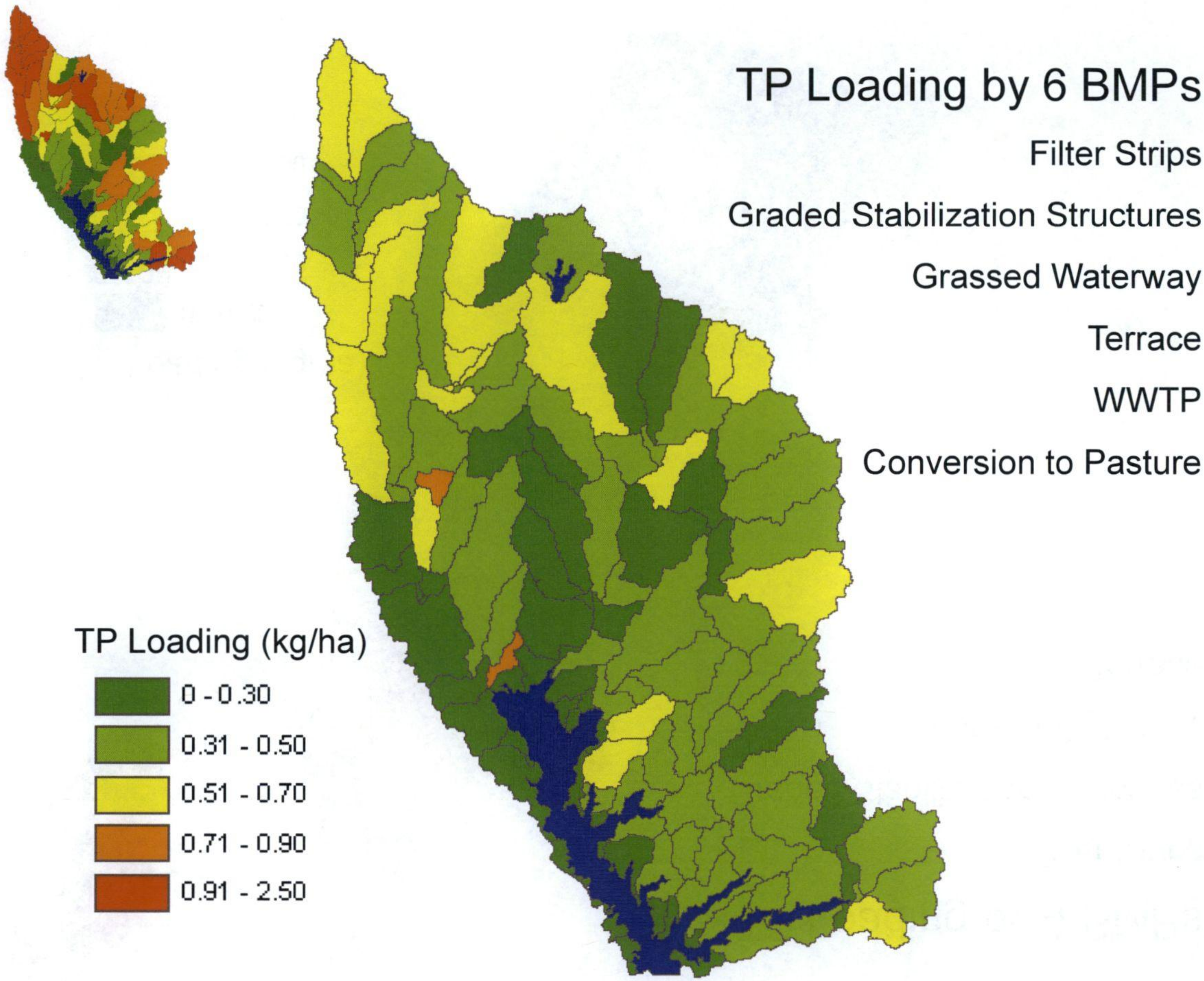
Filter Strips

Graded Stabilization Structures

Grassed Waterway

Terrace





TP Loading by 6 BMPs
Filter Strips
Graded Stabilization Structures
Grassed Waterway
Terrace
WWTP
Conversion to Pasture
TP Loading (kg/ha)
0 - 0.30
0.31 - 0.50
0.51 - 0.70
0.71 - 0.90
0.91 - 2.50

TP Loading by 7 BMPs

Filter Strips

Graded Stabilization Structures

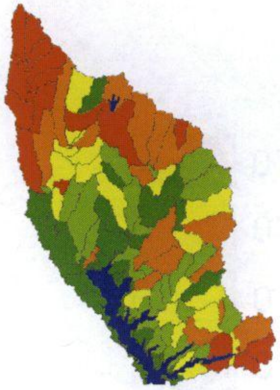
Grassed Waterway

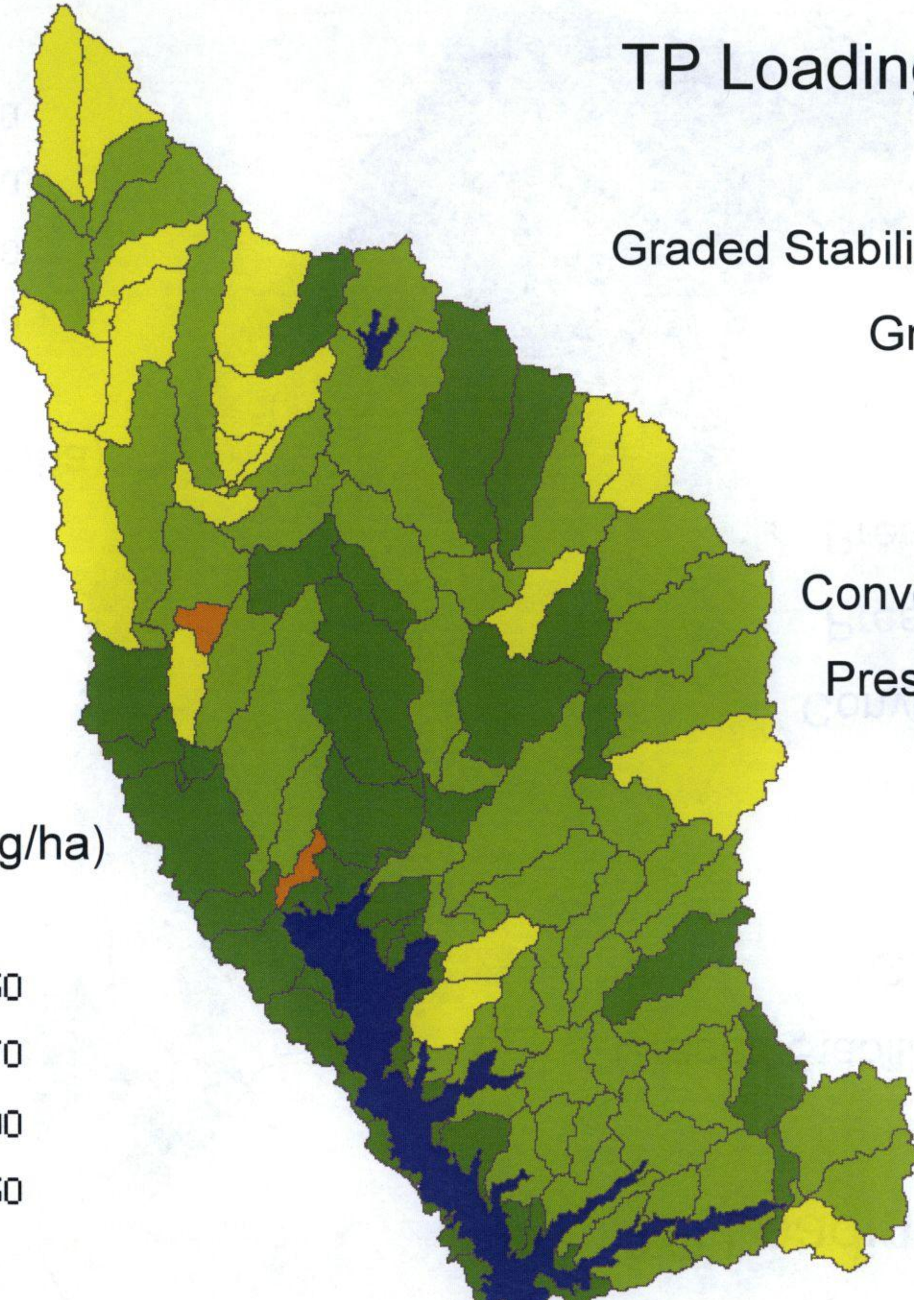
Terrace

WWTP

Conversion to Pasture

Prescribed Grazing 1





TP Loading (kg/ha)

0 - 0.30

0.31 - 0.50

0.51 - 0.70

0.71 - 0.90

0.91 - 2.50

TP Loading by 7 BMPs

Filter Strips

Graded Stabilization Structures

Grassed Waterway

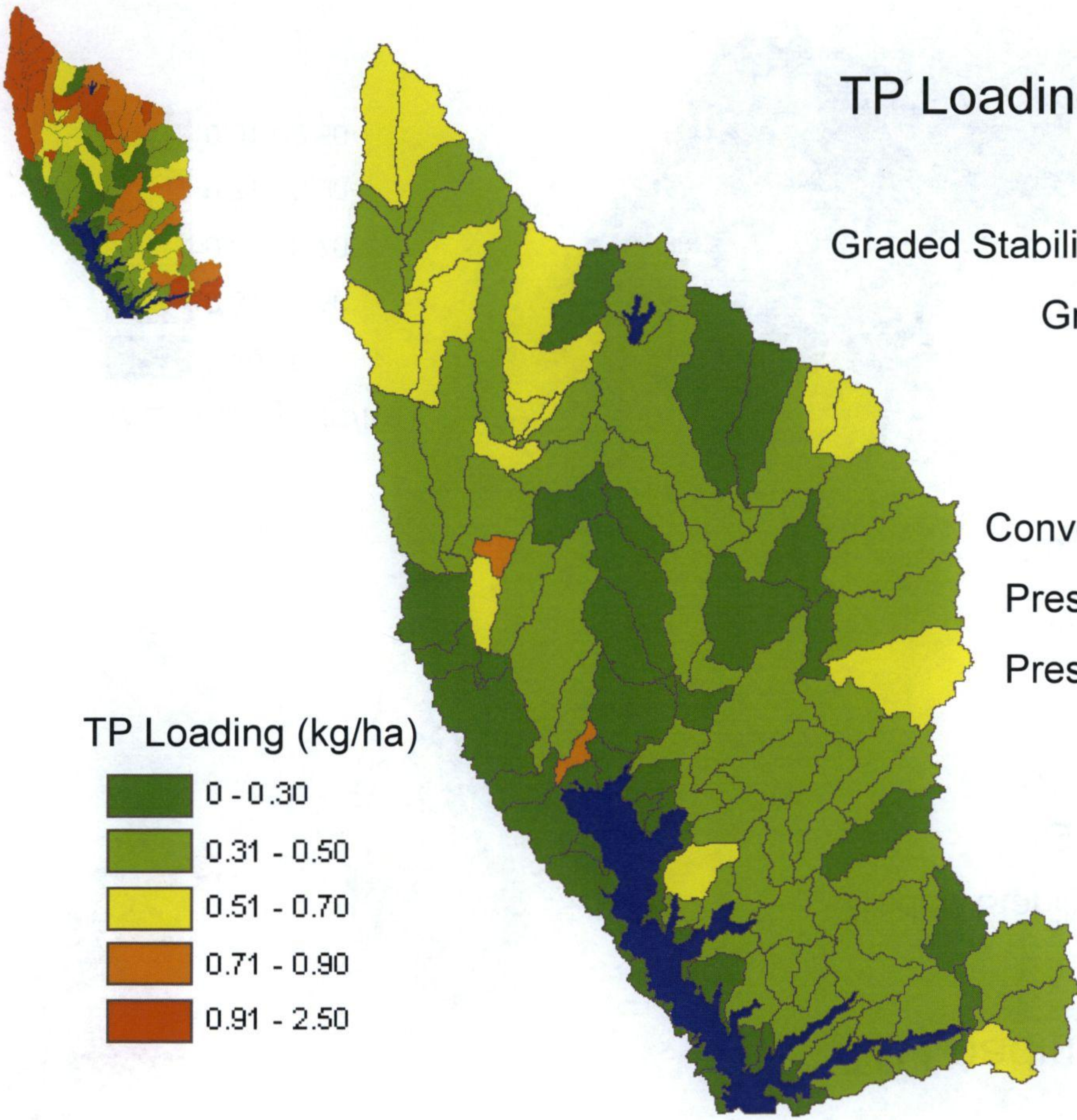
Terrace

WWTP

Conversion to Pasture

Prescribed Grazing 1

Prescribed Grazing 2



TP Loading by 8 BMPs

Filter Strips

Graded Stabilization Structures

Grassed Waterway

Terrace

WWTP

Conversion to Pasture

Prescribed Grazing 1

Prescribed Grazing 2

2000 Ft Buffer