Modeling Atrazine in Seven Texas Watersheds

Lake Bardwell Watershed

Prepared in Cooperation with the
Texas State Soil and Water Conservation Board

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EXECUTIVE SUMMARY

The purpose of this study was to simulate atrazine and sediment loadings in the Bardwell Reservoir Watershed using the Soil and Water Assessment Tool (SWAT) hydrologic/water quality model. Three scenarios were modeled: (I.) current (baseline) – pre-1999 condition; (II.) 319(h) best management practice (BMP) applications, and (III.) application of BMPs on all cropland. Part one of this report discusses model calibration and validation. Part two discusses the evaluation of the BMPs with the model.

Since 1999, the Texas State Soil and Water Conservation Board has been working through the Environmental Protection Agency (EPA) 319(h) grants program to reduce nonpoint source pollution from agricultural activities in this watershed. Technical and financial assistance was provided through the Ellis-Prairie Soil and Water Conservation District for development and implementation of water quality management plans.

SWAT was calibrated/validated to measured stream flow at a USGS stream gage (08064100), and calibrated to measured sediment (TWDB hydrographic survey) in Richland-Chambers Reservoir. Stream monitoring data was used to calibrate SWAT for atrazine loading. Time series plots and statistical measures were used to verify model predictions.

The validated model was applied to evaluate the effects of various best management practices on three levels: farm level; subbasin level; and watershed level. The analysis was performed for the time period from 1974 through 2003. The major BMPs simulated with SWAT were terraces, contour farming, conservation tillage, conservation crop rotation, grassed waterways, conservation buffers, herbicide incorporation, pasture planting (conversion from cropland to pastureland), and farm-scale sediment basins.

Scenario II showed that BMPs at the farm level where they were implemented reduced atrazine loadings 79 to 94 percent, and reduced sediment loadings 81 to 93 percent.

Scenario II showed that BMPs at the subbasin level reduced atrazine loadings 3 to 6 percent, and reduced sediment loadings 2 to 6 percent.

Scenario II showed that BMPs at the watershed level reduced atrazine loading into Bardwell Reservoir by 4 percent and reduced sediment loading by 4 percent.

Scenario III showed that BMPs at the subbasin level reduced atrazine loadings by 78 to 80 percent, and reduced sediment loadings 86 to 90 percent.

Scenario III showed that BMPs at the watershed level reduced atrazine loading into Bardwell Reservoir by 79 percent, and reduced sediment loading by 84 percent.

Predicted sediment volume to Bardwell Reservoir for the 1974 though 2003 modeling period was 1,192,800 metric tons (1,314,837 tons) for the baseline condition (scenario I), 1,149,000 metric tons (1,266,556 tons) for the 319(h) BMP condition (scenario II), and 189,420 metric tons (208,800 tons) for the all cropland treated condition (scenario III). In percentages, sediment reduction to the reservoir for scenario II was 4, and for scenario III, 84.

This study modeled the conservation practices applied through the 319(h) program. There were ten contracts in the Bardwell Reservoir Watershed covering 551 hectares (1,361 ac), or about 1.2 percent of the watershed.

All simulations assume the effectiveness of BMPs remains constant for the entire modeling period, and do not account for loss of capacity in BMPs due to sediment accumulation.

Given these results, the 319(h) project has been effective in reducing nonpoint source pollution at all levels, but the greatest benefit is at the farm level. There exists good potential for further reducing atrazine and sediment concerns through continued water quality management planning and application.

MODELING ATRAZINE IN SEVEN TEXAS WATERSHEDS
Bardwell Reservoir Watershed
Hydrologic Simulation

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Watershed Data

Physical Data

The Bardwell Reservoir Watershed is located on Waxahachie Creek in Ellis County in north central Texas (Figure 1). The 2,443-hectare (6,037 ac) reservoir controls runoff from 45,149 hectares (174.32 square miles), and deliberate impoundment began in November 1965. A search of USGS records indicates storage extremes: maximum contents, 13,827 hectare-meters (112,100 ac-ft), May 22, 1990; minimum observed, 4,625.56 hectare-meters (37,500 ac-ft), December 8, 1999.

The climate is sub-humid with an average annual precipitation of about 917 mm (36 inches). The area is subject to high intensity, short duration thunderstorms during the spring and summer months. Typically, summers are hot and winters are mild with intervals of freezing temperatures as cold fronts pass through the region.

The watershed is within the Texas Blackland Prairie Major Land Resource Area. Soils range from well-drained loams to fine-textured montmorillonitic clays. Soil depths vary from shallow to deep. Upland topography ranges from nearly level to steeply sloping.

In 1998 Bardwell Reservoir was one of nine Texas water bodies found to be in violation of the finished drinking water criterion for Atrazine. One lake, Aquilla, was listed as impaired on the 1998 303(d) list. The remaining eight lakes were found to be threatened with a strong potential for violation, with seven of them, including Bardwell Reservoir, selected for Total Maximum Daily Load (TMDL) development in the spring of 2000.

Partners in this project include the Texas State Soil and Water Conservation Board, the Ellis-Prairie Soil and Water Conservation District (SWCD), USDA-NRCS, and USDA-NRCS Water Resources Assessment Team, Blackland Research Center, Temple, TX.

Project Objectives

The main objectives of this study were to:

- Collect GIS, landuse, management, and measured data for the Bardwell Reservoir Watershed.
- Calibrate the watershed model to measured flow, sediment, and atrazine.
- Simulate atrazine load for three scenarios: (I) Current (baseline) - pre-1999 condition, (II) 319 BMP applications, (III) Application of BMPs on all cropland (all programs).

This report is organized into two parts. Part 1 describes the calibration of the SWAT model for flow, sediment, and atrazine. Part 2 describes the application of the model to evaluate the impact of best management practices (BMPs) on water quality in the watershed.

PART 1 CALIBRATION

INTRODUCTION

The purpose of this part of the report is to describe the calibration of the SWAT model for flow, sediment and atrazine loading. The SWAT model contains many input parameters which describe the physical, chemical, and biological processes. During the calibration phase, the model is run and the results are compared to observed data. The values of the input parameters are refined within the range of acceptability until the model reproduces the observed data.

The Lake Waxahachie, Bardwell Reservoir, and Richland-Chambers Reservoir Watersheds were delineated and modeled simultaneously. The watersheds of the former two reservoirs are subsets of the much larger Richland-Chambers Reservoir Watershed (Figure 2). In addition, since stream gages and water quality sampling sites were located downstream from Lakes Waxahachie and Bardwell, modeling all three in one project facilitated model calibration.

METHODOLOGY

Model Inputs

Landuse / Cover

The landuse/land cover map was derived from the USGS National Land Cover Dataset (NLCD) land use. The land use map for the watershed is shown in Figure 3. The area and percentage of each landuse is indicated in Table 1.

Soils

The Soil Survey Geographic (SSURGO) database for Ellis County was downloaded to create the soils database for the Bardwell Reservoir Watershed (Figure 4). This database provides a much finer resolution of soils than the previously used CBMS or STATSGO data.

The dominant soil series in the Bardwell Reservoir Watershed are Houston (21%), Crockett (11%), Wilson (8%), Trinity (7%), Heiden (7%), Ferris (6%), Eddy (5%), Water (5%), Austin (4%), Burleson (3%), Stephen (3%), Tinn (2%), Crosstel (2%), Axtell (2%), Lewisville (1%), Kaufman (1%), Gowen (1%), Ellis (1%), Lamar (1%), and Branyon (1%). These twenty soil series represent about 92% of the watershed area. Table 2 shows the major soil series and with their relative land areas. A short description of each follows:

Houston. - The Houston Black series consists of very deep, moderately well drained, very slowly permeable soils that formed from weakly consolidated calcareous clays and marls of Cretaceous Age. These soils are on nearly level to moderately sloping uplands. Slopes are mainly 1 to 3 percent, but range from 0 to 8 percent.

Crockett. - The Crockett series consists of soils that are deep to weathered shale. They are moderately well drained, and very slowly permeable. These soils are on uplands. These nearly level to moderately sloping soils formed in alkaline residuum derived from shales and clays. Slopes are dominantly 1 to 5 percent, but range from 0 to 10 percent.

Wilson. - The Wilson series consists of very deep, moderately well drained, very slowly permeable soils that formed in alkaline clayey sediments. These soils are on nearly level to gently sloping stream terraces or terrace remnants on uplands. Slopes are mainly less than 1 percent but range from 0 to 5 percent.

Trinity. - The Trinity series consists of very deep, moderately well drained, very slowly permeable soils on flood plains. They formed in alkaline clayey alluvium. Slopes are typically less than 1 percent, but range from 0 to 3 percent.

Heiden. - The Heiden series consists of soils that are well drained and very slowly permeable. They are deep to weathered shale. These soils are on nearly level to moderately steep uplands. Slopes are mainly 3 to 8 percent but range from 0.5 to 20 percent.

Ferris. - The Ferris series consists of soils that are deep to weathered shale. They are well drained, very slowly permeable soils that formed from weakly consolidated calcareous dense clays and shales. These soils are on sloping or moderately steep uplands. Slopes range from 1 to 20 percent.

Eddy. - The Eddy series consists of shallow to very shallow, well drained, moderately permeable soils that formed in chalky limestone. These soils are on gently sloping to moderately steep uplands. Slopes range from 1 to 20 percent.

Austin. - The Austin series consists of moderately deep, well drained, moderately slowly permeable soils that formed in chalk and interbedded marl. These soils are on nearly level to sloping erosional uplands. Slopes range from 0 to 8 percent.

Burleson. - The Burleson series consists of very deep, moderately well drained, very slowly permeable soils that formed in alkaline clayey sediments. These soils are on nearly level to gently sloping Pleistocene terraces. Slopes range from 0 to 5 percent.

Stephen. - The Stephen series consists of shallow, well drained, moderately slowly permeable soils formed in interbedded marl and chalky limestone. These soils are on gently sloping to sloping uplands. Slopes are mainly 1 to 5 percent but range from 1 to 8 percent.

Tinn. - The Tinn series consists of very deep, moderately well drained, very slowly permeable soils that formed in calcareous clayey alluvium. These soils are on flood plains of streams that drain the Blackland Prairies. Slopes are dominantly less than 1 percent but range from 0 to 2 percent.

Crosstell. - The Crosstell series consists of deep, moderately well drained, very slowly permeable soils that formed in shaly clays. These soils are on nearly level to strongly sloping uplands. Slopes range from 0 to 12 percent.

Axtell. - The Axtell series consists of very deep, moderately well drained, very slowly permeable soils on Pleistocene terraces. The soil formed in slightly acid to alkaline clayey sediments. Slopes are dominantly 0 to 5 percent, but range up to 12 percent.

Lewisville. - The Lewisville series consists of very deep, well drained, moderately permeable soils that formed in ancient loamy and calcareous sediments. These upland soils have slopes of 0 to 10 percent.

Kaufman. - The Kaufman series consists of very deep, moderately well drained, very slowly permeable soils on flood plains. They formed in clayey alluvium. Slopes are typically less than 1 percent, but range from 0 to 2 percent.

Gowen. - The Gowen series consists of very deep, well drained, moderately permeable soils that formed in loamy Holocene alluvium. These soils are on nearly level flood plains. Slopes are dominantly less than 1 percent, but range up to 2 percent.

Ellis. - The Ellis series consists of soils that are moderately deep, to weathered shale. They are well drained, very slowly permeable soils that formed in weakly consolidated shale. These gently sloping to moderately steep soils are on erosional uplands. Slopes range from 1 to 20 percent.

Lamar. - The Lamar series consists of very deep, well drained, moderately permeable soils developing from calcareous loamy sediments. These soils are on gently sloping to moderately steep uplands. Slopes range from 1 to 20 percent.

Branyon. - The Branyon series consists of very deep, moderately well drained, very slowly permeable soils that formed in calcareous clayey sediments. These soils are on nearly level to very gently sloping Pleistocene terraces. Slopes range from 0 to 3 percent.

Topography

Elevations range from about 128 meters (420 ft) on the flood plain above Bardwell Reservoir to about 260 meters (853 ft) at the watershed divide.

Climate

Daily precipitation totals and maximum and minimum temperatures were obtained for National Weather Service stations adjacent to the watershed (Figure 5) for input to SWAT. The model uses rainfall and temperature data from the climate station nearest to the centroid of each subbasin. Climate stations outside the watershed, yet close enough to influence input data to the model, were included in the GIS database. Missing precipitation data was patched from neighboring climate stations, while missing temperature data was generated with the SWAT model. Table 3 lists precipitation stations located in or near the Bardwell Reservoir Watershed and the time periods for which data is available for each station.

Land Management

Information on typical crops and management practices (e.g. crop rotations, tillage, atrazine application rate and timing) was obtained from the Ellis-Prairie Soil and Water Conservation District (SWCD) office and the USDA–Natural Resources Conservation Service (NRCS) office. In addition, detailed information on the water quality management plans (WQMPs) implemented under the 319(h) program was provided. The subbasins containing these farms are shown in Figure 6.

Typical crops grown in the watershed are corn, cotton, grain sorghum and wheat. About fifty percent of the cropland is effectively terraced. The remainder is either not terraced, or has worn down, ineffective terraces. Contour farming is not prevalent in the area, although most landowners with terraced cropland periodically re-build terraces to maintain the effective height.

A three-year rotation of grain sorghum-wheat-corn was assumed for the cropland. Appropriate plant growth parameters for each crop were input for all model simulations.

Model Calibration

No stream gage stations or water quality sampling sites were available within the Bardwell Reservoir Watershed. However, a stream gage (8064100) and several water quality sampling sites were located downstream and were used for calibration.

Significant input variables for the SWAT model for the watershed are shown in Table 4 Input variables were adjusted as needed to calibrate first for flow, then sediment, and finally atrazine concentrations.

Subbasins were delineated using the 30-meter (98.42 ft) DEM and the ArcView interface for SWAT 2000. The subbasin threshold area was set to 2,000 hectares (4,942 ac). Site locations for reservoirs, downstream stream gages and water quality sampling sites were used to define additional subbasin outlets.

Required inputs for each subbasin (e.g. soils, land use/land cover, topography and climate) were extracted and formatted using the AVSWAT 2000 interface. The input interface divided each subbasin into virtual subbasins or hydrologic response units (HRU). A single land use and soil were selected for each HRU. The number of HRU's within a subbasin was determined by: (1) creating an HRU for each land use that equaled or exceeded 2 percent of the area of a subbasin; and (2) creating an HRU for each soil type that equaled or exceeded 5 percent of any of the land uses selected in (1). The total number of HRU's (26) was dependent on the number of subbasins and the variability of the land use and soils within each subbasin. The properties for each of the selected land uses and soils were automatically extracted from model-supported databases.

Flow Calibration

Stream flow was calibrated and validated separately using stream gage 8064100 located on Chambers Creek near Rice, TX (Figure 5). The calibration period was from 1/1/1984 through 12/31/1993 (Figure 8), while the validation period was from 1/1/1994 through 9/30/2003 (Figure 9). A base flow filter (Arnold et al., 1995) was used to determine the portioning of groundwater and surface flow.

Adjustments were made to soil evaporation compensation factor, shallow aquifer storage, shallow aquifer re-evaporation, bank coefficient (fraction of transmission losses returned as base flow), Manning's "n" values for channel roughness and channel transmission loss until the simulated total flow and fraction of base flow were approximately equal to the measured total flow and base flow, respectively.

To measure the accuracy of the SWAT predictions to observed values, the Nash-Suttcliffe coefficient of efficiency (E_{NS}) and root mean square error (RMSE) were used. Significant input variables for the SWAT model are shown in Table 4.

Sediment Calibration

The Lake Bardwell Watershed is a sub-watershed within the much larger Richland-Chambers Reservoir watershed (Figure 1). The modeling was completed concurrently. The sediment calibration settings were developed based upon TWDB hydrographic survey data for Richland-Chambers Reservoir, and applied to all subbasins in the watershed. For additional details concerning the sediment calibration, see the Richland-Chambers report.

Atrazine Calibration

Model calibration was performed using in-stream atrazine concentrations sampled by the Tarrant Regional Water District. Daily in-stream pesticide concentrations simulated by SWAT were compared to grab samples collected at eleven sampling locations (Figure 7). The measured concentrations were obtained from one grab sample collected on a given day. Multiple applications of atrazine were simulated in the HRU's to capture the temporal distribution of the pesticide in the watershed.

Atrazine was calibrated so that the mean of the predicted values was within two standard deviations of the mean of the measured values.

SWAT uses a pesticide database that contains parameters that govern pesticide fate and transport. Table 5 contains the atrazine values and descriptions from the SWAT pesticide database used for the project. In addition, the input variable, PERCOP, in the BSN input file was set to 0.3. PERCOP controls the amount of pesticide removed from the surface layer and lateral flow relative to the amount removed via percolation.

Evaluation of Model Performance

Model prediction performance was evaluated by the mean, standard deviation, root mean square error (RMSE), and Nash-Suttcliffe simulation efficiency (E_{NS}). Nash-Suttcliffe simulation efficiency indicates how well the plot of observed versus simulated values fits the 1:1 line. If the E_{NS} value is less than or close to zero, the model prediction is considered unacceptable or poor. If the E_{NS} value is one, then the model is perfect. Generally, an E_{NS} of 0.6 or higher is considered good.

RMSE is the calculated difference between measured and predicted values expressed as a residual of the means squared. One way to gauge the accuracy of the calibration is to compare the mean measured monthly flow volume with the RMSE. The lower the RMSE compared to the measured values the more precise the comparison.

Results and Discussion

Flow Calibration/Validation:

Stream Gage 8064100 Calibration – Flow calibration results are shown in Figure 8. The low RMSE (6.46) and high E_{NS} (0.89) values indicate that predicted total flow compares well with measured flow. The base flow filter (Arnold et al., 1995) estimated from stream flow records that the groundwater contribution to stream flow was 29 percent. The SWAT predicted base flow was 27 percent.

Stream Gage 8064100 Validation – Flow validation results are shown in Figure 9. Again, low RMSE (8.92) and high E_{NS} (0.79) values indicate that predicted total flow compares reasonably well with the measured flow. Estimated base flow was 29 percent. The SWAT predicted base flow was 29 percent.

The monthly time series shown reveals that SWAT under-predicts flow in some periods and over-predicts in others. This is most likely due to missing precipitation data in the station records or rainfall variability that is not reflected in the measured data. Rainfall variability is caused by localized thunderstorms occurring over climate stations or between stations, and spatial distribution of storms not accurately represented in the precipitation data input in SWAT.

Sediment Calibration: The sediment calibration developed for the Richland-Chambers Watershed was used for the Bardwell Reservoir Watershed. The predicted sediment load for Richland-Chambers Reservoir for the 1987 through 1994 period was 36,350,000 metric tons (40,069,016 tons), which was close to the measured sediment of 37,934,000 metric tons (41,815,077 tons), and well within the 15 percent range designated for the project.

Atrazine Calibration: The atrazine calibration developed for the Richland Chambers Watershed was used for the Bardwell Reservoir Watershed. The Bardwell Watershed is a sub watershed of the larger Richland-Chambers Watershed. Table 6 compares measured and predicted daily in-stream atrazine concentrations for the eleven sampling stations in the Richland-Chambers Watershed. Most sampling sites were represented by only two or three samples. However, RC17 in subbasin 74 had five samples, and RC22 in subbasin 66 had seven samples. Stream flow data was not collected at any of these stations.

The predicted atrazine concentrations fell within two standard deviations of the measured mean concentrations indicating that the model is doing a reasonably good job in simulating the movement and transport of the pesticide in the watershed. Measured atrazine concentrations were assumed accurate.

One should keep in mind that comparing an instantaneous grab sample with the average daily concentration calculated by the SWAT model is a difficult comparison at best.

Conclusions

Part 1 of this report describes the calibration of the SWAT model for flow, sediment and atrazine for the watershed. Since no stream gages were located in the Bardwell Reservoir Watershed, the closest downstream gage was used to calibrate flow. Also, SWAT model parameters developed for the Richland-Chambers Watershed for sediment and atrazine calibration were used for the Lake Bardwell Watershed.

Monthly simulated flow was compared to measured stream gage values. Sediment yield into Richland-Chambers Reservoir was compared to a sediment survey of the lake. Finally, predicted in-stream atrazine concentrations were compared to measured in-stream atrazine concentrations. The results indicate that the model is calibrated properly and performing well.

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Table 1. Land use/cover in Bardwell Reservoir Watershed.

Description	Hectares	Acres	Cover (%)
Cropland	9,130	22,561	20.22%
Pastureland	23,849	58,931	52.82%
Brushy Rangeland	3,625	8,958	8.03%
Open Rangeland	3,972	9,815	8.80%
Urban	2,133	5,272	4.73%
Water	2,440	6,029	5.40%
Total	45,149	111,566	100.00%

Table 2. Soil types in Bardwell Reservoir Watershed.

Soil Series / Land Type	Hectares	Acres	Percent
Austin	8,640	21,350	19.14%
Brackett	118	292	0.26%
Burleson	912	2,255	2.02%
Crockett	34	83	0.07%
Dalco	24	58	0.05%
Dams	27	68	0.06%
Eddy	6,532	16,140	14.47%
Frio	735	1,817	1.63%
Gullied land	1,323	3,269	2.93%
Houston	14,686	36,291	32.53%
Hunt	794	1,962	1.76%
Lewisville	1,617	3,995	3.58%
Pits	47	116	0.10%
Slickspots	10	24	0.02%
Stephen	4,411	10,899	9.77%
Sumter	421	1,040	0.93%
Trinity	1,633	4,035	3.62%
Water	1,981	4,896	4.39%
Wilson	1,204	2,975	2.67%
Total	45,149	111,566	100.00%

Table 3. Climate stations used in Bardwell Reservoir Watershed simulations.

Station Number	Station Name	Data Type	Start Date	End Date
480440	Avalon	Precip	1964	2003
480518	Bardwell Dam	Temp & Precip	1965	2005
484761	Kennedale	Precip	1946	1981

Table 4. SWAT Input Variables for Flow and Sediment Calibration.

Variable	*Adjustment Or Value*
Runoff Curve Number Adjustment	-4
Soil Available Water Capacity Adjustment (mm H^2O/mm soil)	None
Soil Crack Volume Factor	None
Soil Saturated Conductivity (mm/hour)	None
Soil Evaporation Compensation Factor	0.5
Minimum Shallow Aquifer Storage for Groundwater Flow (mm)	0.50
Minimum Shallow Aquifer Storage for Revap (mm)	2.00
Shallow Aquifer Re-Evaporation (Revap) Coefficient	0.10
Channel Erodibility Factor	0.85
Channel Cover Factor	0.85
Channel Transmission Loss (mm/hour)	1.00
Subbasin Transmission Loss (mm/hour)	0.55
Bank Coefficient	0.30
Reservoir Seepage Rate (mm/hour)	0.08
Initial Residue (kg/ha)	1000
Residue Decomposition Coefficient	0.10
Re-entrainment of Channel Sediment – Exponent	2.00
Re-entrainment of Channel Sediment – Linear	0.01
Peak Rate Function	2.00
Manning's "N" Value for the Main Channel	0.06
Manning's "N" Value for the Tributary Channels	0.06

Table 5. SWAT input variables for atrazine fate and transport.

Input Parameter	*Description*	*Value*
SKOC	Soil adsorption coefficient (mg/kg)/(mg/l)	100
WOF	Wash off fraction (fraction)	0.45
HLIFE_F	Degradation half-life of the chemical on foliage (days)	5.0
HLIFE_S	Degradation half-life of the chemical on the soil (days)	60
AP_EF	Application efficiency (fraction)	0.75
WSOL	Solubility of the chemical in water (mg/l)	33.00
PERCOP	Pesticide percolation coefficient	0.30

Table 6. Measured and predicted atrazine concentrations

Sampling Station		Average	Median	SD	Plus 2 SD	Minus 2 SD
RC01 (Sub 83)	*Meas*	3.41	3.41	2.96	9.32	-2.50
	Pred	1.18				
RC03 (Sub 55)	*Meas*	18.00	18.00	8.49	34.97	1.03
	Pred	32.18				
RC04 (Sub 76)	*Meas*	8.58	8.58	10.35	29.28	-12.12
	Pred	2.33				
RC07 (Sub 36)	*Meas*	9.56	9.56	13.35	36.26	-17.14
	Pred	2.49				
RC08 (Sub 73)	*Meas*	6.00	6.00	8.35	22.70	-10.71
	Pred	19.87				
RC10 (Sub 81)	*Meas*	16.20	16.20	3.96	24.12	8.28
	Pred	7.58				
RC12 (Sub 80)	*Meas*	17.44	17.44	13.52	44.48	-9.60
	Pred	6.22				
RC16 (Sub 37)	*Meas*	0.36	0.36	0.16	0.68	0.03
	Pred	0.93				
RC17 (Sub 74)	*Meas*	4.81	4.74	2.20	9.21	0.42
	Pred	5.65				
RC19 (Sub 69)	*Meas*	135.02	35.00	199.73	534.48	-264.43
	Pred	3.20				
RC21 (Sub 65)	*Meas*	7.96	5.76	9.14	26.24	-10.31
	Pred	4.31				
RC 22 (Sub 66)	*Meas*	4.88	3.26	2.47	9.82	-0.05
	Pred	5.38				

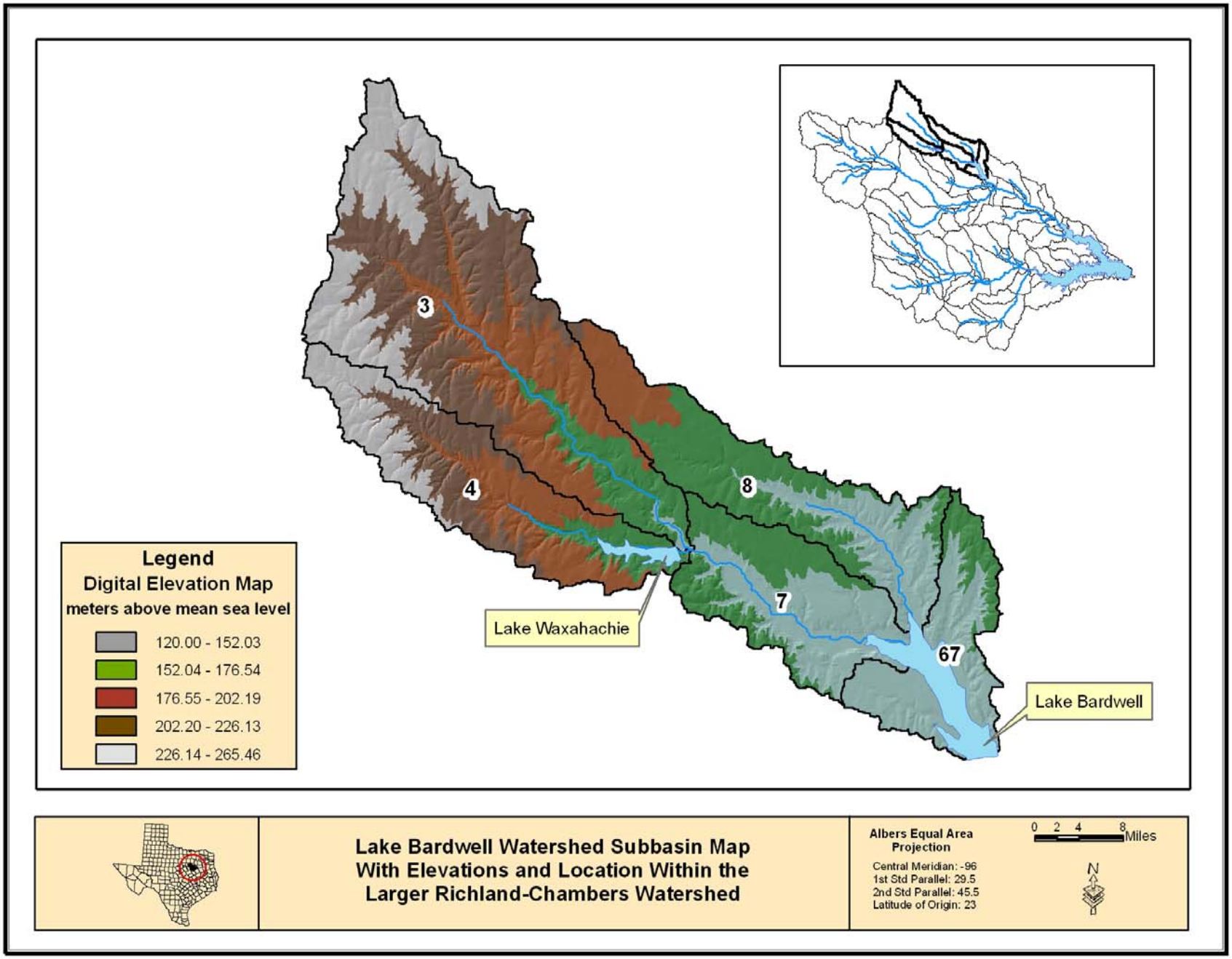

Figure 1. Bardwell Reservoir Watershed showing the location within the larger Richland-Chambers Watershed.

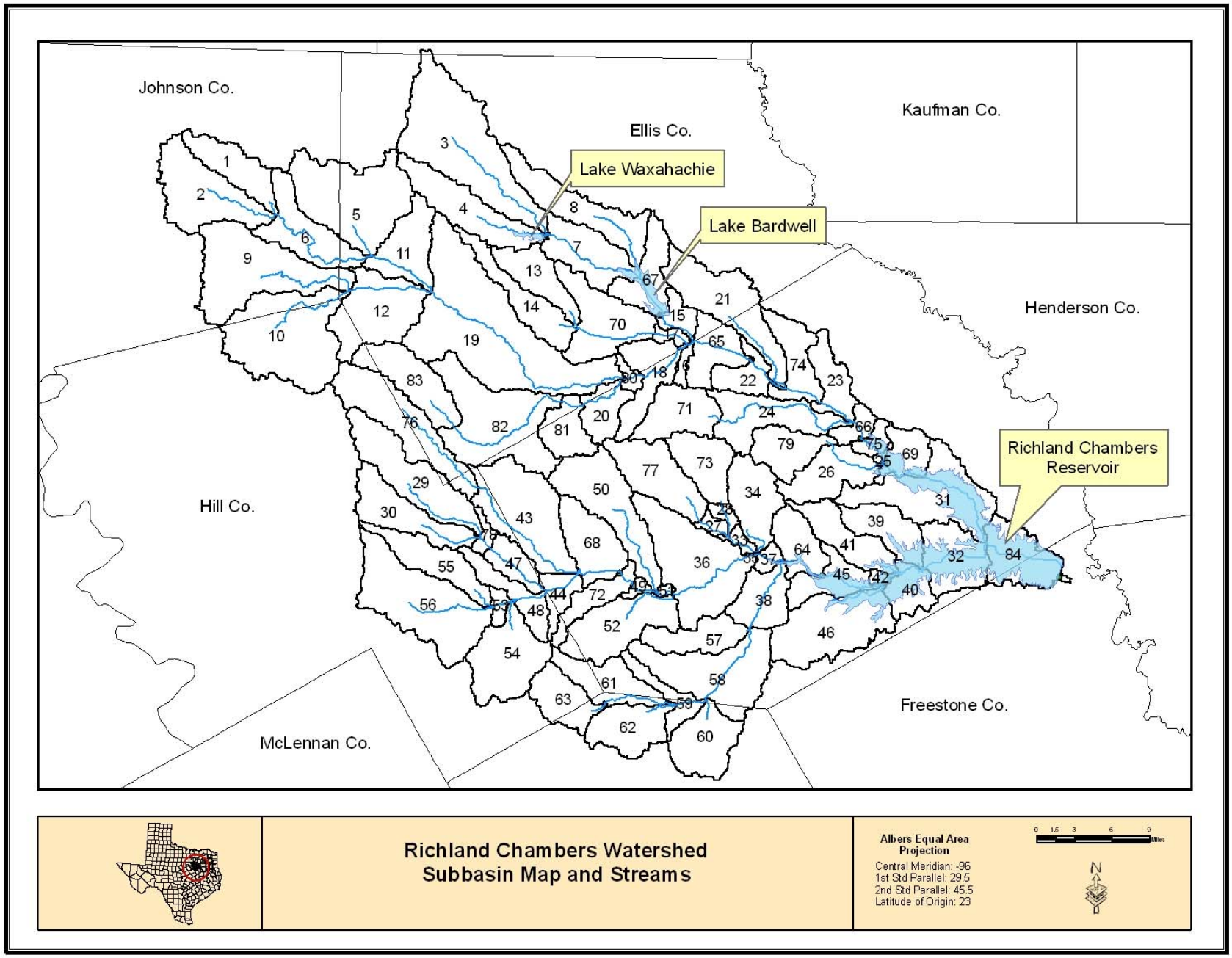

Figure 2. Richland-Chambers Watershed. The Bardwell Reservoir Watershed is a subset of this watershed (subbasins 3, 4, 7, 8 and 67).

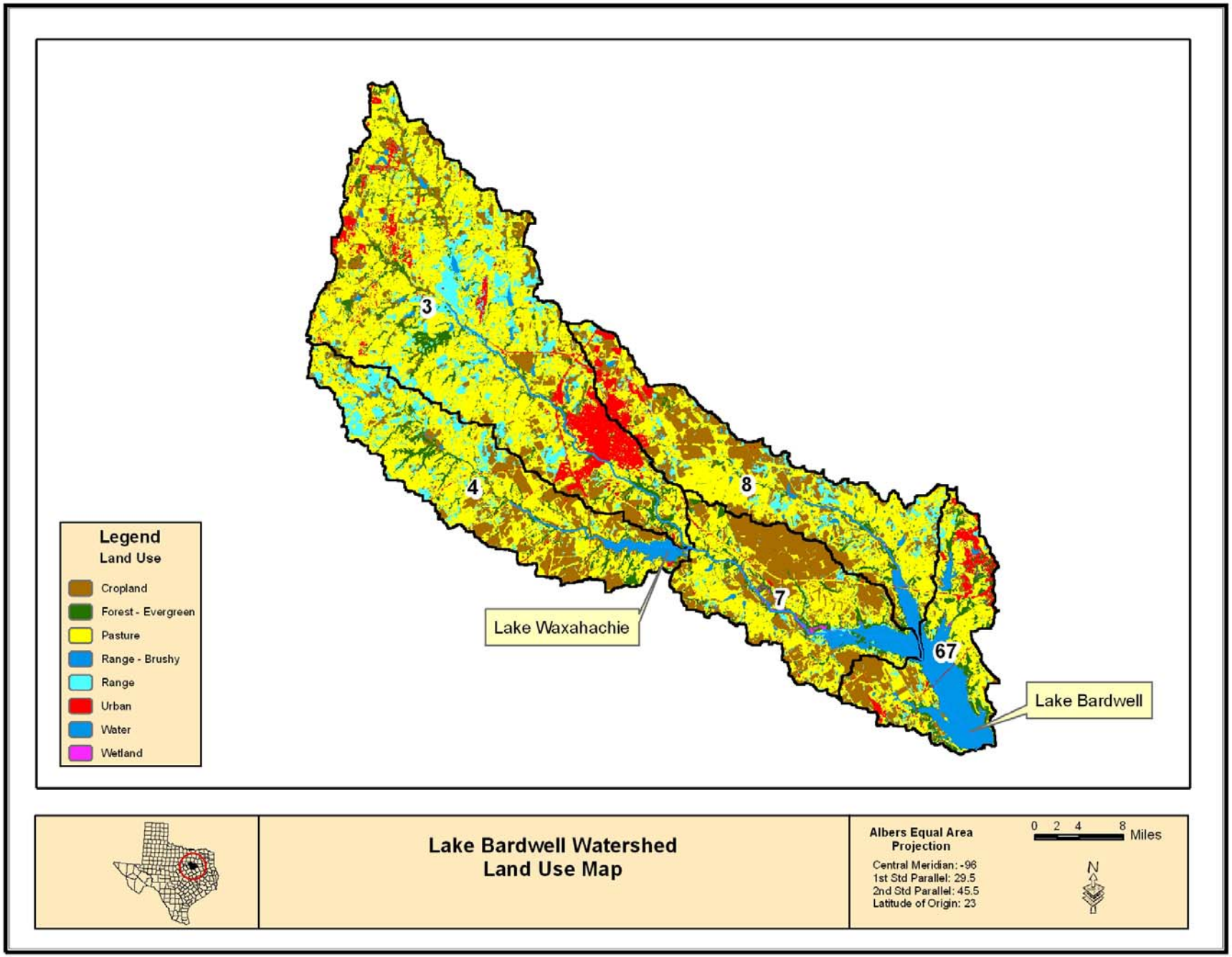

Figure 3. NLCD land use/cover map of Bardwell Reservoir Watershed.

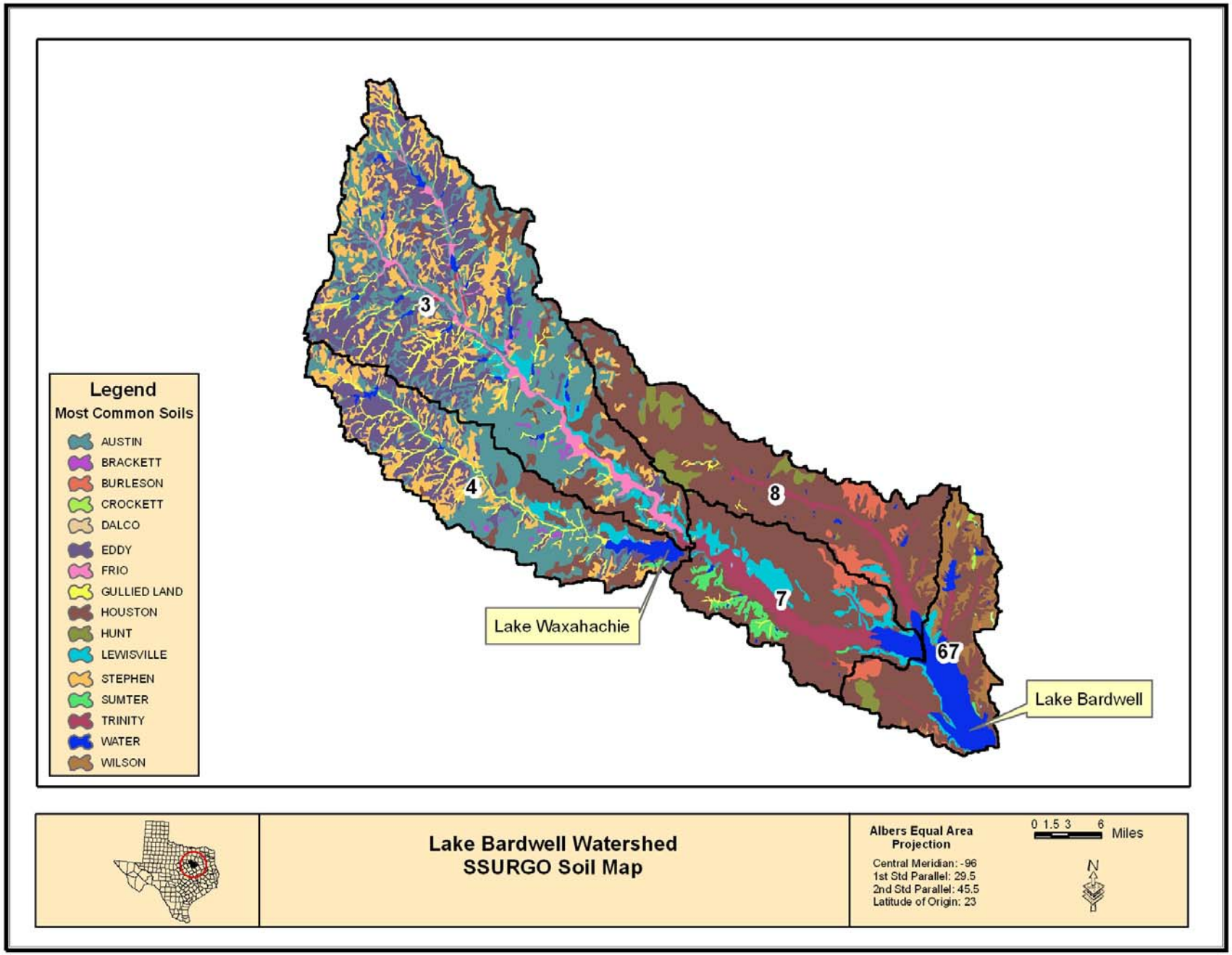

Figure 4. SSURGO soils map of Bardwell Reservoir Watershed.

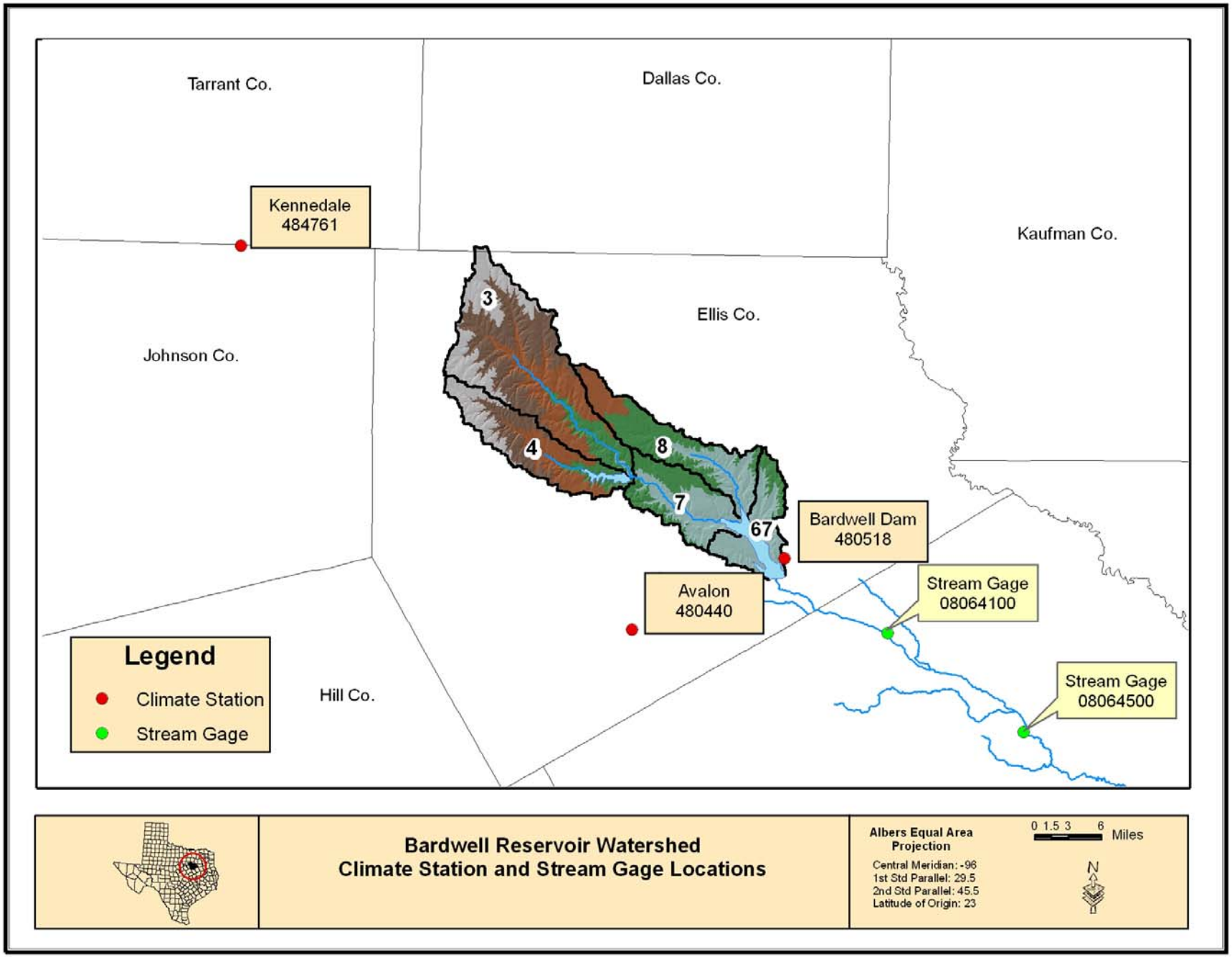

Figure 5. Climate stations and stream gages for Bardwell Reservoir Watershed.

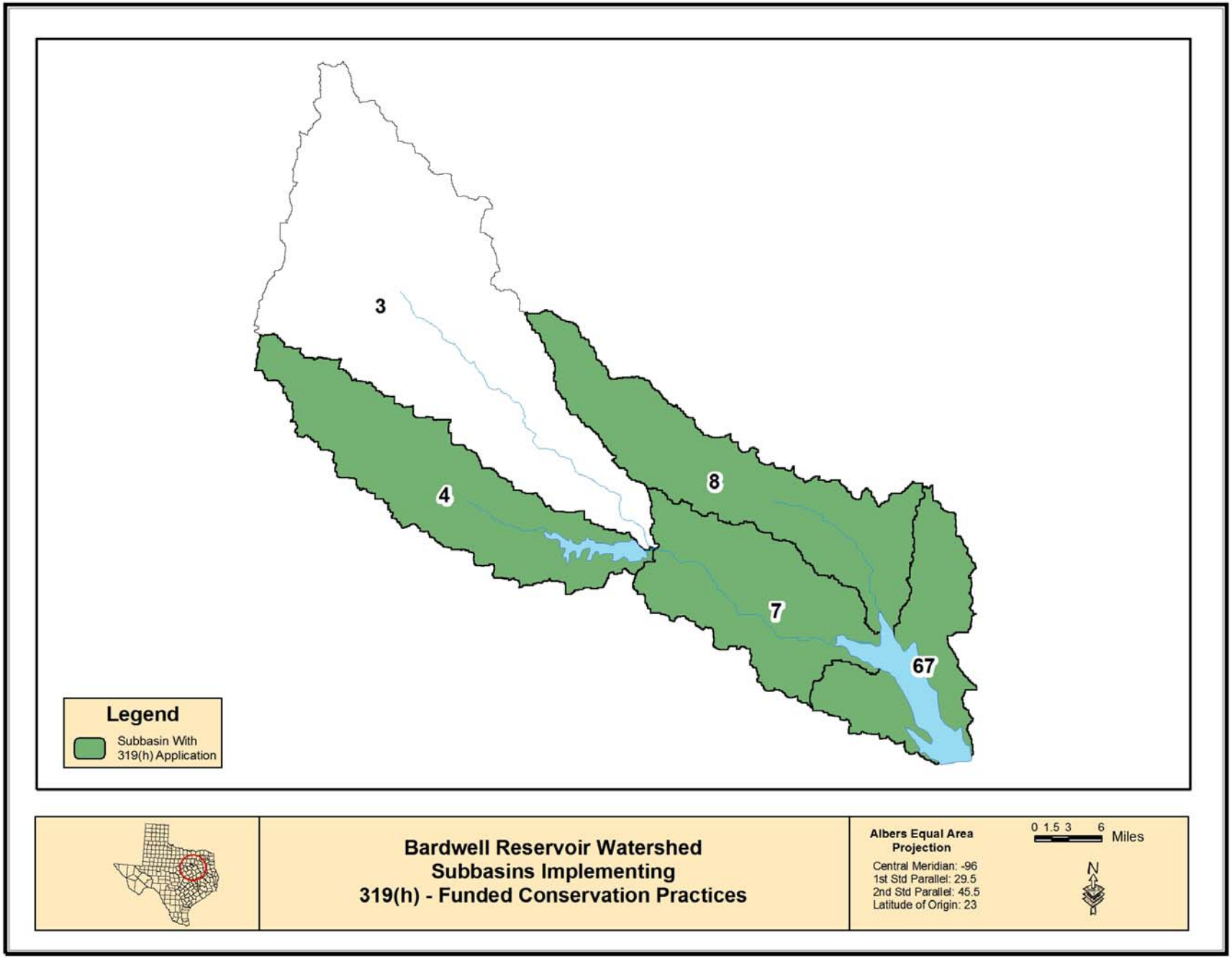

Figure 6. Subbasins implementing water quality management plans with 319(h)-funded conservation practices.

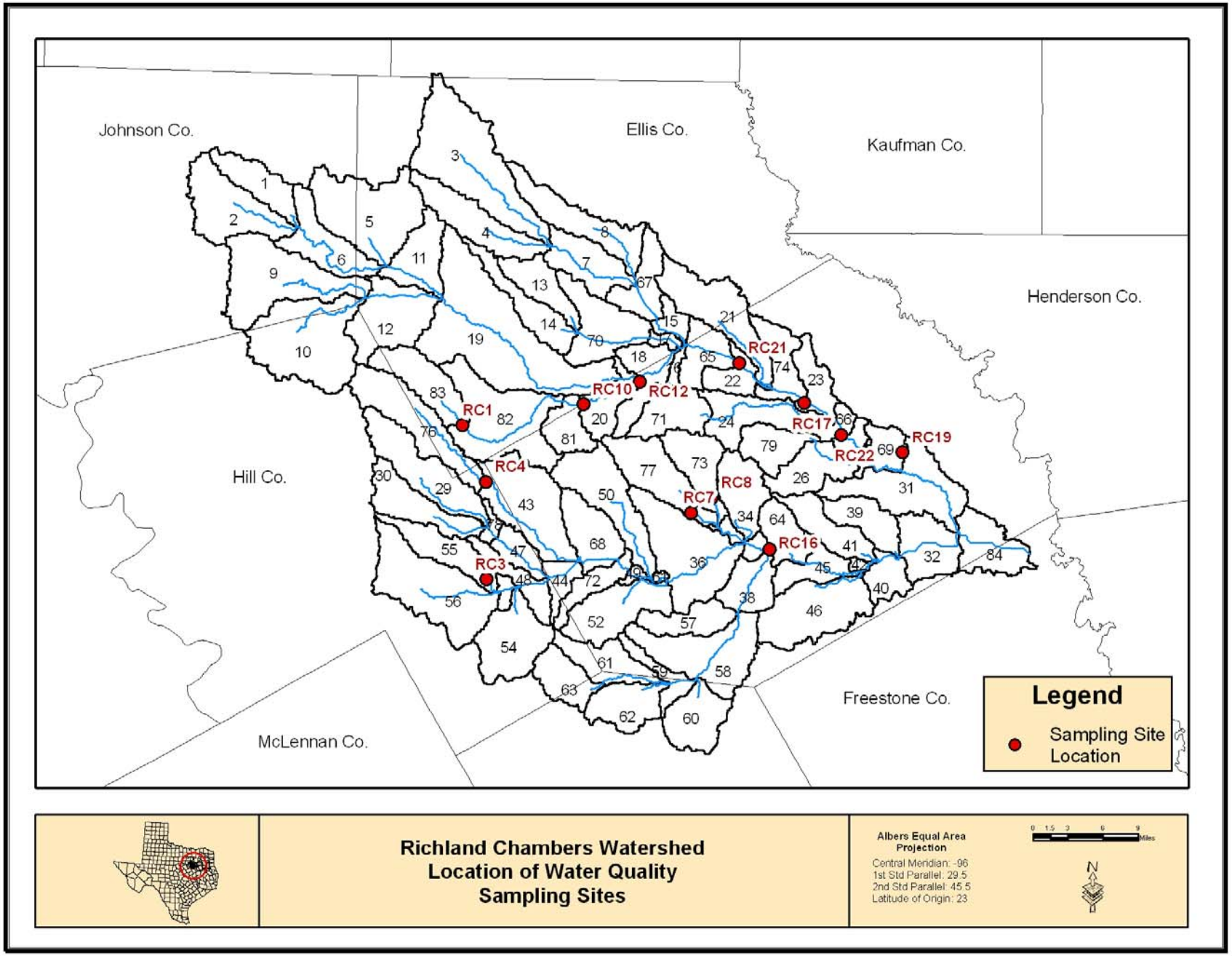

Figure 7. Location of water quality sampling stations in Richland-Chambers Watershed.

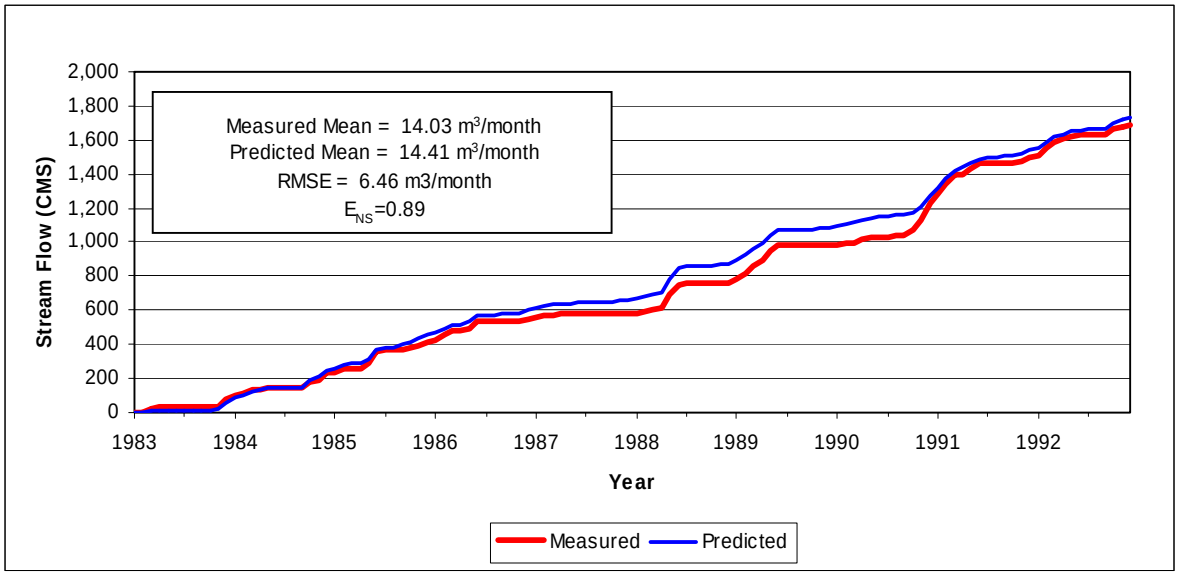

Figure 8. Cumulative monthly measured and predicted stream flow at gage 8064100 (Chambers Creek near Rice, TX), 1984 through 1993. This period was used for flow calibration. Monthly statistics are shown in the box.

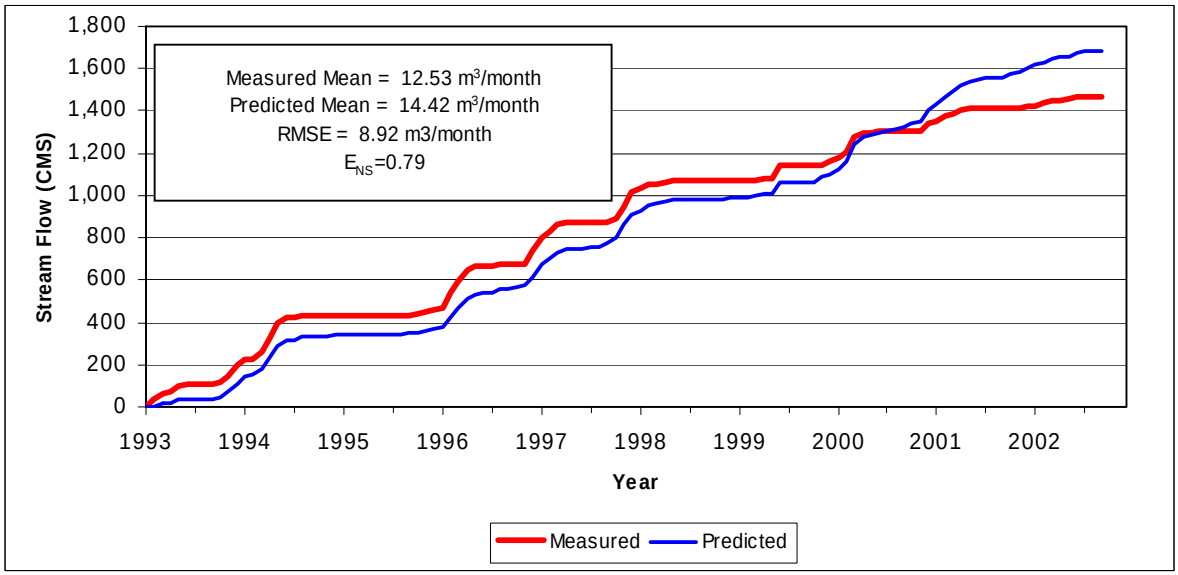

Figure 9. Cumulative monthly measured and predicted stream flow at gage 8064100 (Chambers Creek near Rice, TX), 1994 through 2003. This period was used for flow validation. Monthly statistics are shown in the box.

PART 2: BEST MANAGEMENT PRACTICES

Introduction

The objective of this section of the report is to describe the application of the SWAT model for estimating atrazine loading and sediment yield under the existing conditions of the watershed and analyze the effectiveness of BMPs applied under the 319(h) program.

Methodology

BMP Scenarios

Three scenarios were constructed in order to estimate the reductions in atrazine and sediment due to implementation of WQMP implementation under the 319(h) program. Each scenario was run for the 30-year period, 1974 through 2003.

- Scenario I – Current conditions scenario representing the conditions in the watershed prior to the implementation of WQMPs under the 319(h) program.
- Scenario II – Post BMP scenario representing the conditions in the watershed after the implementation of funded WQMPs under the 319(h) program.
- Scenario III – All cropland treated scenario representing the ideal condition in which BMPs have been applied to all cropland acres.

Changes in sediment and atrazine loadings between the pre-BMP and the post-BMP scenarios provide the percentage of reduction in the watershed.

Scenario I - Existing Conditions

This scenario was modeled with fifty percent of the cropland effectively terraced with no contouring. Existing ponds and dams were included as well as typical management techniques including tillage, fertilization, and conservation practices. A three-year crop rotation of corn-wheat-sorghum was used.

Scenario II - Post BMP Condition

Table 7 shows the various conservation practices (BMPs) by county that were implemented under the 319(h) project.

Major BMPs simulated with SWAT were:

- Terraces
- Grassed waterways
- Contour farming
- Conservation tillage

- Filter strips and field borders
- Conservation crop rotation
- Pasture and hayland planting, range planting
- Prescribed grazing
- Herbicide incorporation
- Installation of planned ponds and grade stabilization structures
- Nutrient and pest management

These practices were applied only to the farms in the watershed that had implemented WQMPs under the 319(h) program. As a percentage of the total land area in the watershed, these farms constituted a relatively small part – about 1.2 percent.

Scenario III - All Cropland Treated

All of the BMPs listed above for scenario II were applied to all cropland acres for scenario III. Cropland conversion to pasture/hayland was simulated at 25 percent. This value was chosen since it is similar to the landuse conversion rate implemented in the 319(h) WQMPs and modeled in scenario II.

BMP Analysis

Results are presented as a percentage reduction in atrazine and sediment loadings at three levels:

- Farm level – This included only the areas in each subbasin where BMPs were applied.
- Subbasin level – Included both the BMP areas and the non-BMP areas within the subbasin.
- Watershed level – The watershed outlet on Waxahachie creek. The effects of reservoir impoundment were ignored for this analysis.

Results and Discussion

The simulation of the watershed hydrology can be separated into two major divisions. The first part is the land phase of the hydrologic cycle that controls the amount of water, sediment, nutrient and pesticide loadings to the main channel in each subbasin. The second part is the routing phase, or water phase, of the hydrologic cycle where water, sediment, pesticide, etc. moves through the channel network of the watershed to the outlet.

The following results described under the farm and subbasin levels are from the land phase, while the watershed results are from the routing phase of the simulation.

Reductions at farm level - scenario II

General locations of the BMP farms are shown in Figure 6, while the types of installed practices and extents are listed in Table 7. The farm-level reductions in atrazine and sediment loadings are shown in Figure 10. These include only the areas where 319(h) BMPs were implemented. Note that there were no 319(h) contracts in subbasin 3.

Atrazine reductions varied from 79 to 94 percent at the farm level. The high percentage atrazine reduction was mostly due to landuse conversion from cropland to permanent pasture. Where the landuse remained as cropland after conservation treatment the combination of conservation practices applied reduced atrazine loading from 71 to 75 percent across the subbasins.

Sediment reduction was from 81 to 93 percent at the farm level. This high reduction is again associated with the landuse conversion of cropland to pastureland. The treated cropland sediment reduction was 70 to 74 percent across the subbasins.

Reductions at the subbasin level - atrazine

Reductions in subbasin atrazine loadings to the channels are shown in Figure 11. Here all the land in the subbasin is considered.

Scenario II - The percentage reductions varied from 3 to 6 percent. Compared to the reduction at the farm level, the percentage reduction is much less, as expected, since the BMP-treated land comprises a relatively small part of the total subbasin area.

Scenario III – In this scenario where all cropland in the watershed was treated, percent reductions varied from 78 to 80.

Reductions at the subbasin level - sediment

Reductions in subbasin sediment loadings are shown in Figure 12.

Scenario II – The percentage reductions varied from 2 to 7 percent.

Scenario III – The percentage sediment reductions when all cropland was treated varied from 86 to 90 percent.

Reductions at the watershed level - atrazine

Figure 13 shows the percentage of atrazine loading reduction on the main channel at the watershed outlet. Refer to the subbasin map in Figure 1 for location.

Scenario II – The percentage reductions varied from 2 to 6.

Scenario III – The percentage reductions varied from 78 to 79.

Reductions at the watershed level - sediment

Figure 14 shows the percentage of sediment loading reduction.

Scenario II – The percentage reductions varied from 2 to 8. At the watershed outlet in subbasin 67 the percent reduction was 4 percent.

Scenario III – The percentage reductions varied from 81 to 89. The reduction at the watershed outlet in subbasin 67 was 84 percent.

Conclusions

The purpose of this study was to simulate the atrazine and sediment loadings in the Bardwell Reservoir Watershed for three scenarios: (I) current conditions (pre 1999), (II) 319(h) BMP applications through WQMPs, and (III) all cropland treated. The study was performed using the SWAT basin scale model.

Scenario II showed that BMPs at the farm level where they were implemented reduced atrazine loadings 79 to 94 percent, and reduced sediment loading from 81 to 93 percent.

Scenario II showed that BMPs at the subbasin level reduced atrazine loadings from 3 to 6 percent, and reduced sediment loadings from 2 to 6 percent.

Scenario II showed that BMPs at the watershed level reduced atrazine loading into Bardwell Reservoir by 4 percent and reduced sediment loading by 4 percent.

Scenario III showed that BMPs at the subbasin level reduced atrazine loading by 78 to 80 percent, and reduced sediment loading by 86 to 90 percent.

Scenario III showed that BMPs at the watershed level reduced atrazine loading into Bardwell Reservoir by 79 percent, and reduced sediment loading by 84 percent.

Predicted sediment volume to Bardwell Reservoir for the 1974 though 2003 modeling period was 1,192,800 metric tons (1,314,837 tons) for the baseline condition (scenario I), 1,149,000 metric tons (1,266,556 tons) for the 319(h) BMP condition (scenario II), and 189,420 metric tons (208,800 tons) for the all cropland treated condition (scenario III). In percentages, sediment reduction to the lake for scenario II was 4, and for scenario III was 84.

This study modeled the conservation practices applied through the 319(h) program. There were ten contracts in the Bardwell Reservoir Watershed covering 551 hectares (1,361 ac), or about 1.2 percent of the watershed.

BMPs simulated with SWAT were terraces, contour farming, grassed waterways, conservation tillage, conservation crop rotation, conservation buffers, herbicide incorporation, and pasture planting (conversion from cropland to pastureland).

Table 7. Locations and types of conservation practices (BMPs) implemented in the Bardwell Reservoir Watershed under the 319(h) project.

Conservation Practice	***Ellis Co.***
328 - Conservation Crop Rotation (ac)	508
330 - Contour Farming (ac)	437
342 - Critical Area Planting (ac)	7
378 - Farm Pond (no)	5
412 - Grassed Waterway (ac)	10
511 - Forage Harvest Management (ac)	293
512 - Pasture & Hayland Planting (ac)	478
512 - Pasture & Hayland Planting (no)	12
528A - Prescribed Grazing (ac)	447
590 - Nutrient Management (ac)	1213
595 - Pest Management (ac)	1213

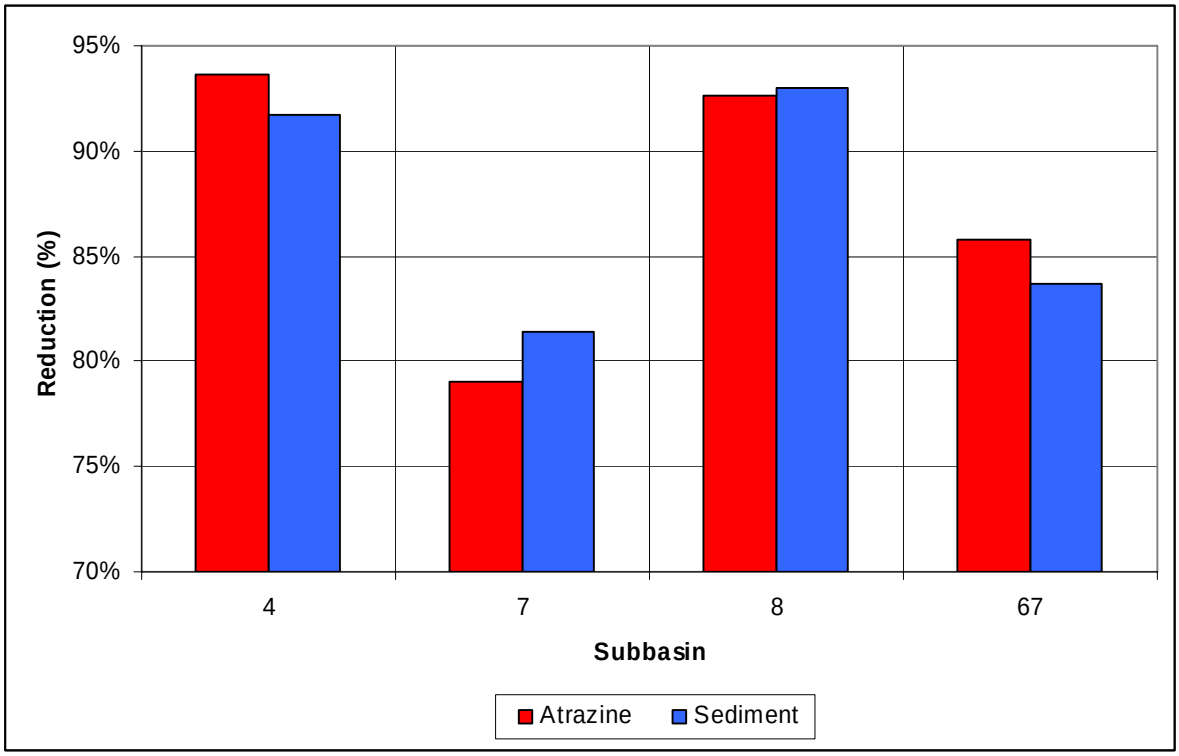

Figure 10. Percentage reductions in atrazine and sediment loading at the farm level where conservation practices were implemented in the Bardwell Reservoir Watershed.

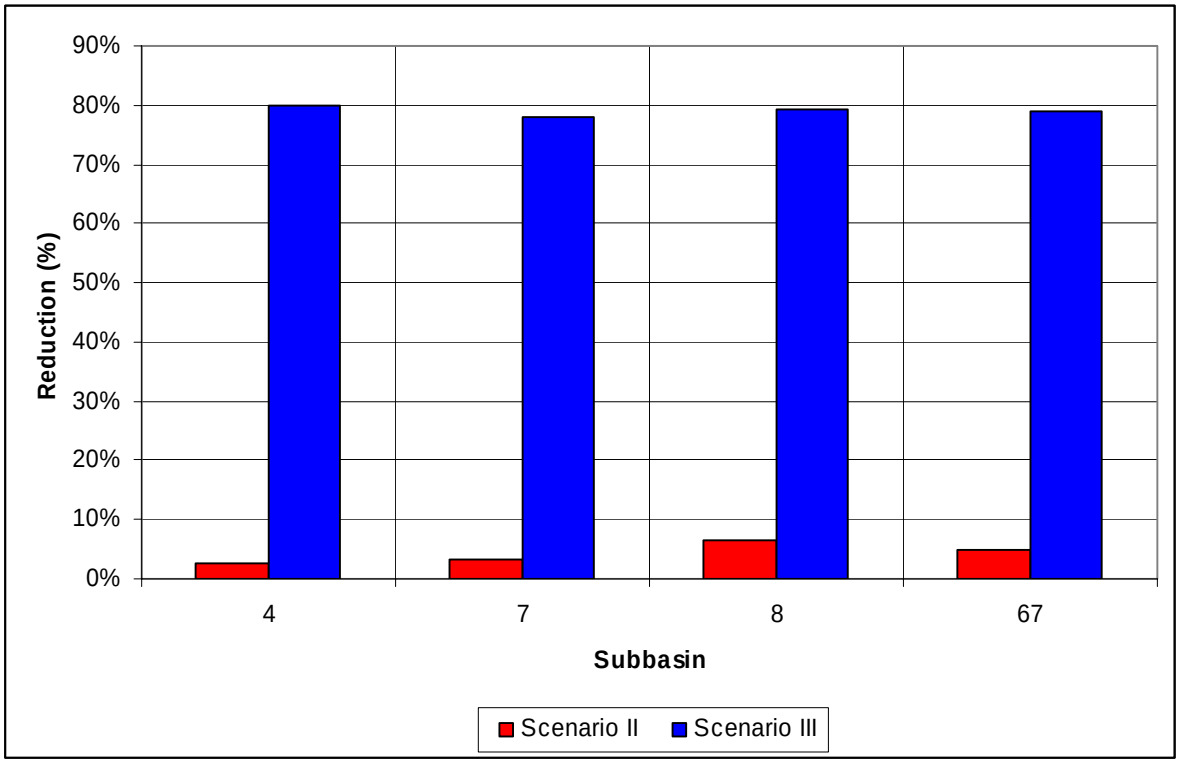

Figure 11. Percentage reductions in atrazine loading at the subbasin level, Bardwell Reservoir Watershed.

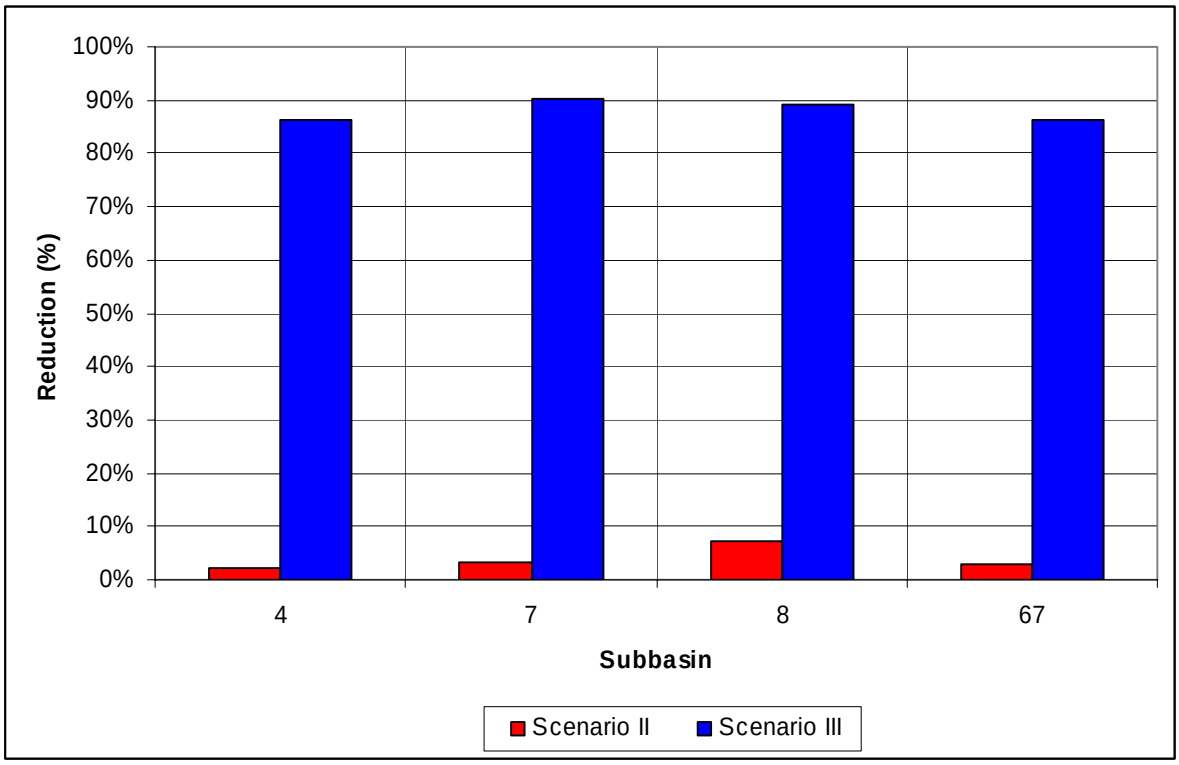

Figure 12. Percentage reductions in sediment loading at the subbasin level, Bardwell Reservoir Watershed.

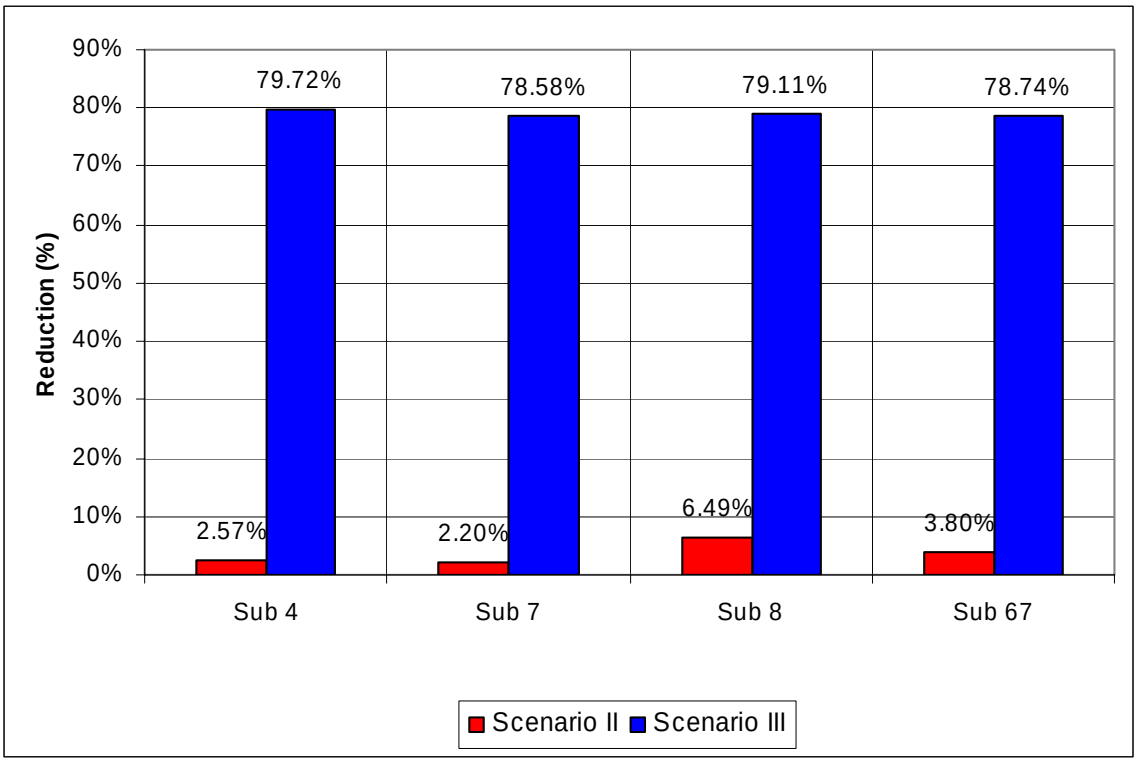

Figure 13. Percentage reductions in atrazine loading at the watershed level, Bardwell Reservoir Watershed

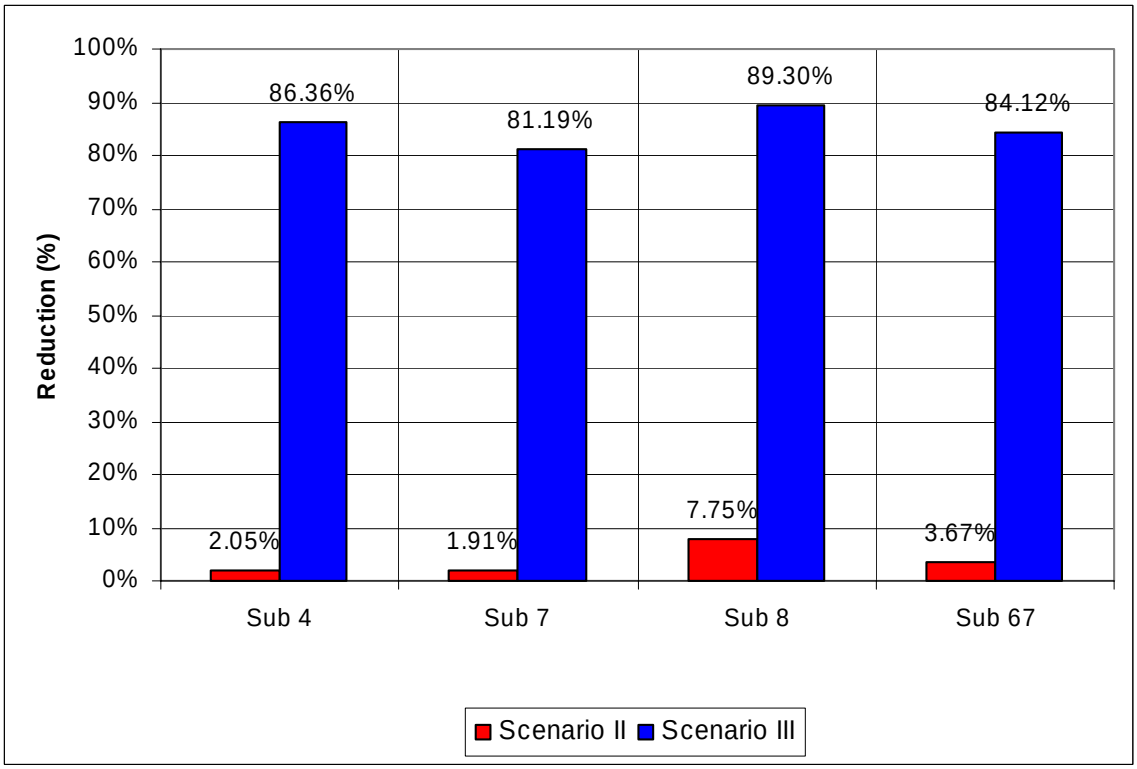

Figure 14. Percentage reductions in sediment loading at the watershed level, Bardwell Reservoir Watershed

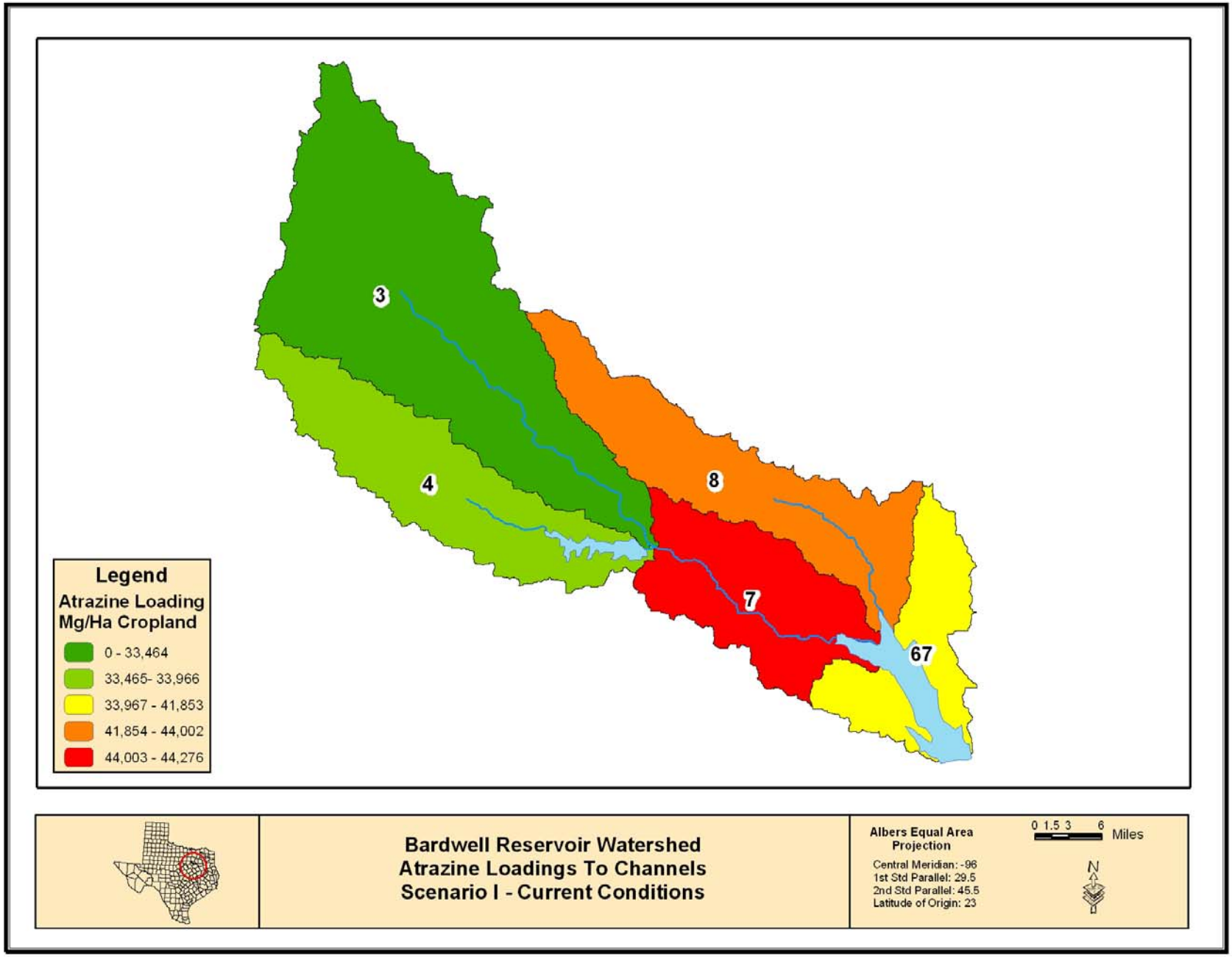

Figure 15. Predicted average annual atrazine yield by subbasin for current condition, Bardwell Reservoir Watershed, 1974 through 2003.

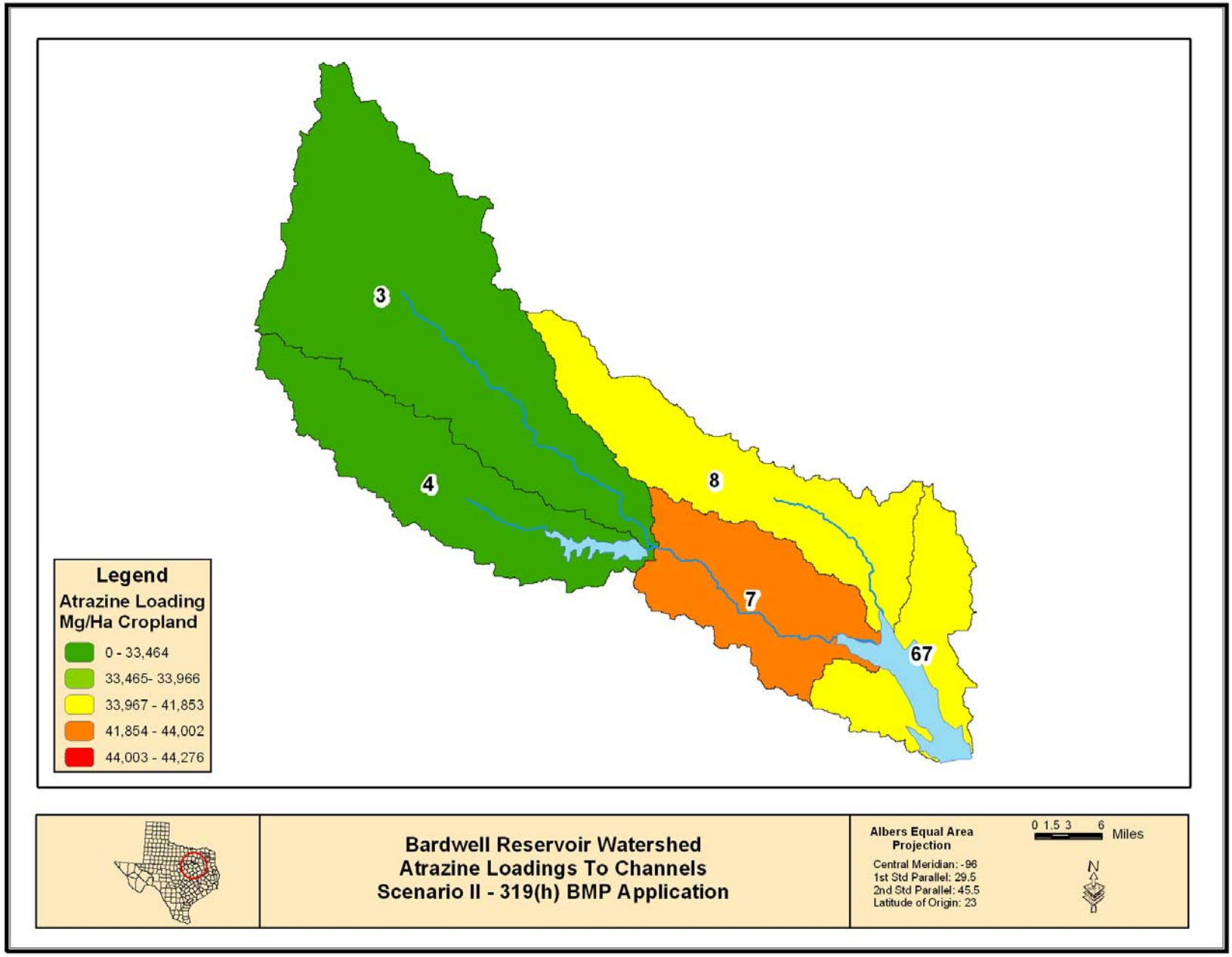

Figure 16. Predicted average annual atrazine yield by subbasin after 319(h) conservation practice implementation (scenario II), Bardwell Reservoir Watershed, 1974 through 2003.

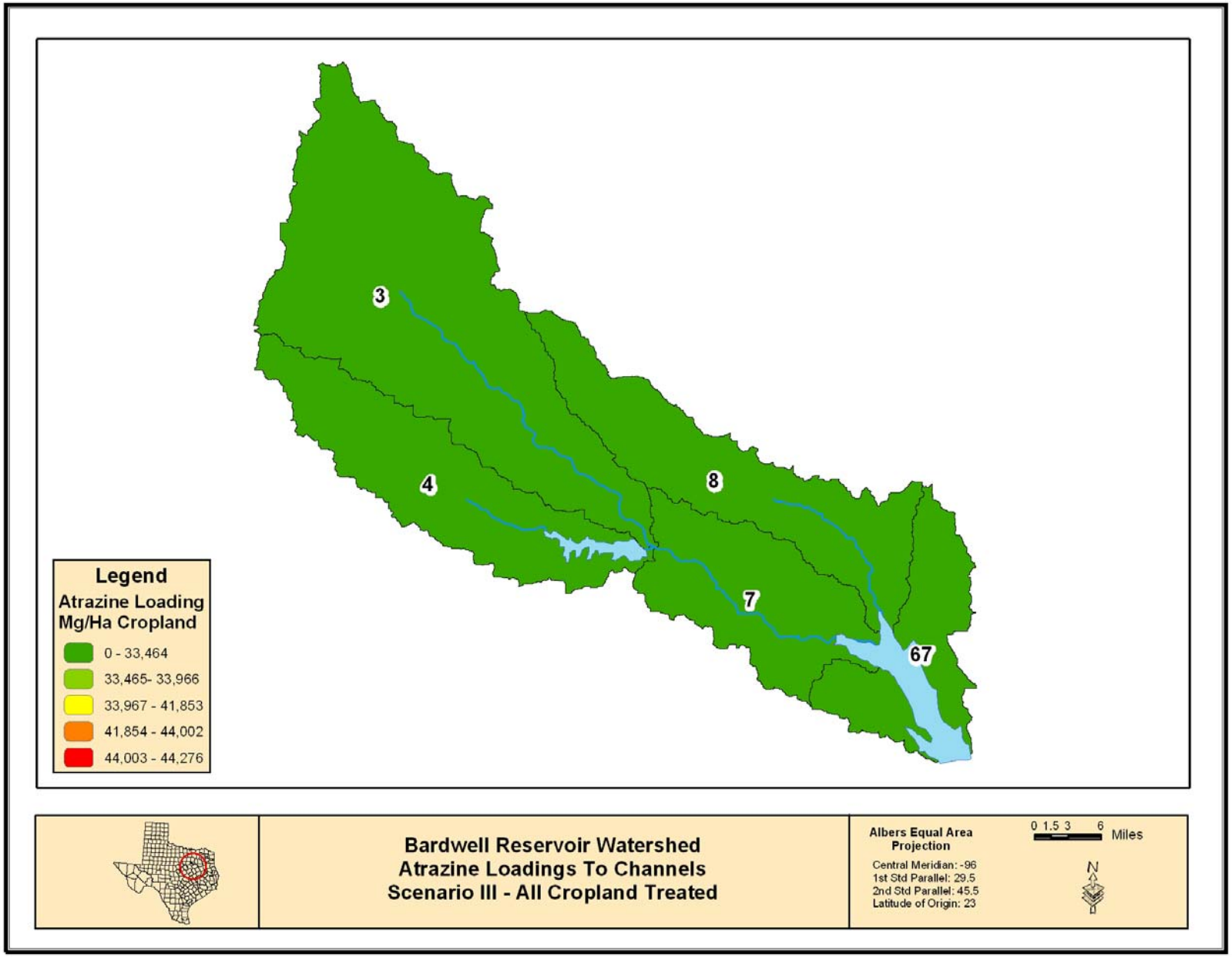

Figure 17. Predicted average annual atrazine yield by subbasin after conservation practice implementation on all cropland (scenario III), Bardwell Reservoir Watershed, 1974 through 2003.

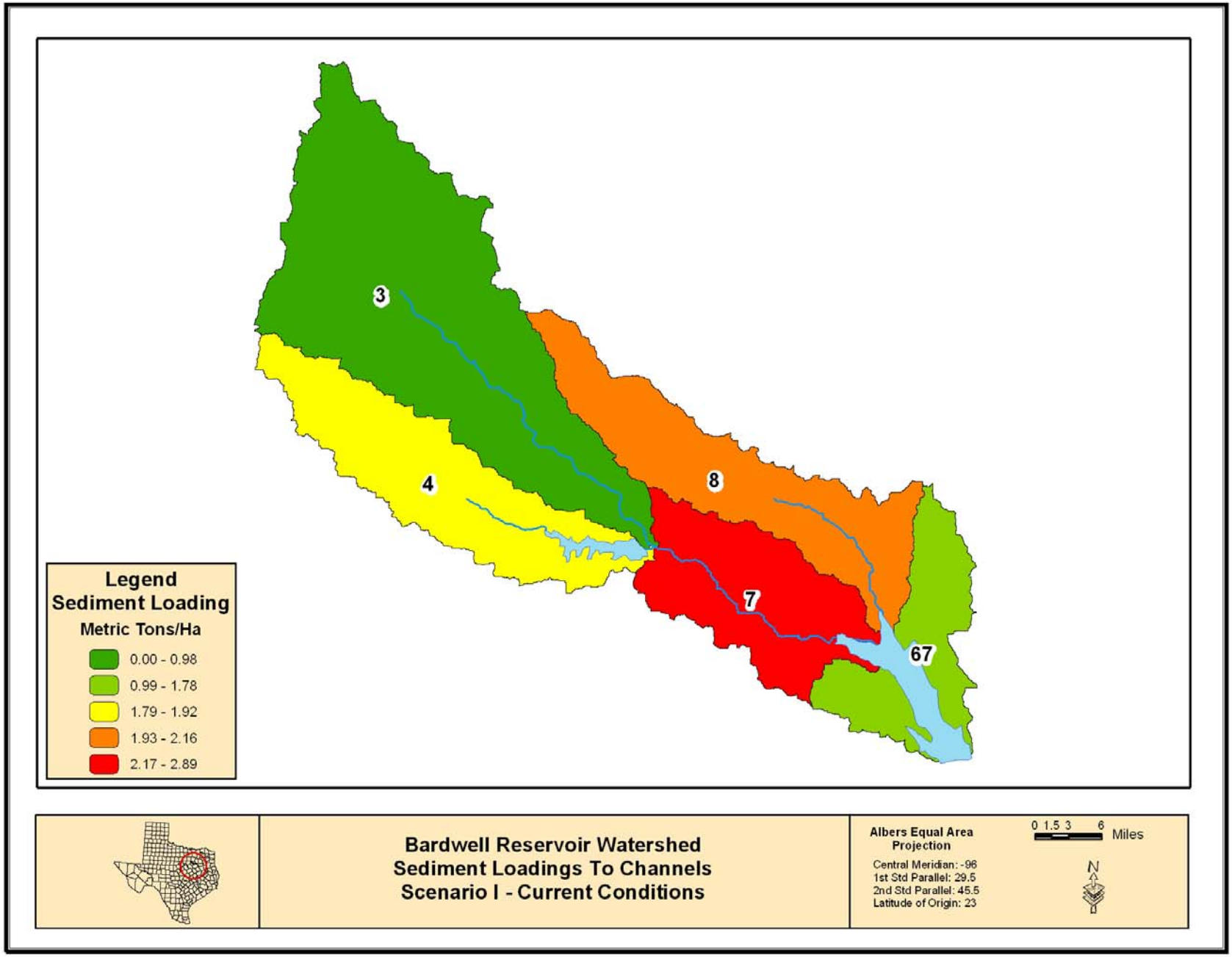

Figure 18. Predicted average annual sediment yield by subbasin for current condition, Bardwell Reservoir Watershed, 1974 through 2003.

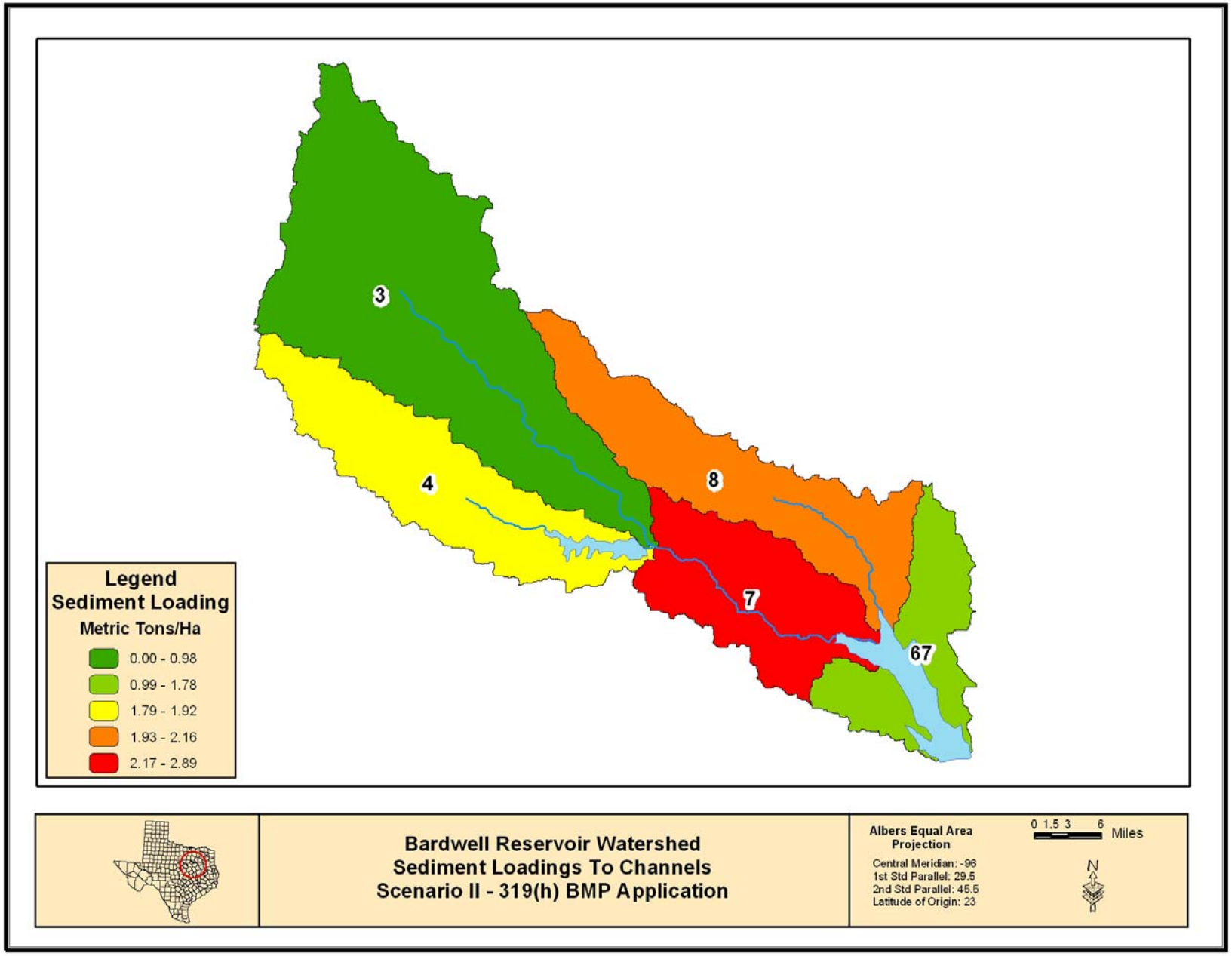

Figure 19. Predicted average annual sediment yield by subbasin after 319(h) conservation practice implementation (scenario II), Bardwell Reservoir Watershed, 1974 through 2003.

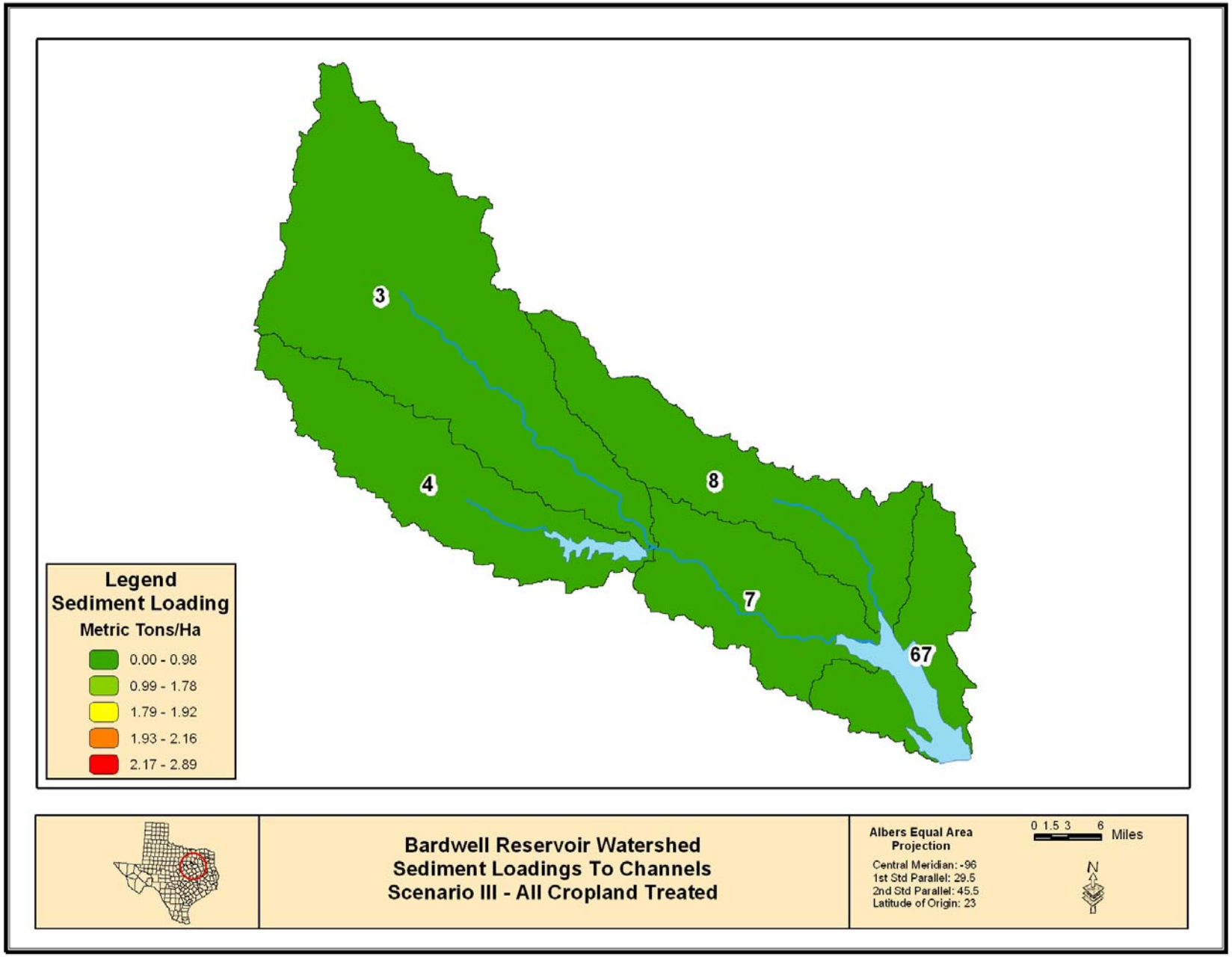

Figure 20. Predicted average annual sediment yield by subbasin after conservation practice implementation on all cropland (scenario III), Bardwell Reservoir Watershed, 1974 through 2003.

APPENDIX

Notes for Table 8 – Appendix

In Table 8, the fraction of landuse in each subbasin is based on actual input into SWAT and will not agree exactly with landuse percentages in Table 1. We set the landuse filter in SWAT at 2 percent, which means that any landuse comprising less than 2 percent of a subbasin was ignored in the model input. In addition, SWAT re-allocates areas to the other landuses when a landuse of less than 2 percent is ignored and dropped out of the model. The result is usually a small adjustment in area for each category of landuse in SWAT input.

Table 8. Landuse/Cover by Subbasin, Bardwell Reservoir Watershed----------

Detailed LANDUSE/SOIL distribution SWAT model class Wed Jul 20 15:12:05 2005

	Area [ha]	Area [acres]
Watershed	45,149.4384	111,566.2489

	Area [ha]	Area [acres]	%Watershed Area
LANDUSE			
Residential-High Density --> URHD	271.7442	671.4919	0.60
Range-Brush --> RNGB	137.4467	339.6368	0.30
Pasture --> PAST	22696.0007	56082.8164	50.27
Range-Grasses --> RNGE	3781.4048	9344.0176	8.38
Water --> WATR	2564.3981	6336.7405	5.68
Wetlands-Forested --> WETF	75.9672	187.7183	0.17
Wetlands-Mixed --> WETL	30.9653	76.5166	0.07
Commercial --> UCOM	874.4596	2160.8281	1.94
RC 319 Row Crop --> RCAG	186.3228	460.4118	0.41
RC 319 Crop2Past --> RCAP	140.1466	346.3084	0.31
Forest-Deciduous --> FRSD	2677.3583	6615.8702	5.93
Forest-Evergreen --> FRSE	1100.3993	2791.1351	2.44
RC 319 Past --> RCPA	56.9835	140.8087	0.13
Forest-Mixed --> FRST	326.9191	807.8315	0.72
Agricultural Land-Close-grown --> AGRC	440.5062	1088.5102	0.98
Residential-Low Density --> URLD	1379.0358	3407.6581	3.05
Agricultural Land-Row Crops --> AGRR	8405.1501	20769.4957	18.62
RC 319 Range Grass --> RCRA	4.2304	10.4535	0.01
Orchard --> ORCD	0.0000	0.0000	0.00
SOIL			
BRACKETT	118.2775	292.2690	0.26
EDDY	6531.8191	16140.4123	14.47
GULLIED LAND	1323.1063	3269.4539	2.93
AUSTIN	8639.9318	21349.6517	19.14
SUMTER	420.9024	1040.0685	0.93
DAMS	27.4541	67.8402	0.06
WATER	1981.2839	4895.8398	4.39
HOUSTON	14686.3989	36290.7378	32.53
LEWISVILLE	1616.8199	3995.2330	3.58

SLICKSPOTS	9.7214	24.0221	0.02	
TRINITY	1632.7522	4034.6026	3.62	
BURLESON	912.4654	2254.7421	2.02	
CROCKETT	33.7550	83.4101	0.07	
DALCO	23.6735	58.4983	0.05	
FRIO	735.4991	1817.4507	1.63	
HUNT	794.0978	1962.2506	1.76	
PITS	46.8069	115.6620	0.10	
STEPHEN	4410.7444	10899.1434	9.77	
WILSON	1203.9286	2974.9606	2.67	

		Area [ha]	Area [acres]	%Wat.Area	%Sub.Area
SUBBASIN #	3	17685.3392	43701.3574	3.48	
LANDUSE:					
Residential-High Density --> URHD		133.7541	330.5132	0.03	0.76
Range-Brush --> RNGB		8.7309	21.5745	0.00	0.05
Pasture --> PAST		10225.1707	25266.9081	2.01	57.82
Range-Grasses --> RNGE		1872.1079	4626.0721	0.37	10.59
Water --> WATR		206.7519	510.8942	0.04	1.17
Wetlands-Mixed --> WETL		0.9001	2.2242	0.00	0.01
Commercial --> UCOM		541.2272	1337.3995	0.11	3.06
Forest-Deciduous --> FRSD		792.6238	1958.6130	0.16	4.48
Forest-Evergreen --> FRSE		693.6133	1713.9532	0.14	3.92
Forest-Mixed --> FRST		244.4658	604.0873	0.05	1.38
Agricultural Land-Close-grown --> AGRC		303.8721	750.8832	0.06	1.72
Residential-Low Density --> URLD		915.1267	2261.3239	0.18	5.17
Agricultural Land-Row Crops --> AGRR		1746.9946	4316.9111	0.34	9.88
SOIL:					
TRINITY		67.7772	167.4808	0.01	0.38
DAMS		20.8822	51.6010	0.00	0.12
HOUSTON		1735.0234	4287.3295	0.34	9.81
STEPHEN		2892.6357	7147.8475	0.57	16.36
HUNT		28.1730	69.6168	0.01	0.16
AUSTIN		5917.8555	14623.3168	1.17	33.46
PITS		27.7229	68.5047	0.01	0.16
WATER		217.9130	538.4740	0.04	1.23
LEWISVILLE		499.9128	1235.3096	0.10	2.83
GULLIED LAND		783.4428	1935.9263	0.15	4.43

Table 8 - 2

	BRACKETT	74.7979	184.8294	0.01	0.42
	FRIO	735.4677	1817.3775	0.14	4.16
	DALCO	23.6725	58.4959	0.00	0.13
	EDDY	4660.0625	11515.2475	0.92	26.35

		Area [ha]	Area [acres]	%Wat.Area	%Sub.Area
SUBBASIN #	4	7955.5408	19658.5391	1.57	
LANDUSE:					
Residential-High Density -->	URHD	0.1801	0.4450	0.00	0.00
Range-Brush -->	RNGB	15.3057	37.8211	0.00	0.19
Pasture -->	PAST	4088.9618	10104.0290	0.81	51.40
Range-Grasses -->	RNGE	906.8175	2240.7914	0.18	11.40
Water -->	WATR	289.6378	715.7095	0.06	3.64
Wetlands-Mixed -->	WETL	3.5113	8.6766	0.00	0.04
Commercial -->	UCOM	50.2387	124.1423	0.01	0.63
RC 319 Row Crop -->	RCAG	15.7559	38.9335	0.00	0.20
RC 319 Crop2Past -->	RCAP	28.9008	71.4152	0.01	0.36
Forest-Deciduous -->	FRSD	638.6077	1578.0315	0.13	8.03
Forest-Evergreen -->	FRSE	122.1755	301.9017	0.02	1.54
RC 319 Past -->	RCPA	13.0549	32.2592	0.00	0.16
Forest-Mixed -->	FRST	31.2416	77.1996	0.01	0.39
Agricultural Land-Close-grown -->	AGRC	29.1709	72.0826	0.01	0.37
Residential-Low Density -->	URLD	7.4728	18.4656	0.00	0.09
Agricultural Land-Row Crops -->	AGRR	1714.5081	4236.6352	0.34	21.55
SOIL:					
TRINITY		2.9711	7.3418	0.00	0.04
DAMS		0.6302	1.5573	0.00	0.01
HOUSTON		1095.3477	2706.6588	0.22	13.77
STEPHEN		1416.5872	3500.4578	0.28	17.81
AUSTIN		2507.7033	6196.6602	0.49	31.52
PITS		8.3731	20.6904	0.00	0.11
WATER		306.1139	756.4228	0.06	3.85
SUMTER		26.5599	65.6308	0.01	0.33
LEWISVILLE		196.1830	484.7780	0.04	2.47
GULLIED LAND		481.6793	1190.2535	0.09	6.05
BRACKETT		43.4862	107.4565	0.01	0.55
EDDY		1869.9059	4620.6310	0.37	23.50

Table 8 - 3

		Area [ha]	Area [acres]	%Wat.Area	%Sub.Area
SUBBASIN #	7	6476.5728	16003.9352	1.28	
LANDUSE:					
Residential-High Density -->	URHD	0.0900	0.2224	0.00	0.00
Range-Brush -->	RNGB	45.4544	112.3200	0.01	0.70
Pasture -->	PAST	2574.9676	6362.8737	0.51	39.76
Range-Grasses -->	RNGE	176.5970	436.3800	0.03	2.73
Water -->	WATR	526.6406	1301.3554	0.10	8.13
Wetlands-Forested -->	WETF	67.4165	166.5895	0.01	1.04
Wetlands-Mixed -->	WETL	11.3411	28.0244	0.00	0.18
Commercial -->	UCOM	41.4040	102.3113	0.01	0.64
RC 319 Row Crop -->	RCAG	109.3605	270.2353	0.02	1.69
RC 319 Crop2Past -->	RCAP	17.4617	43.1487	0.00	0.27
Forest-Deciduous -->	FRSD	538.8818	1331.6039	0.11	8.32
Forest-Evergreen -->	FRSE	53.6452	132.5599	0.01	0.83
RC 319 Past -->	RCPA	4.7705	11.7880	0.00	0.07
Agricultural Land-Close-grown -->	AGRC	0.9901	2.4466	0.00	0.02
Residential-Low Density -->	URLD	5.1305	12.6777	0.00	0.08
Agricultural Land-Row Crops -->	AGRR	2298.1910	5678.9449	0.45	35.48
RC 319 Range Grass -->	RCRA	4.2304	10.4535	0.00	0.07
SOIL:					
	BURLESON	274.6164	678.5909	0.05	4.24
	TRINITY	975.9639	2411.6555	0.19	15.07
	HOUSTON	3755.6111	9280.3029	0.74	57.99
	STEPHEN	3.5103	8.6742	0.00	0.05
	HUNT	7.0207	17.3484	0.00	0.11
	AUSTIN	37.8036	93.4147	0.01	0.58
	PITS	9.3609	23.1313	0.00	0.14
	WATER	286.8576	708.8394	0.06	4.43
	SUMTER	384.4270	949.9383	0.08	5.94
	LEWISVILLE	708.9982	1751.9699	0.14	10.95
	GULLIED LAND	30.4229	75.1766	0.01	0.47
	EDDY	1.9802	4.8931	0.00	0.03

		Area [ha]	Area [acres]	%Wat.Area	%Sub.Area
SUBBASIN #	8	8065.0712	19929.1942	1.59	

Table 8 - 4

LANDUSE:

Residential-High Density -->	URHD	54.5405	134.7724	0.01	0.68
Range-Brush -->	RNGB	45.9005	113.4223	0.01	0.57
Pasture -->	PAST	4014.6704	9920.4513	0.79	49.78
Range-Grasses -->	RNGE	674.1068	1665.7516	0.13	8.36
Water -->	WATR	283.0528	699.4377	0.06	3.51
Wetlands-Forested -->	WETF	5.8501	14.4558	0.00	0.07
Wetlands-Mixed -->	WETL	3.1500	7.7839	0.00	0.04
Commercial -->	UCOM	119.9712	296.4549	0.02	1.49
RC 319 Row Crop -->	RCAG	35.4604	87.6243	0.01	0.44
RC 319 Crop2Past -->	RCAP	79.6508	196.8211	0.02	0.99
Forest-Deciduous -->	FRSD	226.4423	559.5502	0.04	2.81
Forest-Evergreen -->	FRSE	128.5213	317.5825	0.03	1.59
RC 319 Past -->	RCPA	4.5000	11.1198	0.00	0.06
Forest-Mixed -->	FRST	46.1705	114.0895	0.01	0.57
Agricultural Land-Close-grown -->	AGRC	97.6510	241.3005	0.02	1.21
Residential-Low Density -->	URLD	267.4827	660.9631	0.05	3.32
Agricultural Land-Row Crops -->	AGRR	1977.9499	4887.6131	0.39	24.52

SOIL:

BURLESON	465.5747	1150.4583	0.09	5.77
TRINITY	460.1746	1137.1145	0.09	5.71
DAMS	1.7100	4.2255	0.00	0.02
HOUSTON	5894.7893	14566.3192	1.16	73.09
STEPHEN	98.1910	242.6348	0.02	1.22
HUNT	632.7064	1563.4491	0.12	7.85
AUSTIN	176.8518	437.0096	0.03	2.19
WATER	101.7010	251.3083	0.02	1.26
WILSON	147.7815	365.1754	0.03	1.83
LEWISVILLE	57.8706	143.0011	0.01	0.72
GULLIED LAND	27.6303	68.2758	0.01	0.34
EDDY	0.0900	0.2224	0.00	0.00

SUBBASIN # 67	4966.9144	12273.4938	0.98	

LANDUSE:

Residential-High Density -->	URHD	83.1795	205.5407	0.02	1.67
Range-Brush -->	RNGB	22.0552	54.4994	0.00	0.44
Pasture -->	PAST	1792.2302	4428.6903	0.35	36.08
Range-Grasses -->	RNGE	151.7756	375.0450	0.03	3.06
Water -->	WATR	1258.3150	3109.3593	0.25	25.33

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Wetlands-Forested --> WETF	2.7006	6.6734	0.00	0.05
Wetlands-Mixed --> WETL	12.0628	29.8079	0.00	0.24
Commercial --> UCOM	121.6185	300.5254	0.02	2.45
RC 319 Row Crop --> RCAG	25.7460	63.6197	0.01	0.52
RC 319 Crop2Past --> RCAP	14.1333	34.9241	0.00	0.28
Forest-Deciduous --> FRSD	480.8027	1188.0875	0.09	9.68
Forest-Evergreen --> FRSE	102.4440	253.1443	0.02	2.06
RC 319 Past --> RCPA	34.6581	85.6420	0.01	0.70
Forest-Mixed --> FRST	5.0412	12.4570	0.00	0.10
Agricultural Land-Close-grown --> AGRC	8.8221	21.7998	0.00	0.18
Residential-Low Density --> URLD	183.8231	454.2361	0.04	3.70
Agricultural Land-Row Crops --> AGRR	667.5065	1649.4419	0.13	13.44
SOIL:				
BURLESON	172.2104	425.5404	0.03	3.47
TRINITY	125.7595	310.7580	0.02	2.53
DAMS	4.2310	10.4550	0.00	0.09
SLICKSPOTS	9.7223	24.0242	0.00	0.20
HOUSTON	2204.9769	5448.6082	0.43	44.39
HUNT	126.1196	311.6478	0.02	2.54
PITS	1.3503	3.3367	0.00	0.03
CROCKETT	33.7579	83.4175	0.01	0.68
WATER	1068.8206	2641.1091	0.21	21.52
WILSON	1056.2176	2609.9665	0.21	21.27
SUMTER	9.9023	24.4691	0.00	0.20
LEWISVILLE	153.8461	380.1613	0.03	3.10

Table 8 - 6

Appendix Table 9. Predicted mean annual atrazine and sediment loading at the farm level where conservation practices were implemented, Bardwell Reservoir watershed, 1974 through 2003. The subbasins in this table are those that contained conservation practices implemented under the 319(h) project. See Figure 10 for a chart of this data.

	Atrazine Loading (mg)			Sediment Loading (m. tons)		
Subbasin	Scenario I Current Conditions	Scenario II Treated Conditions	AT reduction % I vs. II	Scenario I Current Conditions	Scenario II Treated Conditions	Sediment reduction % I vs. II
4	1,673,705	105,987	94%	330.76	27.28	92%
7	4,473,760	938,393	79%	709.99	132.11	81%
8	6,797,635	502,153	93%	1,301.33	90.63	93%
67	1,735,995	246,462	86%	281.14	45.83	84%

Appendix Table 10. Predicted mean annual atrazine loading at the subbasin level for each modeling scenario, Bardwell Reservoir watershed, 1974 through 2003. See Figure 11 for a chart of part of this data.

			Atrazine Loading (mg)				
Subbasin	Area (ha)	Cropland Fraction	Scenario I Current Cond.	Scenario II 319(h) BMP Treated	Scenario III All Treated	Reduction (%) I vs. II	Reduction (%) I vs. III
3	17,685.00	0.10	61,592,772	61,592,772	12,341,746	0%	80%
4	7,955.60	0.23	61,765,001	60,197,283	12,482,105	3%	80%
7	6,476.60	0.39	111,245,100	107,709,733	24,477,033	3%	78%
8	8,065.20	0.28	98,209,935	91,914,453	20,285,846	6%	79%
67	4,966.80	0.15	30,423,915	28,934,382	6,447,061	5%	79%

Appendix Table 11. Predicted mean annual sediment loading at the subbasin level for each modeling scenario, Bardwell Reservoir watershed, 1974 through 2003. See Figure 12 for a chart of part of this data.

Subbasin	Area (ha)	Cropland Fraction	Sediment Loading (m. tons/ha) Scenario I Current Cond.	Scenario II 319(h) BMP Treated	Scenario III All Treated	Reduction (%) I vs. II	Reduction (%) I vs. III
3	17,685.00	0.10	0.98	0.98	0.29	0%	70%
4	7,955.60	0.23	1.92	1.88	0.27	2%	86%
7	6,476.60	0.39	2.89	2.80	0.29	3%	90%
8	8,065.20	0.28	2.16	2.00	0.24	7%	89%
67	4,966.80	0.15	1.78	1.73	0.25	3%	86%

Appendix Table 12. Predicted mean annual atrazine loading at the watershed level for each modeling scenario, Bardwell Reservoir watershed, 1974 through 2003. See Figure 13 for a chart of part of this data.

Subbasin	Area (ha)	Cropland Fraction	Atrazine Loading (mg) Scenario I Current Cond.	Scenario II 319(h) BMP Treated	Scenario III All Treated	Reduction (%) I vs. II	Reduction (%) I vs. III
3	17,685.00	0.10	54,840,000	54,930,000	11,080,000	0%	80%
4	7,955.60	0.23	56,710,000	55,250,000	11,500,000	3%	80%
7	6,476.60	0.39	163,700,000	160,100,000	35,060,000	2%	79%
8	8,065.20	0.28	82,230,000	76,890,000	17,180,000	6%	79%
67	4,966.80	0.15	263,400,000	253,400,000	56,010,000	4%	79%

Appendix Table 13. Predicted mean annual sediment loading at the watershed level for each modeling scenario, Bardwell Reservoir watershed, 1974 through 2003. See Figure 14 for a chart of part of this data.

Subbasin	Area (ha)	Cropland Fraction	Sediment Loading (m. tons) Scenario I Current Cond.	Scenario II 319(h) BMP Treated	Scenario III All Treated	Reduction (%) I vs. II	Reduction (%) I vs. III
3	17,685.00	0.10	13,330	13,280	3,781	0%	72%
4	7,955.60	0.23	14,630	14,330	1,995	2%	86%
7	6,476.60	0.39	21,940	21,520	4,128	2%	81%
8	8,065.20	0.28	10,440	9,631	1,117	8%	89%
67	4,966.80	0.15	39,760	38,300	6,314	4%	84%