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Assessing the Efficiency of Alternative Best Management Practices to Reduce Nonpoint Source Pollution in the Broiler Production Region of Louisiana

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Abstract

We demonstrate the impact of choosing suites of best management practices (BMPs) to reduce nitrogen, phosphorus and sediment load in Chenier Creek water segment located within the Baouf watershed, Louisiana. Simulation outputs generated from MAPSHED are used to generate regression coefficients and marginal effects which are then used in the optimization model. Results indicated that agricultural land retirement can meet up to 35% goal in phosphorus reduction with $840132. With restriction on ag land conversion to 10% available row crop area, it was found three different BMPs can reduce up to 20% phosphorus compared to no BMP adoption scenario. This goal in reduction of phosphorus can also bring down the nitrogen and sediment pollution by 5 and 33 percents, respectively. Careful modeling of different BMPs and development of optimization model can help to meet the water quality goal in Louisiana.

Keywords: Best management practices, cost, optimization, water quality

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1. Introduction

Best management practices are suggested methods to improve water quality emanating from diffused sources. In economics, most of the studies on best management practices are about whether farmers adopt or do not adopt a given best management practice. We studied best management recommended for a region and see if those are the best suite of practices to reduce pollutant loads at the minimum cost. We combined the existing knowledge on adoption of best management in a region, see how much pollutants can be reduced from the practices supported in the region and how the combination of those practices compared against what has been promoted for farmers to adopt. We demonstrate this for the case of Cheneire Creek Water Segment located in the broiler production region of Louisiana.

River flow quality has become a major concern in the United States and elsewhere due to their effect on the environment. The clean water act (CWA) of 1972 laid out several programs to improve water quality; however, according to the Environmental Protection Agency (EPA) over 40% of assessed waterways do not achieve minimum requirements for their intended use (USEPA 2008).

Under the National Pollution Discharge Elimination System (NPDES) program, all point source (PS) polluters, such as municipal and industrial waste

facilities, are required to obtain permits, which are managed by the EPA and state environmental agencies. The CWA requires states to determine a Total Maximum Daily Load (TMDL) for each watershed that does not meet its intended use. The NPDES program is widely recognized as effectively reducing point source pollution and restoring waterways to their designated uses throughout the United States. However, due to their diffuse nature, nonpoint source (NPS) polluters, which are exemplified by emissions from mobile sources, leaching or runoff from agricultural lands and runoff from residential areas or construction sites, remain an unresolved cause of water quality problems, despite the determination of TMDLs (USEPA 2003). Agricultural runoff has been found to be the largest single contributor to nonpoint source pollution (USEPA 2000).

A diverse range of structural and management methods known as best management practices (BMPs) are used to control effluent runoff. Implementation of BMPs at critical locations throughout various watersheds have been shown to improve water quality in waterways compromised by NPS (Zhen et al. 2004). However, BMPs are being implemented without sufficient studies at the farm or watershed level to determine which combination of BMPs is most effective (NRCS 2004).

The cost of implementation and willingness to adopt are important factors when considering BMP implementation. Farmers or agricultural producers, who are not likely to adopt expensive BMPs, often absorb implementation costs. Moreover, farm managers are interested in maximizing profits while society and

environmental institutions are focused on improving water quality. These public groups are not likely to be concerned with pollution reduction costs unless they cause an increase in taxation, an increase in consumer costs or are shown to be a misuse of public funds. However, achieving the least cost solution is in concert with both public and private interests (Gitau et al. 2004).

The key challenge of structuring an effective BMP program targeted at reducing NPS pollution is achieving a maximum reduction in pollutant loading at a minimum cost (Giri et al. 2012). Selection and placement of BMPs have been shown to be nearly 3 times more cost effective than targeting methods of specified pollutants (Arabi et al. 2006). Once BMPs have been implemented, pollutant reduction from that site can be satisfactorily measured overtime. However, pre-determining the impact of BMPs on a specific site is generally more complicated (Gitau et al. 2004).

Over the past several years a multitude of models and simulation programs have been developed to predict the best combination of BMPs in a given watershed. Modeling techniques include linear programming, Monte Carlo simulation, scatter search and sorted genetic algorithms. Geographic information system (GIS) based simulation software includes SWAT, Mapshed, PRedICT, SWMM and HSPF. Arabi et al (2006) used SWAT and a GA to optimize BMPs for watersheds in Indiana. Mishra et al. (2007) used SWAT to identify areas of high sediment yield and determine structural designs to minimize them. Kaini et al. (2012) use a single objective

optimal control model in concert with SWAT and a genetic algorithm to determine optimal BMP placement for the Silver Creek watershed in Illinois.

In this study we will utilize Mapshed simulation software in conjunction with a multi-objective optimization model and a nondominated genetic sorted algorithm to determine a cost effective BMP strategy for the study area. Multiple studies have utilized Mapshed or its predecessor (AVGWLF) in concert with various optimization techniques to determine optimal BMP placement (McGarety el al. 2005; Markel et al. 2007; Georgas et al. 2009). These methods can be useful tools in reducing nutrient (nitrogen and phosphorus) as well as sediment loads on waterways and helping them reach their predetermined TMDL goals.

2. Literature Review

2.1 Water Policy: A brief history.

The primary legislation governing water pollution in the United States is the Clean Water Act (CWA) initially passed in 1948 (Copeland, 2007). The Cuyahoga river fire of 1969 was cause for water policy change and lead to a major revision of the CWA in 1972 (Freeman 2000). Water quality issues were also a significant motivation for the establishment of the Environmental Protection Agency (EPA) in 1970 (Fisher-Vanden and Olmstead 2013). The goals outlined in the CWA were: 1) the attainment of fishable and swimmable waters by July 1, 1983 and 2) the elimination of all discharges of pollutants into navigable waterways (Freeman 2000). These deadlines were not met in many areas of the country (King 2005) and have been postponed through several amendments.

The CWA was revised several times throughout the 1970s and 1980s. The first major revision of the CWA occurred in 1972 as mentioned above. The 1972 revisions substantially increased federal subsidies, established new goals and deadlines for pollution removal and established new regulation and enforcement methods for municipal waste treatment plants. The 1972 revisions also shifted responsibilities for issuing water quality permits to federal authorities. The CWA was subsequently updated in 1977. The 1977 act extended some deadlines established in the 1972 provisions as well as making clearer delineations between conventional pollutants and toxic water pollutants. The CWA amendments of 1970s deal largely with PS pollution; however, they do have some minor provisions for NPS. This section calls for the establishment of area-wide waste treatment management plans (Freeman 2000).

The WQA of 1987 amended the CWA to address NPS. It establishes that states are responsible for addressing NPS problems within their borders. It stipulates that states must identify NPS sources, establish water quality goals and implement management practices to meet these goals. The 1987 amendment also authorizes the EPA to provide grants to assist with the implementation of BMPs approved by the EPA.

The WQA was the last major amendment to the CWA; however, there have been a few important policy programs related to agricultural runoff since that time. The Rural Clean Water Program (RCWP) was conducted from 1980 to 1990. The programs stated goals were to 1) improve water quality in the project area in the

most cost effective manner 2) Assist farmers in reducing NPS water pollutants in order to meet water quality goals 3) Develop and test programs, policies and procedures for the control of agricultural NPS pollution. The program funded twenty-one test projects across the U.S. which implemented BMPs and monitored their effectiveness. The RCWP helped improve targeting and use of BMPs in the U.S.

The 2002 Farm Bill Conservation Provisions (FBCP) provided technical and financial assistance to farmers interested in conservation and improvement of natural resources. The bill introduced or updated several funding and incentive programs for BMP implementation. The FBCP has an array of programs that target different BMPs and conservation practices and provide assistance through, incentive payment and cost share programs (EPA 2003).

2.2 BMP Implementation

A BMP is defined as: a practice or combination of practices that are determined **(**by state or designated area-wide planning agency**)** through problem assessment, examination of alternative practices, and appropriate public participation to be the most effective, practicable **(**including technological, economic, and institutional considerations**)** means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals **(**U.S. Department of Agriculture Forest Service 1980**)**. More practically, BMPs are a range of structural and management practices used to minimize pollutant impacts on nearby waterways (Kaini et al. 2012). They have been

determined to minimize the influence of confined animal operations and pastures on nearby watersheds (Zhen et al. 2004).

Due to the nature of NPS pollution, which are washed into nearby waterways during storms or snowmelts, BMPs are often designed to anticipate pollutant flows from runoff generating events. Minimum tillage to reduce agricultural field disturbance, limits on impervious sources in urban environments, and filter strips at the edge of agricultural fields designed to reduce sediment and nutrient runoff are all examples of anticipatory BMPs. Other available agricultural BMPs include grassed waterways, barnyard runoff control, contour plowing, reduced tillage, manure storage, and controlled fertilizer application (Ice 2004).

The five best management practices considered in this study are cover crops, conservation tillage, conservation plans, nutrient management and agland retirement (also known as a conservation reserve program). Cover crops are vegetation planted to provide seasonal soil coverage when soil would otherwise be bare. Conservation tillage refers to the practice of leaving crop residue on a field before and after planting the next crop to reduce erosion. Conservation planning involves assessing a farm's natural resource opportunities and accessing challenges and identifying appropriate conservation practices. Nutrient management refers to the practice of using this resource as effectively as possible while minimizing environmental impacts. Agland retirement refers to the practice of setting aside cropland for a certain time period and planting covers that reduce soil erosion and promote water quality (MDA 2013).

Voluntary policies, incentive payments and cost sharing methods focused on BMP adoption have been the primary approaches used to reduce NPS pollution. BMPs are often perceived as having economic disadvantages despite the belief of the USDA that many environmentally friendly practices increase farm profitability (DeVuyst and Ipe 1999). The literature concludes that likelihood of voluntary adoption is low (Cooper and Keim 1996; Rahelizatovo 2004; Paudel et al. 2008;) and that incentives and cost sharing are necessary to improve BMP adoption among farmers.

Involuntary control methods, which force the farmer to adopt less polluting practices through higher input costs or direct regulation, are also available. To raise input costs taxes are imposed on inputs with higher negative characteristics (such as fertilizers that contain more nitrogen or phosphorus). Several studies (Griffin and Bromly 1982, Stevens 1988, Dinar et al 1989, Shortle and Abler 1994 and Horan et al. 1998) that have found that taxing inputs which contain large amount of undesirable nutrients while subsidizing those that do not contain these nutrients to be theoretically effective. However, in a 2002 study Shortle and Horan find that, after examining the fertilizer market, incentives would need to be firm specific. They further determine that gathering the information to design firm specific incentives is extremely costly and impractical.

Some economists have suggested that it may be possible to effectively control the inputs to NPS pollution through Command and Control (CAC) methods. They point to the success of CAC in the reduction of pollution emissions from power

plants (Rosenbaum, 2005). However these approaches have gone largely untested in the United States and have not met with long lasting success elsewhere in the world (Dowd el al, 2008).

2.3 The role of spatial optimization and GIS in BMP implementation

Cost effective NPS reduction in agriculture relies upon the correct selection and placement of BMPs within a given watershed. Factors such as land use, soil variety, topography and interaction with other BMPs all interact to determine the effectiveness of installed BMPs. Because these factors vary throughout different watersheds, site specific BMPs are required to reduce NPS runoff in the most efficient manner. To determine which combination of BMPs is best for a given watershed alternative BMP scenarios must be considered (Veith 2004).

The use of GIS based runoff simulation modeling coupled with an optimization algorithm to estimate the placement of BMPs for nutrient reduction has been explored extensively (Gitau et al. 2004; Veith et al. 2004; Kaini et al. 2012; Alminagorta et al. 2012; Shen et al. 2013). Simulation based modeling incorporates scientific knowledge to quantify site and BMP specific response. Optimization allows for variation in spatial factors across a multitude of variables and circumstances. Through the use of optimization algorithms BMP interaction as well as a range of site dependent characteristics can be assessed (Veith 2004).

Arcview's GIS software provides graphical support for these the simulation models and extracts data from digital maps. GIS software also prepares data in the form utilized by most simulation software (Abbaspour et al. 2007). The use of GIS

software has become relatively widespread based on the inherent advantages of manipulating spatial data in GIS. The Mapshed simulation software manipulates GIS shape and grid files as well as other non-spatial data to estimate NPS runoff (Evans and Corradini 2012).

The use of optimization in combination with an NPS pollutant runoff model has been show to improve BMP cost-effectiveness. Ancev (2003) determined that simulation recommended BMP changes reduced phosphorus loadings in Eucha-Spavinaw watershed near Tulsa, OK. Srivastava et al. (2002) demonstrated a 56% reduction in pollutant loading and a 109% increase in net profits through the use of a simulation model with an optimization algorithm. Veith et al. (2003) used a GIS model combined with a Genetic Algorithm (GA) to reduce NPS pollutant flows in a 1,014-ha watershed in Virginia.

The term model refers to a set of equations or algorithms that are used to simulate a physical system. A multitude of watershed simulation models are available to water quality researchers. Models vary in their complexity and assessment capabilities. More complex models require a larger amount data and make fewer assumptions. It is generally recommended that the simplest model that will sufficiently identify BMP placement be used. However, the model must be capable of quantifying the potential response of the given watershed to site-specific changes. In an EPA sponsored study, Shoemaker et al. (2005) provide a comprehensive overview of more than 65 watershed modeling programs providing

detailed information about model type, level of complexity and water quality factors assessed by each model.

3. Data

3.1 Study area

For this study we chose to investigate agricultural runoff from the Louisiana Broiler production region. This is a region in Northwestern Louisiana that has a high concentration of broiler production. This area includes Bienville, Claiborne, Jackson, Lincoln, Natchitoches, Ouachiata, Red River, Sabine, Union, Vernon, Webster and Winn counties. Due to the structure of the underlying watershed data on Bossier, Caldwell, De Soto, Grant and Rapides counties were also included. The watersheds in this region feed the Mississippi river. This study area was chosen because it has several watersheds on the Louisiana DEQ's list of priority watersheds and has not yet been comprehensively studied with respect to BMPs (LDEQ 2013).

Within this area we chose to comprehensively study one watershed on the LDEQ's list of priority watersheds. From this list we selected the Lower Ouachita subbasin because it lies entirely in the study area. Inside this watershed we chose to focus on Cheniere Creek watershed. This water body is listed as impaired by the EPA and lies entirely within the Louisiana broiler region (EPA 2013).

The Cheniere Creek watershed is primarily located in Ouchita County with a small portion in Jackson County. It covers an area of 38,800 Hectares and centers

around Cheniere Creek, which flows between the Ouchita River and Cheniere Creek. The crop production area in this watershed measures 5492 hectares.

3.2 GIS Layers

Mapshed, the GIS based watershed modeling tool used to simulate watershed characteristics, requires several data layers to estimate nonpoint source loading and BMP effectiveness on a given watershed. These GIS layers were collected from a number of sources and transformed in order to meet the specifications of the program.

Several shape (or vector) and grid layers are required by Mapshed. The Basin layer shows the boundaries of one or more watersheds where the modeling is being performed. This layer is acquired from the Louisiana water mapping service (http://sslmaps.tamu.edu/website/srwp/Louisiana/viewer.htm) and has been clipped so that only the portions of watersheds in Louisiana are assessed. The county layer is a polygon layer, which shows the parish boundaries and is not used to perform any calculations. The land use/cover layer is a grid layer, which uses 16 distinct land use/cover types to help estimate nutrient flows throughout the watershed. These layers were attainted from the Louisiana GIS CD (http://atlas.lsu.edu). The stream layer contains line features of stream segments for the study area. The stream layer was acquired from the USGS. The surface elevation (topography) layer is a grid layer which is used to calculate slope-related data used in the model. It has been obtained from the Louisiana state wide GIS server (\\gid-store.lsu.edu\gis). The physiographic province layer contains areas

with different hydrolic parameters. These parameters are warm rain erosion rate, cool rain erosion rate and groundwater recession rate. This layer was digitized from USGS map of physiographic regions throughout Louisiana. The layers listed above were all obtained in the format required by Mapshed. However, a few layers were obtained in a format not compatible with Mapshed and were manipulated in order to meet with Mapshed formatting requirements.

The animal feeding operation (AFO) layer contains information on the location of farms as well as animal populations by type. Point shape files contain the location of poultry houses and dairy farms. The poultry houses were digitized from a DOQQ file provided as a base map in ArcGIS 10.3. The dairy farm locations were geocoded based on physical addresses obtained from the Louisiana Dairy Refundable Tax Credit Program. Animal totals were obtained from the LSU Agricultural Summary's five year summary, which provides agricultural data for the years 2006-2010. The summary provides yearly totals, which are then averaged over 5 years. Animal totals are averaged over a five year period to minimize the effect of single year market fluctuations which may drastically alter the number of animals in a county for an individual year.

The soil layer contains information on various soil properties such as hydraulic group, erodibility factor and water holding capacity. The map of soil type and soil area was obtained from the Louisiana GIS CD. The hydraulic group, erodibility factor and water holding capacity were attainted from Louisiana state soil surveys (which contain soil information by parish). Soil areas often contain

more than one soil type. For each soil area the three soil properties listed above are calculated by multiplying the properties of the individual soils in the soil area by the percentage of each soil in the soil area. A soil grid layer, Soil Phosphorus (Soil-P), is used to estimate the phosphorus content of sediment runoff to nearby waterways. This layer was obtained from the soil lab at the LSU department of plant, environmental and soil sciences.

The weather layer contains point layers of the location of each individual watershed. In this study eight weather stations are included in the model. Each weather station is linked to a table which contains data on maximum and minimum temperatures as well as precipitation for that weather station as for the longest time period which data is available. If more than one weather station are within the watershed the mean daily temperature and precipitation is used. If no weather stations are within a watershed the mean of the two closest weather stations to that watersheds center are used. Data for this layer was obtained from the National Ocean and Atmospheric Administration's (NOAA) online climatic database (http://www.ncdc.noaa.gov/cdo-web/search). Mapshed requires that data be consecutive for every day of the year with no missing values. In cases where NOAA data contained missing values, estimates were made by averaging the previous and next day's totals. Temperature data was multiplied by .18 and then added to the number 32 [(temp*10*9/5)+32] to change tenths of degrees centigrade into degrees farenheight. Precipitation was divided by 254 to change tenths of a millimeter into inches [prcp/(2.54*100)].

Economic Method

Simulation outputs obtained from the MAPSHED program are used in economic optimization models. MAPSHED program was simulated for three situations – normal parameter values, parameter values at the 10% lower range and parameter values at the 10% upper range. Amounts of pollution load reduction under all BMPs with variation of area from 0 to 100% of available row crop areas are obtained. The load reduction coefficients obtained for each BMP under different land areas are regressed to obtain the load reduction coefficients. These load reduction coefficients are then used in the optimization model. The goal of the optimization model is to meet the desired level of phosphorus reduction in the watershed. Optimal combinations of best management practices are obtained under various phosphorus reduction goal and different value of the technical coefficients.

Results and Conclusions

Regression coefficients that serve as technical coefficients in the optimization model for each BMP are shown in Table 1. Results in Table 1 also show that agland retirement can meet 10% reduction in phosphorus loading goal in the water segment. This reduction constitutes 29% of the total farmland within the study area. The reduction of 10% phosphorus is also capable of reducing 6% nitrogen and 22% sediment in the watershed. Table 2 shows that if all the available land is

allowed to get retired; it will help to reduce 21% N, 35% P, and 77% phosphorus reduction in the study area. This will incur expenses of $840,166.

It is impractical to force all agricultural land to retire to improve water quality goal. Therefore, we restricted total ag land retirement area to 10% of existing farmland. Results from this study are shown in Table 3. Results show that three best management practices are selected in the optimal solution. Those BMPs are cover crops (BMP1), nutrient management (BMP6) and ag land retirement (BMP8). Majority of agricultural land will be practiced with cover crop, followed by agricultural land retirement and nutrient management. These BMPs are able to reduce 5, 20, and 33% loadings of N, P, and sediment in the study area water bodies. The cost of adopting these BMPs was $1,087,109.

Our preliminary results indicated that BMPs are able to reduce N, P and sediments in watershed. The choice of a particular BMP dictates the cost and pollutant load in the waterbodies. Overall societal benefit and cost should dictate the final choice of best management practices in a watershed.

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Table 1. Optimal combination of BMPs to meet the 10% reduction in phosphorus in the Chenier water segment

	BMP1	BMP2	BMP4	BMP6	BMP8		RHS
Minimize	203.15	74.1	2091	81.51	152.98		
Nitrogen	2.4866	0.686	0.4294	4.5349	14.8557	>=	0
Phosphors	1.6011	0.7045	0.3205	1.462	3.04	<=	16722.59
Sediments	0.7381	0.6327	0.3377	0	2.0035	<=	0
Landarea	1	1	1	1	1	<=	5492
Decision	0	0	0	0	1571.672		

Total cost of reduction: $240,434

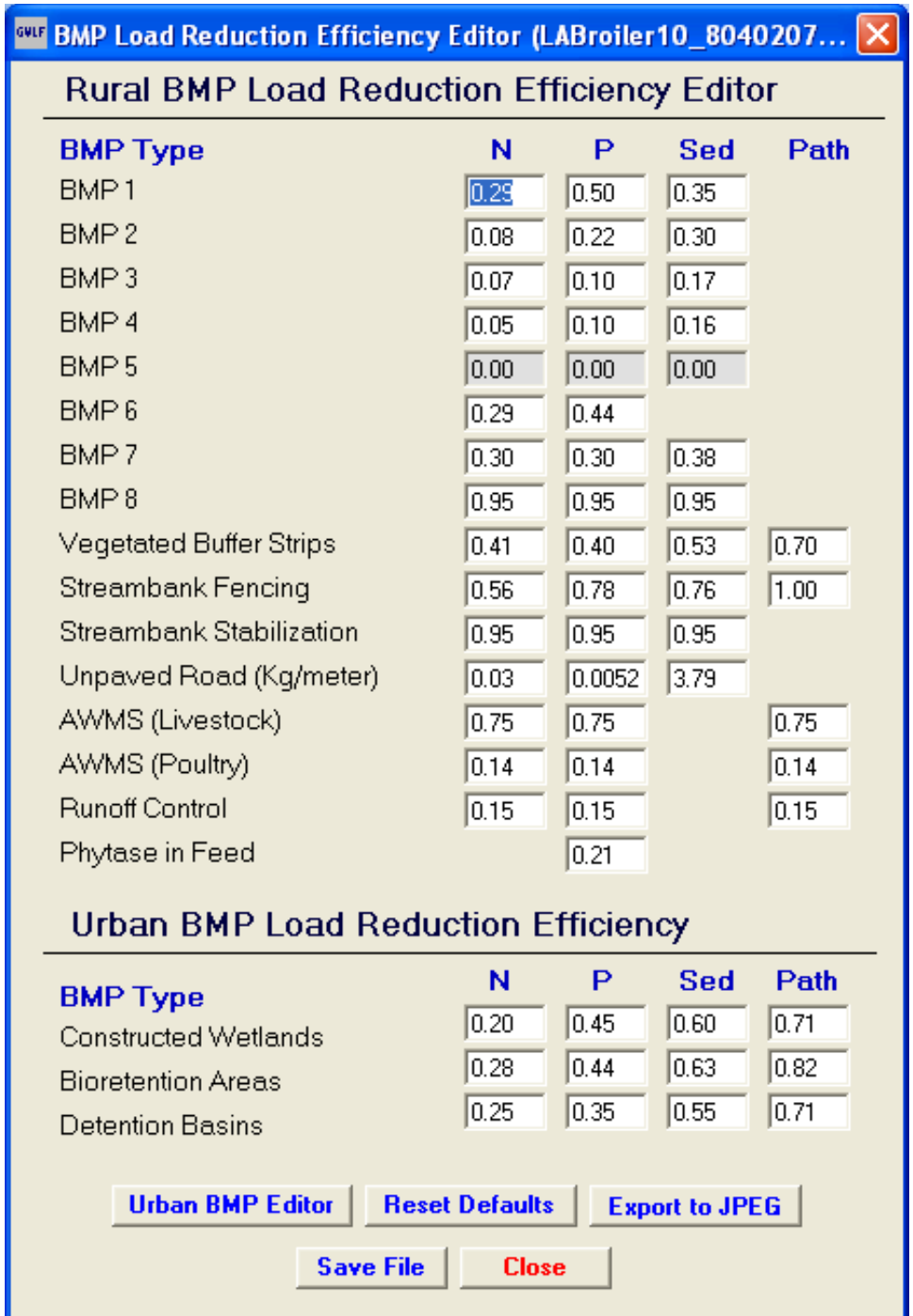
Note: BMP1 refers to cover crop management, BMP2 refers to conservation tillage, BMP4 refers to conservation plan, BMP6 refers to nutrient management and BMP8 refers to ag land retirement.

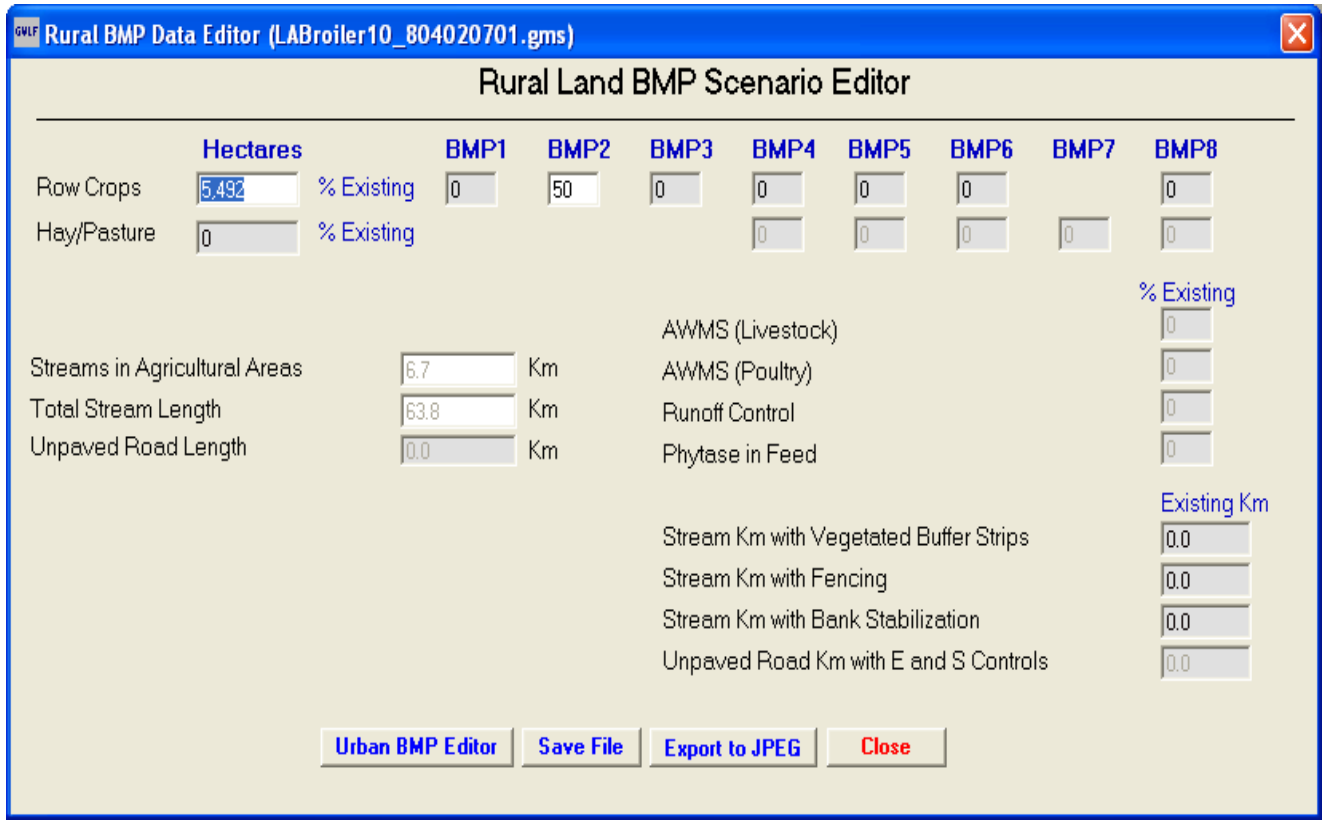
Table 2. Optimal combination of BMPs to meet 35% reduction in phosphorus in the Chenier creek water segment, Louisiana

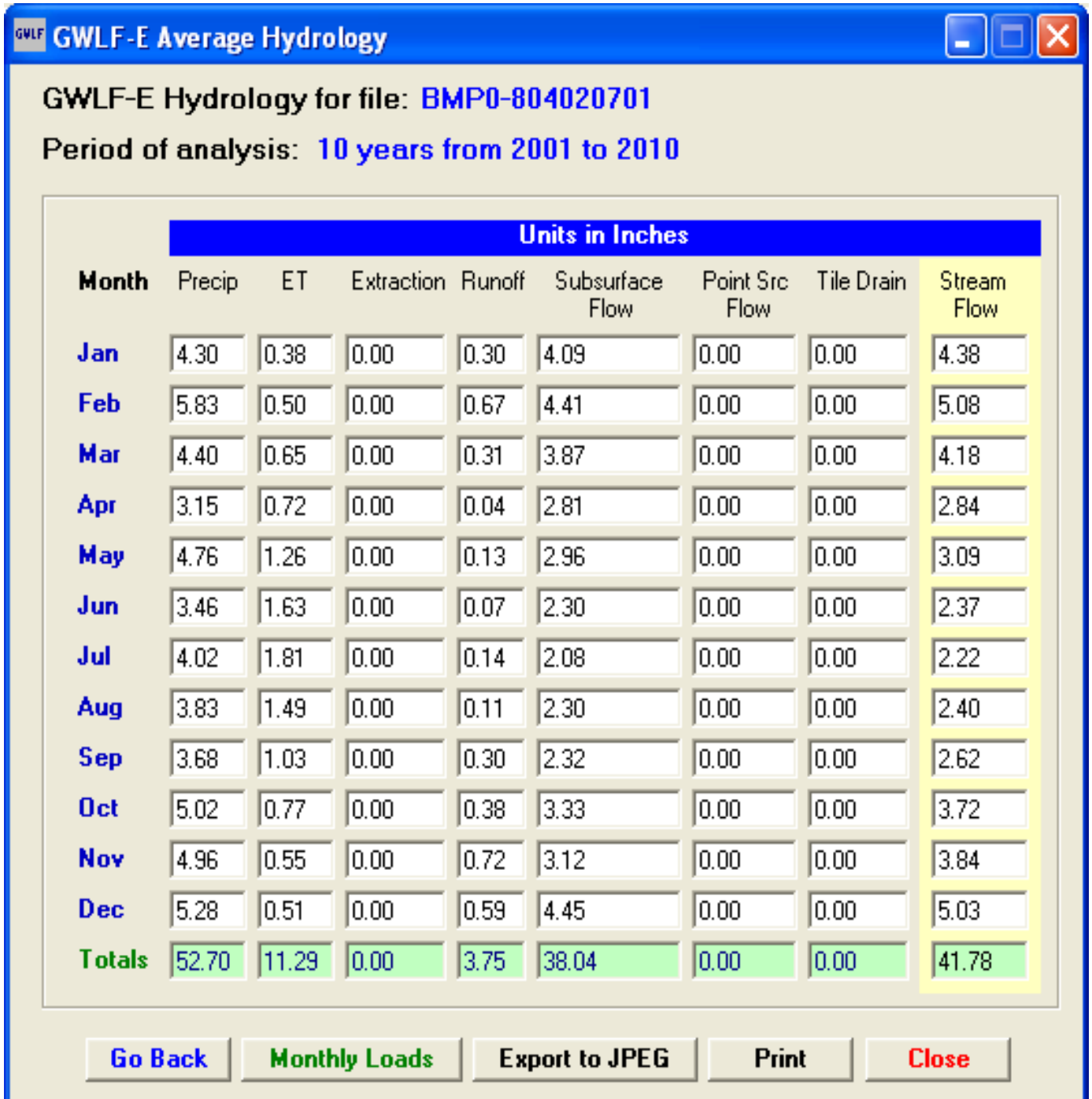
	BMP1	BMP2	BMP4	BMP6	BMP8		RHS	Slack
Minimize	203.15	74.1	2091	81.51	152.98			
Nitrogen	2.4866	0.686	0.4294	4.5349	14.8557	>	0	81584.18
Phosphors	1.6011	0.7045	0.3205	1.462	3.04	>	16695	16695
Sediments	0.7381	0.6327	0.3377	0	2.0035	>	0	11002.77
Landarea	1	1	1	1	1	<	5492	5491.776
Decision	0	0	0	0	5491.776	840131.9		

Table 3. Optimal combination of BMPs and their impacts on nutrient and sediment load in the Chenier creek water segment, Louisiana when agland conversion restriction is imposed

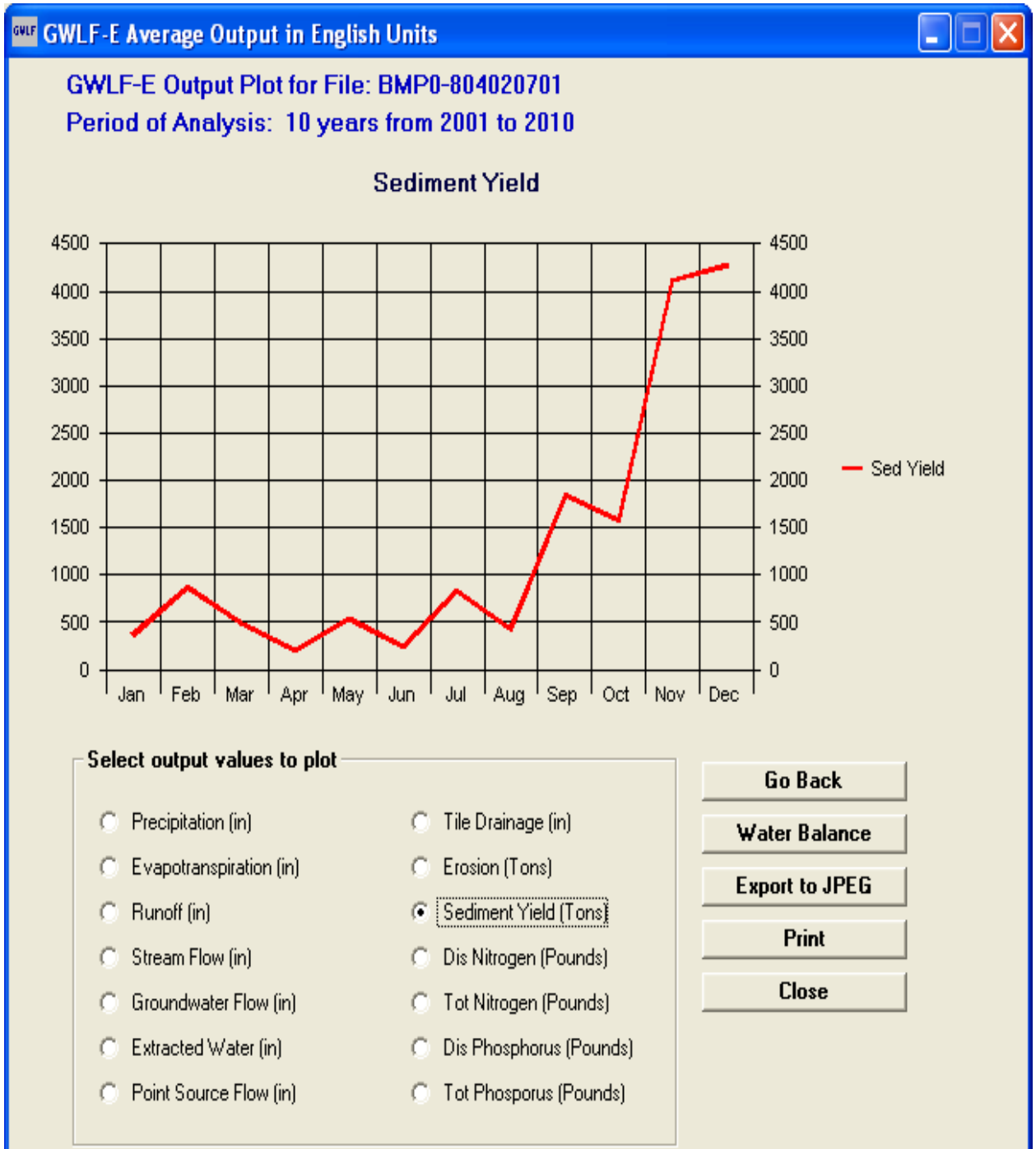
	BMP1	BMP2	BMP4	BMP6	BMP8		RHS	Slack
Minimize	203.15	74.1	2091	81.51	152.98			
Nitrogen	2.4866	0.686	0.4294	4.5349	14.8557	>	0	20464.67
Phosphors	1.6011	0.7045	0.3205	1.462	3.04	>	9582	9582
Sediments	0.7381	0.6327	0.3377	0	2.0035	>	0	4741.997
Landarea	1	1	1	1	1	<	5492	5492
CRP constraint					1	<	549	549
Decision	4934.393	0	0	8.607477	549	1087109		


BMP Load Reduction Efficiency Editor (LABroiler10_8040207...
Rural BMP Load Reduction Efficiency Editor
BMP Type N P Sed Path
BMP 1 0.29 0.50 0.35
BMP 2 0.08 0.22 0.30
BMP 3 0.07 0.10 0.17
BMP 4 0.05 0.10 0.16
BMP 5 0.00 0.00 0.00
BMP 6 0.29 0.44
BMP 7 0.30 0.30 0.38
BMP 8 0.95 0.95 0.95
Vegetated Buffer Strips 0.41 0.40 0.53 0.70
Streambank Fencing 0.56 0.78 0.76 1.00
Streambank Stabilization 0.95 0.95 0.95
Unpaved Road (Kg/meter) 0.03 0.0052 3.79
AWMS (Livestock) 0.75 0.75 0.75
AWMS (Poultry) 0.14 0.14 0.14
Runoff Control 0.15 0.15 0.15
Phytase in Feed 0.21
Urban BMP Load Reduction Efficiency
BMP Type N P Sed Path
Constructed Wetlands 0.20 0.45 0.60 0.71
Bioretention Areas 0.28 0.44 0.63 0.82
Detention Basins 0.25 0.35 0.55 0.71
Urban BMP Editor
Reset Defaults
Export to JPEG
Save File
Close


Rural BMP Data Editor (LABroiler10_804020701.gms)
Rural Land BMP Scenario Editor
Hectares
BMP1
BMP2
BMP3
BMP4
BMP5
BMP6
BMP7
BMP8
Row Crops
5,492
% Existing
0
50
0
0
0
0
0
Hay/Pasture
0
% Existing
0
0
0
0
0
Streams in Agricultural Areas
6.7
Km
Total Stream Length
63.8
Km
Unpaved Road Length
0.0
Km
% Existing
AWMS (Livestock)
0
AWMS (Poultry)
0
Runoff Control
0
Phytase in Feed
0
Existing Km
Stream Km with Vegetated Buffer Strips
0.0
Stream Km with Fencing
0.0
Stream Km with Bank Stabilization
0.0
Unpaved Road Km with E and S Controls
0.0
Urban BMP Editor
Save File
Export to JPEG
Close


GWLF-E Average Hydrology
GWLF-E Hydrology for file: BMP0-804020701
Period of analysis: 10 years from 2001 to 2010
Units in Inches
Month
Precip
ET
Extraction
Runoff
Subsurface Flow
Point Src Flow
Tile Drain
Stream Flow
Jan 4.30 0.38 0.00 0.30 4.09 0.00 0.00 4.38
Feb 5.83 0.50 0.00 0.67 4.41 0.00 0.00 5.08
Mar 4.40 0.65 0.00 0.31 3.87 0.00 0.00 4.18
Apr 3.15 0.72 0.00 0.04 2.81 0.00 0.00 2.84
May 4.76 1.26 0.00 0.13 2.96 0.00 0.00 3.09
Jun 3.46 1.63 0.00 0.07 2.30 0.00 0.00 2.37
Jul 4.02 1.81 0.00 0.14 2.08 0.00 0.00 2.22
Aug 3.83 1.49 0.00 0.11 2.30 0.00 0.00 2.40
Sep 3.68 1.03 0.00 0.30 2.32 0.00 0.00 2.62
Oct 5.02 0.77 0.00 0.38 3.33 0.00 0.00 3.72
Nov 4.96 0.55 0.00 0.72 3.12 0.00 0.00 3.84
Dec 5.28 0.51 0.00 0.59 4.45 0.00 0.00 5.03
Totals 52.70 11.29 0.00 3.75 38.04 0.00 0.00 41.78
Go Back
Monthly Loads
Export to JPEG
Print
Close

Baseline loadings by average monthly loading and total loading.

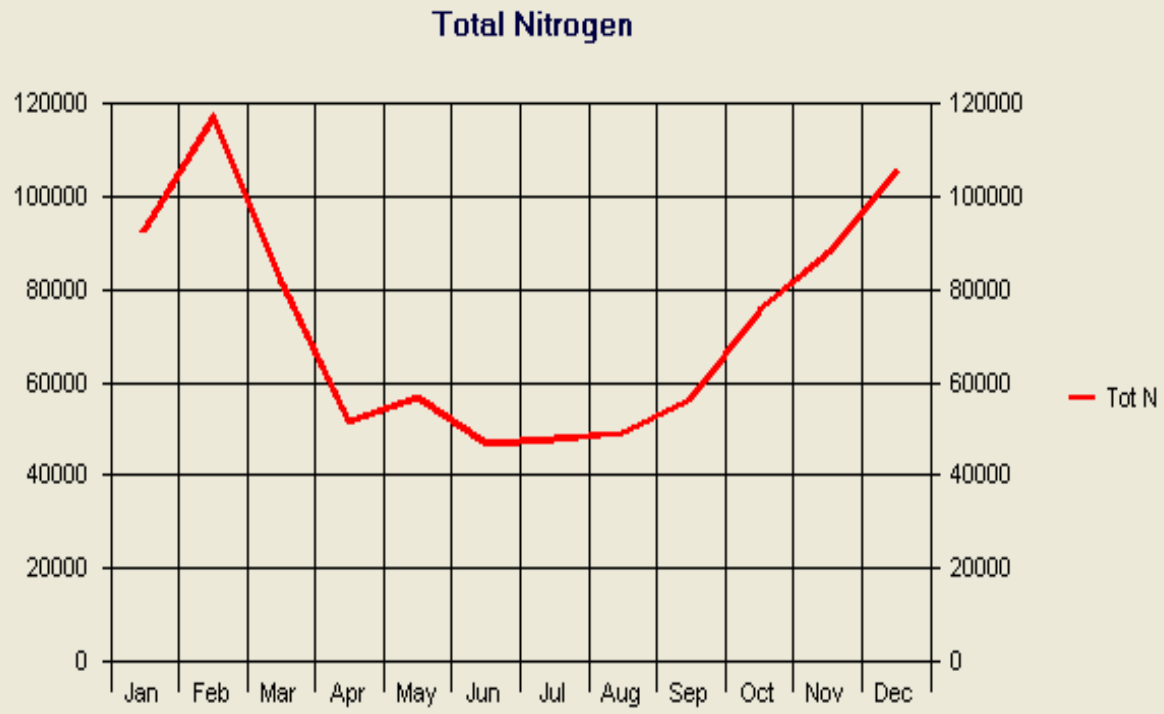

GWLF-E Average Output in English Units
GWLF-E Output Plot for File: BMP0-804020701
Period of Analysis: 10 years from 2001 to 2010
Sediment Yield
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Sed Yield
Select output values to plot
Precipitation (in)
Evapotranspiration (in)
Runoff (in)
Stream Flow (in)
Groundwater Flow (in)
Extracted Water (in)
Point Source Flow (in)
Tile Drainage (in)
Erosion (Tons)
Sediment Yield (Tons)
Dis Nitrogen (Pounds)
Tot Nitrogen (Pounds)
Dis Phosphorus (Pounds)
Tot Phosporus (Pounds)
Go Back
Water Balance
Export to JPEG
Print
Close

Baseline sediment loading by average monthly load.

GWLF-E Average Output in English Units

GWLF-E Output Plot for File: BMP0-804020701

Period of Analysis: 10 years from 2001 to 2010



Select output values to plot

- Precipitation (in)
- Evapotranspiration (in)
- Runoff (in)
- Stream Flow (in)
- Groundwater Flow (in)
- Extracted Water (in)
- Tile Drainage (in)
- Erosion (Tons)
- Sediment Yield (Tons)
- Dis Nitrogen (Pounds)
- Tot Nitrogen (Pounds)
- Dis Phosphorus (Pounds)

Go Back

Water Balance

Export to JPEG

Print

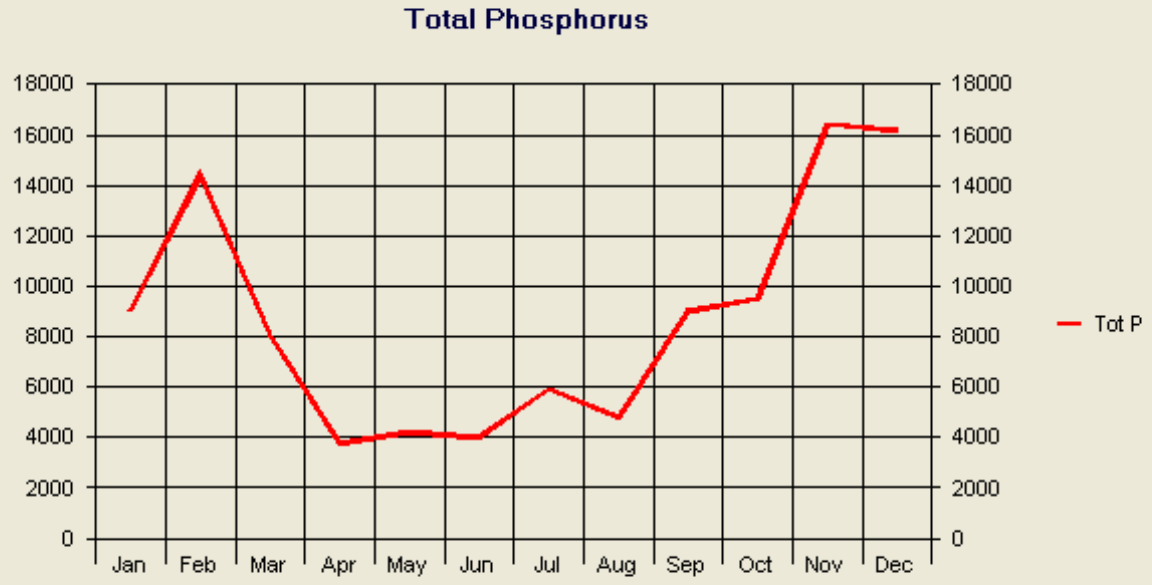
Close

Baseline nitrogen loading by average monthly load.

GWLF-E Average Output in English Units

GWLF-E Output Plot for File: BMP0-804020701

Period of Analysis: 10 years from 2001 to 2010



Select output values to plot

- Precipitation (in)
- Evapotranspiration (in)
- Runoff (in)
- Stream Flow (in)
- Groundwater Flow (in)
- Extracted Water (in)
- Point Source Flow (in)
- Tile Drainage (in)
- Erosion (Tons)
- Sediment Yield (Tons)
- Dis Nitrogen (Pounds)
- Tot Nitrogen (Pounds)
- Dis Phosphorus (Pounds)
- (•) Tot Phosporus (Pounds)

Go Back

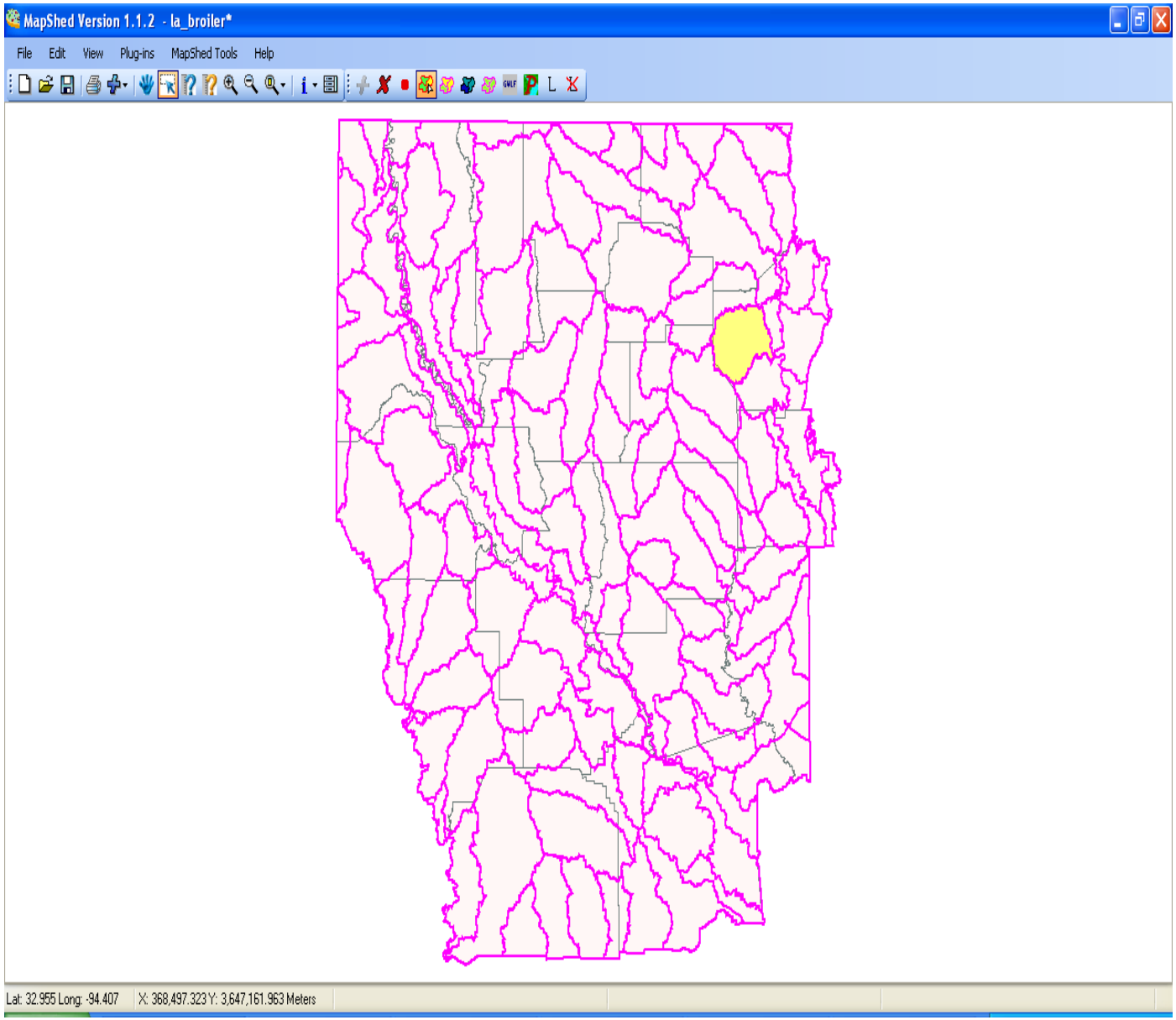
Water Balance

Export to JPEG

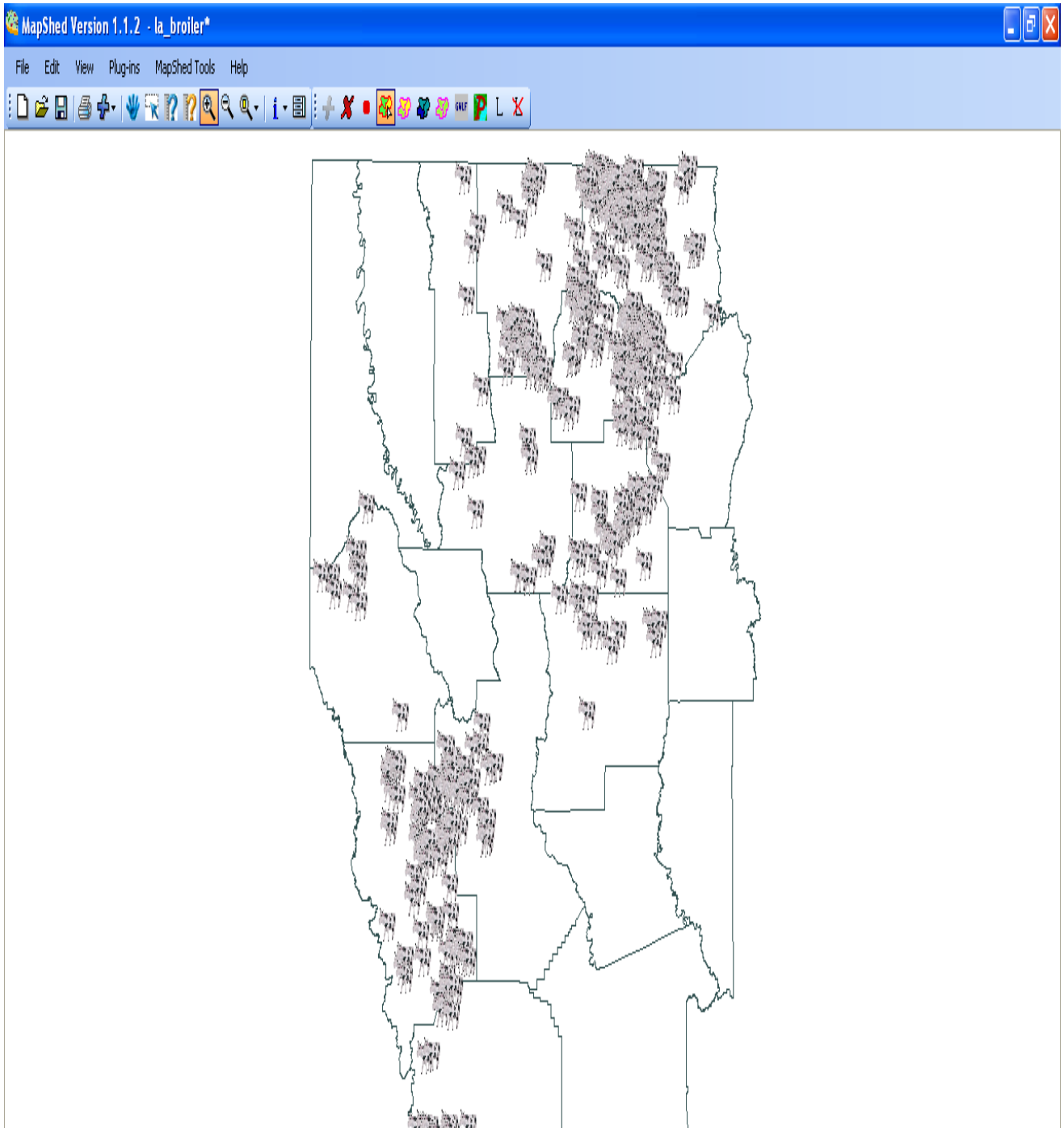
Print

Close

Baseline phosphorus loading by average monthly load.


MapShed Version 1.1.2 - la_broiler*
File
Edit
View
Plug-ins
MapShed Tools
Help
Lat: 32.955 Long: -94.407
X: 368,497.323 Y: 3,647,161.963 Meters

The study area with the focus watershed (Cheniere Creek) highlighted.


MapShed Version 1.1.2 - la_broiler*
File
Edit
View
Plug-ins
MapShed Tools
Help

Animal feeding operations in the Study Area