USDA Conservation Innovation Grants (CIG) Final Narrative Report
Mississippi Nutrient Tracking Tool and CEEOT Project (MS NTT)
NRCS Agreement number 69-3A75-11-224

"Application of a field-level assessment tool (Nutrient Trading Tool, NTT) to evaluate the water quality benefits and cost-effectiveness of farm conservation practices in Mississippi"

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1 EXECUTIVE SUMMARY

The World Resources Institute (WRI) and Texas Institute for Applied Environmental Research (TIAER) successfully completed a USDA Conservation Innovation Grants (CIG) project to apply USDA's field-level assessment tool, Nutrient Trading Tool (NTT) to Mississippi Delta conditions to evaluate the water quality benefits and cost-effectiveness of farm conservation practices to achieve nutrient reduction goals. For our field-level analyses with NTT, we linked the Farm Economic Model (FEM) with the Agricultural Policy/Environmental eXtender (APEX**)** model (Osei et al., 2008). While FEM has been linked to APEX in a macro-modeling system, this was the first time to do so within a user-friendly interface, such as NTT. For our watershed-level analyses, we also used the CEEOT **(**Comprehensive Economic and Environmental Optimization Tool) (Osei et al., 2000; Saleh and Gallego, 2007) which includes the Soil and Water Assessment Tool **(**SWAT**)** model, FEM and APEX.

Regarding Mississippi project participants, between eight and twelve agricultural and environmental stakeholders from Mississippi participated in each of the six project meetings while one and then four famers participated in the two farm producer meetings. Survey responses were mostly positive as stakeholders recognized the usefulness of the NTT tool for a variety of applications and users. Verbal feedback from farmers was also positive.

Our NTT field-scale analysis of 11 practice combinations found the most cost-effective practice combination to achieve the project's 45 percent N and P reduction goal from a test field were pads and pipes[1] with ditch improvement, reservoir and return flow irrigation and a 15 percent nitrogen (N) and phosphorus (P) fertilizer reduction. The second most cost-effective combination was sprinkler irrigation with the 15% N and P fertilizer reduction. Both practice combinations resulted in cost savings thereby improving profitability. In both cases, the cost savings appeared as negative cost-effectiveness values because they reduced nutrient losses while reducing farm-level costs. For these practice combinations, reduced fertilizer costs outweighed a yield reduction while the irrigation practice further increased yields. Single practice scenarios such as the split N application practice had a minimal cost per lb of N reduced estimate. Pads and pipes without ditch improvement and/or the reservoir had one of the largest costs per lb of N and P reduced and by itself did not attain the project's field-scale water quality goal.

Our CEEOT watershed-scale analysis found that the existing implementation of nine federally-funded best management practices (BMPs) in Big Sunflower watershed from 2004 to 2013 attained roughly a third of the project's 45 percent N and P watershed reduction goal (14 and 13 percent, respectively). Federal assistance program data indicate payments of over $18 million associated with these practices. Implementation of additional units of certain practices, primarily nutrient management, pads and pipes, and residue management would help achieve the 45% reduction goal in both N and P at a moderately significant cost. In an ideal situation of perfect information, the optimal practice distribution would entail an additional amount of nearly $10 million in federal public assistance, a figure that is likely to be higher in imperfect real world applications which would also include private farmer costs, technical assistance costs and other transaction costs. The most cost-effective sub-watersheds were identified as being located in the southern portion of the watershed or along the main stem of the Big Sunflower River.

Future research should investigate whether cost-effectiveness estimates measured in dollars per pound of pollutant reduced can become as effective at informing farmer conservation decision-making as estimates measured in dollars per acre which this project found to be the metric that the project farmers more easily understood.

[1] Pads and pipes are essentially an augmentation of dikes that also allows for controlled drainage off the diked field.

2 PROJECT DELIVERABLES

WRI and TIAER provide the following specific project deliverables to NRCS:

1. Two calibrated and validated linked tools (one consisting of APEX and FEM in NTT and the other of APEX, SWAT, and FEM in CEEOT) for use in the project watershed in Mississippi; an instruction manual and protocol for users of the Tool to make it ready for use in watersheds outside the original watershed; stakeholder and producer survey results and analysis on the usability of the Tool:
    a. The Nutrient Tracking Tool (NTT) website for use in the Mississippi delta region can be accessed at: http://nn.tarleton.edu/NTT/
    b. The Comprehensive Economic and Environmental Optimization Tool (CEEOT) is available for download and use by watershed planners and other professionals
    c. The MS NTT Instruction Manual is a stand-alone report (Attachment 2)
    d. Survey results on the usability of NTT are provided in an excel file (Attachment 3).
2. An evaluation of the feasibility of various stakeholders in Mississippi to use the enhanced tool in a variety of applications
    a. See section 4.3 of this report and Attachment 3
3. Analyses of
    a. The environmental and economic benefits and costs of either existing or hypothetical conservation projects – See sections 4 and 5 of this report and Attachments 4,5, and 6
    b. The potential profitability of producers participating in voluntary ecosystem services markets – This analysis was not conducted due to lack of stakeholder interest
    c. The perceptions stakeholders have of the many socio-political and technical challenges and trade-offs facing efforts to improve the effectiveness of public farm conservation funding – See sections 4.3 and 5.2 of this report and Attachment 3

3 OVERVIEW OF PROJECT ACTIVITIES

3.1 Project purposes, goal, and objectives

The project had two purposes. The first purpose was to continue innovating the NTT by linking the Farm Economic Model (FEM) to the NTT's APEX model and calibrating the linked NTT to Mississippi agronomic conditions. The goal of the project is that the new linked NTT tool may help producers, conservation planners, extension specialists, and private consultants identify the most cost-effective conservation practices to achieve farm-level water quality goals while also achieving farm productivity goals. The second purpose of the project was to continue innovating the CEEOT tool by linking the FEM to the watershed-scale Soil and Water Assessment Tool (SWAT) model and APEX. The goal of this effort is that the improved CEEOT tool may help a variety of agricultural and environmental stakeholders improve the cost-effectiveness of local, state and federal cost-share conservation funds and make progress towards achieving local and regional watershed-scale water quality goals.

Thus, the objectives of this project are to:

1. Develop an enhanced version of NTT for use in Mississippi by developing query-able spreadsheet-based database with a user-friendly web-based interface that will generate realistic estimates of (a) the pounds of N, P and tons of sediment reduced and tons of carbon sequestered from conservation practices on assessed farm fields as well as the adjustment factors (e.g. delivery ratios) needed to estimate the watershed-scale impacts at local and regional water bodies

of concern, and (b) the costs associated with the identified conservation practices to inform producers of their most cost-effective options.

2. To train farmers and other stakeholders in the use of NTT and CEEOT in order to (a) allow producers to use NTT to assess their own fields, (b) encourage producer–led and stakeholder support for implementation of cost-effective conservation practices to help address existing local and regional water quality goals, and c) increase understanding by producers and stakeholders of the voluntary carbon and water quality markets. (Note that this third sub-objective was not pursued given lack of stakeholder interest in pursuing discussions about ecosystem markets.)

3. Evaluate and assess the environmental benefits and costs of existing and hypothetical conservation projects; the feasibility of stakeholders to use the tool to improve the cost-effectiveness of federal and state conservation cost-share funding; and the perceptions of relevant stakeholders of the many political, legal, technical, and scientific challenges to improving the environmental effectiveness of investments in conservation.

3.2 Location of the project

The Big Sunflower watershed is an eight-digit watershed approximately 3,017 square miles with 17 12-digit sub-watersheds within the Yazoo watershed of the Mississippi delta. (See Figure 1). The Big sunflower is on the USEPA 303(d) impaired waters list for nutrients, low dissolved oxygen, sediment, and pathogens (MDEQ 2003). The sub-watershed Porter Bayou (about a 12-digit HUC watershed) has a TMDL for nutrients and dissolved oxygen, which calls for an 85 percent reduction in N and a 95 percent reduction in P from agricultural nonpoint sources (MDEQ 2008). The Big Sunflower watershed is one of three HUC-8 watersheds that comprise the "delta area" of Mississippi (the others include: Deer-Steele and the Upper Yazoo). All three delta area watersheds are NRCS Mississippi River Basin Healthy Watersheds (MRBI) project watersheds. Several USEPA 319 Nonpoint Source Pollution Reduction projects have been implemented in the Porter Bayou and Harris Bayou sub-watersheds as well.

3.3 Tasks involved

The team satisfied all of the project tasks (See the USDA CIG project proposal in Attachment 1 for descriptions of the Tasks 1 through 4.5). The Team did not pursue Task 4.3. "Evaluate producer profit potential from ecosystem services markets" because of lack of interest by the local project stakeholders in pursuing this activity based on their previous negative experiences with the U.S. carbon markets.

3.4 Description of project stakeholders

Most of the key agricultural and environmental stakeholders in Mississippi and specifically the Delta region participated in one or more of our five in-person meetings, including: Delta FARM, MS Soil and Water Conservation Commission, MS Department of Environmental Quality, MS Natural Resources Conservation Service, MS U.S. Geological Survey, MS Army Corps of Engineers, MS State University, Alcorn University, and two crop consultants (Mid-South Ag Data and FTN Associates Ltd.). Between eight and 12 individuals representing these various institutions participated in the project meetings providing feedback and suggestions for the development of the tool, etc. A list of participating stakeholders is provided in the Appendix.

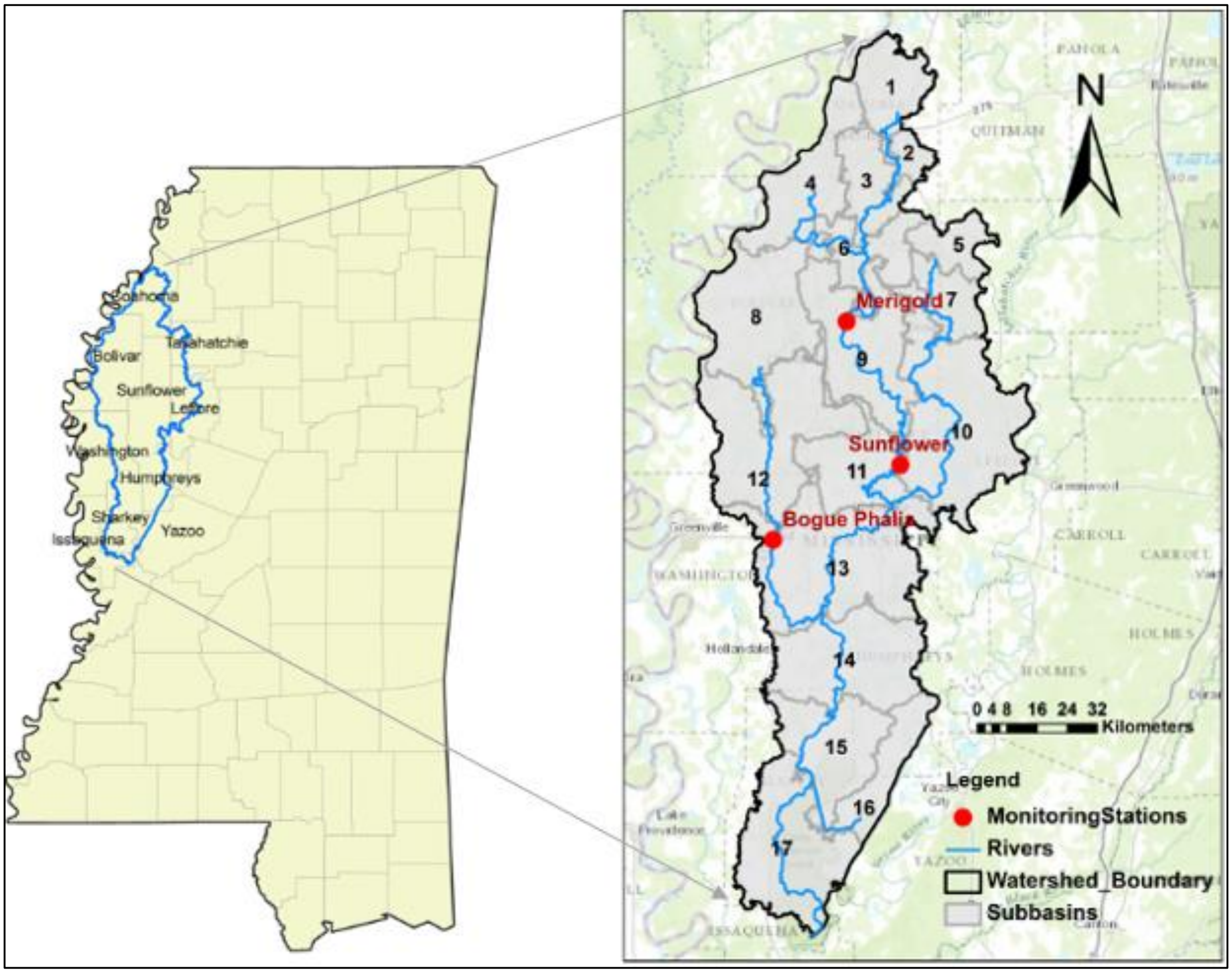

Figure 1. Location map of the Big Sunflower watershed in the Delta area of Mississippi

3.5 Project meetings

Four project meetings were held with the agricultural and environmental stakeholders between 2012 and 2014 and an opinion survey was administered at the end of each meeting: (1**)** April 24, 2012, (2) February 26, 2013, (3) March 18, 2014, and (4) August 27, 2014 (which included one farm producer). A fifth meeting was held with 14 staff of the Mississippi Department of Environmental Quality on August 28, 2014 (reflecting the fifth survey). Two additional webinars were held to address questions and suggestions raised in August meeting: November 17, 2014 (which included four farm producers) and November 19, 2014. Surveys were not administered at the end of the webinars.

4 NTT FIELD SCALE TOOL AND ANALYSIS

4.1 What we did

Forty-seven years of weather data from 1961 to 2007 from the USDA-NRCS-HCE (High-resolution Climate extractor) database and soil data from the USDA SSURGO database for the Big Sunflower watershed were assembled and loaded into the NTT interface prior to calibration of the NTT. Field attribute data and crop management information from Washington County, MS provided agronomic and conservation practice information for a 40-acre field. The NTT simulations were based on this sample field but scaled up to a 400-acre hypothetical field to reflect more typical farm size and economic profile in the watershed. Economic data (2014 input and output prices and NRCS practice payment rates) were obtained from USDA-NASS databases and a USDA-NRCS local office for the Mississippi Delta area. The management practices for the major crops (corn, soybeans, cotton, peanuts, winter wheat, sorghum, and rice) in the Delta area was obtained by the project stakeholders. The Farm Economic Model was linked to the APEX model in NTT. Other activities included a crop yield calibration over the 47-year period for all the five major crops. NTT was validated for the major crops and soils in the Mississippi Delta. Specifically, crop yield, sediment, and nutrient loads from NTT output were calibrated using the information provided by the stakeholders and available literature.

Eleven conservation practices scenarios were evaluated as single or multiple practices (see Table 1). Most notably, pads & pipes, a conservation practice unique to the Mississippi delta area, was included in NTT, which is the first time such a practice has been calibrated in NTT or any field-scale biophysical model (For more details, see Attachment 4's section 6 through 6.11). Note that several other conservation practices were evaluated at the beginning of the project (e.g., cover crops, no till, and riparian buffers) but due to lack of stakeholder interest in the practices, over time, we focused on the practices listed in Table 1 instead. Nevertheless, the NTT can be used in the Mississippi Delta to evaluate the environmental and cost impacts of many additional practices than those listed below.

Table 1. List of conservation practice scenarios included in the NTT project

	Conservation practice scenario
1	Fertilizer incorporation
2	15% nitrogen (N) and phosphorus (P) fertilizer reduction
3	Split N application
4	Split N application and incorporation
5	Furrow irrigation (60% efficiency)
6	Sprinkler irrigation (80% efficiency)
7	Pads & pipes
8	Pads & pipes with ditch improvement
9	Pads & pipes with ditch improvement & reservoir
10	Pads & pipes with ditch improvement, reservoir & tail water irrigation
11	15% N&P fertilizer reduction and incorporation

After NTT evaluates each practice scenario, the Summary Report provides an environmental benefits summary which includes: nutrient loads, crop yields, flow, and sediment loads. Annual results for each evaluated conservation practice scenario includes: total N (lbs/ac), total P (lbs/ac), flow (in.), sediment (t/ac), and crop yield (bu/ac). These estimates are provided for the baseline scenario, the alternative conservation scenario, the difference between the two scenarios, and the difference expressed as a percent change. The environmental benefits associated with the entire field are also displayed.

Economic impact of these scenarios can be viewed by clicking on the economic button. The resulting screen displays four primary economic indicators

- Total Revenue (total receipts from sale of farm products; equal to product price times quantity of product sold)
- Total Cost (the sum of all the costs incurred during production and sale of the farm products generated by this farm)
- Net Return (the difference between total revenue and total cost; this economic metric indicates whether the scenario offers cost-savings or has minor or major costs associated with it)
- Net Cash Flow (the difference between cash inflows (money coming into the farm in the form of sales receipts or loans or interest receipts) and cash outflows (money going out of the farm in the form of cash payments)

Like the environmental benefits summary report, these four economic indicators are displayed the economic impact page for both the baseline condition, the alternative scenario. In addition to the above economic indicators, the environmental benefits are re-displayed, and cost-effectiveness estimates are provided: $/lb total nitrogen reduced), $/lb total phosphorus reduced, and $/tons of sediment reduced.

4.2 What we found

4.2.1 Baseline conditions in the test field

The 40-acre field provided by a producer was identified using the mapping function in NTT and found to consist mostly (82 percent) of Forestdale silty clay loam and nearly level slopes while the remainder was Dowling (Sharkey) soils with 0 to 2 percent slopes (See Figure 2 below). The producer grew continuous corn with minimal tillage passes. Surface-applied elemental N was 193 lbs/acre and 30 lbs/acre of elemental-P, both on the same date (April 7). Disk plowing occurred the day after (April 8) while corn was planted three days later (April 20) and harvested in August (the 20^{th}). NTT simulations were performed for 40-ac. In addition, the 40-acre producer field was under furrow irrigation but a rain-fed scenario was assumed for the baseline condition in order to demonstrate the effect of applying irrigation options to a rain-fed operation. Also, NTT was simulated for an expanded 400-acre hypothetical field, using the 40-ac field information, in order to better reflect the typically larger farm sizes in the Mississippi Delta. No conservation practices were simulated for the baseline scenario (although split N application was already being employed). The baseline N losses were estimated at about 27 lbs N/ac and 1.2 lbs P/ac while the baseline crop yield was about 125 bushels per acre.Net return in the baseline scenario was $189/acre.

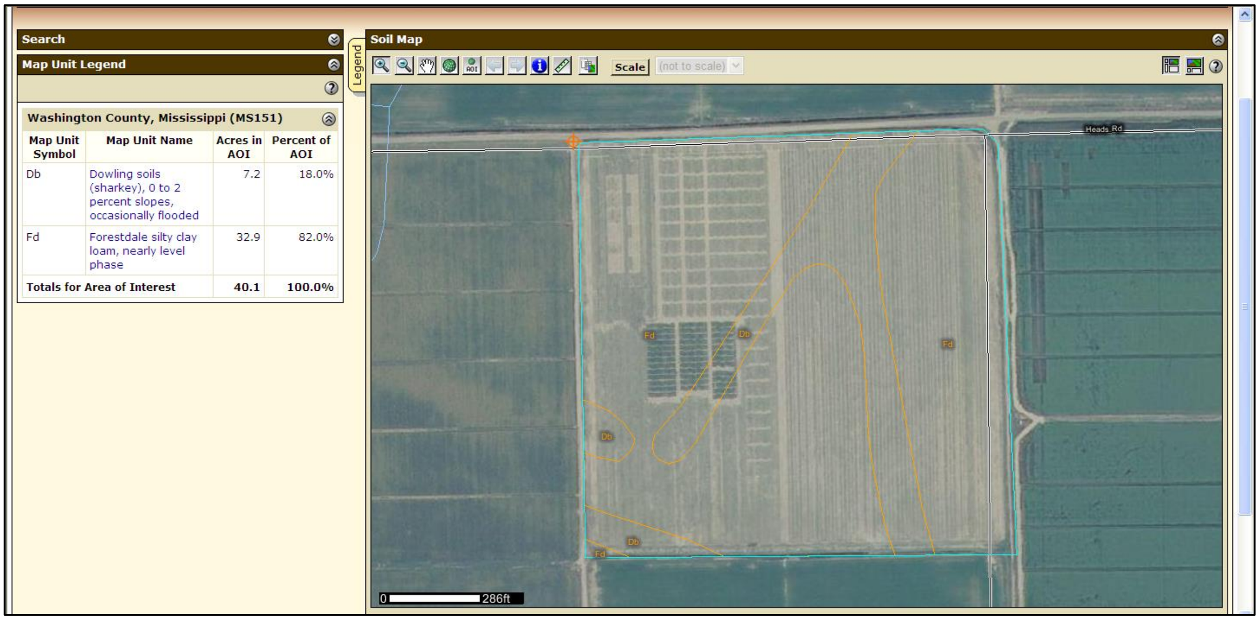

Figure 2. Screen shot of the test field showing field geometry, location and soil type information

4.2.2 Sample findings

Among the four fertilizer-related conservation practices (See the first four rows of Table 2 below), fertilizer incorporation resulted in the greatest N and P reductions (about 42 percent each) from the baseline condition for a small negative cost-effectiveness estimate resulting in a small cost savings or profit to the producer. The practice scenario that offered the largest negative cost-effectiveness estimate and thus nearly a profit of $5/lb of N reduced or $72/lb of P reduced (or about $16/ac in profits) was the 15 percent reduction in N and P fertilizer application. However, this practice achieved modest N and P reductions (nearly 13 percent and 19 percent, respectively).

Of all 11 practice scenarios evaluated (see all 11 rows of Table 2), the sprinkler irrigation scenario offered the greatest cost savings per acre ($130/acre) and the largest cost-effectiveness estimates (nearly $41 in cost savings per pound of N reduced and $353 in cost savings per pound of P reduced) for a modest N reduction of nearly 12 percent and a sizable P reduction of 31 percent. Amongst the four pads and pipes practice scenarios, three of which showed relatively large cost impacts (between $29 and $40 in costs per acre) for a wide range of nutrient reductions. The pads and pipes scenario with ditch improvements, a reservoir, and a tail water recovery system resulted in the second largest cost savings impact (nearly $78/acre) for a sizable N reduction and a very large P reduction.

Table 2. Summary of the environmental effects and costs of eleven conservation practice scenarios
(Note: For reductions in TN, TP, and sediment, a negative value means an increase in losses and positive value means a reduction in losses. For costs, a negative value means an decrease in cost and positive value means an increase in cost.)

		Reductions (%)			Cost-effectiveness ($/unit)**			Cost Impact
	Scenario	Total N	Total P	Sediment	Total N	Total P	Sediment	$/acre
	Baseline Losses*	***26.97***	***1.19***	***1.63***	---	---	---	---
1	Fertilizer Incorporation	42.4	42.0	-4.6	-0.04	-0.94	NA	-0.47
2	15% N&P Reduction	12.6	19.3	9.2	-4.90	-72.44	-111.15	-16.66
3	Split N application	25.7	-1.7	-2.3	0.94	NA	NA	6.53
4	Split N & Incorporation	45.2	36.1	-28.9	0.77	21.75	NA	9.35
5	Furrow Irrigation (60% efficiency)	0.4	23.5	-26.9	-1034.40	-406.37	NA	-113.78
6	Sprinkler Irrigation (80% efficiency)	11.9	31.1	18.8	-40.83	-353.15	-427.57	-130.67
7	Pads & Pipes	4.6	10.1	10.1	23.35	243.24	177.44	29.19
8	Pads & Pipes with Ditch Improvement	30.4	53.5	54.1	6.92	34.00	50.54	30.89
9	Pads & Pipes with Ditch Improvement & Reservoir	26.7	53.8	48.3	5.59	63.00	51.29	40.32
10	Pads & Pipes with Ditch Improvement & Reservoir & Tailwater Irrigation	29.3	63.9	59.0	-9.86	-102.39	-81.09	-77.82
11	15% N&P Reduction and Incorporation	47.9	44.5	-23.9	0.56	13.68	NA	7.25

*** Total N and Total P: lb/acre; Sediment: ton/acre.**
**** Total N and Total P: $/lb; Sediment: $/ton.**

4.2.3 The most cost-effective practices for achieving the 45 percent reduction goal for the test field

Regarding a producer's farm-level goal to attain a 45 percent reduction in baseline N and P losses, the fertilizer incorporation practice provides a substantial reduction of 42 percent for both N and P and offers a small cost-savings (nearly 50 cents per acre). This may satisfy a producer's personal goals and be considered "close enough." Should a program policy goal require more strict achievement of at least a 45 percent N and P reduction, we found the most cost-effective scenario was a combination of the pads and pipes scenario #10 with a 15 percent reduction in N and P fertilizer application. This combination led to a 46 percent N reduction, a 76 percent P reduction, and a cost savings of nearly $40/acre (or a cost savings of $3/lb N reduced or a cost savings of $43/lb P reduced).

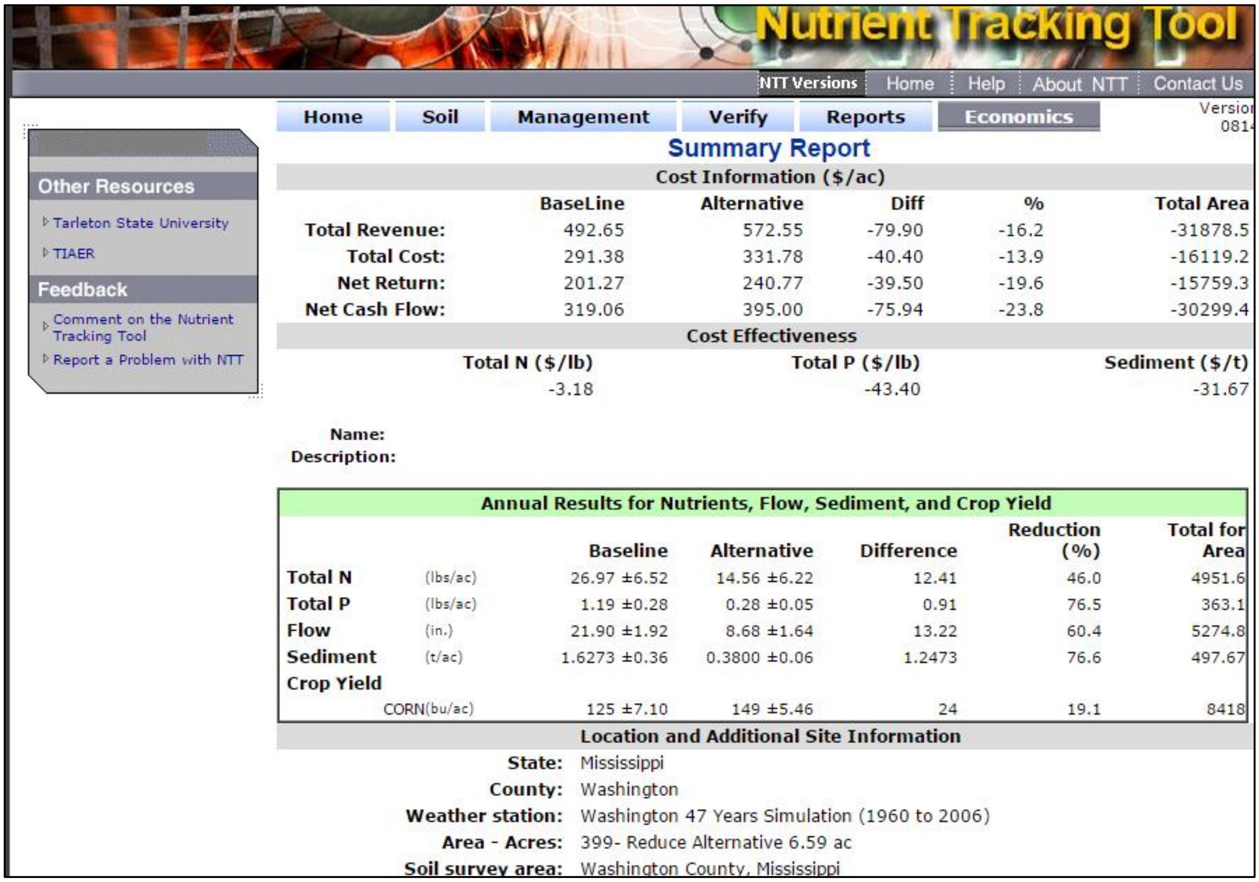

Figure 3. Screen shot of the summary impacts of a pads & pipes, ditch improvement, tailwater irrigation and 15% N and P fertilizer reduction practice scenario

4.3 Feedback on NTT from stakeholders and farmers and survey results

Overall, feedback from the project agricultural and environmental stakeholders was generally positive and support for the project grew with each update to the model to better reflect the agronomic and environmental conditions in the Big Sunflower. For example, at our second meeting, a representative from the MS Soil and Water Conservation commission said, "I am very appreciative and impressed with the work that you've done. Things are much better with this process than at the beginning because the work you've done is reflecting what we keep saying about Southern agriculture and the Delta being so different from everywhere else." (2-26-13) Regarding the project's innovation to generate cost-effectiveness estimates, a representative from a farm trade association said, "Farmers aren't trying to save nutrients, they're trying to make money. So I like you getting into the economic pieces. There's a lot of applications for this. We'd push the conservation practices that show a rate of return. That's the hook to get the farmers in the room." (2-16-13)

Feedback from farmers was also positive. Farmer 1 said, "This is a very thorough and excellent tool and it's getting better as its further developed…I am inspired and encouraged to see the results of some of these practices. We've been a little slow to adopt some of these practices in the Delta." (11-17-14) In addition, all four farmers said that they would "like to take the time to play with it" and that they were open to attending future webinars to keep learning more about the tool.

4.3.1 Possible users and applications of NTT in Mississippi

In addition to verbal feedback during each of the project meetings, survey responses from the agricultural and environmental stakeholders indicated a predominantly positive attitude towards the NTT tool (see Attachment 3 for the raw survey results). After the first and last stakeholder meetings (Survey 1 and 4) and after the meeting with MS DEQ staff (Survey 5), between 79 percent and 100 percent of stakeholders agreed or strongly agreed that the MS-NTT tool would be useful for a variety of users in a variety of applications (See Figure 4). (Note that survey questions and results from meetings 2 and 3 were not sufficiently interesting for inclusion in this brief final report but they can be viewed in Attachment 3).

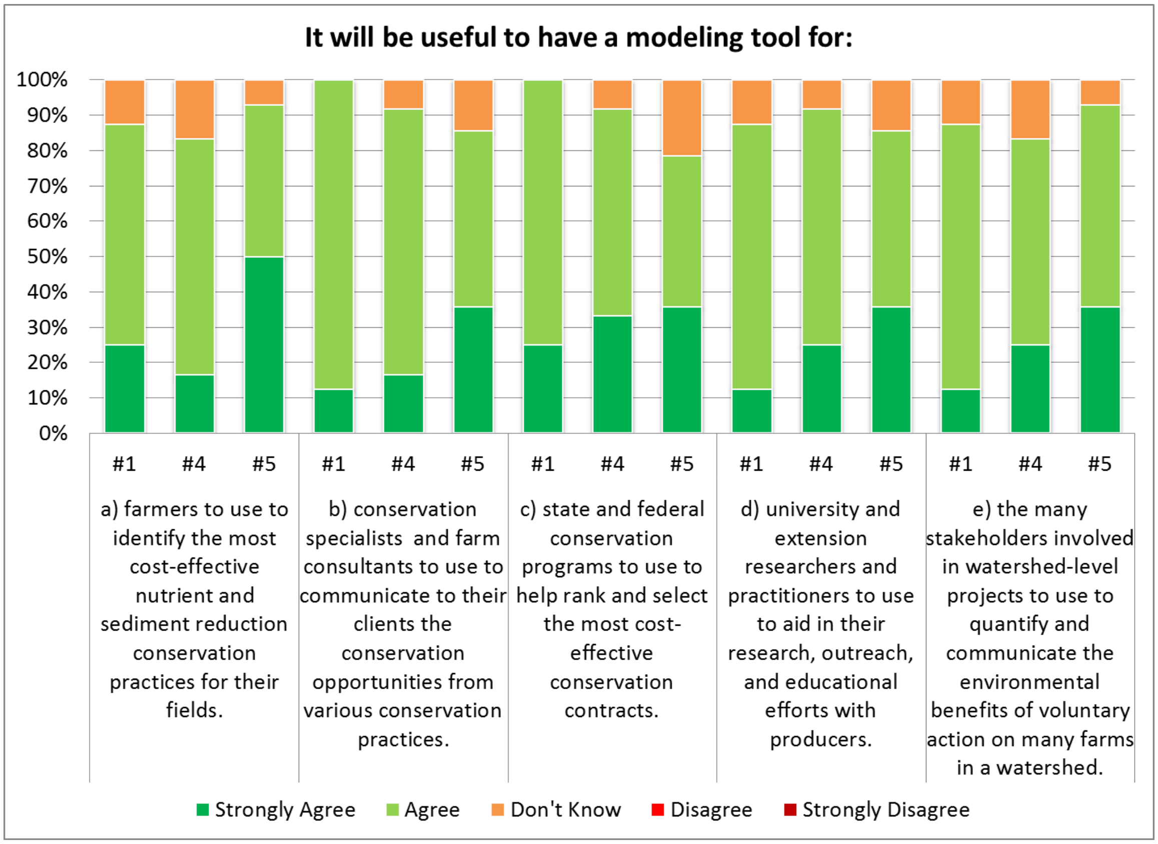

Figure 4. Stakeholder survey opinions on users and applications of the MS-NTT tool
(Note: #1, #4, and #5 refer to the first, fourth, and fifth meetings with stakeholders)

In addition to the possible user groups and applications for the MS-NTT tool, a few stakeholders shared their concerns about some of these applications and offered additional ideas for how they might use the tool. For example, a representative from MS-NRCS said, "Regarding using NTT in NRCS application ranking system. There's potential there but it will be difficult because we don't have batching dates for us to group several applications together in order to rank them by their NTT results. Also, we look at more things in our applications than just nutrients and sediment; we look at soil, water, plants, and animals. So we'd have to figure out a way to use the tool as a supplement to our system. There is a potential there though." (2-16-13)

Another representative from MS-NRCS said he liked the idea of NRCS planners using the tool but had alternative ideas for how they would do so. "I'd see this as a tool for some of our conservation planners to evaluate typical scenarios of practices on typical Delta farms. For example, practice Suite A gets you this many pounds of N and P reductions while Suite B accomplishes just this amount and Suite C accomplishes that most. I can see us training just a few specialists to do this versus training all 70 conservationists. We can then work with the farmers to show them our analysis and encourage them to adopt Suite C because it was the best, as long as it applies to their farms. This approach is an alternative to working one-on-one with farmers and the tool – which would be best – but this idea is more of an educational, marketing application to many farmers all at once."

Regarding survey questions about using NTT to conduct specific policy-related analyses, stakeholders were predominantly supportive of doing so to estimate the nutrient and sediment reductions in MRBI and 319 projects (between 79 and 100 percent) and to identify the most cost-effective practices and costs to achieve local TMDL water quality goals (71 to 85 percent) (See Figure 5). However, just 13 to 82 percent of stakeholders agreed or strongly agreed that it would be useful for NTT to identify the most cos-effective practices and costs to achieve potential future water quality goals associated with the Gulf of Mexico. Surprisingly, the environmental stakeholders at the MS DEQ meeting (Survey 5) were more uncertain and not supportive of this Gulf-related NTT analysis than the predominantly agricultural conservation stakeholders at the first and last meetings (Survey 1 and 4).

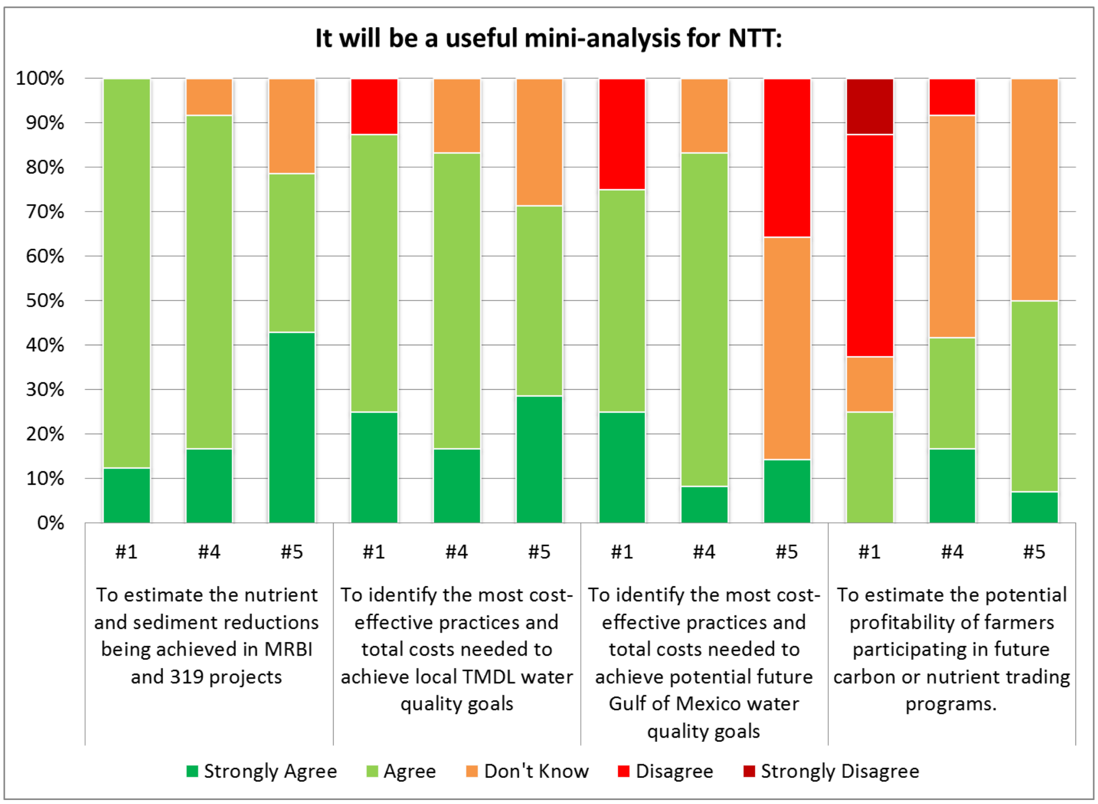

Figure 5. Stakeholder survey opinions on specific applications of the MS-NTT tool

Finally, only 22 to 50 percent of the stakeholders agreed or strongly agreed that it would be useful for NTT to estimate the potential profitability of farmers in future carbon or nutrient trading markets. This reflects the negative experience many stakeholders had participating in the Chicago Climate Exchange carbon trading markets which has largely soured the Mississippi conservation community on ecosystem services markets in general. One representative from the MS Soil and Water Conservation Commission cautioned us that "Nutrient trading cannot drive this (NTT). It's a PR solution (nutrient trading) to a real, technical problem." (2-16-13)

4.3.2 Conceptual challenges with NTT experienced by the stakeholders and farmers

The majority of surveyed stakeholders in all three meetings agreed or strongly agreed that trade-offs inevitably occur when developing scientific and economic modeling tools including, trade-offs between (a) accuracy and expediency, (b) sophistication and usability, and (c) economic efficiency and equity (See Figure 6). For instance, spreadsheet models are very easy to use, but not robust for most applications. However, dynamic mechanistic models such as APEX are very sophisticated and robust, but have a steeper learning curve to use. Furthermore, certain tools and applications that result in very efficient outcomes also lead to distributions of funds or practices that are not equitable. This is the case in most watersheds where the most pollution-generating sources get the most funds for practice implementation because pollution reduction is more efficiently achieved in those areas. Additional trade-offs and modeling limitations regarding the CEEOT watershed-scale analysis is discussed in section 5.2.3 of this report.

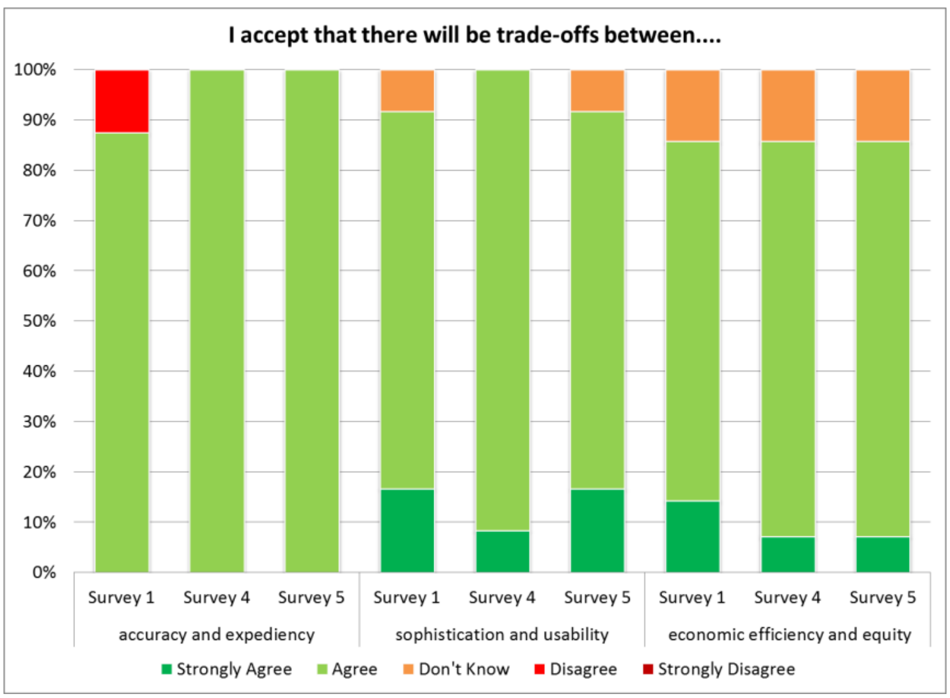

Figure 6. Stakeholder survey opinions on the trade-offs in modeling and tools

There were several concepts that stakeholders and farmers found difficult to digest, including: (a) the weather and crop input data for calibrating the MS-NTT tool and (b) the cost-effectiveness metrics.

When the Team was explaining that the weather data in the NTT reflects an average of 47 years of weather data rather than specific storm events or current weather data and that the crop yield calibration data reflects an average of 47 years of crop yield data rather than today's average crop yields, several stakeholders provided the following reactions. Farmer 2 said, "For the Delta, these yields are close but some are low" (11-17-14) indicating concern that the 47-year crop average did not reflect his farm's yields. A representative from a farm trade association said, “I'm not sure about using 1960 to 2007 weather and crop data. Maybe you could start with 1990 data and go to the present to reflect the major seed development progress.” (11-17-14) A representative from MS State University (MSU) said, “If you're going back to 1960, we were growing crops to feed animals not for grain.” (2-16-13). And, another representative from MSU said, “So our real-time, edge-of-field data is highly influenced by major storm events. Your model is only taking the average of all weather data over nearly 50 years. It will be difficult to explain to farmers that the model only reflects the nutrient losses and reductions, on average, rather than the results after a recent, big rainfall.” (2-16-13)

When asked if the cost-effectiveness estimates in dollar per pound of nutrient reduced was a meaningful metric, Farmer 4 said, “It's hard to wrap your head around.” (2-16-13) and all the farmers offered that it was easier to grasp the dollars per acre net return estimates instead. Furthermore, when either the cost impact metric in dollar per acre or the cost-effectiveness estimates in dollar per pound were negative, it was difficult for farmers to digest that negative was good as it meant a cost-savings or profits. One farmer suggested color coding the NTT results values: “If it benefits us, put it in green. If it's gonna take away from us, put it in red.” (2-16-13)

4.3.3 Reactions to NTT BMP scenario analyses

Farmers offered several reactions to the NTT analysis of the 11 BMP scenarios. Farmer 2 said, “The thing that is totally impressive is the 42 percent reduction from just (fertilizer) incorporation.” When the group of farmers was asked to give feedback on the findings for the 15% N & P fertilizer reduction BMP, Farmer 2 spoke for the group when he said, “I'm surprised that yield doesn't suffer and profits go up.” When asked if any of them have tried cutting back of fertilizer application rates, all the farmers on the webinar said, they've never tried it. Farmer 3 offered, “Even though I see a negative cost-effectiveness estimate and negative means good and that makes sense to me, a drop in fertilizer usually ends up in a decrease in yield so it's hard to accept this finding.” Farmer 2 said again, “It's kind of hard to cut back on fertilizer. We have all types of weather and we get real nervous making a reduction because yield losses can occur.” In reaction to the largest cost-savings coming from the pads and pipes combination scenario with tail water recovery (BMP scenario #10), Farmer 4 said “That's all well and good but it's a boat load of money to do tail water irrigation system. It's a tremendous outlay of money.” (11-17-13)

Farmer 2 offered these thoughts: “Whatever BMP that is showing we can do it for almost no cost like split applying N or incorporating N, we can consider. But the practices with cost, we're just in survival mode right now. Those cost-savings numbers are interesting. If I thought I could make 25% improvement in cash flow, I'd be happy.” However, he cautioned that the recent drop in commodity prices makes it difficult to look into conservation investments, “Even if I see good numbers, cost savings in the net return or cash flow metrics, there's still the upfront investment that I have to make to stomach these costs. The drop in prices has really let the air out of us. We don't know if there's anything to plant. We're in no man's land with no crops showing a return to profit.” (2-16-13)

Many of these comments indicate that a single discussion about the potential cost-savings associated with some conservation practices is insufficient to spur immediate investment in the identified conservation practices. Stakeholders in Mississippi and elsewhere that are beginning to identify practices that offer net cost-savings, practices that have minimal net costs, and practices that have major net costs should consider developing a comprehensive educational campaign to convey the most effective instructional and outreach materials. In addition, stakeholders could consider developing a series of pilot projects with farmers to test out the NTT modeled results and the evidence from the literature that indicates several conservation practices can result in net cost-savings.

5 CEEOT WATERSHED SCALE TOOL AND ANALYSIS

5.1 Baseline nutrient load and BMP assessment and future BMP scenarios analysis

5.1.1 What we did

Model runs were made with weather data for a 32-year period from 1981-2012. Twelve years of simulation (from 1981-1992) was used for model warm-up. Ten years of results from 1993-2002 was used for model validation the remaining used for calibrating the model. Monthly flow, sediment, total nitrogen and total phosphorus from CEEOT-SWAT were calibrated for the watershed using flow and water quality data from United States Geological Survey (USGS). For flow, Nash and Sutcliffe Efficiency (NSE) and R^2 were used to judge the performance of the model. For water quality, predicted and observed averages were used to judge the model performance. In addition, efforts were made to bring the model predicted sediment, nitrogen and phosphorus results within the uncertainty bounds of observations.

Data on BMPs implemented with federal financial assistance was provided by federal and state agency project stakeholders for 2004 to 2013 indicating eight USDA and USEPA sources[2] provided $40 million for 41 practices. However, just nine of these BMPs reflecting over $18 million in payments could be represented in the CEEOT model. There were several reasons why so many practices could not be represented in the model, including: (a) the practice does not reduce nutrients but provides other benefits, (b) an insufficient number or area of the practice was adopted, and (c) the database did not provide sufficient information for some nutrient-reducing practices to be included (e.g., size, volume, and surface area for irrigation storage reservoirs). (See Appendix 3 for which practices were and were not selected). (See Attachment 5 in the Appendix for more details) The calibrated model was used to analyze the nutrient reductions obtained from existing BMPs when compared to baseline. For analyzing the results of future scenarios, the existing BMPs defined in the calibrated model setup were removed to avoid the present BMPs masking the benefits of implementing future BMPs in the watershed.

5.1.2 What we found

5.1.2.1 Extent of BMP implementation

We estimated that about nine percent of the total cultivated cropland area in the Big Sunflower watershed has received at least one BMP of the 41 BMPs recorded in the NRCS databases (including BMP data recorded by USEPA) between 2004 and 2013 (See Appendix 3 for the list of BMPs). Depending on sub-watershed, BMP coverage ranged between three percent and 19 percent of the cultivated area in each of the 17 sub-watersheds (See Figure 12 in Attachment 5). Just nine BMPs were used in the "baseline BMP scenario" to estimate the nutrient reductions achieved from the existing BMPs because they dominated the BMP implementation effort as measured by cropland area: residue management (an aggregation of NRCS code 329 and 329A), seasonal residue management (code 322), nutrient management (590), dikes/pads and pipes (356), irrigation water conveyance (an aggregation of 430 and 430EE), irrigation water management (an aggregation of 443, 339, and 442), grade stabilization structures (410), irrigation land leveling (464), and drainage water management (554). (See section 2.3 in Attachment 5 for more details.)

[2] AWEP, CRP, CTA-GENRL, CTA-GLC, EQIP, WHIP, WRP, and USEPA's 319 Program.

5.1.2.2 Baseline nutrient load; load after BMPs; load to achieve the target goal

We estimated that the nine BMPs in the Big Sunflower watershed's baseline BMP scenario resulted in 5.9 million pounds of N reduced and 1.3 million pounds of P reduced or a 14 and 13 percent reduction in N and P losses, respectively, attaining about a third of the project's target goal of a 45 percent reduction (See Figure 7 below). In the Porter Bayou sub-watershed, baseline BMP scenario resulted in 54.1 thousand pounds of N reduced and 66.4 thousand pounds of P reduced or a three and 19 percent reduction in N and P losses, respectively[3] (See Figure 8 below). (See section 3.2 in Attachment 5 for more details)

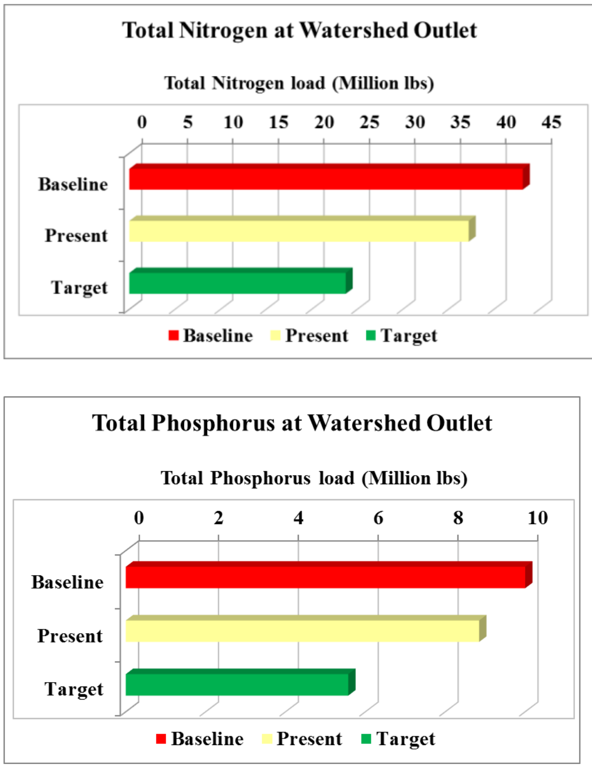

Figure 7. Nutrient loads leaving the Big Sunflower watershed outlet in baseline, present and target conditions

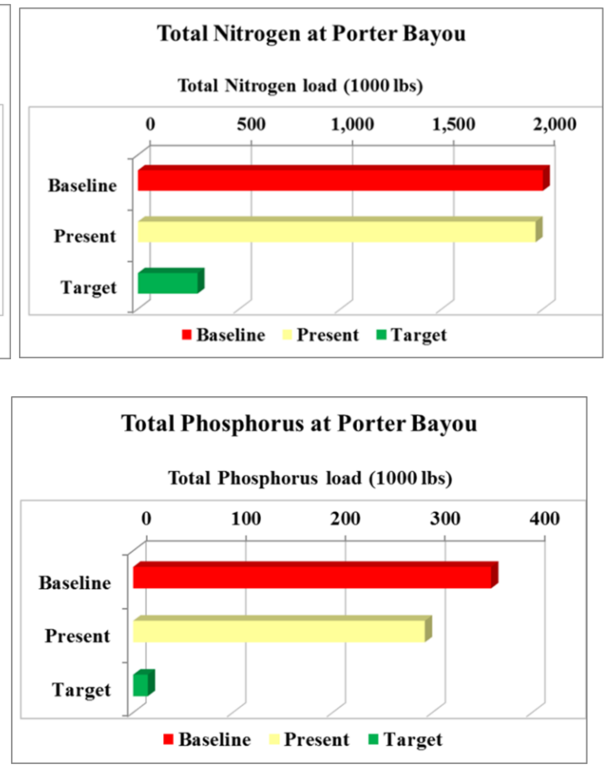

Figure 8. Nutrient loads leaving Porter Bayou sub-watershed in baseline, present and target conditions

5.1.2.3 Which are the most effective BMPs?

Just six of the nine BMPs were used in a "future BMPs scenario" to identify the most effective N and P reducing BMPs (grade stabilization, drainage water management, and irrigation land leveling were left out). These six BMPs were selected because they dominate representation in the watershed and they have major nutrient reduction benefits. We estimated that pads and pipes/dikes provided the most nitrogen and phosphorus reductions. This is likely because the pads and pipes BMP impounds water and does not allow nutrients to easily leave the field. Nutrient management was second in TP reductions but not for TN because the model simulations suggested the crops used almost all the applied N. Residue management showed the third amount of both N and P reductions followed by seasonal residue management. The

[3] A similar reduction of three and 19 percent N and P, respectively, was estimated for the Harris Bayou sub-watershed where major targeting efforts have been occurring.

remaining two irrigation BMPs did not achieve appreciable nutrient reductions as they are focused on water quantity management rather than on nutrient reduction. (See section 3.5 in Attachment 5 for more details.). These findings are applicable for both the existing and future BMPs.

5.1.2.4 Where would future BMPs be most effective?

In general, we found that the most effective sub-watersheds for future BMP implementation are those found in the lower part of the watershed where the estimated delivery ratios are highest for nutrient transport to the Gulf of Mexico (See Figure 9). Specifically, we found that sub-watershed 17 and then 8 are likely the most effective locations[4] for future BMP implementation due, in combination, to their high delivery ratio and their minimal amount of current BMP implementation from the federal conservation program (See Appendix 4). (See section 3.3 and 3.5 in Attachment 5 for more details.)

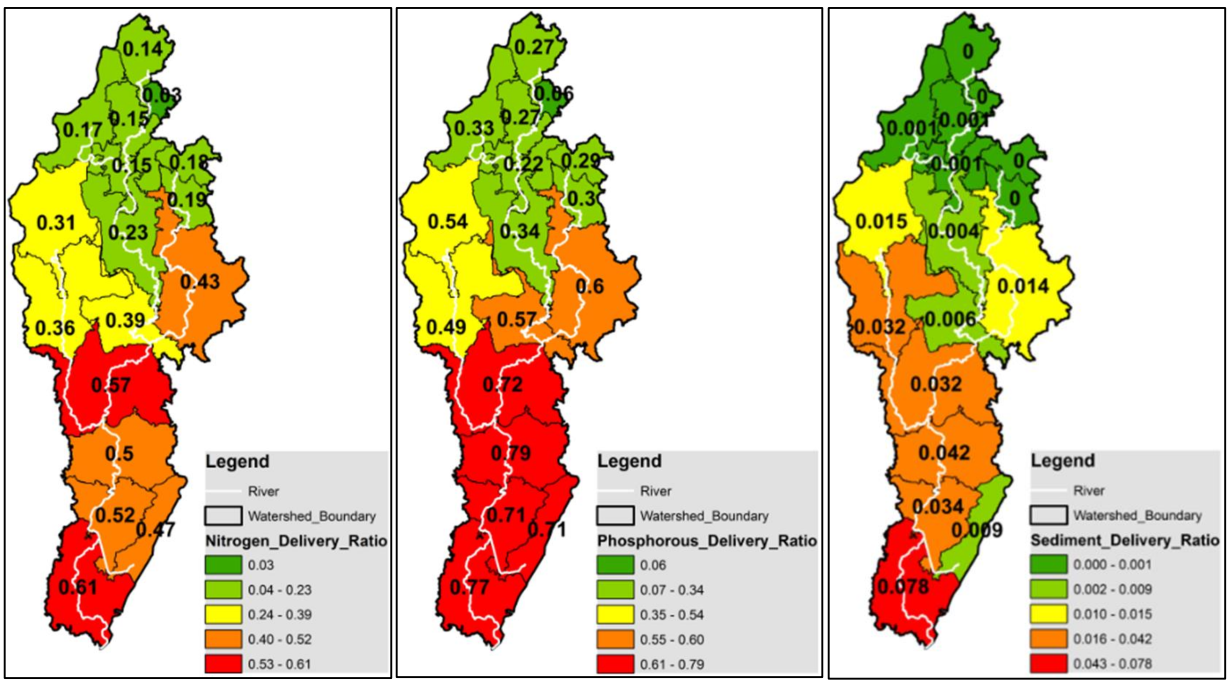

Figure 9. Delivery ratios for nitrogen, phosphorus, and sediment from sub-watersheds in the Big Sunflower watershed to the mouth of the Mississippi River at the Gulf of Mexico

5.2 Economic optimization analysis

5.2.1 What we did

A second analysis using the CEEOT package (SWAT, FEM, and NTT models) was conducted to identify which BMPs and which sub-watersheds are the most cost-effective at (a) minimizing the cost of BMPs while achieving the 45 percent reduction goal and (b) maximizing the environmental benefit given a set budget. The analysis was conducted for both the entire Big Sunflower watershed and the Porter Bayou sub-watershed. (See Attachment 6 for more details.) Table 3 displays the eight BMPs that were used in the economic analysis (note that grade stabilization structures were not included in this analysis due to lack of adequate cost data). Costs reflected in the analysis only include the financial assistance payments associated with BMP implementation rather than the private farmer costs or the associated technical

[4] See Figure 1 for a map depicting the sub-watershed numbers.

assistance costs. The "cost" for each practice and was estimated from county-specific payment rates for each BMP which does not represent actual implementation costs, but simply the amount of government payment for each practice.

Table 3. List of BMPs used in the CEEOT economic optimization analysis and associated average payment rates ($/acre)

	BMP	Payment rates ($/acre)
1	Nutrient Management	6.62
2	Residue Management	13.00
3	Seasonal Residue Management	13.00
4	Irrigation Water Management	9.23
5	Pads and Pipes (dikes)	37.83
6	Irrigation Water Pipes	7.44
7	Drainage Water Management	2.76
8	Irrigation Land Leveling	128.34

5.2.2 What we found

5.2.2.1 Optimal BMP selection and distribution for achieving a 45 percent reduction in TN and TP

We found that the past implementation of eight existing BMPs in the Big Sunflower watershed has reduced total N and total P loads by about 5.3 million and 1.3 million pounds from the baseline level of losses (12.4 % for N and 12.7 % for P)[5], respectively, at an estimated cost of $18.3 million (See Table 4). The distribution of the existing BMPs is shown in Figure 10 below and alternatively, in Appendix 4. To achieve the remaining reductions necessary to achieve the project's desired 45 percent reduction goal, the CEEOT model identified just four of the eight BMPS as offering the most cost-effective additional reductions (residue management, nutrient management, dikes, and irrigation water pipes) at an additional cost of $9.6 million. In addition, just four sub-watersheds were identified by the CEEOT model as being the most cost-effective locations for the additional adoption effort: 11, 14, 15, and 17 (See Figure 11 below with subwatershed numbers displayed in Figure 1).

[5] Note that this estimate includes only 8 BMPs (grade stabilization was omitted due to lack of cost data) while the earlier estimates shown in Figure 7 and section 5.1.2.2 of a 14% reduction in N and a 13% reduction in P from the baseline included 9 BMPs.

Table 4. Costs & load reductions achieved with existing & optimal BMPs for a 45% reduction goal

	BASELINE BMP SCENARIO Implementation of Eight Existing BMPs	FUTURE BMP SCENARIO Future Implementation of Just Four of the Eight BMPs	FULL IMPLEMENTATION Baseline + Future Scenarios
Nutrient load reductions			
Total N (lb)	5,351,624	14,044,466	19,396,090
Total P (lb)	1,293,436	3,256,024	4,549,460
Cost ($)	18,260,313	9,637,987	27,898,300
Cost-effectiveness			
Total N ($/lb)	3.41	0.69	1.44
Total P ($/lb)	14.12	2.96	6.13

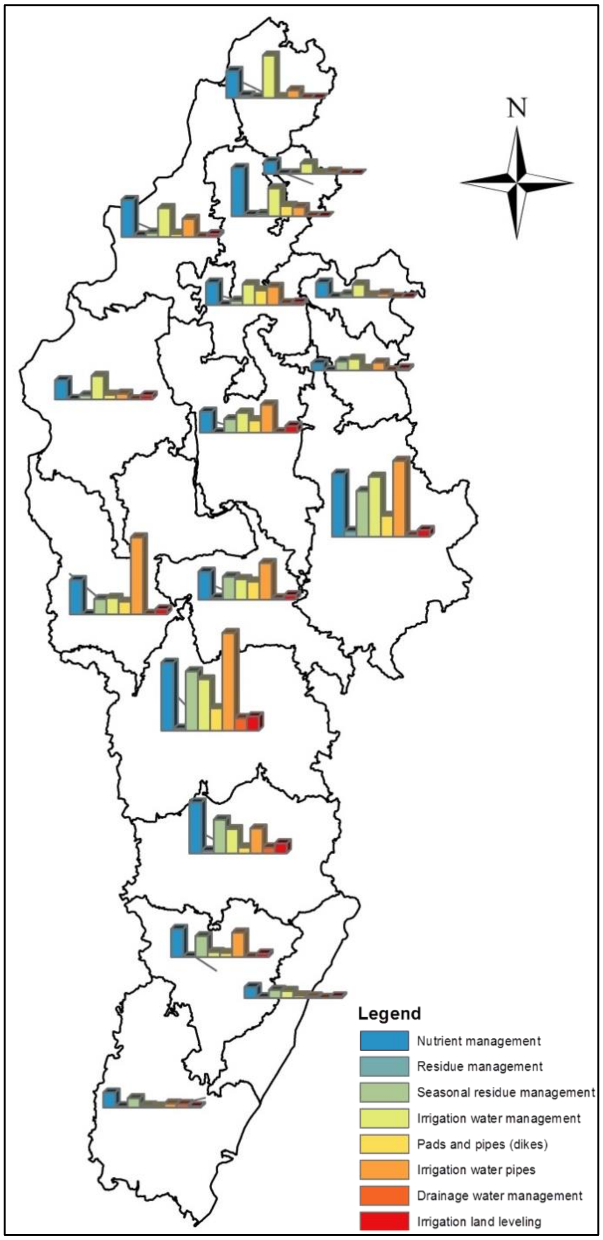

Figure 10. Distribution of existing BMPs in Big Sunflower watershed

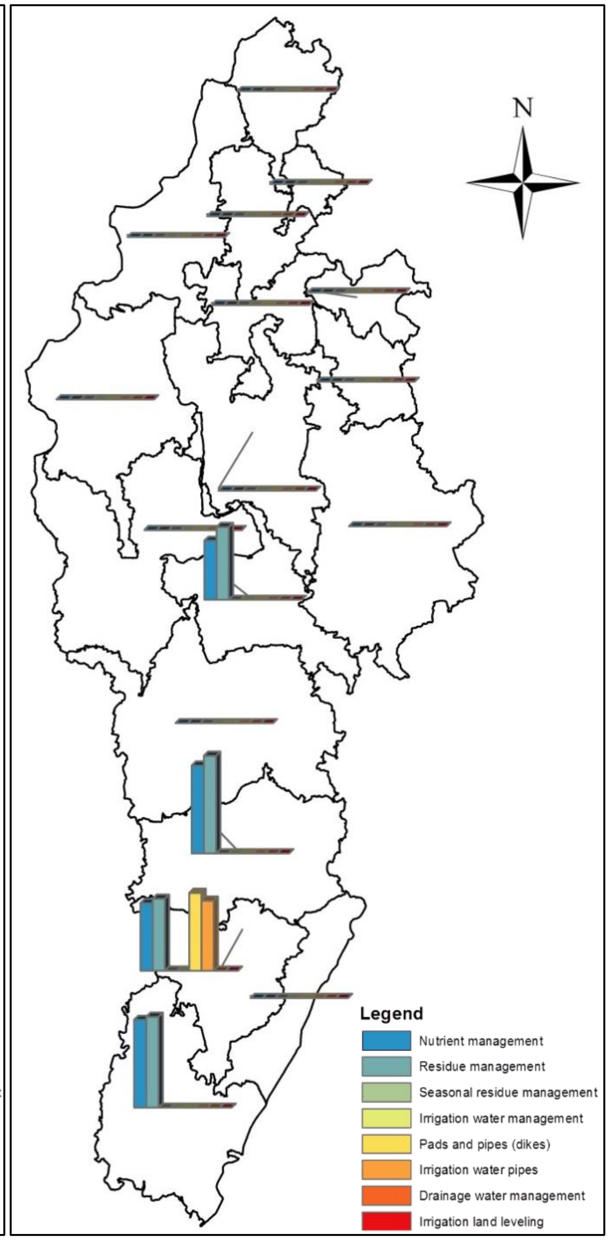

Figure 11. Optimal distribution of additional BMPs (beyond those already implemented) in order to achieve 45% reduction goals

5.2.2.2 Optimal BMP selection and distribution to maximize nutrient reductions with a set budget

Three alternative budgets were selected to illustrate how the CEEOT model can be used to identify the most cost-effective practices and their distribution within the Big Sunflower watershed to achieve the most nutrient reductions possible: $10, $20, and $40 million (See Table 5). For all three budget constraints, BMP implementation was fully optimized, meaning the model assumes no prior BMP implementation occurred in the watershed prior to optimization. The results indicate that the higher the funds available for BMP implementation, the less cost-effective the overall implementation will be. This is because when practice implementation is being optimized, the most cost effective practices and locations are selected with the initial funds, so additional funds would be used to install the less cost-effective practice-location combinations that remain. Overall, the results indicate that the least likely BMPs to be selected by the model under optimization are seasonal residue management, irrigation water management, drainage water management, and irrigation land leveling. Irrigation land leveling is not selected in any sub-watershed even when a $40 million budget is available. In contrast, the most likely BMPs to be selected by the model even with a small budget are residue management, nutrient management, and dikes (pads and pipes). In terms of sub-watersheds, 15, 17, and 14 predominate, followed by 11 and 6. These sub-watersheds are either closer to the outlet of the watershed or are along the main stem of the river. In contrast, even with a $40 million budget for the entire watershed, certain sub-watersheds are not selected: namely, 1, 5, 7, 8, 10, 12, and 16 (See Figure 12 for the distribution corresponding to a $20 million budget).

Table 5. Costs and load reductions achieved with varying budget amounts

	$10 million	$20 million	$40 million
Nutrient load reductions			
Total N (lb)	16,143,933	26,074,013	39,065,310
Total P (lb)	2,986,880	5,122,336	7,802,409
Cost ($million)	10.0	20.0	40.0
Cost-effectiveness			
Total N ($/lb)	0.62	0.77	1.02
Total P ($/lb)	3.35	3.90	5.13

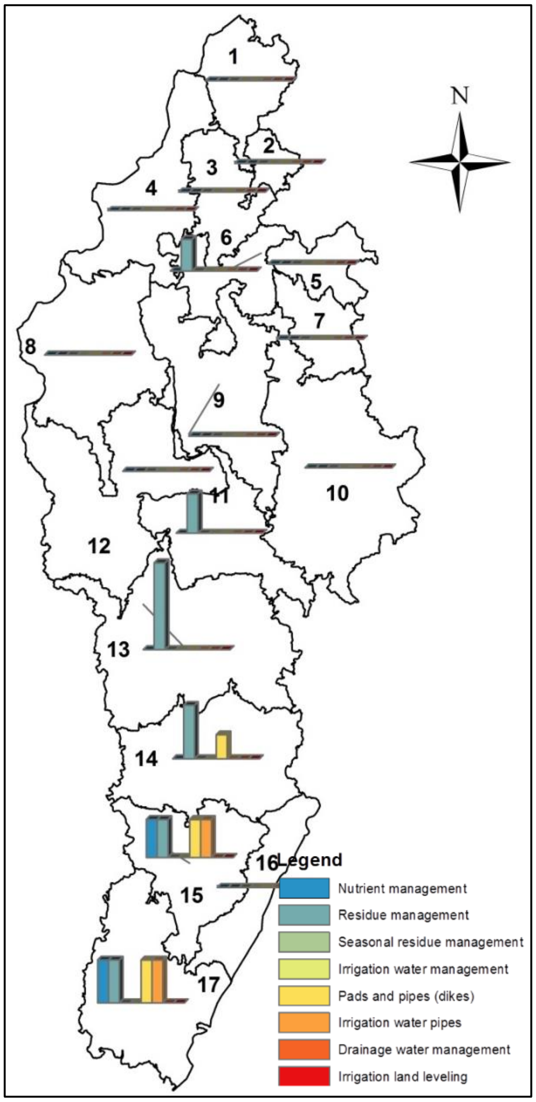

Figure 12. Optimal distribution of BMPs with $20 million budget

5.2.2.3 Attainment of the TMDL in the Porter Bayou sub-watershed

Using the best available information and the calibrated CEEOT model, we found that the 85 percent N reduction goal could not be met with the eight BMPs available to the model and with the land area available for implementation – either in addition to the already existing BMPs in the watershed or with a "No BMP" scenario. Starting with no BMPs in place, the 95 percent P reduction goal (344,000 lbs) could be met at a cost of $4.7 million with 273,000 lbs of N also being reduced as a co-benefit which amounts to a 16 percent N reduction). This scenario entailed maximum implementation of all the practice options with the exception of seasonal residue management and irrigation land leveling. Notwithstanding, the N reduction goal could still not be met when all the land area had received implementation of most of the eight BMPs. (See Section 8 of Attachment 6 for more details)

5.3 Stakeholder feedback on the CEEOT watershed tool and analysis

Feedback on the CEEOT watershed tool and optimization analyses was generally positive as well. At the end of the final webinar, a representative from MS-NRCS said, **"**Congratulations to all the project leaders for a job well done." (11-19-14) A representative from the MS DEQ said that "There are a lot of valuable insights we can take from this tool. We've seen the tool and we like it." (8-28-14) Another representative from MS DEQ said, "We would want to use the watershed tool to target our resources." (8-28-14)

5.3.1 Possible users and applications of CEEOT in Mississippi

During the meeting with MS DEQ, several staff identified three applications for the CEEOT model related to their work on TMDLs:

1. TMDL tracking – to estimate nutrient reductions from existing BMP implementation within a TMDL watershed to estimate progress being made towards the TMDL,
2. development of a TMDL, and
3. TMDL implementation –to help to target state and federal resources.

A representative from MS DEQ said that, "There is increasing pressure from OMB (the Office of Management and Budget) to estimate the cost effectiveness of nonpoint source programs. They are requiring us to report what our pollutant load reductions are. They want to compare the states against each other. EPA is doing this but there aren't established standards for how the states should do this." (8-28-14)

Another MS DEQ representative wanted to know if the CEEOT tool could be used to develop a TMDL. The Team described using CEEOT to develop the TMDL in the Bosque River watershed in Texas.

A third MS DEQ representative said that the CEEOT tool might help the agency balance its work between regulated point and unregulated nonpoint sources. "The tool would give us a way to start talking with farmers about the best places to put the best practices in to have the most impact. It might relieve the point source pressure to meet the future instream numeric criteria." (8-28-14)

5.3.2 Conceptual challenges with CEEOT experienced by the stakeholders

There were two major concepts that the stakeholders had difficulty grasping: (1) the modeling trade-offs between representing "the real world" versus representing subsets of the available data and (2) the ramifications of the partial cost optimization analysis.

It was challenging for the stakeholders to square their perception of "the real world" of BMP implementation with the realization that the model cannot reflect 100 percent of any reality. The Team explained there are many reasons that this trade-off between the real world and the modeled world must be made including the fact that even the best available BMP databases do not include BMPs that have not yet been inspected and certified. One MS-NRCS representative said "We didn't start doing reservoirs and tail water recovery systems until 2009 in the Delta and thus there are some that are not fully installed or they haven't received certification yet so they're not going to be in the database." (8-27-14) Another limitation involves only including BMPs that could be represented in the model. For example, BMPs like weirs, risers, and diversion ditch are used for controlling water flow but they cannot be represented in the model because a) the BMPs are used for diverting water or measuring flow and they don't bring any pollutant reductions c) difficulty in representing physical appurtenances in the model setup. Other BMPs like irrigation system (NRCS code 443), irrigation water management (449), and sprinklers (442) had to be aggregated together in the model because they do the same job of applying the irrigation water more efficiently. Perhaps most unsettling realization by the stakeholders was how few BMPs (six to nine depending on the analysis out of 41) could be represented in the SWAT model because they had sufficient implementation acreage so they could be detected by the watershed-scale model.

Regarding the ramifications of the partial cost analysis, stakeholders found it challenging to put the watershed optimization results into perspective. Because the optimization analysis only included the incentive payments provided by the federal financial assistance programs, the estimates of what it would cost to achieve specific nutrient reductions at the watershed outlet do not represent all the costs associated with actual implementation of the effort. Thus, some stakeholders from MS SWCC and MS NRCS were concerned that the public would conclude that if only the estimated amount of funds materialize then the problem will be solved. The Team made an effort to describe many of the different kinds of additional costs such as:

- Transactions costs associated with actually finding where within each of the priority sub-watersheds the optimal practice locations may be and the outreach assistance needed to then persuade the operators of those optimal locations to adopt the most cost-effective practices
- Technical assistance costs to provide the conservation planning for each farmer's most cost-effective suite of practices, and
- Maintenance costs that would be needed after the practice contract expires as the model (and society) expects the practice to be kept up into perpetuity.

5.3.3 Reactions to the CEEOT watershed analyses

Initially, we had estimated that 38 and 40 percent reductions in N and P, respectively had been attained in the Big Sunflower watershed from the existing BMPs. Stakeholders said the finding seemed appropriate to them as it reflected their decades of hard work and effort in the watershed. However, the Team realized we had misrepresented the pads and pipes BMP in the SWAT model as taking out just one-side of a field when in reality, most farmers install pads and pipes around all four-sides of field because they like to drive around their fields and because some of them like to flood the fields in winter for wildlife habitat management and hunting. As a result, the area of fields enclosed by the pads and pipes BMP, as represented in the model, declined three fold and consequently, the total load reduction estimates for the entire watershed declined as well. This experience underscored the importance of on-the-ground partners and verification (calibration and validation) to ensure proper model set-up.

Thus, the updated and current estimate that only 13 percent and 14 percent N and P reductions, respectively have been achieved from the existing BMPs proved disappointing to the stakeholders. The stakeholders also reiterated that the "true" and precise percentage reduction may never be known because no one really knows how well the current BMPs in the model (which reflect installation between 2004 and 2013) are being implemented and maintained. The stakeholders pointed out that some of them have been working in the Delta since 1986 so a lot more BMPs have been implemented than the ones in the model though they don't know if they're still maintained. A representative from MS-NRCS said, "Regardless of the model telling us we've achieved 19 or 20 percent or 35 percent of the goal, all of us are going to say, 'no, we need to go out and see it.' We need to see that the practices are really in place and well-maintained. Then we need to see the edge of field water quality measurements. Then we need to see the Tier 1, 2 and 3 monitoring results. We may know what practices we put out there but who's to say that the pads and pipes put in 5 years ago are still getting the boards put in properly? Unless you can know the status of every BMP, it's hard to quantify the reductions."

The stakeholders concluded that they are less interested in using the model to determine how much reduction may have been achieved by existing BMPs. Instead, their primary interest in the CEEOT modeling tool is for analyzing options for moving forward. A representative from MS-NRCS said, "It's a powerful tool for targeting analysis. If we use the model, let's look at things that can be done and help decide what road to take. If the tool can tell us, this is the watershed we need to be in and the BMPs that we need to use. Let's use it that way." (11-19-14)

The quality of results from computer modeling tools such as CEEOT are directly related to the quality of the input data getting into the models. Uncertainties are always associated with the input data and therefore the results obtained from the models. In the case of Big Sunflower watershed, some uncertainties are associated with the inclusion of existing BMPs in the model. The stakeholders were disappointed that the BMPs implemented in the watershed prior to 2004 were not represented in the model. Moreover, the existence of some BMPs (some non-structural/cultural BMPs such as residue management or nutrient management could have been practiced for a few years and then discontinued) and their present effectiveness are not known. If the above information were available, they could have been incorporated into the model and the reliability of the results would have improved.

Barring all data limitations, application of the CEEOT tool enabled us to identify which BMP practices are more effective in reducing N and P loads from the watershed, which sub-watersheds are responsible for the greater share of current nutrient load reductions, and which sub-watersheds need to be prioritized for further reductions. In addition, the CEEOT tool's integration with economic optimization methods was helpful in identifying which practices are the most cost effective in achieving specified nutrient reductions. As the stakeholders pointed out, CEEOT could be used to determine alternative ways of achieving target nutrient reductions more efficiently. In order to do that, it is also important to analyze which nutrient reductions have been achieved so far by existing BMPs. The nutrient reduction estimated by CEEOT for currently installed BMPs in the watershed need to be considered as a baseline for further analyses, keeping in mind the unavoidable limitations on data availability.

6 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions and recommendation for NTT

Our NTT field-scale analysis of 11 practice combinations found the most cost-effective practice combination to achieve the project's 45 percent N and P reduction goal from a test field were pads and pipes with ditch improvement, reservoir and return flow irrigation and a 15 percent nitrogen (N) and phosphorus (P) fertilizer reduction. The second most cost-effective combination was sprinkler irrigation with the 15% N and P fertilizer reduction. Both practice combinations resulted in cost savings thereby improving profitability.

In both cases, the cost savings appeared as negative cost-effectiveness values because they reduced nutrient losses while reducing farm-level costs. For these practice combinations, reduced fertilizer costs outweighed a yield reduction while the irrigation practice further increased yields. Single practice scenarios such as the split N application practice had a minimal cost per lb of N reduced estimate. Pads and pipes without ditch improvement and/or the reservoir had one of the largest costs per lb of N and P reduced and by itself did not attain the project's field-scale water quality goal.

Given the reported farmer aversion to conservation practices that have high upfront costs, even though they are told such practices may provide net cost-savings, Mississippi and federal stakeholders should consider developing educational materials to disseminate the literature evidence on practices with cost-savings. In addition, the state and federal stakeholders should consider developing pilot projects with a group of farmers to test the NTT findings and determine if the most cost-effective individual practices or suites of conservation practices do indeed offer net cost-savings.

Once emerging edge-of-field nutrient loss data from MSU are sufficiently ready, the MSU scientists and NTT developers could collaborate to test whether NTT, as currently calibrated, yields similar nutrient loss results as the measured data. In addition, the new edge-of-field data could be used to re-calibrate NTT and ensure that its predictions reflect the newly available data.

Going forward, stakeholders in Mississippi should consider creating one central database to store the Big Sunflower's conservation practice data from the many different sources of public financial assistance. This centralized database would result in quicker and easier documentation and verification of the Big Sunflower watershed BMP inventory and similar inventories in the other two Delta area watersheds (Deer-Steele and Upper Yazoo).

6.2 Conclusions and recommendations CEEOT

Our CEEOT watershed-scale analysis found that the existing implementation of nine federally-funded conservation practices in Big Sunflower watershed from 2004 to 2013 attained roughly a third of the project's 45 percent N and P watershed reduction goal (14 and 13 percent, respectively). Federal assistance program data indicate payments of over $18 million associated with these practices. Implementation of additional units of certain practices, primarily nutrient management, pads and pipes, and residue management would help achieve the 45% reduction goal in both N and P at a moderately significant cost. In an ideal situation of perfect information, the optimal practice distribution would entail an additional amount of nearly $10 million in federal public assistance, a figure that is likely to be higher in imperfect real world applications which would also include private farmer costs, technical assistance costs and other transaction costs.

The most cost-effective sub-watersheds were identified as being located in the southern portion of the watershed or along the main stem of the Big Sunflower River. We estimate that these sub-watersheds have the highest level of nutrient load being delivered from the Big Sunflower River watershed to the Gulf of Mexico and do not have many federal program-related BMPs already implemented at present. Stakeholders should consider verifying the finding, that the four sub-watersheds (11, 14, 15, and 17 shown in Figure 11 with subwatershed numbers displayed in Figure 1) are the most cost-effective locations for additional practice adoption, with best professional judgement and ground truthing.

Should this review confirm that these specific sub-watersheds are the most cost-effective, the Mississippi state and federal stakeholders could conduct outreach to farmers in these sub-watersheds and develop a project to increase adoption of the most cost-effective practices appropriate and acceptable to these farmers and landowners. Regarding financial assistance, in addition to pursuing traditional funding options from the federal conservation programs and landscape initiatives, stakeholders could consider more innovative and creative options such as "crowdsourcing" and even combining the NTT pilot project outlined above with this sub-watershed targeting project in order to achieve the 45% nutrient reduction goal for the Big Sunflower watershed.

7 REFERENCES

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8 APPENDIX

A. Appendix Table of Contents

B. Appendix Contents

1. Standard deliverables listed in section 8 of the proposal announcement

Participation in at least one NRCS CIG Showcase or comparable NRCS event during the period of the grant:

- We participated in the February 12, 2013 "Preparing NTT for Prime Time – Western Regional Meeting" in Portland Oregon organized by Bobby Cochran of the Willamette Partnership among others.
- We participated in an April 7, 2014 "Strategic and business planning process for NTT – stakeholder input" teleconference organized by Dr. Wayne Honeycutt, NRCS Deputy Chief for Science and Technology.

2. List of participating Mississippi agricultural and environmental stakeholders

Name	Organization
USDA MS-NRCS	
Paul Rodrigue	Mississippi-Natural Resources Conservation Service (MS-NRCS)
Walter Jackson	Mississippi-Natural Resources Conservation Service (MS-NRCS)
Kurt Readus	Mississippi-Natural Resources Conservation Service (MS-NRCS)
Al Garner	Mississippi-Natural Resources Conservation Service (MS-NRCS)

Kevin Kennedy	Mississippi-Natural Resources Conservation Service (MS-NRCS)

MS SWCC

Don Underwood	Mississippi Soil and Water Conservation Commission
Mark Gilbert	Mississippi Soil and Water Conservation Commission
Patrick Vowell	Mississippi Soil and Water Conservation Commission
John Henry Anderson	Mississippi Soil and Water Conservation Commission

Farm trade association

Trey Cooke	Delta F.A.R.M.
Dan Prevost	Delta F.A.R.M.
Mark Stiles	Yazoo Management District (YMD)
Dean Pennington	Yazoo Management District (YMD) for Water
Andy Whittington	Mississippi Farm Bureau

MS DEQ

Pradip Bhowal	Mississippi Department of Environmental Quality
Mike Freiman	Mississippi Department of Environmental Quality
Richard Ingram	Mississippi Department of Environmental Quality
Kay Whittington	Mississippi Department of Environmental Quality
Jerry Cain	Mississippi Department of Environmental Quality
Richard Harrell	Mississippi Department of Environmental Quality

Universities

Beth (Poganski) Baker	Mississippi State University
Joby Czarnecki	Mississippi State University
Jairo Diaz	Alcorn State University
John Ramirez-Avila	Mississippi State University
Larry Oldham	Mississippi State University
Robert Kroger	formerly Mississippi State University
Bobby Golden	Mississippi State University

Consulting firm

Robert Mehrle	Mid-South Ag Data
Kent Thornton	FTN Associates Ltd.

Other Federal Agencies

Martin Locke	USDA Agricultural Research Service (ARS)
Henrique Momm	USDA Agricultural Research Service (ARS)
Richard Rebich	US Geological Service
Reed Green	US Geological Service
Matt Hicks	US Geological Service (USGS)
Karen Myens	US Army Corps of Engineers-Vicksburg District

David Johnson	US Army Corps of Engineers-Vicksburg District
Paul B. Rodrigue, PE, CPESC	USDA Natural Resources Conservation Service
Karrie Pennington	USDA Natural Resources Conservation Service

Other

Scott Lemmons	The Nature Conservancy
Stacey Shankle	The Nature Conservancy
Alex Littlejohn	The Nature Conservancy

Mississippi Delta Area Farmers

Pete Hunter
Gip Carter
Buddy Allen
Terry Maxwell

3. List of 41 BMPs implemented in the Big Sunflower watershed from 2004 to 2013, whether they were used in the baseline BMP scenario or the future scenario, and comments

1	BMP	Name of BMP	Programmes								BMP scenario	Future	Remarks
2	CODE		AWEP	CRP	CTA-GENRL	CTA-GLC	EQIP	WHIP	WRP	319	(current conditions)	Scenarios	
3	329	Residue and tillage management			X		X				X	X	
4	329A	Residue management, No-Trill/Strip till			X		X				X	X	
5	344	Residue management, Seasonal		X	X	X					X	X	
6	590	Nutrient management	X	X	X		X				X	X	
7	356	Dike	X	X	X		X	X	X		X	X	
8	430	Irrigation pipeline	X		X		X				X	X	
9	430	Irrigation Water Conveyance			X		X				X	X	
10	430EE	Irrigation Water Conveyance, Pipeline	X		X		X		X	X	X	X	
11	443	Irrigation system, surface and sub-surface	X		X		X				X	X	
12	449	Irrigation water management	X		X		X				X	X	
13	442	Sprinklers			X		X				X		In combination with other BMPs
14	410	Grade stabilization structure	X		X		X		X		X		Total BMP area is small
15	464	Irrigation land leveling	X		X		X				X		Total BMP area is small
16	554	Drainage water management	X		X		X			X	X		Total BMP area is small
17	314	Brush management					X						Too small of an area
18	328	Conservation crop rotation			X								Conservation crops already in crop rotation
19	340	Cover crops					X						Total BMP area is small
20	342	Critical area planting					X						Total BMP area is small
21	348	Diversion Dam	X										Water diversion-Too small area
22	350	Sediment basin					X						Just one or two BMPs
23	351	Water well decomissioning			X		X						Nothing to do with this project-well abandonii
24	362	Diversion					X						Just one or two BMPs
25	382	Fence					X						Not relevant
26	393	Filter strip					X						Total BMP area is small
27	397	Aquaculture ponds					X						Area small-Not very relevant
28	412	Grassed waterway					X						Total BMP area is small

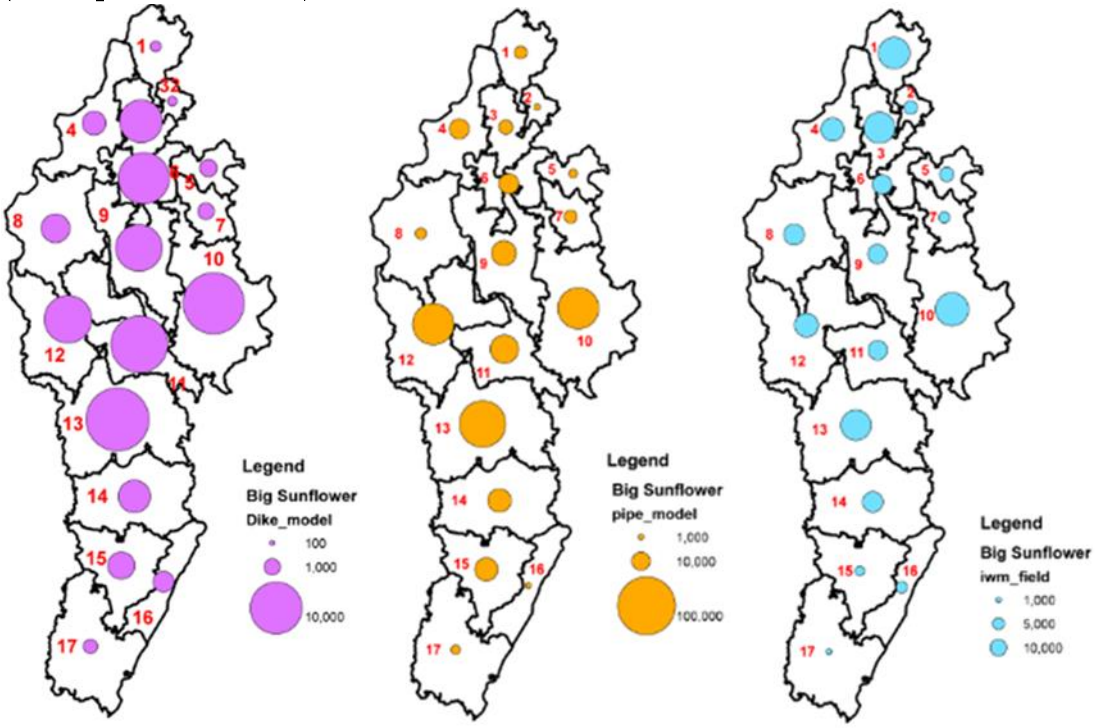
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	BMP	Name of BMP	Programmes								BMP scenario	Future	Remarks
2	CODE		AWEP	CRP	CTA-GENRL	CTA-GLC	EQIP	WHIP	WRP	319	(current conditions)	Scenarios	
21	348	Diversion Dam	X										Water diversion-Too small area
22	350	Sediment basin					X						Just one or two BMPs
23	351	Water well decomissioning			X		X						Nothing to do with this project-well abandon
24	362	Diversion					X						Just one or two BMPs
25	382	Fence					X						Not relevant
26	393	Filter strip					X						Total BMP area is small
27	397	Aquaculture ponds					X						Area small-Not very relevant
28	412	Grassed waterway					X						Total BMP area is small
29	436	Irrigation reservoir	X		X		X			X			Too small reservoirs
30	441	Irrigation system, micro-irrigation			X		X						Too small of an area
31	447	Irrigation system, tailwater recovery			X		X			X			Not many to consider
32	460	Land clearing					X						Too small of an area
33	533	Pumping plannt	X		X		X						In combination with other BMPs
34	561	Heavy use area protection					X						Not relevant
35	587	Structures for water control	X	X	X		X	X	X	X			Water measurement, diversion etc.
36	600	Terrace					X						Total BMP area is small
37	601	Vegetative barrier					X						Total BMP area is small
38	614	Watering facility					X						Livestock drinking water facility-Not relevant
39	642	Water well	X	X	X		X		X				In combination with other BMPs
40	644	Wetland wildlife habitat management					X						Too small of an area
41	646	Shallow water development and management	X	X	X		X	X	X				Wildlife habitat, In combination with others
42	647	Early Successional Habitat Development	X	X	X		X		X				In combination with other BMPs
43	798	Seasonal high tunnel system for crops					X						Not sure what it is

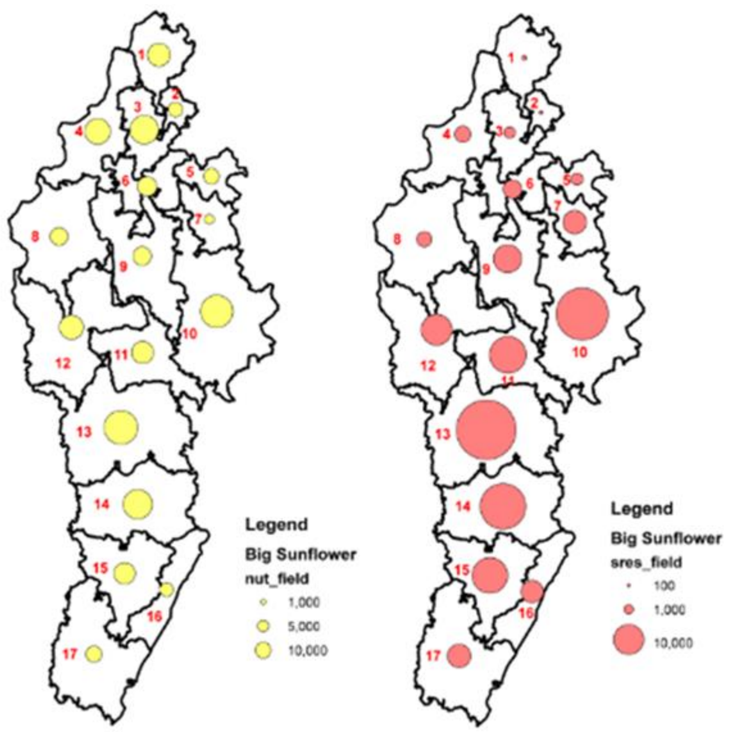
BMPs practices combined and modeled as residue management

BMPs practices combined and modeled as irrigation water conveyance pipeline

BMPs practices combined and modeled as irrigation water management

4. **Distribution and extent of five predominant BMPs in the Big Sunflower watershed (all map units in acres)**





Symbol	Code	BMP
	Dike	Dike / Pads and pipes
	Pipe	Irrigation pipeline
	Iwm	Irrigation water management
	Nut	Nutrient management
	Sres	Seasonal residue management