Evaluation and Validation of a Decision Support System for Selection and Placement of BMPs in the Mississippi Delta

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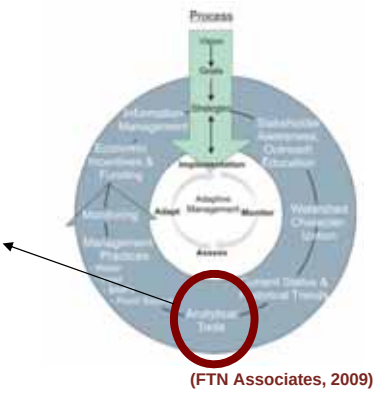
BACKGROUND

The Mississippi River/Gulf of Mexico Hypoxia task force released the Gulf Hypoxia Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico and Improving Water Quality in the Mississippi River Basin in June 2008.

A Planning Team co-led by Delta F.A.R.M and the Mississippi Department of Environmental Quality (MDEQ) and formed by about 30 representatives from agencies organizations and stakeholders groups identified 12 critical elements for a Delta nutrient reduction strategy.

This study is a component of the activities orientated to the evaluation and selection of appropriate analytical tools that can be used to develop the most efficient and effective action plans for areas within the Mississippi Delta Region.



(FTN Associates, 2009)

INTRODUCTION

Prevention and reduction of surface water pollution has been a matter of concern for decades, which has promoted the implementation of best management practices (BMPs).

Considerable number of structural and non-structural BMPs have been developed to control hydrological processes and enhance pollutant load reduction at field and watershed scales.

Modeling tools have been presented as an effective alternative to support the selection of a specific BMP or the best combination of these practices and BMP placement in order to achieve cost-effectiveness in addressing environmental quality restoration and protection needs in different scenarios.

USEPA has presented The **S**ystem for **U**rban **S**tormwater **T**reatment and **A**nalysis **IN**tegration (SUSTAIN) model to be used by watershed and stormwater professionals to develop, evaluate and select optimal BMPs combinations, at multiple watershed scales, and to achieve targeted water quality objectives based on cost and effectiveness.

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BACKGROUND... SUSTAIN Overview

SUSTAIN

SUSTAIN is a framework that facilitates a comprehensive storm water management analysis of watershed at multiple scales.

APPLICATIONS

- Predict load reduction and cost for multiple management alternatives. Evaluating future benefits of implementation and/or adaptation plan.
- Multi-tier evaluation of individual watersheds and of multiple, nested watershed.
- Assist in the development, evaluation, selection and placement of Best Management Practices (BMPs) and Low Impact Development Strategies (LIDs) based on cost and effectiveness.

BACKGROUND… Sustain Structure

SUSTAIN COMPONENTS

Framework Manager	It facilitates the linkages between GIS, external inputs, watershed and BMP simulations, post-processor, feasible options matrix, and the decision optimization engine.
Watershed module	This module performs rainfall-runoff simulations, pollutant sediment generation on a landscape; and routing on flow, sediment, and pollutants through the land surface.
BMP module	This module allows users to select BMPs (from 14 available), configure them based on physical features, and evaluate the BMP performance.
Conveyance module	This module allows users to perform routing of flow and water quality in a pipe or a channel.
Optimization module	Used to evaluate and identify cost-effective BMP placement and selection strategies for a preselected list of potential sites, applicable BMP types, and ranges of BMP size.
Post-processor:	It performs analysis and summarization of the simulation results for decision making.

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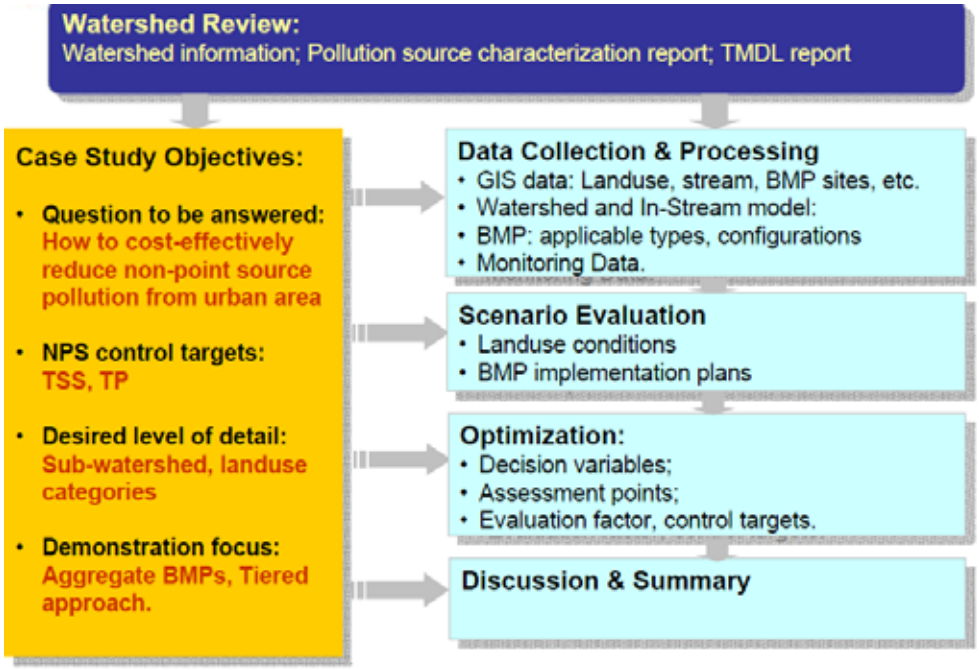
BACKGROUND…Simulation methods

SUSTAIN Simulation Methods

Framework Manager	From the GIS view and database, the framework first develops a simulation network that defines the relationship between land-area units, BMPs, and stream systems on a watershed
Watershed module	It uses simulation routines from SWMM's atmospheric, land surface, and groundwater compartments
BMP module	Prince George's County BMP module and selected buffer zone simulation techniques from the VFSMOD.
Conveyance module	This module uses routine from HSPF/LSPC RCHRES and SWMM Transport compartment.
Optimization module	Two optimization techniques are supported by SUSTAIN: the Scatter Search method and the Non-dominated Sorting Genetic Algorithm II (NSGA-II) method.
Post-processor:	The post-processor uses Microsoft Excel 2003 to develop : storm event classification, storm event viewer, performance summary and cost-effectiveness reports.

BACKGROUND… SUSTAIN Typical Case Study



Source: EPA 2010.

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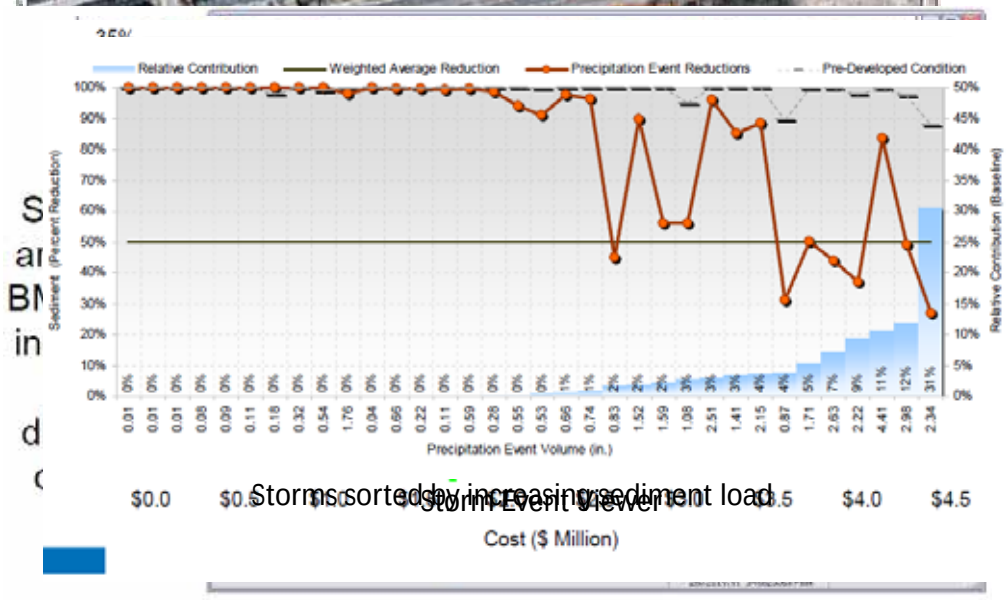
BACKGROUND… SUSTAIN Typical Case Study

Step 6. BMP Optimization: Cost-Effectiveness (CE) Curve and BMPs Selected.



Source: EPA 2010.

OBJECTIVE

To assess the performance and capability of the SUSTAIN model in the context of a real **agricultural** scenario in the Mississippi Delta, where BMPs are implemented.

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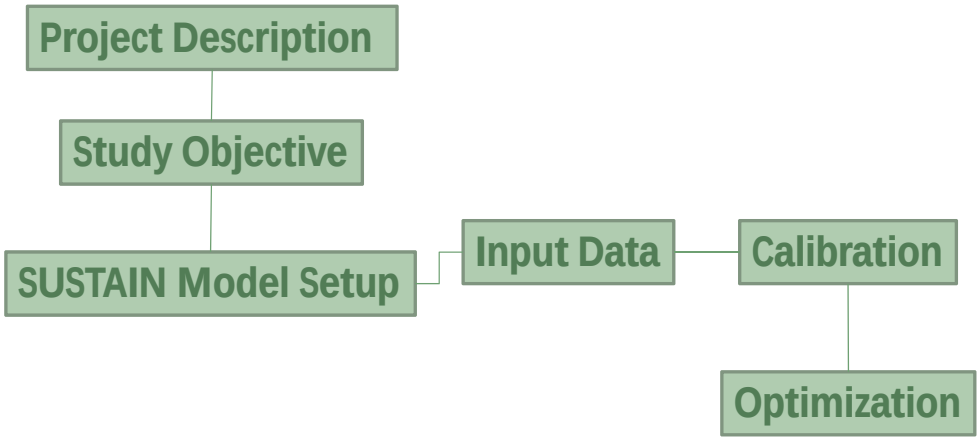
MODEL EVALUATION

Case study: Harris Bayou North Ditch Project



MODEL SETUP

Case study: Harris Bayou North Ditch Project

PROJECT DESCRIPTION

The “Harris Bayou North Ditch Project “ was established and developed by Dr. Robert Kröger from the Department of Wildlife, Fisheries and Aquaculture at Mississippi State University. The project was established in 2010 and samples have been collected since December 2010 to the present.

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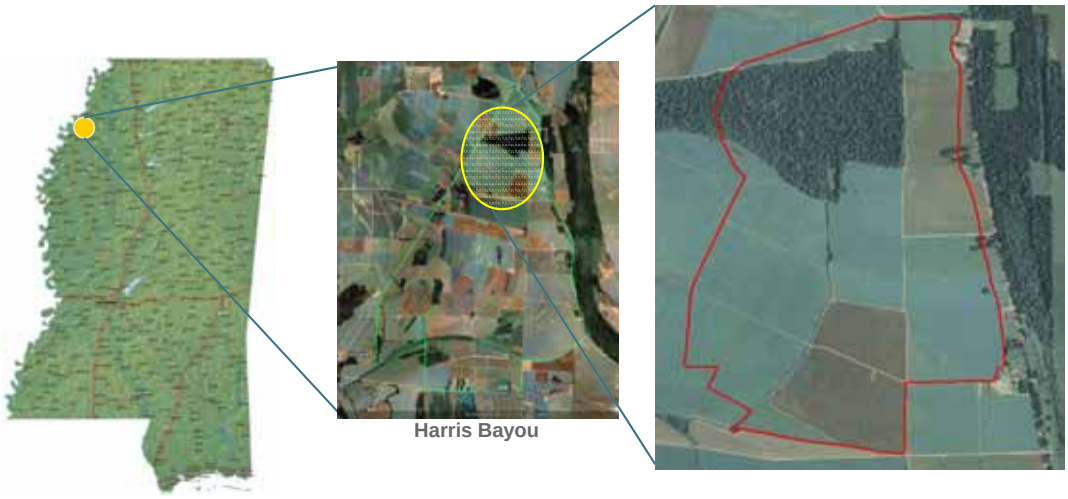
MODEL SETUP

Case study: Harris Bayou North Ditch Project

PROJECT DESCRIPTION... Location



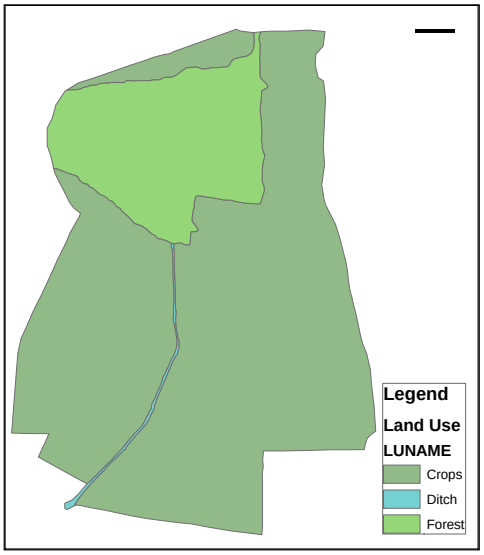
Harris Bayou

East Ditch Study Area

MODEL SETUP

Case study: Harris Bayou North Ditch Project

PROJECT DESCRIPTION... Land Use



The Harris Bayou North Ditch project involves a total area of 758.9 acres, including a ditch approximately 931.93 ft length, which receives the runoff from the study area.

The land use includes a 20% of the area in forest and 80 % in crops (Corn, soybean, and winter wheat).

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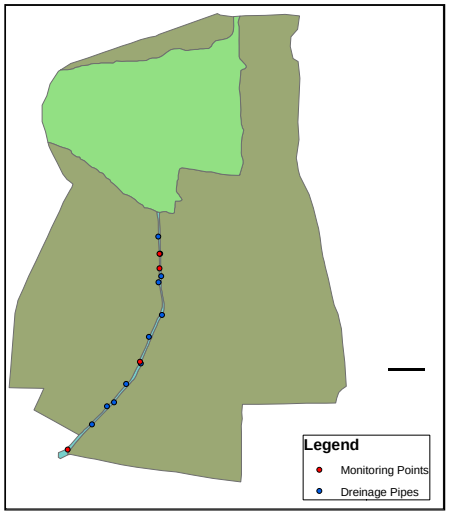
MODEL SETUP

Case study: Harris Bayou North Ditch Project

PROJECT DESCRIPTION... Setup



- BMP's : (3) Low grade weirs
- Monitoring Data: (4) Water samplers
  Water level probes
- Monitoring sites: (1) upstream in the ditch
  (3) Low grade weirs along the ditch
- Structures in the field: (11) Drainages tubes from fields to ditch

MODEL SETUP

Case study: Harris Bayou North Ditch Project

PROJECT OBJECTIVE

To determine the cost-effectiveness curve for the implementation of BMPs for **The Harris Bayou North Ditch project** in the Mississippi Delta (considering the number of weirs installed as a variable) using total suspended sediments and total phosphorus as control targets.

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MODEL SETUP

Case study: Harris Bayou North Ditch Project

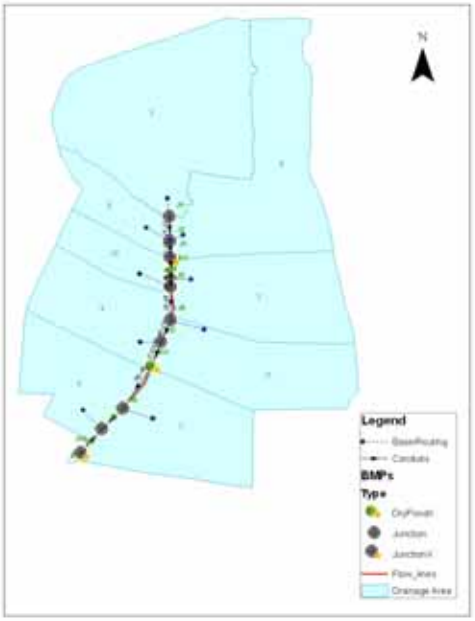
INPUT PARAMETERS

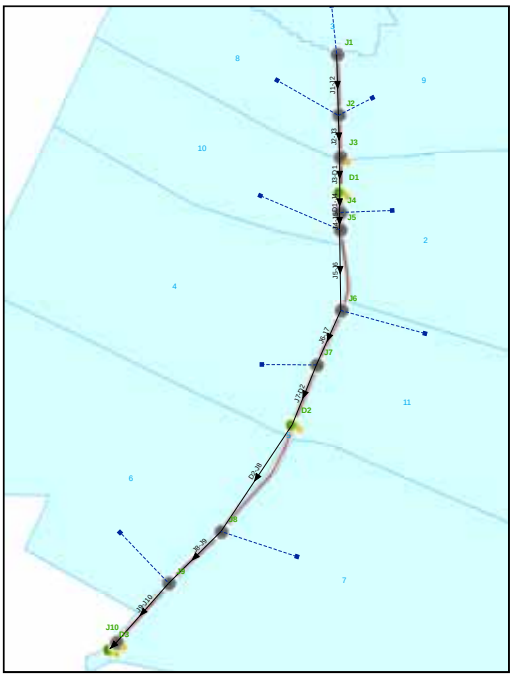
Parameter	Information included
Land Use	Forest and Crops
BMP repre	
Wea	)
Soil S	ld
Flow Routing	•Two stage channel.

Parameter		Information included
Simulation Type		Internal
Simulation Period		From April 2010 to September 2011
Data available for Calibration		Water level (December 2010 to September 2011)
		Grab and Storm sampling (analyzed for TSS and TIP)
		Flow. Computed using water level.

MODEL EVALUATION

Case study: Harris Bayou North Ditch Project





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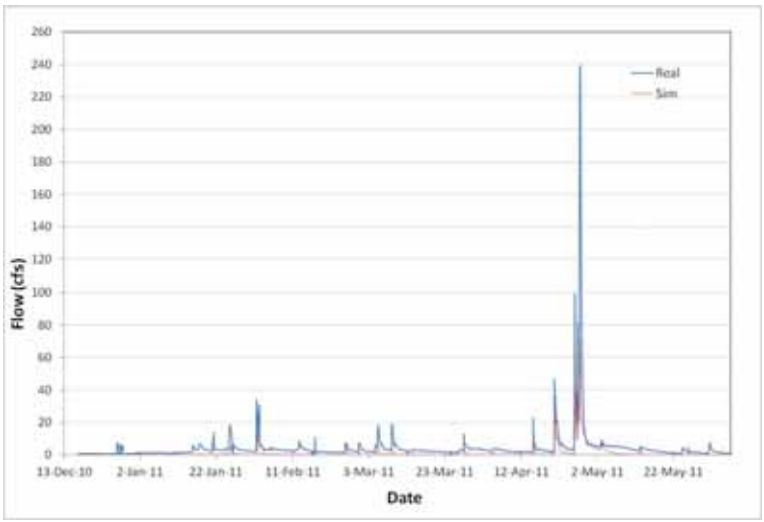
MODEL EVALUATION

Case study: Harris Bayou North Ditch Project

RESULTS ... Internal Simulation



When computing flows, the model is sub estimating the flows. It only represent runoff from the fields, and does not include base flow in the conduits.

MODEL EVALUATION

Case study: Harris Bayou North Ditch Project

RESULTS ... Internal Simulation

During calibration process (step needed prior to optimization) SUSTAIN model was unable to represent the real conditions of the study area. The model not succeed in representing the flow computed from field data.

- SUSTAIN model represents the runoff from the field, but does not have the ability of simulate a remaining flow in the ditch after stormflow events.

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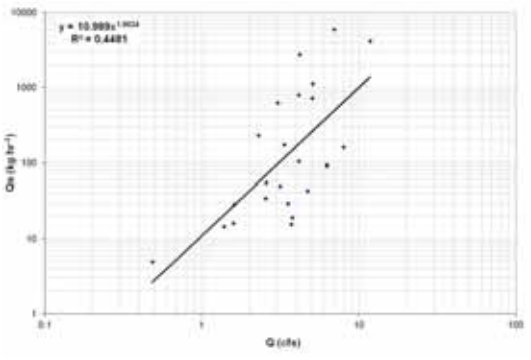
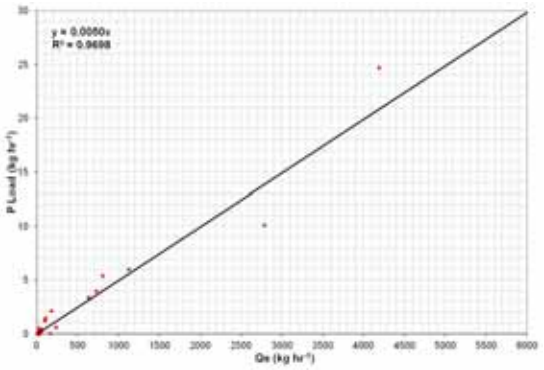
MODEL EVALUATION

Case study: Harris Bayou North Ditch Project

Alternative Solution for external simulation mode



Rating curve to generate sediment loads time series



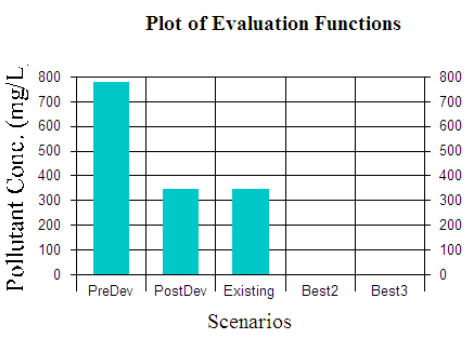
Rating curve to generate phosphorus loads time series

MODEL EVALUATION

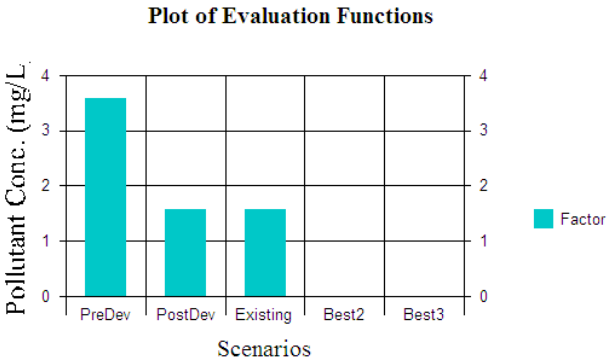
Case study: Harris Bayou North Ditch Project

RESULTS ... Alternative Solution

Weir 1



TSS



PHOSPHORUS

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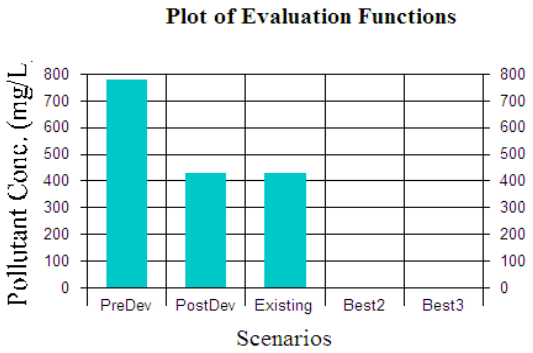
MODEL EVALUATION

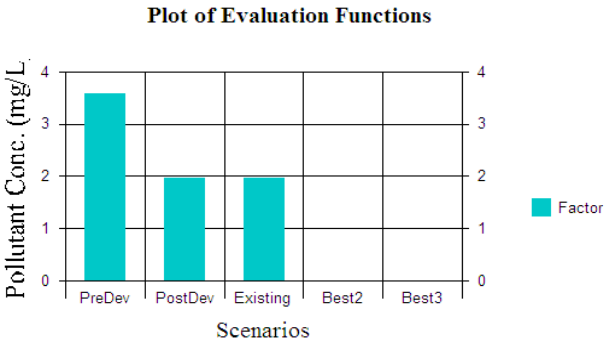
Case study: Harris Bayou North Ditch Project

RESULTS ... Alternative Solution

Weir 2



TSS



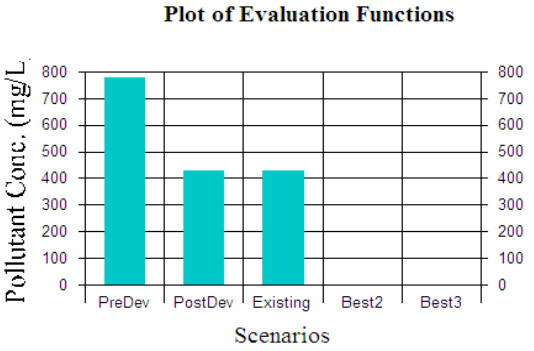
PHOSPHORUS

MODEL EVALUATION

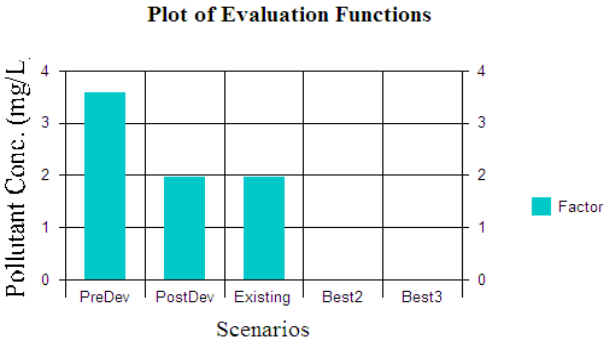
Case study: Harris Bayou North Ditch Project

RESULTS ... Alternative Solution

Weir 3



TSS



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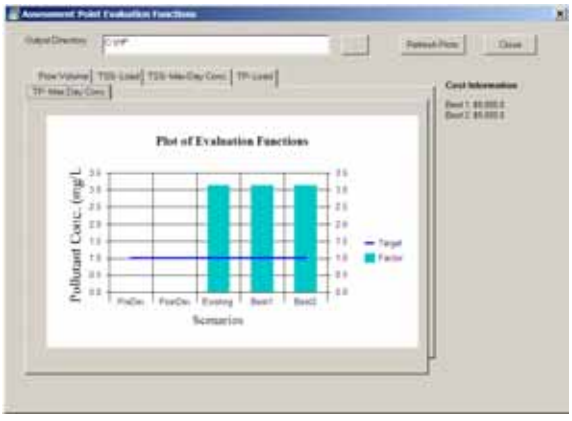
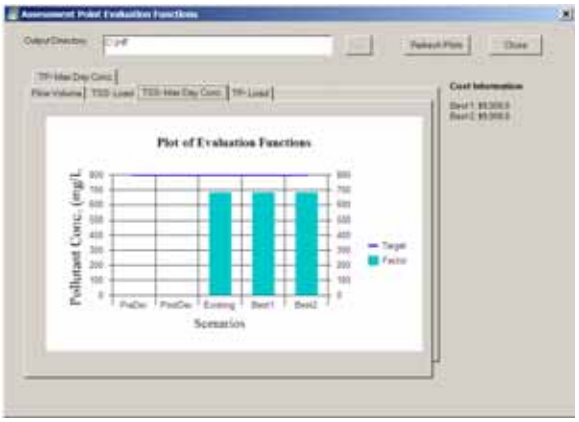
MODEL EVALUATION

Case study: Harris Bayou North Ditch Project

RESULTS ... Alternative Solution





Costs Optimization

MODEL EVALUATION

Case study: Harris Bayou North Ditch Project

LIMITATIONS... Under internal simulation mode

- SUSTAIN only runs under ArcGIS 9.3 v., **not new versions** !!!.
- The model does not represent some of the components properly. For example; when computing flows, the model only represent runoff from the fields, and does not include remaining flow along the conduits.
- First version limitations:

Limited information describing the setup process of the model, and how to work with some of its tools.

Multiple bugs (not documented) that make the model to crash before running, during the input file creation.

The model has options that can not be used with the current version, but it is not mentioned in any of the model documentation.

Excel spreadsheet post processor does not work properly.

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MODEL EVALUATION

Case study: Harris Bayou North Ditch Project

Steps Ahead

- Considering that one of the advantages of SUSTAIN is that it was designed to interface with external models. Time series will be generated by using HSPF/APEX an introduced to SUSTAIN by external simulation to make the optimization analysis.

Improve optimizaton by evaluating gradual change on BMP dimensions

- Prepare a documentation that compile all the limitations and problems (an possible solutions) found for SUSTAIN model version 1.0.

Thanks