Appendix I

Water Quality

U.S. Army Corps of Engineers
Memphis District

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Environmental Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Water Quality Analysis – St. Johns Bayou and New Madrid Floodway: 2012 Revision

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Special Report

Prepared for U.S. Army Engineer District, Memphis

Executive Summary

An analysis was conducted to update and refocus the supplemental assessment of water quality reported by Ashby et al. (2000). Overall, these results confirm those earlier findings. The purpose of this analysis and its predecessor was to describe potential, water quality impacts that may result from the proposed flood control project in the St. Johns Bayou and New Madrid Floodway. Existing water quality data from Federal and state resource agencies and literature-based information on land use effects on water quality were compiled for evaluation. Results of this evaluation were used to describe existing water quality conditions and, in conjunction with land cover and hydrology information, to estimate the transport of selected materials under the differing hydrologic regimes that would result from various project alternatives. This updated analysis agrees with the conclusions of Ashby et al. (2000).

In Ashby et al. (2000), spreadsheet calculations were used to assess relative impacts with and without the project. The rationale for inputs and assumptions in the spreadsheets was discussed with representatives of Federal and state agencies prior to application. In this revision, those earlier assumptions and inputs are carried forward.

Water quality in the project area reflects conditions typical for landscapes dominated by agriculture. In general, nutrient concentrations (with the exception of phosphorus) were not excessively high except during periods of elevated flow, and basin concentrations did not differ substantially from observations for the Mississippi River. As expected, sediment concentrations were generally lower than concentrations in the Mississippi River and increased with runoff. Point sources were the most notable sources of extremes (high nutrients or low dissolved oxygen concentrations).

Material transport differs among constituents and project alternatives, but overall the basin is expected to retain (or remove) material from headwaters and floodwaters during periods of inundation. The authorized project alternatives tend to increase this retention. However, in most years, and during most of each year there is no significant inundation and the overall, long-term functioning of the project area will be to export nutrients and sediment to the Mississippi River.

Based on mass-balance considerations, the impacts of the authorized project on the water quality in the Mississippi River are not expected to be discernible. Further, the project is expected to result in a net reduction in the delivery of nutrients and sediment to the Mississippi River from the project area.

The situation with regard to project impacts at Big Oak Tree State Park has changed dramatically since the previous study. Ashby et al. (2000) concluded that potential impacts to Big Oak Tree State Park from the authorized project were most likely to result from decreased supply of sediments and a decline in sustainability of the site because groundwater was to be used to provide seasonal flooding. However, the plan for mitigation (Section 1.4.2 of Draft EIS) has been altered and now calls for hydrologic reconnection of the Park to the Mississippi River main stem during high water. The park will thus re-experience the natural flood and sedimentation regime; concerns related to the use of groundwater are eliminated, and the park will now serve as a trap for sediments and nutrients that enter the park with Mississippi River floodwaters.

The authorized project, with or without the avoid-and-minimize alternatives, is expected to reduce, or not significantly change, the export of materials from the project area into the Mississippi River. This is a generally positive ecological effect. Further, the limited water quality data that exists for water bodies within the project area give no indication that the project will degrade water quality in these water bodies. Consequently there is little to indicate that additional, water quality, mitigation measures are needed. Mitigation associated with the project that is planned for habitat purposes (e.g., Big Oak Tree State Park) are anticipated to have water quality benefits, but they will not be detectable.

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Preface

This study was conducted for the U. S. Army Engineer District by the Environmental Laboratory, U.S. Army Engineer Research and Development Center. At the time of publication, Dr. Mark Farr was Chief, CEERD-EP-P; Warren Lorentz was Chief, CEERD-EPD; and Patrick Deliman was the Technical Director. The Director of ERDC-EL was Dr. Beth Fleming.

COL Kevin J. Wilson was the Commander and Executive Director of ERDC, and Dr. Jeffery P. Holland was the Director.

Unit Conversion Factors

Multiply	By	To Obtain
Acres	4,046.873	square meters
acre-feet	1,233.5	cubic meters
angstroms	0.1	nanometers
atmosphere (standard)	101.325	kilopascals
Bars	100	kilopascals
British thermal units (International Table)	1,055.056	joules
centipoises	0.001	pascal seconds
centistokes	1.0 E-06	square meters per second
cubic feet	0.02831685	cubic meters
cubic inches	1.6387064 E-05	cubic meters
cubic yards	0.7645549	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
fathoms	1.8288	meters
Feet	0.3048	meters
foot-pounds force	1.355818	joules
gallons (U.S. liquid)	3.785412 E-03	cubic meters
hectares	1.0 E+04	square meters
horsepower (550 foot-pounds force per second)	745.6999	watts
inches	0.0254	meters
inch-pounds (force)	0.1129848	newton meters
kilotons (nuclear equivalent of TNT)	4.184	terajoules
Knots	0.5144444	meters per second
microinches	0.0254	micrometers
microns	1.0 E-06	meters
miles (nautical)	1,852	meters
miles (U.S. statute)	1,609.347	meters
miles per hour	0.44704	meters per second
Mils	0.0254	millimeters
ounces (mass)	0.02834952	kilograms
ounces (U.S. fluid)	2.957353 E-05	cubic meters

Multiply	By	To Obtain
pints (U.S. liquid)	4.73176 E-04	cubic meters
pints (U.S. liquid)	0.473176	liters
pounds (force)	4.448222	newtons
pounds (force) per foot	14.59390	newtons per meter
pounds (force) per inch	175.1268	newtons per meter
pounds (force) per square foot	47.88026	pascals
pounds (force) per square inch	6.894757	kilopascals
pounds (mass)	0.45359237	kilograms
pounds (mass) per cubic foot	16.01846	kilograms per cubic meter
pounds (mass) per cubic inch	2.757990 E+04	kilograms per cubic meter
pounds (mass) per square foot	4.882428	kilograms per square meter
pounds (mass) per square yard	0.542492	kilograms per square meter
quarts (U.S. liquid)	9.463529 E-04	cubic meters
Slugs	14.59390	kilograms
square feet	0.09290304	square meters
square inches	6.4516 E-04	square meters
square miles	2.589998 E+06	square meters
square yards	0.8361274	square meters
tons (force)	8,896.443	newtons
tons (force) per square foot	95.76052	kilopascals
tons (long) per cubic yard	1,328.939	kilograms per cubic meter
tons (nuclear equivalent of TNT)	4.184 E+09	joules
tons (2,000 pounds, mass)	907.1847	kilograms
tons (2,000 pounds, mass) per square foot	9,764.856	kilograms per square meter
Yards	0.9144	meters

1 Introduction

The St. Johns Bayou and New Madrid Floodway project was authorized for construction by the Water Resources Development Act of 1986 (PL 99-662). The project will close the gap in the Mississippi River levee in New Madrid, Mississippi, and Scott Counties in Missouri. The primary purpose of the project is to provide flood control in the St. Johns Bayou Basin and the New Madrid Floodway. The project is designed to eliminate the physical and economic barriers created by frequent flooding in East Prairie, Missouri, and the surrounding area. The project includes channel enlargements and a 1,000-cfs1 pumping station for the St. Johns Bayou Basin and closure of a 1,500-ft gap in the levee and a 1,500-cfs pumping station in the New Madrid Floodway. Complete details of the project are provided in the Environmental Impact Statement (EIS) by the U.S. Army Corps of Engineers, Memphis District (2011).

Areas of controversy early in the project development process included potential impacts on the hydrology and water quality associated with closure of the 1,500-ft gap in the levee. Water quality concerns included the potential impacts of changed hydrology on material transport into and out of the project area, change in pesticide application associated with potential changes in agricultural land use, and impacts to Big Oak Tree State Park, which under the original project design would no longer receive periodic floodwaters from the Mississippi River. However, the current project design calls for hydrologic reconnection of the State Park to the Mississippi River main stem, and the current version of the project should have strong positive effects on the Park. Concerns about material transport were centered on the potential loss of wetland functions that improve water quality of floodwaters and the relationship of this potential loss to the overall water quality of the Mississippi River and the hypoxic zone in the Gulf of Mexico. This analysis revisits that issue.

The objective of the previous study (Ashby et al. 2000) was to compile sufficient water quality data to evaluate the primary concerns relative to the project alternatives. The issues have changed somewhat as seasonal flooding of Big Oak Tree State Park is now intended to use Mississippi River water and follow the natural hydrograph (instead of pumped ground water). The specific objectives from the earlier work that remain relevant include:

- Describe the general water quality in the project area with the most recent available data.
- Qualify the effects of hydrologic changes on water quality for both the area impacted by the proposed project and in relationship to the overall water quality of the Mississippi River.
- Determine the potential effects on water quality associated with potential changes in pesticide use.

The present study revises the work reported by Ashby et al. (2000) and is based on an expanded hydrologic period of record that extends from 1 Oct, 1942 to 12 Nov, 2009 (67 years). Four, differing scenarios that involve the water level regime (existing conditions, authorized project authorized project with added avoid and minimize features, and modified hydrology with elimination of agriculture) were considered for the New Madrid Floodway. Two such scenarios (existing condition and authorized project) were considered for Saint Johns Bayou (avoid and minimize actions are not expected to have substantial, added influence on the water levels). The existing (without project) condition for both basins was represented by the actual, daily, hydrologic data and project alternatives were evaluated using simulated daily water elevations provided by the Memphis District.

2 Methods

Ashby et al. (2000) assessed the potential for project impacts on water by compilation of existing data, evaluation of applicable water quality constituents, and an assessment of potential impacts based on relative changes in mass associated with representative hydrologic conditions with and without the project. In order to describe potential relative changes in mass export of selected water quality constituents, a literature review was conducted to describe general conditions of nutrient transport for wetlands and agricultural lands. Processing (i.e., retention or transport) of constituents was then estimated based on the expected flux of material. The current study expanded on that previous effort by searching for more current data (little was found), expanding the hydrologic period of record to 67 years, and using a modified approach for the analysis of export (SAS software code replaced the spreadsheet).

2.1 Water Quality Assessments

Data collection (Ashby et al. 2000, Appendix A) included a retrieval of water quality data from EPA's Storage and Retrieval System (STORET), and data requests from the University of Missouri Agricultural Research Extension Service, the U.S. Geological Survey (USGS), MDNR, and the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS).

Data retrieved from sources other than STORET were compared to STORET data to ensure that data were not duplicated. Results of data retrievals were compiled into a database (Ashby et al. 2000, Appendix B) for subsequent analyses.

For this revision, the data search was repeated, but newer data were indentified and obtained from only one, additional, surface water monitoring location (St. Johns Ditch at Henderson's Mound, USGS site 07042450).

2.2 Effects of Project on Material Exports

The water quality analysis reported by Ashby et al. (2000) was revised with updated land cover data (provided by the Memphis District), an expanded hydrologic period of record, and a modified approach that uses the actual (or simulated) daily water elevations and places the export of material from the project area into a more complete context. In this revision, instead of evaluating five, representative hydrologic scenarios, the extent and duration of inundation in each season within the 67- year period of record was evaluated under each project alternative to produce a time-series (yearly interval) of exports. Further, the analysis now fully incorporates export from the land within the project area that remains above the level of inundation in each season. This approach allows the influence of various project alternatives to be viewed within the context of total export from the project area. The approach used previously emphasized the relative differences between alternatives. In both the original and revised analysis, only the period of potential inundation (November through May) is addressed directly as this is the period that the proposed project will influence with regard to water levels.

To make use of detailed (daily) hydrologic data (and simulations), and to improve the overall transparency of the analyses, SAS® program code was used to implement the equations from the spreadsheet used by Ashby et al. (2000). Some advantages to this approach are that; (1) the results are calculated as a time-series that can be more easily visualized, (2) the equations and parameters used in the calculations are centralized into a few tables and a series of sequential steps that can be viewed in text form, and (3) the modification of inputs and assumptions is greatly simplified compared with a spreadsheet approach.

A significant change from the approach used in Ashby et al. (2000) was a calculation of the actual 30-day inundation contour on each day in the period of record. In this process, the highest elevation that had been submerged continuously for at least the previous 30 days was identified on each date. These 30-day contours were then screened to determine the maximum 30-day contour for each flood season (two seasons per year). The calculations of export then assumed that all area below this peak contour during the season would behave as "flooded" land and that all areas above it would function as "dry land" during the season. A major advantage to this approach is that it allows us to evaluate the estimated export under the actual, existing condition and compare it to the export expected under any altered (i.e., project) hydrograph. Secondly, this approach computes both the dry land and inundation export/trapping during each season within the inundation period (Nov-May), so that a net, total export for the two inundation periods (seasons) in each year can be calculated separately with differing parameters as appropriate and then summed within each water year to create a time series based on 67 individual years that can then be used for statistical analyses.

In both the previous analysis and the current revision, hydrologic and land cover data were used in conjunction with water quality data to develop export estimates for each basin and each of two "seasons" under differing hydrologic regimes. The estimates were based on water volumes and acres of each land cover type found beneath each one-foot elevation contour (Appendix C). Material transport estimates were then calculated using expected loads and wetland function factors to yield a value, referred to as wetland retention ("wetland function value" in Ashby et al 2000). Wetland retention is thus an estimate of the material that is retained by the land cover (i.e., removed from the floodwater) during inundation. It can be negative or positive depending on whether flooding of an area provokes removal or addition of material.

As in Ashby et al. (2000), the approach was applied separately to the St. Johns Bayou area and the New Madrid Floodway. Two seasons were defined based on proposed changes in the inundation due to flooding. Increased inundation from watershed inputs, associated with proposed changes to winter waterfowl habitat, was used for season 1 (November – January). In season 2 (February - May), decreased inundation is expected as a result of the project removing watershed discharges and preventing Mississippi River backwater flooding.

Calculations in season 2 for both basins assume that backwater flooding retained for waterfowl (season 1) will be partially removed via pumping/gravity flow. Further, it is assumed that Mississippi River water will be allowed to enter into the project level to some extent. The concentration used in the calculations is an expected flood water value based on a review of existing water quality data for both water sources (Mississippi River and Headwater).

In the original analysis, loading estimates were calculated for each scenario using estimated concentrations for two sources of floodwater (i.e., the headwaters and Mississippi River water) derived from the database and wetland function factors. A literature review was conducted to develop general ranges of wetland water quality functions and export coefficients for runoff from upland and agricultural lands. Discussions with a water quality specialist with the USGS and agricultural experts at the University of Missouri Delta Research Center were also conducted to provide input into the development of function factors used in the analyses. The function factors from this previous effort were carried forward in their entirety into this revision.

Ashby et al. (2000) developed wetland function factors for two general types of land covers, (a) those that are described as wetlands, and (b) upland and agricultural lands that are flooded. The first step in assigning a wetland function factor was to determine if the land cover would generally remove materials from the floodwater or export to the floodwater more material than it retained. A negative value was assigned for net removal and a positive value was assigned for net export. As an initial classification, land covers that can be considered as wetlands (cypress/tupelo, scrub/shrub marsh, marsh, bottomland hardwood, riparian, sandbars, open water, and rivers) were assigned a negative function factor for each constituent (except for carbon as described below). Upland and agricultural lands, when flooded, were considered to remove material via sedimentation but also to export material via perturbations to the land associated with farming practices and crop type for a positive net export. The rationale for wetland function factors and export coefficients and the vetting of these values with stakeholders and regional experts are described in Ashby et al. (2000).

2.3 Overview of Water Quality Processes in Wetlands

General information on the impacts of wetland hydrology and wetland type was used to assign wetland function factors, although it is recognized that responses in material cycling are often quite variable. For example, wetlands subjected to different flooding regimes provide a different response for some processes. Litter decomposition can be slightly higher in manipulated (pumping) areas than in natural and impounded wetlands (Conner and Day 1991). In natural and impounded areas, nitrogen was immobilized during spring and summer but mineralized in the manipulated area during the same period (Conner and Day 1991). Phosphorus was not immobilized in the natural and impounded area but was mineralized at a slower rate than in the managed area (Conner and Day 1991). The general conclusion was that burial, or net accumulation of organic matter, nitrogen, and phosphorus, was more prevalent in stagnant, more flooded areas, and mineralization and/or export was greater for the managed areas. Significant removal of nitrogen has been observed for alluvial floodplains (Brinson, Bradshaw, and Kane 1984) and forested wetlands (e.g., bottomland hardwoods in the Atchafalaya Basin flooded for 67 days (Lindau, DeLaune, and Pardue 1994). Removal of total phosphorus by various types of wetlands can also be significant. Kadlec (1997) observed a 94 to 99 percent reduction in total phosphorus concentrations in wastewaters that were subjected to wetland treatments. Often, removal may be attributed to sedimentation of particulate phosphorus, which can be the dominant phase (Lindau, DeLaune, and Pardue 1994). However, relationships of small upland wetlands to the watershed can be highly variable depending on watershed conditions and runoff events. In a watershed that is primarily pasture for sheep grazing, the receiving wetland retained 23 percent of the nitrogen and 38 percent of the phosphorus entering the system (Raisin 1996). Sediment retention is also highly variable and averages about 30 percent of the total entering with a maximum retention of about 95 percent (numerous studies summarized in Adamus et al. 1991). In riparian zones, denitrification is also an important removal process (Pinay and Decamps 1988). Nitrate loss in riparian zones can be as much as 50 to 100 percent in headwater streams with only 15 percent removal associated with sediments (Cooper 1990). As observed for other wetland types (Raisin 1996), retention function of riparian buffers varies with width and frequency of gaps (Weller, Jordan, and Correl 1998). In open water systems and rivers with sandbars, nitrogen and phosphorus removal processes are also occurring but probably to a lesser extent than in vegetated wetland systems such as marshes, swamps, and bottomland hardwoods. More variable hydrologic regimes in the latter systems would tend to increase the transport of materials and result in higher removal rates. Results of intensive studies conducted in the Cache River system in northeastern Arkansas provide relative information on wetland processes for a system in the immediate vicinity of the study area and may be used to provide better estimates of wetland function factors. For example, DeLaune et al. (1996) measured nitrate reductions between 59 and 82 percent, which are consistent with studies described above. Conversely, Dortch (1996) estimated removal efficiencies of 29.5 percent for inorganic suspended solids, 21.4 percent for total nitrogen, and only 3 percent for total phosphorus. These values are probably lower than would be expected in the study area since they were calculated for a flow-through system and represent annual conditions. However, backwater flooding of bottomland hardwood systems during winter and spring may be less effective at nutrient transformation and removal since biological activity is greatly reduced during these seasons (Harris and Gosselink 1990) and estimates from Dortch (1996) may not be that low. Kleiss (1996) estimated a 14 percent decrease in suspended sediment load, which is also lower than would be expected for the study area due to the anticipated hydrology of a gradual flooding and dewatering. However, review of the 1993 flood data for the Mississippi River upstream of the study area (Holmes 1993) indicated that there was little sedimentation in the backwater areas downstream of St. Louis, MO, and a decrease of only 10 to 20 percent may be reasonable.

Wetland function factors for wetland land covers were estimated from the above information, in consultation with wetland experts when possible, and were reviewed by representatives from the Memphis District, EPA, FWS, and MDNR (see Ashby et al. 2000, Table 4). In general, the wetland function factor is an estimation of the percentage of mass of the constituent (nitrogen, phosphorus, carbon, and sediment) that will be retained by (including removal) or transported to the system. This value is usually measured from a mass balance approach and accounts for material already in the land cover. Vegetated wetland types were considered to be similar in removal efficiencies and more efficient than non-vegetated or sparsely vegetated types (e.g., open water, rivers, and sandbars). Values assigned were based on estimates from references noted in Table 4 of Ashby et al. (2000). We reexamined these values, but found no strong justification for altering them from the original values. Further, we were reluctant to make changes that would alter the fundamental, underlying assumptions of the previous analyses and render comparisons with that earlier work more problematic. Values for wetland types where little information was available were assigned relative to values used for cypress/tupelo systems. For many of the land covers, carbon was assumed to be converted to dissolved forms and easily transported, so a positive function factor is suggested. Observations in bottomland hardwood systems in Mississippi (Ashby et al. 1991) and other systems (Harris and Gosselink 1990) support this assumption.

2.4 Estimation of Upland and Agricultural Export Coefficients in Wetlands

Wetland function factors or export coefficients for periodically flooded upland and agricultural land covers have not been developed. Consequently, consideration of material from two sources, (a) material available for export from the land (traditionally measured as export coefficients), and (b) removal from or export to the floodwaters (such as processes observed for wetlands), is required. Export loads for nitrogen, phosphorus, sediment, and carbon were estimated using initial export coefficients (EC) (Beaulac and Reckhow 1982; Peterjohn and Correll 1984; Lowrance et al. 1984), soil fertility measurements (University of Missouri 1996), and representative concentrations. The initial export load was adjusted to account for changes in the availability of material associated with flooding versus runoff. Based on discussions with agricultural experts in the study area, relatively low slopes in the area (1 to 2 ft/mile, Luckey and Fuller 1984), and gradual changes in stage height with flooding and receding, sediment export from the upland and agricultural land covers is expected to be relatively low. Phosphorus concentrations in the soils are relatively high (23 to >70 lb/acre) and similar by cropping options (University of Missouri 1996) but are considered to be less mobile than nitrogen due to a lower solubility. Nitrate does not attach to soil particles but remains soluble and is easily transported with water (Killpack and Buchholz 1993) both as surface flow and subsurface flow. Legume crops such as soybeans can add up to 30 to 50 lb/acre of nitrogen in the study area (Killback and Buchholz 1993) and would result in a higher export coefficient than for other crop types.

These factors were used to adjust the export coefficient (EC), and an individual load was then calculated for each constituent. The individual load for each constituent was then added to the load associated with the floodwaters for estimation of the total load available. Since estimates of loads account for processes that impact concentrations and mass, a wetland function factor of positive 1 is assigned to all upland and agricultural land covers (i.e., 100 percent of the estimated load is available for transport when the floodwaters recede). The net yield is then calculated by reducing the load associated with floodwaters by 10 percent to describe losses from sedimentation.

2.4.1 Nitrogen and Phosphorus

Export coefficients from Beaulac and Reckhow (1982) were used to estimate initial export loads for nitrogen and phosphorus. The median value of the export coefficient was considered as the initial mass available for export. Land covers in the study area that were not represented by those in Beaulac and Reckhow (1982) were assigned a value from a similar land cover. Because the literature-based loads represent annual loads, the initial estimated loads are reduced by a percentage that estimates the available load during the period of flooding. It was recommended that the initial nitrogen load be reduced by 25 percent and the initial phosphorus load be reduced by 50 percent. The rationale for these reductions is based on an expected decrease in the annual export coefficient because consideration is given to the wet period only and a higher particulate phase for phosphorus than for nitrogen. Adjusted export coefficients represent the amount exported for the period of inundation.

Calculation of export coefficients for nitrogen and phosphorus for various land covers is described in Ashby et al (2000, page 8-9).

2.4.2 Carbon

Carbon transport was considered to occur primarily as dissolved organic carbon since there is a considerable amount of tillage and burning of residue which would greatly reduce the export of particulate organic carbon. Export of carbon was based on dissolved carbon concentrations, soil fertility measurements, and export coefficients. Organic matter content in the study area ranges from 1 to 3 percent (University of Missouri 1996). Runoff coefficients for individual land covers were not available and estimates from Peterjohn and Correll (1984) were highly variable, 58.2 to 61.3. A winter value of 3.6 kg/ha (Peterjohn and Correll 1984) was considered representative and an adjustment to account for land cover was not applied.

2.4.3 Sediment

Export of sediment was based on suspended sediment concentrations (USGS data and STORET data) and reported daily loads (Holmes 1993). Sediment retention during inundation was estimated to be 10 percent since there is little evidence of sediment deposition following flooding in the study area. Suspended sediment concentrations were highly variable and ranged from 45 to 451 mg/L . Holmes (1993) reported a mean daily concentration of 317 mg/L and median daily load of 717,000 tons/day for the 1993 flood (measured in the Mississippi River at Thebes, IL). Corresponding values of 302 mg/L and 139,000 tons/day were presented for the period of record. These concentrations were somewhat higher than concentrations observed in the headwater region (e.g., USGS data from Morehouse, station 7024070); therefore, instantaneous sediment loads were estimated at 4.63 kg/sec based on concentrations and discharge measurements. A 60-day period of rain was used to calculate the total load which was then divided by the total area (184,855 ha) to estimate the initial export coefficient.

2.4.4 Calculation of Exports

In 2000, Ashby et al. determined from discussions with Fish and Wildlife Service personnel and agricultural experts that export coefficients for with- and without-project condition would be more representative if transport from the system prior to inundation (existing conditions) was considered. We found no reason to revise that assumption. Under existing conditions, rainfall in November and December can result in high runoff or export. With the project in place, this same period results in retention of rainfall and a decrease in export. Therefore, export coefficients for “with-project” conditions were reduced by 50 percent to account for decreased transport from the project area prior to flood inundation. Material retained or transported in the upland or agricultural land was then calculated in the spreadsheet using the following equations. Appropriate conversions were made to express mass in kilograms and runoff in kilograms per acre.

For export from inundated areas, the volume of water overlying each land cover type from project minimum elevation (260 ft for St. Johns and 263 ft for New Madrid) to seasonal peak elevation is calculated by summing over elevation increments for each basin as:

$$V_{lc} = \sum (A_{zlc} \times V_z) \qquad (1)$$

∑ is from z=project minimum to z=peak seasonal elevation

Where

V_{lc} = total volume (acre-ft) overlying a specific land cover type (lc) at peak inundation

A_{zlc} = area (acres) of selected land cover type (lc) at a selected elevation (z)

V_z = volume increment (acre-ft) per unit area (acre) extending upward from a selected elevation (z) to the elevation of seasonal peak inundation.

The total export (kg) of a selected constituent (total phosphorus, total nitrogen, or sediment) when flood waters retreat from inundated areas is calculated as:

$$Load_c = k \times C \times V_{lc} \qquad (2)$$

Where:

$Load_c$ = mass (kg) of constituent (c) exported during drawdown of flood waters.
k = factor (1.233) that converts mg/L × acre-ft to kg
C = concentration of constituent (mg/L) in flood water.

For areas that are not inundated (i.e., “dry land”) the export is calculated from a seasonal export coefficient (kg/acre) and summing across land cover types as:

$$Load_d = \sum A_{lc} \times EC_{lc} \qquad (3)$$

Where:

$Load_d$ = mass (kg) of constituent (c) exported during periods without inundation

A_{lc} = Total area (acres) of a specific land cover type above the 30-day, seasonal inundation contour

EC_{lc} = seasonal export coefficient (kg/acre) for selected land cover type and constituent. Note that $EC = EC \times 0.5$ with project in place (Ashby 2000).

The total export for a given land cover type is the sum of export under inundation and dry land adjusted for retention effects as appropriate:

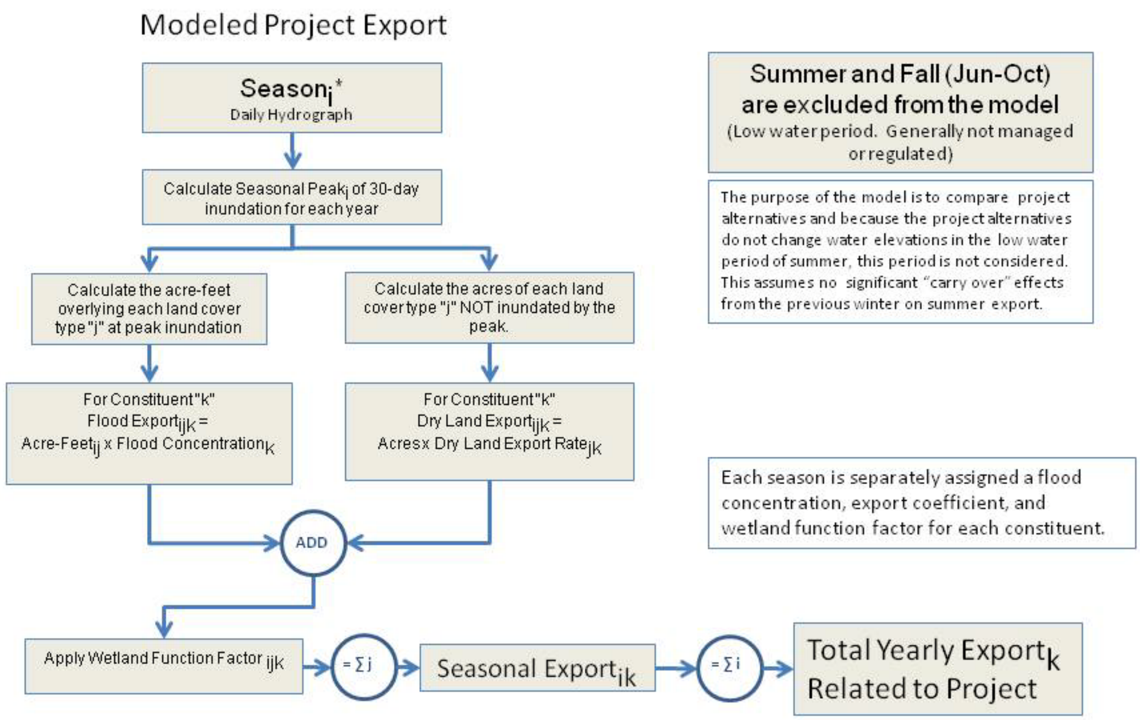
$$\text{Load} = \text{Load}_c + \text{Load}_d \quad (4)$$

$$\text{Wetland Retention (kg)} = \text{Load} \times \text{Wetland Function Factor} \quad (5)$$

$$\text{Net Yield}_{wetland} = \text{Load} - \text{Wetland Retention} \quad (6)$$

$$\text{Net Yield}_{upland} = (\text{Load}_d \times 0.90) - \text{Wetland Retention} \quad (7)$$

The calculation for upland areas assumes a 10 percent reduction in the load due to sedimentation during transport.



*Season 1 (Early Winter) is November-Jan (Ashby et al. 2000). In this season some tributary water is retained by the project for water fowl enhancement.
Season 2 (Late Winter) is Feb-May (Ashby et al. 2000). In this season the project discharges tributary flows to the Mississippi and reduces Mississippi River flood peaks in the project area.

Figure 1. Diagram of calculations used to estimate constituent export in two parts of the inundation season (Nov – May) .

2.5 Evaluation of Project Impacts on Water Quality of the Mississippi River

Ashby et al. (2000) evaluated the potential impacts on water quality in the Mississippi River using the output from the export spreadsheet and a water balance. The water balance included discharge data from 1943 to 1974 and from 1975 to 1998. Although a longer period of record is now available for this analysis, the 23 year record that was used still provides a good representation of the average condition, and the results of that analysis are robust to relatively minor changes in the long-term hydrology. Consequently, this earlier approach and the result were not revised. In summary, the earlier approach used the limited water quality data for the Mississippi River that were available from Hickman, KY, for 1969 and 1970 and from Thebes, IL, for 1994 through 1998. Data from

USGS stations at New Madrid and Caruthersville, MO, were not applicable. While the data from Hickman are not very recent, and the data from Thebes represent values upstream from the confluence of the Mississippi River and the Ohio River, these data were the best available.

Existing conditions allow for periodic movement of water from the Mississippi River into the project area and result in mixing with headwaters in the area, and transport of material into and out of the project area. Hydrologic information provided by the Memphis District indicated that monthly mean flows were highly variable from 1943 to 1974 and from 1975 to 1998. Mean values of 800,000 and 700,000 cfs were considered to represent volumes that would provide floodwaters at elevations of 290 and 282 ft, respectively. A period of 5 days was considered to represent the time of inundation of a representative flood, and relative volumes of headwaters and Mississippi River waters were then calculated for the flooded area. Concentrations for nitrogen, phosphorus, organic carbon, and suspended sediments for the headwaters and the Mississippi River were then multiplied by relative volumes to determine total mass available for each volume. The expected percent removed for each basin was then applied to the total mass available in the appropriate basin, and the difference to the total mass available in the Mississippi River was then expressed as a percentage.

2.6 Evaluation of Potential Changes in Pesticide Usage on Water Quality

Ashby et al. (2000) conducted a literature review to describe the transport of herbicides in surface and subsurface drainages in the region. They also evaluated potential changes in pesticide use and pesticide impact on water quality based on existing water quality data for existing conditions (current practices and existing acreage) and a qualitative extrapolation of potential increase in pesticide usage under the authorized project. They determined that identification of the potential pesticide impact using a spreadsheet analysis was inappropriate because there are limited data that show measurable concentrations in the study area. Experts at the University of Missouri Delta Research and Extension Service were consulted on potential changes in crops, pesticide application rates, and pesticide interactions with crop types and soils. Data used to assess pesticide concentrations in the project area were extracted from the STORET retrieval database. Data from the USGS

National Water-Quality Assessment (NAWQA) study and well-water data from the USDA NRCS were also evaluated. Summary statistics for water quality data from surface sites were presented in Ashby et al (Appendix B; 2000) for detected pesticides. Pesticide data from the NRCS study and the NAWQA data (Morehouse and Rives stations) were also included in their Appendix B. Records from public drinking supplies in the area were also evaluated. Parameters with measurable concentrations at Morehouse were evaluated for application rates using distribution maps from the NAWQA Pesticide National Synthesis Project available at http://water.wr.usgs.gov/pnsp.

2.7 Evaluation of Potential Impacts to Big Oak Tree State Park

The previous analyses by Ashby et al. (2000) that assessed the potential impacts of the authorized project on Big Oak Tree State Park are no longer applicable, as the planned operation of the project no longer includes pumping of groundwater to create seasonal flooding. Instead, the design now calls for reconnection of the Park with the main stem of the River so that the natural flooding regime is restored. A strong, positive effect of this on the ecology within the Park is anticipated. Further, because the Park will now serve as a trap (sink) for sediment and nutrients delivered from the Mississippi River main stem during natural high water, the plan for the Park under the authorized project will have a net positive (albeit non-detectable) influence on water quality in the Mississippi River.

3 Results

The analyses presented here are intended as an update and revision of those presented by Ashby et al. (2000). Consequently, an attempt is made only to present enough of those previous results to allow interpretation of these revisions without continuous reference to the earlier work. Many of those earlier findings are still fully applicable and were not revised here, but are summarized briefly for reference.

3.1 Existing Conditions

3.1.1 Water Quality in Surface Waters

Water quality in the surface waters reflects current land use practices that are predominantly agriculture operations (e.g., row crops). The most detailed data for assessing existing conditions were collected in 1994-1998 as part of the National Water Quality Assessment Program (NAWQA) conducted by the USGS and summarized in Ashby et al. (2000). Water quality observations exhibited seasonal patterns and the influence of flow regime. In general, temperature and dissolved oxygen concentrations fluctuated by season with dissolved oxygen concentrations near 4-6 mg/l in mid-summer. Nitrate/nitrite concentrations were typically less that 2 mg/l in surface waters. Total phosphorus concentrations were quite variable with relatively high values often occurring greater than 0.1 mg/l. Total organic carbon values were mostly less than 2 mg/l with higher values on occasion. Suspended sediments accounted for approximately 58% of the total residue and varied between less than 100 mg/l to values near 300 to 400 mg/l. In 2006, two sites were identified on the 303(d) list in the project area. These sites were a site on the Mississippi River (Water Body IDs: 1707 & 3152) for chlordane and PCBs and Spillway Ditch (Water Body ID: 3134) for sediment (habitat loss).

A query of state agencies and Federal databases resulted in only one station in the project area with recent water quality data. St. Johns Ditch at Henderson Mound, MO, site # 7042450 – New Madrid County has been sampled approximately monthly between 1999 and 2010 for temperature, dissolved oxygen, pH and hardness, suspended and dissolved solids, total nitrogen, total phosphorus, and discharge by the USGS. Discharge reflected seasonal and annual variability with values ranging from near 0 to over 2000 cubic feet per second (Figure 1, bottom panel). In general, dissolved oxygen concentrations were similar to observations between 1994 and 1998 of the NAWQA study. Temperatures varied seasonal with maximum values near 25 – 30 OC (Figure 1-B). Dissolved oxygen concentrations varied between near 4 mg/l and over 9 mg/l (Figure 1-C). Values of pH were mostly between 7 and 8 standard units with hardness concentrations near 125 mg/l with occasional lower values coincident with increased discharge (Figure 1-A). Suspended solids concentrations were predominantly below 50 mg/l except during periods of increased discharge when concentrations ranged between 100 and 200 mg/l (Figure 2-C). Dissolved solids concentrations were mostly between 125 and 150 mg/l with concentrations below 100 mg/l during some periods of increased discharge (Figure 2-B). Total nitrogen was highly variable with concentrations ranging from less than 0.5 to greater than 2.0 mg/l with higher concentrations occurring during periods of increased discharge (Figure 2-C). Total concentrations ranged from near 0.25 to over 0.5 mg/l with higher concentrations occurring during periods of increased discharge (Figure 2-C).

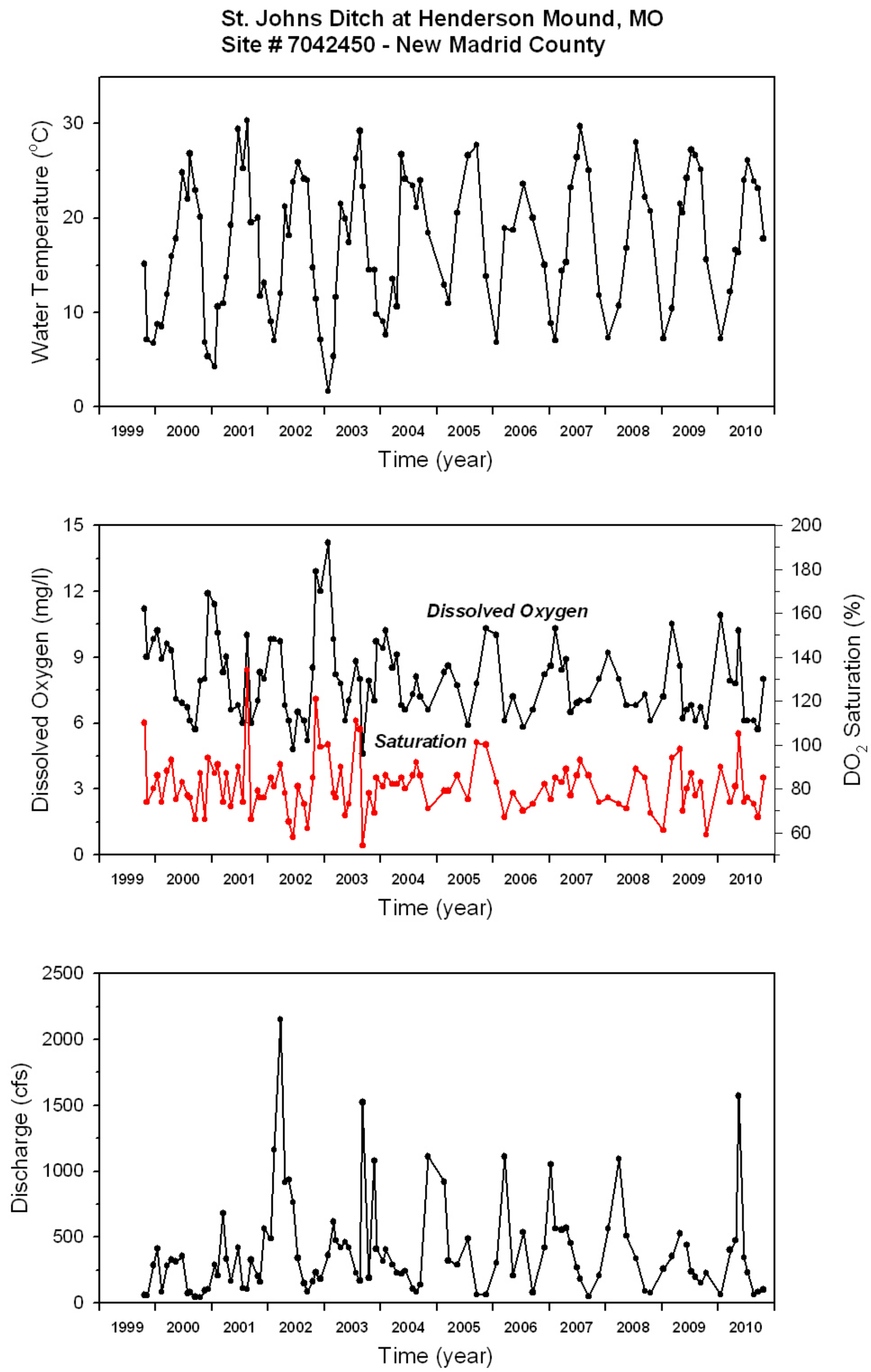


Figure 2. Existing conditions in St. Johns Ditch from 1999 to 2010. Upper panel (A) is the time series of water temperature, middle panel (B) is dissolved oxygen as mg/L or percent saturation, lower panel (c) is discharge in cubic feet per second.

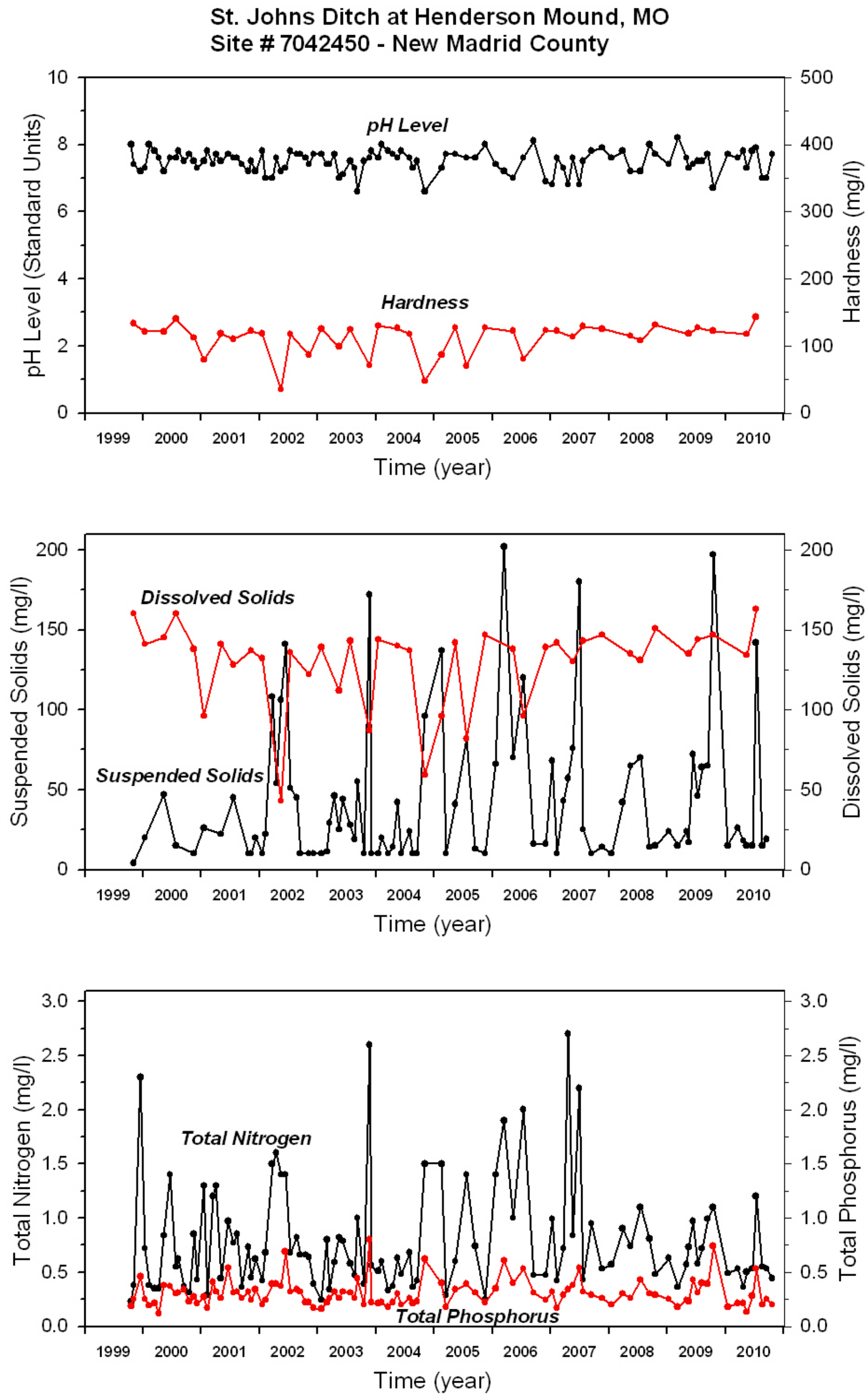


Figure 3. Existing conditions in St. Johns Ditch from 1999 to 2010. Upper panel (A) is the time series of pH and Hardness (mg/L as CaCO3), middle panel (B) is suspended solids (black) and dissolved solids (red) as mg/L, lower panel (c) is total nitrogen (black) and total phosphorus (red) as mg/L.

The 303(d) listings for 2006 and 2010 indicate that water quality in the project area is mostly within acceptable limits with low dissolved oxygen concentrations as the major impairment, but at only a few sites. A review of the proposed 2010 Missouri 303(d) list showed the following impaired waters in the project vicinity; Maple Slough Ditch for low dissolved oxygen in Mississippi and New Madrid Counties and St. John's Ditch for mercury from atmospheric deposition and bacteria in Scott and New Madrid Counties, and Stevenson Bayou for low dissolved oxygen in Mississippi County. Sites listed in the 2006 303(d) list (Mississippi River and Spillway Ditch) were not listed on the 2010 303(d) list.

3.1.2 Export of Nutrients and Sediments

The revised analysis addresses the export of nutrients and sediment from the project area under the existing hydrologic regime and several alternatives. Although these are estimates, the same assumptions are applied to all "with project" alternatives and provide a basis for comparison to existing conditions. The analysis estimates that, overall, there are substantial exports of nitrogen, phosphorus, carbon, and sediment from the project area under existing conditions. This is consistent with the dominance of high-intensity agriculture (row crop), and upland (not inundated) conditions in this landscape. The overall effect of the authorized project (discussed in the next sections) is to increase inundation and thus trap and process (remove) a greater fraction of these materials from the export stream.

3.2 Potential Influences of Authorized Project on Surface Water Quality

The data that could be identified do not provide a thorough baseline of water quality for the few, relatively small, water bodies located within the project areas. But there is indication that these waters are influenced primarily by land use and runoff as typical of an agricultural landscape. Major existing impairments are periods of low dissolved oxygen concentrations (e.g., >10% of observations are < 5 mg/l). Dissolved oxygen concentrations above 9 mg/l indicate higher levels of in-stream primary productivity typical of nutrient enrichment Increased loading (terrestrial export) of sediments and nutrients in periods of high discharge were observed. It is likely that periods of inundation are accompanied by increased sediment accumulation, depressed oxygen levels (during warmer weather), and elevated inputs of plant nutrients to these water bodies. Such conditions are commonly experienced by natural water bodies within an unregulated floodplain. However, the net balance of positive or negative influences of the altered inundation regime on an individual water body can only be evaluated with additional, site-specific data.

3.3 Potential Influences of Authorized Project on Material Exports

The primary emphasis of this revision was the effects of the authorized project and alternatives on the export of material relative to the existing condition. The results show the expected export (under the differing project alternatives) of phosphorus, nitrogen, organic carbon, and sediment from the project area over the period 1943-2009 (Table 1 and Figures 3-10). Because the analysis now fully incorporates export via runoff, the estimates are substantially higher than those reported by Ashby et al. (2000). However, the effect of the authorized project on export, relative to the existing condition remains similar (i.e., 15% reduction in TP and TN export, up to 60% reduction in sediment export). The conclusion of no discernible impact on Mississippi River water quality is also reconfirmed.

Reductions in export from this area could show significant environmental benefits. An analysis by Robertson et al. (2009) showed the St. Johns –New Madrid basin as the number two exporter of nitrogen and phosphorus in the Mississippi-Atchafalaya basin in terms of yield per unit area, with an estimated 400 kg of TP and 3024 kg of TN delivered per square km per year to the river. Our result, limited to about 1/2 of the year (i.e., the inundation period from November through May) when exports are expected to be at a minimum, indicate yields of about 40-60 kg/km^2 of TP and 300-900 kg/km2 of TN between about 10 and 15% of the annual phosphorus rate and between about 10 and 30% of the nitrogen rates reported by Robertson et al. (2009). If these rates are extrapolated to a year (12/7 = 1.7X) they become 17-25% of the SPARROW rate for TP and 17-50% for TN. These lower numbers are in the same general range as the SPARROW estimates and are consistent with retention or trapping of nutrients under inundated conditions.

In the presentation that follows, export from the two areas (i.e., St. Johns Bayou and the New Madrid Floodway) within the overall project is addressed separately. The analysis assumes that effects in the two areas are independent and thus strictly additive. Therefore the effect of any combination of management actions in two separate areas on export can be inferred by adding the separate effects together.

The effect of the project alternatives on material export varies considerably among the constituents and between the two project areas (Table 1). For example, in the New Madrid Floodway, net, average export of total phosphorus export is reduced by about 15-20% by either the Authorized Project or the Avoid and Minimize Scenarios. However, in the St. Johns Bayou, the authorized project shows little effect on total phosphorus export. Likewise, total nitrogen export shows no discernable influence of the authorized project in St. Johns Bayou, but in the New Madrid basin, the authorized project or avoid and minimize scenarios all reduce average N export by about 15%. Likewise, with organic carbon, the project shows little influence on export of the authorized project in the St. Johns Bayou (possibly a 10-15% increase), but in the New Madrid basin, the authorized project cuts export in half, and the avoid and minimize scenarios reduce organic carbon export by about 40%. The pattern of sediment is similar to carbon. The authorized project has little influence on sediment export from the St. Johns Bayou (possible 10% increase), but cuts export from the New Madrid floodway by nearly 60%. The avoid-and-minimize scenarios reduce sediment export from the New Madrid Floodway by about half.

Time series presentations of these same data emphasize the effects of the project and show the strong, positive influence of high water on material export. For example, the difference between existing conditions and the authorized project export of total phosphorus in the New Madrid basin during high water is dramatic (Figure 3), but only accounts for a 15% difference in average, total export over the period of record (Table 1). This is more easily understood in the context of the relatively high "baseline" export (e.g., 30 metric tons/y) of phosphorus that occurs in extended periods without inundation.

Table 1. Total of Season 1 plus Season 2 estimated export (metric tons) of phosphorus, nitrogen, organic carbon and sediment from 81,700 acres () in the New Madrid Floodway (NM) and 47,500 acres in the St. Johns Bayou (STJ) during the period of record 1943 to 2009. Five alternatives for hydrology and land use are modeled in the New Madrid basin, while two are considered in the St. Johns Bayou.

	Minimum	Maximum	Mean	N

T O T A L   P H O S P H O R U S

New Madrid				
1. Existing	29	134	38	67
2. Authorized	30	33	31	67
3.1 Avoid/Minmze 1	30	40	32	67
3.2 Avoid/Minmze 2	30	40	32	67
4.2 Reforestation	24	28	25	67
Saint Johns Bayou				
1. No Action	17	72	22	67
2. Authorized	20	66	24	67

T O T A L   N I T R O G E N

New Madrid				
1. Existing	370	1200	440	67
2. Authorized	370	390	380	67
3.1 Avoid/Minmze 1	370	440	390	67
3.2 Avoid/Minmze 2	370	440	380	67
4.2 Reforestation	150	180	160	67
Saint Johns Bayou				
1. Existing	200	520	230	67
2. Authorized	200	470	230	67

O R G A N I C   C A R B O N

New Madrid				
1. Existing	220	3300	500	67
2. Authorized	250	350	280	67
3.1 Avoid/Minmze 1	250	590	320	67
3.2 Avoid/Minmze 2	250	590	310	67
4.2 Reforestation	200	470	260	67
Saint Johns Bayou				
1. Existing	130	1500	260	67
2. Authorized	200	13000	290	67

S E D I M E N T

New Madrid				
1. Existing	7600	180000	22000	67
2. Authorized	8700	110000	9700	67
3.1 Avoid/Minmze 1	8700	23000	11000	67

3.2 Avoid/Minmze 2	8700	23000	10700	67
4.2 Reforestation	6000	20000	7500	67
Saint Johns Bayou				
1. Existing	4600	74000	10000	67
2. Authorized	7500	62000	11000	67

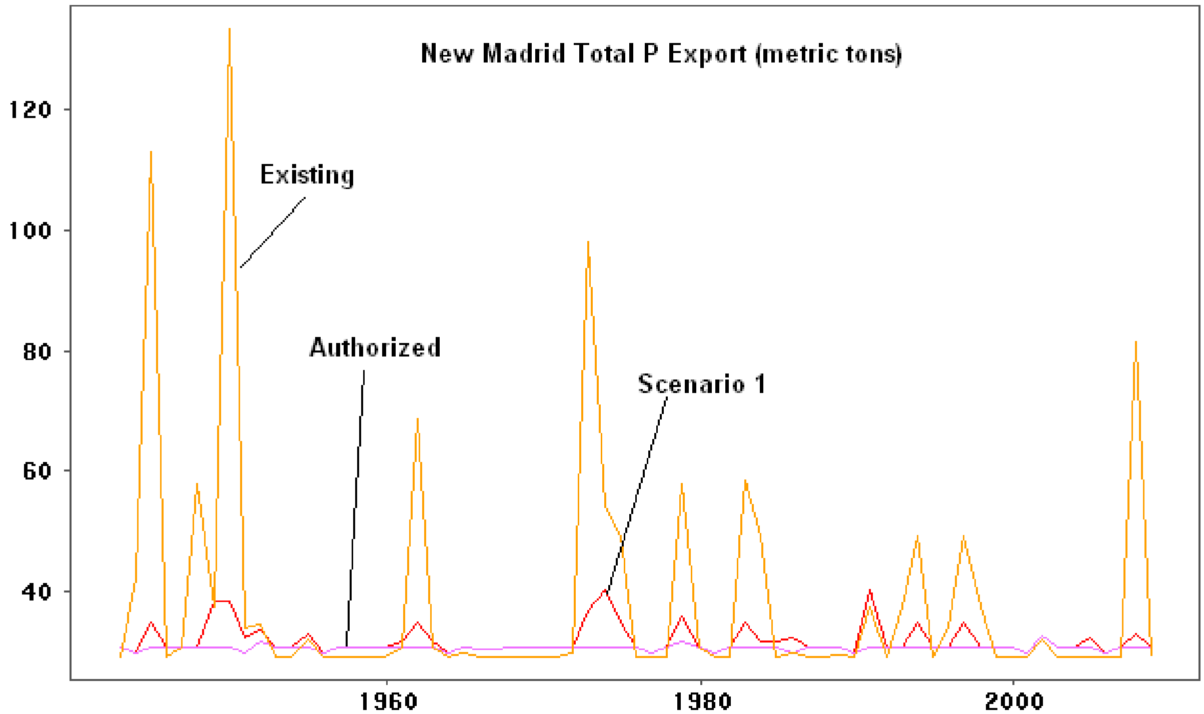


Figure 4. Expected export of total phosphorus (TP) in metric tons per flood season (Nov-May) from the New Madrid Floodway, for the period 1943 to 2009. Existing conditions use the observed hydrograph to calculate expected transport. Simulated hydrographs were used to estimate export for the authorized project, and management scenario 1. Management Scenario 2 is not shown, but very similar to scenario 1. The reforestation alternative is below the line for authorized project but generally parallel to it.

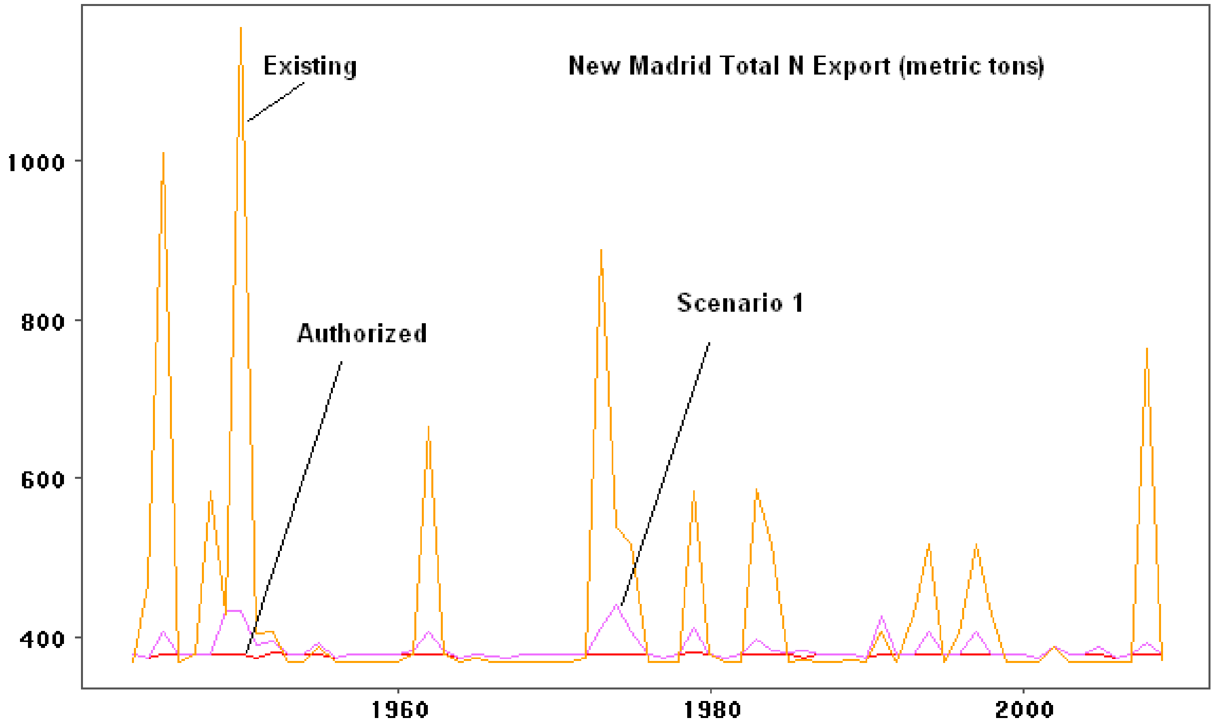


Figure 5. Expected export of total nitrogen (TN) in metric tons per flood season (Nov-May) from the New Madrid Floodway for the period 1943 to 2009. Existing conditions use the observed hydrograph to calculate expected transport. Simulated hydrographs were used to estimate export for the authorized project, and management scenario 1. Management Scenario 2 is not shown, but very similar to scenario 1. The reforestation alternative is below the line for authorized project but generally parallel to it.

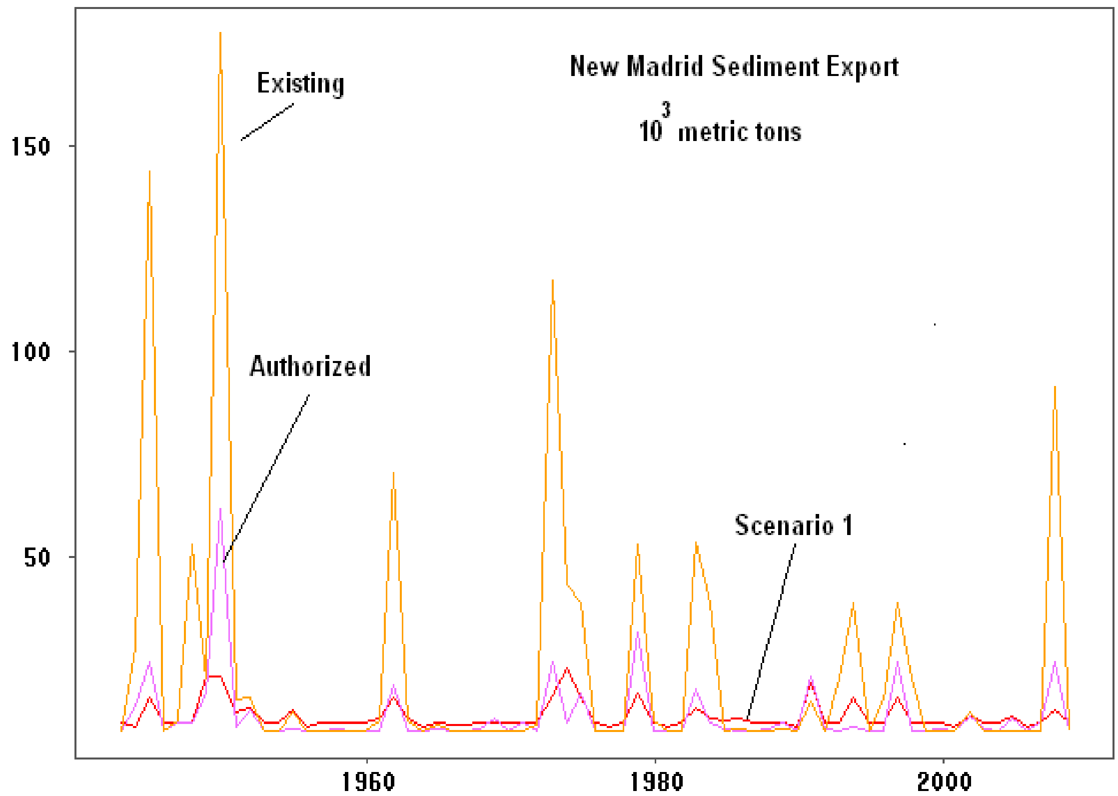


Figure 6. Expected export of sediment in thousands of metric tons per flood season from the New Madrid Floodway for the period 1943 to 2009. Existing conditions use the observed hydrograph to calculate expected transport. Simulated hydrographs were used to estimate export for the authorized project, and management scenario 1. Management Scenario 2 is not shown, but very similar to scenario 1. The reforestation alternative is below the line for authorized project but generally parallel to it.

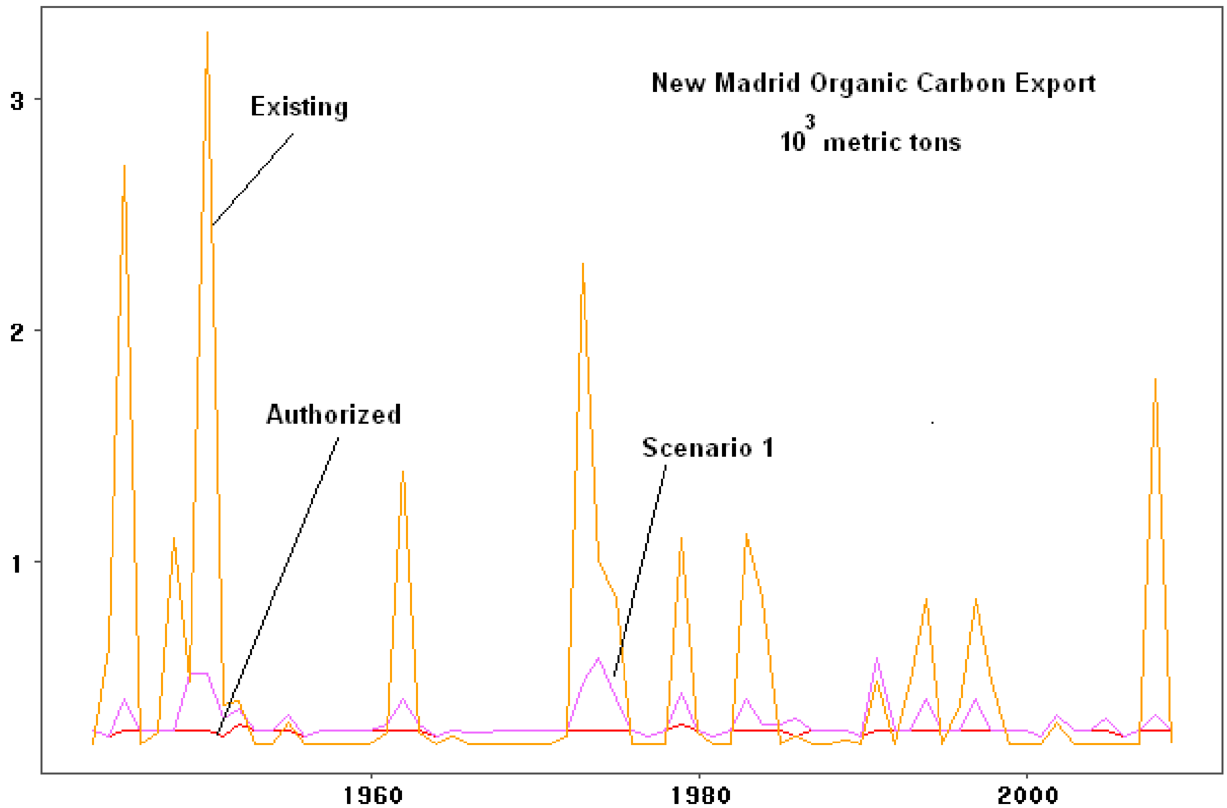


Figure 7. Expected export of total organic carbon (TOC) in thousands of metric tons per flood season (Nov-May) from the New Madrid Floodway for the period 1943 to 2009. Existing conditions use the observed hydrograph to calculate expected transport. Simulated hydrographs were used to estimate export for the authorized project and management scenario 1. Management Scenario 2 is not shown, but very similar to scenario 1. The reforestation alternative does not apply to St. Johns Bayou.

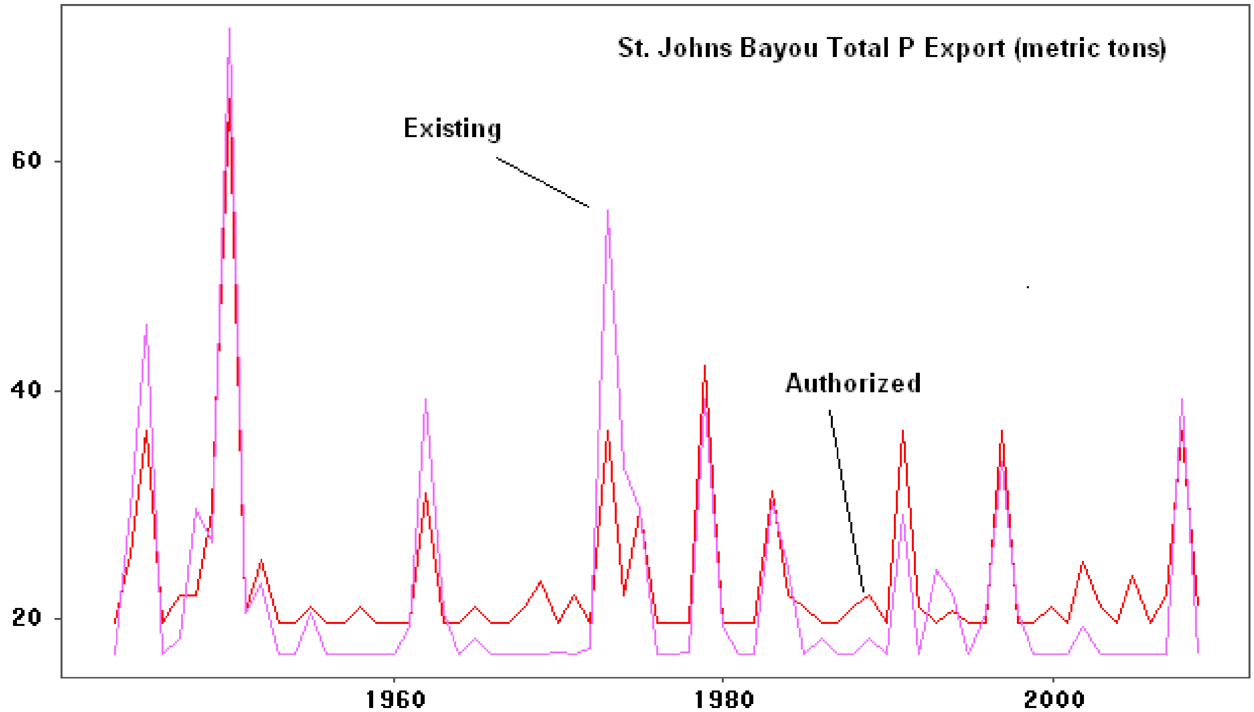


Figure 8. Expected export of total phosphorus (TP) in metric tons per flood season (Nov-May) from the St. Johns Bayou for the period 1943 to 2009. Existing conditions use the observed hydrograph to calculate expected transport. Simulated hydrographs were used to estimate export for the authorized project. The reforestation alternative does not apply to St. Johns Bayou.

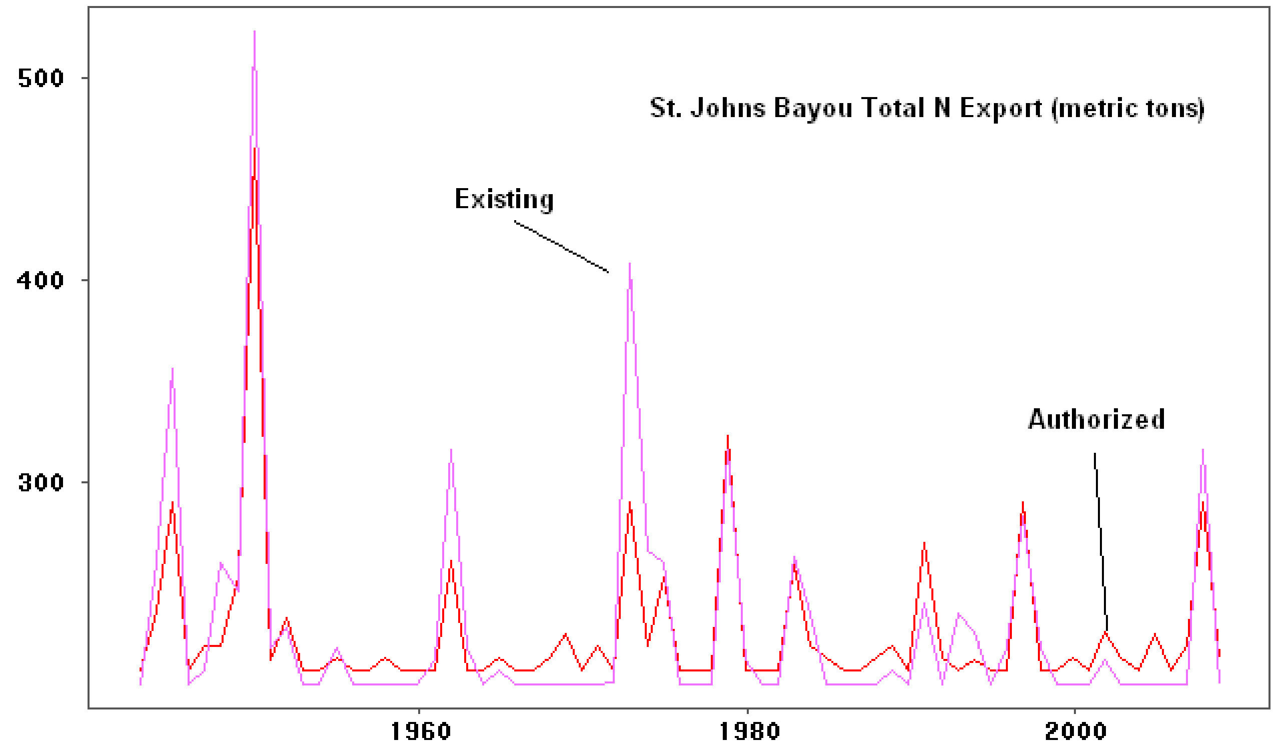


Figure 9. Expected export of total nitrogen (N) in metric tons per flood season (Nov-May) from the St. Johns Bayou for the period of record, 1943 to 2009. Existing conditions use the observed hydrograph to calculate expected transport. Simulated hydrographs were used to estimate export for the authorized project. The reforestation alternative does not apply to St. Johns Bayou.

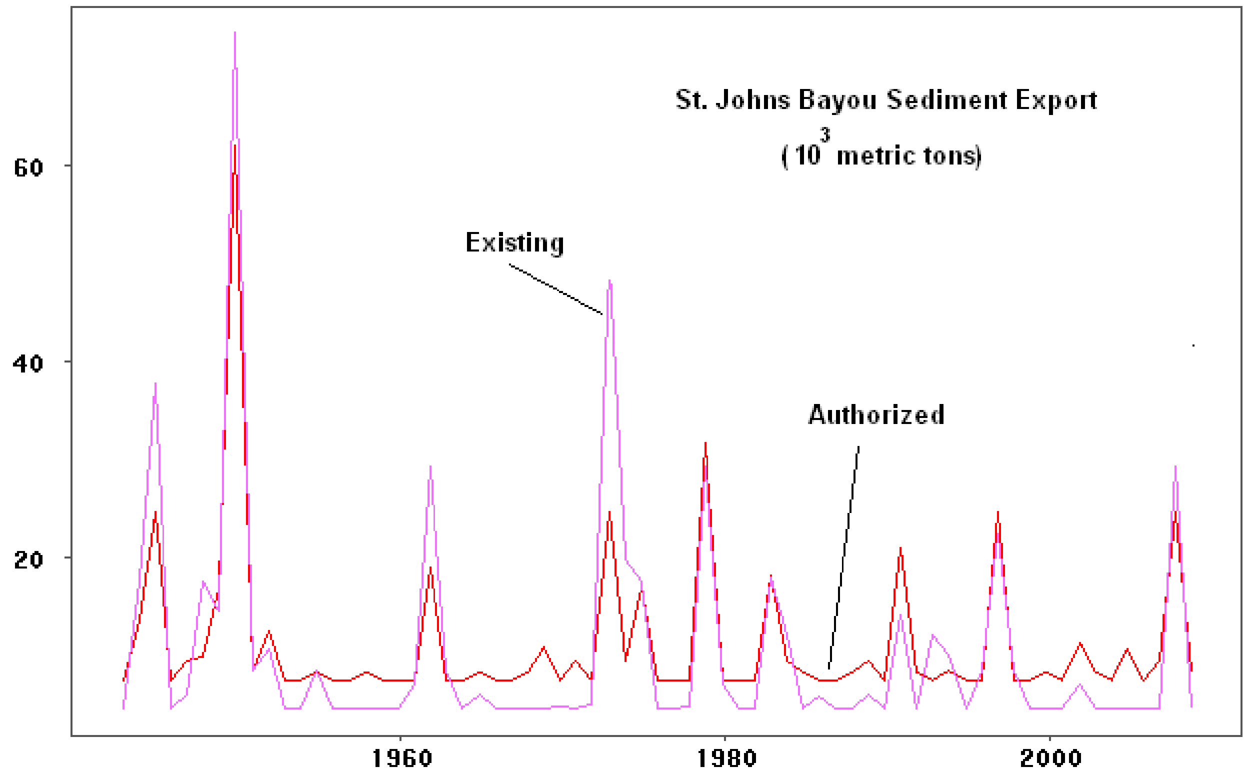


Figure 10. The expected export of sediment in thousands of metric tons per flood season (Nov-May) from the St. Johns Bayou for the period of record, 1943 to 2009. Existing conditions use the observed hydrograph to calculate expected transport. Simulated hydrographs were used to estimate export for the authorized project. The reforestation alternative does not apply to St. Johns Bayou.

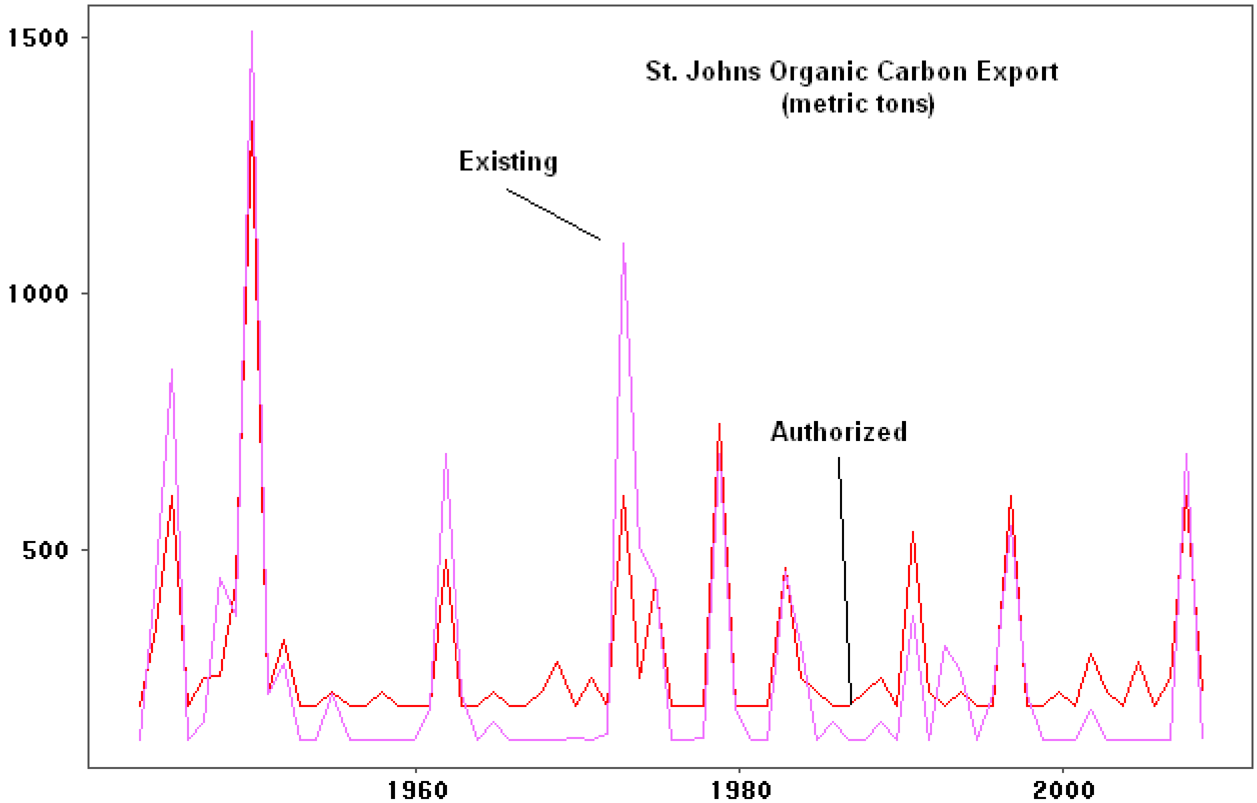


Figure 11 . The expected export of total organic carbon (TOC) in metric tons per flood season (Nov-May) from the St. Johns Bayou for the period of record, 1943 to 2009. Existing conditions use the observed hydrograph to calculate expected transport. Simulated hydrographs were used to estimate export for the authorized project. The reforestation alternative does not apply to St. Johns Bayou.

3.4 Potential Impacts of Authorized Project on Water Quality of the Mississippi River

The analysis by Ashby et al. (2000) concluded that the effects of the project on Mississippi River water quality would not be discernible and that conclusion is not altered by this revision to the analysis. The original conclusion was based on several lines of evidence; including (1) the ratio of project outflow volume to Mississippi River flow volume (< 1 percent), (2) the finding that the project would reduce the material load from the project area to the river relative to the existing condition, and (3) the finding that the project area would likely exhibit a net retention and processing of material that enters it from the Mississippi River, although there could be a small net loss of retention from Mississippi River water relative to the existing condition due to reductions in natural flooding. Ashby et al. (2000) used a mass balance approach to estimate potential impacts of the authorized project on the water quality of the Mississippi River as a percent decrease in material loading in the river relative to a moderate high flow condition. They found the material export for each constituent evaluated was 0.1 percent or less of the main river transport. This is consistent with water balances conducted for the project that indicated a ratio of basin water (22,840 cfs/day) to Mississippi River water (22,840 cfs/day + 4,000,000 cfs/day) equal to about 0.0057.

The project will tend to increase retention relative to the existing (without project condition), but overall the basin will still be an overall net exporter of these materials. The modeling study by Robertson et al. (2009) showed that the basin that includes the project area is the number two exporter (on an area basis) in the Mississippi-Atchafalaya basin so that the effects of the project to increase retention in this basin, particularly in the reforestation alternative (4.2), has the potential for significant, ecological benefits.

There is a potential that a change in flood timing under project operations would also reduce transport of material from the study area to the Mississippi River. The change in hydrology is expected to reduce the transport of particulate material from fallow agricultural lands, although an increase in soluble material could occur with inundation. Conversely, a reduction in backwater flooding from the Mississippi River would decrease the retention of material that might otherwise be processed during flooding. Overall, therefore, the net effect on water quality in the Mississippi River should not be detectable.

3.5 Evaluation of Potential Changes in Pesticide Use on Water Quality

This segment of the previous study was not altered in this revision. Atrazine is still used extensively on crops within the project area and although USEPA has convened a Science Advisory Board to review the use of this pesticide in general, there is no indication that additional restrictions will be imposed on the use of atrazine in the near future. Based on information provided by the University of Missouri Delta Research and Extension Service, Ashby et al. (2000) estimated that 95 percent or more of the corn in the project area will be treated with atrazine at a rate of approximately 2 lb active ingredient per acre (ai/acre). Post-emergence application will be applied to approximately 75 percent and pre-emergence treatment rates will be between 1 and 2 lb ai/acre. About 50 percent of the land receiving pre-emergence treatments will likely receive a second application between 0.5 and 1.5 lb ai/acre. Farmers use arithmetic to keep total atrazine applications below 2.5 and 2 lb ai/acre on a single application.

The literature review by Ashby et al. (2000) indicated that the potential for unacceptable contamination of water resources from atrazine application to corn and corn/soybean rotation is limited (Ashby et al., 2000; Appendix D). The primary concern appears to be the relationship between application timing and precipitation frequency. The worse scenarios for surface-water contamination are high flow/precipitation immediately following the pesticide application. Groundwater concentrations appear to be maximal during precipitation events that produce little run off, at sites subjected to repeated (multi-year), high rates of atrazine application. However, because of the soil types that dominate the project area, infiltration or percolation of pesticides is expected to be of minor importance and the authorized project is therefore expected to have no effect on groundwater concentrations of pesticides. Changes in cropping practices within the project area in response to the project are not expected to alter this conclusion.

3.6 Evaluation of Potential Impacts to Big Oak Tree State

The previous analyses by Ashby et al. (2000) that assessed the potential impacts of the authorized project on Big Oak Tree State Park are no longer applicable, as the planned operation of the project no longer includes pumping of groundwater to create seasonal flooding. Instead, the design now calls for reconnection of the Park with the main stem of the River so that the natural flooding regime is restored. A strong, positive effect of this on the ecology within the Park is anticipated. Further, because the Park will now serve as a trap (sink) for sediment and nutrients delivered from the Mississippi River main stem during natural high water, the plan for the Park under the authorized project will have a net positive (albeit non-detectable) influence on water quality in the Mississippi River. Because the effects on water quality are expected to be non-detectable, but positive, this revision did not explore this quantitatively.

4 Discussion

This revision to the earlier work by Ashby et al. (2000) was not intended to fully repeat that entire effort, but rather to update and refocus portions of that work as newly available data and modifications to the project plan made this appropriate. Substantial portions of the earlier work are copied into this report (with minor changes as needed) so that this document will be better able to stand alone. For the most, very limited new data was uncovered in the revision process. However, a slightly more elaborate approach to analysis was taken so that updated land cover and actual or simulated daily water level information could be easily incorporated, explicitly, into the analyses.

Ashby et al. (2000) reviewed the existing water quality in the project area in detail and those findings were summarized or referenced here. There has been little water quality monitoring activity in the area since that earlier study, and no indication of substantial changes. Thus, it can be concluded that the existing water quality in the project area is still indicative of an agricultural landscape. General patterns of surface water quality include low to moderate nitrogen concentrations, relatively high phosphorus concentrations, moderate to high organic carbon concentrations, and low to moderate sediment concentrations. Increased concentrations of these constituents likely occur in storm runoff. Extreme values were most frequently observed in the vicinity of point sources.

Potential impacts of the project on the water quality of the Mississippi River appear to be minimal based on the assumptions used in the earlier analyses. The present work does not alter that conclusion; any changes in concentration of water quality constituents in the Mississippi River as a result of the project will not be discernible.

Likewise, the earlier work showed that project operations, or changes in agricultural practices as a result of project operations, are not expected to have a significant impact on pesticide concentrations (Ashby et al. 2000). We did not alter that finding in this revision.

Analysis indicates that the authorized project, with or without the avoid-and-minimize alternatives, generally reduces, or does not significantly alter, the export of materials from the project area into the Mississippi River. This is a generally positive ecological effect. Further, the limited water quality data that exists for water bodies within the project area give no indication that the project will degrade water quality in these water bodies. Consequently there is little to indicate that mitigation measures for water quality are needed. Mitigation measures associated with the project that are planned for habitat purposes are anticipated to have a water quality benefit as well.

The potential for negative impacts of the authorized project on Big Oak Tree State Park has been eliminated by a new design that now calls for expanding the area of natural vegetation and restoration of the natural flood regime within the Park by gravity flows of Mississippi River flood water into and out of the Park. Under this design, the park will trap beneficially some of the nutrients and most of the sediments delivered from the River. Although this will have a positive effect on the River and the Park, it will make no measurable change in water quality in the Mississippi River.

5 Conclusions

5.1 Existing Water Quality Conditions and Impacts on the Mississippi River

The Water quality within the project area with the authorized project fully implemented should be similar to conditions that exist now. Existing water quality in the project area is still indicative of an agricultural landscape. There should be no effect of the project during periods of normal, low water. During high water, we anticipate that conditions will generally follow the pattern that is typical of naturally inundated flood plain areas. It is commonly assumed that naturally inundated flood plains are characterized by accumulation of floodwater sediment and nutrients. Further, increased water levels in pre-existing water levels and the influx of organic material in the flood waters will promote oxygen depletion, particularly in deeper locations.

Impacts to the water quality of the Mississippi River with the proposed or alternative project in place are not expected to be discernible. Overall, trapping of nutrient and sediments in the project area is expected to increase, so the effect of the project on Mississippi River water quality should be positive, but it will not be detectable.

5.2 Export of Materials

The effect of the authorized project on material transport varies among constituents and (to a lesser degree) among management scenarios (Figures 3-10). In general the project is expected to reduce, or not significantly alter, the export of nutrients, sediments, and organic carbon relative to the existing condition.

5.3 Pesticides

The impact of pesticides, atrazine in particular, on public groundwater resources is expected to be minimal. Furthermore, the impacts to shallow water resources, i.e., private wells, are also expected to be minimal. A greater potential exists for atrazine contamination to surface waters. The optimal method for reducing this likelihood is the implementation of BMPs. It is a feasible assumption that through adoption of BMPs, in combination with monitoring efforts, the atrazine contamination to water resources can be maintained below drinking water standards. A 5 percent increase in corn should not change the behavior of pesticide application and runoff, so conditions expected for increased acreage should be similar to existing conditions.

5.4 Big Oak Tree State Park

The restoration of a natural, flood-driven, hydrology to Big Oak Tree State Park is likely one of the most critical processes for the recovery and sustainability of the Park. Allowing gravity-driven flows of main stem River water to enter and exit the Park (as compared to ground water pumping) should have a strong, positive influence on the ecology of the Park, but the positive effects on Mississippi River water quality will be too small to detect.

5.5 Mitigation

Analysis indicates that the authorized project, with or without the avoid and minimize alternatives, generally reduces export of materials from the project area into the Mississippi River. This is a positive ecological effect. Further, the limited water quality data that exists for water bodies within the project area give no indication that the project will degrade water quality in these water bodies. Consequently there is little to indicate that mitigation measures for water quality are needed. Mitigation measures associated with the project that are planned for habitat purposes are anticipated to have a water quality benefit as well.

6 References

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Appendix A: SAS Program Code for Calculating Material Exports.

This appendix includes the actual SAS code used to calculate material export. Because Alternative 4.2 includes land use changes (i.e., reforestation) and affects the New Madrid Floodway only, a separate segment of code (included at the end of the listing) is used to calculate loads for this alternative.

To execute this code on a local installation of SAS software, minimal editing is required to accommodate local folder names etc. This code uses input from three sources:

1. Daily elevation spreadsheets. One each for the New Madrid Floodway and St. Johns Bayou. The spreadsheets must have a column for the date and a separate column for the observed or simulated water stages for each scenario. A separate elevation spreadsheet is used for alternative 4.2

2. Two land cover spreadsheets, showing the cumulative acreages of land types below each foot elevation contour. One spreadsheet is used for each basin. A separate land cover spreadsheet is used for alternative 4.2

3. Export and concentration coefficient files (%include), one file is used for each parameter. Examples of the %include files used for this analysis are reported in appendix B.

- This code was run on SAS software version 8, but should be compatible with any version of SAS/BASE

```
OPTIONS SOURCE;
*--------------------------------------------;
* Version 06/21/2011;
*--------------------------------------------;
*----------------------------------------------------------------------------;
* THIS SAS PROGRAM RELIES HEAVILY ON MACROS AND MACRO-VARIABLES
* THIS MAKES THE MODULE EASY TO USE and FLEXIBLE.
* MOST OF THE MACRO VARIABLES THE USER MIGHT WANT TO CHANGE ARE DEFINED
* AT THE TOP OF CODE AND REASONABLY WELL DOCUMENTED;
*-----------------------------------------------------------------------------;

* The bulk of the processing section is wrapped in an Overarching Macro called CALC_ALL
* That starts near the top of code So that the user can easily specify and combine (i.e., MERGE)
* Multiple data step runs (at the bottom);

* The code uses a SEPARATE INCLUDE FILE:
* This auxiliary file contains ALL the export coefs used in the analysis. The
* Separate file allows you to EASILY use alternative Coefs.
* %Let statements let You Specify the Columns in the Daily Elevation Spreadsheets
```

```
* To be used in the Analysis. It requires both spreadsheets use the SAME NAMES for columns.
* You can CHANGE "existing" "Authorized" "Alt1" and "Alt2" in the next lines
* To match the spreadsheet, but you would probably do better
* to alter the SPREADSHEET to match this code!;
* ELEVATION COLUMNS IN THE SPREADSHEETS;
%Let A0 = Existing;
%Let AA = Authorized;
%Let A1 = ALT1;
%Let A2 = ALT2;
*DEFINE THE LOCAL PATH TO ALL YOUR INPUT DATA;
%Let Local_Path = D:\usr2\New_Madrid_St.Johns_Floodway\Data;
*DEFINE THE DAILY ELEVATION INPUT SPREADSHEETS for New Madrid and St. Johns;
%LET NM_Elev_XLS = &Local_Path\NMElev3.xls;
%LET STJ_Elev_XLS = &Local_Path\STJElev3.xls;
*DEFINE THE LANDCOVER INPUT SPREADSHEETS;
%LET NewMadridLandCover_XLS =&Local_Path\Landcover\NMLandcover1.xls;
%LET STJohnsLandcover_XLS =&Local_Path\Landcover\STJLandcover1.xls;
*DEFINE THE FILES THAT HOLD THE VARIOUS COEFS FOR EACH LOADING VARIABLE;
%LET TPcoefFile =&Local_Path\Include_Coefs\PhosphorusCoefs.txt;
%LET TNcoefFile =&Local_Path\Include_Coefs\NitrogenCoefs.txt;
%LET SEDcoefFile =&Local_Path\Include_Coefs\SedimentCoefs.txt;
%LET TOCcoefFile =&Local_Path\Include_Coefs\CarbonCoefs.txt;
*========== THIS ALLOWS OPTIONAL USE OF DRY LAND EXPORT (DEFAULT) ====================;
* THIS IS CONTROLLED BY THE UseDryLandExport macro variable set to 1(yes) or zero(no)
* When 1 (YES), we apply export coef ONLY to the land area above the flood contour
* This export contributes to the "Total Load" that is then subjected to Wetland function
*=====================================================================================;
%Let UseDryLandExport=1; *YES;
*Let UseDryLandExport=0; *NO;
*===============================================================;
OPTIONS NOSOURCE;
%MACRO Calc_all(NMPROJ_ELEV, STJPROJ_ELEV, LoadVar1);
*Let LoadVar1 = &LoadingVar;
%put;
%Put Calculating Loads for Variable &LoadVar1 Using NM Elevation Data &NmProj_Elev ;
*
OVERVIEW: the approach is taken from the Ashby report and spreadsheets.
the central concept is to use two "phases" of export:
1. straight export coefficients that account for export and processing material from "dry land" cond
2. export "concentrations" that apply to flood volumes during inundation.
These coefs or concentrations are customized for differing landcover types within the project area
and are "pro rated" to adjust for the period of inundation.
This adjustment has involved expert opinion to consider seasonality of exports and the
fact that the period of interest (inundation) would be only a fraction of the year and
primarily in the colder months.
The amount (or concentration) that is "available" based on export coefs. and concentration is multip
by the area or the volume of water to calculate a potential export mass. The volume of water is the
peak volume (above flood stage) during the season.
The original analysis assumed water would reach 285 during season 1, and 280 in season 2 with the
project in place. These assumptions are OK for season 1, but underestimate the flood level
in season 2 based on the historic and simulated hydrographs. As a result, in this analysis we see
a much larger flood-related export of TP and other constituents during season 2 than Ashby estimated

To provide a "credit" for runoff material that is trapped during the inundation period the "dry land" export coef
(pro-rated for time) was applied to the area of inundation. The rationale
was that material that would otherwise drain from the area of inundation is now being trapped.
The delivery from the non-inundated portion of the watershed was NOT addressed in the original analysis
of Ashby et al., and so it underestimates the total export from the project area.

The total "delivered material for export" is adjusted by a "Wetland Function Factor" (WFF) to arrive
WFF is a fraction that represents the functioning of the subject land cover type when it is inundated
For example, the cover type might REMOVE 80 percent of the "available" export during inundation,
and this is expressed as a "Wetland Function Factor" of -.8.
If the wetland AUGMENTS the dry land export by 10%, then the WWF is +.1. This is a very rough approx
as it does not allow for variations in the area of land cover type that is inundated.
The spreadsheet approach assumes that the "net available" material during inundation is
fully exported from the system (i.e. into the River).
*===============================================================
Note for the import of Memphis spreadsheets,
```

```
They had to be processed a little to make them "SAS friendly" -
i.e., remove extra heading lines etc. and use nice column titles
that could easily become SAS variable names
*===================================================================
;
* Macro will skip repeated import of spreadsheet elevation data
* (very slow) processing during development or exploration AND
* to allow user flexibility in designating files at the very top of code;
%Macro ImportElev(OutData1,sourceXLS);
%if %sysfunc(exist(&SourceXLS))=1 %then
%DO;
%Put Input File Does Not Exist: &SourceXLS;
%End;
%if %sysfunc(exist(Work.&OutData1)) = 0 %then
%Do;
%Put Importing Elevation Spreadsheet from &SourceXLS to Dataset &OutData1;
PROC IMPORT OUT= WORK.&OutData1
DATAFILE="&SourceXLS"
DBMS=EXCEL2000 REPLACE;
GETNAMES=YES;
RUN;
%end;
%Else %Put Elevation Data Already Available - Import Skipped;
%Mend ImportElev;
%ImportElev(NMElev1,&NM_ELEV_XLS);
%ImportElev(STJElev1,&STJ_ELEV_XLS);
*2. ------------ Process the Elevation Data -----------------;
* To generate 30-day inundation contours
*
* The original Spreadsheet approach assumed that "inundation" behavior
* started immediately at full force once an area was under water for 30 days.
* and continued that way until water receded. - We do not change that here
* The algorithm tracks duration of inundation at each 1 foot contour in 1 day time steps.
* A day is added to the duration in each contour below the current level of inundation.
* The duration is reset to zero in all contours ABOVE the current level of inundation.
* We then search through the contours (starting at the bottom) to find the level where
* duration drops below 30 days. There are simpler codes to do this
* but this seems very straight forward.
* The next step is to cross reference this level of inundation with the total area in each
* landcover type BELOW this level - this is GIS based info provided by Memphis District.
;
* Elevation Range within New Madrid is 263 to 299 MSL = 37 one foot increments;
* NEW MADRID:
*New Madrid and St.Johns have slightly different configurations and so are run in separate steps;
%Put NM Elevation in Dataset NMElev1b is &NMProj_ELEV;
Data NMelev1b;
array ElevW[37] ElevW263-ElevW299; * 1 foot contours with project;
array ElevWO[37] ElevWO263-ElevWO299; *1 foot contours without project;
retain elevW263-elevW299 0.0 elevWO263-elevWO299 0.0;
keep day date2 &A0 &NMProj_ELEV Elev30dW Elev30dWO ElevDiff;
format date2 mmddyy10.;
rename date2 = date;
SET nmelev1;
if &A0 ne .; * "existing" is water elevation w/o project;
date2 = datepart(date);
ElevIndexWO = int(&A0) - 262;
ElevIndexW = int(&NMPROJ_ELEV) - 262;
*put date2= +3 &A0= + 3 ElevIndex=;
do i = 1 to elevIndexW;
ElevW[i] = ElevW[i] + 1;
end;
do i = ElevIndexW+1 to 37;
ElevW[i] = 0;
end;
do i = 1 to elevIndexWO;
ElevWO[i] = ElevWO[i] + 1;
end;
do i = ElevIndexWO+1 to 37;
ElevWO[i] = 0;
```

```
end;
*now find the elevation where duration drops below 30 days;
*With project;
i = 1;
do while ((i < 37) and (elevW[i] > 29));
i = i + 1;
end;
Elev30dW = .;
if i > 1 then
Elev30dW = 261+i;
*now find the elevation where duration drops below 30 days;
*WithOUT project;
i = 1;
do while ((i < 37) and (elevWO[i] > 29));
i = i + 1;
end;
Elev30dWO = .;
if i > 1 then
Elev30dWO = 261+i;
ElevDiff = Elev30dW - Elev30dWO;
run;
*========= END NEW MADRID ELEVATIONS ================;
*================ Process St. Johns Elevation Data ================
* To generate 30-day inundation contours;
* THIS SETUP IS A LITTLE DIFFERENT FROM NEW MADRID - ELEVATIONS;
* Elevation Range in STJ is 260 to 299 = 40 one foot increments;
*==================================================================;
Data STJelev1b;
array ElevW[40] ElevW260-ElevW299;
array ElevWO[40] ElevWO260-ElevWO299;
retain elevW260-elevW299 0.0 elevWO260-elevWO299 0.0;
keep day date2 &A0 &STJProj_ELEV Elev30dW Elev30dWO ElevDiff;
format date2 mmddyy10.;
rename date2 = date;
SET STJelev1;
if &A0 ne .;
date2 = datepart(date);
ElevIndexWO = int(&A0) - 259;
ElevIndexW = int(&STJPROJ_ELEV) - 259;
do i = 1 to elevIndexW;
ElevW[i] = ElevW[i] + 1;
end;
do i = ElevIndexW+1 to 40;
ElevW[i] = 0;
end;
do i = 1 to elevIndexWO;
ElevWO[i] = ElevWO[i] + 1;
end;
do i = ElevIndexWO+1 to 40;
ElevWO[i] = 0;
end;
*now find the elevation where duration drops below 30 days;
*With project;
i = 1;
do while ((i < 40) and (elevW[i] > 29));
i = i + 1;
end;
Elev30dW = .;
if i > 1 then
Elev30dW = 258+i;
*now find the elevation where duration drops below 30 days;
*WithOUT project;
i = 1;
do while ((i < 40) and (elevWO[i] > 29));
i = i + 1;
end;
Elev30dWO = .;
if i > 1 then
Elev30dWO = 258+i;
```

```
ElevDiff = Elev30dW - Elev30dWO;
run;
* ------------- END St. Johns Elevation Data ------------;
* ------------------------------------------------------------------------------------
* The GetPeak30DayElev macro is now used to skip processing if it is already complete,
* but more importantly, to centralize the code for finding seasonal PEAK inundation;
*-------------------------------------------------------------------------------------;
%Macro GetPeak30DayElev(seg);
* EXTRACT THE SEASONAL PEAKS of INUNDATION, with and without project;
* Cannot skip based on existance of Peaks, because Elev Var might change;
%if (%sysfunc(exist(Work.&seg.Peaks)) = 0) %then
%Do; %end;
%Put Calculating &Seg 30 day Peak Inundation Elev ;
Data &seg.Peaks;
set &seg.Elev1b;
retain oldseason 3 peakW peakWO 0;
keep date PeakW PeakWO Season;
seas = 3;
if (month(date) > 10) or (month(date) < 2) then seas = 1;
if (month(date) > 1) and (month(date) < 6) then seas = 2;
if seas ne oldseason then
do; *process the peak from the previous season;
if peakW < 281 then peakW = .;
if peakWo < 281 then peakWo = .;
Season = OldSeason;
if season < 3 then
output; *set to ignore "off season" floods;
peakW = 0;
peakWO = 0;
end;
if Elev30dW > PeakW then PeakW = Elev30dW;
if Elev30dWo > PeakWo then PeakWo = Elev30dWo;
oldseason = seas;
run;
*End;
*Else Put &Seg 30 day Peak Inundation Elev Already Calculated, Step Skipped;
%Mend GetPeak30dayElev;

%GetPeak30DayElev(NM);
%GetPeak30DayElev(STJ);

* Matching Landcover to the original analysis creates an issue because
the export coefs used by Steve Ashby are linked to landcover types
that do NOT match the landcover types provided by Memphis
So some recombinimg/recoding is required.
* Note that Ashby table 4 treats all "natural cover" the same:
(i.e., cypress/tupelo, scrub, marsh, bottomland hardwood) all have the
same wetland function factors. this carries through into the spreadsheets for nitrogen
check that this is also true for phos.
to keep things simple, we process the landcover in the steps that follow
We read in the land cover at each elevation - these are cumulative i.e. total landcover below a
certain elevations.
NOTE:
In winter (season 1) Nov-Feb, the PROJECT holds water for ducks etc.,
In spring and summer (season 2), natural flooding occurs from the Mississippi
(the project can clip the flood peaks).
Because of this clipping, in most summers the elev is lower with the proj. than without.
Ashby analysis split winter into two flood "seasons"
Season 1 is Nov-Jan - held water (internal source)
Season 2 is Feb-May - spring flood water from MissR.
We can ASSUME that the peak during each "season" is the "volume" that drains off and exports
P,N, Carbon. Steve assumed a specific "typical" elevation for the flood seasons. In this revision
we use actual (or simulated) data to get REAL about that, but its still a simplification.
Algorithm note: We step through the data, date by date. When season changes we process the
previous season (we will know the previous peak at that point) and start to capture the
peak for the new season. We actually have three seasons 1. Fall-Winter, 2. Winter-Spring,
and 3. Summer-fall. Bear in mind that seasons 1 and 2 are COLD.
;
```

```
*PROCESS LANDCOVER
We Process the landcover and export conc/coefs into two "Lookup Tables",
one each for NM and STJ.
we then MERGE these with the peak Elevation dataset to calculate export;
* A Macro is used here to avoid repeated (very slow)processing of Excel spreadsheet
* During development or exploration;
%Macro ImportLandCover;
%if %sysfunc(exist(Work.NmLC)) = 0 %then
%Do;
%Put Importing the Land Cover Spreadsheets;
PROC IMPORT OUT= WORK.NMLC
DATAFILE="&NewMadridLandCover_XLS"
DBMS=EXCEL2000 REPLACE;
GETNAMES=YES;
RUN;
PROC IMPORT OUT= WORK.STJLC
DATAFILE= "&STJohnsLandcover_XLS"
DBMS=EXCEL2000 REPLACE;
GETNAMES=YES;
RUN;
%End;
%Else %Put *** Landcover Previously Input, Import Skipped ***;
%Mend ImportLandCover;
%ImportLandCover;


* Now rework the raw landcover input to get it into more useable form.
Keep in mind that stage below 280 in New Madrid is NON-Flooded
and can be treated as "dry land" conditions.
the original approach is to assume the cumulative acreage of each LC type
below the 30-day inundation level is the area that exports in a flood.
The original analysis uses static scenarios with the water reaching a specific elevation.
Consequently the "Volume" associated with the scenario is a simple constant.
Steve assumes that this volume reaches equilibrium with the designated concentration
and Wetland function factor.
Steve does not use acres directly in his spreadsheet to calculate volumes,
but rather uses a fraction of the total inundated area x the total inundated volume
to get the water volume associated with each inundated LC type. This does not fully
address the elevation distribution of the LC type because it assumes that
all inundated land has the same depth of overlying water.
We have the information (i.e., landcover below each 1 foot contour) to do a little better.
We multiply the area at each elev by the depth of water above it.
=============================================
L A N D C O V E R R E G R O U P I N G
=============================================
WE REGROUP the LC into the effective classes Ashby used as follows:
LC class Ashby Class
Corn RowCrop
Cotton RowCrop
Rice RowCrop
Soybeans Soybeans + XX to allow N behavior.
Wwheat RowCrop
WwheatSoy Mixed_Ag
Other_Ag Mixed_Ag??
Fallow Pasture
Forest Forest
Woody_Wet Forest
Developed Urban
Grass Pasture
HerbWetlands Water
Wetlands Water
Open_Water Water
ShrubLand Forest
Pasture Pasture
;
%Macro MakeLCAreasAndVolumes(seg);
* This Macro Calculates Landcover volumes below each elevation contour AND
* Reclassifies the Landcover into a rough match to original classes of Ashby
* See page 10 of ERDC report (2000).
```

```
* We must keep soybeans and soybean mixes separate to allow separate handling for nitrogen.
;
%*this "IF" was intended to prevent unnecessary re-runs of this code segment;
%*if %sysfunc(exist(Work.&seg.Volumes)) = 0 %then
%Do;
%Put Calculating &Seg Land Cover Flood Volumes and Areas;
Data _null_; *Extract the "grand total" area for each class - hold as Variables for later in Macro;
set &Seg.lc end=last;
if last then
do; *save the total acres of each LC as a macro variable for use in volume calc coming next;
call symput('ForestTotal',sum(forest, woody_wet, HerbWetlands, shrubland));*Acres;
call symput('RowCropTotal',sum(Corn,Cotton,WWheat,Rice));
call symput('WetlandTotal',Wetlands);
call symput ('SoybeanTotal',Soybeans);
call symput('NonRowCropTotal',Other_Ag);
call symput('PastureTotal',Sum(Pasture,Grass));
call symput('MixedAgtotal',Sum(WWheatSoy));
call symput('UrbanTotal',Developed);
call symput('UnfloodedTotal',Total);
end;
run;
Data &Seg.volumes;
* dz is one foot, so sum is acre-feet, our value of dz includes conversion to hm3
* volume is just the cumulative sum of areas x dz.;
* areas in THIS VERSION are the UNFLOODED areas that remaining at each elev for dry land export
* this is where the totals (Macro Variables) from immediately above are utilized;
* We hold the accumulating Volumes;
keep Elev_cuml Foresthm3 Wetlandhm3 rowcrophm3 nonrowcrophm3 soybeanhm3 pasturehm3 mixedaghm3 Urba
Forestha Wetlandha rowcropha nonrowcropha soybeanha pastureha mixedagha Urba
MaxHA;
retain Foresthm3 wetlandhm3 rowcrophm3 nonrowcrophm3 soybeanhm3 pasturehm3 mixedaghm3 Urbanhm3 Tot
dz 1.2335 e-3; *dz (1 foot) also converts acre-feet to cubic HM.;
SET &Seg.lc;
*Forest;
Incrmt = Forest + Woody_Wet + HerbWetlands + Shrubland;*combine Acreages;
%IF (&usedrylandexport = 1) %Then
%do;
Forestha = (&ForestTotal - Incrmt)*0.4047; *convert acres to HA;
%End;
%Else %do;
Forestha = (Incrmt)*0.4047; *convert acres to HA;
%End;
Foresthm3 = Foresthm3 + Incrmt*dz;
*Wetlands;
Incrmt = Wetlands;
%IF (&usedrylandexport = 1) %Then
%do;
WetlandHA = (&WetlandTotal - Incrmt)*0.4047;
%End;
%Else %do;
Wetlandha = Incrmt*0.4047;
%End;
Wetlandhm3 = WetlandHm3 + Incrmt*dz;
*RowCrop;
Incrmt = Sum(Corn,Cotton,WWheat,Rice);
%IF (&usedrylandexport = 1) %Then
%do;
RowCrophA = (&RowCropTotal- Incrmt)*0.4047;
%End;
%Else %do;
RowCrophA = (Incrmt)*0.4047;
%End;
Rowcrophm3 = RowCrophm3 + Incrmt*dz;
*Non RowCrop;
Incrmt = Other_Ag;
%IF (&usedrylandexport = 1) %Then
%do;
NonRowCropHA = (&NonRowCropTotal-Incrmt)*0.4047;
%end;
```

```
%Else %do;
NonRowCropHA = (Incrmt)*0.4047;
%End;
NonRowCrophm3 = NonRowCrophm3 + Incrmt*dz;
*Soybeans;
incrmt = Soybeans;
%IF (&usedrylandexport = 1) %Then
%do;
SoyBeanHA = (&SoyBeanTotal-Incrmt)*0.4047;
%End;
%Else %Do;
SoybeanHA = Incrmt*0.4047;
%End;
SoybeanHm3 = SoybeanHm3 + Incrmt*dz;
*Pasture;
Incrmt = Sum(Pasture,Grass);
%IF (&usedrylandexport = 1) %Then
%do;
PastureHA = (&PastureTotal - Incrmt)*0.4047;
%End;
%Else %Do;
PastureHA = (Incrmt)*0.4047;
%End;
Pasturehm3 = Pasturehm3 + Incrmt*dz;
*Mixed Ag;
Incrmt = WWheatSoy;
%IF (&usedrylandexport = 1) %Then
%do;
MixedAgHA = (&MixedAgTotal - Incrmt)*0.4047;
%end;
%Else %Do;
MixedAgHA = (Incrmt)*0.4047;
%end;
MixedAghm3 = MixedAghm3 + Incrmt*dz;
*WATER;
*Water = Waterhm3 + (Wetlands + Open_Water)*dz;
*Urban;
Incrmt = Developed;
%IF (&usedrylandexport = 1) %Then
%do;
UrbanHA = (&UrbanTotal - Incrmt)*0.4047;
%End;
%Else %Do;
UrbanHA = (Incrmt)*0.4047;
%End;
Urbanhm3 = UrbanHm3 + Developed*dz;
*TOTAL;
Incrmt = Total;
%IF (&usedrylandexport = 1) %Then
%do;
TotalHA = (&UnfloodedTotal - Incrmt)*0.4047;
%End;
%Else %Do;
TotalHA = (Incrmt)*0.4047;
%end;
MaxHA = &UnfloodedTotal * 0.4047;
Totalhm3 = Totalhm3 + Incrmt*dz;
rename Elev_cuml = PeakElev;
run;
%*%End;
%*%Else %Put &Seg LandCover Flood Volumes and Areas Previously Calculated;
%Mend MakeLCAreasAndVolumes;
%MakeLCAreasAndVolumes(NM);
%MakeLCAreasAndVolumes(STJ);
*==================================================================================
NOW WE ARE READY TO DO THE FINAL CALCULATIONS USING THE PROCESSED INPUT DATA
WE First define the Flood Concentrations (mg/L) with Suffix C
and non-flood export coefficients (kg/ha/season) with suffix X
AND WETLAND FUNCTION FACTORS (WWF)
```

```
The Suffix 1 or 2 on Macro names refers to Season
THESE ALL COME FROM EXTERNAL FILES TO KEEP THIS CODE A LITTLE NEATER
*==================================================================================
;
%Put;
%Put ==== Reading Coefs from Include Files =====;
%Put;
*=========================================;
* T O T A L P H O S P H O R U S
*=========================================;
%Put Phosphorus Coefs;
%Include "&TPcoefFile" ;
*=========================================;
* T O T A L N I T R O G E N
*=========================================;
%Put Nitrogen Coefs;
%Include "&TNcoefFile";;
*=========================================;
* O R G A N I C C A R B O N
*=========================================;
%Put TOC Coefs;
%Include "&TOCCoefFile";
*=========================================;
* S E D I M E N T
*=========================================;
%Put Sediment Coefs;
%Include "&SEDCoefFile";
%Macro GetExports(Seg,FluxVar,OutData,PeakVar,SeasX);
*seg is segment 'NM' or 'STJ';
*FluxVar is TP, TN, OC, or SED;
*Seasx is season 1 or 2;
* Create Generic Versions of Datasets for the Merge
* This allows TEMPORARY modifications and simplifies coding;
Data ForMerge1; * Use this approach to leave Orig. Dataset Alone and rename Elev to PeakVar;
set &seg.volumes; * resulting dataset has flood volumes and UNFLOODED areas for each LC type;
rename PeakElev = &PeakVar;
run;
%Put Creating &Seg Merge File for Season &Seasx and Flood Elev. &PeakVar with Use Dry Land = &UseDry
Data ForMerge2;
set &seg.Peaks;
if (Season=&seasx);
%If &UseDryLandExport=1 %then
%Do; *Force value to MAX dry land;
if &PeakVar = . then
do;
*put "Fixing missing Value for &PeakVar";
&PeakVar = 281;
end;
%End;
RUN;
*Prepare to Merge (Look up) landcover values to Associate with Time series of Peak Elevations;
proc sort data=ForMerge1; by &PeakVar; run;
proc sort data=ForMerge2; by &PeakVar; run;
* This Step generates an export dataset using the record of PEAK volumes and associated,
* non-flooded areas;
* Note that in season 1 (fall) there is almost NEVER any flooding without the project;
%Put Creating Season &SeasX Export of &LoadVar1 (&Outdata) by Merging Peak Flood with LC Export x El
data &OutData;
keep
Year date Season &PeakVar
Forestkg
Wetlandkg
RowCropkg
NonRowCropkg
Soybeankg
Pasturekg
MixedAgkg MixedAgHm3
ForestHa
RowCropHA
```

```
SoybeanHA
Urbankg Totalkg
TotKgPerHA
;
* ONE = season1 = Nov-Jan - held water (internal source)
* TWO = season2 = Feb-May - spring flood water from MissR.)
* PeakVar is either PeakW or PeakWO
* ForMerge1 is Landcover areas/volumes and ForMerge2 is the Seasonal Flood Peaks for Each year;
* Note that the MINIMUM flood peak isforced to 281 (forces maximum dry land);
;
merge ForMerge2(in=keeper) ForMerge1; by &PeakVar; if keeper;
if &PeakVar < 281 then
Do;
Foresthm3 = 0;
Wetlandhm3 = 0;
Rowcrophm3 = 0;
NonRowCrophm3 = 0;
Soybeanhm3 = 0;
Pasturehm3 = 0;
MixedAghm3 = 0;
*Water = 0;
Urbanhm3 = 0;
Totalhm3 = 0;
end;
* following uses seg, fluxvar, and seasx to define the macro
* to use - so triple &&& is needed for double substitution;
* in season 1 there is almost Never any flooding without project;
*the volumes and non-flooded areas are "picked" from the ForMerge Dataset;
*FOREST LOAD;
FloodLoad = foresthm3*&&&seg.Forest&fluxVar.C&seasx;*Vol x Conc;
NonFloodLoad = 0.5 * &&&Seg.Forest&FluxVar.X&seasx*(ForestHA); *Area x Export Coef;
WetlandEffect = (FloodLoad + NonfloodLoad)* &&&Seg.Forest&FluxVar.WFF&seasx;
Forestkg = FloodLoad + NonFloodLoad + WetlandEffect;
*Forestkg = foresthm3 *&&&seg.Forest&fluxVar.X&seasx *&&&seg.Forest&FluxVar.WFF&seasx;
*WETLAND LOAD;
FloodLoad = Wetlandhm3*&&&seg.Wetland&FluxVar.C&seasx;
NonFloodLoad = 0.5 * &&&Seg.Wetland&FluxVar.X&seasx*(WetlandHA); *Area x Export Coef;
WetlandEffect = (FloodLoad + NonfloodLoad)* &&&Seg.Wetland&FluxVar.WFF&seasx;
Wetlandkg = FloodLoad + NonFloodLoad + WetlandEffect;
*ROW CROP LOAD;
FloodLoad = RowCrophm3*&&&seg.RowCrop&fluxVar.C&seasx; *Vol x Conc;
NonFloodLoad = 0.5 * &&&Seg.RowCrop&FluxVar.X&seasx*(RowCropHA); *Area x Export Coef;
WetlandEffect = (FloodLoad + NonfloodLoad)*&&&Seg.RowCrop&FluxVar.WFF&seasx;
RowCropkg = FloodLoad + NonFloodLoad + WetlandEffect;
*RowCropkg = Rowcrophm3 *&&&seg.RowCrop&FluxVar.X&seasx *&&&seg.RowCrop&FluxVar.WFF&seasx
*NON ROW CROP LOAD;
FloodLoad = NONRowCrophm3*&&&seg.NONRowCrop&fluxVar.C&seasx;*Vol x Conc;
NonFloodLoad = 0.5 * &&&Seg.NONRowCrop&FluxVar.X&seasx*(NONRowCropHA); *Area x Export Coef;
WetlandEffect = (FloodLoad + NonfloodLoad)*&&&Seg.NONRowCrop&FluxVar.WFF&seasx;
NONRowCropkg = FloodLoad + NonFloodLoad + WetlandEffect;
*NonRowCropkg = NonRowcrophm3*&&&seg.NonRowCrop&FluxVar.X&seasx*&&&seg.NonRowCrop&FluxVar.WFF&se
*SOYBEAN LOAD;
FloodLoad = SoyBeanhm3*&&&seg.SoyBean&fluxVar.C&seasx;*Vol x Conc;
NonFloodLoad = 0.5 * &&&Seg.Soybean&FluxVar.X&seasx*(SoybeanHA); *Area x Export Coef;
WetlandEffect = (FloodLoad + NonfloodLoad)*&&&Seg.Soybean&FluxVar.WFF&seasx;
Soybeankg = FloodLoad + NonFloodLoad + WetlandEffect;
*PASTURE LOAD;
FloodLoad = Pasturehm3*&&&seg.Pasture&fluxVar.C&seasx;*Vol x Conc;
NonFloodLoad = 0.5 * &&&Seg.Pasture&FluxVar.X&seasx*(PastureHA); *Area x Export Coef;
WetlandEffect = (FloodLoad + NonfloodLoad)*&&&Seg.Pasture&FluxVar.WFF&seasx;
Pasturekg = FloodLoad + NonFloodLoad + WetlandEffect;
*Pasturekg = Pasturehm3 *&&&seg.Pasture&FluxVar.X&seasx *&&&seg.Pasture&FluxVar.WFF&seasx
*MIXED AG LOAD;
FloodLoad = MixedAghm3*&&&seg.MixedAg&fluxVar.C&seasx;*Vol x Conc;
NonFloodLoad = 0.5 * &&&Seg.MixedAg&FluxVar.X&seasx*(MixedAgHA); *Area x Export Coef;
WetlandEffect = (FloodLoad + NonfloodLoad)*&&&Seg.MixedAg&FluxVar.WFF&seasx;
MixedAgkg = FloodLoad + NonFloodLoad + WetlandEffect;
*MixedAgkg = MixedAghm3 *&&&seg.MixedAg&FluxVar.X&seasx *&&&seg.MixedAg&FluxVar.WFF&seasx
*URBAN LOAD;
```

```
FloodLoad = URBANhm3*&&&seg.URBAN&fluxVar.C&seasx;*Vol x Conc;
NonFloodLoad = 0.5 * &&&Seg.URBAN&FluxVar.X&seasx*(URBANHA); *Area x Export Coef;
WetlandEffect = (FloodLoad + NonfloodLoad)*&&&Seg.URBAN&FluxVar.WFF&seasx;
URBANkg = FloodLoad + NonFloodLoad + WetlandEffect;
*Urbankg = Urbanhm3 *&&&seg.Urban&FluxVar.X&seasx *&&&seg.Urban&FluxVar.WFF&seasx;
*TOTAL LOADS;
Totalkg = Sum(Forestkg,Rowcropkg,nonrowcropkg,Soybeankg,Pasturekg,MixedAgkg,urbankg);
TotKgPerHA = Totalkg/MaxHa;
Year = Year(date);
*if (&PeakVar ne . )then;
output;
RUN;
proc sort data=&OutData; by date; run;
* Do not need to delete ForMerge because we create it fresh each time;
* proc datasets lib=work;
* delete forMerge;
* run;
%Mend getExports;
*==================================================================;
*USE Single MACRO CALL TO PERFORM ALL THE CALCULATIONS for One Basin ;
*==================================================================;
%MACRO RunBasinExports(BasinID,Load);
%Let OutSet1 = &BasinID&Load;
%Put Calc. &Load Exports for &BasinId with Output to &OutSet1;
* FIRST, GET THE "WITHOUT" CONDITION;
%GetExports(&BasinID,&Load,&OutSet1._WO1,PeakWO,1);
%GetExports(&BasinID,&Load,&OutSet1._WO2,PeakWO,2);
*Prepare to Merge Season1 and Season2 results;
proc sort data=&OutSet1._wo1; by year season; run;
proc sort data=&OutSet1._wo2; by year season; run;
Data ExportWo;
merge &Outset1._wo1 &Outset1._wo2; by year season;
run;
*Now Sum across the two seasons;
proc sort data=ExportWo; by year;
proc means data=ExportWo noprint;
var totalkg ;*totkgperHa;
by year ;
output out=Mean_ExportWo sum = totalkgWo;
run;
*Second, GET THE "WITH PROJECT" ALTERNATIVE CONDITION for two seasons;
%GetExports(&BasinID,&LoadVar1,&OutSet1._W1,PeakW,1);*number is season;
%GetExports(&BasinID,&LoadVar1,&OutSet1._W2,PeakW,2);
*Prepare to Merge Season1 and Season2 results;
proc sort data=&OutSet1._w1; by year season; run;*Season 1;
proc sort data=&OutSet1._w2; by year season; run;*Season 2;
Data ExportW;
merge &OutSet1._w1 &OutSet1._w2; by year season;
run;
*Now Sum Across the Two Seasons;
proc sort data=ExportW; by year;
proc means data=ExportW noprint;
var totalkg ;*totkgperHa;
by year ;
output out=Mean_ExportW
sum = totalkgW;
run;
* Combine With and Without into One;
proc sort data=Mean_ExportW; by year; run;
proc sort data=Mean_ExportWo; by year; run;
Data Mean_Export&OutSet1;
merge Mean_exportW Mean_ExportWo;
by year;
drop _type_ _freq_;
if totalkgwo = . then totalkgwo=0;
run;
Title1 "Summary of Annual Mean &LoadVar1 Export from &BasinID";
Title2 "With and Without Alternative (&&&BasinID.Proj_Elev)";
proc means min max mean n data=mean_export&outset1;run;
```

```
Data &Outset1&&&BasinId.Proj_Elev; *BasinID + LoadVar + ELEV colmn;
set Mean_Export&OutSet1;
rename totalkgW = &Outset1&&&BasinId.Proj_Elev
totalkgWo = &Outset1.WO;
run;
%Mend RunBasinExports;
* Now run the two basins ;
* the next call creates TWO basin(2) x Elev_scenario(1) x exportvar(1) datasets;
options pageno = 1;
%RunBasinExports(NM,&LoadVar1);
%RunBasinExports(STJ,&LoadVar1);
* Now Sort the two basin datasets just created to allow merging by year
* Into a SINGLE, two-basin, elevation scenario;
Proc sort data=NM&LoadVar1&&NMProj_Elev; by year; run;
Proc sort data=STJ&LoadVar1&&STJProj_Elev; by year; run;
*NOW PERFORM THE MERGE;
Data Both&LoadVar1&&NMProj_Elev;
merge NM&LoadVar1&&NMProj_Elev STJ&LoadVar1&&STJProj_Elev; by year;
run;
%Mend Calc_All;
* The FinalMerger macro is used to allow the automatic merger of datasets
* from multiple consecutive runs (i.e., different loading variables, differing elev scenarios;
%Macro FinalMerger(LoadVar1,ELEV1,ELEV2,ELEV3);
%Put Creating ALL&LoadVar1 from;
%Put Both&LoadVar1&Elev1 Both&LoadVar1&Elev2 and Both&LoadVar1&Elev3;
Proc sort data=Both&LoadVar1&Elev1; by year; run;
Proc sort data=Both&LoadVar1&Elev2; by year; run;
Proc sort data=Both&LoadVar1&Elev3; by year; run;
Data All&LoadVar1;
Merge
Both&LoadVar1&Elev1
Both&LoadVar1&Elev2
Both&LoadVar1&Elev3;
by year;
run;
*Proc insight data=ALL&LoadVar1; *run;
%Mend FinalMerger;
%MACRO MakeFinalDataset(LV);
%CALC_ALL(&AA,&AA,&LV); * authorized project should be called first;
%CALC_ALL(&A1,&AA,&LV); * Only NM cares about ALT1, STJ stays with "Authorized";
%CALC_ALL(&A2,&AA,&LV); * Only NM cares about ALT2, STJ stays with "Authorized";
*Call FinalMerger to Generate Single Dataset for two Alternatives AND one Load Variable;
%FinalMerger(&LV,&AA,&A1,&A2);
%Mend MakeFinalDataSet;
%MakeFinalDataSet(TP);
%MakeFinalDataSet(TN);
%MakeFinalDataSet(TOC);
%MakeFinalDataSet(SED);

*--------------------------------------------------;
```

******** Version 05/1/2012 *******

***--**

*** Alternative 4a - NEW MADRID ONLY ***

*** this code is derived from the segment above and is very similar**

*** it has been altered slightly to process the different land cover and**

*** to eliminate St. Johns Bayou (not part of Alternative 4.2)**

***--**

```
* THIS SAS PROGRAM RELIES HEAVILY ON MACROs AND MACRO-VARIABLES TO MAKE IT
* FLEXIBLE FOR THE USER.  MOST OF THESE ARE DEFINED AT THE TOP OF THE CODE SEGMENT
* AND ARE REASONABLY WELL DOCUMENTED AS YOU GO THROUGH;


*================ THIS VERSION CAN USE EXPLICIT DRY LAND EXPORT =======================;
* THIS IS CONTROLLED BY THE UseDryLandExport macro variable set to 1(yes) or zero(no)
* When 1 (YES), we apply export coef ONLY to the land area above the flood contour
* This export contributes to the "Total Load" that is then subjected to Wetland function.

*NB: This calculates loads for the "WINTER" seasons of Ashby only - it ignores the low water period
of June-October (5 months) - we COULD assume no export, but the intent is to COMPARE alternatives.

*=========================================================================================;
%Let UseDryLandExport=1; *YES;
*Let UseDryLandExport=0; *NO;



*DEFINE THE DAILY ELEVATION INPUT SPREADSHEETS for New Madrid and St. Johns;
%LET NM_Elev_XLS = C:\A_D\usr2\WOTS_DOTS\New_Madrid_St.Johns_Floodway\2012\Data\NMElev4.xls;
%Let NM_LC_XLS   = C:\A_D\usr2\WOTS_DOTS\New_Madrid_St.Johns_Floodway\2012\Data\NMLandcover1b.xls;

*Specify the name of the "With PROJECT" elevation column
           that you wish to compare to the "EXISTING" column
           NOTE THAT COLUMN LABELED "EXISTING" is required!;

* WITH EXISTING PGM STRUCTURE YOU MUST RESTART SAS FOR EACH ALTERNATIVE
*%LET NMPROJ_ELEV=Alt4;*WithProj; *NEW MADRID Alternative 4;
%LET NMPROJ_ELEV=Alt1;
*%LET NMPROJ_ELEV=Alt2;

*NOTE - the loading Variable is USED in the Macro Call at the very end
*%Let LoadName = TP; *define the loading variable TP,TN,SED,TOC;
*%Let LoadName = TN; *define the loading variable TP,TN,SED,TOC;
*%Let LoadName = SED; *define the loading variable TP,TN,SED,TOC;
*%Let LoadName = TOC; *define the loading variable TP,TN,SED,TOC;

%Let CoefPath = C:\A_D\usr2\WOTS_DOTS\New_Madrid_St.Johns_Floodway\2012\SAS\Include_Coefs;

options NOsource;
*

OVERVIEW:  the approach is taken from the Ashby report and spreadsheets.
the central concept is to use two "phases" of export:
1. straight export coefficients that account for export and processing material from "dry land" conditions
2. export "concentrations" that apply to flood volumes during inundation.
These coefs or concentrations are customized for differing landcover types within the project area
and are "pro rated" to adjust for the period of inundation.
This adjustment has involved expert opinion to consider seasonality of exports and the
fact that the period of interest (inundation) would be only a fraction of the year and
primarily in the colder months.

The amount (or concentration) that is "available" based on export coefs. and concentration is multiplied
by the area or the volume of water to calculate a potential export mass. The volume of water is the
peak volume (above flood stage) during the season.

The original analysis assumed water would reach 285 during season 1, and 280 in season 2 with the
```

```
project in place.  These assumptions are OK for season 1, but underestimate the flood level
in season 2 based on the historic and simulated hydrographs. As a result, in this analysis we see
a much larger flood-related export of TP and Other constituents? during season 2 than Ashby estimated.

To provide a "credit" for runoff material that is trapped during the inundation period in the orig. analysis,
the "dry land" export coef (pro-rated for time) was applied to the area of inundation.  The rationale for
this
is that material that would otherwise drain from the area of inundation is now being trapped.
The delivery from the non-inundated portion of the watershed was NOT addressed in this original
approach, and so underestimates the total export from the project area.

The total "delivered material for export" is adjusted by a "Wetland Function Factor" (WFF) to arrive at net

export.
WFF is a fraction that represents the functioning of the subject landcover type when it is inundated.
For example, the cover type might REMOVE 80 percent of the "available" export during inundation,
and this is expressed as a "Wetland Function Factor" of -.8.
If the wetland AUGMENTS the dryland export by 10%, then the WWF is +1.1.  This is a very rough approximation
as it does not allow for variations in the area of landcover type that is inundated.

The spreadsheet approach assumes that the "net available" material during inundation is
fully exported from the system (i.e. into the River).

*===================================================================

Note for the import of Memphis spreadsheets,
They had to be processed a little to make them "SAS friendly" -
i.e., remove extra heading lines etc. and use nice column titles
that could easily become SAS variable names

*===================================================================
;

* Macro is used for the import of spreadsheet elevation data to avoid repeated
* (very slow) processing during development or exploration AND
* to allow user flexibility in designating files at the very top of code;

%Macro ImportElevXLS(OutData1,sourceXLS);
%if %sysfunc(exist(&SourceXLS))=1 %then
%DO;
  %Put Input File Does Not Exist: &SourceXLS;
  %End;
%if %sysfunc(exist(Work.&OutData1)) = 0 %then
%Do;
 %Put Importing Elevation Spreadsheet from &SourceXLS to Dataset &OutData1;
 PROC IMPORT OUT= WORK.&OutData1
            DATAFILE="&SourceXLS"
            DBMS=EXCEL2000 REPLACE;
     GETNAMES=YES;
 RUN;
%end;
%Else %Put Elevation Data Already Available - Import Skipped;
%Mend ImportElevXLS;

%ImportElevXLS(NMElev1,&NM_Elev_XLS);

*%ImportElevXLS(STJElev1,&STJ_ELEV_XLS);



*2.   ------------ Process the Elevation Data -----------------
*               To generate 30-day inundation contours
*
* The original Spreadsheet approach assumed that "inundation" behavior
* started immediately at full force once an area was under water for 30 days.
* and continued that way until water receeded. - We do not change that here

* The algorithm tracks duration of inundation at each 1 foot contour in 1 day time steps.
* A day is added to the duration in each contour below the current level of inundation.
```

```
* The duration is reset to zero in all contours ABOVE the current level of inundation.
* We then search through the contours (starting at the bottom) to find the level where
* duration drops below 30 days. There are simpler codes to do this
* but this seems very straight forward.

* The next step is to cross reference this level of inundation with the total area in each
* landcover type BELOW this level - this is GIS based info provided by Memphis District.
;


* Elevation Range within New Madrid is 263 to 299 MSL = 37 one foot increments;


* NEW MADRID:
*New Madrid and St.Johns have slightly different configurations
and so are run in separate steps;

Data NMelev1b;
  array ElevW[37] ElevW263-ElevW299; * 1 foot contours with project;
  array ElevWO[37] ElevWO263-ElevWO299; *1 foot contours without project;
  retain elevW263-elevW299 0.0 elevWO263-elevWO299 0.0;

  keep day date2 existing &NMProj_ELEV Elev30dW Elev30dWO ElevDiff;
  format date2 mmddyy10.;
  rename date2 = date;

  SET nmelev1;
  if existing ne .; * "existing" is water elevation w/o project;
  date2 = datepart(date);
  ElevIndexWO  = int(existing) - 262;
  ElevIndexW   = int(&NMPROJ_ELEV) - 262;
  *put date2= +3 Existing= + 3 ElevIndex=;
  do i = 1 to elevIndexW;
    ElevW[i] = ElevW[i] + 1;
    end;
  do i = ElevIndexW+1 to 37;
    ElevW[i] = 0;
        end;
  do i = 1 to elevIndexWO;
    ElevWO[i] = ElevWO[i] + 1;
    end;
  do i = ElevIndexWO+1 to 37;
    ElevWO[i] = 0;
        end;
*now find the elevation where duration drops below 30 days;
*With project;
i = 1;
do while ((i < 37) and (elevW[i] > 29));
  i = i + 1;
  end;
Elev30dW = .;
if i > 1 then
Elev30dW = 261+i;

*now find the elevation where duration drops below 30 days;
*WithOUT project;
i = 1;
do while ((i < 37) and (elevWO[i] > 29));
  i = i + 1;
  end;
Elev30dWO = .;
if i > 1 then
Elev30dWO = 261+i;
ElevDiff    = Elev30dW - Elev30dWO;
run;
*========= END NEW MADRID ELEVATIONS ================;
```

```
* The GetPeak30DayElev macro is now used to skip processing if it is already complete,
* but more importantly, to centralize the code for finding seasonal PEAK inundation;

%Macro GetPeak30DayElev(seg);
* EXTRACT THE SEASONAL PEAKS of INUNDATION, with and without project;
%if %sysfunc(exist(Work.&seg.Peaks)) = 0 %then
%Do;
 %Put Calculating &Seg 30 day Peak Inundation Elev;
 Data &seg.Peaks;
  set &seg.Elev1b;
  retain oldseason 3 peakW peakWO 0;
  keep date PeakW PeakWO Season;
  seas = 3; *default;
  if (month(date) > 10) or (month(date) < 2) then seas = 1;
  if (month(date) > 1) and (month(date) < 6) then seas = 2;
  if seas ne oldseason then
  do; *process the peak from the previous season;
    if peakW  < 281  then peakW  = .;
        if peakWo < 281  then peakWo = .;
        Season = OldSeason;
        if season < 3 then
    output; *set to ignore "off season" floods;
        peakW = 0;
    peakWO = 0;
    end;
  if Elev30dW  > PeakW  then PeakW  = Elev30dW;
  if Elev30dWo > PeakWo then PeakWo = Elev30dWo;
  oldseason = seas;
  run;
  %End;
  %Else %Put &Seg 30 day Peak Inundation Elev Already Calculated, Step Skipped;
%Mend GetPeak30dayElev;

%GetPeak30DayElev(NM);
*%GetPeak30DayElev(STJ);



* Matching Landcover to the original analysis creates an issue because
  the export coefs used by Steve Ashby are linked to landcover types
  that do NOT match the landcover types provided by Memphis
  So some recombinimg/recoding is required.



* Note that Ashby's table 4 treats all "natural cover" the same:
  (i.e., cypress/tupelo, scrub, marsh, bottomland hardwood) all have the
  same wetland function factors.  this carries through  into the spreadsheets for nitrogen
  check that this is true for phos also


to keep things simple, we process the landcover in the steps that follow
We read in the land cover at each elevation - these are cumulative i.e. total landcover below a
certain elevations.

NOTE:
  In early winter (season 1)  Nov-Feb, the PROJECT holds water for ducks etc.,
  In late winter-spring and summer (season 2), natural flooding occurs from the Mississippi
  (the project can clip the flood peaks).
  Because of this clipping, in most summers the elev is lower with the proj. than without.

  Ashby's analysis split winter into two "seasons"
  Season 1 is Nov-Jan - held water (internal source)
  Season 2 is Feb-May - spring flood water from MissR.

  We can ASSUME that the peak during each "season" is the "volume" that drains off and exports
  P,N, Carbon. Steve assumed a specific "typical" elevation for the flood seasons.  In this revision
  we use actual (or simulated) data to get REAL about that, but its still a simplification.
```

```
  Algorithm note:  We step through the data, date by date.  When season changes we process the
  previous season (we will know the previous peak at that point) and start to capture the
  peak for the new season.  We actually have three seasons 1. Fall-Winter, 2. Winter-Spring,
  and 3. Summer-fall.  Bear in mind that seasons 1 and 2 are COLD.;

*PROCESS LANDCOVER
 We Process the landcover and export conc/coefs into two "Lookup Tables",
 one each for NM and STJ.
 we then MERGE these with the peak Elevation dataset to calculate export;

* A Macro is used here to avoid repeated (very slow)processing of Excel spreadsheet
* During development or exploration;

%Macro ImportLandCoverXLS;
%if %sysfunc(exist(Work.NmLC)) = 0 %then
%Do;
 %Put Importing the Land Cover Spreadsheets;

  PROC IMPORT OUT= WORK.NMLC
        DATAFILE= "&NM_LC_XLS"
        DBMS=EXCEL2000 REPLACE;
        GETNAMES=YES;
  RUN;
/*
  PROC IMPORT OUT= WORK.STJLC
            DATAFILE= "D:\usr2\New_Madrid_St.Johns_Floodway\New_Analyses\Landcover\STJLandcover1.xls"
            DBMS=EXCEL2000 REPLACE;
     GETNAMES=YES;
  RUN;
*/
  %End;
 %Else %Put ***  Landcover Previously Input, Import Skipped ***;
%Mend ImportLandCoverXLS;

%ImportLandCoverXLS;

* Now rework the raw landcover input to get it into more useable form.

 Keep in mind that stage below 280 in New Madrid is NON-Flooded
 and can be treated as "dry land" conditions.

 the original approach is to assume the cumulative acreage of each LC type
 below the 30-day inundation level is the area that exports in a flood.

The original analysis uses static scenarios with the water reaching a specific elevation.
Consequently the "Volume" associated with the scenario is a simple constant.
Steve assumes that this volume reaches equilibrium with the designated concentration
and Wetland function factor.

Steve does not use acres directly in his spreadsheet to calculate volumes,
but rather uses a  fraction of the total inundated area x the total inundated volume
to get the water volume associated with each inundated LC type. This does not fully
address the elevation distribution of the LC type because it assumes that
all inundated land has the same depth of overlying water.

We have the information (i.e., landcover below each 1 foot contour) to do a little better.
We multiply the area at each elev by the depth of water above it.

=============================================
  L A N D C O V E R   R E G R O U P I N G
=============================================
WE REGROUP the LC into the effective classes Ashby used as follows:
OLD
LC class      Ashby Class
Corn             RowCrop
Cotton           RowCrop
Rice             RowCrop
Soybeans         Soybeans + ?? to allow N behavior.
Wwheat           RowCrop
```

```
WwheatSoy        Mixed_Ag
Other_Ag         Mixed_Ag??
Fallow           Pasture
Forest           Forest
Woody_Wet        Forest
Developed        Urban
Grass            Pasture
HerbWetlands     Water
Wetlands         Water
Open_Water       Water
ShrubLand        Forest
Pasture          Pasture

The 2012 Alternative uses different LC types :< so here it is again
Agriculture     RowCrop
Fallow          Pasture
Forest          Forest
Developed       Urban
Herbaceous      Pasture
Open_Water      Water
Shrubland       Forest
Pasture         Pasture

;

%Macro MakeLCAreasAndVolumes(seg);
* This Macro Calculates Landcover volumes below each elevation contour AND
* Reclassifies the Landcover into a rough match to original classes of Ashby
* See page 10 of ERDC report (2000).
* We must keep soybeans and soybean mixes separate to allow separate handling for nitrogen.
;

%*this "IF" prevents unnecessary re-runs of this code;
%*%if %sysfunc(exist(Work.&seg.Volumes)) = 0 %then
 %Do;
 %Put Calculating &Seg Land Cover Flood Volumes and Areas;
 Data _null_; *Extract the "grand total" area for each class - hold as Variables for later in Macro;
   set &Seg.lc end=last;
   if last then
   do; *save the total acres of each LC as a macro variable for later calculations;
     call symput('ForestTotal',sum(forest,shrubland));*Acres;
         call symput('RowCropTotal',Agriculture);
            *call symput('WetlandTotal',Wetlands);
            *call symput ('SoybeanTotal',Soybeans);
            *call symput('NonRowCropTotal',Other_Ag);
         call symput('PastureTotal',sum(Pasture,Fallow,Herbaceous));
            *call symput('MixedAgtotal',Sum(WWheatSoy));
         call symput('UrbanTotal',Developed);
         call symput('UnfloodedTotal',Total);
         end;
   run;

 Data &Seg.volumes;
  * dz is one foot, so sum is acre-feet, our value of dz includes the conversion to hm3
  * volume is just the cumulative sum of volume increments (areas x dz) of inundation;
  * areas in THIS VERSION are the UNFLOODED areas that remaining at each elev for dry land export
  * this is where the totals (Macro Variables) calculated just above are utilized;
  * We hold the accumulating Volumes;
  keep Elev_cuml Foresthm3 rowcrophm3 pasturehm3 Urbanhm3 TotalHm3
                 Forestha  rowcropha  pastureha  Urbanha  TotalHa
                 MaxHA;
  retain Foresthm3 rowcrophm3 pasturehm3 Urbanhm3 Totalhm3  0
         dz 1.2335 e-3; *dz (1 foot) also converts acre-feet to cubic HM.;

  SET &Seg.lc;
  *Forest;
  Incrmt = Forest + Shrubland;*combine Acreages;
  %IF (&usedrylandexport = 1) %Then
  %do;
```

```
    Forestha       = (&ForestTotal - Incrmt)*0.4047; *convert acres to HA;
        %End;
  %Else %do;
    Forestha       = (Incrmt)*0.4047; *convert acres to HA;
        %End;
  Foresthm3      = Foresthm3 + Incrmt*dz;

  *RowCrop;
  Incrmt         = rowcrophm3;
  %IF (&usedrylandexport = 1) %Then
  %do;
    RowCrophA      = (&RowCropTotal- Incrmt)*0.4047;
        %End;
  %Else %do;
   RowCrophA      = (Incrmt)*0.4047;
   %End;
  Rowcrophm3     = RowCrophm3    + Incrmt*dz;

  *Pasture;
  Incrmt         = Pasture;
  %IF (&usedrylandexport = 1) %Then
  %do;
    PastureHA      = (&PastureTotal - Incrmt)*0.4047;
        %End;
  %Else %Do;
    PastureHA      = (Incrmt)*0.4047;
        %End;
  Pasturehm3     = Pasturehm3    + Incrmt*dz;

  *Urban;
  Incrmt         = Developed;
  %IF (&usedrylandexport = 1) %Then
  %do;
    UrbanHA        = (&UrbanTotal - Incrmt)*0.4047;
        %End;
  %Else %Do;
    UrbanHA        = (Incrmt)*0.4047;
        %End;
  Urbanhm3       = UrbanHm3      + Developed*dz;

  *TOTAL;
  Incrmt         = Total;
  %IF (&usedrylandexport = 1) %Then
  %do;
    TotalHA        = (&UnfloodedTotal - Incrmt)*0.4047;
        %End;
  %Else %Do;
    TotalHA        = (Incrmt)*0.4047;
        %end;
  MaxHA          = &UnfloodedTotal * 0.4047;
  Totalhm3       = Totalhm3 + Incrmt*dz;
  rename Elev_cuml = PeakElev;
  run;
  %*%End;
  %*%Else %Put &Seg LandCover Flood Volumes and Areas Previously Calculated;

%Mend MakeLCAreasAndVolumes;

%MakeLCAreasAndVolumes(NM);
*%MakeLCAreasAndVolumes(STJ);


*================================================================================
  NOW WE ARE READY TO DO THE FINAL CALCULATIONS USING THE PROCESSED INPUT DATA
  WE First define the Flood Concentrations (mg/L) with Suffix C
  and non-flood export coefficients (kg/ha/season) with suffix X
  AND WETLAND FUNCTION FACTORS (WWF)
  The Suffix 1 or 2 on Macro names refers to Season
```

```
  THESE ALL COME FROM EXTERNAL FILES TO KEEP THIS CODE A LITTLE NEATER
*================================================================================
 ;


*=======================================;
*    T O T A L   P H O S P H O R U S
*=======================================;

%Include "&CoefPath\PhosphorusCoefs.txt";


*=======================================;
*      T O T A L   N I T R O G E N
*=======================================;
%Include "&CoefPath\NitrogenCoefs.txt";


*=======================================;
*      O R G A N I C  C A R B O N
*=======================================;
%Include "&CoefPath\CarbonCoefs.txt";


*=======================================;
*      S E D I M E N T
*=======================================;
%Include "&CoefPath\SedimentCoefs.txt";


%Macro GetExports(Seg,FluxVar,OutData,PeakVar,SeasX);
*seg is segment 'NM' or 'STJ';
*FluxVar is TP, TN, OC, or SED;
*Seasx is season 1 or 2;

* Create Generic Versions of Datasets for the Merge
* This allows TEMPORARY modifications and simplifies coding;

Data ForMerge1;      * Use this approach to leave Orig. Dataset Alone and rename Elev to PeakVar;
  set &seg.volumes; * resulting dataset has flood volumes and UNFLOODED areas for each LC type;
  rename PeakElev = &PeakVar;
  run;

%Put Creating Merge File for Season &Seasx and Flood Elev. &PeakVar with Use Dry Land = &UseDryLandExport;
Data ForMerge2;
  set &seg.Peaks;
  if (Season=&seasx);
  %If &UseDryLandExport=1 %then
  %Do; *Force value to MAX extent of dry land;
     if &PeakVar = . then
     do;
          *put "Fixing missing Value for &PeakVar";
      &PeakVar = 281;
          end;
         %End;
RUN;


*Prepare to Merge (Look up) landcover values to Associate with Time series of Peak Elevations;
proc sort data=ForMerge1;  by &PeakVar; run;
proc sort data=ForMerge2;  by &PeakVar; run;

* This Step generates an export dataset using the record of PEAK volumes and associated, non-flooded areas;
* Note that in season 1 (fall) there is almost NEVER any inundation without the project;

%Put Creating Season &SeasX Export of &LoadVar1 (&Outdata) by Merging Peak Flood with LC Export x Elev;
data &OutData;
keep
  Year date Season &PeakVar
```

```
  Forestkg
  RowCropkg
  Pasturekg
  ForestHa
  RowCropHA
  Urbankg Totalkg
  TotKgPerHA
;

  * ONE = season1  = Nov-Jan - held water (internal source)
  * TWO = season2  = Feb-May - spring flood water from MissR.)
  * PeakVar is either PeakW (with) or PeakWO (without)
  * ForMerge1 is Landcover areas/volumes and ForMerge2 is the Seasonal Flood Peaks for Each year;

  * Notes:  MINIMUM flood peak is forced to 281 (forces maximum of dry land);
  * Ashby reduced Export Coefficients by 50% for upland and ag land covers in Season 1
  *       and had ZERO exports for Ag and Upland in Season 2.
;
  *ForMerge2 is the peak elev., ForMerge1 is landcover area and volume at each elevation;
  merge ForMerge2(in=keeper) ForMerge1; by &PeakVar; if keeper;
  if &PeakVar < 281 then
  Do;* zero inundation!;
   Foresthm3      = 0;
   Rowcrophm3     = 0;
   Pasturehm3     = 0;
   *Water         = 0;
   Urbanhm3       = 0;
   Totalhm3       = 0;
   end;

 *  following uses seg, fluxvar, and seasx to define the macro
 *  to use - so triple & is needed for double substitution;

 * in season 1 there is almost Never any flooding without project;
   *the volumes and non-flooded areas are "picked" from the ForMerge Dataset;


   *FOREST LOAD;
   FloodLoad      = foresthm3*&&&seg.Forest&fluxVar.C&seasx;                    * = Vol x Conc;
   NonFloodLoad    = 0.5 * &&&Seg.Forest&FluxVar.X&seasx*(ForestHA);                * = Area x Export Coef x
1/2;
   WetlandEffect  = (FloodLoad + NonfloodLoad)* &&&Seg.Forest&FluxVar.WFF&seasx; * = negative fraction or one

(second half);
   Forestkg       = FloodLoad + NonFloodLoad + WetlandEffect;
   *Forestkg      = foresthm3    *&&&seg.Forest&fluxVar.X&seasx    *&&&seg.Forest&FluxVar.WFF&seasx;

   *WETLAND LOAD;
   *FloodLoad      = Wetlandhm3*&&&seg.Wetland&FluxVar.C&seasx;
   *NonFloodLoad   = 0.5 * &&&Seg.Wetland&FluxVar.X&seasx*(WetlandHA); *Area x Export Coef;
   *WetlandEffect  = (FloodLoad + NonfloodLoad)* &&&Seg.Wetland&FluxVar.WFF&seasx;
   *Wetlandkg      = FloodLoad + NonFloodLoad + WetlandEffect;

   *ROW CROP LOAD;
   FloodLoad      = RowCrophm3*&&&seg.RowCrop&fluxVar.C&seasx; *Vol x Conc;
   NonFloodLoad   = 0.5 * &&&Seg.RowCrop&FluxVar.X&seasx*(RowCropHA); *Area x Export Coef;
   WetlandEffect  = (FloodLoad + NonfloodLoad)*&&&Seg.RowCrop&FluxVar.WFF&seasx;
   RowCropkg      = FloodLoad + NonFloodLoad + WetlandEffect;
   *RowCropkg     = Rowcrophm3   *&&&seg.RowCrop&FluxVar.X&seasx   *&&&seg.RowCrop&FluxVar.WFF&seasx;

   *NON ROW CROP LOAD;
   *FloodLoad      = NONRowCrophm3*&&&seg.NONRowCrop&fluxVar.C&seasx;*Vol x Conc;
   *NonFloodLoad   = 0.5 * &&&Seg.NONRowCrop&FluxVar.X&seasx*(NONRowCropHA); *Area x Export Coef;
   *WetlandEffect  = (FloodLoad + NonfloodLoad)*&&&Seg.NONRowCrop&FluxVar.WFF&seasx;
   *NONRowCropkg   = FloodLoad + NonFloodLoad + WetlandEffect;
   *NonRowCropkg  = NonRowcrophm3*&&&seg.NonRowCrop&FluxVar.X&seasx*&&&seg.NonRowCrop&FluxVar.WFF&seasx;

   *SOYBEAN LOAD;
   *FloodLoad      = SoyBeanhm3*&&&seg.SoyBean&fluxVar.C&seasx;*Vol x Conc;
```

```
   *NonFloodLoad   = 0.5 * &&&Seg.Soybean&FluxVar.X&seasx*(SoybeanHA); *Area x Export Coef;
   *WetlandEffect  = (FloodLoad + NonfloodLoad)*&&&Seg.Soybean&FluxVar.WFF&seasx;
   *Soybeankg      = FloodLoad + NonFloodLoad + WetlandEffect;

   *PASTURE LOAD;
   FloodLoad      = Pasturehm3*&&&seg.Pasture&fluxVar.C&seasx;*Vol x Conc;
   NonFloodLoad   = 0.5 * &&&Seg.Pasture&FluxVar.X&seasx*(PastureHA); *Area x Export Coef;
   WetlandEffect  = (FloodLoad + NonfloodLoad)*&&&Seg.Pasture&FluxVar.WFF&seasx;
   Pasturekg      = FloodLoad + NonFloodLoad + WetlandEffect;
   *Pasturekg     = Pasturehm3   *&&&seg.Pasture&FluxVar.X&seasx   *&&&seg.Pasture&FluxVar.WFF&seasx;

   *MIXED AG LOAD;
  * FloodLoad      = MixedAghm3*&&&seg.MixedAg&fluxVar.C&seasx;*Vol x Conc;
  * NonFloodLoad   = 0.5 * &&&Seg.MixedAg&FluxVar.X&seasx*(MixedAgHA); *Area x Export Coef;
  * WetlandEffect  = (FloodLoad + NonfloodLoad)*&&&Seg.MixedAg&FluxVar.WFF&seasx;
  * MixedAgkg        = FloodLoad + NonFloodLoad + WetlandEffect;
  * MixedAgkg     = MixedAghm3   *&&&seg.MixedAg&FluxVar.X&seasx   *&&&seg.MixedAg&FluxVar.WFF&seasx;

   *URBAN LOAD;
   FloodLoad      = URBANhm3*&&&seg.URBAN&fluxVar.C&seasx;*Vol x Conc;
   NonFloodLoad   = 0.5 * &&&Seg.URBAN&FluxVar.X&seasx*(URBANHA); *Area x Export Coef;
   WetlandEffect  = (FloodLoad + NonfloodLoad)*&&&Seg.URBAN&FluxVar.WFF&seasx;
   URBANkg        = FloodLoad + NonFloodLoad + WetlandEffect;
   *Urbankg       = Urbanhm3     *&&&seg.Urban&FluxVar.X&seasx     *&&&seg.Urban&FluxVar.WFF&seasx;

   *TOTAL LOADS;
   Totalkg        = Sum(Forestkg,Rowcropkg,Pasturekg,urbankg);
   TotKgPerHA     = Totalkg/MaxHa;
 Year = Year(date); *Need to join seasons by water year!;
*if (&PeakVar ne . )then;
 output;
RUN;

proc sort data=&OutData; by date; run;
* Do not need to delete ForMerge because we create it fresh each time
* proc datasets lib=work;
*  delete forMerge;
*  run;

%Mend getExports;


*=====================================================================;
*USE Single MACRO CALL TO PERFORM ALL THE CALCULATIONS for One Basin ;
*=====================================================================;



%MACRO RunExports(BasinID,LoadVar1);
%Let OutSet1 = &BasinID&LoadVar1;

* FIRST, GET THE "WITHOUT" CONDITION;
%GetExports(&BasinID,&LoadVar1,&OutSet1._WO1,PeakWO,1); *season 1;
%GetExports(&BasinID,&LoadVar1,&OutSet1._WO2,PeakWO,2); *season 2;

*Prepare to Merge Season1 and Season2 results;
proc sort data=&OutSet1._wo1; by year season; run;
proc sort data=&OutSet1._wo2; by year season; run;
Data ExportWo;
  merge &Outset1._wo1 &Outset1._wo2; by year season;
  run;

*Now Sum across the two seasons;
proc sort data=ExportWo; by year;

proc means data=ExportWo noprint;
var totalkg ;*totkgperHa;
by year ;
output out=Mean_ExportWo  sum = totalkgWo;
```

```
run;


*Second, GET THE "WITH PROJECT" ALTERNATIVE CONDITION for two seasons;
%GetExports(&BasinID,&LoadVar1,&OutSet1._W1,PeakW,1);*number is season;
%GetExports(&BasinID,&LoadVar1,&OutSet1._W2,PeakW,2);

*Prepare to Merge Season1 and Season2 results;
proc sort data=&OutSet1._w1; by year season; run;*Season 1;
proc sort data=&OutSet1._w2; by year season; run;*Season 2;
Data ExportW;
  merge &OutSet1._w1 &OutSet1._w2; by year season;
  run;

*Now Sum Across the Two Seasons;
proc sort data=ExportW; by year;
proc means data=ExportW noprint;
var totalkg ;*totkgperHa;
by year ;
output out=Mean_ExportW
  sum = totalkgW;
run;

* Combine With and Without into One;
proc sort data=Mean_ExportW; by year; run;
proc sort data=Mean_ExportWo; by year; run;
Data Mean_Export&OutSet1;
  merge Mean_exportW Mean_ExportWo;
  by year;
  drop _type_ _freq_;
  if totalkgwo = . then totalkgwo=0;
  run;

Title1 "Summary of Annual Mean &LoadVar1 Export from &BasinID";
Title2 "With and Without Alternative (&&&BasinID.Proj_Elev)";
proc means min max mean n data=mean_export&outset1;run;
*proc insight data=Mean_Export&Outset1;
*run;
%Mend RunExports;
```

```
* CALL MACRO AS:  %RunExports(NM,&LoadName);*TP,TN,SED,TOC;
Options pageno=1;
%RunExports(NM,TP);
%RunExports(NM,TN);
%RunExports(NM,SED);
%RunExports(NM,TOC);
```

Appendix B: Export Coefficients, Concentrations, and Wetland Function Factors.

In this revision to the Ashby et al. (2000) effort, we have used SAS software code and Macro variables to perform the calculations. This allows us to localize all the variables that can be readily altered (coefficients) into single listings as input files. The advantage to this approach over the original spreadsheet is that these values are all now listed explicitly, in a readable form, and in a single, accessible location. Values that are changed once in the one “master” list will be reflected in all calculations in the code (and the output).

The listing that follows is the actual SAS program code (a sequence of %Let statements) imported by SAS software as %Include files to perform the calculations in this report. The listings include export coefficients, flood water concentrations, and Wetland Function Factors for each of the export constituents of interest (i.e., total phosphorus, total nitrogen, organic carbon, and sediment), for each of two flood seasons, and each of the two sub-areas in the project (New Madrid Floodway and St. Johns Bayou). The SAS code represents these various input values as MACRO variables and sets a substantial number of these (%LET) that are then used in the calculations. The names of these macros (and hence the values they reference) follow this convention:

<Basin ID> <Land Cover><Constituent><Value Type><Season Number>

Basin Id = NM or STJ
Land Cover = One of eight (Forest, Wetland, RowCrop, NonRowCrop, Soybean,Pasture, MixedAg, or Urban)
Constituent = TP, TN, TOC, or SED.
Value Type = Concentration (c, mg/L), Export (x, kg/ha/season), Wetland Function Factor (WFF)
Season = 1 (fall winter) or 2 (late winter- spring).

For example NMForestTPC1 is New Madrid, Forest, Total Phosphorus Concentration, Season 1;

```
* SAS CODE STARTS HERE FOR PHOSPHORUSCOEFS.TXT;
```

Background. We regroup the LC into the effective classes Ashby et al. (2000) used as follows:

LC class Ashby Class

Corn RowCrop

Cotton RowCrop

Rice RowCrop

Soybeans Soybeans + XX to allow N behavior.

Wwheat RowCrop

WwheatSoy Mixed_Ag

Other_Ag Mixed_Ag??

Fallow Pasture

Forest Forest

Woody_Wet Forest

Developed Urban

Grass Pasture

HerbWetlands Water

Wetlands Water

Open_Water Water

ShrubLand Forest

Pasture Pasture

===============================

Forest = sum(forest, woody_wet, HerbWetlands, shrubland) = tupelo

RowCrop = sum(Corn,Cotton,WWheat,Rice)

NonRowCrop = Other_Ag

Soybean = Soybeans

Pasture = Sum(Pasture,Grass)

MixedAg = WWheatSoy = cotton/soy corn/soy

Urban = Developed

;

```
*Flood Concentration ;
  %let NMforestTpC1       = 0.21; *B19;
  %let NMWetlandTpC1      = 0.21;
  %let NMrowcroptpC1      = 0.21; *B19;
  %let NMNonRowCropTPC1   = 0.21; *B19;
  %let NMSoybeanTPC1      = 0.21; *B19;
  %let NMPastureTPC1      = 0.21; *B19;
  %let NMMixedAgTPC1      = 0.21; *B19;
  %let NMUrbanTPC1        = 0.21; *B19;

*Dry Land Export Coef kg/ha/season - adjusted for length of flood-free period;
  %let NMforestTpX1       = 0.0; *Zero in Ashby sheet;
  %let NMWetlandTpX1      = 0.0;
  %let NMrowcroptpX1      = 1.1; *J19;
  %let NMNonRowCropTPX1   = 0.1; *o19 = herbaceous veg = other ag;
  %let NMSoyBeanTPX1      = 1.1; *L19;
  %let NMPastureTPX1      = 0.04;*P19;
  %let NMMixedAgTPX1      = 0.5; *M19;
  %let NMUrbanTPX1        = 1.5; *J19+ Not in Ashby, not significant;

  %let NMforestTpWFF1     = -0.4;
  %let NMWetlandTpWFF1    = -0.4;
  %let NMrowcroptpWFF1    = 1.0;
  %let NMNonRowCropTPWFF1 = 1.0;
  %let NMSoyBeanTPWFF1    = 1.0;
  %let NMPastureTPWFF1    = 1.0;
  %let NMMixedAgTPWFF1    = 1.0;
```

```
%let NMUrbanTPWFF1      = 1.0;


*Season 2 - Winter Spring  = backwater flooding only, B20;

%let NMforestTpC2       = 0.15; *B20;

%let NMWetlandTpC2      = 0.21;

%let NMrowcroptpC2      = 0.15; *B20;

%let NMNonRowCropTPC2   = 0.15; *B20;

%let NMSoybeanTPC2      = 0.15; *B20;

%let NMPastureTPC2      = 0.15; *B20;

%let NMMixedAgTPC2      = 0.15; *B20;

%let NMUrbanTPC2        = 0.15; *B20;


*Ashby had NO dry land export during season2 in NM -backwater flooding only;

%let NMforestTpX2       = 0.0; *N/A;

%let NMWetlandTpX2      = 0.0;

%let NMrowcroptpX2      = 0.0; *N/A;

%let NMNonRowCropTPX2   = 0.0; *N/A;

%let NMSoybeantpX2      = 0.0; *N/A;

%let NMPastureTPX2      = 0.0; *N/A;

%let NMMixedAgTPX2      = 0.0; *N/A;

%let NMUrbanTPX2        = 0.0; *N/A;


*Ashby uses ONE WWF for both seasons;

%let NMforestTpWFF2     = -0.4;

%let NMWetlandTpWFF2    = -0.4;

%let NMrowcroptpWFF2    = 1.0;

%let NMNonRowCropTPWFF2 = 1.0;

%let NMSoybeanTPWFF2    = 1.0;
```

```
%let NMPastureTPWFF2    = 1.0;

%let NMMixedAgTPWFF2    = 1.0;

%let NMUrbanTPWFF2      = 1.0;



*========  St. Johns Bayou ========;

 *FALL and WINTER (season 1);

 %let STJforestTpC1       = 0.21; *B19;

 %let STJWetlandTpC1      = 0.21; *;

 %let STJrowcroptpC1      = 0.21; *B19;

 %let STJNonRowCropTPC1   = 0.21; *B19;

 %let STJSoybeanTPC1      = 0.21; *B19=d19;

 %let STJPastureTPC1      = 0.21; *B19;

 %let STJMixedAgTPC1      = 0.21; *B19;

 %let STJUrbanTPC1        = 0.21; *B19;


 %let STJforestTpX1       = 0.0; *Season1 export = zero;

 %let STJWetlandTpX1      = 0.0; *;

 %let STJrowcroptpX1      = 1.1; *J19;

 %let STJNonRowCropTPX1   = 0.1; *o19;

 %let STJSoybeanTPX1      = 1.1; *L19;

 %let STJPastureTPX1      = 0.04;*p19;

 %let STJMixedAgTPX1      = 0.5; *M19;

 %let STJUrbanTPX1        = 1.5; *J19+ Not in Ashby;


 %let STJforestTPWFF1     = 1.0;

 %let STJWetlandTPWFF1    = 1.0; *????;

 %let STJrowcropTPWFF1    = 1.0;
```

```
%let STJNonRowCropTPWFF1 = 1.0;

%let STJSoybeanTPWFF1    = 1.0;

%let STJPastureTPWFF1    = 1.0;

%let STJMixedAgTPWFF1    = 1.0;

%let STJUrbanTPWFF1      = 1.0;


*WINTER and SPRING = season2;

*Ashby had NO dry land export during season2 in STJ;

%let STJforestTpC2       = 0.15; *B20;

%let STJWetlandTpC2      = 0.15; *H20;

%let STJrowcroptpC2      = 0.15; *B20;

%let STJNonRowCropTPC2   = 0.15; *B20;

%let STJSoybeanTPC2      = 0.15; *B20;

%let STJPastureTPC2      = 0.15; *B20;

%let STJMixedAgTPC2      = 0.15; *B20;

%let STJUrbanTPC2        = 0.15; *B20;


%let STJforestTPX2       = 0.0;

%let STJWetlandTPX2      = 0.0;

%let STJrowcropTPX2      = 0.0;

%let STJNonRowCropTPX2   = 0.0;

%let STJSoybeanTPX2      = 0.0;

%let STJPastureTPX2      = 0.0;

%let STJMixedAgTPX2      = 0.0;

%let STJUrbanTPX2        = 0.0;


%let STJforestTpWFF2     = 1.0;

%let STJWetlandTpWFF2    = 1.0;
```

```
  %let STJrowcroptpWFF2    = 1.0;
  %let STJNonRowCropTPWFF2 = 1.0;
  %let STJSoybeanTPWFF2    = 1.0;
  %let STJPastureTPWFF2    = 1.0;
  %let STJMixedAgTPWFF2    = 1.0;
  %let STJUrbanTPWFF2      = 1.0;

* SAS CODE STARTS HERE FOR NITROGENCOEFS.TXT;
* NEW MADRID
*Flood Concentration   (row 19) ;
  %let NMforestTNC1       = 1.5; *b19;
  %let NMWetlandTNC1      = 1.5; *h19;
  %let NMrowcropTNC1      = 1.5; *b19;
  %let NMNonRowCropTNC1   = 1.5; *b19 = herb. veg = other ag;
  %let NMSoybeanTNC1      = 1.5; *b19;
  %let NMSoyMixTNC1       = 1.5; *b19 wwheat+soy;
  %let NMPastureTNC1      = 1.5; *b19;
  %let NMMixedAgTNC1      = 1.5; *b19;
  %let NMUrbanTNC1        = 1.5; *b19 not in ashby;

*Dry Land Export Coef kg/ha/season adjusted for length of flood-free period;
  %let NMforestTNX1       = 0.10; *Zero in Ashby;
  %let NMWetlandTNX1      = 0.00; *B19;
  %let NMrowcropTNX1      = 6.75; *J19;
  %let NMNonRowCropTNX1   = 1.87; *o19 = herbaceous veg = other ag;
  %let NMSoybeanTNX1      =15.00; *L19;
  %let NMSoyMixTNX1       = 9.75; *M19;
```

```
 %let NMPastureTNX1      = 3.75; *P19;

 %let NMMixedAgTNX1      = 9.75; *K19 = cotton/soy corn/soy;

 %let NMUrbanTNX1        = 7.00; *Not in Ashby;


*WetLand Function;

 %let NMforestTNWFF1     = -0.4;

 %let NMWetlandTNWFF1    = -0.8;*h21;

 %let NMrowcropTNWFF1    = 1.0;

 %let NMNonRowCropTNWFF1 = 1.0;

 %let NMSoybeanTNWFF1    = 1.0;

 %let NMPastureTNWFF1    = 1.0;

 %let NMMixedAgTNWFF1    = 1.0;

 %let NMUrbanTNWFF1      = 1.0;


*Season 2 - Winter Spring (Row 20);

 %let NMforestTNC2       = 1.2;

 %let NMWetlandTNC2      = 1.2;

 %let NMrowcropTNC2      = 1.2;

 %let NMNonRowCropTNC2   = 1.2;

 %let NMSoybeanTNC2      = 1.2;

 %let NMPastureTNC2      = 1.2;

 %let NMMixedAgTNC2      = 1.2;

 %let NMUrbanTNC2        = 1.2;


*Ashby had NO dry land export during season2 in NM;

 %let NMforestTNX2       = 0.0;
```

```
%let NMWetlandTNX2      = 0.0;
%let NMrowcropTNX2      = 0.0;
%let NMNonRowCropTNX2   = 0.0;
%let NMSoybeanTNX2      = 0.0;
%let NMPastureTNX2      = 0.0;
%let NMMixedAgTNX2      = 0.0;
%let NMUrbanTNX2        = 0.0;

*Ashby uses ONE WWF for both seasons;
%let NMforestTNWFF2     = -0.8; *B21;
%let NMWetlandTNWFF2    = -0.8;
%let NMrowcropTNWFF2    = 1.0;
%let NMNonRowCropTNWFF2 = 1.0;
%let NMSoybeanTNWFF2    = 1.0;
%let NMPastureTNWFF2    = 1.0;
%let NMMixedAgTNWFF2    = 1.0;
%let NMUrbanTNWFF2      = 1.0;


*========  St. Johns Bayou ========;
*FALL and WINTER (season 1);

*Flood Concentration   (row 19) ;
%let STJforestTNC1      = 1.5; *b19;
%let STJWetlandTNC1     = 1.5; *b19;
%let STJrowcropTNC1     = 1.5; *b19;
```

```
%let STJNonRowCropTNC1   = 1.5; *b19 = herb. veg = other ag;

%let STJSoybeanTNC1      = 1.5; *b19;

%let STJSoyMixTNC1       = 1.5; *b19= wwheat+soy;

%let STJPastureTNC1      = 1.5; *b19;

%let STJMixedAgTNC1      = 1.5; *b19;

%let STJUrbanTNC1        = 1.5; *not in ashby;


*Dry Land Export Coef kg/ha/season adjusted for length of flood-free period;

%let STJforestTNX1       = 0.10; *Zero in Ashby;

%let STJWetlandTNX1      = 0.00;

%let STJrowcropTNX1      = 6.75; *J19;

%let STJNonRowCropTNX1   = 1.87; *o19 = herbaceous veg = other ag;

%let STJSoybeanTNX1      =15.00; *L19;

%let STJSoyMixTNX1       = 9.75; *M19;

%let STJPastureTNX1      = 3.75; *P19;

%let STJMixedAgTNX1      = 9.75; *K19 = cotton/soy corn/soy;

%let STJUrbanTNX1        = 7.00; *Not in Ashby;



%let STJforestTNWFF1     = -.8;

%let STJWetlandTNWFF1    = -.8;

%let STJrowcropTNWFF1    = 1.0;

%let STJNonRowCropTNWFF1 = 1.0;

%let STJSoybeanTNWFF1    = 1.0;

%let STJPastureTNWFF1    = 1.0;

%let STJMixedAgTNWFF1    = 1.0;
```

```
%let STJUrbanTNWFF1     = 1.0;


*WINTER and SPRING;
*Ashby had NO dry land export during season2 in STJ;


*Flood Concentration   (row 20) ;
%let STJforestTNC2      = 1.2; *b20;
%let STJWetlandTNC2     = 1.2;
%let STJrowcropTNC2     = 1.2;
%let STJNonRowCropTNC2  = 1.2; *b20 = herb. veg = other ag;
%let STJSoybeanTNC2     = 1.2; *b20;
%let STJSoyMixTNC2      = 1.2; *b20= wwheat+soy;
%let STJPastureTNC2     = 1.2; *b20;
%let STJMixedAgTNC2     = 1.2; *b20;
%let STJUrbanTNC2       = 1.2; *not in ashby;


%let STJforestTNX2      = 0.0;
%let STJWetlandTNX2     = 0.0;
%let STJrowcropTNX2     = 0.0;
%let STJNonRowCropTNX2  = 0.0;
%let STJSoybeanTNX2     = 0.0;
%let STJPastureTNX2     = 0.0;
%let STJMixedAgTNX2     = 0.0;
%let STJUrbanTNX2       = 0.0;


%let STJforestTNWFF2    = -.8;
```

```
  %let STJWetlandTNWFF2    = -.8;
  %let STJrowcropTNWFF2    = 1.0;
  %let STJNonRowCropTNWFF2 = 1.0;
  %let STJSoybeanTNWFF2    = 1.0;
  %let STJPastureTNWFF2    = 1.0;
  %let STJMixedAgTNWFF2    = 1.0;
  %let STJUrbanTNWFF2      = 1.0;
* SAS CODE STARTS HERE FOR CarbonCOEFS.TXT;


Forest     = sum(forest, woody_wet, HerbWetlands, shrubland) = tupelo
RowCrop    = sum(Corn,Cotton,WWheat,Rice)
NonRowCrop = Other_Ag =
Soybean    = Soybeans = Cotton Soy
Pasture    = Sum(Pasture,Grass)
MixedAg    =
Urban      = Developed
Concentrations are mg/L, Exports are kg/ha/season
;
*NEW MADRID
SEASON 1
*Flood Concentration ;
  %let NMforestTOCC1       = 4.0;*b19;
  %let NMWetlandTOCC1      = 4.0;
  %let NMrowcropTOCC1      = 4.0;
  %let NMNonRowCropTOCC1   = 4.0;
  %let NMSoybeanTOCC1      = 4.0;
```

```
%let NMSoyMixTOCC1       = 4.0;*b19 wwheat+soy;

%let NMPastureTOCC1      = 4.0;

%let NMMixedAgTOCC1      = 4.0;

%let NMUrbanTOCC1        = 4.0;


*Dry Land Export Coef kg/ha/season - adjusted for length of flood-free period;

%let NMforestTOCX1       = 0.0;

%let NMWetlandTOCX1      = 0.0;

%let NMrowcropTOCX1      = 3.6;

%let NMNonRowCropTOCX1   = 3.6; *= herbaceous veg = other ag;

%let NMSoybeanTOCX1      = 3.6;

%let NMSoyMixTNX1        = 3.6; *M19;

%let NMPastureTOCX1      = 3.6;

%let NMMixedAgTOCX1      = 3.6;

%let NMUrbanTOCX1        = 3.6;


%let NMforestTOCWFF1     = 0.8;

%let NMWetlandTOCWFF1    = 0.8;

%let NMrowcropTOCWFF1    = 1.0;

%let NMNonRowCropTOCWFF1 = 1.0;

%let NMSoybeanTOCWFF1    = 1.0;

%let NMSoyMixTOCWFF1     = 1.0;

%let NMPastureTOCWFF1    = 1.0;

%let NMMixedAgTOCWFF1    = 1.0;

%let NMUrbanTOCWFF1      = 1.0;
```

```
*Season 2 - Winter Spring;
%let NMforestTOCC2       = 4.0;*b20;
%let NMWetlandTOCC2      = 4.0;
%let NMrowcropTOCC2      = 4.0;
%let NMNonRowCropTOCC2   = 4.0;
%let NMSoybeanTOCC2      = 4.0;
%let NMSoyMixTOCC2       = 4.0;
%let NMPastureTOCC2      = 4.0;
%let NMMixedAgTOCC2      = 4.0;
%let NMUrbanTOCC2        = 4.0;

*Ashby had NO dry land export in season2 in NM, but we use SAME as season 1;
%let NMforestTOCX2       = 0.0;
%let NMWetlandTOCX2      = 0.0;
%let NMrowcropTOCX2      = 3.6;
%let NMNonRowCropTOCX2   = 3.6;
%let NMSoybeanTOCX2      = 3.6;
%let NMSoyMixTOCX2       = 3.6;
%let NMPastureTOCX2      = 3.6;
%let NMMixedAgTOCX2      = 3.6;
%let NMUrbanTOCX2        = 3.6;

*Ashby uses ONE WWF for both seasons;
%let NMforestTOCWFF2     = 0.8;
%let NMWetlandTOCWFF2    = 0.8;
%let NMrowcropTOCWFF2    = 1.0;
```

```
  %let NMNonRowCropTOCWFF2 = 1.0;
  %let NMSoybeanTOCWFF2    = 1.0;
  %let NMSoyMixTOCWFF2     = 1.0;
  %let NMPastureTOCWFF2    = 1.0;
  %let NMMixedAgTOCWFF2    = 1.0;
  %let NMUrbanTOCWFF2      = 1.0;


*========  St. Johns Bayou ========;
  *FALL and WINTER (season 1);

  *Flood Concentration   (row 19) ;
  %let STJforestTOCC1       = 4.0; *b19;
  %let STJWetlandTOCC1      = 4.0; *b19;
  %let STJrowcropTOCC1      = 4.0; *b19;
  %let STJNonRowCropTOCC1   = 4.0; *b19 = herb. veg = other ag;
  %let STJSoybeanTOCC1      = 4.0; *b19;
  %let STJSoyMixTOCC1       = 4.0; *b19= wwheat+soy;
  %let STJPastureTOCC1      = 4.0; *b19;
  %let STJMixedAgTOCC1      = 4.0; *b19;
  %let STJUrbanTOCC1        = 4.0; *not in ashby;

  *Dry Land Export Coef kg/ha/season adjusted for length of flood-free period;
  %let STJforestTOCX1       = 0.10; *Zero in Ashby;
  %let STJWetlandTOCX1      = 0.00;
  %let STJrowcropTOCX1      = 3.6; *J19;
```

```
%let STJNonRowCropTOCX1   = 3.6; *o19 = herbaceous veg = other ag;

%let STJSoybeanTOCX1      = 3.6; *L19;

%let STJSoyMixTOCX1       = 3.6; *M19;

%let STJPastureTOCX1      = 3.6; *P19;

%let STJMixedAgTOCX1      = 3.6; *K19 = cotton/soy corn/soy;

%let STJUrbanTOCX1        = 3.6; *Not in Ashby;


%let STJforestTOCWFF1     = 0.8;

%let STJWetlandTOCWFF1    = 0.8;

%let STJrowcropTOCWFF1    = 1.0;

%let STJNonRowCropTOCWFF1 = 1.0;

%let STJSoybeanTOCWFF1    = 1.0;

%let STJPastureTOCWFF1    = 1.0;

%let STJMixedAgTOCWFF1    = 1.0;

%let STJUrbanTOCWFF1      = 1.0;


*Season 2, WINTER and SPRING;

*Ashby had NO dry land export in season2 in STJ;


*Flood Concentration   (row 20) ;

%let STJforestTOCC2       = 4.0; *b20;

%let STJWetlandTOCC2      = 4.0;

%let STJrowcropTOCC2      = 4.0;

%let STJNonRowCropTOCC2   = 4.0; *b20 = herb. veg = other ag;

%let STJSoybeanTOCC2      = 4.0; *b20;

%let STJSoyMixTOCC2       = 4.0; *b20= wwheat+soy;
```

```
%let STJPastureTOCC2      = 4.0; *b20;
%let STJMixedAgTOCC2      = 4.0; *b20;
%let STJUrbanTOCC2        = 4.0; *not in ashby;

%let STJforestTOCX2       = 0.1; *No Season 2 export in Ashby, but we use season 1;
%let STJWetlandTOCX2      = 0.0;
%let STJrowcropTOCX2      = 3.6;
%let STJNonRowCropTOCX2   = 3.6;
%let STJSoybeanTOCX2      = 3.6;
%let STJPastureTOCX2      = 3.6;
%let STJMixedAgTOCX2      = 3.6;
%let STJUrbanTOCX2        = 3.6;

%let STJforestTOCWFF2     = 0.8;
%let STJWetlandTOCWFF2    = 0.8;
%let STJrowcropTOCWFF2    = 1.0;
%let STJNonRowCropTOCWFF2 = 1.0;
%let STJSoybeanTOCWFF2    = 1.0;
%let STJPastureTOCWFF2    = 1.0;
%let STJMixedAgTOCWFF2    = 1.0;
%let STJUrbanTOCWFF2      = 1.0;

* SAS CODE STARTS HERE FOR SedimentCOEFS.TXT;

*NEW MADRID
*Flood Concentration ;
```

```
%let NMforestSEDC1      = 150.0;*B19;

%let NMWetlandSEDC1     = 150.0;

%let NMrowcropSEDC1     = 150.0;

%let NMNonRowCropSEDC1  = 150.0;

%let NMSoybeanSEDC1     = 150.0;

%let NMSoyMixSEDC1      = 150.0;

%let NMPastureSEDC1     = 150.0;

%let NMMixedAgSEDC1     = 150.0;

%let NMUrbanSEDC1       = 150.0;


*Dry Land Export Coef kg/ha/season - adjusted for length of flood-free period;

%let NMforestSEDX1      = 0.0;  * natural areas have zero sed exp in season 1 or 2;

%let NMWetlandSEDX1     = 0.0;

%let NMrowcropSEDX1     = 130.0; *J19;

%let NMNonRowCropSEDX1  = 130.0; *= herbaceous veg = other ag;

%let NMSoybeanSEDX1     = 130.0;

%let NMSoyMixSEDX1      = 130.0;

%let NMPastureSEDX1     = 130.0;

%let NMMixedAgSEDX1     = 130.0;

%let NMUrbanSEDX1       = 130.0;


%let NMforestSEDWFF1    = -0.8;

%let NMWetlandSEDWFF1   = -0.8;*Minus in Ashby for NM only???;

%let NMrowcropSEDWFF1   = 1.0;

%let NMNonRowCropSEDWFF1 = 1.0;

%let NMSoybeanSEDWFF1   = 1.0;
```

```
%let NMSoyMixSEDWFF1     = 1.0;

%let NMPastureSEDWFF1    = 1.0;

%let NMMixedAgSEDWFF1    = 1.0;

%let NMUrbanSEDWFF1      = 1.0;


*Season 2 - Winter Spring;

%let NMforestSEDC2       = 260; *B20 = MS flood water;

%let NMWetlandSEDC2      = 260;

%let NMrowcropSEDC2      = 260;

%let NMNonRowCropSEDC2   = 260;

%let NMSoybeanSEDC2      = 260;

%let NMSoyMixSEDC2       = 260;

%let NMPastureSEDC2      = 260;

%let NMMixedAgSEDC2      = 260;

%let NMUrbanSEDC2        = 260;


*Ashby had NO dry land export for season 2 in NM, but we use Season 1;

%let NMforestSEDX2       = 0.0;

%let NMWetlandSEDX2      = 0.0;

%let NMrowcropSEDX2      = 130.0;*same as season 1 in this analysis;

%let NMNonRowCropSEDX2   = 130.0;

%let NMSoybeanSEDX2      = 130.0;

%let NMSoyMixSEDX2       = 130.0;

%let NMPastureSEDX2      = 130.0;

%let NMMixedAgSEDX2      = 130.0;

%let NMUrbanSEDX2        = 130.0;
```

```
*Ashby uses ONE WWF for both seasons;
%let NMforestSEDWFF2     = -0.8;
%let NMWetlandSEDWFF2    = -0.8;*negative in Ashby;
%let NMrowcropSEDWFF2    = 1.0;
%let NMNonRowCropSEDWFF2 = 1.0;
%let NMSoybeanSEDWFF2    = 1.0;
%let NMSoyMixSEDWFF2     = 1.0;
%let NMPastureSEDWFF2    = 1.0;
%let NMMixedAgSEDWFF2    = 1.0;
%let NMUrbanSEDWFF2      = 1.0;



*========  St. Johns Bayou ========;
*FALL and WINTER (season 1);
%let STJforestSEDC1       = 150;
%let STJWetLandSEDC1      = 150;
%let STJrowcropSEDC1      = 150;
%let STJNonRowCropSEDC1   = 150;
%let STJSoybeanSEDC1      = 150;
%let STJSoyMixSEDC1       = 150;
%let STJPastureSEDC1      = 150;
%let STJMixedAgSEDC1      = 150;
%let STJUrbanSEDC1        = 150;
```

```
%let STJforestSEDX1       = 0.0;

%let STJWetLandSEDX1      = 0.0;

%let STJrowcropSEDX1      = 130;

%let STJNonRowCropSEDX1   = 130;

%let STJSoybeanSEDX1      = 130;

%let STJSoyMixSEDX1       = 130;

%let STJPastureSEDX1      = 130;

%let STJMixedAgSEDX1      = 130;

%let STJUrbanSEDX1        = 130;


%let STJforestSEDWFF1     = 1.0;

%let STJWetLandSEDWFF1    = 1.0;

%let STJrowcropSEDWFF1    = 1.0;

%let STJNonRowCropSEDWFF1 = 1.0;

%let STJSoybeanSEDWFF1    = 1.0;

%let STJSoyMixSEDWFF1     = 1.0;

%let STJPastureSEDWFF1    = 1.0;

%let STJMixedAgSEDWFF1    = 1.0;

%let STJUrbanSEDWFF1      = 1.0;


*WINTER and SPRING;

*Ashby had NO dry land export during season2 in STJ;

%let STJforestSEDC2       = 260;

%let STJWetLandSEDC2      = 260;

%let STJrowcropSEDC2      = 260;

%let STJNonRowCropSEDC2   = 260;
```

```
%let STJSoybeanSEDC2     = 260;
%let STJSoyMixSEDC2      = 260;
%let STJPastureSEDC2     = 260;
%let STJMixedAgSEDC2     = 260;
%let STJUrbanSEDC2       = 260;

%let STJforestSEDX2      = 0.0;*Ashby has zero dry land export in season2;
%let STJWetLandSEDX2     = 0.0;
%let STJrowcropSEDX2     = 130;
%let STJNonRowCropSEDX2  = 130;
%let STJSoybeanSEDX2     = 130;
%let STJSoyMixSEDX2      = 130;
%let STJPastureSEDX2     = 130;
%let STJMixedAgSEDX2     = 130;
%let STJUrbanSEDX2       = 130;

%let STJforestSEDWFF2    = -0.8;
%let STJWetLandSEDWFF2   = -0.8;
%let STJrowcropSEDWFF2   = 1.0;
%let STJNonRowCropSEDWFF2 = 1.0;
%let STJSoybeanSEDWFF2   = 1.0;
%let STJSoyMixSEDWFF2    = 1.0;
%let STJPastureSEDWFF2   = 1.0;
%let STJMixedAgSEDWFF2   = 1.0;
%let STJUrbanSEDWFF2     = 1.0;
```

Appendix C: Land cover, Land use for the Project Areas.

Table C1. Land cover under alternatives 1 through 3 (no reforestation). Table lists cumulative acres of each land cover type below one-foot contours in the New Madrid Floodway provided by the Memphis District in 2011.

Elev_cuml	Corn	Cotton	Rice	Soybeans	Wwheat	WwheatSoy	Other_Ag	Fallow	Forest	Woody_Wet	Developed	Grass	HerbWetlands	Wetlands	Open_Water	Shrubland	Pasture	Total
281	4.76902	0	2.78377	139.011	0.306429	0.28508	0	6.01038	10.1079	374.7612041	1.56894333	0	4.676031251	220.776	64.03604	0	0.27558	829.367
282	5.59432	0	6.38679	316.633	0.407295	0.2463538	0.00057	6.41954	14.0048	456.032727	2.49424255	0.0251	6.824161562	458.946	74.345843	0	0.40406	1348.76
283	8.93995	0	8.96029	606.639	0.473366	0.683709	0.226002	7.19516	20.579	522.870112	5.65104479	1.54775	7.144257243	531.47	85.301987	0	0.51168	1808.19
284	12.2828	0	9.15393	1058.52	0.516189	1.1926994	0.643929	8.57121	31.1938	618.7989626	10.0160249	1.54775	8.010984018	543.236	147.17825	0	0.62134	2451.49
285	16.6694	0	11.0128	1647.95	0.534648	2.6765719	1.334101	19.2596	49.7715	831.466932	23.2632403	1.54775	8.312065941	547.024	196.77268	0.22638	0.74311	3358.56
286	29.4371	0.04689	26.514	2879.11	0.553466	3.9707245	3.732088	98.7943	102.507	1447.883887	42.9871261	1.54775	24.23923637	559.065	348.81797	0.69956	0.87194	5570.78
287	43.6512	0.06517	66.9739	4766.82	0.562072	6.9648218	5.199456	165.387	158.375	2528.108591	74.8407436	1.54775	43.85524714	578.581	494.8647	1.00615	1.04947	8937.85
288	63.7716	0.84174	148.923	7547.48	0.584751	12.613357	9.025834	189.117	214.615	3433.827428	120.041087	1.553933	50.19945737	615.229	547.25179	1.52991	1.34868	12958
289	109.03	2.38062	155.684	11539.5	0.596072	20.590611	16.68487	194.425	258.041	4337.245654	173.664658	1.660463	55.92311007	623.791	583.61898	1.53651	1.66074	18076
290	201.521	3.73777	196.958	15958.2	0.608698	28.284203	27.71062	198.964	291.411	4994.524551	218.342408	1.702737	64.21511556	627.442	610.27292	1.53967	2.25208	23427.7
291	353.16	83.595	230.514	20727	0.62713	208.52313	204.6967	201.386	332.834	5362.143194	302.388663	1.718568	68.93454072	632.432	618.71713	1.61191	4.50187	29334.8
292	412.275	93.2233	423.543	25110.6	1.367827	282.08174	494.9287	202.967	372.366	5706.567136	416.12274	1.735212	74.79148104	635.433	629.1742	1.62975	6.85336	34865.6
293	641.605	132.34	512.955	29487.9	4.30725	428.71875	761.297	204.236	414.201	6212.161394	584.875123	1.754796	80.70879046	642.15	634.62317	1.64128	9.69355	40755.2
294	1114.48	148.885	524.711	33916.7	8.32405	819.91205	1114.829	206.136	488.962	6613.466933	763.620865	1.772731	85.84684907	652.549	663.57853	1.65281	14.0021	47139.4
295	1408.16	163.671	533.711	37248.6	8.779375	1553.3001	1287.57	207.425	544.117	6902.704913	978.200301	1.801877	88.79533567	654.649	679.73828	1.70535	21.826	52284.7
296	3261.63	180.733	549.978	41718.1	62.78888	4012.0697	1515.974	209.347	617.604	7351.114658	1650.57743	1.859445	93.06169257	655.591	685.50073	1.84699	76.8352	62644.6
297	3788.24	190.966	557.041	44115.4	64.31979	5666.5902	1638.633	210.076	655.506	7618.332684	2001.50149	1.905082	94.05523446	659.708	692.92608	6.11045	89.125	68050.4
298	4440.3	206.814	561.662	45840.6	65.1494	6766.1979	1788.804	210.522	687.565	7830.187653	2190.88339	1.937823	103.6906311	660.744	697.83487	9.28223	100.029	72162.2
299	5227.74	238.867	565.328	48205.1	66.59093	7918.6889	2067.047	212.193	721.616	8058.920586	2419.3891	1.967976	106.3087762	660.958	706.1742	9.28223	114.257	77300.4
300	5976.06	252.717	567.248	50324.7	72.876	8676.0423	2257.165	212.589	785.809	8241.22391	2639.85858	1.972319	109.470987	661.375	712.61124	9.28223	128.189	81629.2

Table C2. Land cover under alternatives 4.2 (reforestation) in the New Madrid Floodway only. Table lists the cumulative acres of each land cover type below one-foot contours in the New Madrid Floodway provided by the Memphis District in 2012.

Elev_Cuml	Agriculture	Fallow	Forest	Developed	Herbaceous	Open Water	Scrub/Shrub	Pasture	Total
280	0.0000	5.6944	341.6648	0.6892	101.9704	68.8053	0.0000	0.0875	518.9115
281	0.0000	6.0094	486.6749	1.5687	263.5505	81.9844	0.0000	0.2756	840.0635
282	0.0000	6.4176	680.1204	2.4981	504.4533	106.9405	0.0000	0.4041	1300.8339
283	0.0000	7.2088	934.3465	5.6487	685.0802	131.6995	0.0000	0.5117	1764.4954
284	0.0000	10.4549	1325.5117	10.1123	870.0565	202.0407	0.0262	0.6213	2418.8237
285	0.0000	30.0915	1973.4250	22.9254	1047.9265	274.3473	0.2216	0.7431	3349.6804
286	0.0000	91.4263	3473.3873	41.9880	1307.0746	370.7959	0.6426	0.8712	5286.1858
287	0.0000	154.5966	6190.4936	71.6164	1569.2754	489.1008	0.9504	1.0487	8477.0819
288	0.0000	183.7912	9667.7479	117.0636	1946.1262	588.9216	1.5174	1.3387	12506.5067
289	0.0000	192.0888	13901.8613	170.1901	2349.2723	633.3565	1.5365	1.6571	17249.9627
290	0.0000	197.0750	18348.8921	214.5861	2720.3600	668.3494	1.5397	2.2348	22153.0372
291	4320.1661	200.3281	18807.0932	280.2049	2740.4700	683.8358	1.6119	3.6509	27037.3610
292	9499.6139	202.4977	19229.6610	392.0078	2756.0521	698.7625	1.6298	6.0490	32786.2738
293	14817.4489	203.9203	19767.9395	552.2536	2776.5150	708.9605	1.6413	8.8913	38837.5704
294	20112.5699	205.5956	20301.7279	730.4029	2801.7414	722.1563	1.6528	13.1230	44888.9697
295	25051.8760	207.0862	20702.4723	946.6277	2809.6863	738.0952	1.7053	20.1839	50477.7329
296	29621.4816	207.9863	21030.2187	1177.9015	2816.2449	765.7787	1.8412	28.0496	55649.5024
297	34521.4528	208.9828	21411.1436	1432.2626	2822.3287	774.3570	5.8603	40.6818	61217.0698
298	39106.6925	209.4241	21725.8558	1718.8947	2834.6830	780.9870	9.0618	63.0279	66448.6269
299	44601.9270	210.9984	22011.5775	2046.1470	2839.4044	789.0727	9.1571	83.1194	72591.4035
300	50064.2471	211.6936	22276.4359	2410.9104	2843.4149	794.9174	9.1827	104.6428	78715.4448

Table C3. Land cover under all alternatives addressed (land use changes are not considered) for the St. Johns Bayou project area. Cumulative acres of each land cover type below one-foot contours Bayou as provided by the Memphis District in 2011.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Elev_cuml	Corn	Cotton	Rice	Soybeans	Wwheat	WwheatSoy	Other_Ag	Fallow	Forest	Woody_Wet	Developed	Grass	HerbWetlands	Wetlands	Open_Water	Shrubland	Pasture	Total
2	281	0	0	1.21069	245.213	0	3.84952491	0	0.0287	17.2372	318.65875	13.0909009	0	10.61023526	0	100.2179	0	0	710.117
3	282	0.12316	0	1.32904	261.45	0	4.12460932	0	0.08909	19.3491	367.8913	15.3581499	0	11.0017082	1.04686	100.2179	0	0.00012	781.981
4	283	0.52133	0	1.75354	280.889	0	4.12559852	0	0.90186	24.0857	418.40358	17.01959	0	11.54813944	1.26746	100.2179	0	0.12589	860.859
5	284	4.13886	0	5.35991	1566.53	0	5.81339027	0	5.59145	75.7357	791.87993	31.73898	0	34.93431091	5.65228	157.2591	0	0.48142	2685.11
6	285	5.5987	0	18.8719	1622.67	0	6.40566644	0	11.0989	85.6194	901.27675	33.95205	0	35.68224431	6.05106	158.4164	0	0.5645	2886.21
7	286	14.9079	0.05722	42.4808	1788.6	0	7.444706	1.66901	38.9125	112.031	1341.9673	41.83514	0	46.70244716	17.9361	187.4483	0	0.83708	3642.83
8	287	41.5957	0.18623	76.4534	2337.84	0	10.702473	15.5431	88.6785	165.648	1965.9984	56.79897	0	64.39894142	31.7637	244.4653	0	1.09947	5101.17
9	288	62.257	0.30161	116.886	2623.92	0	14.8975099	26.1372	152.209	193.224	2315.1985	65.35781	0	70.95372578	40.6145	259.6819	0	1.22902	5942.86
10	289	84.0769	0.59012	171.603	2964.2	0	19.5238603	36.4942	195.548	217.091	2602.3227	84.68511	0	78.04028764	47.9423	270.3363	0	1.42654	6773.88
11	290	134.527	4.01247	277.373	3865.61	0	27.5161152	46.8302	233.169	267.744	3068.2874	126.2018	0	83.54591724	53.0996	291.0613	0	2.86113	8481.84
12	291	250.108	4.06376	910.694	5809.61	0	50.9260244	85.5271	287.12	308.595	3513.5431	211.8649	0	97.20117073	69.2931	298.3148	0	7.41077	11904.3
13	292	349.409	4.9069	1645.66	8293.67	0.3974	84.1057207	115.959	304.996	350.321	3929.7742	330.0897	0	108.9930235	74.6332	306.9947	0	12.9198	15912.8
14	293	414.044	14.8271	1912.39	9863.49	0.55993	133.880191	133.383	313.519	375.797	4150.3872	417.2404	0	122.5301267	76.8525	309.8125	0	23.4761	18262.2
15	294	479.649	18.331	2130.83	11125.8	0.83561	221.026372	150.04	316.678	399.249	4293.4988	479.2179	0	128.6220153	77.144	309.9852	0	44.6081	20175.5
16	295	593.245	27.7974	2324.41	12650.9	2.02612	353.344247	172.863	319.171	422.743	4442.9622	548.3106	0	130.3249801	78.7104	310.3681	0	111.277	22488.5
17	296	1158.92	41.7272	2727.06	17277.7	4.30111	920.442657	335.771	321.446	490.04	4824.7099	840.3831	0	134.9909713	89.9317	310.7694	0	483.202	29961.4
18	297	1878.93	79.323	3094.04	22831.3	9.17949	2013.73599	492.428	325	558.927	5245.6202	1336.553	0	140.0211174	118.232	312.1073	0	938.91	39374.3
19	298	2148.86	100.428	3170.74	24345.9	13.6432	2619.80196	513.191	327.725	595.871	5481.395	1515.923	0	143.3252661	119.529	312.264	0.01647	1073.83	42482.5
20	299	2439.42	129.268	3204	25359.1	19.165	3236.8897	543.526	329.599	628.007	5646.0696	1676.249	0	144.3264053	119.923	312.5108	0.28756	1194.43	44982.8
21	300	2810.53	188.345	3222.32	26257.7	24.5803	3925.12069	581.848	333.294	651.859	5789.1551	1852.064	0	144.7580661	119.968	313.1251	0.77339	1273.93	47489.4